COMPUTERIZED TELEPHONE-ANSWERING IN A BANK

MULTI-ACCESS FORUM

COMPUTER COMPANY IN DECEMBER SHARED PROFITS OF OVER $10 MILLION TO MORE THAN 24,000 EMPLOYEES

John Kane
Hewlett Packard
1501 Page Mill Road
Palo Alto, Calif. 94304

In the week of December 12, 1974, Hewlett Packard of Palo Alto, Calif., distributed $10,847,190 to more than 24,400 employees under the company's profit-sharing plan.

This is the second profit sharing cash disbursement made by HP in 1974, and raises the year's total to more than $20,560,000. Eligible employees receive profit-sharing checks shortly after the midpoint and end of the company's fiscal year.

This is by far the largest dollar amount paid out under the company's profit-sharing program. Also, more HP people participated in the program than ever before.

In 1973, about 21,500 employees received more than $13,300,000.

The wage base of eligible employees increased significantly since the last profit-sharing payment in May. The amount of profit sharing received by each employee is determined by the individual's base wages. Employees are eligible to participate in the program after six months employment.

In HP's Computer Systems Group, more than 2,000 employees at Cupertino, Sunnyvale and Boise facilities received checks totaling $1,116,425. This will raise the year's profit-sharing total for Computer Systems Group employees to more than $1.8 million.

Hewlett-Packard is a leading manufacturer of electronic, medical, analytical and computing instruments and systems and has had a profit-sharing policy since the company was founded in 1939.

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1505 T St., No. 4
Sacramento, Calif. 95817

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3. From Donald A. Dean:

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Thank you for your letter. We are taking $6.50 out of the fund to match your $5.00, and enrolling you for a one year sub.

Let's hope that a year from now everybody will be better off -- especially if the U.S. Government can stop paying over $100,000 a month to the disgraced Richard M. Nixon, and paying over $60 million a month to Thieu, dictator of Saigon, who is imprisoning over 200,000 persons without trial in jails and tiger cages mostly American-built.

If the Symbionese Liberation Army has used computers or attacked computers or come into contact with computers, which I doubt, your story is likely to be FAR MORE appropriate for us to publish. In any case, when you have it ready, let us take a look at it. Best wishes.

⟨?⟩○ ♡✕⟨?⟩⟨?⟩♡○Ə,⟨?⟩○ ○✕&✕○Ə
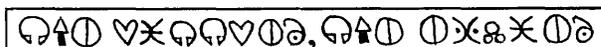
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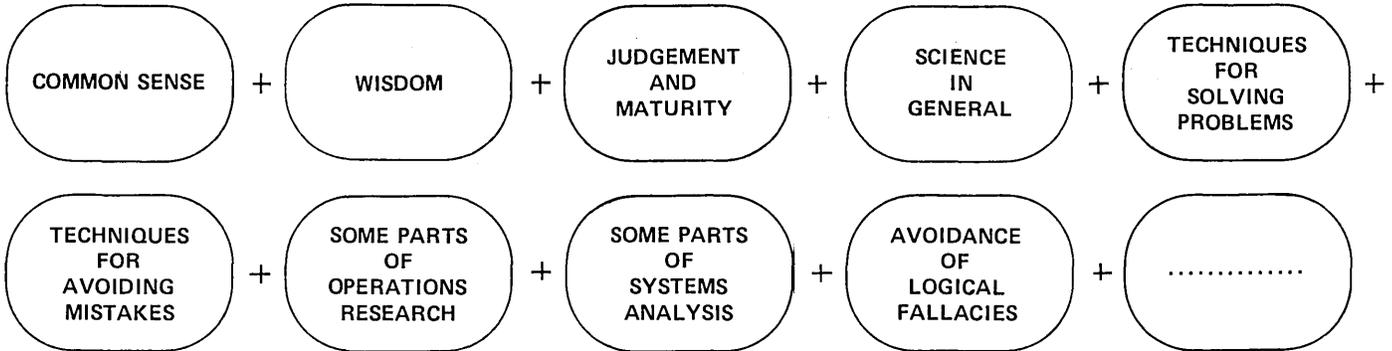
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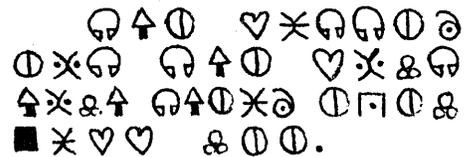
ANNUAL INDEX FOR 1974

It is planned that the annual index for the 13 issues of *Computers and People* (including *The Computer Directory and Buyers' Guide, 1974*) will be published in the March 1975 issue.

If any subscriber needs an annual index urgently, before it is published, please write to Index Editor, *Computers and People.*

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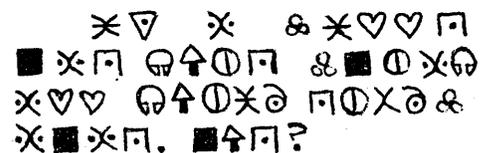
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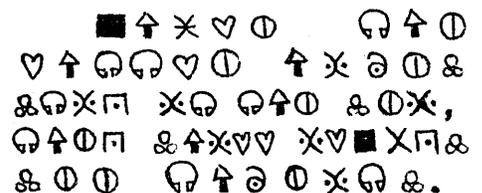
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MONOPOLY

From the dictionary:

    Monopoly
        -- exclusive ownership through legal
            privilege, command of supply, or
            concerted action;
        -- exclusive possession;
        -- a commodity controlled by one party;
        -- a person or group having a monopoly;

    Synonyms: corner, pool, syndicate, trust,
      cartel.

This country and its people, and many other countries and their peoples, have often suffered from monopoly.

One of the latest and most biting examples is shown in the increasing of the price of oil over the last two years. This has demonstrated the dependence of this country and many other industrialized countries on oil, and the demonstrated control of the price of oil by the cartel, OPEC, the Organization of Petroleum Exporting Countries. For a year and a half the industrialized countries of the world (except the Soviet Union) have looked with dismay and gloom at their utter dependence on oil imports. That dependence has been used by OPEC to raise the price of oil by 40 to 70 percent, and more.

Any organization that controls 70 percent or more of the market of any commodity, and controls it year after year according to its own choices and decisions, is a monopoly. In the market of general purpose electronic digital computers, IBM Corp. is a monopoly.

The ways in which most of the monopolistic practices of IBM have been carried out are clearly described in the article beginning on page 7: "IBM and the Maintenance of Monopoly Power". This is one of the most important and informative articles in 24 years of publication of this magazine. This is the second longest article (21 pages) that we have ever published in one issue. (The longest was "The Assassination of President John F. Kennedy: the Application of Computers to the Photographic Evidence" by Richard E. Sprague, in our May 1970 issue, 32 pages. People are still every day or so ordering a copy of that issue.)

According to the laws of the United States, monopoly is wrong. When competition fails and monopoly takes its place, over and over again the consumers suffer. The force of competition is removed. The innate slovenliness and laziness of a great many men and a great many species of life is encouraged. The point of view "It's good enough -- change is painful -- why bother to change?" prevails. This viewpoint applies for men, for organizations, for bureaucracies, and for species of life -- where the competition is the survival of the fittest.

The entire launching of automatic digital computers took place in the years 1944 to about 1950, entirely apart from any recognition by IBM that this field could become more than a scientific toy. Because IBM relied heavily on its installations of rented punch card machines, it had a vested interest in the status quo. IBM did not see for 5 or 6 years the revolutionary importance of performing long sequences of calculations within a single machine, under the control of a stored program, nor the importance of performing these operations at electronic speeds instead of relay speeds. After some six years of delay, IBM began to see what they were missing. So, they mounted a plan, at last, to make automatic digital computers.

The same pattern of delay and later entry by IBM has happened in many other situations from time to time ever since. Here is the pattern: IBM has allowed newcomers to do the exploring and to get their appetites whetted by good profits for two or three years. Then IBM has stepped in and taken the market away, by underpricing and in other ways. The way in which these tricks have been accomplished in many important areas is clearly shown in the article "IBM and the Maintenance of Monopoly Power".

In the United States there once arose a giant oil monopoly by a series of companies organized by John D. Rockefeller, Senior, the grandfather of the present vice president of the United States.

From 1892 to 1911 this monopoly was exercised by the Standard Oil Co. of New Jersey. This company, it was estimated, did three fourths of the oil business in the United States. As a result of an anti-trust suit by the U.S. Government, the U.S. Supreme Court in 1911 ordered the company to cease operations. "It had become for many people a symbol of the overconcentration of business power."

A similar outcome should occur for IBM now. Its continued existence as a single company holding about 70 percent of the market is not good for IBM, not good for the development of automatic digital computers, not good for consumers, not good for progress, and not good for conformity with the laws of the United States. IBM should be divided into half a dozen companies, and ground rules for fair competition established.

Those practices of IBM which are illegal and immoral, and which have been established by persons at IBM who should have known better the law and the ethics of doing business in the United States, should be stopped, and stopped permanently.

How did these practices develop in a company like IBM which has great numbers of law-abiding employees? Probably because these people were afraid of saying to certain executives "That is not right; let's not do it," and they believed they would be discriminated against if they spoke up. The more ambitious an executive is, the more power-hungry he is, the greater is his chance of attaining a powerful position, and the greater must be his willingness to engage in unethical and illegal behavior if such behavior maximizes profit instead of contribution to society.

Edmund C. Berkeley
Editor

IBM and the Maintenance of Monopoly Power:

or

An Economic Analysis of the Market for General Purpose Electronic Digital Computer Systems

Raymond M. Carlson
Bernard Wehrmann
Attorneys for Plaintiff
Antitrust Division
U.S. Department of Justice
26 Federal Plaza
New York, N.Y.

"We conclude, and we feel that the Court will conclude, that IBM's maintenance of monopoly power was neither inevitable nor honestly industrial, but rather the result of policies and actions aptly designed to protect and maintain that power, frequently at the expense of the consumer. ... Conduct or market practices have transformed otherwise neutral structural conditions into barriers to entry."

Table of Contents

Summary

Because of the size and importance of the field of computers and the nature of the relief sought herein, the Government has utilized extensively the tools of economic analysis in its review of the corporate records of IBM and others and in its preparation for trial. We set forth herein, first in synopsis form and then in more detail, the preliminary results of those analyses for whatever use they may be to the Court in viewing the evidence that is to be offered at the trial.

There is first offered a traditional economic analysis directed to the structure of the Government's principal market, the general purpose electronic digital computer systems market, together with an evaluation of market performance in the light of that structure. As will be shown, this analysis demonstrates that the defendant herein, IBM, has had extraordinary market power and has, over time, occupied a position of dominance in that market. These techniques of traditional analysis do not supply an explanation for two factors reflected by the facts of this market, i.e. (1) how IBM has been able to maintain its dominance during a period of rapid growth and technological change; and (2) how IBM has been able to maintain consistently high profits, profits which should have attracted numerous competitors into the market. To reach an understanding of these two factors, further analysis has been utilized to examine IBM's marketplace conduct which, we claim, has been consistently, albeit often subtly, geared to maintaining IBM's dominant position and preserving its sources of market power. It is through IBM's conduct in the market that otherwise neutral or competition-inducing structures have been transformed into barriers to entry and barriers to the growth of competitors.

Plaintiff's pretrial brief, filed herein, dated October 17, 1974, undertook to pull together in understandable fashion a representative sampling of the documents and testimony that are expected to comprise plaintiff's case-in-chief. Wherever possible, the events reflected in the documents and testimony were framed in terms of the part of the pattern of history to which they were deemed to relate. In the detailed analysis contained herein, an attempt is made to provide a further understanding and insight, in terms of major concepts, with respect to their significance in assessing the dynamics of IBM's market power. From this assessment,

utilizing the concepts so presented, we conclude,
and we feel the Court will conclude, that IBM's main-
tenance of monopoly power was neither inevitable nor
honestly industrial, but rather the result of poli-
cies and actions aptly designed to protect and main-
tain that power, frequently at the expense of the
consumer. The additional concept has already been
referred to: conduct or market practices have trans-
formed otherwise neutral structural conditions into
barriers to entry. First, IBM's conduct has influ-
enced benign structure and the result has been anti-
competitive structure. Second, a concerted pattern
of conduct by IBM has itself constituted a barrier
to entry (a factor generally viewed in economic lit-
erature as solely structural.)

The most important of the market practices as
presented herein are leasing, bundling, differentia-
tion of software, fighting machines, tying of pro-
ducts, manipulation of purchase-to-lease price ratios
and education allowances. One might usefully begin
with a description and analysis of any one of these
practices, but the patterns we observe in IBM's a-
bility to dominate the demand for and the supply of
computer systems are perhaps most clearly developed
if leasing is examined first.

The leasing or renting of equipment under a risk
lease has been the primary method by which users
have acquired general purpose computer systems in
the market. Under IBM's risk lease, embracing a
very large portion of the market, the customer has
the option to cancel the lease on 30 days' notice.
A notable feature of the risk lease is that it pla-
ces the risk of technological obsolescence on the
manufacturer of the equipment, not on the user. This
means that unless a manufacturer is able to exercise
control over his customers and his competition, he
is constantly in danger of having his customer base,
and consequently his revenues and profits, eroded
by price-performance improvements in the equipment
resulting either from the application of new tech-
nology or the reduction of prices on current equip-
ment. Yet, up to 80% of IBM's systems went out on
a risk lease basis. IBM's interest in having such
a high proportion of its systems as leased equip-
ment rather than sold equipment indicates that it
has been able to exercise the market control neces-
sary to benefit from a lease-oriented market. The
dynamics of market incentives, especially those in
relation to technological change are analyzed in
some detail in the body of this paper.

The practice of leasing has allowed IBM a substan-
tial measure of control over demand in the market by
eliminating from the market used equipment which
might be offered at reduced prices to compete with
new systems on a price-performance basis. On the

supply side, leasing has acted to deter entry into
the systems market by increasing the capital require-
ments of potential entrants and capital costs of en-
trants.

One element which permitted IBM to exercise suf-
ficient market control to make risk-leasing highly
profitable may be found in IBM's practice of provid-
ing software substantially differentiated from that
of competitors -- that is, IBM's actions resulted in
software which would generally run only on IBM ma-
chines. A key practice which permitted this was
and is bundling. IBM's software was provided "free"
to users of IBM hardware.

The result of IBM's supplying differentiated soft-
ware "free" was two fold and self reinforcing. First,
the normal levers available to consumers in a market
were taken out of the hands of users of IBM soft-
ware. They had no price to bid with -- either for
the type of software to be provided or for the qual-
ity or efficiency of the software that was provided.
Second, since the software that was "given away" by
IBM was differentiated, its acceptance and use made
future changeover to systems supplied by others more
difficult. The cycle continued: the more software
the user takes "free," the more difficult this prob-
lem of eventual changeover; the more difficult the
changeover, the greater the leeway available to IBM,
the supplier of the software, to channel software
development in ways beneficial to him. Differentia-
ted software has become a barrier to entry of new
competition and to the growth of existing competi-
tors, and a means to permit IBM to remain dominant
in the market. An additional effect of IBM's dif-
ferentiated, bundled software is that it has had
the tendency to increase the need for hardware (in-
creasing IBM's revenues and profits) by allowing IBM
to provide software that is less than optimal in ef-
ficiency.

Similar effects of bundling apply to other ele-
ments of the bundled systems. The logic is carried
through once more in the body of the paper this time
for bundled maintenance.

Like leasing, bundled-differentiated-software has,
we submit, acted to restrict competition in the sys-
tems market by raising the capital requirements of
a potential entrant. In the eyes of a customer, a
major desirable characteristic of a computer system
is the relative ease with which the customer can
shift his data processing operations from that sys-
tem to a larger, more powerful system as his needs
grow. When the manufacturer's software is highly
differentiated, such a shift is not easily or cheaply
made between different manufacturers' systems. Con-
sequently, the provision of highly differentiated
software by IBM, the dominant firm, forces a systems
manufacturer, if he is to compete with IBM on an
equal footing, to provide a full line of compatible
computer systems. Similarly, any new entrant into
the systems market, if he is to be successful in the
long run, must offer a similar full line.

The bundled aspect of the software, like the bun-
dled aspect of maintenance, customer education, and
other bundled services, serves to change the nature
of the total product as well. A general purpose
computer system has thus become, in the market, much
more than hardware alone. The practice of bundling
as utilized in the systems market by IBM has increas-
ed the scope of the product to include software,
maintenance, customer education, and other services.
In order to compete with IBM competitors have of
necessity followed suit. This broadening of the
product that a competitor had to provide has served

to compound the entry and growth problems of other systems manufacturers and of potential entrants. Bundling also deprived these firms of the ability to specialize in a given aspect or aspects of the market from the time when the industry was young and expertise at a premium virtually to the present.

The analysis of the situation as it developed in the market place is carried out by looking at three successive time periods.

  1960-1964 -- prior to the introduction of the IBM 360 series systems;

  1964-1968 -- the market as it responded to the new incentives implied by the 360;

  1968-1972 -- IBM's use of its market power to control price and exclude competitors in the systems market and its related submarkets.

The evidence will sustain the conclusion that IBM's practices of leasing, bundling, and the differentiation of its software were not practices that the natural growth of the industry forced upon IBM. Rather, they are practices which IBM has used to mold the market to its own ends. In the systems market IBM's conduct has acted upon the relatively neutral economic institutions of the industry which determined performance and has created major barriers to competition from the existing systems manufacturers and from potential entrants.

We do not claim that these IBM practices have been totally successful in stifling competitive threats to IBM's dominance of the systems market. The evidence will show that IBM's actions have at times created opportunities for entry into various related markets and submarkets. Recognizing this, IBM has countermoved with specific strategies designed to contain such entry and to dampen threats to its dominance of the systems market. Such strategies include the announcement of fighting machines to undermine the viability of specific systems manufacturers attempting to overcome the barriers erected by IBM; the tying of competitive products to ones facing little or no competition; the manipulation of interfaces to undermine the viability of peripherals manufacturers which were eroding IBM's rental base and threatening to enter the systems market; and the manipulation of purchase-to-lease price ratios to destroy the viability of leasing companies which were a serious threat both to IBM's practice of bundling and to the software lock-in of its lease base. Leasing companies will be seen to have become the agents which provided the opportunity for the fundamental economic mechanism for achieving efficiency -- specialization -- to re-emerge once again in the systems market. They also were successful in developing an effective market for used IBM systems. For the first time in the history of the systems market IBM was forced to reckon with its own prior products sold as used systems -- something automobile manufacturers and many other businesses have always had to do. IBM was slow to recognize the threat that leasing companies posed, but quick to take actions designed to protect its dominance once the threat was recognized.

Careful analysis shows that the systems market can be understood in terms of the following major characteristics. Competition takes place at essentially three levels:

  Primary Systems Competition: Those systems which are immediately substitutable for one

another at the prices prevailing in the market. Generally the most effective substitutes for a given installed system are other systems which are essentially software compatible with that system. (Noncompatible systems can be primary competition for each other with first-time system's users.)

Secondary Systems Competition: Those systems which are substitutes for one another in performance at the prices prevailing in the market, but which require substantial changeover costs before one can be substituted for the other. Secondary competition for an installed system of a given manufacturer are general purpose systems which are not software compatible, but which are capable of performing essentially the same group of tasks. Such competition has generally been provided by one mainframe manufacturer for another.

Tertiary Competition: Those products which are direct substitutes for particular elements of the system at the prevailing prices in the submarket for those elements.

These classifications may shade into one another and clearly there are lesser levels of competition, for example, less direct substitutes for elements of the system. But hopefully these broad outlines will prove useful to the court in analyzing the complexity of the industry and clarifying its major developments.

The more detailed analysis of the structure, conduct and performance of the systems market which follows is grounded in the market facts found in plaintiff's pretrial brief, generally spanning the period from 1960 through 1972. The analysis has been developed with the object of providing a means for testing the economic thesis that the maintenance by IBM of its position of dominance was not due to historical accident, but to a continuing, successful effort to maintain and reinforce barriers to entry and to preserve that position of dominance and the monopoly rents it entailed.

I. Introduction

The Government has charged IBM with monopolization of the manufacture and marketing of general purpose electronic digital computer systems (the "systems market"). The monopolization charged in the Government's complaint is, of course, "monopolization" in the legal sense proscribed by the Sherman Antitrust Act. Plaintiff's legal theory and expected proof of its charges have been set forth generally in its pretrial brief dated October 17, 1974. Whether there is or has been "monopoly" or "monopolization" in an economic sense,/*/ however, is the subject of this analysis.

This analysis will develop and discuss the answers to the following questions basic to an understanding of the economic relevance of plaintiff's case: "Is there a realistic, definable economic market such as that alleged by the Government in which to ascertain whether that market has been monopolized, is competitive, or is something in between?" "What is the economic structure of that market?" "Has IBM 'monopolized,' that market in an economic sense?"

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* The legal and economic concepts of "monopoly" and "monopolization" may not always be coincident. See Attorney General's National Committee to Study the Antitrust Laws, Report 339 (1955).

Definition of the Market

IBM is charged with having monopolized the systems market. The product involved is the electronic digital computer system which comprises the hardware, software, maintenance, and services necessary to perform a broad range of commercial applications as the primary function of the system. The initial question that must be asked and answered in an economic analysis of this question is simply: "Does this market, as defined by the Government, make economic sense?"

No analysis of the condition of competition in an industry or market could proceed unless a determination has first been made of the appropriate boundaries delimiting the relevant economic activity. In making this determination of product market boundaries, the following factors should be considered:

1. Whether the product has characteristics sufficiently identifiable to distinguish it from other products.

2. Whether the firms producing the product consider the trade and commerce in the product to constitute a distinct, identifiable market.

3. Whether there is a distinct class of customers for the product.

4. Whether, on the demand side, there are any close and directly available products which users substitute for the product in question, and the extent to which any appreciable rise or fall in the price of the substitute immediately affects the quantity of the product demanded and vice versa.

With these factors in mind, an examination of the product market advanced by the Government shows it to be a recognizable economic market, appropriately defined.

The "general purpose electronic digital computer system," the expression used by the Government to describe the relevant product, has identifiable, distinct characteristics. The system, as the multifaceted product, comprises elements of both traditional "products" and "services." The traditional product aspects of the system are the hardware (the central processing unit, the input and output devices, and the memory and storage devices), and the software (the computer programs) that enable the system to perform a broad range of business applications. The service aspects of the complex product known as the system are the maintenance, training, systems analysis, consulting and other support services that enable the customer to use the system properly for these purposes. The combination of these elements into such a system results in a multifaceted product produced and marketed by only a few suppliers. For an extended period of time this multifaceted product was offered to the market at a single price.

One notable characteristic of the general purpose computer system is that the system, after installation with a customer, soon becomes integrated with and becomes a part of the customer's internal office data flow. Like other record-keeping systems, the computer system becomes tailored to the peculiarities of the customer' operations; the business operations also become tailored to the peculiarities of the computer system. This complicates changeover from an installed system to one with different peculiarities.

The firms which manufacture and market general purpose systems consider themselves to be competing in a distinct, recognizable market for such systems. The suppliers to this market are easily identified and have, in fact, been referred to in the trade as a group variously known as the "mainframe manufacturers," the "systems suppliers," and also as what used to be "IBM and the seven dwarfs."

The customers for general purpose systems are (a) those businesses and other organizations seeking to convert their internal record keeping and data processing operations from manual to computerized techniques, and (b) those businesses and other organizations seeking to replace or upgrade their existing systems installations. The product these customers seek is the complete system, comprising all the elements previously described, although customers do from time-to-time purchase system elements separately. These, however, are generally procured as additional or replacement elements to existing systems -- an aftermarket.

One should include in the market two or more products if consumers in fact use them interchangeably for a given purpose. To know whether in fact that is true one should determine if an appreciable fall in the price of one product would promptly lead to a relatively large diversion of purchasers from the other product. If so, the products are close and directly available substitutes for one another. The market for general purpose computer systems does not appear to have any such close substitutes. Customers who need to have a general purpose system have no economically feasibile alternative product to turn to -- the customer can only seek alternative suppliers of the product.

In general, economists agree that supply substitutability is a phenomenon of the short run. If the production facilities of firm X are to be considered supply substitutable into production of product A, a given firm must have essentially all facets for production of product A and for its delivery to the customer profitably at or very near the prevailing market price. This implies also that all product development has been completed by firm X for producing product A. The shift from supplying product B to supplying product A must involve little more than setting the salesman to the task of taking orders for product A and "turning on the production line" in order to be supply substitutable.

There are some facts about supply substitutability on which disagreement among economists is essentially semantic. If firm X has marketing, production, and distribution facilities which are supply-substitutable into production of product A (though they are now used in producing product B) is firm X in the market or out? This is not an important operational question. The important operational question for market measurement is "Is product A being produced by firm X, and if so in what quantity?"

Supply substitutability goes to the question of the power of one supplier to raise his price for product A without attracting entry of new suppliers, such as firm X, rather than that of "Who is currently supplying product A?" It relates the market power of firms currently producing product A, rather than their share of the production of product A. (The output by firm X of product A is zero in any case.)

Consideration of the above-outlined factors will thus establish that the systems market defined by

the Government is an appropriate market in which to evaluate the conditions of competition or monopoly.

II. Analysis

Structure of the Market

Having determined that the manufacture and marketing of general purpose computer systems constitutes an appropriate economic market in which to ascertain the nature and quality of competition, traditional analysis leads to an examination of the structural characteristics of the market. The basic characteristics which must be examined include:

1. The number and relative size of the competitors.

2. The share of the market held by each of the competitors. (The degree of concentration in the market.)

3. The opportunity for or barriers to entry by new competitors.

The Product Market

The principal product sold in the electronic data processing industry, the systems market, is the electronic digital computer system used primarily for general business purposes. Such a system is capable of performing and includes those scientific applications normally encountered in the commercial environment. This is what we call the general purpose electronic digital computer system. The system is a multi-faceted product made up of both goods and services, to-wit: hardware, software, maintenance and other services required for a borad range of applications. The market for this product is often referred to herein and in plaintiff's Pretrial Brief as the systems market./*/

As plaintiff's Pretrial Brief has noted, in Section I thereof, the hardware of the system consists of the computer which performs five functions: input (through peripheral equipment), processing, control and storage (through the central processing unit), and output (also through the peripheral equipment). The software consists of three major types: operating systems, assemblers and compilers, and applications programming. Operating systems are designed to allow the computer to manage the operation of the hardware efficiently. Assemblers and compilers are essentially translation devices designed to allow the computer to assist in the process of programming: e.g., humans write programs in "languages" reasonably intelligible to them, the computer uses a compiler to translate from those languages to a language intelligible to the computer. Maintenance service is required for both the hardware and the software. Other services consist of consulting, systems analysis, education, training, etc.

The Competitors

The companies currently competing in the systems market, collectively known as the "mainframe companies" or "mainframers" are IBM, Univac, Honeywell, Burroughs, CDC, NCR and SDS (Xerox). Most recently, DEC and Friden (Singer) have made limited entry into this market. Three other firms, GE, Philco and RCA, had earlier provided such systems but have since left the market. All of these companies are attempting or have attempted to provide some size range of

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* See the discussion of the systems market, beginning at page 49 of Plaintiff's Pretrial Brief.

this multi-faceted product to users.

For purposes of the analysis herein we group these firms into four categories, according to our understanding of the characteristics of their prior experience and their method of entry: Group 1, IBM and Univac, which were firms that had provided systems for the automation of the office data-flow of business firms and other organizations before the introduction of the computer; Group 2, Burroughs, NCR and Singer, firms involved in offering other office machines to customers, a base they sought to protect by entry into the systems market; Group 3, Philco, GE, RCA and Honeywell, well-managed firms of large size with general business acumen, command over resources and familiarity with electronic technology, which attempted to enter directly into the systems marketplace; Group 4, CDC, SDS, and DEC, computer-based companies that used a specialized base in computers as the entering wedge in their efforts to enter the systems market.

The Customers

The heart of the users group has consisted of those firms and other organizations attempting to automate the office data-flow through use of computer systems. Gradually this group has become expanded with the expanding capabilities of the rapidly advancing technology of computers. A computer system capable of automation of office data-flow thus is necessary, but may no longer be sufficient, for success in the systems market.

IBM's Market Position

IBM's data presented in Plaintiff's Pretrial Brief suggests that based on the value of installed systems, by the early 1960's, IBM had attained a dominant market share among those firms providing general purpose systems to the marketplace. This is one of several measures of relative market shares that the Government will rely upon. Others are the share of the value of systems shipped new annually and the share of total revenues from systems annually. We believe the evidence will show that IBM maintained a dominant market share of the systems market throughout 1960-1972, despite many substantial changes in technology and rapid market growth in the market -- an unusual economic event. Published data indicate furthermore that during the period 1960 to 1972 IBM achieved very high profits, e.g., a return on its adjusted stockholders' equity of over 30% during this period -- and a cash flow return on adjusted stockholders' equity averaging over 50%. These data suggest that IBM had substantial market power and that its profits were high and sustained during the period. Our study herein gives attention to reasons which serve to explain the phenomenon of continued high market share and high profits over such an extended period of time.

Principles of Market Dynamics in the Systems Market

In the systems market in the presence of secondary competition, that is, in a situation in which the systems of one manufacturer are substantially differentiated from those systems of another (as when the software of one will not run on the hardware of the other), market incentives especially in relation to technological change become sharply etched. An analysis of these incentives is important to the understanding of the strategies followed by the various firms in the systems market. We begin by examining the implications of secondary competition among mainframe companies and then the market incentives in relation to technological change

implied by two additional conditions: (1) the condition in which all systems are sold and (2) the condition in which all systems are leased. In the last section the types of leases and their implications are discussed.

Implications of Secondary Competition

When competition between mainframe companies is on a secondary basis, a given systems manufacturer generally finds that his primary competition consists of his own systems of an earlier generation. Even here this is true only if his new system is software-compatible with systems of the preceding generation. If the systems of the mainframers are otherwise comparable, customers are likely to prefer the new system supplied by their current manufacturer to those of others. This provides that manufacturer with an advantage over others in access to those customers. It follows that in these circumstances once a firm has established a dominant position in the market, he can use this advantage to maintain that dominance.

Incentives to Technological Change in a Sales Oriented Market

For analytical purposes, we consider a situation in which the systems marketers are in secondary competition with one another in a market that operates on an outright sales basis only. We assume further that these marketers employ solid state components in the hardware of their systems, components which do not, in the ordinary sense, wear out. The customers of these marketers own their systems; the fixed costs of ownership are therefore sunk costs. For these users only the variable costs of operating the system are avoidable. Logic would indicate that these users would move to new systems only on condition that a new system would provide very substantial price/performance improvement. Absent such a demonstration, the marketer's potential would be limited to finding new customers or supplying new needs of existing customers.

Clearly, in a market where one firm has a dominant market position, that firm's competitors have no real chance to attract the dominant firm's customers to their systems unless they can, for example, provide a substantial, measurable technological improvement, or a sharply reduced cost for the customer, or both. This sales oriented marketplace would therefore provide the marketers with an incentive to innovate and furnish substantial technological change in succeeding generations of equipment.

Disincentives to Technology Change in a Lease Oriented Market

The situation in the sales oriented market may be contrasted with the incentives to a manufacturer operating in a market in which secondary competition prevails and in which marketing takes place through leasing. If all equipment is in the marketplace on a leased basis, then the manufacturer faces a very difficult problem if he introduces technology which is substantially advanced over that which previously existed. If all equipment is leased, then the user of the equipment faces (and can avoid) the full rental payment each month for the old equipment he uses. When a new generation of technology is introduced, the user can be expected to compare his current rental for his existing system with the performance he receives therefrom against the rental of the new technology and the performance which it would provide. If the price-performance characteristics of

the new system provides some advantage over the old, the customer can be expected to change over quite readily -- assuming the new system's programming is compatible with the old. If the technology is changing rapidly, this incentive can imply potentially difficult revenue problems for a given manufacturer. For example, if the price performance of one generation of systems over systems of the prior generation were fourfold and all systems were leased, then a customer would be able to get four times the performance for the existing rental price by moving to new generation equipment. If his performance requirements were static, then the user would be able to turn in his old system in exchange for the new and pay rentals only one quarter as high as before. Even if his expected performance requirements were doubled, he could turn in the two old systems in exchange for one new at the same rental price and still meet his new performance needs.

There is thus a clear economic disincentive to substantial technological change in a lease-oriented market. If all of the systems marketer's revenues are dependent upon rentals, that marketer must be able to estimate rather precisely the rate of technological change before he sets the rental price for a given system; the rental price must in turn prove to be reasonably accurate in order for him to market the system at a profit. For equipment with a long, indefinite physical life, such as solid state equipment, the economic life will be determined by the rate of technological change. If the manufacturer's estimate of the rate of technological change is inaccurate, he faces severe economic losses and perhaps disaster.

Clearly, the differentiation of one system from another eases the problem of rapid technological change in a lease-oriented market. In such a market there are sure to be substantial costs of changeover from the system of one manufacturer to that of another, in effect an insulation from competition as to systems provided by another manufacturer.

In this context, the early announcement of technological change takes on particular significance. Merely by announcing new technology a manufacturer may be able to hold on to his installed base of leased equipment. This factor plus the insulation of his market from others provided by differentiation may give him the opportunity to delay the actual introduction of new systems into the marketplace, in order to assure the profitability of his lease base. The announcement itself may be sufficient to convince current customers that they will not lose out on new technology. A delay in the introduction of new technology may permit the given manufacturer to achieve a profit from the systems already on lease in the market prior to the introduction of the new systems.

Types of Leases and Their Implications

Leases provide a mechanism for allocating risks between the user and the supplier of long-lived equipment. One of the most significant of these risks is the risk of technological obsolescence of equipment. Essentially there are two types of leases providing the user and supplier alternative trade-offs for this technological risk. The first type is the "risk lease" often referred to by IBM as an operating lease, and the second is the "financial lease." With the risk lease the supplier assumes most of the technological risk; with the financial lease the user assumes this risk.

Risk Lease Versus Financial Lease

The user of sophisticated equipment such as a computer system may consider himself relatively unqualified to determine the degree of technological risk in using a given product in relation to the supplier of that asset. If this be true, and it certainly is if the supplier has monopoly power over the product in question, the user will not readily assume this risk. The supplier can assume this risk through a lease of generally short duration in relation to the expected life of the asset in question. For example, IBM's standard lease term is for one year for its systems with a 30-day cancellation clause after one year.

A second form of lease, the financial lease, is one in which the user of the equipment commits himself to pay rentals sufficient over the life of the lease to cover the purchase price of the equipment plus interest on the portion of the principal subject to delayed recovery. Here, the lessor of the equipment faces little technological risk. The full purchase price of his equipment plus interest on the capital invested in that equipment is covered by the single lease contract. The user of the equipment in assuming the risk is acting in a manner very closely paralleling that of a purchaser of the equipment.

Implication of These Leases for IBM

IBM has consistently provided only risk leases in the computer systems market. For a number of years it was prohibited from long-term leases by the 1956 Consent Decree in settlement of an antitrust case brought by the Justice Department. It is through the risk lease that the supplier of the equipment assumes the risk of technological obsolescence; in the case of IBM, however, technological obsolescence presents little risk. Hillary Faw of IBM states categorically in his memorandum, "Thoughts for Consideration," November 21, 1969:

> "The viability of IBM's risk lease is dependent on price leadership and price control."

Faw goes on to state that IBM maintains price control in the computer systems market by controlling the "...timing of new technological insertion..." i.e., the rate of technological obsolescence.

If IBM determines the rate of technological change in the marketplace, and through choice of the rate of technological change assures profitability of each generation of equipment placed in that marketplace, IBM in fact faces little real technological risk.

Faw makes reference to the success of the risk lease in another document entitled "Impact of Leasing Companies Operations on IBM Program Rental Life," April 25, 1968:

> Successive generations of rental programs accurately life-predicted and priced, have been the key factor in IBM's ability to manage to a relatively consistent profit margin over time.

Such consistent success within a technologically volatile market implies the existence of great market power and its consistent exercise to control a complex, growing and changing market.

III. IBM's Dominance of the General Purpose Computer Systems Market, 1960-1963

Calculations based on IBM documents indicate that IBM believed itself to hold almost 80 percent of the value of installed computer systems throughout the period 1960-1963. Table III-1 shows the size and share of IBM's activity in the systems market, based on material presently available to the Government.*

Table III-1
IBM Share of Installed Systems in Points
(Dollars of Monthly Rental) at Year-end
1960-1963 in Thousands

	1960	1961
Total Installed Market	N/A	47,211.1
IBM's Share	N/A	79.5%

	1962	1963
Total Installed Market	68,293.9	91,379.7
IBM's Share	81.8%	81.7%

Table III-1 shows that the absolute value of the installed base was growing rapidly in these years. The market as a whole was to continue to grow at a rapid rate almost until 1972, the close of the period at issue. Despite the attraction that rapidly growing markets such as this one hold for new business, very little entrance occurred in the period.

For the leading firm, IBM, the general purpose computer systems market was a highly profitable one in these early years. Table III-2 shows the adjusted total corporate profitability of IBM in the early 1960's, as well as the rate of return on stockholders' equity the firm experienced. It also shows IBM's rate of adjusted cash flow compared to adjusted stockholders' equity. The cash flow ratio shows the large cash generation capacity of IBM more clearly than does the profit ratio.

In addition to rapid expansion and to high profitability, at least for the dominant firm, certain characteristic ways of doing business in the general purpose computer systems market were already firmly established in this early period. The two most prominent were bundling and leasing, while the effect of software lock-in as a structural element of the market was to become increasingly important in the later years of this period. This dominant position early in the history of the computer systems market had significant implications for IBM's future market position.

The Effect of Bundling and Leasing on Structure

Certain advantages accrued to IBM from the way that it carried on its business in the market. Table III-2 shows the availability of cash to IBM. This and other advantages were institutionalized through ways of doing business that created barriers to entry for a would-be competitor. The most significant of these ways of doing business which IBM adopted are bundling and leasing.

Bundling: Bundling is the practice of providing all facets of a general purpose system -- hardware, software, maintenance, customer education, and other services, etc. -- at a single price based only upon the amount of hardware selected by the customer. In the very early years of the computer industry when

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* It is expected that corroboration of the total size of the market and IBM's market share will be provided by the statistical submissions of IBM and their collation with data being gathered by other mainframe firms into appropriate exhibits.

users were relatively unsophisticated there was concededly some justification for bundling. However, at all times the practice had the effect of constraining the competitive potential of the industry in several important ways.

Table III-2
IBM Corporate Profits ($1,000's) and Rate of Return on Stockholders' Equity (Adjusted), *

	1960	1961
Adjusted Net Earnings ($000)	$159,405	$199, 543
Adjusted Net Earnings After Taxes/Adjusted Stockholders' Equity	25.7%	24.1%
Adjusted Cash Flow/ Adjusted Total Stockholders' Equity	60.8%	54.2%

	1962	1963
Adjusted Net Earnings ($000)	$232,373	$242,716
Adjusted Net Earnings After Taxes/Adjusted Stockholders' Equity	26.2%	25.1%
Adjusted Cash Flow/ Adjusted Total Stockholders' Equity	57.5%	54.4%

The most obvious effect of bundling on competition was that it created a barrier to entry into the general purpose systems market by significantly increasing the breadth of goods and services a would-be competitor had to supply to this market before he could be considered an effective participant. This implied larger capital requirements and increasing levels of technical and managerial talent. Potential competitors could be penalized severely for inadequacy in any facet of the general purpose system. New entrants faced the task of entering against an established firm which already had a broad-based, dominant market position. In short, the practice of bundling offered potential systems manufacturers significantly increased opportunities to fail.

In addition to raising barriers to entry in the systems market, bundling also effectively foreclosed the development of some of the submarkets which eventually emerged in the industry after IBM unbundled (mid 1969), particularly in the areas of software, maintenance and services. In an environment where bundled pricing was the standard, it was impossible for a significant submarket for any of these items to emerge during the period 1960-1964.

Bundling's Impact on the Maintenance Submarket

Testimony of witnesses will show that regional scale economies exist in the provision of maintenance services for computer systems. A key element in the provision of maintenance is rapid repair of equipment that is down. This is increasingly true for computer systems which are integrated into the real-time management of businesses and other organizations.

It is important to recognize, however, that scale economies in the provision of maintenance -- economies of scale in the maintenance submarket -- do not necessarily result in a barrier to entry into the systems market. In fact, just the opposite can be true. The determining factor is the ownership of the maintenance firm of optimal scale in a given region, not the existence of such a firm.

An independent maintenance firm of optimal scale in a region could provide the same level of service to customers of all systems manufacturers. A new systems manufacturer attempting to establish his business in the region would find that such services would facilitate his entry into the market. His costs of entry would almost certainly be lower if a skilled, experienced, efficient maintenance organization were in being and at his disposal. In its absence, such service has to be provided by the new entrant himself, with all of the attendant start-up and learning cost that such a course of action implies.

A maintenance firm of optimal scale which is a captive of another systems manufacturer would, on the other hand, constitute a barrier to entry of the new firm. Not only would that new firm face all the startup costs, but his organization would be expected to furnish maintenance service comparable to that provided by the experienced, established firm. The differential in the costs of maintenance per system for one of his systems as compared to his established competitor could foreclose many regional markets to him.

During the period 1960-1972 IBM has been the dominant firm in the systems market. Approximately 70 percent or more of the value of systems installed in the United States have been IBM systems. The bulk of these have been leased. Not only did IBM provide its own maintenance service; through its captive maintenance group, it provided it on a bundled basis to its leased customers (and still does). These IBM customers are thus foreclosed as potential customers of independent maintenance firms. A substantial portion of the market is not available for them. IBM provides its customers maintenance for an apparently zero price through bundling. Other mainframe firms have been forced to follow suit. The bulk of the market has thus been foreclosed to independents.

The independent firm providing maintenance (or other services) has to charge a positive price for his goods. If purchased by an IBM customer from an independent organization, the result would be to add to the total cost of his system. IBM's bundled price remains the same whether or not various elements of the system were actually provided to the customer by IBM. From the point of view of the potential entrant into a given submarket, his competitor, IBM, is supplying the same product he is, but at zero (additional) price to the customer. From the point of view of the customer he has to pay IBM whether he uses the service or not. From IBM's point of view, IBM has been paid whether its services were used or not.

IBM is well aware of the role that independent maintenance firms can play in facilitating the entry of competition into the systems market and related submarkets. It is well aware of the impact of bundling maintenance on the likelihood of development of strong, national, independent maintenance firms. Economies of scale in maintenance have thus become a barrier to the entry of new firms and the expansion of existing firms in the systems market.

The importance of bundling to IBM in other submarkets also must not be underestimated. With no

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* The adjustment removes marketable securities and income derived therefrom as disclosed in appropriate portions of the financial statements.

competition supplying software for its systems, IBM can be said to have incentives to produce inefficient software. Within the limits of the indirect competition provided by other systems manufacturers, the less efficient the software, the more the hardware required to produce a desired amount of data processing, and the greater IBM's revenues and its profits from increased hardware usage.

Finally, an additional result of bundled pricing was that it permitted discrimination among customers. Each customer was charged the same rate for equivalent amounts of hardware, but there was no way to know how much zero-priced support IBM provided to any given customer. If an account was particularly prestigious, or for some reason particularly important for IBM -- perhaps because of its growth potential or a competitor's threat -- IBM had the option of providing massive support to insure the account remained under its control.

Leasing as a Barrier to Entry

Leasing in an industry subject to rapid technological change is a means of transferring the risk of technological obsolescence from the user back to the manufacturer. In theory such risk does exist for the manufacturer, but in the presence of software lock-in and its dominant market position, the risk to IBM from its leasing is greatly reduced. Further, the practice of leasing provides substantial benefits to IBM in the form of the enhancement of capital barriers to entry into the systems market, and the elimination of a used computer market.

The risks to a new entrant from leasing through risk-leases have reinforcing negative effects: they greatly expand the systems manufacturers' need for capital while simultaneously making more difficult the attraction of capital. Capital attraction is more difficult for two reasons. First, the requirement to lease delays the realization of revenues and thus delays the potential profitability from marketing a given system; absolute dollar profits have to be greater to compensate for their delay in being realized. At the same time there is increased need for capital and increased risk that a given system will not be profitable -- profitability depends upon keeping the system on lease over an extended period of time and despite technological advance in the industry -- a factor the new entrant cannot control. The result has the attributes of a vicious circle. Risk leasing leads to an increasing need for capital and simultaneously to a decreasing ability to attract capital. Rapid success in placing systems on lease in the market exacerbates both aspects of the problem. When combined with bundling, absolute costs are further magnified, capital recovery delayed, and risks increased further.

IBM's practice of maintaining a fixed lease price for its systems over their entire lifetime has permitted it to render obsolete whole generations of its own equipment. Simply by maintaining the prices for its older equipment at their original level despite the existence in the market of new equipment of much greater performance provided at the same price, IBM gave added attractiveness to the new generation in comparison with the former.

Since it owns the equipment it leased, IBM is in a position to remove the older generation of equipment from the market when it is turned in. A resource that IBM is not able to obsolete physically is thus obsoleted economically and removed from the market. The result is that sales and lease levels of the new equipment are unimpaired by the threat

of primary competition which the preceding generations of equipment generally have represented.

In the presence of bundled pricing, leasing places an enormous capital requirement on systems manufacturers. Not only must they provide all facets of the general purpose system, but they must wait approximately 45-50 months before they have recovered the dollar value of the system's purchase price.

Thus, the combination of a bundled, multifaceted product made up of hardware, software, maintenance and services offered at a lease price increased the capital required of would-be market entrants by major proportions. By foreclosing many market opportunities, bundling prevented specialization in one or several submarkets of the systems market from developing. The impact is two fold. These submarkets are significantly less competitive; fewer independent firms have been able to enter them. The absence of independent specialists has inhibited the entry and growth of competition into the systems markets.

During the 1960s business practices in the systems market have been oriented to IBM's advantage. This has impeded the entrance of new mainframe firms and the growth of existing firms.

IBM's Competition in the Early 1960's

This discussion of IBM's competition in the period 1960-1964 again makes use of the concepts of primary and secondary competition presented in the synopsis. In this period, IBM's competition was basically on the secondary level of comparable, but not compatible systems. Throughout, the market programming and product development groups were to become increasingly sophisticated in this understanding of the phenomenon of software lock-in, both as a technical matter and as a concept around which to organize business decisions.

In the early 1960's, IBM had eight competitors in the general purpose computer systems market. The competitors were:

> Burroughs
> Control Data
> General Electric (GE)
> Honeywell
> National Cash Register (NCR)
> Philco
> RCA
> Univac (Sperry Rand).

Altogether these firms accounted for about a fourth of the installed base of general purpose systems, with no one firm accounting for as much as ten percent of the market.

Competitors fell into three basic groups, based on the orientation of the firms at the time of entry into the general purpose systems market. Like IBM, Remington Rand (later Sperry-Rand) had participated in the market for punched card equipment, although on a much smaller scale than IBM. A second group of companies entered the market from a base in the manufacture and marketing of office accounting and business machines. Both National Cash Register and the Burroughs Corporation enjoyed large customer bases and established contacts with banking, merchandising and other firms which would be potential systems customers. Finally, a third group of competitors, General Electric, Philco and RCA, attempted to become systems manufacturers building on their expertise in electronics. Minneapolis-Honeywell first became involved in computer systems through a joint venture with Raytheon Corporation, another high technology firm heavily involed in electronics. By the end of 1962, Philco-Ford's computer

division had effectively withdrawn from the general purpose market. It did continue to produce special purpose and military computers.

Each of these competitors approached the market in slightly different ways. Burroughs and NCR, with less than five percent of the market in the early years, focused initially on the smaller-sized systems, a submarket in which NCR has continued to concentrate. Honeywell and Univac had a fairly complete product line, concentrating their efforts in the middle of the market with medium-sized systems; this is the submarket that historically had provided the dominant share of the revenues to be had in the general purpose market. RCA and G.E. did not manufacture a full range of equipment in these early years. G.E. tended to focus on projects which later led them in the direction of time-sharing computers. RCA, like Honeywell and Univac, had its product line in the middle of the market, and perhaps in a narrower range than either Honeywell or Univac.

IBM's machines ran the gamut from the small systems favored by companies like NCR to the large computer systems designed for the electronic data processing needs of major government agencies. In each of these markets, the practices of bundling and leasing had been so institutionalized that they influenced structural characteristics of the market leading to substantial barriers to entry.

Three Specialized Firms

Other submarkets for computers were being developed by firms other than IBM, based primarily on their technical sophistication. Initially they operated outside the systems market and also outside its barriers to entry. They were thus able to achieve significant penetration, growth, and profitability. These firms used outright sales and separate pricing for each of the components of their computers as the primary mode of marketing their products.

The first of these specialized submarkets was the market for very large scale computer systems -- "super" computer systems -- engaged primarily in sophisticated, scientific calculating for organizations with the capital and the technical know-how to take upon themselves the risk of technological obsolescence. Control Data Corporation (CDC) was formed by people who knew this market well. The second was a market for small and medium scale scientific computers, utilized in laboratory work and in specialized institutions. Scientific Data Systems (SDS -- later to be purchased by Xerox) grew up primarily to serve this market. SDS's machines were marketed to the scientific community, which frequently found advantages in providing their own software and support rather than depending on the systems manufacturer to supply software. CDC also was active in this market. CDC and SDS were, initially at least, rather specialized firms that were able to enter submarkets of the computer industry where the enormous barriers stemming from the practices of leasing and bundling were not so insurmountable as in the general purpose systems market.

Finally, the early years of the decade saw the organization of Digital Equipment Corporation, whose first products were very small central processing units designed primarily for use in process control and the monitoring of scientific experiments. Again, the market was almost exclusively a purchase market and little software or support was provided, in comparison with the amount provided in the general purpose market.

Each of these companies that had started in a specialized market segment was later to use the base it had developed in these market areas in an attempt to penetrate the general purpose systems market. Two of the firms -- CDC and SDS -- were to evoke strong competitive responses from IBM later in the 1960's. Their primary significance at this point is in the evidence they provide that since the requirements for leasing and bundling are absent, entry does occur in these submarkets. Successful entry there allows the formation of the capital and the development of the organization necessary to underpin ventures into the general purpose systems market.

Competitive Strategies and the Advent of the 360 Series

By the end of the 1960-1963 period some of IBM's competitors undertook to break IBM's existing dominant position by breaking the software lock-in of IBM's customers to IBM systems. Competitors had discovered that many attempts to woo IBM customers foundered on the high costs of changing over to a new system. A competitor had to offer IBM users a sufficiently better price for an equivalent system so that the customer could afford to reprogram his software. If a competitor provided an inexpensive way to transform an IBM customer's software so that it would be used on his own systems, he would have a product much more attractive to that customer. These competitors began moving to a form of competition offering not only systems of comparable performance -- the kind of secondary competition described earlier -- but also emphasizing a kind of compatibility within these systems -- the kind of compatibility that moved them into primary competition with IBM for IBM's installed base.

In 1963, Minneapolis-Honeywell introduced the MH-200 Series, which had a "liberator" program capable of translating programs written for the IBM 1400 series to a form in which they could be run on the MH-200. General Electric also attempted to break the lock-in of IBM's 1400 series customers by its "capacitrix" compatibility system.

In this period General Electric was also one of the largest users of IBM's 7000 series computers. In a project initially intended for its internal benefit, GE undertook to enhance, expand and improve on the 7090 systems with a new system of its own, essentially compatible with the 7090 series. After the announcement of the IBM 360 series, GE decided to offer this system on the open market as what became known as the G.E. 600 series systems, at substantial price/performance improvement over the 7090 and 7094. Univac 1100 series machines had architecture also similar to the 7090 systems.

Thus for a brief period in the 1960's IBM customers were in a position to choose between continuing with IBM or changing to another manufacturer's less expensive, performance comparable, and software compatible systems. This engendered real concern within IBM. IBM believed that there was "no way to stop the Minneapolis machine." It also regarded the overall situation in the market as "extremely dangerous" to itself. IBM's response was the early introduction of the 360 family and this response effectively foreclosed the threat of primary competition that had been posed by Honeywell and GE. The introduction of the IBM 360 series had major effect on the organization and performance of the general purpose systems market. These effects are discussed separately in the following section.

IV. IBM's Dominance of the General Purpose Computer Systems Market, 1964-1968

The introduction of the IBM 360 series changed markedly the nature of the general purpose, electronic digital computer systems market. Its announcement in the first half of 1964 effecitvely forestalled the competitive inroads that were being made by firms like Honeywell, with its "Liberator" for-the M-H 200 Series, Univac and General Electric.

Table IV-1 shows IBM's share of the installed base of general purpose systems for the years 1964-1968. The figures, which are derived from IBM's own measuring of the market at the time, show that IBM believed itself to have a market share of the installed base between 81 percent and 74 percent.

Table IV-1
IBM Share of Installed Base in Points
(Dollars of Monthly Rental)
at year end 1964-1968

IBM's share of Total Installed Points (1964-1968)

	1964	1965	1966
Total Installed Points	117043.1	139210.4	187812.0
IBM's share	81.0	78.9	74.3

	1967	1968
Total Installed Points	234209.5	248735.6
IBM's share	75.2	74.6

In this period, as in the period before, the absolute value of the installed base was continuing the rapid growth that characterized the market through the end of the decade.

For IBM, if not for most of the other firms in the market, profitability remained high. The extraordinary burden placed on IBM's resources by the acceptance of the Series 360 in the marketplace, shows in the data in Table IV-2. IBM's profits failed to keep pace with its growing revenues. Adjusted Rate of Return on Adjusted Stockholders Equity was at about 27% in 1964, dipped to a low of 16.7% in 1966, and rose again to 28.3% in 1968. The ratio of adjusted cash flow to Stockholders Equity followed the same pattern reaching its low of 37.7% in 1966, but rebounding to a high of 61.2% in 1968.

These data are in accord with the proposition discussed in abstract earlier that a lease-oriented market places enormous pressure on a firm's resources of cash and simultaneously reduces accounting profit. In later sections we will see that the profit and cash flow pressures on IBM in 1966 were extremely significant, and the action it took to overcome them.

The IBM dominance of the general purpose systems market was clear, and the competition to IBM in that market was limited to the same six competitors that had survived the period 1960-1963. There was entry in several submarkets of the computer industry including CDC in the large and medium scale scientific markets, SDS in the small to medium scale scientific markets, and General Electric in the time-sharing market. In each of these submarkets, where it previously had no product offering, IBM announced a fighting machine to curb the growth of the new entrant in that submarket and insure that the new entrant would not develop a base from which to enter IBM's principal market.

Table IV-2
IBM Corporate Profits and Adjusted Rate of Return on Adjusted Stockholders Equity, 1964-1968

	1964	1965	1966
Total Adjusted Profits	$411,554	458,385	507,805
Adjusted Net Earnings After Taxes/Adjusted Stockholders Equity	26.9%	21.7%	16.7%
Adjusted Cash Flow/Adjusted Total Stockholders Equity	58.0%	46.6%	37.7%

	1967	1968
Total Adjusted Profits	633,268	841,271
Adjusted Net Earnings After Taxes/Adjusted Stockholders Equity	19.4%	28.7%
Adjusted Cash Flow/Adjusted Total Stockholders Equity	45.8%	61.2%

Within the general purpose systems market, leasing by the manufacturer remained the dominant financial arrangement, and IBM maintained a bundled pricing policy until 1969. The effects of these two practices on the structure of the market have been discussed. The introduction of the 360 family of computer systems, however, was a significant new element in the market.

The Advent of the 360

During this period when software was comparatively rudimentary, there were nevertheless substantial costs to the user involved in moving either from a system of one manufacturer to the system of another or even between systems of one manufacturer, over and above the explicit costs of the new system. Such costs included software reprogramming and the inherent reorganization of internal record keeping procedures.

A given manufacturer could establish competitive advantage for himself by making his systems of a new generation software-compatible with his systems of previous generations and thus readily (and less expensively) substitutable for them. In other words, he made his own systems primary competition for each other by minimizing or eliminating the costs of changing between noncompatible systems. Software compatibility was also often achieved within a sub-family of systems of a given generation, permitting a user to move from smaller systems to larger within that sub-family without fundamental software changeover.

During this period then, the main primary competition for a system of a given manufacturer was generally another of his own systems; systems of competing manufacturers generally remained only secondarily competitive. (There are substantial implications of these facts which are spelled out below.)

The Honeywell "Liberator" changed this, for IBM customers, by providing a mechanism for allowing the MH 200 system to approximate primary competition with the IBM 1400 system sub-family. In larger systems

Univac and GE were approaching primary competition for the IBM 7000 Series sub-family of systems, Univac with its 1100's and GE with its nascent 600 series, both patterned after 7000 systems. The two IBM subfamilies were experiencing penetration of their software differentiation and thus began receiving primary, not secondary, competition from these companies. This threat, combined with the problem for IBM that its own systems subfamilies were only secondarily competitive with each other -- and thus no more attractive to a user wishing to shift from one to another than were the systems of competitors -- were important facts of life in the market prior to the introduction of the 360.

As shown in the Government's pretrial brief, IBM believed that there was "no way to stop the Minneapolis machine." It also regarded the overall situation in the market to be "extremely dangerous" for itself. These were motivating factors for introducing the 360 Series as fighting machines.

The 360 Series constituted a direct confrontation of IBM's rivals in the systems markets; it was introduced before it was fully developed; it was intended as the mechanism to reverse the unfavorable market trend that IBM faced as its markets became increasingly competitive.

The situation following the introduction of the 360 Series was substantially different from that before. Within the 360 family the systems were intended to be upward software compatible, removing the troublesome problem of changeover -- and opportunity for competitors -- which had existed where an IBM user wished to move between the 1400 and 7000 series systems with the 360. IBM established itself as its only primary competition for customers moving up to larger general purpose systems, over the full range of systems from small, to medium, to large. Further, the 360 series systems were not software compatible with systems of competitors; thus, again, only secondary competition existed between the IBM systems and competitive systems.

The fact that the 360 Series was not designed to be software compatible with either of its previous systems subfamilies was a major problem for IBM. Data formatting, word size and basic instruction sets were all changed in the 360 from both the 1400 and the 1700 Series. (For IBM software of the 360 Series to be incompatible with the software of the MH-200 and of the Univac 1100 Series and the GE 600, it had to be incompatible also with IBM systems of earlier generations.)

IBM did, however, expend substantial effort to facilitate the transition from systems of previous generations to the 360. Their transition approach contrasts sharply with that used by Honeywell with its "Liberator". IBM used combination hardware-software bridges as shown in the Government's pretrial brief, to allow the 360 systems to "emulate" the hardware of earlier generations. This emulation was made possible through extensive use of micro-programming hardware (very fast read-only memories) plus software translation of word lengths and data formats to account for the differences between the systems. The software of these earlier generation machines would thus run directly on the machines of the new generation, frequently as efficiently as on their native machines. (As it turned out IBM experienced difficulty with the operating systems or other software of the new 360 system during its first two years. When this occurred IBM was able to fall back on emulation of earlier generation software to get them through.) Emulation Bridging was relatively

inexpensive and proved to be rather effective. (It cost IBM approximately $5 million to develop and install and it generated over two million points of additional features on 360 systems to allow it to run.*)

Honeywell's Liberator was intended to translate IBM software once and for all into software for its MH-200. Once a program was translated, the user was "liberated" from the old program which could then be discarded. A new programming would take place in software for the MH-200 itself. The customer would be free of his past.

The difference between the IBM and Honeywell approaches has proven to be substantial as will be seen.

IBM was reasonably successful in achieving software compatibility for its full family of systems (though there were substantive incompatibilities between the 360/20 and larger systems and from systems using the disk operating system (DOS) and the more versatile operating system (OS-360).)

Alternate Approaches to Compatibility

IBM's approach to software upward compatibility differs substantially from that of Burroughs. The significance of the difference has been highlighted by Mr. Ray McDonald, Chief Executive of Burroughs. Mr. McDonald has publicly expressed his displeasure and that of the industry generally with IBM's approach to system compatibility introduced with System 360.

McDonald's main objection to IBM's approach was that it failed to provide the user with "real choice." IBM users could not readily switch among system suppliers since IBM's compatibility within the 360 family was in contrast with incompatibility with systems of other manufacturers -- it was achieved at the level of IBM assembly code, which would not run on systems of other manufacturers. Once a customer selected the IBM 360, he was effectively locked-in to IBM by the software changeover costs required to make his programs run on systems of other manufacturers. For 360 customers who had been users of earlier IBM systems, the changeover costs would include also costs for changeover of the software for those systems.

Burroughs' approach to software compatibility was longer range, but it did, and does, provide the user with real choice. Burroughs announced in 1963 and delivered in 1964 the B-5000 computer system.

An improved version, the B-5500, was announced and delivered in 1964. The Burroughs system was programmed in standardized, higher level language with specifications that were public knowledge. Any system for which a compiler of that language was built could run the Burroughs programs directly no matter who built the system. From 1964 on, Burroughs' customers have had a choice to elect to use computer systems of other manufacturers. Despite this option, Burroughs' market share has increased over the years.

Burroughs' software is relatively efficient; the hardware and the software were simultaneously developed; the logic of the Burroughs systems is designed efficiently to execute the software instructions directly in higher level language. For systems of many other manufacturers, higher level language compilers were developed well after the basic hardware logic and systems architecture of the systems were

determined. Today, Burroughs' systems are software
compatible in standardized higher level languages.
They are also software compatible with systems of
other manufacturers.

Translated into the analytic terms of this paper,
we note that Burroughs achieved its software com-
patibility in a manner which allowed competition to
take place through PRIMARY competition -- it provided
its users a choice to use its systems or those of
others with equal facility. For Burroughs this pri-
mary competition was one way; their software would
run on systems of others; the software of others
would not run on their systems. IBM achieved soft-
ware compatibility in a manner which made its soft-
ware "machine independent" only so long as the ma-
chine was manufactured by IBM. IBM's approach re-
sulted in only SECONDARY competition between it and
other systems manufacturers, and little real future
choice to a customer once committed to IBM.

Implications of the 360

When IBM introduced the System 360 full family of
compatible computer systems it effectively aggregated
two important markets. First, in contrast to the
situation prior to 1964, peripheral equipment could
be transferred from one system type to another over
the full family of the 360 system. An IBM tape drive,
for example, could be used on any one of the 360's
from the 360/20 through the 360/75. Prior to that,
each system subfamily generally had its own specially
designed peripheral equipment not interchangeable be-
tween subfamilies. The second major aggregation which
took place was the aggregation of the market for soft-
ware. It was intended that any software package could
be run on any IBM 360 system from the smallest to the
largest. Both moves resulted in substantial scale
economies for IBM, spreading development costs over
a much broader base of systems. The market response
to the two aggregations was substantially different
as a result of the different institutional mechanisms
through which these products were made available to
the market.

Each piece of peripheral equipment was provided
to the customer with a separate price for that piece
of equipment. Software was bundled into the price
of the central processing unit with no separate price
for an item of software.

In the peripherals market the response was a burst
of new competition; new firms sprang up, new peripher-
al equipment was offered to users of IBM systems as
we will examine in detail below.

In the software area very little new competition
resulted during the period of bundled pricing of the
IBM software. Since there was no individual price
for software, the normal avenues for market response
to the newly aggregated and potentially profitable
market were obviated. The user of the system had
no direct way to influence the quantity or quality
of the software provided to him by the manufacturers.
Potential software suppliers would have had to charge
a price high enough to maintain them in business, but
their chief competitor, the manufacturer, charged a
price of zero. He also had very ready access to the
customer.

This contrast shows the significance of bundling
as a mechanism which prevented the development of a
competitive response to market opportunities in re-
lation to IBM systems. Where products were separate-
ly priced -- as they generally are in private markets
in this country -- competition sprang up; where pro-
ducts were bundled in price, little new competition
resulted.

IBM's Compatibility Task Forces

In 1964 prior to the delivery of the system 360
and prior to the announcement of the 360/20, IBM es-
tablished task forces to analyze the implications
of its new 360 series of software-compatible, periph-
eral-compatible family of systems./*/ IBM's objec-
tive was to determine the market opportunities which
the 360 would provide to competitors. There was a
task force to investigate possible responses to periph-
erals compatibility. IBM was made aware of the im-
plications of the new aggregation of the peripherals
market. In 1964, with the report of the I/O group
of the task force, it recognized that the aggregation
of the market presented substantial market opportuni-
ties for manufacturers of the peripheral equipment,
both the independent manufacturer and the other main-
frame companies. The group recommended several ac-
tions to inhibit competitive response.

The processor group of the Compatibility Committee
indirectly dealt with the aggregation of the market
for software. The IBM group's report on this sub-
ject did not anticipate the development of software
competitive to that of IBM; rather it recognized the
possibility that other mainframe manufacturers might
well develop new systems hardware which would access
the IBM-developed, compatible software. This poten-
tial market response was necessarily indirect be-
cause of bundling. The response of competitors to
the newly aggregated market would necessarily have
to come about through their providing hardware which
would allow access to the IBM software rather than
with software itself. Frequent mention in the IBM
documents to the Honeywell MH-200 shows the source
of IBM's concern. In a footnote to item B(1)(b)
"Super" model 30, the MH-200 is described as "... An
incomplete attempt in this direction..." aimed at
the IBM 1401./**/

IBM's task forces proceeded on a gaming basis.
Groups of IBM managers established themselves as
teams in the role of potential competitors to in-
vestigate the attractiveness of various of the IBM
360 line systems as targets for competitors. The
IBM teams identified the 360/30, the potentially
largest seller of the IBM systems, as the most like-
ly to attract competitors. Three classes of com-
petitive companies were anticipated. Group A, was
a group of competitive firms which were conscious
of their image and did not have existing systems
competitive with the 360/30. RCA and Univac were
identified as the companies with these characteris-
tics. IBM's expectation was that these firms might
announce a competitive system soon and eventually
provide a 360-compatible mode in those systems to
allow IBM 360 programs to run on their hardware.
(Indeed, both RCA and Univac eventually did so.)
Group B consisted of those firms which had not en-
tered the commercial computing market, but had re-
mained in the scientific and/or data entry submarkets.

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*In a document entitled, "Report of System/360 Com-
patibility Committees," dated August 21, 1974, to
Mr. P. W. Knaplund from Mr. J. P. McDermott, Chair-
man of the Processor Groups, and Mr. W. W. Eggleston,
Chairman of the I/O Group, IBM reported on "... pos-
sible competitive developments compatible to the
System/360 ..." and undertook "... to recommend pre-
ventive action to reduce the exposure which may ex-
ist." Another report dated October 19, 1964 from
Mr. B. O. Evans to Mr. P. W. Knaplund addressed the
same issue.

**See Page 5 of McDermott, Eggleston Report cited
in the previous footnote.

Here the report identified Control Data and the Burroughs Corporation as the firms with these characteristics. It was anticipated that these firms might also announce systems compatible with the 360/30, but they would do so later than the firms in Group A. They were judged at least equally qualified to offer such systems. Group C consisted of those mainframe competitors which already had recent entries in the commercial data processing market, and therefore would find themselves impacting their own offerings, were they to introduce new systems in these areas. G.E. and Honeywell were identified as firms with these characteristics. IBM's conclusion was that neither of these firms would attempt compatibility with the 360/30. It is important to note, however, that the Honeywell MH-200 with its Liberator was the Honeywell's already announced competitor system to the 360/30. It was not expected that Honeywell would attempt to provide a second, expensive Liberator, this time for the 360/30 programs.

IBM's task force recognized that competitive, compatible systems were unlikely to become important until a substantial number of 360/30's had been installed in the marketplace, implicitly not for 18 months to two years. Also implicit in the analysis was the need for competitors to provide greater performance calculated as in the order of 1.7 x the 360/30 at approximately 20% lower price in order to compete with IBM. Indeed, these were the assumptions of all of the task groups which operated in the processor area. IBM's analysts recognized further that the maintaining of the IBM 1401 software in being presented substantial difficulty for potential competitors: the fact that 1401 software would run on 360 systems made it necessary for competitors to provide compatibility with more than one generation of IBM software when converting IBM customers over from 360 systems to their own systems or alternatively, they would be foreclosed from such customers. IBM recognized further that the introduction of a full line of compatible equipment like the 360 series implied greater difficulty for firms to enter competitively against IBM since competitors would be called upon to provide a growth path for customers. In other words, competitors would be required to introduce more than one IBM-compatible computer system at a time to provide opportunities for firms whose computing requirements would grow over time; otherwise, customers would be unlikely to change over.

A great deal of attention was paid in the IBM task force efforts to mechanisms for preventing competitors from achieving compatibility with IBM's systems. It is clear that IBM viewed its card input-output equipment to be substantially free of competitors. The same was true of its disk random access memories. The assumption was that competitive firms would purchase these input-output devices directly from IBM and provide them to their customers. Card and disk customers were deemed less attractive to competitive firms.

Explicitly, the report showed IBM's sensitivity to the lack of competitive performance of its tape drives which were of older design. The task forces clearly identified tape systems as the most vulnerable to competition.

The processor task force recommended the residency of the operating system for the 360/30 in the disk memory rather than in both tapes and disks ("...It now appears that special REDUCED SUPPORT will be required for the tape version." Emphasis added.) in order to make more difficult the achievement of compatibility by competitors. The requirement for the use of a disk drive for the operating system would necessitate the purchase of the disk-file from IBM, making the price differential for the system as a whole substantially less and thus making more difficult the changeover from an IBM system to that of a competitor.

The development of primary competition in the general purpose market led IBM to introduce System 360 substantially ahead of schedule and to attempt the simultaneous introduction of new software and new hardware, a feat which made it worthwhile for many 1400 and 7000 users to incur the costs of changeover.

The simultaneous introduction of new software and new hardware proved extremely difficult for IBM, and it was almost two years after initial delivery of the 360 hardware that 360 software was functioning effectively. IBM's size and dominant market position, however, served to minimize the risks to IBM in this venture. The early announcement of System/360 had the effect of putting a freeze on the market, which waited to see if IBM's new system was all that it claimed. During the two years it took IBM to get the 360 functioning properly, its many customers in the main continued to utilize their IBM 1400 series and 7000 series computer system. When IBM experienced 360 software difficulty, customers who had shifted over to the 360 fell back on their 1400 and 7000 emulators. Thus, while the market waited, IBM 1400's and 7000's (or their software) were still bringing in revenues and profits. IBM's risks in bringing out System/360, which might appear to have been great, in fact represented hardly any risk at all, in view of its dominant position in the market and its large base of functioning equipment already in being.

The introduction of System/360 served to minimize IBM's exposure to primary competition in a second manner. Prior to System/360 other mainframe manufacturers which normally represented competition on a secondary basis, were able to compete against IBM on a primary basis in those cases where a customer needed increased capacity beyond the limits of his present subfamily of systems. Neither the IBM system nor the competitor's were compatible with the customer's installed system. Since reprogramming was required to move to a larger IBM subfamily, the competition was not inherently disadvantaged. They could compete with IBM on an equal basis. This opportunity for primary competition largely disappeared with the 360 introduction. With upward compatibility throughout the series, there were no capacity increases which required reprogramming. The realization of the fully compatible family of systems eliminated a potential avenue of vulnerability for IBM.

Secondary Competition: System/360 also increased the costs of competition to secondary competitors. Prior to the 360, a competitor could offer a single system or subfamily of systems. He was not particularly disadvantaged by such a limited offering, since changes between subfamilies required substantial reprogramming in any case. With the advent of System/360, however, a competitor had to find a way to match the breadth of the 360 line of compatible systems in order to assure his customer the least expensive browth potential. This need to compete on a full line systems basis significantly raised the level of resources required of systems manufacturers, in terms both of capital required and managerial and technical talent that had to be brought together. It substantially raised the barriers to the entry of new firms into the systems market and to the growth of old.

Equally important, however, was the impact on IBM itself of the escalation in absolute costs of introducing a new full family of compatible systems. As noted earlier, some key financial implications are evident in Table IV-2. Despite its own enormous existing internal capital resources, IBM found it necessary to generate more profit and cash to develop, build, lease and maintain the 360's. It did so in significant part by a shift in the purchase price as compared to the lease price for a given system. An apparently trivial decrease of purchase price of 3% accompanied by an increase of lease price of 3% proved to be sufficient to lead to a flood of new purchases of IBM 360 systems by large financial institutions seeking profitable outlets for their funds by leasing computer systems. These leasing companies had a significant impact on IBM and its way of doing business as discussed below and in the succeeding section.

Tertiary Competition: Although System/360 significantly limited primary and secondary competition, it provided opportunities for a third mode of competition which had not previously affected the systems market. The aggregation of the peripherals market by the 360 family has already been alluded to.

System/360 substantially modified the patterns of competition in the general purpose systems market. It destroyed some of the lines of competition and suppressed the possibility of other lines. In addition it created opportunities for new lines of competition. The period of 1964-1968 was one in which individual competitors began to assess the 360 environment and explore new lines of primary, secondary and tertiary competition.

Competitive Reaction to IBM's System/360

IBM's course of conduct which had increased the costs and risks of secondary systems competition through offering a bundled and leased product took on additional significance with the advent of the System/360. The bundled and leased product now had to be replicated for an entire family of general purpose systems. Several of IBM's competitors attempted to by-pass this expensive and risky means of doing business. As noted earlier, SDS and CDC marketed computer systems optimized for scientific use, designing and marketing their products in a manner different from that dictated by IBM for general purpose systems. The systems were purchased rather than leased, and were marketed to users with sufficient sophistication to develop software to meet their own specialized requirements. SDS and CDC, therefore, were not obliged to lease a substantial portion of their systems, nor did they have to provide the level of software and other support required of competitors in IBM's principal market. So long as SDS, in the small to medium scale scientific market, and CDC, in that market and that for the super-computer, limited their products to these particular submarkets, they could avoid the resource requirements of the general purpose market. Their approaches proved profitable, and both companies grew rapidly in the early 1960's.

As the companies increased both their resources and their reputations, however, they came to represent competition for IBM in two respects. Their entry into the scientific submarkets threatened to hamper IBM's ability to compete on a primary basis in those markets just as IBM had foreclosed such competition in the general purpose market. If those companies became firmly established in their submarkets, IBM would be locked out by the software lock-in of scientific customers by SDS and CDC. Al-

though much less substantial than the problems implied by lock-in in the systems market, nonetheless this would be a problem. IBM acted at a time when it could still represent primary competition to CDC and SDS for first-time-users in the new markets which those firms were pioneering. IBM did not wish to have to enter as secondary competition into those markets. On another level, these companies represented potential secondary competition to IBM if they were able to use the resources and reputations earned in the scientific market to achieve entry into the general purpose market. It was too late for them similarly to hope to be primary competition to IBM in that market.

IBM's response to these threats was immediate and precisely focused. It announced the 360/90 in the large-scale scientific market and the 360/44 in the small- to medium-scale scientific market, neither of which had been part of the original concept of System/360. The extent to which these machines were designed to undermine the competition in their respective submarkets rather than to contribute to the current performance of IBM is demonstrated by the returns which IBM accepted on them. As documented in the Government's pre-trial brief, IBM lost approximately $100 million on the 360/90. It accepted a return of less than 2.5% on the 360/44, although its returns on 360 CPU models 30 through 65 ranged from 37% to 45%. These two fighting machines were clearly aimed at preventing the growth of CDC and SDS in their respective markets, and at forestalling the entry of these companies into the general purpose market by undermining their potential resource bases.

General Electric chose a different approach in avoiding the large and demanding package IBM had conditioned the market to expect. G.E.'s approach was time-sharing, through which it hoped to provide customers directly with the services normally provided by a computer system, without actually providing the computer system itself. With time-sharing, G.E. hoped to establish data processing centers (computer utilities) where their 645 computer would be connected by telephone lines to remote terminals in the offices of customers. This would provide the customer with rapid access to the computer services he required for particular tasks, yet would obviate the need for the customer to purchase or lease his own system, and the need of G.E. to market an entire family of compatible systems. The implications of G.E.'s approach for IBM were the same as those stemming from the approach of CDC and SDS. G.E., in developing a submarket in which IBM had no product, threatened to become established in that new submarket and in doing so threatened to become, in this case, a stronger secondary competitor in the general purpose market. And IBM's response to G.E.'s threat was the same as it had been to CDC and SDS.

In the time-sharing submarket IBM marketed the 360/67, another machine which had not been originally conceived as part of the System/360 by IBM. Again, as with the 360/90 and 360/44, the return accepted by IBM on the 67 is indicative of the intent of the machine. The Government's pre-trial brief documents losses of approximately $100 million associated with the 67. Its effect was to stop orders for G.E. machines, severely curtailing G.E.'s potential market for such a product and forcing G.E. to compete for customers along the lines which IBM had established to maintain its dominant position in the general purpose systems market. Development difficulties by both G.E. and IBM suggest that IBM need not have bothered.

RCA attempted a more frontal assault on IBM's hegemony, utilizing a strategy reminiscent of Honeywell and its "Liberator" program. RCA's strategy consisted of manufacturing a family of systems the elements of which were software-compatible to a large degree with the IBM System 360. This approach posed a primary competitive threat to IBM's installed base, which RCA hoped to penetrate to achieve the 10 percent share of the market that it considered necessary to attain in order to be a viable force in the market.

The Opportunity for Peripherals Manufacturers

While the introduction of IBM's System/360 increased barriers to entry in the systems market, it created market opportunities in the area of plug compatible peripheral equipment. Within three years after the introduction of the 360, non-IBM manufacturers were offering replacement tape and disk devices designed specifically for use on these IBM Systems. These manufacturers found that they were able to provide IBM customers with peripheral equipment comparable to IBM's at significantly lower prices than IBM charged, and often with increased performance. As a result, the number of firms engaged in the manufacture and marketing of plug compatible tapes and disk drives and their associated controllers grew rapidly after 1967 and installation of these devices in IBM systems grew apace. Plug compatible memory manufacturers were to emerge later, and eventually the success of the plug compatible manufacturers (PCM's) of tapes, disks and memories began to impact IBM revenues substantially and threaten its profits.

In addition to their importance as a tertiary mode of competition with IBM -- being substitutable for IBM products but affecting only part of a computer system -- the independent peripheral manufacturers threatened to become even more damaging competition to IBM. The technical expertise and reputation for reliability developed by these PCM's, coupled with their financial success, reduced the barriers to their ultimate entry into the systems market. In fact, at the beginning of the next decade, Memorex and Mohawk Data Sciences, with strong foundations in peripheral equipment already established, began to move toward entry into the general purpose systems market.

Leasing Companies: Even more of a threat to IBM's dominance, perhaps, was the role played by independent peripheral manufacturers in the primary competitive threat that risk-leasing companies were to become to IBM. Inexpensive, reliable plug-compatible peripheral equipment reduced the dependence of risk-leasing firms on IBM and greatly assisted them in maintaining their lease rates at competitive price levels.

The risk-leasing company which bought IBM systems and leased them to customers for one, two, or three year (and even five year) periods were very much products of the System 360 environment. Starting in the period 1967-1968, the rapid growth of these companies was facilitated both by the development of plug compatible peripherals manufacturers and by a decision by IBM in 1966 to modify the relationship of the purchase price to the lease price of the 360 computer systems to increase the attractiveness of purchasing. (As shown above and according to IBM documents, IBM required the increased cash flows to maintain its profit goals.) Risk-lease firms used accounting assumptions different from IBM's as to the expected economic life of IBM systems in the hope of making a profit. They seized on the opportunity

provided by IBM's modification of the sales/lease price ratio and purchased a large number of IBM's 360 systems.

Once launched, leasing companies began to engage in primary competition with IBM. They acted as brokers who would assemble parts of systems from several different suppliers, peripherals from PCMs and services from independent service companies. The leasing companies were in effect breaking that large and expensive package into manageable portions to be supplied by different companies. Resource requirements for competition against IBM were thus substantially reduced. Even more important, specialization was being reintroduced into the systems market. Firms were being rewarded if they could do one thing well, rather than punished because there might be one of many things they did not do well.

In the final analysis leasing companies were only dependent on IBM for the CPU, for without the CPU they were unable to provide IBM's large installed customer base with an "IBM-System"; without it they could not gain access to the large, tested library of IBM compatible software.

However wise their initial assumptions regarding the rate of technological change in the computer systems market, leasing companies also provided the first large scale used equipment market for computer systems. Used equipment owned by these leasing companies could be expected to be provided at reduced rental prices, in order to maintain its price-performance competitiveness in the face of changing technology in the computer systems market. Because these systems were software compatible with systems provided to customers directly by IBM, they thereby had some effect on the rate at which new systems could be marketed by IBM.

Concluding Remarks

The period 1964-1968 was one during which IBM effectively contained primary competition that, it thought, threatened it in 1963 and 1964. Only RCA among the mainframe companies persisted in a strategy of creating systems designed to penetrate IBM's software lock-in. However, by 1968 new competitive threats to IBM's dominance were beginning to emerge. CDC and SDS were selling stripped-down scientific computer systems and moving toward IBM's market stronghold. G.E. was trying to sell time-sharing as one means of avoiding the need to supply a full line of computer systems comparable to IBM's 360 series.

In a new area, plug compatible peripherals manufacturers were beginning to erode IBM's revenues by picking off pieces of IBM's installed systems, working with leasing companies in putting together new systems and, later, in the threat they posed as entrants into the general purpose systems market.

Leasing companies, which were sometimes viewed as benign firms which used aberrant accounting procedures to justify their existence, had come to be seen by IBM as an increasing threat to its control of the market.

By the end of 1968, these developments can be viewed, from IBM's own documents, as placing increasing pressure on IBM. Its ways of dealing with these pressures will be discussed in the following section covering the period 1969-1972.

V. IBM's Dominance of the General Purpose
Computer Systems Market, 1969-1972

The period 1969-1972, which closes out the thir-
teen year period at issue in this case, saw IBM react
to the increasing pressures brought on it by periph-
erals companies and leasing companies. It also wit-
nessed the exit of two of the largest U.S. industrial
manufacturing firms from the general purpose systems
market. By 1972, both RCA and General Electric
reached similar decisions that effective competition
in the industry was impossible and that their cor-
porate resources could better be spent pursuing op-
portunities in other markets.

During the period, IBM documents indicate that it
believed itself to hold over 70 percent of the total
installed monthly rental points./*/ Table V-1 shows
that over the twelve year period at issue, IBM's mar-
ket share had dropped about ten percent, from a high
of slightly over 80 percent to the 71 percent figure
shown for 1972.

Table V-1
IBM's Share of Total Installed Monthly
Rental Points (1969-1972)

	1969	1970
Total Installed Points	341,722	385,653
IBM share	75.4	72.9

	1971	1972
Total Installed Points	407,921	430,603
IBM Share	72.3	71.7

IBM's total corporate profitability reflected the
market position that IBM had developed and maintained
in the general purpose computer systems market. Fig-
ure V-2 shows that IBM's Adjusted Net Earnings after
Taxes as a percent of Stockholders Equity was in the
range of 20 to 25 percent, once the marketable secur-
ities which IBM holds are removed from the balance
statement. Cash flow figures remained high, IBM's
flow between 44 and 53 cents on every dollar of Ad-
justed Stockholders Equity. (Again, IBM's return on
the money it had invested in cash and marketable se-
curities is not included).

Table V-2
IBM Corporate Profits (in $000) and Rate
of Return in Stockholders Equity,
1969-1972 (adjusted)

Adjusted Net Earnings	$884,498	924,054
Adjusted Net Earnings After Taxes/Adjusted Stockholders Equity	23.1	20.4
Adjusted Cash Flow/ Adjusted Stockholders Equity	49.4	43.9
Adjusted Net Earnings	999,884	1,179,804
Adjusted Net Earnings After Taxes/Adjusted Stockholders Equity	20.7	25.3
Adjusted Cash Flow/ Adjusted Stockholders Equity	44.4	53.2

NOTE: The adjustment removed from the figures mar-
ketable securities and any income derived therefrom.

By 1968, IBM's System/360 had dissipated the
threats of competition which had grown up around IBM's
installed base of its 1400 and 7000 computer systems.

*More precise measures of the size of the market and
market share will be available at the conclusion of
the program of discovery.

However, as firms in the computer industry adjusted
their strategies to cope with the new realities of
the marketplace various new competitive threats had
begun to emerge. IBM used fighting machines and the
complex, integrated strategy of System/370 to combat
the primary, secondary and tertiary competition which
had developed in response to System/360.

Leasing Companies

IBM's attitude toward leasing companies changed
dramatically over a brief period. First they were
looked upon as purchasers of IBM systems (and hence
cash providers to IBM); then they were perceived as
"discount houses" for getting IBM systems to users
on a risk-lease basis. (It must be noted, however,
that IBM received the full retail price and profit
for systems purchased by leasing companies). Then
they became recognized as systems assemblers, buying
various elements of the system from multiple, inde-
pendent vendors.

By serving as a ready, cash-on-the-barrelhead
customer, leasing companies had facilitated the en-
try of new firms into submarkets of the systems mar-
ket. By 1969 IBM had partially unbundled its sys-
tem pricing; what IBM had done "voluntarily" was
helped along to a much greater degree by the leasing
companies. Through their efforts, specialization
was reintroduced into the systems market: firms
entered individual submarkets, grew and prospered.
The one-vendor (who is the full systems manufacturer)
approach to the market was in danger of being re-
placed by the one-vendor (who is the leasing com-
pany), the assembler of the system's components on
the basis of the best performance for a given price.
Firms were rewarded for being able to perform a given
task or tasks well, rather than held in check by
their inability to accomplish one of the many tasks
implied by the full systems approach. Consumers
were provided a new choice of products and services
at prices competitively determined in the various
submarkets.

Since the leasing companies provided systems soft-
ware-compatible with IBM's systems, IBM perceived
that the leasing companies could unsettle its usual,
profitable approach to leasing especially in the
period after production of the 360 models was ended.
If IBM maintained the rental price for the systems
it owned, as had been its policy, while the prices
for leasing company owned systems were determined
competitively among the many leasing companies in
the market, then, since the leasing-company-owned-
IBM-systems are software-compatible with the IBM-
owned-IBM-systems, those of the leasing company
could be readily substituted for those of IBM. IBM-
owned systems would be displaced; average lease lives
would drop; profits would drop. Hillary Faw stated
in an April 25, 1968 IBM internal document: "A re-
duction of three months in 360/30 rental life would
cost $116 million in profit (11% reduction)."/**/
In effect a used equipment market would be estab-
lished for IBM systems. The dual, favorable results
to IBM from the ABSENCE of a used systems market --
pressure on users to move to a system of a new gen-
eration or alternatively the luxury of adding to the
average lease life at original rental rates (and thus
also to profitability) of the old generation -- were
both threatened by the presence of a used systems
market.

**April 25, 1968, Hillary Faw, Jr., "Impact of
Leasing Companies Operations on IBM Program Rental
Life." This paper attached to a May 16, 1968 memo
from H. A. Faw, Jr., to R. W. O'Keefe.

IBM's Response to Leasing Companies

These perceptions on IBM's part led it to study
the factors which affected the profitability of leas-
ing companies. Its conclusions were that an increase
in the ratio of purchase prices to lease prices, to-
gether with an increase in the price of maintenance
for purchased systems, would severely constrain the
ability of leasing companies profitably to risk-
lease the successor system to the IBM 360 family of
systems, the new IBM 370 Systems. It was expected
that leasing companies would have to purchase their
370 systems during the first two years they were on
the market to attain even minimal (6% or greater)
profitability./*/ In addition, the first IBM 370
systems brought out -- the IBM 370/155 and 370/165
-- had their major revenue and profit impact on the
installed base of IBM 360/50 and 360/65 systems, the
very machines which leasing companies had purchased
most heavily. The price performance improvements in
the IBM 370/155 and 370/165 severely undermined the
revenue and profit expectations of the leasing com-
panies.

Within two years after delivery of the first 370/
155's and 370/165's, IBM announced the 370/158 and
370/168, which provided significantly improved price/
performance over the 155 and 165 and left those who
had purchased 155's and 165's holding technically
obsolete equipment. This rapid technological obsoles-
cence of equipment of the size normally purchased --
by leasing companies and by others -- did not go un-
noticed in the market.

The effect of IBM's actions on leasing companies
was dramatic. The profitability of their 360 inven-
tory was severely undermined and very few of these
firms were able to justify purchasing IBM 370 sys-
tems on a risk-lease basis.

The value of the risk-leasing firms to the user
remains, however, in the used systems market that
they have created. Stuck with technically obsolete
equipment, leasing firms have kept that equipment
producing revenue by price drops and shrewd use of
technological upgrading of equipment in-place. In
this way, they have impinged on IBM's ability to
obsolete their equipment economically. Their impact
is short run, however. IBM's 370 price shift (mere-
ly those two described) made leasing companies un-
able to perform a similar function with the IBM 370
systems.

The Exits of General Electric and RCA

In addition to the effective curtailment of the
risk-leasing companies, the period 1969-1972 saw
the exit of two general purpose computer systems
manufacturers.

General Electric: The General Electric Company,
one of the corporate giants in the United States,
left the general purpose computer systems market
in the first part of 1970. The story of its exit
is described in the pre-trial brief herein. In
terms of this analysis it is sufficient to note
that, prior to its exit, General Electric had under-
taken several studies on its long-term viability in
manufacturing general purpose systems. Despite the
fact that GE was well along in the design of an ad-
vanced product line of fully compatible systems, its
management concluded that, after years of financial
losses totaling over $100 million, it would not be

*Memorandum from S. D. Jennings to B. G. Beitzel,
Sept. 30, 1968, "Leasing Company Economics".

in the best interests of the firm to invest the $500
million that its analysis had indicated was necessary
to remain a viable force in the market. General
Electric sold its general purpose systems manufact-
uring business to Honeywell.

RCA: By 1969-1970, RCA's Spectra 70 series had
attained a software compatibility with System/360
which had permitted it to make some inroads into
IBM's installed base. RCA had undertaken a business
strategy which emphasized primary competition with
IBM. Its marketing plan of a 10% price break and
10% performance improvement over comparable IBM 360
models provided an attractive alternative to cost-
conscious users. But IBM's announcement of the
System 370 in 1970 left RCA facing the two-way street
of compatibility. Now it was RCA's installed base
which became vulnerable to the improved price/per-
formance of the new IBM system.

To protect its base from erosion and to maintain
its hopes of eroding IBM's installed base, RCA aban-
doned its plans for early introduction of a new pro-
duct line incorporating significant technological
improvements and quickly introduced a souped-up
Spectra 70 called the "RCA" series. The new series
offered price-performance improvements comparable
to the IBM 370, and it did prevent IBM from impact-
ing RCA's customer base. However, RCA customers
with leased systems began returning their old Spec-
tras for the new RCA series machines in order to
cash in on the new price-performance break. As a
result, new RCA series systems were installed, many
older Spectra 70 systems were returned, creating a
great deal of activity and expense with no increase
in revenues for RCA.

This phenomenon of a firm impacting its own in-
stalled base is a direct result of price-performance
competition in a lease market. From its dominant
position IBM has been able to choose the time and
place for this competition so that, for instance,
it was not forced to impact its own base before the
360 Systems had reached their profit goals. A firm
like RCA, however, was not able to affect the tim-
ing of the competition and was forced to impact its
own base of Spectra 70 systems before it had reached
its break-even point.

Like the leasing companies, RCA was also affec-
ted by IBM's actions against plug-compatible peri-
pherals manufacturers. In the spring of 1971, IBM
announced the Fixed Term Plan (FTP) for IBM peri-
pheral equipment. RCA judged the effect of the
plan to be to lower IBM rental prices by about 8%,
which reduced the price-performance advantage that
the RCA series had enjoyed over the 370 line. For
RCA, however, the more ominous part of FTP was that,
as part of the plan, IBM users were required to sign
one- and two-year leases for their peripheral equip-
ment with substantial penalties for nonfulfillment.
Those who signed up for the plan were thus subject
to a reverse-tie -- the IBM peripherals would at-
tach only to an IBM CPU. They were therefore fore-
closed from accepting RCA's offer of compatibility
with better price performance.

Shortly after the announcement of the Fixed Term
Plan, RCA announced that it was exiting from the
general purpose systems market, accepting a one-
time loss of $490 million, later adjusted to $418
million before taxes.

Like General Electric, RCA too had estimated the
capital requirements for continuation in the market
to be in the range of half a billion dollars. Like
GE, RCA had decided that, given the chance of success,
the price was just too high.

IBM's Actions Against Peripherals Companies

IBM's efforts to destroy the viability of peripherals companies represented an integrated strategy comprised of pricing policy changes and fighting machines. The strategy evolved from the recommendations, made by the "Cooley Task Force" or Peripherals Task Force, convened in 1970 after IBM had designated peripherals a key corporate strategic issue. These recommendations were:

1. Pricing changes;

2. Accelerated development of new products;

3. Mid-life enhancements of announced products;

4. Tying or physically incorporating parts of one product into another product so as to reduce market exposure;

5. Tying competitive products to noncompetitive ones and offering the two together.

IBM struck first at peripherals manufacturers in September of 1970 by announcing the 2319A disk drive as "new" disk drive. In fact it was essentially a physical rearrangement of its standard 2314 drive announced for attachment to the 370/145 CPU. The 2319A represented a significant price reduction per spindle over IBM's standard 2314. Independent peripherals manufacturers had made significant inroads into the market. With the 2319A IBM attempted to foreclose the peripherals manufacturers from the 370/145 marketplace by integrating part of the control unit (a "competitive" product) for the disk drive into the CPU (a "noncompetitive" product) of the 370/145. The rest of the control unit was placed into the box with the disk drive, making it more difficult for plug compatible machine manufacturers (PCM's) to interface with the IBM system in providing their products. This move also reduced the revenues to the PCM firms by decreasing the dollar value of the controller not tied to the CPU. Thus a smaller proportion of the product was available for replacement by the PCM's. Before the change, the PCM's supplied both the full controller and the disk drive. The 2319A was significantly cheaper than the same number of spindles for the 370/145 without an integrated control function (called by IBM the integrated file adapter).

In December of 1970 IBM announced the 2319B, which permitted 2319's to be attached to all 360 and 370 CPU's via a 2314 control unit. The 2319B represented approximately a 25 percent price reduction over a comparable number of 2314 spindles. IBM was able to discriminate against its "old" customers (with 78,000 installed spindles) by not allowing the monthly rentals on their 2314's to be reduced while cutting price on the 2319B. IBM limited its exposure to revenue loss further by restricting output of the 2319's to 2000 spindles in the first year.

IBM did take one across-the-board price action. It removed the extra use charge for the disk drives, the charge it made for customers who used equipment leased from IBM on more than one shift. IBM documents show that this charge represented approximately 14 percent of such revenues.

The effect of the 2319B announcement was to force the PCM's to reduce the rental on their ENTIRE lease base, thereby impacting their revenues and profits. IBM's peripherals task force had studied this effect before the fact and surmised that the forced rental reductions would deprive Telex and Memorex of substantial profits.

The second link in IBM's peripherals strategy was the fixed term plan and extended term plan, which had a pronounced effect on PCM's. The plans offered 8 percent and 16 percent discounts for IBM peripherals on 1- and 2- year leases, respectively. In addition, however, the plans also eliminated additional use charges for those machines on which they had not already been eliminated. This meant actual rental reductions of 30-40 percent from those prevailing before the peripherals task force went into action. The plans and consequent rental reductions were offered, however, only on equipment receiving competitive pressure from PCM's: tapes, disks, printers, card reader/punches.

The effect on PCM's was devastating. IBM documents show that in the first seven months after the fixed term plan was announced, PCM tape and disk drive installations fell 62 percent and 48 percent, respectively.

The effect on IBM was not devastating. IBM used its market power to increase rental prices on its CPU's, only two months after offering long-term lease discounts on its peripheral equipment. The increased rentals on the processors more than offset the decreased rental on peripherals.

Because of its power in the market, IBM was able to shift its prices and profits to the processor and maintain its overall system price and profit. It succeeded in impacting the independent PCM firms in the process.

The third link in IBM's peripherals strategy was the "SMASH" Plan or "Plan 725 Product Announcement." The plan was announced in August of 1972 and served as a warning to any PCM'er who remained unconvinced that IBM would not tolerate either PCM erosion of its base, or the growth of PCM's into systems companies. More importantly, the plan provided a warning to the investment community as to the real risks faced by PCM'ers.

Essentially Plan 725 introduced the 370/158 and 168, the upgraded versions of the 370/155 and 165. The 158 and 168 had very large minimum memories tied into the price of the CPU and 3330 disk controllers inside the CPU box. The prices of the add-on memory and of the controller were reduced substantially and the price of the "host" CPU was increased more than proportionally. IBM succeeded in smashing the two areas where competitive pressure was most likely -- disk drives and memories.

The strategy of IBM vis-a-vis PCM's was made clear by the Cooley Task Force. Lower prices on products receiving competition where possible was one approach. Another -- avoid decreasing total revenue by tying "competitive" products to "noncompetitive" ones and market the two as a tied package. Also, incorporate parts of products into other products to make the job of interfacing more complex. And -- offer mid-life product enhancements to obsolete the PCM's lease base and reduce revenues and profits to those firms.

IBM recognized PCM's to be a threat arising out of two conditions. First, there had been rapid increase in the value of peripheral equipment as a percentage of total value of hardware in the system -- from about 20 percent in the early 1960's to an estimated 70 percent by 1975. Perhaps more importantly, and as already pointed out, IBM aggregated a market for peripheral equipment when it introduced System/360 which was attractive to PCM firms and allowed them to grow and prosper. These

factors, combined with IBM's history of high profits on peripherals, made the market a natural place for competitive forces to interact.

IBM was able to use its market power to stop that interaction. IBM analyzed the determinants of PCM viability, determined that these factors were within its control, and took actions to destroy that viability. It was only a matter of a year or two before the PCM market experienced the impact of IBM's power.

The Effects of IBM's Actions on the PCM Market

The effects of IBM's actions on the plug compatible peripherals market were immediate and pronounced. Telex Exhibit 676 (reprinted below) shows the after-tax profits of seven of the major plug compatible peripheral manufacturers for the years 1969 through 1972. In 1969 each of these companies except Storage Technology, the most recent entrant, was profitable. The group as a whole netted more than $17 million in after-tax profits. Again in 1970, these firms netted over $17 million with all companies but Storage Technology reporting a profit.

PLUG COMPATIBLE MACHINE (PCM) INDUSTRY /1/
NET PROFIT (LOSS) AFTER TAX /2/
($ Million)

Calendar Year	CalComp	Marshall/3/	Memorex	Potter
1969	.96	.98	6.9	2.21
1970	2.02	.42	3.45	2.42
1971	.98	(5.19)	(14.57)	2.06
1972	(9.7)	(9.88)	1.28	(.86)
	(5.74)	(13.67)	(2.94)	5.83

Calendar Year	Storage Technology	Tracor/3/	Telex	Total
1969	--	2.06	4.59	17.70
1970	(0.69)	2.02	7.83	17.47
1971	(4.09)	(.11)	3.32	(17.60)
1972	2.83	(27.2)/4/	.66	(42.87)
	(1.95)	(23.23)	16.40	(25.3)

/1/ IBM excluded.
/2/ Source: Public information.
/3/ No longer in PCM industry.
/4/ Special charge of $27.12 million from discontinuance and divestiture of computer products operations.

In 1971, however, IBM's predatory actions had their intended effect on the peripherals companies. In that year only three of the seven firms had after-tax profits, and as a group the firms lost as much money as they had earned in 1970. The 1970 profit of $17 million turned to a 1971 loss of $17 million. The three companies which did manage to report a profit in 1971 showed substantial reductions from the previous year. The profits of Telex and Cal Comp were cut over 50 percent, while Potter's dropped 20 percent.

The next year was even more disastrous. In 1972, the seven PCM companies lost over $42 million -- more money than they had earned in 1969 and 1970 combined. Two of the seven companies were nonetheless able to operate at a profit in 1972, but at sharp reductions from the levels prior to IBM's im-

plementation of its strategies designed to maintain dominance in these submarkets. Telex's profit in 1972 was only 10 percent of what it had been in 1970, while Memorex's was less than half its 1970 figure.

Not one of the companies escaped the effects of IBM's actions. Five of the seven companies had over-all net losses for the period combining the two years prior to IBM's actions (good years for the peripherals companies) and the two years after. Only Telex was able to show a profit for both 1971 and 1972, albeit at a severely reduced level.

The net effect of IBM's integrated strategy vis-a-vis plug compatible peripherals manufacturers is found in the lower right hand corner of Telex Exhibit 676. The net effect of IBM's actions -- first inducing the entry of plug compatible manufacturers and then disciplining them when they began to appear successful -- was an overall loss for the PCM firms in excess of $25 million.

IBM's market power is again evident. Once the PCM firms began to establish themselves as profitable, on-going enterprises, IBM brought to bear its pricing and fighting machine weapons. And suddenly the market was filled with the "dying company" -- just as IBM staff members had predicted in the briefing that preceded the decisions to go ahead with the recommendations of the peripherals task force.

It is difficult to find net benefit to consumers in these actions. Consumers were subjected to price discrimination marketed as "technological advances" that were illusory or not delivered. Price cuts on peripherals were to be balanced by price increases on IBM's central processors. The overall price the consumers paid for their systems would thus remain roughly the same, at the cost of a loss of useful and innovative competition in peripherals.

From the consumer's perspective fewer viable choices are now available. There is the lessened prospect that new peripherals manufacturers will enter in the future. To the extent that consumers have accepted IBM's invitation to 12- or 24-month contracts, they are more tightly tied to IBM's systems than before since their peripheral equipment will run only with IBM CPU's, and therefore, during the length of the contracts, would-be systems competitors are effectively precluded from the market.

IBM's marketing practices vis-a-vis terminal manufacturers represent an additional weapon in IBM's arsenal for the elimination of competition. The competitive weapon it employed was the manipulation of the software interface. IBM's actions in the terminals area against Sanders Associates, Inc., are particularly revealing of the potential of this weapon.

In 1966 IBM introduced its 2260 cathode ray tube (CRT) display terminal for use with System/360. In late 1966, Sanders offered a similar product, the 720, capable of being used in conjunction with 360 systems through the 2260 interface. Sanders delivered a follow-up product, the 620, in late 1968. IBM acknowledged the inferiority of its own terminals in its "DP Group Operating Plan 1969-1970":

1. Terminals
   ... To put the case simply, our prices are high, our function is no better than equal (often inferior), and our timing is late.

In 1971, IBM announced a new CRT terminal, the 3720, for delivery in late 1972. At approximately the same time, Sanders had announced its new display terminal, the 600. Both products were capable of being used with System/360, and it appeared that the superior characteristics of the new Sanders' offering would serve to maintain and even enhance Sanders' position in the terminal marketplace. IBM's marketing plan for the 3720, however, rendered that appearance invalid. In the fall of 1972 IBM announced its virtual systems software in conjunction with its System/370 computers. The virtual system software did not include support for the 2260 interface, rendering all Sanders equipment, and all IBM 2260 equipment, unusable with the 370 line. IBM's 3720, however, was not similarly disabled. IBM had, unannounced, built into the 3720 the capability of interfacing with the new virtual system software. IBM thus effectively eliminated competition for the 3720.

The motivation behind IBM's action is clear. Its offerings in the terminal market were inferior at a time when terminals were beginning to play an increasingly important role in the systems of final users. Independent terminal manufacturers were making inroads with intelligent terminals (terminals with some processing capacity), while IBM was still offering the 2260. Even the 3720 was not superior to the products independent manufacturers had had on the market for several years. In order to establish for itself control of the terminal market, IBM seized not upon a superior product, but upon a mechanism which obsoleted the superior offerings of independent manufacturers.

IBM's refusal to support the 2260 interface in conjunction with the 370 system software effected an immediate and drastic cutback in Sanders' orders, in its order backlog, and in its lease base. Although eventually, as a result of negotiations based on a ruling in the Telex case, IBM was forced to reinstate software support for the 2260 interface, IBM's strategy had served its purpose. In addition to effectively denying all Sanders and other independent terminals access to 370 systems for more than two years (during which time 370 users had no alternative to IBM terminals), the IBM strategy forced Sanders to reprogram its terminals to emulate the IBM devices in order to achieve interface with the CPU. Sanders achieved this emulation only at a significant degradation of the original capabilities of the terminal, thereby reducing its superiority over comparable IBM equipment.

The future implications of IBM's actions vis-a-vis Sanders are ominous. They serve as a warning that any competitive equipment which must interface with an IBM CPU through system software is subject to obsolescence. IBM continues to have the power to act unilaterally in such a manner, and although it may be forced to reinstate discontinued software support, the time loss by independent manufacturers in negotiations can prove fatal to their competitive viability. More ominous still is IBM's stated intent to "load" all software for the terminals for its systems from the CPU rather than directly at the remote stations. This means that shifts in software standards can be achieved virtually instantaneously. In turn this means that IBM possesses the weapon which can render terminals manufactured by independents completely inoperative at its whim. These messages will not be lost on users who contemplate such products in the future, nor on the capital markets which are called upon to support ventures attempting to compete with IBM.

VI. Concluding Observations on IBM's Dominance of the Systems Market, 1960-1972

The foregoing analysis shows that IBM has maintained market dominance, that its position of dominance was threatened during the 1960 to 1972 period, and that it has met those threats with tools artfully designed and implemented. The analysis supplies the explanation for the high level of profitability that IBM has maintained throughout the period, as well as for the absence of entry into the systems market. In short, IBM has enjoyed continuing monopoly rents derived from its market power, fortified by its use of that market power over the years to foreclose meaningful competition, to impede the expansion of existing systems competitors, and to control the prices in the market place.

It has been demonstrated that, when IBM's customers were given a choice of competitive systems or peripheral products, significant numbers of them chose the competitive offerings. IBM's excellent monitoring system for tracking competition and competitive inroads provided the intelligence as to these competitive threats to IBM's dominance. Consistently throughout the period 1960-1972, when IBM's base faced erosion sufficient to weaken or diminish its market power, IBM devised and implemented strategies which protected that base. The Government's pretrial brief has alluded to written evidence, found in the files of and written by IBM's highest management personnel, reflecting IBM's specific intent to maintain its dominant position and to utilize its dominant position to that end. The conduct described in the pretrial brief has also, as we have seen, been of the nature that gives rise to the necessary inference that IBM has acted in ways consciously designed to maintain its dominant position. It is our view that the perspective provided herein gives further support to the thesis that IBM has monopolized, as the Government has charged, and that the locus of that monopolization is the systems market, as that market was defined in the Government's pretrial brief and as it has been examined herein.

As we have noted the sources of IBM's power, it is apparent that that power is not confined to any one area or attributable solely to one practice or a combination of practices. Rather, IBM's ability to manipulate the multitude of factors in a changing market to its own ends is deemed to stem directly from its dominant position in the systems market. Given this power and IBM's demonstrated propensity to utilize it, a restructuring of the market in major proportions can be the only effective, long term relief. From that restructuring, and that restructuring alone, can there be expected a future market context in which competition can be the regulator, rather than monopoly power, and the consumer and society as a whole enjoy the benefits of competition in this most important area of the American economy. □

Computers and the Future of Education

Prof. Joe Raben
Dept. of English
Queens College
City Univ. of New York
Queens, L.I., N.Y.

"We are now on the brink of making the educational process what it has always promised to be, the liberation of the human spirit, the 'leading out' of the mind."

The Lighthouse Construction, and the Indian

I'd like to begin this article with a story. Up in Nova Scotia, a group of engineers spent a year supervising the construction of a lighthouse. All the time they were working, an elderly Indian would come every day and watch them. He never approached the white engineers, but just sat on a high point and studied the operation closely. Although there was no conversation, a spirit of friendship grew up between the engineers and the familiar figure, who became a sort of honorary supervisor of the project.

It was natural when the lighthouse was complete, that some words of farewell be spoken. So on the last day of the job, the engineers climbed up to where the Indian was watching them.

"Well," they said, "it's all finished. You've sat up here for a whole year watching us. You saw us take the soundings, and put up the cofferdam. You saw the foundations poured, and all the brickwork. Then you saw us install the lights and foghorns and test them out. Tell us, what do you think of it?"

The Indian paused reflectively and then said: "You guys put in a lot of work and money there, but I think it's all wasted. You can flash your lights all you want and you can blow your horn all night, but that damn fog is going to come in just the same."

Technology in the Educational Process

That story has relevance, I think, to the way we all have -- Indians and all others -- of fitting new information into pre-existing patterns of thought. If we grow up in a culture that tries to control nature by lighting fires and banging drums, we find it very difficult to comprehend that other cultures accept the fog and only try to warn ships away from rocky coastlines. What all of us need, therefore, is to see our own value systems occasionally from the point of view of people who live outside them.

The general problem I am concerned with is technology in the educational process. Let's try to look at that problem like the Indian sitting on high ground, not understanding exactly what was going on. And before we turn to our special interest -- computers in education -- let's look out across the historical horizon at an earlier technological development that was also adapted to an academic use. Perhaps we can decide whether, that time, all the sound

and glare really drove some fog away, or whether we only put up a marker to warn future travelers of dangerous shoals.

An Earlier Technological Development

Just as today many people are convinced that computers have a real contribution to make to education, so when television first became readily available, many people felt that it could help improve the quality of teaching in our schools. This marvelous machine was at the apex of our industrial accomplishment, not only in the technology to design it but in the capacity of our system to produce it in quantity and at a price that guaranteed its availability to almost anyone who wanted to buy it. What wonders could it not perform in making over our educational institutions?

Well, we all know what was generally done with TV in American universities. Sets were hung around large auditoriums so the students, jammed in by the hundreds, could at least see the face of a man who was talking to them from somewhere down in front, or perhaps even in another room. And the talking head could be played over and over, if the students would come to certain rooms at certain hours, and sit again in front of TV screens. Locked into a system that assumed, as if it were a law of nature, that teaching consists of having one person talk to assembled groups of listeners, most educators apparently saw television as a marvelous way of creating even bigger auditoriums, and of giving the same lecture repeatedly without the bother of being physically present to deliver it.

What is the True Nature of TV?

Only in the last few years have people had the wisdom to reverse that process and ask, "What is the true nature of the medium and what are its potentials for education?" Now, in a series like "Civilization," we are beginning to see an imaginative application of television to the teaching process. It certainly is not perfect, and in another generation we will, I hope, look back at its imperfections from new levels of accomplishment. But "Civilization" has one fundamental value that indicates the right thinking of its originators: it is based on a knowledge of how television works. It communicates by the imaginative blend of three components: well-written scripts, a clear awareness of how visual impact may be achieved, and a profes-

sional pacing that matches the simplicity of complexity of the points it is making. This series does not try to force the medium into unnatural modes, particularly archaic ones that have survived largely because there once was no television.

Getting into the Same Room with the Student

In the pre-television age, the only effective way for one person to communicate directly with another was to get into the same room with him and talk to him. For some types of instruction, that is still the preferred method. But for many other types of instruction, it may be the worst possible method. What, for example, do we gain by herding students INTO classrooms on spring mornings to read them poems about the importance of getting OUT of classrooms on spring mornings and enjoying nature? Why not let those students who even need a poem to urge them out-of-doors on such a day simply read the poems without destroying them with true/false questions on a quiz?

> Until every instructor is an absolute master
> at his chosen task, until we have not one
> single frustrated misfit clinging to a tenured
> position, until no instructor is ever assigned
> to cover a class he has not proven his quali-
> fications to teach, let no one assert the su-
> periority of human teachers over the possible
> advantages of technology in the classroom.
> And, ultimately, let us accept the truism
> that for many kinds of learning, we would do
> better to abandon all forms of teaching, and
> let the student learn for himself.
> -- George Bernard Shaw

Shaw is increasingly recognized as one of the master-spirits of our time; and he is reported to have asked that his plays never be taught in school. "Look," he said, "at what they have done to Shakespeare!"

Some Good Lectures

Still, for certain kinds of learning, there may be genuine educational reasons -- not economics, not convenience -- for gathering a group together and having someone lecture to them. I recently had the pleasure of hearing a graduate student of archaeology lecture on the construction methods of the ancient Romans -- but he was standing at the time on Hadrian's Wall in northern England. Or, to consider another aspect of education, if one is trying to transfer a standardized skill or technique (say, in laboratory procedures or in physical education), perhaps the best method is to perform it before a group of students, and then let them practise it under supervision.

But What About Other Foci?

But what if the focus is on an intellectual procedure: a mathematical routine, a grammatical analysis, a syllogism in logic? What if it depends on recognizing subtle relationships: an understressed pattern in a painting, a musical melody repeated in a variation, a poetic image based on a complex metaphor? What if my intention is to transfer a certain amount of objective data: a sequence of historical events, the analysis of some phenomenon in economics, the structure of a sociological or psychological organism? Where is the benefit to students of being assigned to seats in a lecture hall, required to arrive at a precise time and stay until another precise time, and to look alert without obviously reading a newspaper, sleeping, talking, writing love letters, or doing homework for another class? All

of us, as former students, can recall the hours of enforced tedium we spent in such lectures. And teachers, if they are candid, must admit that, once they earned the right to impose rather than suffer, they have contributed in their turn to the boredom of their students.

Wasted Hours and Years: Bus Riding

The basic cause of this apparently endless cycle of wasted hours and years is the general attitude of educators that equates students in a school with passengers on a bus. Notice how many parallels there are. The driver-conductor determines approximately where and when the bus moves, but he is himself required to follow a detailed route and timetable. The passengers can enter and leave only at specified points along the route, and must move along only as fast or slowly as everyone else. Each passenger occupies a fixed seat, unless the bus is too crowded and he has to stand in the aisle. This is, of course, an efficient, economical way to move large numbers of people from one place to another. But is it any wonder that millions of people accept the much greater expense and trouble of driving their own cars whenever they can?

And is it any wonder that so many students rebel against being treated like bus passengers? How many thousands of teacher-hours every day are devoted to punishing student-passengers who fail to get into their class-buses at precisely the assigned moment, fail to have the proper ticket-homework for that day's ride, get bored with another run over the familiar route and try to engage in conversation with a fellow-passenger? We punish the bright student who could get there faster himself; we punish the slow student who cannot keep up; we punish the student who simply is not interested, at least not at that hour of that day. Having made all the rules about how this particular bus company is to be run, we are shocked when our captive riders are resentful, even to the extent of occasionally vandalizing the bus.

There are only two other institutions in our culture in which we lock people away from society with a set of rules that control their behavior, give them no voice in how those rules will be administered, and then punish them for infractions. Those institutions are the military and the penitentiary. Neither of these is noted for its concern with education.

Enlarge the Bus?

Looking back at early educational television and recognizing that it was often considered only as a way of enlarging the bus may alert us to future dangers of forcing a new technology into an old (and possibly inappropriate) pattern. What, then, do we see when we look at the current applications of computers? Are we simply following old habits of thought, and perpetuating, without critical evaluation, instructional methods inherited from the past? Are we repeating the mistake of shaping the computer to older modes of thought, rather than developing its potential to open up for us new approaches?

"Administration" of Education, and "Supermarket Trading Stamps"?

One of the most prominent uses of the computer today in the academic milieu is in programming students into classes and in recording their attendance and grades. In both of these activities, I am not aware that any substantial change has occurred in

our fundamental thinking. In keeping with our conception of students as passengers on a bus, we have utilized the computer to maximize the rate of seat-occupancy. If we can fit the optimum number of students into the matching number of classrooms, laboratories, or lecture halls, and see that an appropriately certificated instructor meets them for the uniform number of hours, then we believe that the cause of education has been served. So firmly have we embedded into our institutional thinking the concept that collecting hours of attendance entitles us to a certificate of education -- as trading stamps from the supermarket entitle us to electric blankets or movie projectors -- we ourselves are trapped along with the students. Instructors complain of inattention and even open resentment in their classrooms, but what other response is appropriate to enforced attendance?

It is decades since we conceded that compulsory worship does not make most people religious; how soon before we add freedom of learning to freedom of worship? Why not capitalize on the computer's ability to keep track of each student as an individual rather than as a unit in the mass? Must each one sit through exactly the same number of hours as every other one? Must the boy or girl who can snap up math or Latin or computer science go through exactly 45 class hours to get their credit, while their slower classmates are denied the few extra weeks needed to master the same material?

Student-Controlled Chunks of Education

With proper programming of our machines, we can allow each student not only to initiate his own instruction at a time that suits him, but also to cut it into chunks that match his spurts of enthusiasm. And what's more, those students can take their examinations whenever they feel ready for them, without the pressure of mass attendance, for it is now simple to store thousands of questions and let a random selection be given to each student when he calls for it.

But there is naturally more to the computer's role in education than programming a student into a class and then recording his grades at the end of the semester. Computer enthusiasts in the educational world have also tried to harness the power of the computer to the actual teaching process. It is here that probably the greatest challenge presents itself, not only to our immediate practical success or failure but to our long-range potential for making the computer an agency of intellectual enslavement or liberation. If we concentrate only on a true-false approach, that is, if we continue to insist that teachers have the right answers which the student is required to guess, then we continue to divide our whole culture between "we" and "they." The mystique of the computer will then only reinforce the sense that an impersonal dominating society, embodied by "City Hall" (which everyone knows you cannot fight), has devised another means of compelling obedience. The computer already seems to be determining our elections, leaving the bewildered citizen, if he bothers to vote at all, casting his ballot as a kind of bet on the predicted winner. The same kind of omniscience should not creep into our schools. Kids are smart enough to see through their human teachers; we should not try to bluff them with machinery.

Making the Student the Master

We need, instead, to make the students masters of the computers. First of all, even what goes into memory should be largely under the control of the user. Take, for example, the way we teach foreign languages. Whether the course is conducted by a human teacher or a computer, we assume that there is a basic vocabulary to be mastered, and we drill that until it can be repeated by rote. But is there really a universal vocabulary among students of high school or college age? Aren't some of them concerned with television personalities while others are deep into nuclear physics? Can either of these groups develop a genuine interest in a second language when all they are able to discuss is how to order an omelette in a restaurant? Why can't each student learn the vocabulary that interests him or her at the moment -- stamp-collecting, rock music, dinosaurs, clothing styles?

And if that principle is valid, for languages, may it not be implemented in other subjects? Are there perhaps some boys who would be more interested in history if they could approach it through the evolution of armor, or in mathematics if it could be brought to them first through studying principles of ancient weapons? Are there some girls who might respond to the same subjects if they could be presented in terms of changing styles in clothing or in the mathematics of planning a garden? This is not to say that we must confine students within sexual stereotypes: some girls may want to study the trajectories of rockets while some boys are fascinated by the mathematical patterns in seashells. The point is that while no two individuals in a group at any time may respond to the same approach to a subject, the lecture-quiz system demands that all students respond, simultaneously, to the presentation of a particular instructor, following a particular syllabus and textbook.

Are Progressions of Learning Inevitable?

We have become so completely accustomed to thinking of inevitable progressions of learning in certain areas, particularly in the sciences and mathematics, that it may take an intense rethinking of the whole subject to come up with an alternate approach. Certainly, students who flourish under the conventional method and teachers who successfully operate under it should be encouraged to continue with what works for them. But wouldn't both groups benefit from the option of moving ahead, back, or sideways to follow genuine interests rather than doggedly pursuing someone else's idea of what should be taught at that moment? The computer's capacity to follow an almost infinite number of branches can certainly allow us the freedom to learn what, as, and when we are ready. And that, in the end, is the only real learning.

The Proclaimed Goal: Life-Long Learning

After all, the proclaimed goal of our entire elaborate educational institution is to encourage and enable people to go on learning by themselves after the formal portion is complete. Shouldn't we therefore begin that process as early as possible? Shouldn't some subjects be entirely unstructured, with the student reading at his own pace and coming to an available instructor for guidance only when he feels the need for it? Can we honestly argue that the sacred number of hours must be spent, that the rigid schedule must be met, before that mysterious phenomenon, education, has occurred? If computers really have the power many of us believe they do, let's use that power to pry open some of the beliefs we never have fully explored.

Such a total revaluation of our intellectual needs and the best available means of satisfying

them is not only possible but necessary. The educational establishment that our computers are now being used to bolster is already undergoing changes which will alter its fundamental character. For example, although we still base our undergraduate curriculum on an expected four-year attendance, the American Council on Education has recently reported that merely a shade over half of our students actually complete their degrees within that conventional period. In fact, it is only after ten years that three-quarters of any incoming class have completed what we still habituate ourselves to calling a four-year course.

The Relevant Criteria

Students who stretch their formal education over a period as long as a decade must be spending at least as many hours at some kind of outside employment as they are in classrooms. They have learned to expect judgment on many more relevant criteria than the accumulation of points on a true-false examination. Their employers do not compel them to sit by the hour listening to droning voices from the front of a lecture hall. Even in mass production industries, the inexorability of the assembly line is yielding to worker demands for individualization. When a single automobile factory in Sweden recently inaugurated a system to allow each worker to move around into different jobs, and to allow each crew to operate at its own pace (provided only that it generally matched the production quotas of the plant as a whole), management personnel came from all over the world to learn how the same system could be established in their own plants. If men and women are conquering the treadmill in an economic environment, they are not likely to tolerate it in the world of ideas and learning.

The Problem of Bilingualism

There are obviously other ways in which student pressures are going to present new challenges to the educational process and for which computers will help to provide responses. Take, for example, the problem of bilingualism. For a variety of reasons, there are large and apparently perpetual minorities in this country for whom English is not a natural medium of education. In the past, we either left such people out of the educational process or compelled them to struggle along with minimal comprehension. There is now no reason why parallel or supplementary instruction cannot be provided in Spanish, Chinese, the major American Indian languages, or any other language for which there is reasonable demand. And in keeping with the same spirit of plurality of cultures, we need not limit such instruction to the subjects available to speakers of English. While it will be important to open the gates of learning that may be closed by illiteracy in English, there may be equal importance in supplying instruction in the history and culture of the minority groups themselves.

Really Democratic Fulfillment

Such a tailoring of education to the special needs and receptivity of special groups is a clear fulfillment of the democratic promise we are now reaffirming as the Bicentennial approaches. An equally pressing obligation commits us to leveling the educational barriers which now segregate shameful numbers of our citizens for reasons other than their membership in minorities. In large tracts of the country, and in large sectors of our cities, thousands, and probably hundreds of thousands, of students are cut off from high-level education by poverty.

Thousands more are locked away in prisons. Some adjustment of the imbalance of educational opportunities suffered by these groups can be made through time-sharing. In fact, many other partially disenfranchised individuals -- housewives, fully employed students, physically disabled students, any one at all who cannot easily enroll in a regular course of study at a conventional school -- can overcome at least some of that handicap by studying whenever the leisure and energy are available to do so.

The idea that one must be on a campus by mid-September, must perform certain rituals of registration, must be ready for exams by January, and in the meantime have read a certain number of pages, ticked off a certain number of boxes on true-false tests, listened to a quota of records, looked at another quota of slides, run the prescribed number of times around the gymnasium, memorized a basic list of French irregular verbs, and performed the customary experiments in chemistry -- that idea of education must inexorably yield to the growing interests of increasingly individualized curricula.

Supply of Warm Bodies to Fill Classrooms?

The times are moving too fast for us. Even if a review of all the instructional methods available determines that in particular instances human instruction is preferable, we cannot always supply all the warm bodies we need to cover the classrooms. Think of all the developments in science that cannot be taught everywhere because only a few advanced researchers at major universities understand them. How long does it take for new theories in sociology or psychology to find their way into the general curriculum? And now that one quarter of the earth's population -- the oldest extant civilization -- has been taken out from a diplomatic limbo, where will we find enough instant teachers of Chinese?

Teacherless Teaching

We must begin to accept the principle of teacherless teaching, or self-guided learning. We must stop the procession of talking heads, live or on screens, and begin to encourage students, from the very beginning of their contact with school, to develop their own interests and to follow them as far as they want to. Each student will then feel freer to dabble in an infinite number of subjects, knowing that he will not mar his record with a drop if he finds a particular course not to his taste. He will be able to move at will from one topic to another, according to his own evolving conceptions and associations rather than accept the preordained progressions devised by others. He will move through many subjects with ease and growing mastery because he will determine his own pace. Linked to his computer through growing networks will be the data banks of museums and libraries, now being stored for future retrieval. And whether he finds himself alert and ready to learn in the early morning or the middle of the night, his access to knowledge will await the touch of his finger on the key that unlocks his terminal.

Sights at Will, Music at Will, ...

In this new learning environment, the student need not be restricted to verbal or symbolic information. Since the cathode-ray tube on his terminal is designed to project visual images, he can call up all kinds of pictures, and the treasures of the world's art collections will be his to command.

He can have performed on a tape recorder whatever

Microcomputers – Present Properties

and Probable Applications

Tom Gilb
Consultant
Iver Holters Vei 2
N 1410 Kolbotn
Norway

"Programming is a vital link in functioning systems, but I have seen no discussion of the problems of undetected errors in program logic as a future source of unreliability in a microprocessor system."

The main purpose of this article is to assess the potential market area for microcomputer technology. Accordingly, we will attempt to make a systematic analysis of:

- The basic attributes of the microprocessor and associated components, which make it different from competitive technologies (conventional electronics, mechanical systems, larger computer technology).

- The economic and social environment in which these technological and economic attributes compete for potential application.

- The known areas of actual or experimental application of microprocessors today.

- The high probability areas of future applications.

- The speculative, or brainstormed, application areas for the next ten to fifteen years.

It is hoped that this analysis will give interested persons a relatively non-technical overview of the potential impact of this new technology. In particular, it is hoped that this report will give present and potential producers and marketers of microprocessor-based systems a tool for evaluating different aspects of their participation in the market. In particular, producers of microcomputer technology might find here a more comprehensive list of potential partners for actual application of their generalized (OEM) technology.

Attributes of the Microprocessor
which Determine Application Usefulness

1. Speed: The current cycle times are 1.4 microseconds to 20 microseconds. This is sufficient to allow the processor to take over many control applications and some low-rate data applications. Projected immediate future speeds of 10 to 500 nanoseconds will allow microcomputers to participate in systems as a data stream processor at up to 500,000 bits per second.

2. Space: The present space requirements are less than one half of corresponding minicomputers. One Traffic Controller box is reported to be 17 x 17 x 9 inches square (43 x 43 x 23 cm.). The Norwegian general purpose microcomputer system, DI-1000, based

on the INTEL 8080 is entirely contained in a space 9 x 20 x 41.5 cm. (7,470 cu. cm.). This is 17.5% of the space of the Multisonics system (42,527 cu. cm.) mentioned above. This includes power supply, cooling, and space for 6 Europe-Standard boards, and is enough for CPU, 35 kByte memory and two spare slots. The space attribute alone opens new application areas where space is a major constraint. Portable systems have become practical, carriable by humans.

3. Weight: One half to one tenth of comparable pre-microprocessor systems. The Multisonics 901 above weighs 41 pounds or 18.7 kg., the Norwegian DI-1000 weighs less than 11 lb. or 5 kg.

4. Cost: One example of a microprocessor configuration (MCS-4 + ROM, RAM) was estimated to displace $150 to $600 in manufacturing cost while it cost $100 (1, p.106). "Electronics" published an estimate by W. Davidow of Intel Corp. that use of microprocessors can "frequently increase product line profits by 10% to 20%". For example he illustrated a before tax profit of 11% being increased to 24% with the use of microcomputers. His unstated assumption was that the competition doesn't compete, they stay with old techniques and prices.

The important point is that the economics of microprocessors are primarily due to: (1) simplification of the total cycle of design, production, and maintenance; (2) the shortening of the product development cycle time from "six to 12 months to only a few weeks"; to quote Davidow.

5. Reliability: Microprocessor faults are more difficult to isolate and correct than standard LSI chips, but the basic reliability is assumed to be 5 to 10 times better than before simply because there are far fewer connections (1800 fewer per Read Only Memory is one example) outside the chips. This is one of the primary causes of failure in older component types. I fear that lack of experience with the new technology, including a lack of experience with future generations of this technology, has already led us to underestimation of the new problems of reliability which will replace the old ones. I find the current literature (1, 3, 4, 5) unwilling to discuss potential reliability problems, partly due to lack of sufficient experience, partly due to faith that the new technology represents an improvement, and partly due to the fact that the technology itself offers practical compensation for unreliability.

Some of the key words here are "distributed logic," built-in stand-alone logic (in terminals so that we are less dependent on central unit breakdown), self-diagnosis (6,p111), redundant logic for error detection and correction, etc.

6. Programming: There is a recognition that programming is a vital link in functioning systems; but I have seen no discussion of the problems of undetected errors in program logic as a future source of unreliability in microprocessor systems. I suggest that this is underestimated currently, and that the problem will increase in severity as the memory capacity available increases.

7. Maintainability: This is defined as the probability of repair within a given time. From the application point of view, effective maintainability, implies automatic, semi-automatic, or human technician (even amateur) shifting a card. A major factor in this is expected to be that hardware parts are less diverse, more standardized, the variations being in the programs. Thus that vital factor in maintainability, spare parts on site, is more easily accomplished.

Again, it would be hiding one's head in the sand to pretend that microprocessor system maintainability is solely a function of hardware. Program faults will have to be analyzed and repaired, and this will present substantial problems. I have already watched traditional hardware engineers with "updated training" spending six weeks searching for a fault which made an entire system fail several times daily. Finally, a microprogram specialist was brought in from abroad; he identified and repaired the bug in a day. This should be a warning to those who are considering the design of maintainability in their products. Analysis should be highly automated; human training and organization of maintenance talent must be considered much more carefully than it is at present.

Failure in a program cannot be repaired by putting in a standby hardware unit. The logical equivalent to hardware spare parts in software is an independently authored program, which hopefully is without the same "random" bugs as the present ROM-program (7).

7. Reproduceability: It is important that the hardware modules can be automatically mass produced in large quantities at increasingly less cost.

The fact that hardware and software design can proceed in parallel relatively independently, has been given as a major advantage in shortening the lead time needed to get products into the marketplace. Certainly, the blend of Read Only and Random Access Memory types, where even the ROMs are field modifiable, allows hardware production and development to proceed in spite of certain unknowns, which in hard-wired systems would require delaying experimentation and analysis before final hardware production could be committed.

In the exhilaration over the flexibility of programmable replacements for less-flexible hardware, it seems that engineers are uncritically dismissing the problems of designing and testing adequately the software. It may look easy while still limited by fairly small memory space, but obviously that is going to change rapidly. Large memory options will lead to pressures for correspondingly large programs. This will lead directly to the now well-recognized software engineering problems which are still largely without adequate solutions.

8. Power Consumption, and Dissipation: Power consumption is lower; for example, a traffic controller based on the INTEL 8008 used 50 watts, compared to 200 watts of previous Integrated Circuit technology. The improvement depends of course on the technology and configuration of whatever you are comparing against. The Norwegian DI-1000 based on Intel 8080 uses about 28 watts for CPU, memory, and asynchronous interface, while the built-in power supply is dimensioned for 73 watts. Battery operated portable units have been reported. It is possible to reduce power consumption by a factor of ten by increasing the cost of the electronics equipment, if portability or remote operation is more important than cost.

Since Random Access Memories will lose data during intermittent power failures, a battery might be necessary. This would ensure memory continuity for several minutes. It might be more realistic and practical to ensure that applications can automatically restart, regardless of lost RAM data, after a power failure.

In regard to power dissipation: a 256-bit memory array (based on silicon on sapphire C-MOS) dissipates "less than one microwatt per bit in standby and 0.2 milliwatts per bit when operating at a 5 MHz rate." (4,p.37). Corresponding figures for conventional TTL circuits, which until recently dominated computer architecture, are in the range of 5 to 50 milliwatt per gate or about two orders of magnitude more. In spite of this, the circuits warm up enough so you can feel the temperature with your fingers; and air-cooling systems are still necessary, since the circuitry is sensitive to its potential to overheat.

9. Expandibility and Modifiability: Application designers praise specifically the adaptive ability of microprocessors as being a major positive attribute. Addition of various memory chips or cards is fairly convenient, as is erasure of Programmable Read Only Memory using ultra-violet light and writing of modified programs. Easier at least by comparison with conventional circuits. This attribute strongly suggests that this technology is desirable in unpredictable and highly varied application areas. At least as important is the fact that production runs can be extended in spite of change, which helps keep the unit cost at a competitive level in spite of high initial hardware design costs.

The Present and Future Environment for Microprocessors

The above attributes of microprocessors will not in themselves allow us to predict the future application area and market extent.

We must consider the need for applications in general; and we must view all competitive alternatives. In addition, since we are interested in the future, rather than the present or the past, we must assume that conventional alternatives will themselves change in various ways in order to be competitive. Computers in particular must be expected to take full advantage of the semiconductor technology. Minicomputers will not only make use of microprocessors as task delegation units, but will make the fullest possible use of the semiconductor technology available. I make this obvious point only because I have observed a tendency for microprocessor enthusiasts to compare their technology to older semiconductor technology in minicomputers. The minicomputers will "catch up"; we must not confuse the microprocessor concept with recent semiconductor advances, simply because microprocessors have been faster in taking advantage of the technology.

Environmental Factors

Here is a list of some of the environmental factors which must be considered when evaluating the direction and volume of growth of the microprocessor market. Quantum Science has estimated this market will grow from 73 thousand units made in the US for world consumption in 1974 to three million units in 1978. During the same period the minicomputer market will, according to Quantum Sciences, increase only slightly from 38 thousand to 40 thousand units in 1978.

- Cost and availability of skilled labor for production of "machines" (both mechanical, electro-mechanical and electronic): Increased demand in the face of high cost or unavailability of necessary production labor makes microprocessor replacement technology more tempting, since it has a very small labor content.

- Cost and availability of skilled labor for any other type of work: This factor naturally affects the general need for automation, in which the microprocessor is increasingly an alternative.

- Competitiveness in the marketplace for any particular product line: This will influence the transition to microprocessor technology due to its frequently lower costs and shorter implementation time. The possibility of tailored logic without different hardware increases the attraction.

- Scarcity of capital: The scale of capital investment needed to initiate product lines and market them seems to be reduced by the advent of the microprocessor. This in itself has already led to a mushrooming of companies engaged in utilization of microprocessor technology. Well capitalized ventures will of course always be better off, for the same old reasons. But individuals with good ideas for products will find the microprocessor route less costly and less risk-filled than designing the same products using alternative technologies, most of which have higher capital costs (design, tooling, production machinery).

- Need for local solutions: A microprocessor will tend to be preferred to less flexible or less adaptable technologies wherever it can satisfy local needs through inexpensive local modification of products -- in particular where language, law, or tradition dictates variations, or makes these variations more competitive.

- The extent of presently automated applications in a particular area: Microprocessors are frequently a replacement component for present computer or electronics technology. Thus microcomputers will be likely to spread with greatest effortlessness in already established application areas using minicomputers or electronic automation.

- Rapid change: By identifying areas of rapid or traumatic change, we are likely to find areas of potential application for microprocessor technology, since a key characteristic is operational adaptability (via stored program) and long term adaptability (via modified or extended programs). (8).

General Areas for Application of Microcomputers

Before looking at detailed application areas it might be useful to consider the more general classes of applications. The basic functional categories appear to be:

- DATA MANIPULATION: piping bit streams automatically in, massaging the bits in short batches, and piping the result out. For example telecommunications, typesetting.

- DATA COLLECTION: registering events in some form of buffer storage (paper, floppy disks or semiconductor memory, tape cassettes, etc.) for later readout. This may include selection of significant events and summarization and categorization processing. For example, in situ water environment loggers or streetlamp failure recording.

- PROCESS CONTROL: event or parameter registration and evaluation, combined with automatic control impulses to other machines. For example, post surgery patient monitoring with doctor alarm or communication (dialing), or glass bottle emptiness evaluation combined with bottle removal from production line.

- MAN-MACHINE INTERACTION: characterized by a dialog between the microcomputer and a person. For example shipping economic/freight calculations using a specialized "calculator" (9); or a tennis simulation game-playing machine.

Each of these areas seems sufficiently distinct to require specialization. The difference between human and machine requirements are sufficient illustration of that need. Further, all four of these seem to have at least some potential applications in any broad field of human activity (such as factory, medicine, transport, education). Recognition of this will lead to the search for at least one application for each functional area within the field of human activity we are analyzing for potential application of microprocessors.

There is admittedly a danger when solutions go in search of problems; but I suggest it is reasonable that we take the initiative in pointing out solutions to potential users, thus creating faster market growth.

Possible Applications -- Set 1

The following is a list of actual or proposed microcomputer applications derived from "Electronics" (1).

INDUSTRIAL: Numerical controlled machine tools; air and water quality analysis at proposed nuclear power plant sites; typesetting; process control and logging; torque measurement for fasteners on auto assembly lines.

COMMUNICATIONS: character by character decoding (raising the capacity of a NOVA minicomputer ten times by taking over this task); intelligent microwave repeater (now being built by Collins for a private network); police car units, police base station interface between car unit reception and central computer; increased utilization of voice transmission channels by microprocessors built into base of a telephone for digitalization of voice (future); encryption (secret code) devices in pairs to secure digital communication; output power variation control for radio frequency transmission; cable TV transmission.

CONSUMER: Point of sale article/price registration; supermarket checkout; weighing scales; bank teller terminals; 1000 microcomputers will be put into

traffic light controls in Baltimore by TRW; car-exhaust emission control (cleaner air); combustion timing; automatic transmission control; automatic car speed control; anti-skid braking (1, p.95; Ford is testing this now); on board diagnostics (Ford's present engine control software is contained in 1,500 12-bit words); apartment house heating and cooling regulation.

COMPUTER PERIPHERALS: optical readers (Optical Scanning Corp.) in card machines and floppy disks in the future; medical terminals ("Superbee" using Intel 8008); control of CRT display refresh memory (Digi-Log); communications interfaces (see above); editing functions in display terminals or data entry devices; data entry/data recorders.

INSTRUMENTS: frequency synthesizers (simplifying input command settings); in-circuit IC testers (Testline); Automatic capacitance bridge (Boonton Electrics Corp.); recorders (Digitrend 220); Interfacing circuitry for oscilloscope and programmable calculator (Tektronix Inc.); infra-red distance meter (HP-3805A which takes 3,000 measurements to find an average with suitably small standard deviation).

Possible Applications -- Set 2

Here is my own collection of potential applications: (some are running)

Medical diagnostic machine (Leeds University is looking for one, according to "Computing" April 4, 1974, for £ 5000)
Public street light control and recording (presently planned in Oslo)
Plotter and Stereo plotter control
Point (on map, etc.) digitalizing systems
Coin-operated Solarium timers
Electricity Meters which can be read remotely by telephone (Westinghouse)
Ship hull stress and wear measurement (WEDAR, Statronic A/S Norway)
Ship diesel machine control
Control of refrigerated containers on ship or truck (Statronic A/S)
Computerized bartenders (Kross has sold 100 at £ 2500)
Camera control (there is a 400-transistor equivalent in Polaroid SX-70; maybe professional movie cameras or TV cameras are the immediate area)
Hotel room service calculation, refrigerator drink dispenser, maid communication, tele-call recorder (number, time, cost).
Home recorder of outgoing telephone calls: date, time, number dialed, cost. Maybe large offices would be the first to appreciate this.
Restaurant bill, tax, tip calculation, menu selection. (Holiday Inn/Motorola are experimenting in the Hotel and Restaurant area)
Security devices: badge and codeword check at doors; recording of time and person entering; breakin alarm recording and data transmission.
Household cooking ovens which reduce meat shrinkage (Univac Simulation).
Elevator and fire detection system control in buildings.
Gasoline pump (including remote read-out for self service and cash automat).
Currency exchange (bank, airport) calculators and activity totals.
Game-playing machines: football and other sports, generalized pick-a-game

Cassette tape-juke box (a California group is using Intel 8008 for this)
Ticket collection and validation devices (London Underground)
Airport passenger movement control and boarding via boarding card reading.
Sport statistics: by coach or player and activity statistics.
Ticket printing devices including statistics on sales (bus, railways).
Household device logic: sewing machines, washing machines, cook or bake.
Amateur computing market, such as amateur radio.
General Purpose Home Computer: Programs distributed on cassettes or floppy disks, The big market here is the program publishing industry (pop star: Bobby Fischer's Chess Program). Give away the hardware?

Possible Applications -- Set 3, Partial

In order to further stretch our imagination, the following set is based on a selection by subjective means from a list of over 2000 known and collected computer applications (2). Previously mentioned applications, however, will not be included again here.

Office: billing and invoicing; capital investment analysis; catalog design; consumer credit verification; postage calculation (weigh, indicate mode of sending, calculate correct postage, dispense amount, print any necessary text); flexible time recording; message switching; optical character recognition.

Plant and production: automatic manufacture of cartons, and automatic packaging of goods; logging fuel consumption; collecting data on progress of jobs; control of automatic lathe operations; analysis of machine troubles, for both corrective and preventive maintenance; precision measuring; quality control.

Advertising: computer-controlled electric signs and displays.

Banking: signature verification (a microprocessor unit to do this was exhibited at Eurocomp-74).

Educational and Institutional: computer assisted instruction; student registration; test scoring; accounting of test results; control of laboratory experiment.

Farming: automated feeding system for fish hatchery, livestock, etc. And so on ...

(For a list of a total of over 150 reasonably possible future applications of microcomputers please write the author.)

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Computer Professionals: What Their
Social Concerns Need to Be

Richard E. Sprague
Hartsdale, N.Y.

*"The computer profession, whether they like it or not, is involved in the fundamental
issue of partisan applications of computers to controversial political issues."*

Controversial, or Not Controversial?

As an original member of the Special Interest
Committee on Computers and Society (SICCAS) and a
present member of the Special Interest Group on Com-
puters and Society (SIGCAS) -- both of these being
subdivisions of the 20,000-member Association for
Computing Machinery -- I have been much interested
for a long time in the question:

> What are the activities and discussions that
> are appropriate for computer professionals
> who are deeply concerned with the relation of
> computers and society, and who desire to see
> the great power of computers used to benefit
> people and not harm them?

For persons who support "the establishment" in
the United States, i.e., the existing system of
government, business, industry, and the Pentagon --
persons who unquestioningly accept "business as
usual," and "the American way of life" (and who pro-
test only the deaths of 55,000 Americans in Viet Nam),
there are activities and discussions which are "ac-
ceptable" or "safe" -- and there are other activities
and discussions that are "not acceptable" or "contro-
versial." In such other activities one is "sticking
one's neck out" or "rocking the boat" or "asking for
trouble."

But any group or committee on society and compu-
ters, if it sticks to the discussion of activities
which are "acceptable" or "safe" is, I believe, con-
demned to:

- inability to find subjects that are worth
   discussing or being active about;
- boredom and attrition of members;
- ineffectiveness.

Why?

The Important Issues

The answer, it seems to me, is that in the Water-
gate United States of 1972-74, people have finally
begun to realize where the important issues lie. The
important issues that are related to computers, or
more broadly, to information sciences or systems
and people, are for the most part political or cri-
minal in nature. Some of the issues are also moral.
In the last decade politics, morality, justice, and
U.S. law, are turning out to be quite slippery and

relative in nature. Consequently, SIGCAS, ACM, and
other professional societies have generally avoided
these issues. The grounds usually given are that
they are too controversial, too political, or not
directly connected with or caused by computer pro-
fessionals. These grounds are not firm and true.

Yet, I would venture to say that a large percent-
age of SIGCAS members, like myself, joined the group
originally, anticipating that important, fundamen-
tal issues would be debated. In the last five years,
I have not seen this desire satisfied; so I have
turned to other organizations that HAVE taken up
the issues.

Issues Rejected for Discussion

What issues have been rejected by SIGCAS? Let's
start with one example that I know about, and then
consider two others that I can guess were also con-
sidered and rejected.

In the formative period of SICCAS, I proposed to
Bob Bigelow, who in turn proposed to the SICCAS and
ACM officers that the subject of "Political Assassi-
nations in the U.S." be placed on the agenda for
consideration and discussion.

I felt then, and still feel now, that the issue
and question of 'Who has been assassinating or at-
tempting to assassinate our political leaders, and
why?", is one of the most important if not THE most
important problem of our time.

SICCAS rejected my proposal. Yet it has been
proved beyond reasonable doubt that the four "lone
madmen," credited by the authorities with the assas-
sinations of John Kennedy, Robert Kennedy, and Dr.
Martin Luther King, and the attempted assassination
of George Wallace were not acting alone. It has
been proved, (with the exception of Arthur Bremer)
that they did not even fire the fatal shots. The
larger questions of who did and why they did, in
the four cases, remain largely unanswered.

The Project of Computerized Analysis of the
Evidence, in the Assassination of Pres. Kennedy

What has this issue got to do with computers or
computer people? Let me relate a little history.
In 1968, when a vast amount of evidence of conspir-
acy began to turn up in the President Kennedy assassi-
nation case, a newly formed group, called the Com-

mittee to Investigate Assassinations, proposed using computers to store, sort, correlate and analyze the evidence in the case. From 1969 through 1973 strong efforts were made by individual members of the group to apply computers to the evidence and to accomplish a computerized analysis of the evidence. This turned out to be a Herculean task. Only limited success and limited results were achieved in this effort, and the effort terminated in 1973.

The Project of Computerized Enhancement of the Nix Movie of President Kennedy's Assassination

Also in 1967, projects sponsored by government and news media were undertaken using computers, and photographic or optical technology, undertaking to prove that there was no conspiracy in the assassination of the President. For example, specifically, United Press International employed the Itek Corporation to analyze an amateur movie taken of the assassination by Orville Nix. The effort was to prove that there were no assassins on the so called "grassy knoll," in Dealey Plaza, Dallas, Texas, where the assassination of President John F. Kennedy took place. Itek published a report of a supposed technologically based study reaching this conclusion. The data entering into the study were selected so as to preclude any other conclusion.

Recently, UPI decided they might have been wrong. They contacted the Jet Propulsion Laboratory along with Cal Tech, to do another computer enhancement study of the Nix film, to determine whether it shows a man on the knoll with a rifle. Because of JPL's present military and government contracts, it was decided that it would be better if Cal Tech conducted the study, even though JPL technology and equipment would be used. This, of course, seems to imply that the military or the Federal Government is not interested in exposing any conspiracy. (The recent films "Executive Action" and "The Parallax View" imply the same thesis.)

The Computer Profession, Whether They Like It or Not, is Involved

Now, the point of this particular situation is that the computing profession is, whether they like it or not, involved in this fundamental issue, in a very active and very political way -- the partisan application of computers to controversial political issues. Itek's results supported the Federal Government's stance "no conspiracy," while Cal Tech's studies, if permitted to continue, could destroy the Warren Commission's conclusion of a lone assassin, and "no conspiracy." The Nix film in its raw form, 8 mm color, which I have seen, DOES appear to the unaided eye to show a man with a rifle on the grassy knoll, and also a red flash from the rifle at the exact moment of the fatal shot.

Lecturing to ACM Computer Groups and other Groups on the U.S. Political Assassinations

Partially as a result of these two early efforts to use computers in the analysis of evidence in the JFK assassination, I wrote a very long article, "The Assassination of President John F. Kennedy: the Application of Computers to the Photographic Evidence," which was published in the May 1970 issue of "Computers and Automation" (since January 1974 the magazine has been named "Computers and People"). The article dealt only briefly with how computers could be used; it was devoted primarily to a discussion of the photographic evidence of the assassination and a non-computerized analysis of it. As an indirect result of that article, when I became a national

lecturer for the ACM in 1970, I was invited to speak at various ACM chapters on the Photographic Evidence of the JFK Assassination. For two successive years, I spoke before fifteen ACM chapters, and twenty DPMA (Data Processing Management Association) and other chapters and groups on this subject. Some ACM audiences were expanded to include other people on college campuses where student chapters were the host. The reception of these talks in nearly every instance was described as "fantastic," "intense interest," "record-breaking attendance," etc. Some of these sessions lasted five or six hours although originally scheduled for two hours.

After I stopped giving these lectures to ACM groups, the demand continued. So two other lecturers, Bob Saltzman and Bob Katz, continued to fill the demand. Bob Saltzman was the computer professional who did most of the systems work and programming for the general evidence analysis project mentioned earlier. Bob Katz has lectured before university groups now totaling on the order of over 50,000 people; he has given over 100 lectures.

Intense Interest

I mention all of this to show that among computer professionals and managers and probably especially among SIGCAS members and also in what may be referred to as "the outside world," there is intense interest in this issue. Not I, nor Bob Saltzman nor Bob Katz drew and held the interest of large audiences for periods of up to eight hours in one meeting. It was not even, perhaps, the photographs, the slides, the famous Zapruder film showing the seconds of assassination of President Kennedy, that drew and held the attention of large audiences. It was the gut feeling on the part of the professional persons in the audience that somehow Americans have all been deceived, that persons and organizations at high levels wielding enormous power, killed our elected President Kennedy. That is the issue.

Publishing of Facts and Evidence Counter to the Interests of the Establishment

The editor and publisher of "Computers and Automation" (now "Computers and People") has been one of the very few editors in this country to face squarely up to the issue of deception and lies -- i.e., an issue relating to the integrity, honesty, and ethical standards of every professional in data processing and information handling. For four and a half years the pages of this magazine have dealt directly and openly with the concealment of truth in really important ways that are deeply antagonistic to the establishment. (On a smaller scale, every magazine in the computer field which fails to report clearly and completely on the monopoly practices of IBM in the computer field is also failing in its duties to the computer professional.)

Now at last, as a result of the Watergate cases, the Ervin Committee, the impeachment report of the House Judiciary Committee, and the resignation of President Richard M. Nixon under fire, many Americans are beginning to learn some hard lessons. Other magazines, newspapers, and news media have begun to sidle up to the issue of political assassinations in the United States.

Why should not SIGCAS take the lead in opening up this subject? Why shouldn't projects like the image inhancement project and the evidence analysis project be supported and openly, publicly discussed by our profession? Why shouldn't the fundamental questions about the assassinations of our leaders

be raised by the professions of information sciences and computing? Can it be true that non-establishment views must not be aired?

The Committee of Congressman Henry B. Gonzalez

Congressman Henry B. Gonzalez of Texas has recently released a public statement that he and other Congressmen will introduce legislation to reopen an inquiry into the assassination of President John F. Kennedy. In addition, several private organizations and associations including the American Federation of Scientists (AFS) have initiated lobbying activities with Congress to investigate our intelligence agencies including the CIA. Part of these investigations would encompass an examination of whether and how the various agencies and bureaus were involved in the three major political assassinations and the attempted assassination. If the AFS can take a position like this, why cannot SIGCAS take a similar position?

Analysis of Still Classified Evidence

Surely, we have reached the enlightened state that ownership, sponsorship, and control of huge segments of our industry and profession by the government, big business, or intelligence agencies, would not deter us as professionals or as human beings or as citizens of the U.S., from seeking the truth about these issues. If we suspect that the clandestine part of the CIA, or wealthy oilmen and companies from Texas or Louisiana, or individuals working for the FBI, Justice Dept., or the military, murdered our President Kennedy, our Senator Kennedy, and our civil rights leader and Nobel Prize Winner, Martin Luther King -- let's get this right out into the open, into public view. Let's get ALL of the still "classified" evidence out into the open. Let's analyze, professionally and honestly, that evidence we DO have, using the best technology available.

A Second Issue: Activities of the Clandestine Intelligence "Community"

The second issue that SIGCAS may have considered and rejected is an issue that has been exposed to view by several groups. An organization I belong to, called "The Organizing Committee for the Fifth Estate," has decided to concentrate on the issue. It is the growing, illegal, immoral, and clandestine use of various methods and policies by the intelligence "community" in the U.S. This development could lead us toward what we may call "technofascism," a dictatorship in the U.S. by technologists in the interests of the military-industrial complex. The methods involved include the use of computer technology and information systems. The Fifth Estate defines the clandestine intelligence "community" as including secret divisions or departments or contractors or subcontractors of agencies and groups at four levels of government; federal, state, regional, and local.

Evidence is mounting that all four levels are currently increasing (and not decreasing) the amount of illegal, unethical, immoral, and unconstitutional activity, aimed at reducing or limiting the rights of citizens and increasing the power of the clandestine groups. Not all of this secret effort involves the use of computers, of course. But a substantial portion of it does sufficient to rightly occupy the attention of SIGCAS. The Fifth Estate's objectives are to seek out and to expose to public view all of this clandestine activity, wherever it may be. The Fifth Estate's objectives also include trying to end the activity through any legal means available.

Many aspects of the Watergate collection of crimes reveal these unconstitutional, illegal, and immoral operations.

A Technological Base

One of the principles the Fifth Estate uses in its approach is that technofascism (for example, as conceptualized in George Orwell's famous book "1984") is not possible without a technological base, controlled and implemented by the leaders of a movement toward a closed society. The beginnings of such a base and movement are with us now. Thus the role of the Fifth Estate and a possible role for SIGCAS, is to discover these activities, expose them to public view, and to appeal to the technologists involved to reveal what is going on and to help stop the trend toward technofacism.

Some more examples of these activities are the clandestine work of the Central Intelligence Agency, Justice Dept., FBI, and the intelligence divisions of the Dept. of Defense. At the local level, one of the best examples is the clandestine portion of the Los Angeles Police Dept., employing over 1000 secret, provocateur-type agents. The regional level is perhaps the most frightening, because it is not controlled by either state or federal governments. It runs its own show and makes extensive use of technology including computers. There are presently three major regional clandestine groups; one on the west coast, a second around the Michigan area, and a third in the south.

The illegal activities of these groups include agents, provocateurs, terrorist actions, assassinations, false propaganda, discrediting of legitimate political organizations, and many other para-military activities.

A Third Issue: Information and Weapon Systems to Subvert Governments Globally

The third issue is the use of computers and other information systems in weapons and in military systems all around the world in order to subvert or change indigenous governments and to support other governments that are preferred by or make deals with U.S. establishment interests.

The most recent example is the CIA-aided overthrow of the elected Allende government in Chile, and the bringing to power of a dictatorship (instead of the elected government) which has tortured and murdered many thousands of Chileans on proscribed lists.

The biggest example is the ten year war in Viet Nam, producing at least one million deaths. In fact, the Viet Nam war still goes on, with American technology still deeply involved. There are many other examples.

Why should not SIGCAS speak out on the topic of the ACM members who are involved in programming or designing or implementing the information systems for destruction of indigenous governments and murdering thousands of people around the world? If SIGCAS let it be known that this subject was open to public debate, ACM anti-militarists sprinkled throughout the U.S. war machine might speak up. Professionals at Rand Corp., Mass. Inst. of Technology, Hudson Institute, Cal. Tech., Jet Propulsion Laboratory, Dept. of Defense, and other "think tanks" and installations might become encouraged to report some very important and very wrong activities; they might "blow the whistle" on some of these activities.

To sum up, I recommend again, as three controversial issues for discussion under the heading of computers and society and the social responsibilities of computer people the following:

1. Who is assassinating our political leaders and why?

2. What activities are leading us toward "technofascism," how can they be exposed and stopped?

3. Where and how is the American establishment using technology in other countries around the world to help suppress people and murder them?

These three issues are not antiseptically clean applications of computers to society. They include the ways in which computers are being applied by modern, up-to-date, technological versions of the departments of dirty tricks, and they lie straight on the road to Orwell's "1984." ☐

WHO'S WHO IN COMPUTERS AND DATA PROCESSING

THE SIXTH CUMULATIVE EDITION

WHO'S WHO ENTRY FORM
(may be copied and expanded on any piece of paper)

1. Name (Please print)_____
2. Home Address (with Zip)_____
3. Organization_____
4. Its Address (with Zip)_____
5. Your Title_____
6. Your Main Interests:

   Applications ( )   Logic   ( )   Sales   ( )
   Business   ( )   Management ( )   Systems ( )
   Construction ( )   Mathematics ( )   Other   ( )
   Design   ( )   Programming ( )   please specify:

   _____

7. Year of Birth_____
8. Education and Degrees_____
9. Year Entered Computer Field_____
10. Your Present Occupation_____
11. Publications, Honors, Memberships, and other
    Distinctions:_____
12. Do you have access to a computer? ( ) Yes ( ) No
    a. If yes, what kind: Manufacturer? _____
       _____Model?_____
    b. Where is it installed: Organization?_____
       Address?_____
    c. Is your access: Batch ( )   Time-Shared ( )
       Other ( ) Please explain_____
13. Do you subscribe: — to *Computers and People* (formerly
    Computers and Automation):   ( ) Yes ( ) No
    — to *The New York Times*:   ( ) Yes ( ) No
14. Associates or colleagues who should be sent Who's Who
    entry forms (name and address)

    _____

    _____

    (attach paper if needed)

When completed, please send promptly to: Who's Who Editor, *Who's Who in Computers and Data Processing*, RFD 1, No. Grosvenordale, CT 06255

music he is interested in hearing, while on his screen he watches the notes that represent it. He can hear great poetry spoken, he can watch a surgical operation performed, he can have a geometrical theorem demonstrated, he can watch the re-enactment of a historical event. And no nervous human teacher, .anxious about distractions to himself and to the other students in the class, will have to concern himself over whether that student is chewing gum, doodling, or in any other way relieving the tensions of his own concentration. We give adult workers in our factories soft music to ease their efforts; when can we begin to show equal sympathy for the strains we impose on hyperactive kids when we compel them to sit for hours and listen to us talk at them?

The Liberation of the Human Spirit

To sum up: we are now on the brink of making the educational process what it has always promised to be, the liberation of the human spirit, the "leading out" of the mind. To make of computers only another, but more efficient, means of locking students into fixed patterns would be a betrayal of the great potential in the machine and of the potential in people. We can go one of two ways — either we can feed humans into our computers to reduce their differences and produce a more homogenized population, or we can place individual freedom first, allowing the machine to further each man and woman's quest for a unique, distinct personality and a place to develop it.

The Elevator, and Fear

Having begun this talk with one anecdote that illustrates the insights we often are granted when outsiders observe a phenomemon they are not familiar with, let me close with another. An anthropologist, I am told, brought some people from a remote Pacific island for their first visit to Honolulu. Leaving them seated in the lobby of a hotel, he went to the desk to register. The islanders, who had never seen an elevator, watched in fascination as the doors opened and closed, with people walking in and out. Returning with the room keys, the anthropologist said: "OK, Let's get into the elevator."

"Oh, no," came the reply. "We've seen what happens. People go in looking one way and come out looking different. We don't want that to happen to us."

Readers of this article have ridden enough elevators to know better. But have we really spent enough time working with and thinking about computers not to fear some magic transformation? Are we completely free of the apprehension that we cannot trust machines to enter more freely and completely into the educational process? The philosophy we adopt and implement as we proceed to enhance the role of computers on our campuses will show whether we ourselves are free of superstitions. ☐

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Computing and Data Processing Newsletter

THE DEVELOPMENT OF COMPUTER CHESS PLAYING TECHNIQUES COULD HELP SCIENTISTS FIND ANSWERS TO MANY SIMILAR COMPLEX PROBLEMS

News Bureau
Univ. of Southern Calif.
Los Angeles, Calif. 90007

A computer scientist at this university has programmed a computer to play chess -- with an eye toward eventually solving much more complex problems from what is learned at the chessboard.

Dr. Frederic Carlson says the computer plays "sound novice chess" and, in time, will be able to compete quite ably against good opponents.

"It's fascinating as an intellectual exercise to program the computer well enough to play chess at all," said Dr. Carlson, himself rated an "expert" at the game. "But the important part is what this work could lead to.

"Techniques developed in programming a computer to play chess have been used in writing programs to solve other types of problems, particularly those involving a search among many alternate pathways, as in a telephone-switching system or an electric-power grid.

"We believe we can develop a language to express intricate, generalized demands to the computer. If this is so, we can apply that same approach to other complicated problems -- for instance, electoral redistricting.

"Eventually we hope that in writing chess programs we'll gain important clues to how the human brain works. We hope particularly to find out how it analyzes patterns -- like chessboards -- and quickly abstracts what is important from what is trivial."

Carlson has collaborated with Dr. Albert Zobrist, a computer scientist at the University of Arizona, in the initial programming. Another USC faculty member, the mathematician Charles Kalme, serves as a "tutor" to the computer. Dr. Kalme is a senior chess master with a rating of 2,445. The world champion Bobby Fischer, by comparison, rates 2,785.

"The main problem, of course, is instructing the computer to generalize. We decided that it might be better to have it 'learn' generally good and bad board positions from Dr. Kalme than to simply memorize thousands of correct responses to specific moves by the opponent.

"We believe the machine eventually can become better than its teacher, therefore we must somehow duplicate inside the machine the same processes that enable a world champion to become better than the players who taught him.

"Regardless of its ability to "learn," however, the computer offers some powerful advantages. It calculates at great speed, and its memory capacity allows it to accept huge volumes of advice from teams of experts.

"In time, the computer could know more than any one of its tutors." "And once it receives advice, the system will always heed it."

The chess player who challenges the computer finds its opening moves disconcerting. The system usually responds within one second to any of its opponent's first half-dozen moves.

"We claim no credit for this speed. Machine time is costly; so it has become standard practice to provide the computer's memory with a plentiful stock of opening moves."

After it completes these early moves, the computer shifts over to a more deliberate pace, usually taking about 25 seconds before selecting the next move. Despite its speed and the counsel of Dr. Kalme, the computer (an IBM System 370, model 158) is currently playing at a level almost a thousand points below its tutor.

COMPUTER ANSWERS THE TELEPHONE TO SPEED BANK TRANSACTIONS

Charles W. Barber, Vice President
Rapides Bank and Trust Co.
Alexandria, La. 71301

A computer that answers phone calls at this bank has speeded up customer transactions ranging from loan applications to check clearances.

The computer responds with electronically simulated words and numbers when bank employees inquire about customer accounts on push-button telephones.

When people visit a bank, they don't want to spend their time waiting in line. The new system enables a teller or bank officer to determine a customer's loan status or checking and savings account balance within 30 seconds.

Using the push-button telephone, the bank employee enters the customer's account number, the type of inquiry, and a special security code which prevents unauthorized use of the system.

The computer searches through thousands of accounts stored in its memory and provides an immediate on-the-phone response.

Among the system's 47-word vocabulary are banking terms such as balance, account, loan, interest, credit and debit.

Employees at any of the bank's five branch offices can "call" the computer in the bank's main office downtown. Up to six separate inquiries can be handled at once.

The computer also updates accounts instantly. For example, once the computer indicates that there are sufficient funds to cover a check, the teller simply keys in the amount of withdrawal and the computer automatically updates the account balance. An employee at another branch could call immediately after a transaction and receive an updated audio response on that account.

Before the bank installed the phone-answering computer employees called the bookkeeping department to obtain information on accounts. The new system enables the bookkeeping department to work without interruption. It also eliminates the customer's waiting on the phone while a person at the other end of the line searches through hundreds of files to find the correct information.

The new system is saving the bank $10,000 annually in paper costs. Before installing the system, the bank compiled eight copies of a 320-page Installment Loan Trial Balance every week. The large printout, which contained payoff dates, interest, due dates and other loan information on almost 20,000 accounts is no longer necessary with the new audio response system.

A second computer stores and processes all bank transactions and updates the phone answering computers on a daily basis. Both are IBM computers.

AIR QUALITY SIMULATION MODEL DEVELOPED FOR ST. LOUIS

R. M. Neudecker
IBM Research Division
Yorktown Heights, N.Y. 10598

A mathematical model that describes with a new level of precision how air pollution spreads over large cities has been developed by scientists of International Business Machines Corporation.

The model will be used as part of the U.S. Environmental Protection Agency's St. Louis Regional Air Pollution Study (RAPS). The study is a research program with the immediate aim of developing and validating improved air quality simulation models upon which better strategies for managing air quality may be based.

"According to our recent studies, this model is of a type that seems to offer the best possibility for obtaining accurate predictions of air quality," says Dr. Francis Pooler, Jr., research coordinator for the EPA.

The new model enables a computer to simulate -- with a realism previously unattainable -- the complex interactions among geographical features and meteorological conditions which, together, produce the varying patterns of air pollution over a city.

Working at the keyboard of a computer-controlled graphic display system, an investigator can quickly and easily alter the representation of a city's environment by typing commands into the computer. And seconds later, the results can be seen on a TV-like screen.

In this way it is possible to test the effects of, for example, changing the wind's speed and direction, creating a temperature inversion layer in the air, erecting a new smokestack on the outskirts of town -- or performing any of a variety of other changes too costly or even impossible to do in the real world. The results of an action appear on a display screen as contour lines representing different concentrations of pollution.

With the information gained from simulation experiments, EPA investigators hope for an improvement in their ability to predict the effects of various pollution sources -- both existing and contemplated -- on the overall air quality of an urban area. "Better prediction will lead to better techniques for managing air quality," says Dr. Pooler.

St. Louis was chosen by the EPA as the center for a Regional Air Pollution Study because, as a representative urban area, its topography is relatively flat and because the transport of air-borne pollutants is not much influenced by factors outside the metropolitan area.

Developers of the model are Dr. Ching Cheng Shir of the IBM Research Laboratory at San Jose, California and Dr. Liau Jing Shieh of the Company's Data Processing Division Scientific Center in Palo Alto, California. They see the association with the EPA as an opportunity to further refine their work, making the model respond even more realistically to changing atmospheric conditions. They also plan to adapt it for use in cities other than St. Louis. Currently, they are collecting the geographical, meteorological and pollution data that will permit the model to simulate the air quality of Venice, Italy.
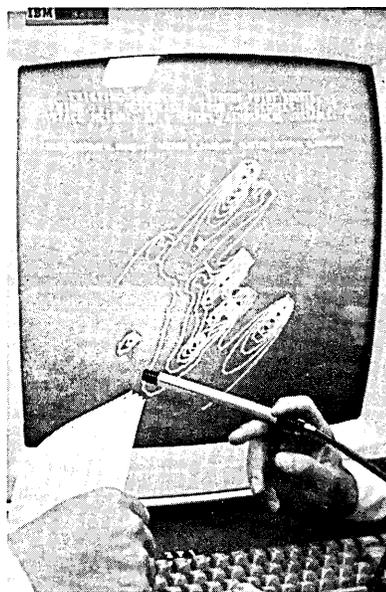
Approaches to Pollution Modeling -- Based on the general physical principle of conservation of mass, the new model is a specific form of a well-known approach to pollution modeling called the "concentration diffusion equation." The equation describes the factors that control the diffusion or spread of gases through the atmosphere. Its solution gives the concentrations of gas at points on a rectangular grid structure overlying some geographical area.

The concentration diffusion equation, when properly applied, gives a more accurate, more detailed description of atmospheric dispersion processes than

other approaches to air pollution modeling. But one crucial fact explains its lack of widespread use: few cities have gathered the large amounts of data needed to operate the model successfully. And if detailed and accurate data about pollution sources and air motion are not available, the results from using even the most realistic models can be considered as only a crude estimate.

One objective of the EPA's Regional Air Pollution Study is to build up a large collection of accurate data on pollution sources, pollution concentrations, and atmospheric conditions. With a better data base in hand it will become possible to use and validate a variety of advanced models.

In the absence of sufficiently detailed data, simplified modeling approaches based on statistical assumptions have been used. Most widely accepted of these is the "gaussian plume" model, which assumes a particular mathematical form for the concentrations of pollution downwind from a smokestack. Dr. Shieh and his Palo Alto associates used such a model in a previous study of air pollution in New York City.

One important limitation to the gaussian plume model is the fact that it is unable to handle the not-infrequent situation of near-zero wind speed.

Performance and Characteristics -- An early test of the new model's performance was conducted using data collected by the EPA in St. Louis during a 25-day period in February 1965. The data set is one that is customarily used by air quality researchers to test their models. It includes information about pollution source locations and emission rates, wind direction and speed, and other meteorological conditions. More detailed data is now being collected by the EPA in its current study at St. Louis.

In the test reported by the IBM researchers, the air-borne transport of sulfur dioxide from 44 major sources scattered throughout St. Louis and environs was computed in time and three-dimensional space. Also included were the effects of general pollution (automobile exhaust and smoke from home furnaces and small industries, for example) emitted in each of the region's 1200 subdivisions assumed for simulation.

The model has a number of features intended to yield a high accuracy of simulation. One such feature is a method of accounting for air turbulence around the city's buildings. A surface-roughness factor based on average building height and density is determined for each of the 1200 subdivisions.

Performance testing was done by comparing computed concentrations of sulfur dioxide with actual measurements made by the EPA at ten monitoring stations around the St. Louis metropolitan area. As expected, the computed results were in better agreement with measurements at stations some miles from the center of the city. Near the central stations, the buildings are more dense and the greater turbulence of the air complicated the description of the transport processes.

The correlation (a statistical measure of the agreement between two sets of numbers) between computed and observed results for the entire area was 52 per cent. This was half again as good as the performance of a "gaussian plume" model used in an earlier simulation of St. Louis air quality. It is the highest correlation ever reported by any model tested with the St. Louis data set.

COMPUTER HELPS STATE ENGINEER TRACE WATER RIGHTS IN THE DRY HIGHLANDS OF WYOMING

George Christopoulos
Deputy State Engineer
State Engineer's Office
Cheyenne, Wyoming 82002

For a century or more users have worried about getting their fair share of water in a state that scarcely has enough to go around. Today information stored in a computer helps the State Engineer's office figure out who has rights to water in the Wyoming high country. Here average rainfall is 14 inches a year and almost nothing can grow without irrigation. The computer is stored with facts and figures on the 113,000 water rights throughout the state, the time when each right was filed and its uses and restrictions. Thus the computer produces records that engineers can use to determine which user holds what rights and who has priority in case of a dispute.

Streams carry melted snow from the rugged mountain country to the ranchlands below. Each water user is limited in the amount to which he is entitled. Water in Wyoming is distributed on a priority basis, and it is important to know the priority date of a water right, the amount of the appropriation and where it is to be used. The deputy state engineer for the State of Wyoming authorizes water usage. The computer helps make sure that every user is aware of what he's entitled to under the laws of the state. Laws and court decrees governing water usage are numerous and often complicated. Many can be traced to the 1870s and '80s, before Wyoming joined the union. There are water permits in the archives signed by Buffalo Bill (William F. Cody). Even in his time, with very few people in the area, water was a precious commodity in Wyoming.

The basis of Wyoming water law is that the state owns the water, regardless of its source. Thus anyone who uses water for any purpose must get state approval -- even if it comes from wells on his own property. Water rights are included in the legal property record. All valid water rights remain in force as long as they continue to be used.

The demand for water continually changes. If a rancher wants to build a new stock pond, for instance, or put another 40 acres under irrigation, he doesn't have the right to use the water unless he secures a proper permit. So the potential user applies to the State Engineer, specifying the amount of water he expects to use and where and how it will be used. The computer can then help determine whether conflicting water rights exist on the given parcel of land, by printing out a complete list of all water rights related to the property since the state began keeping records.

If there are no conflicts with existing rights the applicant receives the permit that allows him to divert the water, when it is available, in priority.

Everyone must have a court-decreed right or a right issued by the State Engineer in order to use Wyoming's water. He must live up to the rules to keep his rights. Field administrators check periodically to make sure that water is being used for its stipulated purpose. If doubt exists, a quick check with the computer system can help engineers settle the issue.

The computer also can produce facts and figures relating to the size and yield and location in Wyoming of about 16,000 reservoirs and stock ponds, and about 28,000 water wells. The computer is an IBM system 370 model 155.

GAMES AND PUZZLES for Nimble Minds – and Computers

Neil Macdonald
Assistant Editor

It is fun to use one's mind, and it is fun to use the artificial mind of a computer. We publish here a variety of puzzles and problems, related in one way or another to computer game playing and computer puzzle solving, or to the programming of a computer to understand and use free and unconstrained natural language.

We hope these puzzles will entertain and challenge the readers of *Computers and People*.

NAYMANDIJ

In this kind of puzzle an array of random or pseudorandom digits ("produced by Nature") has been subjected to a "definite systematic operation" ("chosen by Nature") and the problem ("which Man is faced with") is to figure out what was that operation.

A "definite systematic operation" meets the following requirements: the operation must be performed on all the digits of a definite class which can be designated; the result displays some kind of evident, systematic, rational order and completely removes some kind of randomness; the operation must be expressible in not more than four English words. (But Man can use more words to express it and still win.)

NAYMANDIJ 752

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2 3 6 0 6 3 8 7 1 5 1 5 2 7 5 9 0 1 6 1
5 4 4 0 5 5 5 2 5 4 7 4 6 3 8 9 3 3 8 1
3 3 7 5 6 9 6 5 1 5 8 8 8 2 0 8 0 2 2 8
7 7 5 2 8 4 2 3 5 5 5 7 1 4 4 3 1 5 7 2
3 8 5 0 8 7 9 3 5 0 8 9 3 7 5 5 5 8 7 3
8 7 5 2 2 0 4 4 5 2 8 5 2 8 6 3 7 0 6 4
0 1 6 5 3 6 5 5 0 2 8 5 9 2 9 2 1 0 0 4
4 3 8 8 5 5 5 3 8 0 0 6 8 3 2 4 1 0 2 1
0 2 7 5 9 1 2 3 4 1 9 5 0 6 1 8 1 6 6 2
6 6 7 2 5 0 8 8 2 1 0 0 2 4 8 2 2 6 2 4
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MAXIMDIJ

In this kind of puzzle, a maxim (common saying, proverb, some good advice, etc.) using 14 or fewer different letters is enciphered (using a simple substitution cipher) into the 10 decimal digits or equivalent signs for them. To compress any extra letters into the 10 digits, the encipherer may use puns, minor misspellings, equivalents like CS or KS for X or vice versa, etc. But the spaces between words are kept.

MAXIMDIJ 752

NUMBLES

A "numble" is an arithmetical problem in which: digits have been replaced by capital letters; and there are two messages, one which can be read right away and a second one in the digit cipher. The problem is to solve for the digits. Each capital letter in the arithmetical problem stands for just one digit 0 to 9. A digit may be represented by more than one letter. The second message, which is expressed in numerical digits, is to be translated (using the same key) into letters so that it may be read; but the spelling uses puns, or deliberate (but evident) misspellings, or is otherwise irregular, to discourage cryptanalytic methods of deciphering.

NUMBLE 752

```
      T H E R E
          I S
    ─────────────       UA = NW
      I S E G O T
    O H G O E W
    ─────────────
    O U S N E I T

    92430 61386 29887 154
```

We invite our readers to send us solutions. Usually the (or "a") solution is published in the next issue.

SOLUTIONS

MAXIMDIJ 751: Life is not simple.

NUMBLE 751: The poor feed the rich.

GIZZMO 751: HONTEM: intellectual activity; FLEEN: university.

NAYMANDIJ 751: Make V of 2's.

SIXWORDO 751: (To be published in the March issue -- no room in this issue)

"RIDE THE EAST WIND: Parables of Yesterday and Today"

by Edmund C. Berkeley, Author and Anthologist

Table of Contents

The Fox of Mt. Etna and the Grapes

Once there was a Fox who lived on the lower slopes of Mt. Etna, the great volcano in Sicily. These slopes are extremely fertile; the grapes that grow there may well be the most delicious in the world; and of all the farmers there, Farmer Mario was probably the best. And this Fox longed and longed for some of Farmer Mario's grapes. But they grew very high on arbors, and all the arbors were inside a vineyard with high walls, and the Fox had a problem. Of course, the Fox of Mt Etna had utterly no use for his famous ancestor, who leaping for grapes that he could not reach, called them sour, and went away.

The Fox decided that what he needed was Engineering Technology. So he went to a retired Engineer who lived on the slopes of Mt. Etna, because he liked the balmy climate and the view of the Mediterranean Sea and the excitement of watching his instruments that measured the degree of sleeping or waking of Mt. Etna. The Fox put his problem before the Engineer. ...