[7/22/80]

Historical Narrative

The 1960s

Table of Contents

Page

Page

V. IBM'S SYSTEM/360 AND THE 1960S

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Richard Case, in 1962, was a member of the Advanced Systems Group which was responsible for the design and development of System/360, and personally headed the engineering group which was at that time designing what was announced as the IBM System/360 Model 60. (Case, Tr. 72010, 73235-38.) During this time frame, Case also served on IBM's Architecture Committee (Case, Tr. 72008-09; DX 3538), which was responsible for developing System/360's architecture. (Case, Tr. 72008-09.) Case's function on the Committee was to represent all of the 360 engineering groups. (Case, Tr. 72012, 73238.) In 1964 to 1965, Case was Assistant Manager of OS/360 (Case, Tr. 77966-67; DX 3538) and assisted Dr. Frederick Brooks (Manager of OS/360) in the

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the 1960-61 time period. As we have seen, by that time IBM was marketing more than 15 different processors and at least seven separate lines of second generation computer systems. (See above, pp. 126-49.) The architecture of those systems was "quite dissimilar", as was their programming. (DX 4740, Evans, p. 3925.) Whatever software compatibility there was existed only over a very narrow range of processor performance.

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design and development of System/360's programming support. (Case, Tr. 77966-67, see also Tr. 77977, 77982.) Case was a co-inventor on the original System/360 patent. (Case, Tr. 71998-99; DX 3538.)

Bob O. Evans was Director of Systems Development and Planning for DSD from early 1961 to mid-1962 (Evans, Tr. 101269; DX 8081 (Tr. 101035)), and initially responsible for "personally evaluating . . . the 8000 series" and deciding whether IBM should pursue the project. (Evans, Tr. 101269.) During this period, Evans also served as Vice-Chairman of the SPREAD Committee. (Evans, Tr. 101270; DX 1404A, p. 3 (App. A to JX 38).) In the 1962 to 1965 time frame, Evans was Vice-President of Development for DSD (DX 8081 (Tr. 101035)), and assumed "worldwide responsibility for coordination of the development" of System/360. Evans, Tr. 101061.)

Paul W. Knaplund was Manager of Systems Marketing for the Data Processing Division (DPD) in 1960 and was responsible for understanding and informing IBM's product divisions of "the functions and prices necessary for IBM products to be economically attractive to users". (Knaplund, Tr. 90467, see also DX 9033 (Tr. 90458).) In the latter part of 1960, Knaplund became Manager of Systems Development for the General Products Division (GPD) and was responsible for projecting profitability for and meeting profitability objectives of various IBM products, including the 1401 and 1620 processors and IBM unit record equipment. (Knaplund, Tr. 90464-68; see also DX 9033 (Tr. 90458).) In 1963 Knaplund was named Assistant Group Executive, Product and Profit Planning for the Data Processing Product Group DPD (Knaplund, Tr. 90474; DX 9033 (Tr. 90458)), and "was directly involved in the preparations and discussions that resulted in the System 360 announcement of April 7, 1964". (Knaplund, Tr. 90474-75.) In the 1964 to 1966 time frame, Knaplund assumed further executive responsibilities as Vice President and Group Executive of the Data Processing Product Group, and as Vice President and Group Executive of the Systems Development and Manufacturing Group, which required him "to deal with functional, pricing and schedule issues" relating to System 360 and other products. (Knaplund, Tr. 90468, see also DX 9033 (Tr. 90458).)

In addition, the input/output equipment had been developed "almost uniquely" for each processor in order to optimize the performance of each of the different system types. (DX 4740: Evans, Tr. (Telex) 3925.) The result, of course, was a very limited flexibility in attachment possibilities. As Evans testified, because peripheral equipment differed for different families or attached in different ways to different processors, customers "had great difficulty in moving even from one member of a processor in one family to another, let alone moving from one family type to another". (DX 4740: Evans, Tr. (Telex) 3925-26.) In this regard IBM's computer systems were no different from the computer systems of its competitors. (See pp. 156-70, 203-11, 229-37, above.) The result of this situation was that customers generally acquired set systems and had very little flexibility to change their configurations as business demands changed.

a. <u>8000 Series and the SPREAD Committee.</u> In the early 1960s, IBM's General Products Division (GPD) was responsible for the development and manufacture of IBM's small and intermediate systems, such as the 1401 and 1620, as well as IBM's disk drives. (Knaplud, Tr. 90464-65; DX 13890, pp. 16, 18; see also DX 1404A, p. 10 (App. A to JX 38).) IBM's Data Systems Division was developing and manufacturing IBM's larger systems, the 7000 Series, as well as IBM's tape drives. (DX 4740: Evans, p. 3919; DX 13890, p. 16; see also DX 1404A, p. 10 (App. A to JX 38).) DSD and GPD were achieving great success in the marketplace with their current lines--particularly with the 7090 and 1401. (DX 1404A, pp. 81-82, 85, 86, 89 (App. A to JX 38).) In fact, the 1401, which had been announced in October 1959, was the most successful computer system that IBM had ever introduced, with domestic shipments of more than 1600 by year end 1961. (DX 1404A, p. 75 (App. A to JX 38); DX 2609B, p. 94.)*

Nevertheless, neither of the Divisions was resting on its laurels; they were planning for the future. If IBM was to continue to compete successfully, it would have to commit itself to the development of even better products. Such a commitment would require large financial investments by IBM. T. J. Watson, Jr., IBM's Chairman, fully understood this requirement and reported the following to IBM's Managers in an April 24, 1961, Management Briefing:

> "[O]ur competition is getting stiffer all the time . . . . The best way to meet this competition is to keep our prices competitive. Prices involve costs and earnings . . . . We need constantly to spend large sums in research and development of new products which will not produce revenue for some years to come. Without funds for this vital expense, competition would eventually surpass IBM." (DX 8886, p. 43.)

Thus, within both divisions, improvements and extensions to the then current product lines were being developed. At GPD, Engineering Manager Ernest S. Hughes, Jr. (DX 1399, p. 2 (Tr. 33869)), had set up two groups of engineers--one to pursue improvements to the 1400 family and another to outline and define a replacement for the 1400 family. (Hughes, Tr. 33915.) At DSD, development was even further alone. A machine called the 8106 had been under design for some years and was already under construction within DSD when

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* We are aware that DX 2609B is not in evidence but we rely on it because it represents a sworn response by an IBM executive which reflects information taken from IBM's accounting books and records.

Dr. Frederick P. Brooks, Jr., came to the Division in 1960 as Systems Planning Manager. Thereafter, IBM began to develop the 8106* into a series of machines called the 8000 Series. (Brooks, Tr. 22771.) By 1961, IBM had spent many millions of dollars on the 8000 Series development. (Evans, Tr. 101047.)

Despite the relatively advanced state of the 8000 project and the money IBM had already invested in it, there was "vigorous debate" within the company over whether the 8000 was the right way to proceed. (Brooks, Tr. 22665-66.) With the first elements of the 8000 nearing announcement, B. O. Evans, who at that time was Director of Systems Development and Planning for DSD, was charged with evaluating the 8000 to determine whether it was a "leadership" program. (Evans, Tr. 101045-46, 101269.) Evans was charged by DSD's Group Executive, T. V. Learson, to get the 8000 into production if it was the right thing to do or, if Evans thought the 8000 Series was the wrong approach, to do what was right. (Evans, Tr. 101046.) Evans concluded that the 8000 Series was "wrong" for a variety of reasons:

> <u>One</u>, the family was based on "contemporary transistor technology" and would not be "far-reaching enough". In Evans' view, it would have been a "terrible mistake" to build a new family of machines that could be rendered obsolete by competitive products incorporating much better transistor technology that would soon be available. (Evans, Tr. 101048; see also DX 4773, p. 3.)

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* The 8106 was an outgrowth of the STRETCH program. (Brooks, Tr. 22771.)

Two, the 8000 had a "lackluster" plan with respect to peripherals. (Evans, Tr. 101048-49.)

Three, the 8000 Series was planned to be "a range of five different machines: a small scientific machine, a small business machine, a medium to high performance business machine, a higher speed scientific machine . . . [a] superspeed scientific machine." (Evans, Tr. 101051.) Evans thought that offering this "collection of differing machines with kind of loose ties . . . in their structure" was "a basic mistake from the user's standpoint". (Evans, Tr. 101049.)

Although Evans believed that the 8000 Series would be an improvement over IBM's existing product line and might give IBM a "momentary advantage" over competition, he recommended its cancellation. (Evans, Tr. 101049; see also DX 4773, p. 1.) On June 27, 1961, W. B. McWhirter wrote Learson that IBM's Regional Managers had been apprised of the reason why the 8000 was withdrawn:

> "[T]he 8000 Series offered insufficient advances to insure our competitive position at this time--[it] is being replanned with new technology to provide a major breakthrough . . . ." (DX 14059.)

In late 1961, T. V. Learson, then IBM Vice President and Group Executive, appointed a task force called the SPREAD Committee to develop a new plan for IBM's data processing products during the 1960s. (JX 38, p. 2; see DX 1404A, p. 7 (App. A to JX 38).) Its Chairman was J. W. Haanstra, Vice President of Development for GPD and its Vice Chairman was Evans, who had become Director of Systems Development and Planning for DSD. (DX 1404A, p. 3 (App. A to JX 38);

DX 8081 (Tr. 101035).) Other members of the SPREAD Committee included Dr. Brooks and J. W. Fairclough, Manager of Product Development at IBM's Hursley Laboratory in England,* who had been in charge of yet another processor development, the SCAMP.** (Tr. 71984-85; DX 4779.) The Committee issued a report of its recommendations in December 1961. (JX 38, p. 2.) That report is Exhibit A to the System/360 Stipulation of Fact (JX 38) and is also Defendant's Exhibit 1404A.

The SPREAD Committee recommended "termination of the proliferation of IBM products and the development of a family of compatible processors which would employ a common technology (Solid Logic Technology or SLT), a compatible set of peripherals and a compatible program operating system". (JX 38, p. 2.) The report and recommendations of the SPREAD Committee were accepted by IBM management

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* The remaining members of the SPREAD Committee included D. T. Spaulding, Group Director of Product Line for the Data Processing Group; J. D. Aron, Programming and Technology Coordination Manager for FSD; W. P. Heising, Programming Systems Planning Manager, Development for DSD; H. Hellerman, staff member, IBM Research; W. H. Johnson, Director of Product Evaluation, Corporate Headquarters; M. J. Kelly, Senior Engineer and Technical Advisor for GPD; D. V. Newton, Manager, Mathematics and Programming for DSD; B. G. Oldfield, Manager, Systems Development for FSD; S. A. Rosen, Data Processing Manager for the Queens IBM New York Branch Office; and J. Svigals, Manager, Systems Marketing for DPD. (Tr. 71984-85; DX 1404A, p. 3 (App. A to JX 38).)

** SCAMP was an experimental computer built in 1960 by IBM's Hursley Laboratory in England. (JX 38, p. 5.) SCAMP's control function was implemented by the technique of microprogramming. (Id.) Although the SCAMP project was cancelled in favor of System/360 (DX 4779, pp. 2-3), Fairclough was able to convince the SPREAD Committee of the benefits of microprogramming, which the Committee adopted as the principal means of implementing control functions in System/360. In addition, because microprogramming techniques were better known in IBM's British lab than in the United States labs at that time, design of the Model 40--which was the lead System/360 model in development--was assigned to Hursley. (Brooks, Tr. 22806-07.) (The importance of microprogramming is discussed below at pp. 302-03.)

and the development of the New Product Line (NPL), which ultimately became System/360,* began in 1962. (JX 38, p. 3.)

The principal alternative course of action, which the SPREAD Committee considered and rejected, was the addition of improved successors to the then existing product lines, rather than development of an entirely new line. (Case, Tr. 73571.) The one course of action that IBM could not afford to take was simply to maintain the status quo and continue marketing its current products. That much was plain from the "product survival charts" incorporated in the SPREAD Report. (DX 1404A, pp. 73-91 (App. A to JX 38).) Those charts "showed that all of the existing products in the IBM product line were estimated to have very short lives, that they would be very quickly coming out of users' installations . . . [b]ecause other systems manufacturers were developing new and better products and that the evaluation was that all of the existing product line was very rapidly heading toward being non-competitive". (Evans, Tr. 101271-72.)

According to Paul Knaplund, the "'Product Survival Charts'

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* The processors included in the April 7, 1964, System/360 announcement and their NPL designations are set forth below:

System/360	NPL Designation
2030	101
2040	250
2050	315
2060 and 2062	400
2070	501

(JX 38, ¶ 4, p. 3.)

. . . projected displacement of both announced and planned to be announced IBM central processing units (CPU's) by newer products as users' needs grew and changed and as new technologies and equipment features enabled electronic data processing (EDP) suppliers to offer improved products. Those charts demonstrated . . . that IBM had to move rapidly ahead with the development of a new line of CPU's or else competition would soon displace IBM's EDP business". (Knaplund, Tr. 90473.)

The survival chart for the 1401 (DX 1404A, p. 75 (App. A to JX 38)) made the point graphically. This most successful of IBM's systems, announced only two years earlier, was projected to reach a peak of installations by 1965, with installations declining rapidly thereafter. Projections for the rest of the product line were similar. The charts indicated that if IBM did not introduce new, improved products its entire installed base would be replaced by its competitors. In the face of these projections, the SPREAD Committee stated the need for new products to be developed and delivered by 1965. Accordingly, they recommended announcement of the first processors in the line during the first quarter of 1964. (DX 1404A, p. 57 (App. A to JX 38).)

The SPREAD Report, and the Systems Architecture Group which was responsible for implementing its recommendations, created a product plan that went far beyond the recognized competitive need for new and improved products and set forth a revolutionary concept of a future product family. This concept represented a commitment to a vision of the future development of the industry far more daring and far-reaching than any of IBM's competitors ever attempted. The concept, subsequently embodied in IBM's System/360, held the potential, if successfully implemented, for enormous business success for IBM and also for revolutionizing the EDP industry. It sought not just competitive success with existing users but a vast expansion of the number and types of EDP users and uses. At the same time, the magnitude of the commitment--the devotion of virtually the entire business to that concept--carried with it a risk of staggering proportions. Both internally and externally, the IBM System/360 program came to be referred to as a "you bet your company" undertaking. (Evans, Tr. 101126; see also Friedman, Tr. 50378; Case, Tr. 73561-62.)

b. <u>The SPREAD Report and S/360.</u> The concept for the New Product Line (NPL), which became 360, embodied a number of objectives including:

(i) the clear assertion of price/performance and technological leadership;

(ii) the merger of business and scientific capabilities in a single family of systems (in fact, the attainment of a series of computer systems that would be an industry leader in the performance of all applications, hence the origin of the name "System/360" to denote the full 360 degrees of the circle (Evans, Tr. 101129));

(iii) upward and downward compatibility across a broad family of processors;

(iv) a comprehensive set of systems software;

(v) compatibility of a wide range of peripherals across the entire family of CPUs; and

(vi) the substantial user flexibility attainable from the resulting modularity of the boxes constituting a 360 computer system. (DX 1404A (App. A to JX 38).)

Each of the objectives held the promise of greater customer acceptance and a substantial broadening of the demand for and use of computers, and each raised its own particular challenges and risks. The attainment of each objective posed obstacles in development, design and manufacturing, each of which carried with it the possibility of failure. These objectives, and the manner in which IBM successfully attained them, are discussed in the following pages.

(i) <u>Price/Performance and Technological Leadership--Generally.</u> The 8000 Series was cancelled because it would not have been a "leadership" product for a significant period of time, either technologically or in a price/performance sense. System/360, its replacement, was clearly intended to be both. In December 1962, T. V. Learson, IBM Vice-President and Group Executive of the Corporate Staff, wrote to Evans that IBM's aim was to make the new line "economical as hell, simple to operate and the best on the market". (DX 4795.) IBM's Chairman wrote in June 1963 that it was important for IBM to "make these machines good enough so they will not be just equal to competition", because IBM expected that once they were announced IBM's competitors would "immediately try to better them" and "I [Watson] want our new line to last long enough so we do not go in the red". (DX 4806.)

The price/performance of System/360 turned out to be a spectacular improvement over IBM's earlier product line. (Rooney, Tr. 12123-24; Welke, Tr. 17079-80, 17304-05; see also Northrop, Tr. 82711; PX 3638.) In a memorandum written to Evans and Kennard just prior to the System/360 announcement, the Manager of Market Analysis for the Data Systems Division stated that "[i]t is difficult to estimate the competitive jolt NPL will create. Never before has a single announcement obsoleted so much existing equipment at one time" since "NPL will have an advantage over all existing systems offered by major competitors". (PX 1099A, p. 1.) In particular, the Model 30, intended largely to replace the 1401, had "six times greater internal speed" than that system. (DX 3726 (Tr. 78990); see also DX 4740: Evans, Tr. (Telex) 4034-35; DX 4755.)

The following comparisons at the time of announcement illustrate these improvements:

	1401	Model 30
Rental Price (with maximum memory)	$2,680 (DX 573, p. 6)	$3,875 (JX 38, p. 33)
Maximum Main Memory Capacity (Chars.)	4,000 (DX 573, p. 3)	65,536 (JX 38, p. 32)
Performance (instructions/second)	5,000 (DX 4740: Evans, Tr. (Telex) 4034-35; DX 4755)	30,000 (DX 4740: Evans, Tr. (Telex) 4034-35; DX 4755)
Performance/Rental Price	1.87	7.74

	7090	Model 75
Rental Price (with maximum memory)	$43,500 (DX 572A, p. 6)	$60,300 (JX 38, p. 394)
Maximum main memory capacity	196,608 (6 bit characters) (DX 572A, p. 5)	1,048,576 (8 bit characters) (JX 38, p. 394)
Rental per million characters	$100,708 (DX 572A, p. 6)	$35,286 (JX 38, p. 394)
Performance (multiplications/second)	38,200 (Case, Tr. 74220)	366,000 (Case, Tr. 74220)
Performance/Rental Price	.88	6.07

Knaplund testified that just prior to announcement IBM considered 360 price/performance to be superior to the best known competitive systems and substantially superior to the best of IBM's older computer systems. (Knaplund, Tr. 90503; see also PX 1099A.) T. V. Learson wrote in July 1964 that System/360's price/performance had achieved a 30% to 50% improvement over IBM's previous product line. (DX 1525.) Moreover, the analytical methods used at the time to predict price/performance understated the comparative advantages of System/360 by failing to take into account the benefits to the user stemming from the use of disks, the advantages of compatibility, the System's improved reliability, the advantages expected to come from its software and the availability of large memories. (Knaplund, Tr. 90504-05; see also PX 1099-A, p. 1; PX 6204, p. 1.)

The price/performance and other advantages of System/360 were recognized outside of IBM as well. For example, plaintiff's witness Frederic G. Withington of Arthur D. Little reported in October 1964 that "[w]ith the introduction of their System 360 equipment, IBM established the new price-performance standard for equipment within the computer industry for the next several years" (PX 4829, p. 16), an opinion which he reiterated during his testimony. (Withington, Tr. 56591-92.) Withington also testified that System/360, at the time of its announcement in 1964, was "regarded as the best in terms of incorporating the most recent developments in systems program and machine architecture". (Tr. 56590.) Similarly, in a June 1964 presentation to G. E.'s Executive Office, John Weil called System/360 an "excellent product line with outstanding peripheral offerings" and stated that it was "no longer possible to offer equipment with a significant advantage over IBM". (PX 320, pp. 13-14.) Additionally, RCA's June 1964 "Five Year Plan" noted that System/360 "has and will have a significant impact on the marketplace and other suppliers are obliged to meet its capabilities". (PX 243, pp. 5-6.)

(ii) System/360 Component Technology. In explaining his recommendation to cancel the 8000 Series, Evans had written: "New technology is essential to a new IBM machine family. Committing a new family's lot to current technology is opening IBM to a major competitive coup". (DX 4773, p. 3.) The improvements in price/performance offered by 360 could not have been achieved without the superior circuit technology that Evans had envisioned. (Case, Tr.

73244; Evans, Tr. 101048.) Development of such technology (called Solid Logic Technology or SLT) had already begun in IBM when the SPREAD Committee met. The Committee recommended the use of SLT as processor componentry because it "promised improved cost/performance and reliability." (JX 38, p. 5; DX 1404A, p. 7 (App. A to JX 38).) Case testified that "the entire System/360 line . . . was predicated on the availability of the new SLT technology." (Case, Tr. 72303.)*

SLT development, which had begun prior to 1961, was accelerated in April of that year on the recommendation of IBM's Advanced Technology Study Committee that a "high priority SLT program" be established. (JX 38, p. 5.) According to Erich Bloch, who headed the Advanced Technology Study Committee until September 1964, that Committee had been charged with recommending the logic component technology that IBM should use in its future EDP equipment and with establishing the schedule and cost objectives for its implementation. (E. Bloch, Tr. 91468-69, 91492, 91686; see also DX 9117, p. 2.)

The Committee decided that the new technology had to be producible at half the cost of the then current SMS (Standard Modular System) technology and be four times as fast. (E. Bloch, Tr. 91492-93.) These performance goals were influenced by both the technology performance and computer performance that could be achieved by IBM competitors, including both computer manufacturers and component

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* "In fact, in its early states, the System/360 project was known as the SLT family." (Case, Tr. 72303.)

manufacturers. According to Bloch, the existence of such competitors and their introduction of new products and processes since the 1960s has forced IBM to be alert to their offerings in order to remain competitive in terms of cost, performance, reliability and function. (Tr. 91690-92.)* As T. V. Learson later put it, prior to the introduction of System/360, "IBM had been in the market for a long time with the old circuitry . . . . It was time for a change. Competitive action told us so . . . ." (PX 1900, p. 7.) Because of such "competitive pressures", the Committee decided that the development of the new technology had to be accomplished within 18 months and the delivery of machines incorporating the technology to customers begun within three years. (E. Bloch, Tr. 91686-87; see also DX 9117, p. 3.)

The Committee considered three courses of action: improvement of the existing technology; development of monolithic technology; and further development of a hybrid technology (SLT) with discrete semiconductor components combined with screened circuit elements. (E. Bloch, Tr. 91492.) SMS was the packaging for discrete components used by IBM in its second generation equipment. (Case, Tr. 72265.) It had been designed and developed by IBM for Project STRETCH and was superior to the discrete component packaging available from outside suppliers because it was optimized for use in EDP equipment. (E. Bloch

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* Bloch included such firms as Texas Instruments, Fairchild, Motorola, Intel, Mostek, AMD, Hitachi, Fujitsu, Philips and National Semiconductor. (E. Bloch, Tr. 91691-92.)

Tr. 91486-87.) Despite its contribution to IBM's successful line of second-generation computers, the Committee concluded that SMS technology had apparently been pushed close to its limits in terms of cost, performance and reliability and would not yield the desired performance improvements. (E. Bloch, Tr. 91493; see DX 9117, pp. 4-5, 8.)

In order to gain additional information about the feasibility of going directly to monolithic circuitry,* IBM was advised by other companies, including Fairchild, Texas Instruments and Motorola, concerning their development activity with monolithic technologies. (E. Bloch, Tr. 91694-95.) The Committee concluded that while monolithics could meet the performance requirements laid down they could not be produced in the time or at the cost desired. (E. Bloch, Tr. 91492-94; see also Gibson, Tr. 22625-27; DX 4782.) The Committee therefore recommended moving part, but not all of the way to monolithics: the continued development of the "hybrid (SLT) configuration". (E. Bloch, Tr. 91492-94.)

That recommendation was based on several advantages to the SLT technology: first, it would lend itself well to automation and to a fast production buildup; second, it would lend itself "to a product spectrum of applications" in processors of all sizes as well as input/output devices; third, it would be capable of providing the

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* "[T]he total integration of all devices . . . and interconnecting wiring in a single piece of semiconductor material". (E. Bloch, Tr. 91492.)

necessary speeds or performance ranges; and finally, the semiconductor packaging would accommodate the semiconductor well, provide the needed electrical characteristics and give the desired packaging densities. (E. Bloch, Tr. 91699-701.)

These anticipated advantages were in fact realized and SLT became a high-performance technology for its day, offering a substantial increase in speed at a substantial reduction in size. (Case, Tr. 72301-03; E. Bloch, Tr. 91705; see also PX 3587 (Tr. 25334).) SLT was a "significant advance" in IBM computer technology: it required less space, power and cooling per circuit than SMS; it had higher performance and "ten times the reliability" of the earlier technology--all at a reduced cost. (E. Bloch, Tr. 91496-97; see also McCarter, Tr. 88380; Evans, Tr. 101132.) Thus, SLT enabled IBM to offer "very substantial gains" in price/performance. (Evans, Tr. 101132.) Further, SLT "lent itself to automation" (E. Bloch, Tr. 91705) and IBM took advantage of that fact by investing heavily in the development of automatic tools. (Case, Tr. 72298-301.) "IBM coordinated the development of tools, the development of a design automation system and the production and testing of components with the development of the components themselves. Each of the parts of the technology took into account the other parts." (E. Bloch, Tr. 91497-98.)

Such automation enabled IBM to reduce production costs and improve the reliability of its circuits. (Case, Tr. 72301; E. Bloch, Tr. 91497.) IBM's "substantial investment" in automatic manufacturing techniques was a very important factor in allowing IBM to make System/

360 much more powerful for the same price or to be a lot less costly for the same power. (Case, Tr. 72301.) From 1965 to 1969 SLT technology and the automation which accompanied it gave IBM a cost advantage over other component manufacturers who moved their assembly outside the United States in order to get a cheaper labor source for the relatively labor-intensive production processes. (E. Bloch, Tr. 91708.) No other computer manufacturer had the equivalent of SLT technology at the time of System/360's announcement and delivery (Evans, Tr. 101131), despite the substantial benefits that it held and despite the fact that SLT was an extension of the existing transistor technology which was readily available to everyone.

Only with the benefit of hindsight, however, was it obvious that the SLT decision was the correct one. During the middle 1960s, up to about the beginning of 1966, criticism of the decision was expressed within IBM. Critics thought that SLT had been the wrong choice, that by being more aggressive IBM could have gone to monolithic circuits and taken a larger jump forward.* (E. Bloch, Tr. 91695-96.) Implicit in that criticism was the apprehension that IBM would be the victim of a competitive coup by other companies moving beyond IBM in circuit development.

This failed to happen. Based upon a comparison of the cost and capabilities of IBM's SLT circuits with competitive monolithic circuits that became available from the mid-1960s forward, Bloch

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* Bloch also testified that the criticism "died down" when it became clear that "SLT met all the goals" set for it in a way that could not have been done with monolithics. (Tr. 91696.)

concluded that SLT had as good a performance as those later developed products, was "much denser" and was produced at lower cost than the products which IBM's competitors acquired from outside vendors. (E. Bloch, Tr. 91704-05; see also Withington, Tr. 56591.) Moreover, when IBM did convert to monolithic circuits in 1968-1970, it was able to use a great deal of what had been done in SLT to ease the transition into monolithics. (E. Bloch, Tr. 91698; Dunlop, Tr. 93991.) This planning for the future had been taken into account by the Advanced Technology Committee and for that reason IBM designed techniques and tools during the SLT development that could be adapted to the manufacture of monolithic circuitry. (See E. Bloch, Tr. 91500, 91703, 91494 and Case, Tr. 72300-14 for details of the carryover of SLT development into monolithics.) SLT still is being used by IBM in secondary circuit functions of newer products. (E. Bloch, Tr. 91499.)

The advantages of automation, of taking an intermediate step toward monolithics, and of coordinating circuitry, component and product development could be fully realized only through in-house development and manufacture. Accordingly, the Advanced Technology Study Committee recommended the establishment of a components division which would be able to manufacture SLT on a large scale. (E. Bloch, Tr. 91562.)

Case called IBM's decision to develop and build its own new circuitry "perhaps the riskiest single decision that had to be made by IBM in the development of System/360". (Tr. 73514.) It required a substantial capital investment in a new business--developing and manufacturing transistor components--in which IBM had had little prior experience. Not surprisingly, there was considerable debate within IBM whether components was an "appropriate business" for IBM to get into, and the decision to establish the Components Division in 1961 continued to be second-guessed well into the 1960s--long after IBM had committed itself to the point when there was no turning back. (Case, Tr. 73515.) In short, as T. V. Learson put it in 1966: IBM "had to become, in a very short time, the largest component manufacturer in the world". (PX 1900, p. 9.) If IBM were successful, the potential benefits overrode those risks:

(a) in-house manufacture could help IBM reduce its total costs by eliminating middle-man profits;

(b) by designing the new circuitry and the new machines simultaneously, IBM could get the best new circuitry earliest because IBM would not have to wait for another firm to finish its circuit development process and make the circuit available in order to explore the circuit's potential characteristics and use in a computer system;

(c) unlike other manufacturers who were less integrated and who would have to adapt generalized circuitry to their particular needs, IBM would be able to enhance the price/performance of its computer systems by tailoring its own circuitry to the requirements of System/360. (Case, Tr. 73245-48; see also E. Bloch, Tr. 91563.)

In-house manufacture would also permit IBM to accelerate the training of computer engineers in both the characteristics and use of the new circuit technology. According to Case, it was believed that IBM "could synchronize the development activities between the circuit development organizations and the computer development organizations more effectively if they were in one corporation rather than if they were in two or more corporations." (Case, Tr. 73250.)

Such synchronization was to grow increasingly more important. Bloch testified that as the integration level of components increases, "more and more of a machine is on a single component. And therefore when one has in mind the designing of a new computer one can learn a lot by just looking at the individual components that go into it." (Tr. 91929; see also Case, Tr. 73251-52.) As the degree of component integration increased during the 1960s both symbiosis in development and confidentiality became increasingly more important reasons for in-house development.

IBM's Advanced Technology Study Committee took the long view in 1961. It was building for the future (E. Bloch, Tr. 91929) and considered the benefits which might be derived later on from a long-term kind of process worth the risk. (E. Bloch, Tr. 91928.)

That long range planning paid off handsomely. Case testified that IBM achieved the objectives that it set with respect to the design, development and manufacture of SLT (Tr. 73267) and that the ultimate success of System/360 was "in large measure" dependent on the success of that circuit development activity. (Tr. 73253.)

(iii) Single Family for All Applications. The SPREAD Committee recommended development of a single line of processors to "meet the needs of the commercial, scientific, and communications and control markets". (DX 1404A, p. 12 (App. A to JX 38).) That objective called for a "fundamental change" in IBM's design emphasis (DX 4740: Evans, Tr. (Telex) 3925-28) but one which was thought to be necessary for developing user requirements. At the time of the SPREAD Report, IBM's product lines were "distinctly either commercial or scientific in their emphasis". (DX 1404A, p. 13 (App. A to JX 38).) This was true of other vendors' product lines as well. Up to that time, customers who wanted to do what had traditionally been considered both "scientific applications" and "business applications" generally acquired two computers. (Case, Tr. 73329.)

By the end of the 1950s, however, the distinctions between business and scientific applications were beginning to blur, and "customers themselves were not observing [the] lines between scientific and business machines in actual practice". (Case, Tr. 73274-75; see also Tr. 73276-83, see pp. 81-83, 102, 148, 162, 213-15, 239, above.) Evans testified that "more and more" often, the "scientific side" of a user's operation needed the data handling capabilities associated with business data processors and the "business side" needed the arithmetic and logic capabilities associated with scientific systems. (DX 4740: Evans, Tr. (Telex) 3927-28.) The history of the 1950s and early 1960s is full of examples of "business" computers doing "scientific" applications and vice versa. (See above, pp. 15-21, 38-45, 81-83, 102, 138-49, 162-68, 206-15, 242-44.)

That user need for "dual use" was a major factor in the SPREAD Committee's thinking. According to Evans, "One of the premises from the beginning was there would be great savings to the users if we could combine in the single machine the ability to cover the full range of business applications and scientific applications as well. So our concept was a single machine that would be equally able in either of those areas". (Tr. 101052.)

Although the Committee foresaw the need for separate development of ruggedized products for military purposes, it stated that "standard products will satisfy about 32 percent of the available military market" and that a basic objective should be "to further penetrate the ultra-reliable portion of the military market with the SPREAD family". (DX 1404A, p. 44 (App. A to JX 38).)

Thus, in accordance with these recommendations, it became an objective to design the NPL architecture for the "broadest possible range of applications . . . equally well suited" to what had previously been considered scientific or business computing. An instruction set and processing capabilities were to be designed to be "equally suitable to both of those classes of applications and indeed well suited to the broadest possible range of applications that one could think of" (Case, Tr. 73268-69), including process control applications and communications control applications. (Case, Tr. 73321). Evans testified that the name "System/360" was chosen for the new line to indicate the "full circle of the applications ability of the machine". (Tr. 101129.)

The combining of capability to do the whole range of applications in a single machine promised great savings to users and great returns to IBM. It was far from clear, however, that the objective of designing "dual purpose" computers could be accomplished without a degradation of either performance in business applications or performance in scientific applications or, indeed, in all the application areas. Evans testified that this risk was perceived by IBM management and "haunted" them.* (Tr. 101052, 101129.)

> "The question was whether we could build machines that in their own right as a scientific performer would be the best and also had the ability to do the business kind of a problem, or in so doing would we really be building mediocrity and someone could come along and optimize as the industry had done before and build better scientific machines, better business data processors, and in the process negate our plans and our aspirations." (Tr. 101052; see also Case, Tr. 73538-39.)

The risk that competitors might specialize and, in so doing, outdistance a line of products aimed at a wide variety of applications was compounded by the risk that, even if 360 was as powerful as more specialized competitive machines in their specialties, customers might reject System/360 because they just "might not see it that way". (Case, Tr. 73538-39.) In the face of these risks, some people in IBM became proponents of continuing work on the pre-existing "scientific" and "business" product lines. During 1962 and 1963 there was continued a project to build a scientific computer compatible with and as a successor to the 7094 (Brooks, Tr. 22843-44; Case, Tr. 74574); and as late as December 1963-January 1964, a group in the General Products Division led by John Haanstra opposed development of the 360/30 in

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* Case testified that IBM management "frequently" inquired of the 360 design group whether the performance objectives for System/360 were being met for both business and scientific use. (Tr. 73539.)

favor of extending the 1401 line in its place. (Evans, Tr. 101187-88, 101275-76; Hughes, Tr. 33970-71.)

Such fears were not unfounded. As we shall see, competitors did attempt to offer more specialized systems* to meet the needs of certain users and were successful in competing against System/360 where customers wanted such relative specialization rather than the more generalized range of functions which System/360 offered. Some of the history of the latter part of the 1960s is the history of IBM's attempts to respond to such competition.

Despite the risks, the concept proposed by SPREAD was pursued. System/360 was designed to be a machine equally powerful in scientific and business applications and with facilities for real-time applications, which "machines of that age had not been able to address before System/360 with real power and versatility". (Evans, Tr. 101144.)

Weil testified that the distinction between scientific and commercial processing was "erased" "[i]n a practical sense, with the announcement of the IBM 360". (Tr. 7189; see also Beard, Tr. 10342; Friedman, Tr. 50378; O'Neill, Tr. 76194-96.)** That testimony was

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* The "specialization" offered by competitors was a matter of degree--many "specialized" competitive offerings could be and were used to perform a range of applications, but were marketed as more "tailored" machines to attract certain users. For example, G.E. initially targeted its 600 series primarily for engineering and scientific applications (Weil, Tr. 7026-27) and CDC originally designed its 6000 series to perform scientific applications. (Norris, Tr. 5617, 5618, 5629; see pp. 423-24, 672-80, 690, below.)

** Weil also testified that "Since the early sixties, it really hasn't been economically important to design a computer system only consistent with Weil's assessment of 360 in June 1964:

> ". . . System/360 integrates into a single set of equipment the capability for business data processing, scientific calculation, data communications, and process control. It seems clear that all of these are now but facets of the basic information handling and processing system.". (PX 320, p. 13.)

System/360's ability to "do the 360 degrees of the circle" resulted in acceptance by users who could not get the same range of performance from other architectures. (Evans, Tr. 101132-33.)* Its broad range of applications helped simplify customers' acquisition decisions, enabled them to achieve economies of scale by acquiring one large-capacity, rather than two smaller-capacity, machines and permitted them to reduce the required training and improve the efficiency of their EDP staffs. (Case, Tr. 73327-28; see also Weil, Tr. 7059-60.) The combination of business, scientific, and other applications in the same line also helped reduce IBM's costs. It enabled IBM to concentrate on a single machine type with fewer sets of program support and software and with a single set of training and education for customers and IBM personnel. (Case, Tr. 73328-29, see also Tr. 73387-89.)

Some of the benefits associated with the "erasure" of the business-scientific distinction and some of the techniques used to

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for business or only for scientific applications, except at the extreme ends of this spectrum, where you are trying to do as much scientific calculation as you possibly can within the limits of the technology". (Tr. 7190.)

* The diversity of applications to which users applied System/360 are described in more detail in the Appendix to this section.

effect it were also associated with the achievement of another objective of the SPREAD Committee. This was the objective of having a single compatible line of processors with compatibility extending over a wide performance range. Compatibility in this sense meant that programs written for one processor in the line could be run on a second processor, provided that the second processor had at least the minimum memory capacity and complement of input/output and auxiliary storage devices required by the program, and that successful execution of the program did not depend on the speed of the CPU.* (Case, Tr. 73368-69; see also Brooks, Tr. 22681-82.)

(iv) System/360 Compatibility. The SPREAD Committee recommended the development of a new family of compatible processors by IBM:

> "IBM customers' needs for general-purpose processors can be most profitably met by a single compatible family extending from the smallest stored-program core-memory machine to the machine for customers growing beyond the 7094 and 7030. There are processor needs above and below this range-it is not yet evident that these can be compatible with the new processor family." (DX 1404A, p. 8 (App. A to JX 38).)

The new family was to consist of at least five CPUs--those five to be upward and downward compatible with one another. (DX 1404A, pp. 16, 25 (App. A to JX 38).) According to Evans, this concept of compatibility envisaged by the SPREAD Committee and implemented in System/360 was "just a mile apart from the rest of the world". (Tr. 101141.)

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* These three requirements are satisfiable in 90 to 99 percent of all the programs that normal businesses execute, according to Case. (Tr. 73368-69.)

Prior to the introduction of System/360, it was generally true that the computer lines of a particular manufacturer were not compatible with one another. (Welke, Tr. 19193.) Although both IBM and a number of its competitors had achieved upward compatibility over a "very narrow performance range" covered by two or three machines, no one had achieved the full upward and downward compatibility over the "very substantial" systems performance range of System/360. (Evans, Tr. 101140-41.) Thus, several months after System/360 was announced, Withington wrote that "the degree of upward and downward compatibility that is achieved with System 360 . . . is certainly by far the greatest to date". (PX 4829, pp. 17-18; see also Case, Tr. 73406-10.)

The SPREAD Committee viewed compatibility for an entire family as a "major advance" that would appeal to customers and "sell more processors". (DX 1404A, p. 35 (App. A to JX 38).) From the customer's perspective, the Committee regarded compatibility as a "powerful selling tool" because it would

(1) protect his programming investment;

(2) permit phased growth;

(3) minimize his investment in personnel training;

(4) expand the available labor market of personnel trained to operate in his environment;

(5) simplify the adaptation of his applications to several processors;

(6) permit him to transfer applications among installations;

and thus

(7) provide an incentive for him to convert to System/360 from non-compatible families. (Id., pp. 35-40.)

Such benefits did, in fact, accrue to customers. For example, John Jones, Vice-President, Management Information Services at Southern Railway testified that compatibility was of "very great benefit" to him as a user because

> "it provides me the option of changing or upgrading the capacities and capabilities of my installed network and gives me an alternative which under some circumstances is a very attractive one in that I do not have to do reprogramming if I choose not to do it." (Tr. 80007-08; see also McCollister, Tr. 11068; Friedman, Tr. 50377; Case, Tr. 73427-28; Knaplund, Tr. 90507-08; PX 1215, p. 1.)

Since System/360 was compatible over a far broader range of processor capacities than any previous EDP line, those advantages of compatibility were made available "to a great many users of all sizes"--from the large, multiple-location user who would be able to reduce his training, system development and programming costs to the small first-time user who could plan to grow rapidly without incurring reprogramming costs. (Knaplund, Tr. 90507-08.) Of course, this meant that a "great many users" would be attracted to System/360. As Brooks testified:

> "We believed the compatibility would make it possible to make machines a lot easier to use, that it would serve the customers better, and that it would permit IBM to furnish a better level of customer support. . . . [M]aking a machine more usable makes it more marketable." (Brooks, Tr. 22692; see also Case, Tr. 73427-28.)

Joseph Rooney, who held a position as an IBM Branch Manager and later became the President of RCA's Data Processing Division, testified that there was a "high degree of program compatibility" within System/360, which provided an advantage to IBM in that

> "Their clients could grow from a smaller system to a larger system, or if the economic situations were such that they wanted to go to a lower system, they could do so without having to reinvest in their software. It also was an advantage if you had a multi-faceted organization that had large computers and small computers, and some commonality of applications that they wanted to use on both types of systems. It gave the client the advantage of not having to modify his software to do so". (Rooney, Tr. 12550-51; see also Spangle, Tr. 5026; Beard, Tr. 10325.)

Withington testified that "[t]here is an advantage to a manufacturer in standardizing on a single system set of programs because that minimizes his total cost of development, maintenance and customer support of such systems programs". (Tr. 56612.) In addition to the tremendous competitive advantage* that IBM would derive from offering users a compatible family, the SPREAD Committee recognized that compatibility was "clearly advantageous to [IBM's] development and manufacturing". (DX 1404A, p. 8 (App. A to JX 38).) Commonality in processor logic and programming were anticipated to provide IBM with economies in training of field personnel, development of program-

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* The SPREAD Committee anticipated that this advantage was one that competitors would not be able to overcome during the rest of the decade unless they adopted new approaches to the achievement of compatibility:

> "Competitors appear to be relying heavily on common programming languages to achieve compatibility. The new processor family guarantees to IBM a compatibility level which will not be possible, in the 1965-1970 period for a non-compatible family of processors relying on common programming languages." (DX 1404A, p. 40 (App. A to JX 38).)

As we discuss later in the testimony concerning specific companies (see pp. 383-84, 480-82, 619, 623, 644, 660-61, 696, 705, below), a number of IBM's competitors did just that, albeit several years after IBM.

ming and standardization of installation and maintenance procedures. (DX 1404A, pp. 36-41 (App. A to JX 38); see also PX 1215, p. 2.) System/360 compatibility permitted IBM to realize these and other benefits. Case testified that training of programmers, salesmen and systems engineers was made "considerably easier" because they had to be trained for one group of machines instead of for different incompatible machines. (Tr. 73387-88.) IBM also achieved cost reductions in manufacturing because of the ability to share parts among the various models of System/360 and to provide common training to manufacturing personnel. (Case, Tr. 73388.) Finally, IBM had to develop fewer operating systems than it would have for incompatible processors, and the design of the individual models was facilitated because commonality of design permitted the various engineering groups to communicate effectively and assist in one another's design efforts. (Case, Tr. 73388-89.)

The decision to provide a compatible line over a large performance range was recognized within IBM as a risky one. From a competitive standpoint, the SPREAD Committee anticipated that a single compatible line could be marketed against by competitive salesmen who would be able to develop "knock-offs" applicable to the entire family. It would also provide a more nearly unitary target against which competitors might react more effectively with their own product and price moves. (DX 1404A, p. 40 (App. A to JX 38).) Perhaps most importantly, it would "encourage competition to be compatible with [IBM] in order to tap [IBM's] support efforts". (DX 1404A,

p. 40 (App. A to JX 38).) That latter possibility was one that IBM plainly foresaw throughout the 1960s and one that came to fruition in different ways in the latter half of the 1960s and in the 1970s with the explosive growth of leasing companies and the advent of plug-compatible peripheral and CPU suppliers. (See pp. 750-96, 807-14, 819-26, below.)

The compatibility objective presented risks from a technical standpoint as well. Just as the attempt to combine business, scientific and other applications in the same line raised the possibility that the new system would do none of them as well as a more specialized machine, so too the attempt to achieve compatibility between very fast processors and relatively slower ones raised the possibility that none of them would be truly optimal. Case testified that

> "It was thought prior to System/360 that having one machine architecture for both the fastest and the slowest machines in a product line and, in fact, all places in between, could not be right because either the fast machines would be unnecessarily restricted in the amount of function and capability that they could provide . . . or alternatively, that the slowest and cheapest machines would be far too expensive by virtue of having to provide the richness of the instruction set that was provided by the larger and more expensive machines in the product line." (Tr. 73520.)

According to Evans, the "real challenge" of System/360 from an architectural standpoint was to build a compatible family with a performance range of 1 to 100 from the smallest machine in the family to the largest--it was "something that had never been done before".* (Evans,

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* The 360 announcement letter stated that the processors covered a performance range of 50 to 1. Evans called this a "conservative statement" and stated that the performance range was 100 to 1 at announcement and had since been expanded to nearly 1,000 to 1. (Tr. 101177-78.) Evans testified that IBM successfully met its challenge and that System/360's "performance range, unprecedented in the industry", was a major factor in attracting customers to the 360. (Tr. 101144.)

Tr. 101057-58.) The difficulty of this undertaking was clearly recognized by the SPREAD Committee:

> "It is not evident that downward compatibility can be attained through the whole product range. The group recommends, however, that the design requirement for downward compatibility be stated as a firm ground rule and that development proceed on this basis until the Phase I review. If, at that time, it appears that economically competitive downward compatibility cannot be achieved across the whole processor range, then the range shall be broken into two segments with downward compatibility to be achieved within each segment." (DX 1404A, p. 17 (App. A to JX 38).)

Enfield, President of The Computer Software Company and former IBM Product Administrator for the DOS operating system, testified that downward compatibility was achieved for System/360 through the Model 25. (Tr. 19977; see also Case, Tr. 73520-24.) For IBM to achieve that level of compatibility without incurring unacceptable expense or performance penalties at the low end of the line required a "technological change in the way computer systems were built . . . in IBM". (Case, Tr. 73520.) That technological change was the introduction of microprogramming or "firmware". (Id.)

Microprogramming was invented by M. V. Wilkes of Cambridge University in 1951. (JX 38, p. 5.) Case testified that IBM was the first computer manufacturer to use firmware in the building of computers. (Tr. 73222.)* Its use required the application by IBM of "new technical components" (such as transformer and capacitor read-only storage) and a new design "discipline". (Case, Tr. 73521.)

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* That use began with the experimental SCAMP built at Hursley in 1960 (JX 38, p. 5) and continued with System/360. IBM continued its innovations in "firmware" later in the decade with the invention of the floppy disk. (Case, Tr. 73223.)

Through the use of firmware (rather than hardware or software) IBM was able to achieve a number of the design trade-offs which System/360 required.* It was the "technical device . . . most responsible" for the fact that IBM System/360 computers were able to be designed efficiently for both business and scientific applications (Case, Tr. 73225; see also Evans, Tr. 101142-43), as well as the method by which IBM was able to achieve full upward and downward compatibility.**

Some measure of the success that IBM achieved in implementing the architectural objectives laid down for System/360 may be gleaned from the longevity of that architecture. Compatibility and applicability to a wide range of applications were characteristics (assuming that they were effectively implemented) that would undoubtedly be desirable in future systems. Accordingly, Case testified:

> "We tried to develop the computer architecture which would be extendable, which would be useful not only for the machines that were going to be announced in 1964, but also for subsequent machines as far into the future as we could plan for. . . . We were thinking in terms of 15-20 years . . . and we would like to have had that last even longer if that were possible." (Tr. 73347.)≠

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* The need for such trade-offs was understood by the SPREAD Committee, which imposed as an "engineering ground rule" the use of microprogramming controls unless "conventional" control systems could provide a cost/performance improvement of better than one-third. (DX 1404A, p. 20 (App. A to JX 38).) Microprogramming was used in the System/360 processor models 2020, 2030, 2040, 2050, 2065, 2067 and 2085. It was not used in the 2044, 2075, 2091, 2095 and 2195. (JX 38, ¶ 8, pp. 5, 6.)

** As we explain later, it was also the means by which System/360 enabled users to run programs written for earlier IBM computer systems.

≠ To lengthen the life of the 360 architecture, the 360 design group chose a memory addressing structure that provided for the eventual

The architecture of System/360 lasted through the 370 into the 303X and 43XX lines and continues to the present time. (Evans, Tr. 101133; see also H. Brown, Tr. 82972; PX 4505, p. 1; PX 4531, p. 1; DX 860, p. A; DX 9405, pp. 552, 1013.)

(v) Emulation. Withington called IBM's introduction of the System/360 "a substantial risk" for two main reasons:

> "One, IBM adopted a new machine architecture and a dependence on systems programs to cause the machine to be usable to the users. This was a large step in terms of the evolution of machine architecture and design, and it was not immediately certain either whether it would work well or whether the users would accept it.
>
> "The second primary area of risk was the lack of compatibility between the 360s as announced and the predecessor IBM machines.
>
> "It was immediately obvious that the willingness of the customers to reprogram from the older machines to the 360s was a major question relating to its probable degree of success." (Tr. 56592-93.)

The disadvantage of offering a new incompatible line was clearly recognized by the SPREAD Committee. It was, however, a disadvantage that had to be overcome rather than avoided if the Committee's concept for the new line was to be instituted. As the

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attachment of 16 million bytes of main memory without modification and about 2 billion bytes with only a "small" modification. That eliminated one of the "major reasons" that previous architectures had been short-lived: the limitation on the amount of main memory that could be effectively used with those architectures. (Case, Tr. 73347-49.) The 8-bit byte was another factor which gave System/360 architecture greater longevity than previous systems. It permitted the use of 360 in applications that required character sets which made those applications difficult to achieve on the 6-bit byte and 7-bit byte computers which preceded System/360. (Case, Tr. 73349-50.)

SPREAD Report noted, "Since [the new] processors must have capabilities not now present in any IBM processor product, the new family of products will <u>not</u> be compatible with our existing processors." (DX 1404A, p. 12 (App. A to JX 38), emphasis in original.)

The SPREAD Committee anticipated that the new capabilities provided by System/360 would induce many users to switch to System/360 despite the need to convert their programming. Indeed, for many of these users, the very fact that they wanted to implement new functions rendered the entire question of conversion moot:

> ". . . While incompatibilities are a marketing disadvantage, it should be noted that systems reprogramming will, in many cases, be required, independent of the processor used. This will occur whenever the user wishes to obtain the benefits of any of the following:
>
> "a. Random access rather than batch processing
>
> "b. The integration of communication facilities
>
> "c. The simultaneous operation of multiple processors
>
> "d. Multiprogramming to achieve efficient on-line operation."
>
> (*Id.*, p. 12; see also Currie, Tr. 15184-85; Withington, Tr. 57683-84.)

In "many cases", therefore, the reprogramming effort involved in switching to System/360 would be no more than a "natural outgrowth" of the systems improvements that the user wished to achieve--improvements that would require a new programming effort whether or not that user switched to an incompatible processor. (DX 1404A, p. 12 (App. A to JX 38).) However, the Committee also recognized that "[s]ome customers [would] be dissatisfied unless an alternative [was] provided to permit utilization of [their] prior machine investment". (*Id.*,

p. 39.) IBM provided customers with that alternative in the form of emulators.*

Other manufacturers of computer systems also recognized the desirability of facilitating conversion and provided users a number of aids, such as simulators** and translators,† to ease the transition between incompatible systems.†† As late as August 1963, IBM was still working on software simulation as a means of providing System/360 compatibility with prior systems. However, work on providing conversion through emulation had commenced within IBM prior to that time. (Hughes, Tr. 34047-48.) On August 1, 1963, D. H. Furth, Corporate Director of Programming, sent a memorandum to Evans expressing the view that it was "feasible" to use read only memory control (microprogramming) to achieve compatibility. He wrote:

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* An emulator is a combination of hardware and software that permits one computer system to execute programs written for another system. (JX 1, p. 45.)

** A simulator performs the same function as an emulator, but is implemented entirely in software. (Goetz, Tr. 17654.)

† A translator is a computer program that takes as input the source programs of a particular computer and translates them as closely as possible to an equal program in the same or a different language that would run on the equipment to which conversion is desired. (King, Tr. 14769-70.)

†† GE offered a 1401 simulator which permitted programs written for a 1401 to be run on its 400 line and a 7090 simulator which permitted programs written for the 7090 or 7094 to be run on GE's 600 line. (Weil, Tr. 7029-32.) RCA developed a simulator that allowed programs written for IBM's 650 computer to run unchanged on the RCA 301. (DX 561, p. 13.) Honeywell offered a LIBERATOR program which translated IBM 1400 Series programs into programs usable on the Honeywell 200. (R. Bloch, Tr. 7578, 7588-89, 7605-06, 7886-89; Goetz, Tr. 17652-54, 18822-23; Enfield, Tr. 20052-54; DX 6661, p. 6.)

"Since such a hardware simulation would appear to be very economical from the customer's point of view and since it would eliminate some half dozen simulators from an already mountainous Programming Systems load, it would appear reasonable to pursue the realization of this feasibility as part of the overall NPL program." (DX 2872.)

By October that recommendation had been accepted, and Brooks wrote that "We are hopeful that microprogrammed simulation can add substantially to the bag of tools for aiding conversion". (DX 2900.)

During 1964, IBM announced microprogram-based compatibility features on System/360 for the 1401, 1410, 1440, 1460, 1620, 709, 7010, 7040, 7044, 7070, 7074, 7080, 7090, 7094, and 7094 II processors.* (JX 38, pp. 30, 289, 292, 334, 526; DX 14305.) Withington testified that System/360 was "the first major use of microprogramming for purposes of establishing backward compatibility."** (Tr. 56606.) He also testified that

"implementation of emulation using control store and microprograms, while it is more expensive [than software emulation], is regarded by users as preferable in most cases because it is so much faster". (Tr. 56371-72; see also DX 2900.)

The provision of emulators on System/360 afforded users a hardware alternative to conversion. (PX 449, p. 9.) It permitted them to transfer jobs to System/360 and to concentrate on new application areas without immediately having to convert their existing applications.

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* Case estimated IBM's cost of developing the 1401 compatibility feature on the Model 30 as $200 thousand and the cost of developing the 7090 emulator on the Model 65 as one-half million dollars. (Tr. 74557-62.)

** Withington defined "backward compatibility" as "the use of emulation . . . for the purpose of allowing programs written for a manufacturer's prior computers with different instruction sets to be executed on the newer computers". (Tr. 56606.)

(JX 38, p. 30.)

Although programs run in emulation generally ran slower than they would have if rewritten to run in native mode on the new systems,* they could be run effectively enough to permit users to forego reprogramming if they chose to do so. (Beard, Tr. 9057-58, 9956-57, 10029-30, 10318-19; see also R. Bloch, Tr. 7608-09, 7614-15, 7881-82; McCollister, Tr. 11287-89; Rooney, Tr. 11853, 12395-96.) Goetz testified that emulators were generally considered an "effective means of running programs from one computer system on another". (Tr. 17655, 18778.)

Because 360 was incompatible with IBM's second generation equipment the conversion from IBM's second generation equipment to 360 involved as large a task for users as would converting to another vendor's systems. (Beard, Tr. 9058-59, 9953-60, 10324-25; McCollister, Tr. 11069; Goetz, Tr. 18935-36; Enfield, Tr. 20020-21.) Indeed, in some instances conversion to non-IBM equipment would have been easier than conversion to 360. Weil testified that GE was initially "overjoyed" with the announcement of System/360 because GE had introduced a system "designed to displace" IBM's 7090s and 7094s and believed that "it would be easier . . . to convert from the 7090/7094 to the 600 series" than to 360. (Tr. 7060-61.)

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* Of course, such programs might very well run faster in emulation mode than they had in native mode on the equipment for which they were written. For example, Enfield testified that a 360/30 operating in emulation mode could execute 1401 programs 3 to 3 1/2 times faster than a 1401. (Tr. 20263.)

Jones testified that Southern Railway ran benchmarks which showed that conversion from an IBM 7000 Series system to an IBM 360 was "about equal in difficulty" to conversion to an RCA or Burroughs machine, but not as easy as conversion to a Univac 1108. (Tr. 79042-43; see also Hart, Tr. 81936.)

Nevertheless, IBM was successful in getting users to convert to System/360 from IBM second generation systems. (Withington, Tr. 57680-81.)* One reason for that success was, undoubtedly, the benefits that users were able to derive from System/360's improved price/performance and new capabilities. As Withington agreed,

> "if [users] perceive it to be in their economic interest, [they] will absorb the cost of conversion for the future benefit that they expect to receive from [a] newly acquired computer system". (Tr. 57677; see also Hart, Tr. 80222-24.)

Hart, head of the Computer Science Department of the General Motors Research Laboratories, testified that his department went from a 701 to a 704 to a 7090/94 to a System/360. (Tr. 81938-39.) Several years after these changes, Hart wrote "conversion costs must be taken into account when changing computers; however, in retrospect, the value of each of the above changes far exceeded the costs incurred". (DX 3753 (Tr. 80193).) He explained that improvements in sheer computer speed, reduced computation costs, and the availability of "new kinds of capabilities" were all reasons for changing computer systems. To

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* It should be noted that IBM's success in getting users to convert was not unique. According to Withington, between 1964 and 1970, some 90% of second generation equipment users converted to a non-compatible computer system of either the same or a different manufacturer. (Tr. 57677-83.)

decide whether conversion is justified, "you take into account the costs of making the change, the benefits which are going to result from the change, [and] determine whether the benefits exceed the costs." (Tr. 80222-24.)

A similar cost/benefit analysis was performed by NASA, circa 1965. NASA had just made a "large purchase" of second generation machines to lower its operating costs, when a "new series of equipments"* became available with multiprogramming capabilities, I/O flexibility, memory sizes, program logic and the ability to use remote I/O devices that made it

> "possible to effect a consolidation of [NASA's] ADP resources . . . into a powerful central complex without compromising availability, quality or power available to any user. At the same time the cost per computation of these newer machines was considerably lower than their old second generation equivalents". (DX 5440, pp. 2-3.)

NASA decided to convert "at the earliest possible time". (Id.)

NASA's analysis of the conversion difficulties was:

> "This conversion has created a considerable workload and has resulted in overlapping of older and newer equipments with its attendant increased rental costs during the conversion period." (DX 5440, p. 9.)

It concluded, however,

> "The benefits from the more complex software and the flexibility of the new machines far outweigh any conversion cost we may incur." (Id.)

Despite the powerful incentives that users had to incorporate System/360's new capabilities, it seems clear that 360 would

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* The new equipments included IBM 360s, Univac, CDC and GE computers. (DX 5440, p. 5.)

have been far less successful without emulators. Xerox's Competitive Reference manual noted the success of IBM's emulation approach to converting second generation users to 360 (PX 449, p. 9), and McCollister testified that it was a "very widespread practice" in the late 1960s for IBM users to choose the option of emulation on 360. (Tr. 11287-88.) An IBM Corporate Programming Study based on a November 1967 customer survey estimated that "more than half of the systems hours now being used by our Models 30, 40, 50 and 65 are being used in emulator mode". (PX 2161, p. 3.)

(vi) System/360 Software. Prior to the advent of operating systems, each programmer had to write instructions that would schedule his tasks and control the various equipments he required for his particular jobs. As computer systems became faster and more complex, it became increasingly important to manage efficiently the resources they provided. Operating system software relieved programmers of the need to incorporate scheduling instructions in each program they wrote and, in effect, turned over the job of scheduling to the computer itself. According to Dr. Perlis, operating systems enabled users to "take advantage" of a computer's total processing power, including its multiprogramming and multiprocessing capabilities.(Tr. 1848-49; see also Welke, Tr. 17113; Goetz, Tr. 17476-77; Enfield, Tr. 20737-38; Case, Tr. 73443.)

Given the complex "new market demands" and modes of use at which System/360 was being aimed--i.e., "multi-terminal, on-line, real-time, multiprogramming operation" (DX 1404A, pp. 7, 8, 9, 54 (App. A to JX 38))--it was imperative that IBM automate as much as possible the system's resource management task. IBM embarked on the creation of a set of operating systems of varying complexity.* The most complex of these, OS/360, was particularly ambitious.

OS/360 was designed to let customers "make the maximum possible use of the relatively greater speed of the . . . System/360 central processing units". (Case, Tr. 73438.) Since multiprogramming was anticipated to be a "normal" mode of use, facilities (such as an interruption mechanism) were to be included to make multiprogramming "easier, straight forward and efficient". (Case, Tr. 73438-39.) In addition, OS/360 was to contain facilities that would permit programmers to develop applications more efficiently, optimize the utilization of peripherals and simplify maintenance. (Case, Tr. 73438-41.)

Within IBM, it was recognized that "no one [had] ever undertaken a programming task of [OS/360's] magnitude". (PX 1092, p. 4; PX 1900, p. 8.) Dr. Perlis called OS/360 a "really major effort", one which "generalized every aspect of operating systems known at the time and tried to in a sense build a system that would be all things to all men". (Tr. 1887.) Mr. Welke, President of International Computer Programs, called OS/360 "a major programming effort" which ranked "along with . . . the great undertakings of mankind". (Tr. 17313; see also Rooney, Tr. 12576.)

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* To account for the varying degrees of speed and complexity of operation that users might desire, IBM provided with 360 a "spectrum of operating systems . . . each of which offered a different memory/ function trade off for the customer". (Brooks, Tr. 22759.)

So ambitious an undertaking entailed significant risk, and as we shall see, OS/360 was quite costly and difficult to perfect. Apart from the difficulty of constructing the operating system at all, there was the additional risk that users would reject the multiprogramming environment--an environment that was most often not used in earlier generation systems. (Case, Tr. 73526.) That would mean that IBM's investment in the hardware and software needed to permit multiprogramming would be reflected in System/360's prices and would have accomplished little more than to make the systems less competitive. In addition, OS/360's "extensive" resource management, data management, languages, aids to program development and error recovery techniques did not come "without a price". (Case, Tr. 73527-29.) The use of those capabilities would take up auxiliary storage space, main memory space and time on the CPU--an "operating system overhead". (Case, Tr. 73529.) There was a significant risk that users would be unwilling to accept such "overhead" for the richness of function provided by OS/360. (Case, Tr. 73528-30.)

OS/360 did, in fact, run into "difficulties in design, in correctness [and] in completion".* (Perlis, Tr. 1887.) However, "when the system finally worked it had properties that were beyond about any other operating system around". (Id.; see also Palevsky, Tr. 3180; Rooney, Tr. 12576; Currie, Tr. 15186; Welke, Tr. 17308-12.) It must be remembered that OS/360 was only one of five general program-

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* Many other computer systems suppliers experienced similar difficulties in designing complex operating systems during the 1960s. (See discussion below, pp. 364-66, 479, 502, 568-72.)

ming packages that IBM announced in 1964 for use with System/360. (Brooks, Tr. 22759; McCarter, Tr. 88388; JX 38, ¶ 9, p. 6.) The others--Basic Programming Support (BPS), Basic Operating System (BOS), Disk Operating System (DOS) and Tape Operating System (TOS) were less complex sets of systems software. These operating systems "worked reasonably well from the start" and were well accepted by customers. (Withington, Tr. 58596-600; Enfield, Tr. 20947-52, 21120; Brooks, Tr. 22853-54, 22862-63; McCarter, Tr. 88388; DX 1410; PX 6217, pp. 3-4.) DOS in particular, which was less complex than OS/360 but still 25 to 50 times as complex as the systems software provided with the 1401, was highly rated by users and widely used. (Enfield, Tr. 20299-300, 20741-42, 20088-89, 20943-48.) Case testified that "if it had not been for the operating systems for System/360 . . . the value of that equipment to users would have been considerably less than it was and . . . the orders and acceptance for that equipment would have been a lot less than they otherwise were". (Tr. 73443-44.)

(vii) <u>System/360 Peripherals.</u> Case testified that one of the design objectives for System/360 was to provide "a wide variety of peripheral equipment that could be combined in a very wide range of configurations". (Tr. 73416.) Prior to announcement, the "breadth" of 360's peripherals were viewed within IBM as a prime motivation for users to re-systemize their applications and convert to 360. Thus, in January 1964, Brooks wrote:

> "Even though present applications can be simply mapped onto System/360, many new system concepts will offer substantial incentive for the customer to re-plan his application. These include file orientation, communication facilities, large memories, bulk stores, etc." (DX 1172, p. 1.)

The April 7, 1964, 360 announcement contained "many features different from those previously offered by IBM". Included in the announcement were "direct access storage devices (including the 2311 disk drive, the 2321 data cell and the 2301 drum storage device); control units, high performance tape drives (including the 2400 series and the 7340 Hypertape drive Model 3); visual display units (including the 2250); 7770/7772 audio response units; communication and data acquisition equipment (including the 1070 process communication system); and a printer, the 1403-N1". (JX 38, ¶ 6, p. 4.) IBM also announced numerous additional peripheral devices for use with System/360 subsequent to the April 7 announcement--including the 2314 disk drive, new terminals, additional models of the 2400 tape drive, the 2420 tape drives and optical character recognition equipment. (Id.)

The 360 announcement letters describe some of these peripherals as follows:

1015 Inquiry Display Terminal: "Used to interrogate and receive visually displayed replies from a System/360, mdl 30, 40 or 50." (JX 38, p. 43.)

1070 Process Communication System: "A Tele-processing System designed for two-way data communication between remote process locations and a central data processing area." Applications include "control of oil fields, petroleum and natural gas pipelines, utility distribution systems; data collection in refineries, chemical plants, steel mills, and manufacturing processes . . . . The 1070 forms a complete tele-processing system when attached to . . . System/360, via a 2701

Data Adapter or 2702 Transmission Control". (Id., p. 39.)

1403 Model N1 Printer (originally announced as 2201 Mod. 3): "[p]rinted output for a System/360, model 30, 40 and 50. . . . maximum speed, 1,100 lpm". (Id., pp. 84, 198.)

1418 Optical Character Reader: "Optically reads data from printer card or paper documents. . . ." (Id., p. 70.)

1419 Magnetic Character Reader: "Reads magnetically inscribed data from card and paper documents. . . . Documents read at maximum rate of 1600 documents a minute." (Id., p. 71.)

2250 Display Unit: "A cathode ray tube unit for displaying output in alphameric and graphic form for System/360. . . . An input/output unit which offers increased speed and flexibility for file inquiry, inventory control and dynamic monitoring of computer operations and continuous process control." (Id., p. 85.)

2301 Drum Storage: "High performance random access storage for a System/360, mdl 50, 60, 62 or 70. . . . [D]esigned for applications such as main memory extension, programming system residence and table or index storage." (JX 38, p. 86.)

2311 Disk Storage Drive: "For fast, flexible access . . . 85 millisecond average access speed . . . 156 KC/312 KD data rate . . . 7.25 million character or 14.5 million digit capacity". (Id., p. 31.)

2701 Data Adapter Unit: "For attachment of remote and local input/output devices operating via various customer or common carrier facilities to a System/360. . . . Accommodates a variety of data communication and data acquisition operations. . . . Specific adapters enable the 2701 to communicate . . . with the following terminals:

"1060 Data Communication System . . . .

"1050 Data Communications System . . . .

"1033 Printer . . . .

"1031 Input Station . . . .

"1070 Process Communication System . . . .

"1053 Printer . . . .

"AT&T 83B2 Selective Calling Terminals . . . .

"Western Union Plan 115A Outstations . . . .

"Common Carrier TWX Stations . . . .

"1009 Data Transmission Units, 1013 Card Transmission Terminals, 7702 Magnetic Tape Transmission Terminals or 7740 Communication Control Systems . . . .

"7701 Magnetic Tape Transmission Terminals or 7750 Programmed Transmission Control Units . . . .

"7710 Data Communication Units, 7711 Data Communication Units, or another System/360. . . ." (Id., p. 90.)

2702 Transmission Control: "For on-line attachment of various asynchronous input/output devices via private or commercial common carrier transmission facilities to a System/360. . . . [A] modular unit with a variety of features to meet a customer's data communication needs with a System/360". (Id., p. 93.)

Multiplexor Channel: "[P]ermits simultaneous operation of I/O units on time-sharing principle . . . primarily designed to handle multiple terminals and low speed I/O units." (Id., p. 31.)

The combination of those and other peripheral product announcements and the announcement of six central processing units with a wide range of memory options was "unprecedented in the industry". (Evans, Tr. 101134; JX 38, pp. 14-25; see also PX 4829, pp. 16-18.)* This range of peripherals was important to customers when considering System/360 against competitive systems because it greatly expanded their ability to change or add to their systems as their requirements changed and "played a large part" in customer decisions to go to 360.** (Evans, Tr. 101134; see also PX 4829, p. 18; Withington, Tr. 56770-71.)

The broad range of peripherals announced with 360 promoted two of the SPREAD Committee's primary objectives--the creation of a single system able to perform all applications and one that would address increasingly important new applications (i.e., multi-terminal, on-line, real time applications). The announcement of new disk drives, tape drives, communication controllers, card and printer I/O, ter-

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* "[T]here has never been a time when any of the general purpose competitors to IBM have offered more variations on peripheral equipment, the total breadth of applications and systems program functions and the total number of alternative processors" being offered by IBM. (Withington, Tr. 56770.)

** We do not mean to imply here that all of the peripherals announced with 360 were successful. A number were soundly rejected by users. For example, the 2321 data cell was a "major product failure" which failed to achieve success because of unreliability; IBM had to supersede the 1015 terminal with the improved 2260 because the 1015 was simply not competitive; and Hypertape turned out to be a "failure" even though it was judged within IBM to be technically superior to competitive offerings. (Case, Tr. 74205-06, 72787-88; Withington, Tr. 58534, 56475-76; JX 38, pp. 346-47; PX 6671, pp. 15, 26; PX 2990, p. R3; DX 13949.) As we discuss below, IBM acted quickly to shore up areas in the product line which were not judged to be superior to competitive offerings. (See below, pp. 390-95.)

minals, audio response equipment, magnetic and optical character readers and paper tape and process control units meant that users could build configurations specifically tailored to their application requirements--whatever those requirements. Dr. Gibson testified that one of the features of 360 that permitted it to be used for both scientific and business applications and "erase the previous distinction" was "the very wide range of input/output equipment easily attachable through a common interface, . . . [which] made it relatively simple to configure a commercial system . . . or one optimized for scientific computing". (Tr. 2948-49; see also JX 38, p. 28; PX 3638, p. 1; PX 4829, p. 18.)

In addition, the variety of remote I/O and communications equipment offered with System/360 underscored 360's emphasis on new applications. Weil of GE wrote that System/360 "has major strength in a variety of new mass storage devices and a whole new array of remote terminal equipment . . . . It has many of the features which will make possible its application in direct access systems." (PX 320, p. 13.) Displays, remote data collection equipment, remote process control equipment, communications controllers, data communications equipment and on-line banking equipment were all made available to permit users to bring the power of 360 to bear at the point of transaction--in real time. The ability of a System/360 to communicate with other computers or terminals "opened up a whole new gamut of applications in industries, airline reservations industries, modern business, so that remote stations could have access to the enormous data in a central computer and do so in real time". (Evans, Tr. 101136.) The ability to do such applications resulted in sales of systems that otherwise would not have been sold. (Evans, Tr. 101135.)

The importance of System/360's peripherals to the success of the product line cannot be overestimated. As Mr. Norris of CDC testified, the speed, performance and price of peripherals are "important considerations in determining to acquire one system or another". (Tr. 6019-20; see Withington, Tr. 56239, 56246-47.) Thus, even a single peripheral device--such as a disk drive, terminal or printer--which is sufficiently better than competitive offerings can swing the total system decision. (Id.; Currie, Tr. 15495-96; Rooney, Tr. 12048-49; DX 13949.) In this respect, of all the peripherals offered with System/360, the 1403 N1 printer and the 2311 and 2314 disk drives were most critical to 360's success.

1403 N1 Printer. We discussed earlier the importance of the 1403 printer to the success of IBM's 1401 computer system, and how that printer gave IBM a "tremendous advantage" in the marketing of systems until competitors began to offer "satisfactory alternatives" by 1963 or 1964. (See above, p. 143.) In 1964, IBM announced the 1403 N1 Printer for use with System/360. The 1403 N1 ran at almost twice the speed of its predecessor (1100 lines per minute compared to 600 for the 1403) and cost only about 15% more than the 1403. (Evans, Tr. 101137; DX 3617; see also Enfield, Tr. 20266; JX 38, p. 207; DX 573, pp. 4, 6.) At the time of its introduction IBM's competitors did not offer a printer that matched the 1403 N1 in print quality, price and speed. (Evans, Tr. 101137; see also Case, Tr. 72881.) IBM's competitors recognized and acknowledged the excellence of IBM's printers. Beard (former Chief Engineer of RCA's Computer System Division) testified that RCA began offering the 1403 with its Spectra Series because there were applications for which customers desired print quality "of a very high standard". Such customers "insisted" on "1403 chain printer type quality" and "after resisting these requests some period of time" RCA acquiesced and "put the 1403 into the RCA computer line". (Tr. 10322-23.)

The 1403 N1 was particularly important to System/360's ability to perform certain business applications. For a customer with applications such as payroll, billing, accounts receivable and inventory control, the ability of a computer system to do his work is determined "in large measure" by the speed, quality and reliability of the printer. (Evans, Tr. 101137; see also Currie, Tr. 14971-72; Withington, Tr. 56253.)

Currie testified that XDS was at a "disadvantage" to IBM with respect to its line printer for customers that wanted to do "any significant amount of business data processing". (Tr. 15459.) As late as 1969, XDS was only "marginally competitive" in peripherals and its line printers "were not acceptable to some of our users". Those printers lacked the range of "speed/performance" that some customers wanted and did not produce as high a quality print as a chain printer or a train printer. (Currie, Tr. 15006-08.)

CDC also experienced "substantial problems" in marketing some of its computer systems because they incorporated printers that "lacked sufficient reliability to meet normal customer expectations" and had "a poor print quality, in terms of wavy print". To help solve these problems CDC acquired the Printer Division of Holly Carburetor in 1966. (G. Brown, Tr. 51528-29.) CDC ultimately developed a "1403N-1 type" printer of its own, but it had to be "reworked and re-developed" in the 1969-70 time frame in order to effect reliability improvements. The changes resulted in a design that was "more like the original IBM design". (G. Brown, Tr. 51541-46.)

While CDC attempted to copy the 1403 N1 design and RCA simply incorporated it into RCA's product line, Grumman Data Systems took advantage of the 1403 N1's superiority by offering to attach it to a number of non-IBM computer systems. As late as 1975, an advertisement for Grumman Data systems stated:

> "For years people have been trying to imitate the IBM 1403. Unsuccessfully. Now, with the Grumman Printer Controller you can connect your present computer to an IBM 1403 and give yourself the best printing in the business.
>
> "The IBM 1403 has built an extraordinary record. Highly reliable, high speed operation. Unusually consistent, clearly readable printouts. (No wavy lines so typical of drum printers.) Type fonts your operator can readily interchange. And, of course, it handles form changes easily.
>
> "With the Grumman Printer Controller you can improve your printing quality, speed, and reliability. All at an attractive, and perhaps, money-saving price. Speaking of price, you can buy our controller or rent it. We provide maintenance of course.
>
> "With our printer controller you can connect the IBM 1403 to your present DEC, Xerox, GE, or CDC computer. We'd like to hear from Burroughs, Univac and the other computer users, too." (DX 94B.)

Grumman later offered the 1403 N1 for attachment to Burroughs, Data

General, Digital Scientific and Univac computers. (DX 2782A; DX 7984.) The 1403 N1 was also offered with Computer Machinery Corporation computers. (DX 11665.)

Gordon Brown testified that the quality and reliability of a printer is "an extremely important criterion in the selection of a computer system". (Tr. 51528-29.) The 1403 N1 was a real boon to the acceptance of 360.

<u>System/360 Disk Drives.</u> As we discussed earlier, IBM's superiority in direct access storage technology during the 1950s and early 1960s contributed greatly to the success of IBM's first and second generation systems. (See above, pp. 91-95, 149-53.) IBM maintained that superiority with the disk drives introduced for use with System/360. Both the 2311 and 2314 were substantial improvements over IBM's earlier disk drives and both proved critically important to the success of System/360. These disk drives were more than just superior to competitive offerings, they were unique in the industry: there simply were no similar competitive offerings for several years after their introduction. Thus, they gave IBM a competitive advantage in the marketing of 360 systems that competitors were unable to match until the late 1960s, and even then, competitors were able to do so only by adopting, in one way or another, IBM's disk technology.

IBM announced the Model 2311 disk drive on April 7, 1964. The 2311 had approximately twice the access speed, twice the data rate and two and one-half times the storage capacity of the 1311. (Case, Tr. 72741-42; JX 38, p. 86; PX 4252, p. 1; DX 3554D; see also

Enfield, Tr. 20264-65; Haughton, Tr. 94998.)

IBM announced the 2314 disk drive on April 22, 1965. The 2314 had a faster access speed, double the data rate and almost four times the storage capacity per spindle of the 2311. (Case, Tr. 72742-43; JX 38, pp. 86, 439; DX 3554D; see also Haughton, Tr. 94998.)

Beard testified that the 2311 represented a "technological advance" over prior random access storage methods. "It provided not only . . . fast access time but it provided . . . for the first time, the degree of reliability that was required of random access devices . . . . [I]t was really the first very reliable disk file that . . . was offered by anyone". (Tr. 9048-49.) Beard also called the 2314 an "advance over prior random access devices", adding that his comments on the 2311 applied "perhaps more importantly" to the 2314 because the 2314 offered greater storage capacity and a more "practical cost" for random access storage than did the 2311. McCollister testified that the 2314 was "[v]ery definitely" an advance over prior disk drives because, for example, "it had a capacity in a pack of approximately 28 million bytes as compared with 7 1/4 million bytes in an earlier model". (Tr. 9597.) Withington agreed that both the 2311 and 2314 were unmatched by comparable competitive products during the initial years in which they were marketed. (Tr. 58800, 56240-41.)

IBM foresaw and depended upon the widespread acceptance of disk drives as a key factor in the ultimate success of System/360. IBM Vice President Knaplund testified:

> "An important element of the System 360 forecast was the anticipation that disk files would be used extensively, both in applica-

tions that had historically utilized magnetic tape or punched card storage and in the development of new communications oriented--or 'teleprocessing'--applications." (Tr. 90506.)

However, the demand for the 2314 disk drive "turned out to be very surprising in the rate that customers found use for it". (Case, Tr. 72743.) IBM "totally underestimated the demand for such devices" and "we [in IBM] found ourselves hard pressed to deliver the devices as fast as customers were demanding them". (Id.) It is important to note that the use of disk drives was not common on second generation computing systems. According to Case, fewer than twenty percent of computer systems prior to 1964 used direct access storage devices. (Tr. 73527.) Nevertheless, IBM "gambled" that System/360 would be widely used in "operational-type" applications (as opposed to batch-type applications) and that disks would play a "pivotal role" in such applications. (Evans, Tr. 101139.) System/360's more advanced operating systems were designed in a way that required a direct access storage device for their successful operation. The higher performance and greater function necessary to achieve such operation could not have been provided with magnetic tapes and the use of drums would simply have made the cost of storage too expensive. (Case, Tr. 73451-53.) IBM was therefore betting that users would be willing to trade-off the expense of disk drives for the increased efficiency of operation and the additional function that a disk-based system would be able to provide*--that users would accept widely an approach to

* The "significance" of the disk drive was that it provided a functional capability of having information on-line and readily available. (Rooney, Tr. 12142.) The random access capability of

computing that had not been widely accepted before.

In hindsight, that bet was a good one. As Case testified, today "nobody thinks of developing a wide range of computing equipment or a family of computer systems without having a direct access storage device as a prerequisite for the operating systems". (Case, Tr. 73452-53.) Back in 1964, however, nobody but IBM had that thought or acted upon it as forcefully.* As a consequence, the tremendous acceptance of IBM's disk drives swept before it all of the other approaches to random access storage then being offered:

> "During that period the entire industry and the users began to appreciate the importance that disk drives were going to play in the great majority of general purpose computer systems. Before that time, alternatives were being experimented with, such as particularly magnetic card devices, and also I think no one realized the degree to which the transaction processing mode of use was going to prove popular. I believe only IBM among the major competitors at the time offered an alternative between magnetic card devices and disk drives, with developments proceeding along both lines. A number of the other manufacturers committed themselves almost entirely to the magnetic card devices, sometimes also using magnetic drums.
>
> "When it became apparent that the class of magnetic card devices was not going to be successful in the marketplace, for reasons of reliability, and that the disk drive was a critical product, many of IBM's competitors were left for a while without a satisfactory option." (Withington, Tr. 56240-41.)

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disks "permitted a new and more effective approach to doing customers' work", particularly in real-time applications such as those performed by banks and airlines. (McCollister, Tr. 9591.) System/360's emphasis on disk drives made possible more efficient use of CPU, main memory and peripherals; increased the range of functions and services that could be provided by the operating system; and made possible a "more valuable" mode of operation (random processing of transactions) than the sequential access mode of processing that was common prior to the emphasis on disk drives. (Case, Tr. 73468-70.)

* As we discuss below NCR, Burroughs, Sperry Rand, Honeywell and RCA all offered different approaches to random access storage, and all of those approaches failed in the face of the tremendous user acceptance of disk drives. (See below, pp. 94, 383, 473-74, 549-50, 659.)

Both the level of performance and the attractiveness of System/360 were substantially dependent on the 2311 and 2314 disk drives. (McCollister, Tr. 9370, 9591-92; Rooney Tr. 12122; Knaplund, Tr. 90506-07; Evans, Tr. 101138.) The 2311 was "far more" important to the marketing of System/360 than the 1311 had been for IBM's earlier systems, because the 2311 "offered an improved price/performance . . . was supported to a greater degree by systems programs . . . and, therefore, was easier to use, and . . . was more reliable". (Withington, Tr. 56246-49.) And the 2314 was, if anything, even more important. It provided "a functional capability very much needed in terms of price/performance in the competitive marketplace and without that capability you were in a weak competitive situation against IBM". (Rooney, Tr. 12193.) Within IBM the 2314 was recognized as a "catalyst to make many systems sales for previously undeveloped application use of computers" and as a "door opener that beats competition". (PX 1967, pp. 1, 3, see Page, Tr. 33122.) According to Case, IBM's emphasis on the use of disk drives with System/360 contributed to the objective of growing the market for IBM products in particular and computer system products in general. (Tr. 73468-70.)

Not surprisingly, other systems suppliers wanted the kind of "catalyst" for systems sales that IBM already had. Eventually, they either acquired them from OEMs or from IBM itself or they undertook to manufacture them themselves. As we discuss below, the acceptance of 360 spurred the growth of peripheral equipment manufacturers, some of whom supplied IBM 2311 and 2314 type disk drives directly to IBM end users. During the latter part of the 1960s, however, these manufacturers served as a prime source of disk drives for many systems suppliers. (See pp. 753-59, below.)

Memorex was the first of the PCMs to offer IBM plug-compatible disk drives, in 1968. (See p. 770, below.) During the years 1967-70, Memorex hired almost 600 former IBM employees, three of whom became Memorex Vice-Presidents. (JX 34, pp. 1-2.) In 1967, Memorex hired a number of disk drive engineers from IBM, including Roy Applequist, who had designed IBM's voice coil actuator. (Guzy, Tr. 32858-64; Gardner, Tr. 38585, 39143.) Applequist designed the voice coil actuator for Memorex's 630 disk drive, which, according to an independent engineering assessment, was "directly derived" from IBM's 2314B (3330) and "not the result of coincidence". (Gardner, Tr. 39143; DX 1418, p. 151; see also Spitters, Tr. 55259-61; DX 2572.) D. J. Guzy, former Executive Vice President of Memorex, testified that the hiring of Applequist and other IBM engineers was important to the success that Memorex achieved with the 630; and that the 630 and 660* were styled and intended to be, respectively, 2311-type and 2314-type disk drives. (Tr. 32316, 32776, 32899.) Memorex marketed the 630 and 660 not only directly to IBM end users, but also to a number of different systems manufacturers, including RCA, Univac, DEC, Burroughs, Honeywell, SEL, Hewlett-Packard, Siemens, Phillips and ICL. (Guzy, Tr. 33168; DX 1302, pp. 1-3; DX 1308, p. 1.)

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* Memorex did not begin volume production of the 660 until the second quarter of 1969. (DX 1268, p. 17.)

ISS was formed in December 1967 by twelve former IBM employees who had resigned from the San Jose Laboratory, where they were responsible for disk drive development. A number of this so-called "dirty dozen" had worked on IBM's Merlin (3330) program. (Whitcomb, Tr. 34555-56; DX 4756B, p. 96; DX 4739: Wilmer, Tr. (Telex) 4266; DX 4741: Yang, Tr. (Telex) 6116.) Like Memorex, ISS manufactured 2311-type and 2314-type disk drives, the 701 and 714, which were marketed by Telex to IBM end users beginning in 1969. (PX 4732A, p. 12; DX 4242, p. 8; DX 4250, p. 7; DX 4756A, pp. 36, 72.) ISS also marketed disks OEM to Hewlett-Packard, Itel and Storage Technology Corporation. (DX 86A, p. 2; DX 4113: Terry, Tr. (Telex) 3310-12.) The ISS 2311-type drive was similar to IBM's 2311 except for the addition of a voice coil actuator, and the ISS 2314-type drive was functionally equivalent to IBM's 2314, again except for the addition of a voice coil actuator. (Page, Tr. 33072-73; Ashbridge, Tr. 34812-13.) ISS was eventually acquired by Sperry Rand (in 1973) for its advanced disk technology, technical capabilities, highly qualified personnel, plant facilities and highly profitable OEM customer base. (DX 86A, pp. 1, 4, 5; DX 87, p. 12.) After the acquisition, ISS became the developer and manufacturer of disk subsystems for use in Univac systems, but continued marketing 2314-type disk drives to IBM users and to OEM customers. (Eckert, Tr. 988-89; McDonald, Tr. 4060-63.)

CalComp also offered 2311-type and 2314-type disk drives, manufactured by Century Data Systems, to end users and on an OEM basis. (DX 10735, pp. 10-11; see pp. 776-777, below.) CalComp shipped its first plug-compatible (2311-type) disk drive in June 1969

(PX 5324, p. 46; DX 4756A, p. 8), and later became the "first company to produce and ship a 2314 equivalent". (PX 3707A, p. 38; DX 10735, p. 10.) Century Data marketed these disk drives to leasing companies such as Randolph and to other systems suppliers such as Nixdorf, Burroughs and Univac (PX 3146A, p. 1; PX 5581, p. 10; PX 5582, p. 7; DX 1886, p. 7; DX 12194.)

Similarly CDC manufactured and marketed 2311- and 2314-type disk drives, both end-user and OEM. CDC's OEM customers included Honeywell, GE, Siemens, RCA, XDS, ICL, SAAB, CII, Burroughs and Telex. (G. Brown, Tr. 51056-57, 51080-81, 51095-96; see pp. 682-84, 1074-77, below.)

RCA did not even wait for PCM's to copy IBM's technology, but went directly to the source. "It was apparent [to RCA] that this capability which was offered by IBM was going to be required by RCA in order to successfully market its products."

> "This capability at the time was not available from any other source. So, therefore, when we announced the Spectra 70 family or series, which came out about eight months after the IBM 360 announcement, we announced as a part of the RCA product line this particular Model 2311 disk pack file capability and we obtained these files by buying them from IBM, the same as any other customer would buy them from IBM." (McCollister, Tr. 9370.)

Although RCA had its own disk drive development program, RCA subsequently contracted with Memorex to supply disk drives for use with RCA computer systems because Memorex' development program was further ahead than RCA's "which was going to be about a year later than Memorex's". (Beard, Tr. 8575.) RCA went to Memorex at a time "when we had in parallel our own development going on" because RCA was "under a handicap in selling the Spectra 70 Systems" due to lack of "a comparable product to the IBM 2314 at the time". RCA "couldn't afford in the marketplace to wait that additional year" necessary for RCA's development program to produce the required disk drives "[b]ecause we were losing too many sales for the lack of it" to IBM. (Id.)

GE, on the other hand, attempted to build an IBM plug-compatible 2311-type drive. (Ashbridge, Tr. 34812-13; G. Brown, Tr. 51536-37; Spain, Tr. 90227.) But "it met with limited success and arrived to the marketplace much too late to meet market, or customer requirements". (G. Brown, Tr. 51536.) GE entered into an exclusive contract with Greyhound Computer Corporation to sell the device, but Greyhound ended up having to take a significant write-off on its investment in the GE equipment and even sued GE. (Spain, Tr. 88753, 88755.)

Not until the very end of the 1960s had IBM's disk technology been sufficiently spread around the industry for some of IBM's systems competitors to have pulled even. Thus, the January 5, 1970 Phase III Level Forecast Assumptions for IBM's soon-to-be announced Merlin* disk drive reported:

> "System Manufacturers
>
> "From the announcement of the 2314 in 1965 until late in 1968 IBM had significant competitive advantages in this product area, as no competitor could offer a direct access device with the price, capacity, performance, and interchangeability characteristics of the IBM 2314. The situation today, however, has changed radically as most system manufacturers now have announced devices which are virtually identical in specifications to the IBM 2314. The chart below tabulates the status of the ten major system

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* As we shall see, the Merlin (3330) drive put IBM right back in the lead in disks. (See below, pp. 898-902 .)

manufacturers in this regard.

Marketed By	Mfg. By	2314 Type	Media	Status
Burroughs	Burroughs	No	Fixed Disc	Delivered
CDC	CDC	Yes	2316	Announced FCS 2Q70
DEC	Memorex	Yes	2316	Imminent Delivery
GE	IBM	Yes	2316	Announced
Honeywell	Honeywell	Yes	2316	Announced FCS 2Q70
IBM	IBM	Yes	2316	Delivered FCS 1Q67
NCR	NCR	No	Strip	Delivered
RCA	RCA	Yes	2316	Announced FCS 1Q70
SDS	Memorex/CDC	Yes	2316	Imminent Delivery
Univac	Univac	Yes	2316	Announced FCS 1Q70

"The rental prices offered by CDC, GE, Honeywell, RCA, and Univac are within a few percentage points of the IBM 2314. (CDC and Honeywell discount by approximately 10% for three to five-year leases.) Burroughs and NCR use radically different approaches and price comparisons cannot be weighed properly due to the lower performance levels of their devices. To date, competitive system manufacturers have not had any significant price advantage in the file facility environment." (DX 7858, p. 2.)

(viii) Standard Interface/Modularity. IBM adopted a "standard interface" for the peripherals in the compatible 360 line. This meant that (with some exceptions*) the same peripherals would

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* Such exceptions as existed came about as a result of design trade-offs. Some peripherals such as the 2301 and 2303 drums with high speeds, for example, were not made attachable to the slower models of System/360 (such as the Models 20, 22, 25 and 30) because those smaller CPUs could not accept the high data rates of these peripherals. (Case, Tr. 73449-50.)

In some instances (such as with the 360/25) peripherals were attached directly to the CPU rather than through the standard interface because designing a "native attachment, closely integrated with the computer", provided "somewhat greater performance at somewhat lesser cost". (Hughes, Tr. 71941; Case, Tr. 73450; see also PX 2209A, pp. 15, 17.) In such cases, of course, the cost/performance improvements were achieved at the expense of some of the configuration flexibility that was afforded by the standard interface. (Hughes, Tr. 71941-42, 71995.) The dilemma of when to make such trade-offs was a difficult one both during the development stages of System/360 (see Gardner, Tr. 38387-88, 38958-61, 39110-13; DX 1656, DX 1657, DX 1658, DX 1659) and thereafter. (See Haughton, Tr. 95019-24; DX 1662.)

attach to all processors in the line and would do so in the same way. The standard interface, together with compatibility, helped maximize the benefits that customers could derive from the broad range of peripherals offered with 360 and the compatibility across the entire line. It helped give System/360 a configurability that was unmatched by competitors and permitted customers the utmost flexibility to optimize their data processing systems by piecemeal or modular changes. At the same time, it enabled IBM to reduce costs through economies in development and manufacturing. Others undoubtedly recognized these benefits and also moved toward more modular product lines--but not until well after IBM had done so. (Case, Tr. 73446, 73474-75, 73523.)

The requirement for a standard interface for the New Product Line was implied by two of the architectural and engineering "ground rules" set out in the SPREAD Report--i.e., that "all channels shall appear identical" to any I/O device type and that "the I/O gear shall not need to be changed" when one processor is substituted for a slower one. (DX 1404A, pp. 19-20 (App. A to JX 38).) Case and Hughes testified that the standard interface became a "design objective" for System/360. (Hughes, Tr. 34102-03; Case, Tr. 73446.) Case explained:

> "[W]e had as an objective to design a number of different peripheral devices that would each be able to plug into central processing units of the whole System/360 family. We wanted to do this in a way which would maximize the degree of choice that customers would have in selecting peripheral devices to go with central processing unit models, and to do it in a way which would minimize IBM's development expenses in designing those

peripheral devices, and do it in a way which would help us to reduce our manufacturing costs of the peripheral devices by achieving as large as possible a production run of each particular device.

"The technique that we chose to accomplish these objectives was called the System/360 channel to control unit interface, often abbreviated with the words 'standard interface'". (Case, Tr. 73446.)*

The standard interface, together with compatibility, provided IBM with a number of development and manufacturing advantages. "It reduced the design time of many groups" who would otherwise have spent time designing their "own pet means of attachments". (Hughes, Tr. 71939.) Instead, the CPU and peripherals designers were able to concentrate on building "the best products they knew how" and on "advancing the state of their art as far as possible". (Case, Tr. 73447.)

The standard interface, together with compatibility, also helped IBM reduce development costs by reducing the number of circuits that had to be designed to permit each peripheral to attach to each CPU. Prior to System/360, peripherals that attached to the central processing unit did so by means of a unique interface. As a result, a separate design effort and set of circuitry was required for each such attachment to the central processing unit. With much of System/360, only a single design effort and set of circuits was required

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* The control unit to peripheral device interface was not standardized, however, which meant that each device required its own control unit. The objective of the New Attachment Strategy in the 1970s was to standardize the device to control unit level interface and thereby achieve benefits similar to what had been obtained with the standardization of the control unit to channel interface in System/360. (Case, Tr. 74079-83; Haughton, Tr. 95010-32.)

because of the standardization of the interface between the control unit and the channel of the central processing unit. (Case, Tr. 73446-48.)

The standard interface, together with compatibility, helped simplify and cost reduce IBM's manufacturing process. "[I]t led to higher quantity production runs of the peripheral devices since the same peripheral device and the same attachment, or plug-in circuitry, was associated with the interface to any of the CPU models". (Hughes, Tr. 71939-40; Case, Tr. 73448.) Because of this commonality, similar economies were achieved in the testing process. That was particularly important to IBM in getting 360 ready for announcement. Hughes testified that

> "since we had a multitude of I/O devices and a prescribed time to get it done, [compatibility and the standard interface] helped us a great deal in both our engineering and all aspects of testing . . . to get the total job done". (Tr. 71939-40; see also Case, Tr. 73533.)

Case testified that a related objective of the 360 Advanced Systems Group was to develop "elements of a computer system which could be put together, or configured in a wide variety of ways". (Tr. 73416.) That objective, which Case called "modularity", was promoted by the standard interface because it allowed users to plug any peripheral device into different 360 central processing units "without changes in the central processing unit". (Case, Tr. 73448; see also Hughes, Tr. 34109.)

Not only did IBM achieve the modularity objective set for System/360 (Case, Tr. 73420), it did so to an extent that other manufacturers were unable to match for almost a decade. Among the manufacturers and marketers of computer systems from 1964 to 1972,

> "IBM was the leader in providing . . . modularity.[*] With the announcement of the System/360, IBM provided the first line offering anything like the degree of modularity which has since become available from all the major manufacturers.
>
> "During the 1960's, all of the manufacturers, including IBM, evolved their product lines further in the direction of making them more modular, but . . . it is fair to say that throughout the period . . . IBM's product line remained the most modular of all the general purpose product lines available". (Withington, Tr. 58268-69.)

Accordingly, System/360's modularity provided benefits to users that were unavailable from competitors and provided an incentive to acquire 360s that did not exist with respect to competitive systems. As Case testified:

> "The achievement of the modularity objective was . . . very helpful to IBM in enabling the computer products produced by IBM to be chosen by customers in a way that would optimize the price/performance of their installation, and in a way which would provide for convenience and small accepted changes in the installation as the requirements of the enterprise changed.
>
> "That is an important benefit to customers for two reasons:
>
> "First, . . . they can most accurately adjust the capabilities of their computing installation and, hence, the cost to them of their computing installation to their real needs.
>
> "Second, . . . they are able to change the performance or the capabilities of their configuration to match their changing requirements . . . without changing the entire installation, but just adding or subtracting parts, or boxes from the installation." (Tr. 73427-28; see also Navas, Tr. 41394-95; Withington, Tr. 56193.)

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* "[A] modular line of computer systems is one in which every element of the system, including processor, storage, peripheral equipment, and systems programs can be independently exchanged for a compatible larger or successor module in such a manner that over time the installed computer system may evolve to a much different or a much larger or a much more capable one without any particular point in time being identifiable as one in which the entire system was converted from one to another." (Withington, Tr. 58268, see also Tr. 58269-76.)

IBM's achievement of modularity for System/360 "helped to remove limitations on the use of computing equipment that had previously existed" because it relieved users of the need to make "system" changes. (Case, Tr. 73435-37.) IBM, more than any other firm,* reaped the benefits of user demand for modular acquisition alternatives:

> "Because the achievement of the modularity objective was useful for customers, it was of benefit to IBM in that it tended to increase the value of IBM products as compared to the products of others, and with an increased value, our sales tended to increase and that was important in the achievement of the total success, or the total order rate for System/360 computers and the peripheral devices that were part of those computing systems." (Case, Tr. 73428.)

There were, however, risks associated with modularity and the standard interface. The design trade-offs necessary to create a system which could be assembled in a wide range of configurations, might have resulted in a design that was not optimal for any particular configuration, at a cost higher than it need otherwise have been. Development of the standard interface entailed a similar risk "that no one attachment or no one plug-in capability [would be] optimal for

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* Other companies followed IBM's lead in making their product lines more modular, but were not as advanced or fast moving. For example,

a) Modularity "was beginning to appear" in Honeywell's line by approximately 1966, but it "was still far less than available in the IBM line" and did not "span the range of available modular options that IBM's line did" through the 1960s;

b) By 1977, Univac's line was "probably still deficient" compared to IBM; and

c) "Burroughs' modularity was restricted by the narrowness of its product line . . . through most of the 1960s". (Withington, Tr. 58271-75.)

the particular device involved". (Case, Tr. 73531-32.) Thus, the question of separate control units versus native attachment of peripherals became a matter of some controversy within IBM, involving important dissenters (such as Haanstra) from the stand-alone control unit method of attachment which was finally adopted for most of 360. (See DX 1656; DX 1657; DX 1658; DX 1659.)

There was risk to IBM of another type as well. 360's standard interface and modularity of design, together with its wide-ranging compatibility, presented an attractive target for competitors. The new, modular environment in which 360 would be offered created the prospect that other manufacturers would produce "modules" that would be marketed in direct competition with comparable IBM products. The standard interface of System/360 offered others the same advantages it gave IBM*--and more. As Case testified,

> "It reduces their design costs as it did for IBM, and it allows them to achieve higher production runs as it did for IBM, and it allows users to conveniently plug in peripheral devices of their manufacture just as it allows the convenient plug-in of devices of IBM manufacture". (Tr. 73474-75; see also Navas, Tr. 41395-96.)

Moreover, such competitors would have the further advantage

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* That was particularly true because IBM published a number of manuals which were readily available "at a nominal charge of a couple of dollars" and which described the mechanical, electrical and logical characteristics of IBM's interfaces in a way that permitted manufacturers of peripheral devices to design "workable and safe" attachments of their devices to an IBM channel and which permitted CPU manufacturers to attach IBM peripherals to their own CPUs in a like manner. (Shoemaker, Tr. 30867; Case, Tr. 74125-50; Peterman, Tr. 99441-43; DX 7590, Perkins, pp. 21, 24; DX 7591, Hilyer, p. 15.) IBM's OEMI (Original Equipment Manufacturers Information) Manual for System/360 was first made available in 1965. (Case, Tr. 74145.)

of being able to copy IBM's designs and use IBM's software without having to invest in developing either. As a consequence they could be expected to have lower costs than IBM and to offer their products at lower prices than IBM initially charged. (Case, Tr. 73523; Cary, Tr. 101333-37, 101339, 101374, 101629-31; see also Wright, Tr. 13236-38; Enfield, Tr. 20765-68; G. Brown, Tr. 51812; Powers, Tr. 95376-89, 95412-13, 95475-82; PX 3312A, p. R14; PX 3594A, pp. 4, 26, 36, 40; PX 3681A, p. R-1; PX 4880, p. 3.)

The prospect that others would be able to "tap" IBM's support and offer compatible products in competition with IBM was foreseen by the SPREAD Committee and others within IBM prior to 360's announcement. (Knaplund, Tr. 90497-98; DX 1404A, p. 40 (App. A to JX 38); see also PX 3908A.) That prospect became a reality in the late 1960s and in the 1970s--with numbers of competitors offering replacements for each and every box in IBM's systems. IBM could not keep to itself the advantages of compatibility, modularity and the standard interface.* On the other hand, IBM really had little

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* John Navas of Memorex explained the benefits for a manufacturer of plug-compatible products in being able to attach a single disk drive model to a variety of 360 processors:

> "From the standpoint of a company such as Memorex, it would tend to reduce product cost to minimize the number of models of a given type of disk drive which we would be producing. That would result in a higher production volume for each type of unit, and would result in less development expense associated with developing the various models . . . .
>
> "If Memorex had had to produce unique models of its 630 for each of the various models of IBM System/360 . . . it would have probably increased the development expense, caused an increase in manufacturing costs, and increased the difficulty and administrative expense associated with lease base management". (Tr. 41395-96.)

alternative but to provide such features if 360 was to succeed. It was a matter of responding to "a competitive necessity". Because of user demand, "the manufacturers attempting to compete were forced to maintain continuous developments of different modular types of equipment that could be configured together". (Withington, Tr. 56174.)

However, the great modularity of System/360 meant that IBM would have to price each and every box in the system carefully.* According to Knaplund, IBM had to make those prices attractive on a box-by-box basis because users made box-by-box performance comparisons between IBM and its competitors; because System/360 was susceptible to such a wide range of configurations that a single box price that was out of line could make the whole system unattractive; and because competition was anticipated from suppliers of plug-compatible peripherals and CPU's who would attempt to replace IBM's products on a box-by-box basis. (Knaplund, Tr. 90496-98.) That last reason, in particular, made competitive box prices for System/360 "critical". (Id.)

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* IBM has always priced its products on a box basis, with each unit of EDP hardware (such as a CPU, tape drive, disk drive or terminal) offered at a consistent price regardless of the type or number of boxes that a user combined to configure his system. (Knaplund, Tr. 90495-500; Akers, Tr. 96665, 96675-76; Cary, Tr. 101386-87.)

Appendix

Examples of System/360 Uses

The following are some of the diverse applications for which System/360s have been used:

By a French research and consulting firm to study ways of increasing the power output of large hydroelectric dams (DX 13677, p. 16);

By a petroleum exploration company to prepare seismic reports (id., p. 14);

By a manufacturer of animal feed concentrates for feed formulization (DX 13678, p. 9);

By the Deutsches Elektronen Synchrontron in Hamburg, Germany, to evaluate photographs of bubble traces left by invisible elementary particles in an electron accelerator (DX 13679, p. 20);

By a Japanese steelmaker for automatic control of the steel manufacturing process (id.);

By Swissair for automated message switching and automatic passenger check-in and weight-and-balance calculating (id.);

By a paint manufacturer to signal corrections for deviations in ingredients and production cycle (id., p. 10);

By scientists in New England to simulate and study the life cycle of lobsters (id.);

By African Ivory Coast harbor authorities to compile and analyze statistics on tropical wood exports (id., p. 13);

By a Swiss chemical manufacturer to operate an automated warehouse (DX 13680, p. 28);

By BOAC to calculate tariffs, management statistics and flight plans (id.);

By Japan's national broadcasting company to maintain schedules and budgets for 640 television shows and 1,200 radio programs, and to control actual broadcasts (id., p. 16);

By IBM's Field Engineering Division for computer assisted instruction (DX 3364, p. 9);

By an air freight company for instantaneous tracking of daily shipments (id., p. 22);

By the architectural department of a county council in England to design municipal buildings (id., p. 24);

By a supermarket chain to calculate unit prices (PX 5767, p. 13);

By American Airlines (360/65) for airline reservations (Welch, Tr. 75385-86), field maintenance reliability applications (O'Neill, Tr. 75848-53), crew qualification and takeoff power assist (id., Tr. 75909-10), flight planning (id., Tr. 75928), and calculation of estimated time of arrival (id., Tr. 75976);

By Aspen Computype, Inc. (360/40) for typesetting (DX 6078, McCaffery, p. 9);

By Autocomp, Inc., (360/40 and 360/50) for typesetting (DX 4039, Kendall, pp. 7-8);

By AVCO Computer Services in Wilmington, Massachusetts, (360/75) for:

drafting applications	structural ring and frame analysis
FORTRAN flowcharting	antenna pattern prediction
geometric design	communication link analysis
mathematical functions	plasma attenuation analysis
frequency distributions	drag coefficient analysis
movie making	aerodynamic heating analysis
perspective plotting	heat transfer analysis
trajectory analysis	thermochemical equilibrium analysis
financial analysis	flow field analysis
production control	boundary layer analysis
statistical analysis	penetration aids analysis
mathematical analysis	decoy model analysis
applied statistics	radar cross section analysis
structural load analysis	finance applications
structural shell analysis	manufacturing applications

(DX 6816, pp. 3, 10, 12, 13);

By Bowne Timesharing, Inc., (360/40 and 360/50) for time-sharing text editing (DX 6090, Abrams, pp. 9-10);

By Carnation Corporation (360/40) for telecommunication applications and linear programming (Navas, Tr. 39177-78);

By Computone Systems, Inc., (360/50) for architectural design and mathematical modeling (DX 4069, Robeson, pp. 16-17);

By Continental Illinois National Bank & Trust (360/50) for on-line credit authorization (DX 4756, p. 7);

By DP&W, Inc., (360/30) for business and engineering applications (DX 4076, DiPietro, pp. 8-9);

By the San Francisco Federal Reserve Bank (360/50) for message switching (Withington, Tr. 57540; DX 2667, p. 3);

By the Fluor Corporation (360/50) for project planning and control, process simulation, process analysis, refinery simulation, structural design, piping design, electrical design and mechanical design (DX 4023, Neher, pp. 11-12, 17);

By General Motors Research (360/50) for timesharing (Hart, Tr. 80505-08);

By the New York Police Department (360/40) for automated dispatch and identification of police vehicles (DX 4756A, p. 58);

By the Orange Coast College District in Costa Mesa, California (360/50) for computer assisted instruction, grade reporting and student registration (King, Tr. 14761-62);

By Pacific Southwest Airlines (360/65) for passenger service applications (O'Neill, Tr. 76019);

By Proprietary Computer Systems, Inc., (360/65) for:

banking services
accounting
manufacturing control
three dimensional COGO
stress analysis
digital signal processing
reliability calculations
electrical engineering
fast fourier transforms
matrix analysis
chemical engineering
graph plotting
transducer calibration
thermal analysis
linear programming
CPM analysis
PERT analysis
Monte Carlo analysis
Markov analysis
integration
differentiation
non-linear equations
regression analysis
descriptive statistics

(DX 3960, Barancik, pp. 11-12);

By Pyramid Industries, Inc., (360/40) for time sharing (DX 4756D, p. 23);

By Southern Railway (360/50 and 360/65) for on-line monitoring of railroad cars (DX 4756D, p. 42), (360/50) for peripheral processing (J. Jones, Tr. 79848, 79413-14), (360/30) for card to tape, tape to card, and tape to print processing, and peripheral processing (id., Tr. 79843);

By TBS Computer Centers Corporation (360/30 and 360/40) for data communication, remote teleprocessing, accounting reports and statistics, inventory, cost analysis, market research, production control, accounts receivable and payable, traffic studies and order analysis (DX 7134);

By Union Carbide (360/30) for message switching (McGrew, Tr. 77271).

System/360's uses within the Federal government alone illustrate graphically the broad range of applications performed by 360 users. For example, 360s have been used:

By the Headquarters, U.S. Marine Corps (360/20), for "Automated Communications Processing System" (DX 2992,* pp. 619, 1123-1125);

By the Veterans Administration, Austin, Texas (360/20), for "Patient Care" (DX 2992, pp. 1073, 1158);

By the Veterans Administration, Washington, D.C. (360/20), for "Facility Planning and Construction" and "Fiscal Accounting" (DX 2992, pp. 1078, 1158);

By the Veterans Administration, Philadelphia (360/20), for "Insurance" (DX 2992, pp. 1076, 1158);

By the Defense Nuclear Agency, Headquarters, Field Command (360/20), for "Logistics - Supply" and "Stockpile Management" (DX 2992, pp. 546, 1121; DX 4593, p. 133);

By the Department of Air Force, Air Force Systems Command, Los Angeles, California (360/20), for "Telecommunications" and "Command and Control" (DX 2992, pp. 452, 1120; DX 4593, pp. 103, 104);

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* DX 2992 is the Stipulation and Amended Response of Plaintiff to IBM's Interrogatory 5(e). Examples of applications taken from DX 2992 are described here in the same terms in which they are described in DX 2992.

By the Atomic Energy Commission, Division of Technical Information (360/20) for "Operations Control and Support" (DX 2992, pp. 118, 1113; DX 4593, p. 72);

By the Atomic Energy Commission, Oak Ridge Office (360/20), for "Scientific and Engineering" (DX 2992, pp. 91, 1113; DX 4593, p. 61);

By the Department of Commerce, Office of the Secretary (360/20), for "General Administration" (DX 2992, pp. 149, 1117; DX 4593, p. 74);

By the Department of Commerce, Bureau of the Census (360/20), for "Statistical Programs" (DX 2992, pp. 157, 1117; DX 4593, p. 77);

By the Department of Air Force, Air Force Systems Command, Eglin AFB (360/20), for "Research, Engineering" (DX 2992, pp. 442, 1120; DX 4593, p. 101);

By the Department of Air Force, Air Force Communications Service, Offutt AFB (360/20), for "Weather, Environment" (DX 2992, pp. 411, 1120; DX 4593, p. 94);

By the Marine Corps Headquarters, FMFLANT (360/20), for "Automated Communications Processing System" (DX 2992, pp. 631, 1123-25);

By the Department of Navy, Naval Intelligence Command (360/20), for "Intelligence Data Handling System" (DX 2992, pp. 733, 1123-25; DX 4593, p. 156);

By the Department of Navy, Naval Research Laboratory (360/20), for "Laboratory Support Systems" (DX 2992, pp. 610, 1123-25);

By the Department of Navy, Commander Naval Reserve (360/20), for "Navy Manpower and Personnel Management Information System" (DX 2992, pp. 657, 1123-25; DX 4593, p. 138);

By the Department of Navy, Pacific Fleet Commander in Chief (360/20), for "Air Logistics Support Systems" (DX 2992, pp. 722, 1123-25; DX 4593, p. 152);

By the Defense Supply Agency, Lemoncove, California (360/20), for "Communications" (DX 2992, pp. 802, 1126);

By the Export/Import Bank of the U.S. (360/20), for "Payroll and Personnel", "Accounting" and "General Administration" (DX 2992, pp. 818, 1127);

By the National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md. (360/20), for "Scientific" and "Engineering" (DX 2992, pp. 907, 908, 1144);

By the National Aeronautics and Space Administration, Jet Propulsion Laboratory, Pasadena, California (360/20), for "Business-Commercial" (DX 2992, pp. 937, 1144);

By the Department of Treasury, Office of Treasurer (360/20) for "Administration of Government Finances" (DX 2992, pp. 1066, 1155; DX 4593, p. 194);

By the U.S. Defense Communication Agency (360/20 and 360/30), for communication control and as terminals (DX 7524, Levine, pp. 34-36, 57);

By the Atomic Energy Commission, Brookhaven National Laboratory (360/30), for "Personnel Management" and "Operations

Control and Support" (DX 2992, pp. 6, 1113);

By the Civil Aeronautics Board (360/30) for "Traffic Capacity", "World Benefit Study", "Air Cargo" and "Payroll, Manpower Distribution" (DX 2992, pp. 134, 1116);

By the Department of Army, Air Defense Board (360/30), for "Research, Engineering" (DX 2992, pp. 174, 1120);

By the Department of Air Force, Air Force Finance Center (360/30), for "Finance, Accounting", and "Payroll, Benefits" (DX 2992, pp. 279, 1120);

By the Department of Air Force, Air Force Systems Command (360/30), for "Research, Engineering" (DX 2992, pp. 433, 1120; DX 4593, p. 99);

By the Defense Communications Agency, European Area (360/30), for "Communications Control and Management" (DX 2992, pp. 550, 1122; DX 4593, p. 133);

By the Defense Nuclear Agency, Headquarters Field Command (360/30), for "Test Command", "Accounting and Finance", "Communications Processing" and "Data Automation" (DX 2992, pp. 546-47, 1121; DX 4593, p. 133);

By the Department of Labor, Bureau of Labor Statistics (360/30), for "Statistical and Economic Survey Appl." (DX 2992, pp. 884, 1142; DX 4593, p. 175);

By the National Aeronautics and Space Administration, Johnson Space Center (360/30), for "Scientific" and "Business-Commercial" (DX 2992, pp. 971, 1144);

By the National Aeronautics and Space Administration, Goddard Space Flight Center (360/30), for "Mission Control" and "Data Reduction" (DX 2992, pp. 907-8, 1144);

By the Tennessee Valley Authority, Computing Center Branch (360/30), for "Power Supply and Use", "Fertilizer and Munitions Development", "Financial Management" and "Personnel Management" (DX 2992, pp. 1068, 1156; DX 4593, p. 194);

By the Securities and Exchange Commission, Office of Data Processing (360/30), for "Mass Information Storage and Retrieval", "Statistical and Economic Analyses" and "Administrative Processing (Personnel, Payroll, etc.)" (DX 2992, pp. 1025, 1151, DX 4593, p. 191);

By the Department of Transportation, Transportation Systems Center (360/30), for "Financial Administration", "Inventory, Supply and Logistics" and "Planning, R and D" (DX 2992; pp. 1034, 1154; DX 4593, p. 165);

By the Social Security Administration (360/30) for real time claims tracking and real time tape library control (DX 5792, pp. 17-18);

By the Department of Navy, Marine Corps - COMCAB West (360/30), for "Automated Communications Processing System" (DX 2992, pp. 571, 1123-25);

By the Department of Navy, Chief of Naval Operation (360/30), for "Space Surveillance System" (DX 2992, pp. 669, 1123-25; DX 4593, p. 141);

By the Department of Navy, Ordnance Systems Command (360/30), for "Ordnance Support System" (DX 2992, pp. 694, 1123-25; DX 4593, p. 145);

By the Defense Supply Agency, Assistant Director of Plans (360/30), for "Logistics - Depot Level" and "Communications" (DX 2992, pp. 812, 1126; DX 4593, p. 135);

By the Defense Supply Agency, Assistant Director of Plans (360/30), for "Headquarters Management" (DX 2992, pp. 815, 1126; DX 4593, p. 136);

By the Federal Deposit Insurance Corporation, Division of Research (360/30), for "Economic Research", "Fiscal Accounting", "Bank Liquidation" and "Bank Statistics" (DX 2992, pp. 823, 1130; DX 4593, p. 171);

By the Department of Health, Education, & Welfare, Food and Drug Administration (360/30), for "Disease Prevention and Control" and "Consumer Protection" (DX 2992, pp. 855, 1137; DX 4593, p. 173);

By the Atomic Energy Commission, Albuquerque Office (360/40), for "Material Management", "Facilities Management", "Operations Control and Support" and "Scientific and Engineering" (DX 2992, pp. 35, 1113; DX 4593, p. 46);

By the Department of Commerce, National Oceanic and Atmospheric Administration (360/40), for "Mapping, Charting and Marine Description" (DX 2992, pp. 148, 1117; DX 4593, p. 74);

By the Department of Commerce, National Oceanic and Atmosphere Administration (360/40), for "Environmental Prediction and Warning" (DX 2992, pp. 150, 1117; DX 4593, p. 74);

By the Department of Commerce, Office of Administration Domestic International Business (360/40), for "Statistical Programs", "Economic Analysis" and "Industrial Mobilization" (DX 2992, pp. 157, 1117; DX 4592, p. 46);

By the Department of Army, U.S. Army Munitions Command (360/40), for "Research, Engineering" (DX 2992, pp. 169, 1120; DX 4593, p. 126);

By the Department of Air Force, Air Force Logistics Command (360/40), for "Supply, Inventory Control, Cataloging" (DX 2992, pp. 273, 1120; DX 4593, p. 87);

By the Department of Air Force, Aerospace Defense Command (360/40), for "Telecommunications", "Command and Control", "Intelligence" and "Tracking" (DX 2992, pp.418, 1120; DX 4593, p. 96);

By the Department of Air Force, Air Force Systems Command (360/40), for "Research, Engineering" (DX 2992, pp. 428, 1120; DX 4593, p. 98);

By the Department of Transportation, FFD Aviation Administration (360/40), for "Inventory, Supply and Logistics", "Mission Support, Operations" and "Planning, R and D" (DX 2992, pp. 1039, 1154; DX 4593, p. 166);

By the Office of Economic Opportunity, Office of the Comptroller (360/40), for "Payroll Accounting", "Personnel Accounting" and "Research and Development" (DX 2992, pp. 1015, 1146; DX 4593, p. 191);

By the Securities and Exchange Commission, Office of Data

Processing (360/40), for "Mass Information Storage and Retrieval", "Statistical and Economic Analyses" and "Administrative Processing (Personnel, Payroll, etc.)" (DX 2992, pp. 1025, 1151; DX 4593, p. 191);

By the Veterans Administration, Department of Data Management (360/40), for "Loan Guaranty" and "Facility Planning and Construction" (DX 2992, pp. 1073, 1158; DX 4593, p. 195);

By the Veterans Administration, Department of Data Management (360/40), for "Patient Care" (DX 2992, pp. 1078, 1158; DX 4593, p. 196);

By the Department of Navy, Director of Naval Laboratories (360/40), for "Laboratory Support Systems" (DX 2992, pp. 685, 1123-25; DX 4593, p. 143);

By the Department of Navy, Air Systems Command (360/40), for "Air Logistics Support Systems" (DX 2992, pp. 565, 1123-25; DX 4593, p. 139);

By the Federal Deposit Insurance Corporation, Division of Research (360/40), for "Economic Research", "Fiscal Accounting" and "Bank Statistics" (DX 2992, pp. 823, 1130; DX 4593, p. 171);

By the Government Printing Office, Assistant Public Printer (360/40), for "Inventory Accounting and Control" and "Electronic Printing" (DX 2992, pp. 834, 1135; DX 4593, p. 171);

By the Department of Health, Education and Welfare, Food and Drug Administration (360/40), for "Disease Prevention and Control" (DX 2992, pp. 855, 1137; DX 4593, p. 173);

By the Defense Nuclear Agency, Headquarters, Field Command

(360/40), for "Accounting and Finance", "Nuclear Weapons Materiel Control", "Stockpile Management" and "Test Command" (DX 2992, pp. 546, 1121; DX 4593, p. 133);

By the Department of Navy, Marine Corps (360/40), for "Manpower Management System" (DX 2992, pp. 615, 1123-25; DX 4593, p. 159);

By the Department of Navy, Pacific Commander-in-Chief (360/40), for "Intelligence Data Handling System" (DX 2992, pp. 753, 1123-25; DX 4593, p. 163);

By the Air Force Aeromed Installation (360/40) to simulate bombing equations, radar signal acquisition and airborne computers (DX 5640, Mayer, p. 34);

By the Army (van-mounted 360/40s) for maintaining a running account in the field of supply and demand of field support services (Wright, Tr. 13394-95; DX 913);

By the U.S. Army Strategic Communications Command (360/40) for message switching (Wright, Tr. 13412-13);

By the Atomic Energy Commission, Chicago Office (360/44), for "Material Management", "Financial Management" and "Scientific and Engineering" (DX 2992, pp. 84, 1113; DX 4593, p. 60);

By the Department of Air Force, Air Force Systems Command (360/44), for "Research, Engineering" (DX 2992, pp. 284, 1120);

By the Department of Air Force, Strategic Air Command (360/44) for "Command and Control" (DX 2992, pp. 319, 1120; DX 4593, p. 80);

By the National Aeronautics and Space Administration, Office of Manned Space Flight (360/44), for "Simulation" (DX 2992, pp. 984, 1144; DX 4593, p. 188);

By the National Aeronautics and Space Administration, Advanced Research and Technical Office (360/44), for "Test Data Acquisition" (DX 2992, pp. 904, 1144; DX 4593, p. 177);

By the National Aeronautics and Space Administration, Flight Research Center, Edwards Air Force Base, California (360/50), for "Scientific", "Engineering", "Data Reduction" and "Business Commercial" (DX 2992, pp. 905, 1144);

By the Railroad Retirement Board, Data Processing and Accounts Bureau (360/50), for "Research and Actuarial Services", "Process of Unemployment and Sickness Benefits" (DX 2992, pp. 1021, 1149; DX 4593, p. 191);

By the Tennessee Valley Authority, Computing Center Branch (360/50), for "Resource Development and Management", "Power Supply and Use", "Fertilizer and Munitions Development" and "Personnel Management" (DX 2992, pp. 1068, 1156; DX 4593, p. 194);

By the Department of Transportation, Federal Highway Administration (360/50), for "Inventory, Supply and Logistics", "Planning, R and D" and "Mission Support, Operations" (DX 2992, pp. 1050, 1154; DX 4593, p. 170);

By NASA's Flight Research Center in Edwards, California (360/50), for reduction and analysis of flight data, scientific theoretical calculations and administrative data processing (DX 5308, p. 1);

By NASA's Kennedy Space Center (360/50) for real time inventory management, integrated launch vehicle modification status, payroll and remote file inquiry (DX 5256, pp. 6, 63);

By the U.S. Coast Guard and Geodetic Survey Office (360/50) for developing aeronautical charts, analyzing satellite data, providing tidal data, locating earthquakes and assisting in geomagnetic studies (Wright, Tr. 13410-12; DX 13678, p. 9);

By duPont's Savannah River Laboratory Plant (360/50) for neutron thermalization and reactor kinetics (H. Brown, Tr. 83244-49);

By the Department of Navy, Commander-in-Chief Pacific Fleet (360/50), for "Intelligence Data Handling System" and "CINCPAC Support Information System" (DX 2992, pp. 752, 1123-25; DX 4593, p. 162);

By the Department of Navy, Commander-in-Chief Pacific Fleet (360/50), for "Material Management Information System" (DX 2992, pp. 714, 1123-25; DX 4593, p. 148);

By the Department of Navy, Facilities Engineering Command (360/50), for "Ordnance Support Systems" (DX 2992, pp. 717, 1123-25; DX 4593, p. 148);

By the Department of Navy, Air Systems Command (360/50), for "Air Logistics Support Systems" (DX 2992, pp. 658, 1123-25; DX 4593, p. 138);

By the Federal Deposit Insurance Corporation, Division of Research (360/50), for "Economic Research", "Bank Merger Analysis" and "Fiscal Accounting" (DX 2992, pp. 823, 1130; DX 4593, p. 171);

By the Government Printing Office, Assistant Public Printer (360/50), for "Payroll, Earnings and Leave Accounting", "Electronic Printing" and "Inventory Accounting and Control" (DX 2992, pp. 834, 1135; DX 4593, p. 171);

By the Department of Health, Education and Welfare, Food and Drug Administration (360/50), for "Disease Prevention and Control" and "Consumer Protection" (DX 2992, pp. 855, 1137; DX 4593, p. 173);

By the Atomic Energy Commission, Albuquerque Office (360/50), for "Facilities Management", "Operations Control and Support" and "Scientific and Engineering" (DX 2992, pp. 35, 1113; DX 4593, p. 46);

By the Department of Army, White Sands Missile Range, New Mexico (360/50), for "Research, Engineering" (DX 2992, pp. 177, 1120);

By the Defense Communication Agency, NMCS Support Center (360/50), for "Gaming, Modeling, and Systems Development", "Command and Control" and "Damage Assessment" (DX 2992, pp. 551, 1122; DX 4593, p. 133);

By the Department of Air Force, Sacramento Air Material Area, McClellan Air Force Base, California (360/50), for "Personnel" and "Education" (DX 2992, pp. 273, 1120);

By the Department of Air Force, Aeronautical Systems Division, Wright Patterson Air Force Base, Ohio (360/50), for "Research, Engineering" (DX 2992, pp. 282, 1120);

By the Department of Air Force, Pacific Air Force (360/50), for "Command and Control" (DX 2992, pp. 456, 1120; DX 4593, p. 105);

By the Department of Air Force, Strategic Air Command (360/50), for "Intelligence" (DX 2992, pp. 322, 1120; DX 4593, p. 80);

By the Atomic Energy Commission, Savannah River Office (360/65), for "Material Management", "Financial Management" and "Scientific and Engineering" (DX 2992, pp. 115, 1113; DX 4593, p. 71);

By the Department of Army, Safeguard, Whippany, N.J. (360/65), for "Research, Engineering" (DX 2992, pp. 165, 1120);

By the Department of Air Force Ogden Air Material Area, Ogden, Utah (360/65), for "Payroll, Benefits", "Procurement, Contract Administration" and "Law Enforcement" (DX 2992, pp. 275, 1120);

By the Department of Air Force, Air Force Systems Command (360/65), for "Research, Engineering" (DX 2992, pp. 438, 1120; DX 4592, p. 67);

By the Department of Air Force, Aerospace Defense Command (360/65), for "Command and Control" (DX 2992, pp. 418, 1120; DX 4593, p. 96);

By the Department of Air Force, Air Force Systems Command (360/65), for "Intelligence" (DX 2992, pp. 428, 1120; DX 4593, p. 97);

By the Defense Communications Agency, NMCS Support Center (360/65), for "Gaming, Modeling, and Systems Development", "Command and Control" and "Damage Assessment" (DX 2992, pp. 551, 1122; DX 4593, p. 133);

By the Department of Navy, Marine Corps Automated Service Center, Kansas City, Missouri (360/65), for "Manpower Management System" and "Personnel Accounting System" (DX 2992, pp. 628, 1123-25);

By the Department of Navy, Naval Air Development Center, Warminster, Pennsylvania (360/65), for "Laboratory Support Systems" (DX 2992, pp. 568, 1123-25);

By the Department of Interior, Geological Survey (360/65), for "Recreation Use and Preservation" (DX 2992, pp. 877, 1140; DX 4593, p. 174);

By the Department of Labor, Departmental Data Processing Center (360/65), for "Accounting and Payroll Services" and for "Statistical Data Gathering" (DX 2992, pp. 883, 1142; DX 4593, p. 175);

By the National Aeronautics and Space Administration, Goddard Space Flight Center (360/65), for "Scientific" and "Engineering" (DX 2992, pp. 908, 1144);

By the National Aeronautics and Space Administration, Goddard Space Flight Center (360/65), for "Data Reduction" (DX 2992, pp. 907, 1144);

By the National Aeronautics and Space Administration, Johnson Space Center (360/65), for "Simulation" (DX 2992, pp. 983, 984, 1144);

By the Tennessee Valley Authority, Computing Center Branch (360/65), for "Power Supply and Use", for "Fertilizer and Munitions Development" and for "Employee Health and Safety" (DX 2992, pp. 1068, 1156; DX 4593, p. 194);

By NASA's Johnson Space Center (360/65) for Skylab simulation (DX 7536, Woodling, pp. 23-24);

By the Navy Computer Sciences Department in San Diego (360/65) for processing complex scientific and management type data and for time sharing (DX 5100, pp. 17, 28);

By the Air Force Eastern Test Range (360/65) for mechanized range scheduling, radar data reduction, trajectory measurement, optical infrared system data reduction (DX 5023, pp. 1-4);

By the California Institute of Technology's Jet Propulsion Laboratory (360/75) for real time mission control, simulation and real time telemetry (DX 5296, pp. 4, 6, 7);

By the Naval Electronics Laboratory Center in San Diego (360/65) for interactive time sharing (DX 4334, pp. 1, 5);

By the Department of Air Force, Air Force Systems Command (360/67), for "Telecommunications" and "Command and Control" (DX 2992, pp. 451, 1120, DX 4593, p. 103);

By the Defense Communications Agency, NMCS Support Center (360/67), for "Command and Control" and "Damage Assessment" (DX 2992, pp. 551, 1122; DX 4593, p. 133);

By the Department of Navy, Post Graduate School (360/67), for "Management Information System for Education and Training" (DX 2992, pp. 588, 1123-25);

By the National Aeronautics and Space Administration, Ames Research Center (360/67), for "Scientific" and "Business-Commercial" (DX 2992, pp. 888, 1144);

By the Atomic Energy Commission, Idaho Office (360/75), for "Material Management", "Financial Management", "Personnel Management" and "Operations" (DX 2992, pp. 77, 1113; DX 4593, p. 58);

By the National Aeronautics and Space Administration, Goddard Space Flight Center (360/75), for "Scientific", "Engineering" and "Mission Control" (DX 2992, pp. 907, 908, 1144);

By the National Aeronautics and Space Administration, Jet Propulsion Laboratory (360/75), for "Data Reduction" (DX 2992, pp. 946, 1144);

35. The System/360 Commitment. System/360 was a "fantastic undertaking" involving "fantastic risks". (Cary, Tr. 101359; see also Brooks, Tr. 22868; Case, Tr. 73561; Evans, Tr. 101126.) 360 was "vastly different" from anything IBM had previously undertaken in terms of "magnitude, complexity and functional characteristics", and was "fundamentally new and different" compared to competitors' EDP offerings as well. (Knaplund, Tr. 90515; Evans, Tr. 101126; PX 1092 p. 1; DX 1172, pp.1-2.) It was clear from the outset that no half-way measures would suffice to carry out the SPREAD Committee's plans--and non was taken. IBM committed more "skill and energy" and "corporate resources" to the successful implementation of System/360 than to any previous undertaking in its history. (PX 1900, p. 4.)

Virtually the whole IBM's EDP operations were involved in the development and manufacture of System/360. The scope and magnitude of the undertaking required a worldwide, interdivisional effort on IBM's part. "From its inception, System 360 was designed, developed and tested for worldwide use, and was in fact used worldwide". (McCarter, Tr. 88377; DX 1404A, p. 8 (App. A to JX 38).)*

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*The 360/30 was developed in Endicott and was manufactured in Endicott, Sindelfingen, Germany, and Mainz, Germany. (Dunlop, Tr. 93647.) The 360/40 was developed in Hursley, England, and manufactured in Poughkeepsie, Essones, France, and Montpellier, France. (Id.; Hughes, Tr. 33921-22.) The 360/50 was developed in Poughkeepsie and manufactured (assembled) in Poughkeepsie, Essonnes, and Montpellier. (Dunlop, Tr. 93649.) The 360/20 was developed in Boeblingen, Germany and manufactured (assembled) in Sindelfingen, Vimercate, Italy, San Jose, and Boca Ratan. (Id.; Hughes, Tr. 71942-43.) System 360's SLT circuit packaging was designed in Endicott and East Fishkill, and manufacturered in East Fishkill, Endicott, Essones and Sindelfingen. (Dunlop, Tr. 93649-50.) The 2401 tape subsystem was developed in Poughkeepsie, and manufactured (assembled) in Poughkeepsie, Essones, Montpellier and Boulder. (Dunlop, Tr.

Within IBM, it was recognized that achievement of SPREAD's recommendations would require "great effort" to "control and coordinate the work of several divisions and that of the IBM World Trade Corporation". (Knaplund, Tr. 90470-71.) At the time of SPREAD there were 15-20 engineering groups generating processor products in IBM. (DX 1404A, p. 7 (App. A to JX 38).) These groups resided in four principal areas--DSD, GPD, FSD (Federal Systems Division) and WTC (World Trade Corporation). (DX 1404A, p. 49 (App. A to JX 38).) If a single compatible line of processors was to be achieved, design control had to be centralized in a single location.* Accordingly, the SPREAD Committee recommended the establishment of a systems architecture group that would be charged with formalizing the design objectives for NPL and providing logical specifications for the hardware and software. (DX 1404A, p. 49 (App. A to JX 38).) Such a group--the NPL Architecture Committee--was formed in early 1962, and served in the role of "advisor" to the various

93650.) The 1403N1 printer was developed in Endicott and manufactured in Endicott, Raleigh, Sindelfingen and Vallingby, Sweden. (Dunlop, Tr. 93650-51.) The 2311 was developed in San Jose and manufactured in San Jose and Sindelfingen. (Dunlop, Tr. 93651.) The 2671 paper tape recorder was developed in LaGaude, France, and manufactured in Essonnes and Montpellier. (Dunlop, Tr. 93651.)

* Centralized control of worldwide development efforts made good sense from another standpoint as well. The SPREAD Report projected a very rapid increase in the growth of computer usage outside the United States during the 1960s; whereas the average domestic growth rate was projected to be 15%, the foreign rate was projected at 37%. (DX 1404A, p. 11 (App. A to JX 38).) So large an element of demand obviously could not be ignored in the development of new products, and the Committee recommended that the needs of users worldwide be taken into account in all phases of NPL development. (DX 1404A, p. 49 (App. A to JX 38).)

NPL engineering groups. (Case, Tr. 74487-88, 74492-9 .) They held "dozens if not a hundred or more meetings" relating to NPL. (Case, Tr. 74469.)

On the manufacturing side, too, a number of disciplines were imposed to assure that there were no major discrepancies among the products produced on either side of the Atlantic. IBM's plants worked "very closely" together to develop "worldwide manufacture plans" and employee training plans. (Dunlop, Tr. 93651-52.) IBM also introduced, for the first time with System/360, the concept of "single engineering control". (Dunlop, Tr. 93641, 93646.) Under this concept any laboratory responsible for designing a part, component or product was also responsible for releasing that design to all the plants, worldwide, that were going to manufacture that part, component or product. (Dunlop, Tr. 93641.) By introducing this concept, IBM was able to:

(a) achieve a "high level of confidence" that all parts, wherever in the world produced, would perform in a comparable fashion;

(b) achieve the ability to exchange parts or assemblies or products among manufacturing locations in times of technological difficulty or great demand;

(c) avoid duplication of engineering effort, since there was no need to design the same product or component twice in two different places. (Dunlop, Tr. 93642-43, 93645.)

Apart from the need to impose new disciplines, it was apparent that a "substantial" segment of IBM's "new product development resources in the electronic data processing (EDP) area" would be required to announce the New Product Line in the first quarter of 1964. (Knaplund, Tr. 90471.) Brooks testified that the original estimate for 360 programming was between $100 and $200 million. (Tr. 22706.) That estimate was exceeded by better than $25 million. (Id.) Brooks' staff in DSD alone grew from "20 or 30" in June 1961 to "several hundred" by February 1964. (Brooks, Tr. 22669.) A presentation made to IBM Chairman, T. J. Watson, Jr., in November 1964 showed that IBM's annual research and development expenditures rose from approximately $175 million per year in 1961 to $275 million per year in 1964. (PX 6671, p. 6.)*

More investment still was needed to meet the requirements for SLT components. The 1961 decision to manufacture SLT in-house required a rapid buildup in manufacturing facilities and resources. (Knaplund, Tr. 90546; E. Bloch, Tr. 91562.) To meet the projected volumes for 360, IBM had to become "in a very short time, the largest component manufacturer in the world". (PX 1900, p. 9.) In 1961, IBM established a Components Division to "focus all of its resources in terms of both manufacturing and development on that goal of making SLT components."

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* It is interesting to note that, in the 1959-64 period, IBM's research and development (R&D) expenses were not only absolutely higher than some of its major competitors (Burroughs, NCR, Sperry Rand and CDC), but were more than double the expenditures as a percentage of revenue for Burroughs or NCR or Sperry Rand. Each of their ratios of R&D to revenue remained about level over that period. Among the four, only CDC, which was developing the highly successful 6600, showed an increasing R&D to revenue ratio. (PX 6671, pp. 5-6.)

(E. Bloch, Tr. 91562, 91891-92.) In 1963, the Components Division opened a new plant in East Fishkill, New York as a manufacturing development site for System/360 components. (E. Bloch, Tr. 91563, 91891-92.) Prior to the 360 announcement, IBM hired "a large number of people" and "started to build additional buildings" in order to meet the anticipated SLT requirements. In addition, IBM's Endicott location was enlarged to help produce packages for mounting SLT modules (E. Bloch, Tr. 91892) and part of a plant in Essonnes, France, was converted into a "component facility" to help meet "worldwide requirement[s]". (E. Bloch, Tr. 91893, 91563-64.)

Perhaps as significant as the magnitude of IBM's investment in 360 was the fact that all of those resources were being put into a single project: IBM was "putting a lot of eggs in one basket . . . and the success of the company was in many ways to be determined by the success of that one project". (Case, Tr. 73561; Evans, Tr. 101128.) If 360 were rejected by customers there would be few alternatives around for IBM to offer and none that was thoroughly funded or covered a very large part of the product line. (Case, Tr. 73562.) Thus, once the die had been cast and the decision made to go forward with the SPREAD Committee's recommendations, IBM's fortunes became "inextricably tied up with the NPL project". (Case, Tr. 73562.) Within IBM and without, the 360 project came to be known as the "you bet your company" venture. (Friedman, Tr. 50378; Case, Tr. 73561-62; Evans, Tr. 101126.) If that venture had failed, IBM would have become a "radically different company, if even in the computer business". (Evans, Tr. 101128.)

Despite the risk, IBM decided to develop the 360 line because "[w]e thought that the System/360 development was the best way to more rapidly grow the market, more rapidly expand demand for our products". (Case, Tr. 73606.) It was the sort of risk that IBM was forced to take by competition if it was to succeed. Seemingly safer alternatives to 360 continued to be advanced within IBM right up to the time that 360 was announced. (See, e.g., Case Tr. 73589-92; PX 1074; PX 1090.) As they had rejected the 8000 series, IBM management rejected those alternatives because they would not have given IBM the kind of long range solutions that it needed in the competitive environment of the day. (Evans, Tr. 101277; see also DX 4806.)

System/360 represented a price/performance improvement over IBM's existing equipment which Learson described as "a price reduction of 30-50%." (DX 1525.) Within IBM, it was recognized that no "single announcement" had ever "obsoleted so much existing equipment at one time". (PX 1099A.) IBM was forced to make such an announcement. The SPREAD Committee had set as an objective the creation of a plan that would "optimize the conflicting demands" of "market need" on the one hand and "impact on present installed processors" on the other (DX 1404A, p. 7 (App. A to JX 38))--but IBM had to impact its own line or stand by and watch others do so.

In an effort to blunt the impact of System/360 on IBM's existing product line, IBM Treasurer K. N. Davis recommended that 360 be offered for sale only. Davis made the suggestion because technology and price/performance were "changing and improving so rapidly" that he believed it might be in IBM's interest to transfer to customers some of the risk of technological obsolescence. In addition, System/360's price/performance on a rental basis was so superior to existing IBM systems on rent that customers would rapidly displace those systems with 360s. (Knaplund, Tr. 90511-12.) The recommendation was rejected because "IBM had to continue to offer a rental option in order to remain competitive": competitors offered that option and customers found it desirable. (Knaplund, Tr. 90512-13.) In this respect, IBM's experience was no different from its competitors. For example, McCollister testified that RCA offered its systems on a lease basis because the customers insisted upon it and because all other manufacturers in the industry offered it. (McCollister, Tr. 9298-300; see also Palevsky, Tr. 3145-46; Spangle, Tr. 5531; Oelman, Tr. 6160.) Indeed, customers as well as IBM could perceive that technology was changing and would not have been willing to accept the risk of obsolescence. Competition ensured that they did not have to do so.

As Withington agreed, IBM had to introduce a product line comparable in performance and function to System/360 if it wanted to stay in business because its existing line would have become "obsolete" and unmarketable. (Tr. 56524, 56539.) Thus, IBM Vice President and Group Executive Learson wrote to C. J. Bashe, Manager of Technical Development, GPD, and T. C. Papes, Manager of Systems Development, GPD, in July 1963:

"The 101 [announced as the System/360 Model 30] must be engineered and planned to impact solidly the 1401.

"I know your reluctance to do this, but corporate policy is that you do it. It is obvious that in 1967 the 1401 will be as dead as a Dodo bird.[*] Let's stop fighting this." (DX 1406.)

Hughes testified that this letter was passed down to him through the management chain to emphasize the importance of the 360/30 program and the company's policy with respect to that program. He understood that the 360/30 would make the 1400 family obsolete--and had to do so. (Tr. 33965-66, 33972-73.) Despite the fact that by 1964 IBM had shipped thousands of 1401 systems, of which 75-80 percent were still owned by IBM and on lease to customers, it was perceived that "[i]f we didn't obsolete it and replace it, someone else would". (Hughes, Tr. 33962-63, 33965; see also Tr. 34062.) That same view was echoed in a letter written by a Staff Vice President to the President of Southern Railway in April 1964, recommending the acquisition of 360/30s to replace Southern's 1404s:

> "This will reduce the IBM rentals by $4,000 a month in Atlanta. There is also a good possibility that we will be able to eliminate the 1401 computer in Washington, using computers in Atlanta by tape to tape control from Washington. This would also save us $4,000 to $5,000 per month rental in Washington. Prices of computers have been coming down while the computer capacities are being increased tremendously. If IBM does not bring out new computers at reduced prices, their competitors take the business."

According to John Jones of Southern Railway who helped draft that letter, it reflected his view of competition in 1964--i.e., that if IBM and others did not bring out new products to meet competition, competitors would take their business away--the kind of competition which

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*By year-end 1966, IBM had installed over 10,000 1401s, far and away the largest number of any system type that IBM had ever shipped at that time. (PX 1900, p. 7.)

had increased "tremendously" since then. (J. Jones, Tr. 78991-97.)

It was a view that was shared by IBM's competitors as well:

> "There is no looking backward in our industry [the computer business] as you undoubtedly know. If one stops to ponder the past and be self-satisfied, the more aggressive competitors will quickly charge past." (Hindle (DEC), Tr. 7447; DX 517, p. 2)

and

> "It was our finding that the life of a family of computers was quite limited . . . and that you did not bring out a family of products that simply met the price/performance characteristics of the then existing competition. You had to bring out something that would exceed the price/performance of the existing competition because you knew full well that they were going to be moving ahead of you. It is a constant leap frogging game." (R. Jones (GE), Tr. 8867)

* * *

> One gets "to a point in which the price/performance is so improved over equipment of days of yore that it is clear that . . . users are going to move to new equipment, and either [one is] going to provide that new equipment or [one's] competitors are going to provide it". (R. Bloch (Honeywell/GE), Tr. 7761-62; see also Hindle (DEC), Tr. 7448; R. Jones (GE), Tr. 8865; Hangen (NCR), Tr. 10423-24, 10431; Currie (XDS) Tr. 15175-76; Brooks, Tr. 22705, 22795-96; Withington, Tr. 56560, 56565; DX 426, pp. 7-8.)

As we have already discussed, it was the recognition that competitors would supplant IBM's installed base if IBM took no action, as reflected in the SPREAD Report's "product survival charts", which had triggered the NPL project to begin with. The SPREAD Committee's prediction that IBM's highly successful second generation line would be superseded by competition starting in about 1965, turned out to be accurate as to substance, but overly optimistic as to time. As Withington testified, the industry was in a state of "technological ferment during the period 1956 through 1964", with "new technologies . . .

new types of components . . . [and] significant software products . . . being invented and employed at a rapid rate" and new models of computer systems superseding older computer systems at a "rapid rate" and achieving "relatively rapid success in the marketplace". (Tr. 56459-60.) In 1963 and early 1964, the "leapfrogging" which was "characteristic" of the computer industry (R. Jones, Tr. 8846) had occurred. In July of 1963 Learson could say that "in 1967 the 1401 will be as dead as a Dodo bird" (DX 1406) because it was already being surpassed by newer models of computer systems.

Indeed, at the highest level within IBM there was concern that the System/360 might not be enough of an improvement to recover its costs. Thus Watson, writing to Learson in June 1963, stated concerning the New Product Line:

> "I think it important to note, however, since we seem to have suffered for a few months or even years because our machines predated the effective competitive machines now in the marketplace, that we now make these [System/360] machines good enough so they will not be just equal to competition, for I am sure that once they are announced our competitors will immediately try to better them. This is all to the good and I am for competition, but I want our new line to last long enough so we do not go into the red." (DX 4806.)

Similarly, writing in November 1963 to a group of IBM executives, Watson said:

> "There is a great deal of running about and extra effort being expended in all areas of the IBM company now because once again we have allowed ourselves to become somewhat non-competitive without recognizing one simple obvious fact. In bringing new machines and devices to the marketplace, our competitors in today's market are simply not going to stand still. We should recognize that in every area, they will take the best we have and immediately start working in a tough, hard-minded fashion to produce something better.
>
> "We find ourselves in our present position because we seem to assume our competitors will stand still in certain

areas after we announce a superior product . . . .

"I believe that whenever we make a new machine announcement, we should set up a future date at which point we can reasonably assume that a competitor's article of greater capability will be announced. We should then target our own development program to produce a better machine on or before that date." (PX 1077, pp. 1-2.)

Charts prepared by DSD Market Evaluation Manager, J. C. Wick, comparing the price/performance of the New Product Line to competitive products in February 1964, showed that 360's price/performance was superior to that of recently announced machines from RCA, Burroughs, CDC, Honeywell, Univac and GE, but also showed quite clearly that those competitive machines had a price/performance advantage over the earlier announced IBM machines of the 1400 and 7000 series. (PX 1099A, pp. R2-R3.) We discuss some of the competitive announcements which created this situation in the histories of these competitors during the early 1960s. However, some of the announcements merit particular attention here.

In October 1963, DSD President G. F. Kennard wrote to T. J. Watson, Jr., and A. L. Williams: "RCA has recently announced the 3301. . . . Initial performance specifications indicate that the 3301 has about 50 percent better processing capabilities than the IBM 7010" at a comparable price. (PX 2952.) In November, 1963, it was reported within IBM that GE was discussing in public a new series of machines planned for announcement before the end of the year. "In one case GE stated, system cost would be approximately the same as the IBM 1410 but would be 40% faster." (PX 3624, p. 4.) GE announced the

400 Series in December 1963,* and at the same press conference revealed the future availability of its 600 family.** (Weil, Tr. 7181; DX 488; DX 490.) The 400 series offered a 1401 simulator which permitted IBM 1401 programs to be run on or converted "easily" to the 400. It was aimed at 1401 users. (Weil, Tr. 7031-34.)

The CDC 6600, which CDC began discussing with customers before announcement (Norris, Tr. 5937-38) in 1962 (JX 10, ¶ 4), caused IBM Chairman Watson to ask "why we have lost our industry leadership position by letting someone else offer the world's most powerful computer". (PX 1045.) CDC's 3600, which had been announced in May 1962, was viewed within IBM as "technically superior to the 7094". (PX 1026A.) By April 1963, O. M. Scott, IBM Vice President and Group Executive, was reporting to Watson and others that "3600-type competition" was creating a "serious situation" and that such competition (from CDC's 3600 and 6600 and from Philco's 212) was able to offer "one-and-a-half to two times the performance of the 7094 at a lower price". (PX 1025.) Scott added that the 501 (360/70), as planned, would enable IBM "to favorably compete with the CDC 3600". (Id.) On April 23, 1963, Watson determined to "just sit tight" and stay with the 501 approach "unless the roof falls in", but wrote that IBM had an active program in DSD called the "7094 B prime" which was sufficiently advanced to be announced in June 1963. (PX 2807.) Within two weeks,

* GE announced the Models 425, 435, 455 and 465. The 455 and 465 were never delivered. (Weil, Tr. 7181; DX 490, pp. 1-3.)

** The 600 family was actually announced in the summer of 1964 (Weil, Tr. 7197-98; DX 491, p. 1) and was aimed at IBM 7090 and 7094 users. (Weil, Tr. 7033-38.)

cascading losses to CDC's 3600 caused a reevaluation of that decision, and Watson asked Scott to advise him when the situtation got "out of control". (PX 3619.) One week later, Scott reported back that IBM was repeatedly "being beaten" by CDC's 3600, 6600 and 1604, Philco's 212 and Remington Rand's 1107. He recommended announcement of the 7094-B' "at the earliest possible date". (PX 3620.) IBM announced the 7094 Mod. II on May 16, 1963 (DX 13958), but this extension of the 7090 series still "could not meet either the performance level or the price of a comparable CDC 3600." (PX 320, p. 15.) As a result, CDC's success with the 3600 continued unabated. (PX 320, p. 15.) With virtually all of IBM's development resources tied up on 360, IBM was simply unable to respond effectively at that time--all of IBM's eggs were indeed in the 360 basket.* (See Case, Tr. 73589, 73561; Evans, Tr. 101128.) In the meantime, CDC was able to achieve success "by concentrating on an area of IBM price weakness, and by showing a major price performance advantage to potential customers". (PX 320, p. 15.)**

Perhaps most important of all, however, was the announcement

* At just about this same time CDC's chief development engineer for the 6000 Series, Vice President Seymour Cray, at CDC's June 1963 corporate planning meeting, urged that CDC announce the 6600 and a successor in order to "slug" IBM because he speculated that IBM had "madea mistake in putting all [its] eggs in an integrated circuit basket". (DX 13526, Forrest, pp. 748-50.)

** No competitor was able to offer such an advantage once 360 was announced. (PX 320, pp. 4-14) of the Honeywell 200 in early December 1963. (McCollister, Tr. 11367; PX 1079; DX 167) This machine offered substantially improved price/performance over the 1401. (McCollister, Tr. 11237; Knaplund, Tr. 90475; Evans, Tr. 101188; DX 167.) It also offered a conversion program called the "LIBERATOR" which made the H-200 to a considerable degree compatible with IBM's 1401. (R. Bloch, Tr. 7605-06; McCollister, Tr. 11237; Goetz, Tr. 17652; DX 167; DX 488.)

Within IBM the H-200 announcement was viewed as "even more difficult than we anticipated". (PX 1079.) Within two days of the announcement, Learson wrote to T. J. Watson and A. L. Williams that the 101 (360/30) would have to be announced "as soon as possible"* and priced at its "lowest projection" in order to be competitive. (Id.) IBM's marketing force regarded the H-200 as a real challenge (Evans, Tr. 101186) and at least one person in IBM called it "the most severe threat to IBM in our history". (PX 3912.) By February of 1964, the Sales Division was "reeling from losses" to the Honeywell 200 and "wanting a more competitive answer". (Evans, Tr. 101196.) Because of the H-200, IBM's Data Processing Division continued and intensified its pressure for the earliest possible announcement of System/360, earlier still than even the then-planned mid-March announcement date. (Knaplund, Tr. 90475; JX 38, ¶ 16; PX 1095; DX 2983.)

As competitive pressure mounted, the debate whether to go forward with 360 as planned or to announce extensions to the existing

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* The target announcement date at that point in time was March 1964. (PX 1079.)

product lines was rekindled. The latter approach would be safer and easier: it would not be as "revolutionary" as 360 and would therefore run a lower risk of user rejection. (See, e.g., Case, Tr. 73590, 73512; Evans, Tr. 101127.) Moreover, it would not require users to convert their existing applications programs. In November 1963, IBM's Corporate Staff advanced the position that "new marketing developments"* required a change in IBM's processor strategies. They recommended the announcement in May-June 1964 of "several improved current line systems--such as the 7074X, 7010X and 7094X". In their scheme of things the NPL announcement was to be put off for 6 to 12 months. (PX 1074, pp. 2-3.)

The Honeywell 200 announcement provided perhaps the sharpest temptation to depart from the System/360 plan. In early 1963, IBM had a 1401 built out of SLT circuitry to establish the feasibility of using SLT in the New Processor Line. (Hughes, Tr. 33952-53; McCarter, Tr. 88394; JX 38, ¶ 7; DX 4800.) The Honeywell 200 prompted sharp debate within IBM whether a new technology (SLT) version of the 1401 (called the 1401S) should be brought out and the 360/30 announcement delayed or cancelled. (Hughes, Tr. 33953-54; Evans, Tr. 101188, 101195.) The chief proponent of this new plan was GPD President John Haanstra, who had been Chairman of the SPREAD Committee. Haanstra

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* These new developments included the announcement of competitive processors offering easy conversion to IBM customers and other new competitive offerings with improved price/performance as well as "the continuing unattractiveness of programming conversion and associated expense to our customers". (PX 1074, p. 2.)

believed that the 1401 was a "fundamentally sound" approach to meeting user needs and that the 360/30 approach was "improper" because it created the exposure of requiring customers to convert:

> "We must have a position which sticks to the 1401 as a fundamentally sound andproper [sic] method for commercial data processing. I do not believe that we should in the GP small machine area imply in any fashion whatsoever that the 1401 approach to problem solving is out of date and that people must change.
>
> ". . . .
>
> ". . . [I]n the final analysis we must sustain a position of 1401 as a right programming approach now and into the future. An approach which implies that we must convert is basically improper." (PX 3913.)

The Data Processing Division, however, regarded the 1401S as only a fallback position in the event that the 360/30 was not ready soon enough or was not good enough:

> "The best solution . . . is a 101-H machine with a competitive price to the H-200 and a performance equal to or greater than the H-200, ready for announcement by mid-February. . . . This system would not only compete head on with the H-200 but offer the customer the opportunity to grow in the NPL line, which is the direction we want them to take.
>
> "The 1401S machine, which has been discussed, is a second choice to the system described above and has been supported by us only because we have not received a commitment that the 101-H machine could achieve the performance desired or meet an early announcement schedule." (PX 1090.)

Evans was sure that it was a mistake to produce the 1401S instead of the 360/30, and that it would not make sense to do both. As early as September 1963 he had inveighed against "continual competition with temporary machines" because they would "only dilute [IBM's] already overcommitted resources and ability to meet the NPL challenge". (DX

2983.) In his view, if the 1401S had proceeded, it would have "delayed if not killed" the 360/30 and "wreaked havoc with the costs of the rest of the System/360 line". (Evans, Tr. 101195-96.) In addition, Evans regarded a decision to produce the 1401s as relegating the NPL more to the scientific area and signalling "a discrete scientific line, probably along the 7090 philosophy particularly if competition does the H 200 type of thing to the 7090 family". He felt this would erode the basis for NPL and lead to a processor policy of "discrete 1400-type commercial, discrete 7090-type scientific, plus various custom units for new application areas", as "the inevitable conclusion". (Evans, Tr. 101275-76; PX 6668 (DX 14514).) As we shall see below (pp. 379-81), GE was in fact attempting to do "the H 200 type of thing to the 7090 family. Evans was right.

Although contingency plans were laid for a possible February 1964 announcement (PX 6202), IBM decided not to proceed with the 1401S. Evans testified that the 1401S was ultimately rejected

> "[b]ecause the evaluations and conclusions of senior management were that it was not an advanced system that would solve the applications of the future as we then saw them--that . . . it was a machine that would not have long life and would not be competitive for more than a short period, and that the 360 family plan with all of its advanced features and functions and capability and the unusual power it brought the users was a substantially better plan". (Tr. 101277.)

In short, the 360/30 was expected to be "a better overall performing system than the 1401 had been or could have been, had we extended its life". (Hughes, Tr. 33953-54.)

a. <u>Preparation for Announcement.</u> It was clear by the end of 1963 that announcement of System/360 was required for IBM to remain competitive. (Knaplund, Tr. 90475.) We have already discussed how, beginning in 1961, IBM began applying massive resources to the NPL project. Evans testified that the "whole 360 program had been on a crash basis . . . since almost inception" and that by the latter part of 1963 it had become an "enormous program with its own inertia". (Tr. 101190, 101198-99.) In December of 1963, development of the line was "on or ahead of the schedule called for two years earlier in the SPREAD report" (Knaplund, Tr. 90477),* and two of the prime movers of the project, Evans and Brooks, were recommending announcement of the entire family in the first part of 1964.**

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* A PERT chart (DX 1405), prepared by Ernest Hughes in October 1962, laid out the job to be done in order to accomplish the Model 30 program. (Hughes, Tr. 33933-34, 33947.) The chart showed that the Model 30 would be ready for first customer shipment on August 1, 1965, if the sequence of events identified on the chart were "successfully completed". (DX 1405; Hughes, Tr. 33947.) According to Hughes, all of those tasks were completed "close" to the dates projected for their completion back in 1962, and the first 360/30 was actually shipped in June 1965. (Tr. 33947-49; see also JX 38, ¶ 24.) This was so despite the fact that IBM's Product Test organization was of the view that the System/360 Model 30 central processing unit was farther behind in their testing procedure than any of the other System/360 central processing units announced in April 1964. (PX 1107, p. 7.)

** By the time 360 was announced, engineering models of all the processors had been built (Brooks, Tr. 22695-96); full instruction set compatibility across the five processors had been achieved (Brooks, Tr. 22785); a complete processor had been built using SLT technology and demonstrated to establish the feasibility of the new circuitry (Hughes, Tr. 33952-55; JX 38, ¶ 7, p. 5; DX 4800); many thousands of SLT modules had already been produced (DX 4796, p. 8); most of the processors and some of the peripheral equipment were in the early stage of product test (McCarter, Tr. 88383; JX 38, ¶ 19); all, or almost all, the memories had undergone technical evaluation testing (Brooks, Tr. 22699); microprogramming and multiprogramming had been tested on the Model 40 (McCarter, Tr. 88382-83); and four estimating, forecasting and pricing cycles had been completed (DX 1172, p. 2). Product Test had been involved with the development from the beginning (McCarter, Tr. 88375; DX 1165): by the time of announcement, In September of 1963, Evans wrote to DSD President Kennard:

> "NPL is good--it is simple and powerful--it is ready enough --proven enough. IBM should go forward with . . . full announcement in the first or second quarter of 1964 with programming systems committed." (DX 2983.)

Although the SPREAD Report had not recommended announcing the entire NPL family at once, by December 1963 it was plain that there were powerful reasons for doing so. On December 27, 1963, Evans proposed that the NPL family be announced as a group in March 1964:

> "[T]he customers must better understand the abilities of the architecture and conversions necessary. It would be unwise of us to announce systems sporadically in an effort to optimize market penetration or profit. It is proper that IBM announce all the systems in a group so that our customers have the benefit of the family and can properly plan." (DX 4815; see also Evans, Tr. 101072-75.)

Less than one month later, Brooks wrote to Gibson, Haanstra and Kennard, stating that the equipment was "technically ready for announcement" and recommending announcement on April 7. (DX 1172.) He emphasized that System/360 "<u>must</u> be announced at one time" (id., p. 3):

> "Piecemeal announcement would utterly confuse and misguide the customer in his planning. He could not make the best selection from the available models until all the models are announced." (<u>Id.</u>; see also Knaplund, Tr. 90486-88; Brooks, Tr. 22782-84.)

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thousands of tests had been made and "literally hundreds of problems and potential problems" had been identified and resolved. The componentry, systems and product testing program already completed was more extensive than the entire program IBM had previously undertaken for any system. (McCarter, Tr. 88390-93; Evans, Tr. 101065-66, 101082; DX 1172, pp. 2, 5; see also DX 4815.)

RCA, Honeywell and GE all announced systems that were, by comparison, in an embryonic stage of development. (See Spangle, Tr. 4997-99; Weil, Tr. 7232-35; McCollister, Tr. 9635-41.)

Knaplund testified that he "understood that simultaneous announcement . . . would place an unprecedented load on the development of manufacturing resources of the product divisions". However, the advantages outweighed the risks. Since IBM was unquestionably going to produce a compatible line, only by fully informing customers as to the full compatible range, including prices and functional specifications, could they evaluate properly IBM's offering. "It was my business judgment that partial announcement by IBM would result in customer confusion, superseding orders following subsequent IBM announcements, and churning of the order backlog in IBM's production schedules." (Knaplund, Tr. 90486-88.)

The March or April announcement dates recommended by Evans and Brooks were virtually mandated by the first shipment dates planned for the 360 processors, which ranged from June 1965 for the 2030 to January 1966 for the 2070. (See JX 38, ¶ 24.) It was "generally industry practice on most computer systems at that time to announce a system at least a year, and frequently as much as two years, ahead of the actual first delivery".* (Weil, Tr. 7064; see McCollister, Tr. 9635, 9641, 9646; Hangen, Tr. 10761-62; Knaplund, Tr. 90483-84; PX 355, pp. 33-36; PX 2226A,pp. 13, 19, 27; PX 2432, pp. 19, 22, 28; DX 573; DX 4769; DX 4774; DX 8962.)

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* There were "practical reasons" for this procedure from both the manufacturer's and the customer's viewpoint, each of whom needed time to prepare for delivery and installation. (Weil, Tr. 7064-65; Withington, Tr. 58738-46; J. Jones, Tr. 79034-36; Akers, Tr. 96537-40; DX 3726.)

Such lead time was particularly important in the case of System/360. Thus, Brooks wrote in January 1964: "The breadth of System/360 and the number of innovations, particularly in gross systems concept, will require substantial lead time between announcement and proper installation." (DX 1172, p. 1; see also DX 3726; DX 4815.) That time would be necessary to:

(1) permit customers to replan their applications and take advantage of 360's new concepts such as file orientation, communications facilities and large memories;

(2) permit customers to assimilate the "sheer amount of new abilities, new options, new specifications, and new prices" that 360 would provide and select the best configuration of equipment to perform their applications;

(3) permit IBM and customers to educate their personnel and prepare them for proper installation and maintenance of 360;

(4) permit IBM to avoid deferred installations and consequential inventory build-ups;

(5) permit customers to determine the need for and submit RPQs for special requirements; and

(6) permit customers to prepare their physical sites for 360 installation.

(Withington, Tr. 58738-46; J. Jones, Tr. 79034-36; Knaplund, Tr. 90483-88; Akers, Tr. 96537-41; DX 1172, pp. 1-2; DX 3726; DX 4815.) As Southern Railway's President was advised by his EDP staff in 1964, "there is always a year to 18 month delivery lag from ordering to delivery. This amount of time is usually . . . required for planning and programming". (DX 3726.)

Over the course of the NPL development, there were numerous proposed announcement dates considered by various IBM personnel, ranging from mid-1963 to mid-1965. (Brooks, Tr. 22796; JX 38, ¶ 15, p. 8; PX 1079; PX 1092; DX 1404A, pp. 57, 70, 119 (App. A to JX 38); DX 4782; DX 4786; DX 4790; DX 4814; DX 4815.) In December 1963, Paul Knaplund was assigned responsibility for assembling the technical evaluations, forecasts, cost analyses and profit projections that IBM top management would need to address the 360 announcement decision. Beginning in January 1964, he conducted weekly meetings with IBM line and staff management to identify and assess the magnitude of outstanding problems and outline programs to solve those problems, so that he and they would be prepared to make judgments and advise top management on the advisability of proceeding with the 360 announcement. (Knaplund, Tr. 90474-77.)

On March 18, 1964, IBM Chairman T. J. Watson, Jr. made the final decision to announce all of the models of the new line simultaneously on April 7, 1964. IBM's Product Test Department did not support the April 7 announcement--all other departments whose effort was required to provide the products, features and services offered in the System/360 announcement did support it. (Gibson, Tr. 22648; Brooks, Tr. 22799-800; Hughes, Tr. 34003; Knaplund, Tr. 90483, 90493; E. Bloch, Tr. 93311; JX 38, ¶¶ 18, 22; DX 1165; DX 9161.)

Evans, Brooks and McCarter explained the organization and role of the Product Test Department, in addition to all the other testing that was done at the time within IBM; how IBM management used the Product Test position to isolate problems and challenge the product development personnel to determine how they would solve those problems; and how Product Test, after it took its non-support position, later supported the shipment of System/360 to IBM's customers. (McCarter, Tr. 22568-70, 88362-93, 88434-55; Brooks, Tr. 22786-88, 22850-53; Evans, Tr. 101065-66, 101083-95, 101174-78; PX 2126, pp. 2-5, 35-37; PX 4005; DX 1165; DX 1172, pp. 2, 5; DX 1409; DX 4815; DX 8083.) As G. B. McCarter* testified,

> "It did not follow from Product Test's non-support of March 16, 1964, that IBM could not or would not deliver what it committed to customers. . . . To the contrary, Product Test's input was one of the mechanisms, like internal targets, designed to ensure that it would." (Tr. 88404.)**

In fact, the processors announced on April 7, 1964, were all shipped on or before the dates estimated for shipment at announcement, except that the 2060 and 2062 on the one hand, and the 2070 on the other, were superseded by faster memory versions

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* McCarter was DSD Manager of Product Test, and was the person who presented the position of the Product Test organization for all IBM divisions to IBM management prior to System/360 announcement. (McCarter Tr. 88373, 88380-81.)

** Prior to 360, there had been numerous occasions on which IBM announced products without Product Test support, including the 1403 printer; 1302 disk file; the 709, 7090 and 7074 systems; and more than two dozen software programs. (McCarter, Tr. 88371-72, 88602-05; Evans, Tr. 101093-94; DX 4768; DX 7680; DX 9005.)

called the 2065 and 2075, respectively, which were delivered on or before the dates planned for their predecessor processors in April 1964. (JX 38, ¶ 24.) Those first shipped systems, as planned, were made available with the simpler operating systems offered with 360. (Brooks, Tr. 22853.) However, as we mentioned earlier, there were "significant schedule slippages in OS/360 software", (the most advanced operating system for 360) which meant that some customers "received the full announced capabilities later than originally planned". (JX 38, ¶ 25; DX 4740: Evans, Tr. (Telex) 3933-34; Welke, Tr. 19410, 19631; see also Enfield, Tr. 20947-48; PX 4834, p. 23.) The problems with OS/360 occurred even though Product Test "cumulatively did more testing of OS/360 than we ever had before for any set of programs for a particular system" (McCarter, Tr. 88390-93), and despite the fact that IBM's programmers believed prior to April 7, 1964 that they could produce OS/360 "in the way that it was originally intended". (McCarter, Tr. 88390-93; Evans, Tr. 101119; DX 5609.) IBM, like the rest of the industry,* misjudged the "enormous complexity" of developing complex operating systems. (Perlis, Tr. 1320, 2001-03; Spangle, Tr. 4997-99; Weil, Tr. 7215-21; McCollister, 9696-98; Welke, Tr. 19281-82; Brooks, Tr. 22762-63; Withington, Tr. 55914, 56729-30; McCarter, Tr. 88390-92; Evans, Tr. 101119.)

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*Withington testified that "all manufacturers attempting the most advanced systems programs in that time had difficulties". (TR 56729-30.) For example:

(a) Burroughs announced but never delivered the B8500 and B7500, in part because of software problems. (Perlis, In a way, the modularity and standard interface of the System/360, which made hardware testing easier, as already discussed

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Tr. 1320-21, 2001-03; Withington, Tr. 56599-600.)

(b) Univac was compelled to delay the introduction of its EXEC 8 operating system for two to three years. (Perlis, Tr. 2001-03.) Earlier, Lawrence Livermore Laboratory was compelled to rewrite "completely" the software that Univac had provided with the LARC computer because the Laboratory was "not satisfied with it". (Fernbach, Tr. 517-18.)

(c) Xerox "had difficulty producing the UTS [operating] system that [it] had announced". UTS was delayed for several years, costing XDS several millions of dollars in revenue. (Perlis, Tr. 2001-03; Currie, Tr. 15303, 15352-54.) XDS also experienced delays in its XOS operating system. (Currie, Tr. 15704.)

(d) The MULTICS operating system was never delivered by GE, even though GE, MIT and Bell Labs believed it could be feasibly designed. Honeywell finally completed the development three years behind the original schedule. (Weil, Tr. 7232-35; Wright, Tr. 13373-76; Withington, Tr. 56730-31.) GE also had difficulty in making GECOS perform to their customers' satisfaction. Three different versions were eventually constructed, and none ever met the advertised capabilities. Because of those difficulties GE withdrew its Models 625 and 635 from the market for a year or two in late 1966 or early 1967. (Weil, Tr. 7215-21; Withington, Tr. 56730-31.)

(e) The Honeywell 8200 was unsuccessful, in part, because of software development difficulties. Honeywell had to spend "large amounts of money, more than we had planned" to develop the software. (Spangle, Tr. 4997-99.) Honeywell also took longer than anticipated to develop its Series 60 line because of "difficulties in developing software and microprogramming". (Spangle, Tr. 5008.)

(f) RCA's TSOS was delayed "on the order of six to (see above, pp. 360-62), made software testing harder. It allowed customers great flexibility in the range of configurations which they could choose, and that, coupled with the wide variety of ways in which OS/360 could be used, led to "a very complex hardware-software system" which was literally impossible to test adequately. (McCarter, Tr. 88544-45.) As Enfield testified:

> "Systems software by its nature cannot be adequately tested in a single environment but must in fact be tested . . . in a user environment in order to establish the many different types of configurations, the many different types of generation options, the many different types of operating environments.
>
> ". . . .
>
> "If you were to take the various permutations of the options available to the user, the number of different tests that would have to be performed [in testing systems software] would exceed the time available for testing. I am talking about millions of different permutations and combinations of features that can be selected by the users. To test in each of those environments would preclude the issuance of first release of any operating system . . . . [b]ecause as soon as you got around to testing the 999,000 somebody would come out with another option and you'd have to go all the way through it again." (Tr. 20294-97; see also Perlis, Tr. 1347-48.)

Only by expending "considerable internal efforts" was IBM

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twelve months, possibly more", and performed poorly and unreliably. (McCollister, Tr. 9694-95, 9707-08; Rooney, Tr. 12132-34.) RCA's VMOS also experienced delays, which were estimated to constitute a "potential problem" of some $2 million in monthly rentals from lost accounts plus a loss from delayed installations of $3 1/2 million. (Rooney, Tr. 12335-36, 12349-50, 12358; Conrad, Tr. 14088-89, 14133; DX 872, p. A.) The difficulties with and instability of TSOS/VMOS "endangered [RCA's] position with any customer who had equipment on order and who planned to use this operating system". (McCollister, Tr. 9704-05, 9710-11.)

able to remedy the problems with OS/360--but IBM did so and provided customers a "very sophisticated, very complex software system, a software system that permitted the customer a great deal of flexibility . . . the customer could do a great deal with a minimum amount of effort", which in turn caused System/360 "to show steadily increasing performance relative to competition and remain saleable longer". (Perlis, Tr. 1887-88; Palevsky, Tr. 3180; Rooney, Tr. 12576; Currie, Tr. 15186; Welke, Tr. 17308-13; McCarter, Tr. 88389; PX 1900, pp. 3-4, 8; PX 4833, p.16; PX 4834, p. 23.)

b. <u>360's Success and Impact on IBM.</u> System/360 was launched on April 7, 1964, and the internal doubts about its reception were soon dispelled. (See Knaplund, Tr. 90515; DX 4740: Evans, Tr.(Telex) 3932-33.) Orders for the systems "far exceeded IBM's forecasts" (Gibson, Tr. 22636-37; Case, Tr. 73258; Knaplund, Tr. 90547; Evans, Tr. 101123; Cary, Tr. 101780-81; JX 38, ¶ 28; PX 1900, pp. 7, 10; DX 9331) and exceeded by thousands IBM's production plans which were based on those forecasts:

Estimated and Actual Production Versus
Gross Orders Booked for System/360 Models
Announced on April 7, 1964

	Estimated	Actual	Gross Orders Booked
1965	589	668	4,487
1966	2,897	3,132	4,526
1965 & 1966 (combined)	3,486	3,800	9,013

(JX 38, ¶ 28.) By October 1966, IBM's 360 order backlog represented an income of "almost three times . . . [IBM's then-current,] worldwide, annual sales of all products". (PX 1900, p. 10.)

As we discussed earlier, IBM management authorized substantial increases in plant capacity prior to 360's announcement in order to meet anticipated production and delivery requirements--including the establishment of an SLT manufacturing plant in East Fishkill, N.Y., and the addition of a new building at IBM's Endicott, N.Y., plant site for the manufacture of SLT cards and boards. (See above, pp. 344-45.) It was management's judgment that these manufacturing capacity increases "adequately provided for the component and box production volumes required to support the System/360 announcement together with planned future announcements". (Gibson, Tr. 22635-37; Knaplund, Tr. 90545-46; E. Bloch, Tr. 91895-96; DX 7691, p. 4; DX 9333.) However, because the total orders were far beyond what was forecast and because larger size processors and more memory and peripherals than anticipated were being ordered, the demand for SLT modules also far exceeded IBM's expectations. (Knaplund, Tr. 90547; E. Bloch, Tr. 91899-906; Dunlop, Tr. 94774-75; DX 9331; DX 9332; DX 9333; DX 9334.) By May 1964, only a little more than one month after announcement, the projected "Maximum Annual Module Requirements" had increased from 70-90 million to 130-190 million. (DX 9331; see also E. Bloch, Tr. 91899-900, 91905-06; Dunlop, Tr. 94774-75; DX 9332; DX 9333.)

It was plain that the manufacturing capacity planned at announcement would be insufficient and IBM began moving to meet the increased demand. By the third quarter of 1964 additional component production capacity was approved as an addition to IBM's Burlington, Vermont, plant site, and plans were initiated for additional assembly plant locations. By the end of 1964, IBM top management had approved expansion of the Federal Systems Division's Owego, N.Y., plant "to increase manufacturing capacity for SLT cards and boards"; and in the first part of 1965, two new plant sites in Boulder, Colorado, and Raleigh, North Carolina, were approved "to increase IBM's overall EDP manufacturing capacity". (Knaplund, Tr. 90547-48; E. Bloch, Tr. 91905-08; Dunlop, Tr. 93670; PX 5771, p. 28; DX 9038.) In addition, IBM provided special tools and training to Texas Instruments employees so that Texas Instruments might serve as an additonal source for SLT components. (E. Bloch, Tr. 91908.)

By October 1965, IBM announced that it was "completing more than three million square feet of new manufacturing space" to meet requirements for System/360--including plants in Boulder, Colorado; Raleigh, North Carolina; Montpellier, France; Vimercate, Italy; and expansions of existing facilities in Owego, Fishkill and Endicott, New York; Burlington, Vermont; and San Jose, California. (DX 9038.) New plants were later added in Boca Raton, Florida and Brooklyn, New York. (Dunlop, Tr. 93670.)

IBM also began hiring substantial numbers of new employees. Between year-end 1964 and year-end 1967 IBM increased its work force by approximately 50%--adding more than 70,000 new employees.

(PX 5771, p. 3; DX 13680, pp. 3-4; see also Knaplund, Tr. 90549-50; Dunlop, Tr. 93670; DX 4740: Evans, Tr. (Telex) 3934.) Evans testified that it was "an enormous job" to get the supply of parts flowing, hire the people and train them in order to meet 360 commitments. At one point, IBM "even rented a circus tent to temporarily store parts" until more permanent facilities could be secured. (Knaplund, Tr. 90549-50; DX 4740: Evans, Tr. (Telex) 3934.)

In January 1965, IBM combined all product division manufacturing functions in a single manufacturing division. It was believed that "by unifying responsibility for scheduling and producing all the principal System 360 equipment, . . . manufacturing efficiency could be increased and information flow accelerated". (Knaplund, Tr. 90548-49.) The Systems Manufacturing Division (SMD) was thus created, with former GPD President C. E. Frizzell at its head. (Id.) By June 1965 Frizzell reported to IBM management that the production buildup would enable IBM to meet product shipments committed to customers. (Knaplund, Tr. 90550-51; DX 1154; DX 1155; see also E. Bloch, Tr. 91915; DX 9333.)

Within a few months, however, an "unforeseen" technical difficulty developed in the production of SLT technology. (Knaplund, Tr. 90551-52; E. Block, Tr. 91915-18.) The problem took about three months to sold, despite intensive efforts by IBM to do so, and the delay put IBM several months behind the schedule for SLT production needed to satisfy existing customer commitments. (Knaplund, Tr. 90551-52; E. Block, Tr. 91917-19.) This was reported to IBM Chairman

Watson, who immediately informed IBM's Board of Directors and issued a public statement advising that "during 1966 most System/360's will be delivered 60 to 120 days later than originally scheduled". (Knaplund, Tr. 90551-52; DX 9038.) Knaplund testified that, but for the unanticipated production problems, System/360 shipments at that point "would have continued on the committed plan". (Tr. 90552-53.)* In the end, although many 360 hardware deliveries were made as scheduled and committed, there were some significant schedule slippages despite all of IBM's efforts to prevent them. (See Knaplund, Tr. 90849-54; JX 38, ¶ 25.)

The production, delivery and installation of System/360 required a massive effort on IBM's part, which placed a severe strain on the corporation. (Cary, Tr. 101359-60; PX 1900, pp. 4, 8; DX 4740: Evans, Tr. (Telex) 3932-34; DX 8886, pp. 107-08, 111; DX 13677, p. 5; DX 13678, pp. 6-7.) In November 1965, Watson wrote to all IBM managers: "We're carrying out an assignment that in many respects is one of the largest and most complex ever given to an industrial electronics organization--almost a complete replacement of our principal product line". (DX 8886, p. 107.) It was a task that some in IBM likened to "trying to swallow an elephant". (Cary, Tr. 101359.)

As we have discussed, IBM had to build new facilities and

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* Despite the problem, IBM's SLT output for 1965 was higher than that planned in April 1964; IBM was also able to achieve a 74% increase of production in 1966 over 1965. (Knaplund, Tr. 90943-46; E. Bloch, Tr. 91917.) In May 1966, the 2,000th System/360 was shipped. (JX 38, ¶ 27, p. 10.)

hire and train many new employees. The size of the job was compounded by the software difficulties with OS/360. IBM placed a "top priority" on the solution of those problems and, at its peak, had over 1000 people working on OS/360. Some 5000 man-years went into its design, construction and documentation between 1963 and 1966. (PX 468, p. 31; DX 13677, p. 7; see also DX 4740: Evans, Tr. (Telex) 3932-34.)

The breadth and complexity of System/360 together with the new, advanced applications for which it could be used required IBM to provide "the most extensive total programming systems support ever developed". (DX 13677, p. 7.) It also meant that IBM would have to provide customers more assistance than ever in installing, understanding and applying 360 and all its revolutionary new concepts. (Case, Tr. 73590; Evans, Tr. 101127-28; DX 1172.)

The need to expand quickly to meet the unforeseen explosion in demand for 360, to hire and train new employees and to support customers in their installation and use of the new systems placed "tremendous capital demands" on IBM. (Cary, Tr. 101525-26; DX 8886, p. 111; DX 13677, p. 5; DX 13678, p. 7.) During 1964 IBM had prepaid $160 million in debentures and promissory notes. (PX 5771, p. 36) As a result, it did not have sufficient money on hand to finance the required expansion and had to raise it. In 1966 IBM raised approximately $371 million through an equity offering, the first such offering since 1957. (DX 13889, p. 20; DX 13678, p. 39.) IBM Chairman T. J. Watson, Jr., explained to IBM's stockholders:

"Because of the plant construction program and the System/360 production build-up, 1966 required a worldwide investment of approximately $1.6 billion in rental machines and parts, factory, laboratory and office equipment, and land and buildings. To help finance this expansion in our business, additional capital stock was offered to stock holders last June. $371 million of new capital was raised in this manner."* (DX 13678, p. 7.)

In 1966 and 1967 IBM raised its lease prices and decreased purchase prices by 3 percent. (PX 4481A, p. 1.) A "major consideration" for the change was "to encourage purchase, and thus, increase the amount of cash needed to finance higher-than-anticipated demands for the 360". (PX 6153, p. 2; Cary, Tr. 101525-26.)

IBM's multi-billion dollar investment yielded fantastic rewards, changing the face of IBM and of the computer industry for all time. Chairman T. J. Watson, Jr. called 360, at the time of announcement, "the most important product announcement in company history". (PX 1900, pp. 7-8.) He could not have been more right. System/360 was a "phenomenal success", perhaps the greatest "in the history of American industry". (Cary, Tr. 101781.) As we have already seen and as IBM's current Chairman, Frank T. Cary, testified, "customers loved it", and "ordered it in quantities way beyond

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* In 1965, IBM had reported that "the plant expansion program and System/360 production required a record worldwide investment of $1.1 billion in 1965 for rental machines and parts, factory and office equipment, and land and buildings". (DX 13677, pp. 6-7.)

anything that we had anticipated". (Tr. 101781.) 360 shipments exceeded by more than double the estimates made prior to announcement. (Case, Tr. 73258.)

The effect on IBM was profound. At year-end 1963, when the production buildup for 360 was begun, IBM employed 138,281 people worldwide (PX 5771, p. 3); by year-end 1969, IBM's employment had nearly doubled--to 258,662. (DX 3364, pp. 3-4.) Over that same period, IBM's manufacturing floor space in the United States climbed from just over six million square feet to more than fourteen million square feet--more than double. (DX 13963 DX 13964 , pp. 1-3.) At year-end 1965, before volume shipment of 360 had begun, IBM had worldwide revenues of $3,572,824,719 (DX 13677, p. 5); by year-end 1970, IBM's worldwide revenues had increased more than two times, to $7,503,959,690. (PX 5767, p.3.) Just prior to the 360 announcement, IBM had approximately 11,000 systems installed in the United States. By the time 370 was announced, that number had tripled to approximately 35,000. In the interim IBM's corporate growth, revenue and profits were "way beyond anything that [IBM] had anticipated". (Cary, Tr. 101360, 101781; DX 4740, Evans, Tr. (Telex) 3934-35.)

These numbers demonstrate the extent to which IBM's success, as it stood on the threshhold of the 1970s, was the result of an overwhelming acceptance by users of System/360 and of IBM's ability to put the system into production and install it in unprecedented and unforeseen numbers. As T. V. Learson wrote in October 1966:

> "Observers have characterized the 360 decision as perhaps the biggest, in its impact on a company, ever made in American industry--far bigger even than Boeing's decision to go into jets, bigger than Ford's decision to build several million Mustangs.
>
> "IBM has certainly not been the same since, and never will be again". (PX 1900, pp. 8-9.)

36. <u>Initial Competitive Responses to System/360.</u> The System/360 announcement and its subsequent success provoked a host of competitive responses from a variety of different sources, including systems suppliers, leasing companies, peripherals manufacturers and software houses. As we discuss below, System/360 spurred the rapid growth of leasing companies, software suppliers and peripherals suppliers in particular, and each applied increasing pressure on IBM as they grew in strength. In this section, we review the more immediate actions taken by a number of systems suppliers. (These actions are discussed in more detail below, pp. 377-84.)

We saw above how, by the time of the System/360 announcement, IBM's earlier computer lines had been "leapfrogged" by competition, and how System/360 gave IBM a price/performance advantage over competitive machines. Indeed, as Knaplund testified, it was understood that the price/performance advantage of System/360 as measured by IBM employees understated the true superiority of System/360 compared to competitive offerings.* (Tr. 90503-05.) The System/360 announcement, therefore, forced IBM's competitors to reduce prices or increase performance in order to remain competitive. Weil of GE said in June 1964:

> "The entire competitive picture in the information processing business at this time in 1964 is characterized

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* According to Knaplund, the methods available within IBM at the time for making price/performance comparisons could not adequately evaluate several advantages of System/360: the use of disks, the improved reliability, the factor of compatibility and the software support. (Tr. 90504-05, see Tr. 90506-09.)

> by the impact of the IBM System/360 . . . announcement and by the reaction to this announcement of our competitors.
>
> ". . . .
>
> "The System/360 is an excellent product line with outstanding peripheral offerings." (PX 320, pp. 12-13.)

The result, according to Weil, was that it was "no longer possible to offer equipment with a significant advantage over IBM". (Id., p. 14.) In July 1964, Learson reviewed the price reductions in the industry that had taken place since the System/360 introduction and wrote:

> "There can be only one conclusion; namely, the cost/performance of computers today is less than it has been and . . . the price structure surrounding the main body of our line is threatened by: (a) Present day cost[,] (b) New technologies, as typified by NPL[.] Perhaps what we are missing is that NPL was a price reduction of 30-50%, so that competition is forced to come along with us." (DX 1525.)

And they did, with price reductions, product announcements or both. In order to be competitive, most companies tried to price their products to achieve anywhere from a 5 to as high as a 40 percent price/performance advantage over IBM's 360 line. Despite the acknowledged difficulties of comparing the performance of systems (see, e.g., Palevsky, Tr. 3269-71; McDonald, Tr. 4207), such a pricing policy was common among competitors, who felt they needed to offer something better than IBM to attract customers. (See below, pp. 377-84) IBM monitored these reactions in some detail, and undertook to respond.

a. RCA. RCA both reduced prices on its current products and shaped its planned new announcements in reaction to 360.

In approximately May 1964, according to internal IBM reports, RCA reduced the price of its 3301 between 20 and 35 percent. (PX 2956, p. 1; DX 1525; see also PX 4829, p. 19.) Within IBM the price reductions were seen as "drastic", as "the first significant competitive reaction to System/360" and as making "the 3301 very competitive in the model 40/50 area". (PX 2956, p. 1.)* Withington wrote that the "primary reason for the price reduction . . . would seem to be a requirement for a competitive product during the interim until RCA announces its 'counter-360' efforts". (PX 4829, p. 19.)

Soon after, RCA announced the Spectra 70 Series, which was designed to be compatible with the 360 line. (See below, pp. 551-58.) The preliminary design of that series had started in 1963, with "[m]ajor design efforts. . . . under way by the latter half of '64". (Beard, Tr. 8459; see p. 551 below.) The strategy of compatibility with IBM equipment had been considered prior to the 360 announcement (Beard, Tr. 9113-14), and was firmly decided "within two weeks, three weeks at the most, after the announcement". (McCollister, Tr. 9630.) By making its Spectra 70 compatible with IBM's System/360, RCA hoped to be able to persuade 360 users to move to Spectra: it was "aimed primarily at the IBM 360 series range of computers". (Beard, Tr. 8459; see pp. 552-58 below for a fuller explanation of this strategy.)

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* In July 1964, Learson interpreted the 3301 price decrease as something forced upon RCA by the "bad price/performance ratio" of the 3301 product and its failure to sell. (DX 1525.)

Within IBM the announcement of Spectra was noted in a memorandum from C. E. Frizzell, President of GPD, to T. J. Watson, Jr. Frizzell wrote that the series offered better price/performance than IBM in CPU-memory speed, magnetic tapes and high speed printing but assured Watson that he was "moving rapidly to meet this challenge and expect to respond effectively in the very near future". (DX 960.)

b. GE. Weil testified that at the time of the 360 announcement, GE assessed 360 as a "very strong and very competent" competitor to its current system, the GE 400. (Tr. 7060.) As noted earlier, his own assessment in 1964 was that it was "no longer possible to offer equipment with a significant advantage over IBM". (PX 320, p. 14.) Then he reported at the same time (June 1964) that GE was planning to announce a new series of magnetic tape units "which will permit adjustment of our 400 line system prices to increase our competitiveness". (*Id.*, p. 16.) IBM sources reported that GE did reduce prices on the 400 in reaction to System/360. Learson wrote in July 1964:

> "GE has not officially reduced prices, but they are selling their 400 line at 18% off. They have also reduced their extra shift to a 10% charge.
>
> "Further, GE is selling their 635, a competitor to the 7094, at no extra shift charge." (DX 1525.)

A September 1964 Competitive News Release from the Data Processing Division's Commercial Analysis Department confirmed price reductions of 8%-15% and went on to say, "The price reduction gives the GE 400 a price/performance advantage over comparable System/360 configurations." (PX 2966, p. 3.) However, Knaplund felt that the price reductions were necessary for GE to remain competitive after System/360. (Id., p. R1; see below, pp. 490-93.) A subsequent price/performance evaluation made within IBM concluded: "While the recent price reductions have improved GE's position, the System/360 Model 30 retains its price/performance superiority." (DX 13445.)

General Electric announced its 600 series in the summer of 1964. Although planned long before the 360 announcement to displace IBM's 7090 and 7094 computer systems (see below, pp. 493-505), GE called the 600s a "family . . . for business, scientific and real-time use". (DX 491, p. 1.) Weil had compared the 600 series against the 360 line in a June 23, 1964 internal GE presentation and concluded that the 600 is "either just a little more favorable or just a little less favorable than comparable members of the 360 series. We are, however, able to deliver our equipment a year earlier than IBM". (PX 320, p. 16; see below, pp. 493-505.)

GE saw itself as being able to capitalize on one of the risks IBM had taken with the 360--the risk involved in making the older lines obsolete. Weil testified that the computer group at GE was "initially at least overjoyed with what had occurred because it meant right at the time we were introducing a system designed to displace 7090s and 7094s, IBM had itself abandoned the 7094 and 7090 computer series and brought out an entirely different computer series, and it was our belief at that time that it would be easier, if you were a user, to convert from the 7090/7094 to the 600 series than it would be to convert to IBM's new 360 series. We regarded that as a fortuitous occurrence and potentially to our advantage." (Tr. 7060-61.) The user of the 7094 was "forced . . . to either go to a 360 or to some other competitive system, and we were sitting there with a system designed to make that conversion as easy as possible." (Tr. 7062.)

c. CDC. According to Weil, CDC also reduced prices in response to System/360. (PX 320, p. 16.) At IBM, Learson analyzed CDC's behavior as follows:

> "CDC followed [360's pricing] with a price reduction of their 3600, which was no longer competitive with the 360-Model 70. In dropping the price of the 3600, they had to keep their deck of cards in order and so moved the 3200 and 3400 downward. Reductions of 20-40% were made." (DX 1525.)

And Withington wrote:

> "Control Data's main reliance is on price; apparently its intention is to provide a lower cost answer to every System 360 model. After the System 360 announcement, the price of every existing Control Data computer was reduced, and the prices of the later models are still lower. . . . This should unquestionably help Control Data's position because . . . the market is becoming increasingly price-conscious." (PX 4829, p. 21.)

Several months later, CDC announced new members of its current product lines--the 6000 and 3000 series. The formal announcement of the 6400 (a "scaled down" 6600) and the (never delivered) 6800, to go with the existing 6600, was made in mid-December 1964. (Norris, Tr. 5626, 5965-67; DX 319, p. 1.) The 3300 and 3500 were announced in 1965. (PX 355, p. 35.)

d. <u>Sperry Rand.</u> Sperry Rand came out with new products in short order after the announcement of System/360. Two weeks after the 360 announcement, Univac management met to consider the Univac Product Line Strategy. They decided to enhance and expand the 1050 program to provide a compatible line of systems from the 1004 through the 1050 Mod V. (DX 14, p. 1.) Learson reported in July that Sperry was "announcing new models of 1050 and 1004 where the price/performance ratio is not following the historical trend in the original announcement, so they are, in effect, using this as a method of price reduction". (DX 1525.) Univac management also decided to extend the 1107 program to the 1108 and 1109, which were to be program compatible upwards with the 1107, for large scale users. (DX 14, p. 1.) In mid-1964 Sperry Rand announced its 1108 at a price which Withington described as "impressive when compared to that of the System 360". (PX 4829, p. 20.) Withington wrote that, in terms of price/performance, "IBM's initial offerings in the 360 line were inferior to it". (PX 4830, p. 22; see below, pp. 477-80.) (We shall see later IBM's response to this rather quick "leapfrogging".)

By 1965, Univac's Product Line Task Force was contemplating the introduction of an entirely new product line in reaction to System/360. It faced a dilemma in that two of the three models under development were likely to benefit from new technological developments if their development could be delayed, but waiting would have meant that a full family could not be announced at one time. (DX 16, p. 2.) Univac finally compromised and announced the

9200 and 9300 (rather than an entire family). (McDonald, Tr. 3821; DX 70, p. 9.) These systems "aimed at compatibility" with 360 (Eckert, Tr. 908) but achieved it only in part. (See below, pp. 480-86.)

e. Burroughs. Burroughs also responded with a new product introduction. In August 1964 Burroughs announced the B5500 (PX 2082, p. 95), "a more powerful successor to the earlier B 5000", and what was to become the first member of the 500 System family. (PX 4829, p. 22.) Withington described the B 5000 family as "incorporat[ing] very advanced design features, facilitating the use of compilers and executive programs", but he concluded that "Burroughs apparently has not attempted to answer the System 360 across the board". (Id.) By 1966 Burroughs had turned the 500 family into "a major new product line" (PX 4832, p. 21), adding the B 6500, 2500 and 3500 to the 5500 and the very large (and never delivered) 8500. (Id.; DX 10262, p. 8; see below, pp. 644-50.)

f. Honeywell. After the 360 announcement, Honeywell took its successful 200 system and turned it into a compatible "family of computer systems": the 120, the 1200, the 2200, the 4200 and the 8200. (DX 13849, p. 27; see below, pp. 619-29.) Honeywell also abandoned its attempts to develop a mass storage system after the 2311 introduction and began buying disks OEM.

g. SDS. SDS announced successive new products beginning in 1964 with what it termed "the first computer to use monolithic integrated circuits, the SDS 92" (DX 44, p. 5), and eventually, the Sigma series, which was announced beginning in 1966. (Palevsky, Tr.

3223-24; see below, pp. 703-04.) A press release at announcement stated that "Sigma . . . represents the first family of computers with an entirely new design since the IBM 360 announcement" (DX 52, p. 1), and, as IBM had done with 360, SDS stressed the new line's universal applicability. (See below, pp. 704-05.)

37. IBM's Responses (1964-66). With competitors responding rapidly to the initial System/360 announcements, IBM was soon faced with the need to respond in turn or lose the competitive advantage it had obtained by the introduction of System/360. It chose to respond.

IBM did so by introducing new products, improving existing products and lowering prices. This section discusses IBM's initial responses,* particularly IBM's reduction of extra shift charges, improvement of memory speeds, announcement of improved tapes and disks, introduction of the Model 20, and development of the Models 44, 67 and 90.

a. Reduction of Extra Shift Usage Charges. At the time of the System/360 announcement, IBM was charging its rental customers a flat rate for 176 hours of computer use per month--the Monthly Availability Charge, or MAC. For use beyond that number of hours, an additional use charge was billed at a rate of 40% of the per-hour MAC rates. (DX 14295, p. 44.)

One of the ways that competitors responded to 360 was by reducing or eliminating charges to customers for using machines on extra shifts. An IBM Wins and Loss Report for June 1964 cited "erosion of extra shift" as one of the most significant aspects of competitive announcements since System/360. (DX 13824, p. 2.) On July 29, 1964, Learson wrote that GE had reduced its extra shift on the 400 line to

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* IBM's planning for its future products is discussed later. (See below pp. 878-922.)

10% and was offering its newly introduced 635, "a competitor of the 7094", with no extra shift charge at all. (DX 1525.)

IBM reduced its additional use charge from 40% to 30% on August 11, 1964, effective retroactively to July 1. (DX 13823.) It was not enough, and IBM received pressure for additional reductions. On August 13, 1964, Evans and others in IBM were notified by DSD's Advanced Systems Group that:

> "We are currently facing severe competition in the medium and large scale scientific areas from such machines as the GE 625, GE 635, PDP-6, etc. A goodly part of this problem is due to our additional use charges. GE, particularly, is offering their 600 series on a 24- hour basis. Even in cases where we are price competitive on a single shift basis, we rapidly become non-competitive when additional use is involved. The 30% extra shift charge is good but not nearly enough." (DX 13640, p. 1.)

In addition, IBM was losing orders to the Honeywell 200, particularly at service bureaus. In October DPD "fought" for a reduction in extra use charges to 10 percent, this being, as Cary wrote to T. J. Watson, Jr., in the beginning of December, one of "the instances where we have 'screamed' for action". (PX 1265, pp. 2, 4.)

On October 14, 1964, IBM announced a further reduction in its extra shift charge for System/360 to 10%. (DX 14134.)

b. <u>Memory Improvements.</u> Within two months after 360 was announced it became clear that the memory speed of certain IBM systems had been surpassed by newly announced competitive machines.* A June

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* Even before the announcement of System/360, IBM had been seeking to include faster memories in certain IBM computers. Evans testified that, for the Model 60, a 3/4-microsecond memory, which he called "startling in test", had been planned. However:

1964 Wins & Loss Report cited "the fast memory speeds of [competitors'] new systems" as one of the "three most significant aspects of competitive announcements".* In particular, the memory speeds of the Honeywell H-2200, the NCR 315 RMC, the Univac 1108, the GE 635 and the CDC 3800 were mentioned. (DX 13824, p. 2.)

Haddad, then Director of Technology and Engineering, addressed this problem further in a July 28, 1964 letter to Vice President and Group Executive Gibson:

> "I am becoming increasingly concerned over the possibility that some of the 360 machines will be technically obsolete before they are delivered. With the recent round of price-cutting by some of our competitors, it is even more important that our machines remain technically superior.
>
> "There is obviously a strong trend toward the use of faster memories across the board. This is exemplified by the Univac 1108 . . . the NCR 315 . . . the CDC 3800 . . . the H2200 . . . and the RCA 3301. . . . All of these examples appear to give the competitor a memory speed advantage at an equivalent 360 machine level." (DX 13825.)

The need to improve memory speed, and with it processor price/performance, was particularly acute for the larger models of

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> "As we proceeded down the 360 development program, and so to make certain that we could deliver what we were committing, we decided in 1963 or early 1964 to use available memories that were technologies that were proven and memories that had been in production. And so instead of one Model 60 with three-quarter microsecond memory, we made 2 models at that performance range. A Model 60 with a two microsecond main memory, and a Model 62 with a one microsecond main memory and that's what we announced." (Tr. 101111.)

Similarly, the Model 70 was announced with a one-microsecond main memory because the 3/4-microsecond main memory was not yet fully tested. (Evans, Tr. 101112.)

* The other two were the "magnitude of price cuts" and the "erosion of extra shift". (DX 13824, p. 2.)

the 360 line, the 60, 62 and 70. An IBM "Wins and Loss Report" for August 1964 reported that "there have been no credited orders for Models 60, 62 and 70 since June and only a few in the uncredited category". (PX 3630, p. 2.)

Within IBM it was believed that the Models 60, 62 and 70 compared particularly poorly with CDC's new entries. On October 19, 1964, Ralph A. Pfeiffer, Jr., then Vice President and Federal Regional Manager for DPD, wrote to Cary comparing IBM's models to the CDC 6800. (The CDC 6800 had not yet been formally announced and was never in fact delivered). He stated his belief that "our model 70, with a little less than half the performance of the 6600, rents for approximately the same amount" and recommended "that DPD request a 100% performance improvement in the Model 70 with no increase in rental price and not more than a 20% increase in purchase price". (PX 1214.) On December 1, Cary recommended that the price of the one-microsecond memory on both the Model 70 and the Model 91 be reduced "in order to make our bids . . . more competitive from a price/performance standpoint". (PX 1256) DX 14504).) Those price reductions were announced on December 23. (JX 38, pp. 329-30; JX 10, App. A, ¶¶ 3, 5, pp. 2-3.)

That day, DSD President Kennard wrote to A. K. Watson:

"As you know, we have undertaken a number of actions to improve the product line and to provide specific responses to certain technical requirements. An example of this is time sharing. We have redesigned the 2362 1 microsecond memory and released new models reflecting this redesign. The net effect is a lowering of the rental and purchase price, and lower systems prices on S/360 Models 62, 70 and 91.

"We have also determined, through analysis of the requirements for peripheral I/O devices, that we could achieve substantial operating efficiencies and enhance our price performance by developing a new multiplexor channel. We have done this and combined the multiplexor function with the already announced selector channel function. The net result is reflected in a potential systems price reduction of from $5,000 to $10,000 per month. When the new higher speed multiplexor selector channel (2870) is integrated into our plan, it is apparent that the 2860 price for its function had to be re-evaluated. We have completed this evaluation, and this has resulted in a lowering of the purchase and rental price. This price adjustment has been released to DPD along with the 2870 multiplexor channel." (DX 13827.)

However, these price reductions were not enough. In December 1964 Kennard wrote to Watson and A. L. Williams that the performance of the 6400, as indicated by CDC, would place it between the Models 62 and 70 while "[f]ield reports indicate a price somewhat above our Model 50". He reported that steps were being taken to improve the competitiveness of those machines, including an increase in the memory speed from one microsecond to three-quarters of a microsecond for the Models 62 and 70. This and other improvement programs for the Model 70 and Models 60/62 were targeted for release in January 1965. (DX 14322.)

The competitive advantage of CDC 6400 and 6600 over IBM models continued to be a concern. On March 10, 1965, C. B. Rogers, Jr., then Director of Product Programs for DPD, wrote to Learson:

> "The CDC 6600 overpowers our 70 . . . for approximately the same rental. . . . The new entry of the CDC 6400 . . . clearly out-performs our Model 62 by a factor of 2 at a substantially lower price for both purchase and rental. . . . It is accurate to say we are in trouble." (PX 1389, pp. 1-2.)

By April 1965 IBM was ready to announce a faster memory: the 750 nanosecond (3/4 microsecond) memory. On April 22, IBM announced the Model 65 and Model 75, each having a memory speed of three-quarters of a microsecond. The faster performing Model 65 superseded the Models 60 and 62, and the faster performing Model 75 superseded the Model 70.* (JX 38, p. 393.)

c. Tape Drive Improvements. Soon after its announcement of System/360, IBM also recognized the need to improve its peripherals in order to maintain the superiority it had achieved in the 1950s. On August 21, 1964, the System/360 Compatability Committee reported that because of the nature of 360, peripheral manufacturers could be expected to market compatible replacements for IBM's peripherals:

> "(1) I/O manufacturers, whether independent or divisions of computer manufacturers, are in a position to market devices of comparable IBM capacities at approximately 20% less price.
>
> "(2) It appears that I/O manufacturers will attempt to sell tape drives and terminals to System/360 customers.
>
> "(3) There will probably be concerted activity from competitors in marketing I/O devices on System/360 in the Federal Government." (PX 3908-A, p. 4.)

They stated that:

> "The heretofore heavy emphasis on processor planning as the criterion for improved price/performance should be re-oriented towards I/O developments. The across-the-board improvements in price/performance which will be required in the 1967-68 time period will probably be brought about more by improved I/O capability than by CPU and memory improvements. As part of the regular development effort, such activity will be necessary in any event to keep System/360 a viable product line . . . ." (Id., p. 22.)

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* IBM did not limit its memory improvements to its larger models. On January 4, 1965, IBM announced that the memory for the Model 30 had been improved, from two microseconds to 1-1/2 microseconds. (See PX 1288, p. 2; PX 1637, p. 2; DX 14135.)

Technological improvement was additionally important, the Committee reported, because

> "competitors will attempt to market I/O devices, with particular emphasis on tape drives, directly to 360 users." (Id., p. 24.)

Tape drives, in particular, were an area that needed improvement. A presentation to the DP group staff in November 1964 by a group headed by C. J. Bashe entitled "Group Staff Review of IBM's Technological Position in the Marketplace" summarized IBM's position relative to its competitors from the viewpoint of research and development. That presentation reflected IBM's unparalleled commitment to R&D and showed that IBM, in comparison to CDC, Burroughs, NCR and Sperry Rand, had consistently devoted a larger portion of its revenues to research and development. (PX 6671, p. 5.) Nevertheless, it showed areas in which IBM was not ahead. The report concluded:

> "We are ahead of competition in some but not all of the technology areas critically important to system performance. We do not have an unassailable position of leadership in any function." (Id., p. 27.)

It recommended attention to "box-by-box superiority" and concluded that half-inch compatible tape drives was an area in which IBM was "inferior". (Id., pp. 15, 26-27.)

A General Managers' meeting was scheduled by Knaplund for December 4, 1964, at which technical managers were expected to report on action plans to solve the problems in the areas in which "IBM must take immediate action to attain technical superiority". One of the topics was "[a] superior performance 1/2" tape drive to be announced in 1965". (PX 1251 (DX 14503), p. 1) This was considered necessary because:

"We're outclassed in half-inch tape and apparently can't sell one-inch tape equipment. We need a tape drive that is superior in performance and acceptable." (Id., p. 4.)

A week later, on December 11, a Peripheral Task Force reported. This group considered the use of small systems to control peripherals, as in tape-to-printer or card-to-tape applications. Such applications were common applications for the 1400 series computers and it was expected that the 360 Model 20 and Model 30 would also be used for such purposes. But the Task Force believed that IBM had a problem and could "expect to lose approximately 500 systems [in that application area] by the end of 1965 with the presently announced product line", with losses expected to continue thereafter. To minimize such losses, the Task Force recommended the announcement of the 2400 series tape drives on the Model 20 "immediately" and stated:

"Low Cost Tape should be announced on the Model 20 primarily to satisfy the longer term problem (after 1965)."

Further:

"Low Cost Tape on the Model 30 is required to provide more competitively priced configurations particularly to those customers requiring 1401 compatibility." (PX 1271, p. 3, see pp. 6, 8, 12, 14.)

IBM's fears about its lack of technological superiority in tapes were made even more immediate by additional actions of its competitors. On December 11, 1964, the same day the Peripheral Task Force issued its report, C. E. Frizzell, President of GPD, reported to T. J. Watson, Jr., on the recent RCA Spectra 70 announcement. He listed among the "significant advantages" of the Spectra 70:

> "One-third higher speed magnetic tape drives at equivalent rentals compared to IBM. . . . Availability of magnetic tapes on the Model 15 gives them a magnetic tape system in a price range where we have no current entry." (PX 1272 (DX 960), p. 2.)

Honeywell, CDC and GE tape drives were also a problem. On December 22, T. V. Learson wrote to T. J. Watson, Jr., concerning "out-performed, out-priced market areas". He listed "low cost tape systems" as one of these and stated: "This is largely the Honeywell 200 story". He called for "[t]apes on the 360/20 [to be] immediately announced". (PX 1288, pp. 1-2; see DX 13955, p. 4.)

IBM improved its tape drives in two steps. The first step was the announcement of the 2415 tape drive and control unit on April 5, 1965. (JX 38, p. 377.) The 2415, a lower cost unit for the Models 20 and 30, solved the tape drive needs of users of those models. The second and more important step was the announcement on August 9, 1965, of the 2401 Models 4, 5 and 6 tape drives and control units. These 2401s incorporated several advantages in tape technology including: 1600 bit per inch density, phase encoding recording and twice the data transfer rate of IBM's earlier models. (<u>Id.</u>, p. 484.)

For the time being, IBM appeared to have solved its problems in tapes with the new 2401s and the 2415. (PX 4256; DX 13950, p. 2.) Soon, however, competition, particularly from PCMs, would push IBM to improve its tape drives even more. (See below, pp. 886-90.)

d. <u>Disk Drive Improvements.</u> As we have seen, IBM made the disk drive an integral part of its System/360. (See above, pp. 323-28.) The 2311 disk drive, announced as part of System/360 (JX 38, p. 86), was "the first very reliable disk drive". (Beard, Tr. 9048.) Competitors initially were unable to offer a similar product. (Case, Tr. 72744; see also Withington, Tr. 56240-41.)

For several years prior to introducing the 2311, IBM had marketed the 2302, which was a drum-like file with very high capacity. The 2302 was larger than the 2311, but with not as much versatility as the 2311. Soon after System/360 was announced IBM found that

> "it was beginning to be apparent that customers had a far greater need for data stored in disk drives than we had anticipated a year or two earlier when System/360 was under development and when the 2311 disk drive was first introduced." (Case, Tr. 72742-43.)

Thus, IBM needed a disk drive larger than the 2311 to replace the 2302 and supplement the 2311. (PX 3226A, p. 4.)

Against that background IBM introduced its 2314 for two reasons: first, since the 2314 would be larger than the 2311 it would "provide a better relation to competition than the 2302 files". (Id.) Second, because the improved price/performance of the 2314 would improve the overall system performance of 360 systems on which it was used, "the 2314 was announced . . . to sell more 360 systems". (Id., p. 5.)

IBM announced the 2314 on April 22, 1965. (JX 38, p. 439.) The 2314 "[v]ery definitely" represented an advance over prior disk drives. (McCollister, Tr. 9597.) Compared to the 2311, the 2314 provided an increased capacity of four times per spindle (Case, Tr. 72742), an improvement of two times in data rate (id.), and the ability to operate on-line. (PX 1967 (Tr. 35690).) Beard, who then worked as Chief Engineer of RCA's computer division, testified that while "the 2311 demonstrated the reliability" of random access devices, "[t]he 2314 not only offered the reliability but also a practical cost for the random access user". (Beard, Tr. 9049.)

The superiority of the 2314 provided substantial benefits to IBM. The 2314 "turned out to be very surprising in the rate that customers found use for it". IBM "totally underestimated the demand for such devices" and was "hard pressed to deliver the devices as fast as customers were demanding them". (Case, Tr. 72743.) It also had the desired effect on systems sales:

> "The availability of the 2314 has been the catalyst to make many systems sales for previously undeveloped application use of computers." (PX 1967 (Tr. 35690).)

And:

> "The 2314 is an example of where the product developed a market beyond our initial forecast expectations. Every company should have a door-opener that beats competition--the 2314 is such a product and will continue to be only if our pricing policy can stand the challenge of competition." (<u>Id.</u> (Tr. 35692).)

Withington echoed the advantage which the 2314 gave IBM over its competitors:

> "During that period the entire industry and the users began to appreciate the importance that disk drives were going to play in the great majority of general purpose computer systems. . . . I believe only IBM among the major competitors at the time offered an alternative between magnetic card devices and disk drives, with developments proceeding along both lines. . . . When it became apparent that the class of magnetic card devices was not going to be successful in the marketplace, for reasons of reliability, and that the disk drive was a critical product, many of IBM's competitors were left for awhile without a satisfactory option." (Tr. 56240-41.)

e. <u>Introduction of the Model 20.</u> IBM's success with its 650 and 1401 had shown that small, low cost computers were important because they helped grow the market by permitting users who otherwise might have been unable to afford them to obtain computer systems. (See above, pp. 39-44, 141-47.) In the face of that experience, the SPREAD Committee had recommended that IBM develop a "very small" processor, even though such a processor might not be fully compatible with the rest of the 360 line. (DX 1404A, pp. 35-36, 69 (App. A to JX 38).) The development of such a small processor was assigned to the World Trade Corporation's German laboratory in Stuttgart. (Hughes. Tr. 71942-43; Knaplund, Tr. 90478.) In early 1964 that small processor was judged "not to be as far advanced in development as the Models 30 through 70", and it was therefore not announced with the rest of the 360 line in April 1964. (Knaplund, Tr. 90489.)

The need for a low-cost computer was evident within IBM. A document of April 15, 1964, entitled "Forecast Assumptions for the 1430N Data Processing System" (the 360/20), stated:

> "The 1430N Data Processing System will offer the advantages of stored programming to customers and prospects for whom mechanization of data processing has heretofore been either impracticable or confined to conventional punched card equipment.
>
> "The 1430N, which will have a subset of the NPL instruction set, will be the smallest member of the System/360, and will benefit strongly from the impact of the recent announcement of the NPL line.
>
> "This system will bring the world of the System/360 down to the price range the small user can afford.
>
> "For the first time a new technological breakthrough, like the one realized with SLT for the System/360, will be made available at lower cost to the small customer at the same time as to the larger user.
>
> "The 1430N system offers growth within the system and upward growth into the System/360, Model 30." (DX 13829, p. 1.)

Even though, as this suggests, the 360/20 was in large part expected to be acquired by new users, it was anticipated that a variety of customers would find it attractive, including:

"(1) Small companies characterized by one accounting machine installations [sic].

"(2) New customers in this size range.

"(3) Larger unit record customers who have not yet moved to a system. In some cases, these customers will use multiple 1430N systems. Others will use a 1430 along with some unit record equipment.

"(4) Users of large data processing systems who still have a considerable amount of unit record equipment installed. In these cases, the 1430N would replace some or most of the unit record equipment supporting the larger systems.

"(5) The Communications Market. This market will be characterized by customers having a number of branch locations requiring frequent and/or prolonged contact with the central data processing center or among each other." (Id., p. 2.)

After the announcement of System/360, the need for the Model 20 increased. On July 20, 1964, Opel wrote to Learson concerning banking product deficiencies and stated that "[w]e need to have a more competitive response to the [Univac] 1004 and other competitive small card processing systems". (DX 14477.) Writing after the announcement of the Model 20, Withington observed that IBM had to announce "such a computer to protect its position" from "the Univac 1004 and 1005, the Honeywell 120 and the GE 115". (PX 4830, p. 20.)

IBM announced the Model 20 on November 18, 1964. (JX 38, p. 296.) Because of the need to keep its cost down, the processor did not share all the features of the 360 line. First, the Model 20 contained only a subset of the 360 instruction set and, hence the

Model 20 was not compatible with the rest of System 360 to the extent that the other members of the System 360 line were compatible with each other. (Case, Tr. 73575; JX 38, p. 297.) Second, the 360/20 did not use the System/360 standard interface for attaching peripherals and instead used "native attachment". (Hughes, Tr. 71992; Case, Tr. 74085.) This was done so that IBM could offer the 360/20 at a more competitive price:

> "In order to achieve [the lowest possible price], you have to have the lowest possible cost to the manufacturer, and in order to achieve that it is sometimes necessary and was in the Model 20 necessary to design a special unique means of attaching disks to the Model 20, because using the standard interface for that purpose on the Model 20 would have been more expensive and would have therefore unnecessarily increased the price of the Model 20." (Case, Tr. 74085.)

The Model 20 announcement stated that it was "a System/360 for card processing . . . a stored program approach for smaller business needs". (JX 38, p. 296.) As noted above, however, IBM's forecasts for the Model 20 anticipated many potential users other than small users. The 360/20 was in fact used in a variety of ways by a variety of users. For example, an IBM Competitive Daily Report stated that "[t]here are about 600 Model 20's installed with communications equipment and 700 installed in large customer accounts". (PX 3773, p. 2.) And Wright testified that a sample configuration of a multiprocessor Model 67 system contemplated the use of 360/20s in connection with the Model 67 in various ways including as concentrators for terminals. (Wright, Tr. 13348-49.) Similarly, DX 4851, a memorandum on the GUIDE Project on Remote Batch Computing of February

1966, contemplated a large 360 as "the central facility" of a system in which "[t]he remote terminals may be small typewriter keyboards; but, more likely, will be Model 20 360's, Model 30's, or even larger machines with their own operating systems". (DX 4851, p. 5.) "The bulk of the terminals planned for use would be small computers[,] mostly 360's Model 20 or 30." (Id., p. 6.)

As it turned out, the 360/20 was more than merely a good competitive response; like the 1401 in its day, it became the largest selling of the 360 systems with more than 7400 installed in the United States by 1970. (DX 2609B, p. 182.)

In December 1965, Withington summarized the effect of IBM's competitive responses:

> "Soon after the System 360 line of computers was announced, it became apparent that despite the basic soundness in the line there were a few deficiencies and weak points. IBM, apparently desiring to establish a product position now that will remain sound for a number of years, has moved very vigorously to remedy the deficiencies. It has announced new products to add to the line, improved the price-performance of the initially announced products, and adjusted marketing policy in certain respects.
>
> ". . . .
>
> "The 360/20 extends the line downward in price, while still retaining most of the features of a full-scale computer system. Considering the appearance of the Univac 1004 and 1005, the Honeywell 120 and the GE 115, one had to expect IBM to announce such a computer to protect its position in a market area representing important dollar volume. It should be effective protection; the 360/20 offers very competitive price-performance characteristics. . . .
>
> ". . . .
>
> "The 360/65 appeared when it was clear that the initial 360's at the 'top of the line' could be bested by the competition. The 360/65 cannot, at present; it offers price-performance as good as anything on the market. . . .

". . . .

"When pressed by competition, IBM has also made significant improvements in the previously announced products --even before delivery of the first models. The 360/30 initially showed a price-performance characteristic inferior to those of some of its competitors, so IBM increased its speed sharply by substituting a faster memory at no increase in price. The initial terminals and control devices for remote input-output were too expensive, so IBM has supplemented the initial offering with a number of lower-cost devices. Perhaps most important overall, IBM increased the packing density of all its magnetic tape units from 800 characters per inch to 1600, at a small increase in price, by using a new recording technique. This factor is important to the overall productivity of most computer installations, so the entire 360 line benefited considerably. The competitors will be able to match this improvement, but for the time being IBM's position is improved." (PX 4830, pp. 20-21.)

f. The Model 90 Program. As we have already discussed, during the 1950s IBM undertook a number of leading edge development projects designed to advance the computing state-of-the-art. Each of those programs (such as the 701, SAGE, NORC, STRETCH and various projects for NSA*) was a response to the needs and demands of users (predominantly government agencies) who required computing capabilities beyond the most advanced then available. All of the projects advanced the computing state-of-the-art and, in so doing, substantially benefited computer users and helped serve the nation. In addition they proved extremely valuable to IBM by serving as training grounds for future IBM managers and engineers and proving grounds for important new concepts that were incorporated into subsequent IBM computer products (See pp. 68-78, 126-35, above.) With the first STRETCH computers commencing shipments in 1961, IBM began work on its next "super computer". (DX 4775.)

The SPREAD Report contemplated the development of a "very large processor" beyond that which could easily be made compatible with the rest of the line. (Brooks, Tr. 22713-14; Knaplund, Tr. 90477-78, 90517; DX 1404A, p. 16 (App. A. to JX 38).) Work on the "high end" was under way even as the SPREAD Committee was meeting. As Brooks testified: "at any point in time there was somebody working on a machine beyond the fastest one we had; in any project there should be somebody looking for a successor to it". (Brooks, Tr. 22844.)

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* The NSA projects are discussed at length in the classified NSA stipulation which is DX 3420A, at ¶¶ 79-86, 333-369.

"In January 1961, a general review was made in IBM of the state-of-the-art in components and organizational improvements, with the goal of making a successor to STRETCH. . . . In August 1961, the program was designated Project X (ten times STRETCH)." (JX 10, ¶ 5.) A general timetable for development was decided upon, and deliveries projected for 1966 or 1967. Responsibility for Project X was given to the Data Systems Division in October 1961. Development of the Project X computer, which was later redesignated "Project 604" and which ultimately became the 360/90 program,* proceeded throughout 1961-1963. (JX 10, ¶ 5.) The Model 90 program was an effort to "push technology" and build "the most powerful computer" possible at the time. (Knaplund, Tr. 90571-72; PX 1034; PX 1036; PX 1041.)

The impetus for the Model 90 program was much the same as the impetus for IBM's earlier efforts to "stretch" the state-of-the-art. Beginning in 1961 and carrying through the Model 90 announcements in 1964 and 1965, an increasing number of "leading-edge" customers requiring advanced solutions to complex computing problems began "pressing" IBM for systems with higher performance than IBM then had available. (Wright, Tr. 12903-94; JX 10, ¶¶ 4, 9; PX 1061.)** Not surprisingly, as it had in the 1950s, a good deal of this pressure

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* The Model 90 program consisted of the System/360 Models 2092 I, 2092 J, 2091 and 2095. (JX 10, ¶ 1.)

** Such customers included the Atomic Energy Commission (AEC) facilities, the Weather Bureau, various universities, and the National Security Agency (NSA), as well as private research organizations. (JX 10, ¶¶ 4, 7, 9, 13.)

came from the Federal government:*

> "Because of its need for more and more computer capability, the government has encouraged EDP suppliers to advance the state-of-the-art. For example, in the past 20 years, the total computing power within AEC supported facilities has on the average almost doubled each year. AEC has encouraged EDP manufacturers to advance the state-of-the-art because of its requirements for advanced computers. Throughout its history, AEC has acquired some of the most advanced computers available." (JX 10, ¶ 15; see Knaplund, Tr. 90920-21; PX 1061; Plaintiff's Admissions, Set IV, ¶ 37.0, 53.0-.6, 82.0; DX 7518, Mount, pp. 63-64.)

In the climate of the early 1960s, such demands were not taken lightly. As Dr. Robinson, IBM's Director of Scientific Computing testified:

> "At that time in history, the President of the United States and the people at large had dedicated themselves towards a substantially higher level of scientific and engineering and technological achievement than the country had experienced prior to that time due to a variety of considerations, including the Russian success in areas of technology and science, and a national goal had been stated relative to the need for the country to achieve great leaps forward in various areas of science and technology." (Tr. 23049.)

Knaplund testified that in August-September of 1963 "IBM top management was deeply concerned that IBM's efforts had not yet developed a competitive offering for a number of very large and influential users, especially the federal government laboratories for atomic energy research, weapons development, space exploration and weather research, and defense contractors to the government".** (Knaplund,

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* According to Knaplund, government users and contractors were "right in the forefront" of customers who had the "largest and most demanding computational requirements and therefore needed the most powerful computing equipment". (Tr. 90921.)

** "Mr. T. J. Watson, Jr., and others expressed concern that IBM was not responding adequately to the needs of the United States

Tr. 90518-19; see Wright, Tr. 12897, 12893-94.)

Development of advanced, state-of-the-art computers was not only in the nation's interest, but in IBM's self-interest as well:

First, as demand for such capabilities increased, so too did the potential business opportunity in meeting those demands. Thus, in August 1963, T. V. Learson wrote:

> "I am informed that a machine 10 times 7090 has a market of some 53 machines. If the market is anywhere near this number we will be committing a very serious crime in not moving Project X . . . at a more rapid pace". (PX 1040; see also Norris, Tr. 5617; Wright, Tr. 12893-94; Brooks, Tr. 22718-19; Knaplund, Tr. 90920.)

Second, there was promotional value in being able to offer the world's most powerful computing capabilities to solve the problems of highly advanced users. As Wright testified:

> "[I]f you could take one of those leading edge customers, or prestige, if you want to use that term, and get him to use a data processing system to solve a new problem that other people had not yet solved, then generally many other people would follow his leadership and use the data processing system in a similar way to solve a similar problem." (Tr. 12899-900; see also Dunwell, Tr. 85840; PX 1041; PX 1082; PX 1160.)

Third, the opportunity to work on projects at the technological leading edge of the industry offered a powerful incentive for

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Government for advanced EDP systems in connection with the Government's high priority defense and related programs". Thereafter, he ordered that IBM inquire of government users directly to make certain that their needs were being taken into account in IBM's "super computer" (Model 90) development, and ordered acceleration of development efforts on a more powerful computer than even the Project X computer. (Knaplund, Tr. 90519-20.)

the best young talent to come to work for companies who undertook such projects. These projects therefore served as important training grounds for future employees. IBM's experience on SAGE and STRETCH had provided ample proof of the benefits to be gained in that respect. (Dunwell, Tr. 85549-50; Crago, Tr. 85979-80.)

Fourth, "super machine" development held the promise of substantial future value which would be realized through the incorporation of new learning in later products. (Eckert, Tr. 836-37; Lacey, Tr. 6657; DX 13526, Forrest, pp. 106-07.) This benefit, although quite tangible, was difficult to quantify in advance. IBM's experience on STRETCH had shown that, although high technology projects might lose money when all the costs of research were allocated to them,* they could still turn out to be very profitable in terms of "technological fallout". (Gibson, Tr. 22593; Case, Tr. 73606-08; Dunwell, Tr. 85791-94, 85880-82; Hurd, Tr. 86595-98.)** "Many of the technological developments made in the STRETCH program were of significant benefit to other IBM programs." (JX 10, ¶ 3; Case, Tr. 73606-08; Dunwell, Tr. 85538-49; Hurd, Tr. 86592-93; E. Bloch, Tr. 91485-89; DX 3171; DX 8923.)/ Thus, T. J. Watson, Jr., writing to IBM

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* One of the problems in trying to evaluate the profitability of a program like STRETCH is that the value of technological fallout was not credited to the program nor were the costs allocated to the benefited products under IBM's internal method of cost allocation. (Knaplund, Tr. 90526-27; JX 10, ¶3.) That value had to be taken into account in deciding whether to embark on a like program.

** That view was held outside of IBM as well. (See DX 5423, Smagorinsky, p. 94; DX 13526, Forrest, pp. 106-07.)

/ In a letter written to Thomas J. Watson, Jr., on April 8, 1964, Stephen Dunwell, who had been Manager of Project STRETCH, called System/360 the "image of STRETCH" because of all the 360 features which first appeared in STRETCH. (DX 3171.)

President A. L. Williams in May 1965, stated:

> "Although four or five years ago there was some doubt as to whether or not we should continue to try to lead in this area because of expense and other considerations, at some point between two and three years ago, it became evident that the fallout from the building of such large-scale machines was so great as to justify their continuance at almost any cost. Therefore, for the past two years, under Vin Learson and Dick Watson, this subject has had the highest priority, at least in the upper areas of the management of the corporation." (PX 1469.)

There were many others within IBM who felt the same way. For example, Dr. Gibson, then IBM Vice President and Group Executive, testified that one reason for undertaking the Model 90 program had been that

> "the designing, building and operation of such an advanced computing system had, in the past, and was believed would continue to provide very valuable experience in programming, in architecture, in reliability and in technology". (Tr. 22644.)

And Dr. DeCarlo, IBM Director of Systems Research and Development, wrote in June 1964 concerning the Model 90 program:

> "We can be intuitively sure that the technological benefits which will flow from this commitment will filter through the rest of the product line. Surely there can be no doubt the STRETCH program spawned highly successful financial programs". (DX 7692, p. 3; see also McCarter, Tr. 88408; DX 1141.)

Although these reasons for embarking on the Model 90 program antedated the announcement of the CDC 6600,** CDC's announcement

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** The CDC 6600 was publicly announced in July 1962 (JX 10, ¶ 4) but was discussed with customers earlier. (Norris, Tr. 5934, 5938; DX 308; DX 309; DX 310; DX 13526, Forrest, pp. 191-97, 205-06, 225-30, 232-42, 245, 504-08, 570-74, 580-81.)

brought the importance of that program home to IBM management with greater force. STRETCH had maintained IBM's lead in the large scale, advanced computer field. (Dunwell, Tr. 85736, 85741-42; see also PX 1469.) Within IBM, the CDC 6600 caused concern about IBM's industry leadership in state-of-the-art computing and about the perception of IBM's role by its customers. In August 1963, T. J. Watson, Jr., wrote:

> "Last week CDC had a press conference during which they officially announced their 6600 system. I understand that in the laboratory developing this system there are only 34 people, 'including the janitor.' . . .
>
> "Contrasting this modest effort with our own vast development activities, I fail to understand why we have lost our industry leadership position by letting someone else offer the world's most powerful computer." (PX 1045.)

The matter of computers having very advanced capabilities was a "top priority" among the subjects discussed at the September 5, 1963, IBM Executive Conference in Jenny Lake, Wyoming. (JX 10, ¶ 7.) These discussions included "what actions could be taken by IBM to catch up to and surpass CDC in the area of very high performance computer systems". (Knaplund, Tr. 90519-20.) IBM Research was instructed by IBM's Chairman

> "to ensure that IBM does have clear leadership in the computer field--meaning a computer which is sufficiently far ahead of any other computer--that it will maintain that position of leadership and prestige for at least three or four years after announcement". (PX 1049.)*

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* Watson, himself, wrote one month later:

> "As leader in the industry, I don't see how we can afford any other position than having the most powerful machine on the market. . . . [W]e should promptly commit ourselves to a machine of sufficient power so that our leadership will be unquestioned". (PX 1051.)

DSD was instructed to move ahead "as fast as possible" with Project X (which was already planned to have twice the capability of the CDC 6600) and Research was instructed to accelerate its work toward a machine with ten times the capability of Project X. (JX 10, ¶ 7; see also Knaplund, Tr. 90520; PX 1021; PX 1036; PX 1041.)

While there were reasons independent of CDC for undertaking the Model 90 program, CDC's growing success spurred IBM to advance the pace of the program by increasing the time and resources allocated to it. (JX 10, ¶ 8; PX 1021; PX 1041; PX 1082; PX 1204.) Nevertheless, the Model 90 was not announced with the rest of the 360 Series on April 7, 1964, because Paul Knaplund (who was responsible for bringing before IBM management recommendations concerning the number of processors to be announced with System/360) "did not feel that the Model 90 had progressed far enough to warrant a general announcement". (Knaplund, Tr. 90520-21; see also DX 9080.)* The first Model 90s--the 2092 I and 2092 J--were announced on August 17, 1964.**

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* Customers were informed, however, "that the Model 90 development effort was under way. That information was supplied in a footnote to the System 360 announcement". (Knaplund, Tr. 90521; JX 10, ¶ 1.)

** No Model 92s were ever delivered. It was superseded by the 91 and 95, which had improved memories. (JX 10, ¶ 31.)

The Model 2091 was announced in November 1964.* (JX 10, ¶ 1.) Each of the Model 90 systems delivered to customers performed well and to customers' satisfaction and passed acceptance tests imposed by the government where such testing was performed. (McCarter, Tr. 88413; DX 3162, DX 3167, DX 3224, DX 3266.)

The first Model 90 computer was delivered nine months late because "IBM encountered unexpected, substantial and critical problems in the Model 90 circuitry (ACPX) in 1965". These circuit problems were "a major reason for the slippages in the delivery of the Model 90 computers." (JX 10, ¶ 30; see E. Bloch, Tr. 91940-43; JX 10, ¶ 33.)** The principal problem, known as the "cracked stripe problem",

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* Product Test non-supported these announcements because it could not perform its standard type "announcement testing". (JX 10, ¶¶ 17, 21; PX 1177.) McCarter explained:

> "To do this [to undertake the Model 90 program] it was necessary to work closely with customers to understand their needs. This requirement for customer involvement meant that public disclosure of intention and negotiation with individual customers had to precede the development of a product to a level where Product Test could conduct announcement testing. Hence, the Model 90 program was not susceptible to the kind of product testing applied to other parts of System 360." (McCarter, Tr. 88409.)

According to Knaplund, because of the "very advanced technological nature of the program" IBM management placed "primary reliance" on the judgments of IBM's top technical people in proceeding with the announcements. (Knaplund, Tr. 90523-24.) After deciding not to announce in April 1964 but before deciding to do so in August 1964, IBM management had already received information from the National Security Agency that the (ACPX) ASLT circuitry on which the Model 90s depended was feasible. (See the classified NSA Stipulation, DX 3420A, ¶¶ 387-415, especially ¶¶ 403, 411-415.)

** Advanced computers have frequently been delayed because of unforeseen problems. (JX 10, ¶ 34.)

could not have been foreseen because it appeared only when a sufficiently large number of components had been put together in an operating machine. (Gibson, Tr. 22640-41; E. Bloch, Tr. 91940.) That problem was discovered much earlier than it would otherwise have been because of the high current densities in the Model 90 circuits. As a result IBM was able to correct the problem on the rest of the 360 line before most had been built and to inform the rest of the industry about the problem before they ran into similar difficulties. (Case, Tr. 73594-95.)

Discovery and solution of the cracked stripe problem was an example of the kind of technological fallout expected from the Model 90 program. As that program proceeded, additional fallout resulted from developments in

- thin film technology (Gomory, Tr. 98273-75; JX 10, ¶ 32; DX 3164);
- monolithic circuitry (Case, Tr. 73593; JX 10, ¶ 32; DX 3164);
- transistor technology (JX 10, ¶ 32);
- packaging technology (Case, Tr. 73593; JX 10, ¶ 32; DX 3164);
- interconnection technology (DX 3164);
- memory technology (PX 3050; DX 3164); and
- machine organization (Case, Tr. 73593; PX 3050).

Although the anticipated technological fallout from the Model 90 program was realized, the 90 series did not fare well competitively. Only 15 Model 91s were manufactured (four for internal use) and two Model 95s were manufactured "specially for NASA".* (JX 10, ¶ 35.)

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* By contrast, "CDC manufactured 94 Model 6600/6700 computers and 121 additional 6000 Series computers". (JX 10, ¶ 36.) Mr. Norris, Chairman of CDC, called the 6600 "particularly" successful. (Tr. 5849-51.) And in 1969, CDC Vice President, J. W. Lacey, speaking to a CDC graduate orientation class, said that CDC was widely recognized to have "a world-wide leading position in large computers"--an area which CDC was able to "dominate" after delivery of the 6600 in 1964. (DX 438, p. 7.) According to an IBM offer of proof (DX 1185, pp. 3-4.) CDC's revenues and gross profits between 1964 and 1972 from the sale and lease of 6600s exceeded CDC's targets, and although DX 1185 was not received in evidence, we rely on it because it is consistent with the other evidence more fully set forth below in the CDC history.

g. <u>The 360/44</u>. As discussed above, one of the risks in providing a line of computers like System/360 intended to do all applications equally well was that, for some applications, at least, the machines of the family would be less suitable for some customers than competitive machines, optimized in their design for such applications. Additionally, there was a risk that not all customers would be willing to accept the "overhead" associated with System/360's highly functional systems software--that some number would attempt to locate alternatives with less function and better price/performance.*

For some (certainly not all) users in such areas, this turned out to be true. Knaplund testified that:

> "In the months following the System 360 announcement, marketing personnel began to report that, although many users found the System 360 products adequate for data acquisition and data reduction, some felt that a general purpose processor more tailored to those specific applications would be required. The Data Processing Division urgently requested that the Product Group undertake development of a system to meet these needs." (Tr. 90539.)

The need for a competitive response became increasingly apparent during the latter part of 1964 and into 1965. Learson wrote to Watson in December 1964 concerning the acceptance of the Models 40 and 50 in the "Intermediate Scientific Area": "Our position here since announcement in April, 1964 is that we have won 44, lost 44, and have 172 doubtful situations. CDC and SDS have a total of

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* In this context price/performance means strict throughput per dollar leaving aside questions of function, reliability and service.

five machines which out-price, out-perform us by a good margin". (PX 1288, p. 2.) This was just one of many cries for a competitive answer. (See PX 3615; PX 3630; PX 3566; PX 1439A.)

In August 1964, DSD began a program (called the "42S") whose objective was to develop a processor "within the general architecture of the System 360 family" but with better price/performance than the Models 40 and 50 for "data acquisition, data reduction and certain scientific calculations."* (Knaplund, Tr. 90539.) That program culminated in the announcement of the 360/44 in August 1965. (PX 1589A.)

The Announcement Letter described the Model 44 as "a powerful computer . . . designed specifically for the small to medium-sized scientific user . . . ideally suited for customers and prospects who want raw binary speed and high throughput to solve a wide range of scientific problems, including high speed data acquisition jobs". (PX 1589A, p. 1; see also Knaplund, Tr. 90539.) To reduce costs and achieve the "raw binary speed and high throughput" needed for this "lean, hard system", some sacrifice in compatibility with the rest of

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* In April 1965, Knaplund wrote that, "The performance needed [in the Model 44] approaches the Model 50. The system price required is close to that of the Model 30". He went on to say:

> "Wherever possible within the framework of our main thrust price/performance curve . . . we must and will bend every effort to preserve complete compatibility for marketing, as well as programming reasons. But when an anomalous performer is required, we must be prepared at all times to offer lean, hard systems with slight incompatibilities, if these incompatibilities help mitigate impact and/or cost.
>
> "Such is the case with the Model 44 . . . ." (PX 1439A.)

System/360 had to be made.* (Knaplund, Tr. 90540; PX 1439A; PX 1538; PX 1589A, p. 1.) The required cost savings were achieved "by eliminating read-only storage through the utilization of hard-wired logic for the interpretation and execution of stored program instructions, by reducing the number of instructions directly executed by this hard-wired logic, by simplifying the checking logic and by taking advantage of lower component costs". The required performance increase was achieved "by using hard-wired logic in place of read-only storage and by including within the processor a single disk storage device known as RAMKIT for program residence." (Knaplund, Tr. 90540.)

Apart from its inability to execute the complete System/360 instruction repertoire,** the 360 Model 44 was "basically the same" as the other 360 processors. (PX 1541, p. 6; see also PX 1589A.) A "New Product Programs Status Report on the Model 44 Program", dated one month prior to the announcement, even indicated that the 44 would

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* The IBM Product Group Policy for Processor Architecture (released July 30, 1964) envisaged the need for deviations from compatibility in order to "keep pace with systems technology and market requirements". Exceptions from the rule of compatibility were permitted only to achieve cost or performance improvements greater than 10%. (DX 9036.) The improvement anticipated in this instance "substantially exceeded 10%" and was therefore "consistent" with the Policy. (Knaplund, Tr. 90540.)

** Even this difference could be eliminated, albeit at some sacrifice in throughput. At announcement, IBM offered as an RPQ an extended instruction set package (implemented primarily by software) which eanbled the Model 44 to execute the "full range of System 360 instructions". (Knaplund, Tr. 90541; PX 1589A, p. 1.) In 1968, an improved version of this feature was provided. According to the announcement letter this "Commercial Feature" offered approximately a 20% improvement in internal performance compared to the prior RPQ. (PX 3563A.)

be manufactured in the same facility as the Model 40 and that schedule restraints would require the substitution of Model 44s for production of Model 40s "on a one-for-one basis." (PX 1541, pp. 4, 6.) This substitution never happened because additional manufacturing capacity sufficient to meet the demand for both Model 40s and 44s was authorized prior to the Model 44 announcement. (Knaplund, Tr. 90542; DX 1154; DX 1155, p. 2.)

The Model 44 was not particularly successful. It failed by a wide margin to meet the level of acceptance forecasted at the time of its announcement. (PX 2163A, p. 4; PX 2419, pp. 6-8.) At least to some in IBM, it appeared that this was because IBM had learned to meet customer needs generally, but had not successfully learned to specialize within that talent. Thus, Opel, who at the time was IBM Vice President and Assistant Group Executive, Plans and Controls, wrote in 1967: "Why has this happened? Are we unable to plan, build, and market a specialized machine?" (PX 1974.) And again, in August of that year: "It seems to me that when we specify a product for a limited market, it fails. Perhaps this is due to the way we sell or, perhaps it is due to the realities of market acceptance. I'm not sure which." (PX 2099; see also PX 3555.)

In part, however, the Model 44 was unsuccessful because it was relatively quickly outperformed by later systems of competitors. By the end of 1967, at least some in IBM believed that "hardware performance was excellent at announcement time, but recent competitive announcements have now bypassed the Model 44". (PX 2125, p. 48.) That situation continued to worsen so that by 1970 one group in the company wrote: "As a result of being consistently outperformed by the XDS Sigma 5, PDP 10 or CDC 3300, the Model 44 is seldom proposed." (PX 2567, p. 93; see PX 2871A.)

h. <u>The 360/67.</u> The SPREAD Report called for the New Product Line to be communications-oriented, multiprogramming systems that would be capable of performing time sharing.* (Brooks, Tr. 22859-60; DX 1404A, pp. 12, 18, 19, 24, 26, 33 (App. A to JX 38).) That objective was met, and 360 as announced included time-sharing capability.** (Brooks, Tr. 22859-60; Knaplund, Tr. 90532-33.) However, a number of highly sophisticated customers with advanced requirements rejected 360's time-sharing approach and demanded

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* Time sharing refers to "the use of a computer by many people at once with each user having the illusion that he is the sole user of the computer". (Perlis, Tr. 1862-63; JX 1, p. 115.)

** This was not the beginning of IBM's involvement in time sharing. IBM participated in a number of time-sharing development efforts before System/360 was ever announced. For example:

-- Both SAGE and SABRE were rudimentary time-sharing systems. (Wright, Tr. 13664-65; Crago, Tr. 85975-76.)

-- In 1960-61, Dr. Gerrit Blauuw of IBM designed a "dynamic address translation unit" which was a predecessor for the dynamic relocation hardware (Blauuw Box) used in the Model 67. (Brooks, Tr. 22866; Wright, Tr. 13332.)

-- In the "early sixties", IBM developed a system that would execute FORTRAN programs interactively and edit them--one of the "important efforts" in adapting a batch processing language to time sharing. (Perlis, Tr. 2042-43.)

-- In 1963 MIT, working with IBM, implemented CTSS (which Perlis called "the first example . . . of a general purpose time sharing system") on IBM 7090 series systems. (Perlis, Tr. 1881; see also Brooks, Tr. 22739-40; Morse, Tr. 30986.) CTSS was described by Perlis as a "creative masterpiece". (PX 299.)

Additional time-sharing work, including work on the design of relocation hardware, was ongoing in various IBM research labs. (See Wright, Tr. 13325-28; Knaplund, Tr. 90533; DX 4823.)

time-sharing facilities not available with System/360, specifically dynamic relocation hardware.*

In early 1964, Project MAC** at MIT sought proposals for the development of "an extremely advanced timesharing system". (Weil, Tr. 7108.) IBM bid a multicomputer configuration of a System/360 Model 50; CDC bid a 6600; RCA bid its 3301; GE bid a 635; and Univac bid "a complex multiprocessor system" then being designed for a classified military weapons system. Digital Equipment Corporation bid "a multiprocessor version of its PDP 6 computer" and was "in among the finishers". The winner was General Electric and, in addition, "a $1 million PDP-6 was purchased by MAC as a peripheral processor". (PX 2961, pp. 1, 3, emphasis omitted.) GE won with a "modified" version of the 635 and "proposed working jointly with [MIT] in the development of the software that would reside on that hardware". (Weil, Tr. 7111-12.) MIT "had determined that System 360 would not satisfy their needs and that they would accept only a system incorporating some form of dynamic relocation hardware". (Knaplund, Tr. 90533.)

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* Dynamic relocation hardware provided a "means for interrupting a program at an arbitrary point, moving it out of core, proceeding with the interruption, bringing the interrupted program back into memory at a new location, and starting it again". (PX 1194A, p. 3; see also Weil, Tr. 7287-88; Wright, Tr. 13331-32; Knaplund, Tr. 90532-33.)

** Project MAC was an advanced research project in time sharing funded by the Advanced Research Projects Agency (ARPA) of the Department of Defense. (Wright, Tr. 13288-89; Weil, Tr. 7111; DX 5613, pp. 2-3.)

Shortly thereafter, Bell Labs also ordered a time-sharing system from GE. (Weil, Tr. 7116-17.) Rooney testified that, after the MIT and Bell Labs orders, within IBM "there was a great deal of talk about the need for such a system in our line". (Tr. 11747.)

In mid-August 1964, IBM formed the Time Shared Task Force

> "to develop an IBM plan for time shared systems . . . because of the loss of the MAC account at MIT and other critical customer situations in the area of real time, time shared systems requirements". (PX 3502, p. 1.)

The task force was comprised of individuals in IBM "most knowledgeable" about remote computing and time sharing, who in turn scheduled meetings with a number of the leading experts in the field such as Professor F. J. Corbato (of Project MAC), Dr. J. C. R. Licklider (of ARPA), Mr. J. Schwartz (of SDC) and Dr. B. Galler (of the University of Michigan). (PX 3502, pp. 3-7.)

In early September, Nat Rochester, a member of the Task Force (PX 3502, p. 2) wrote to C. H. Reynolds, the Chairman:

> "System/360 has been almost universally rejected by the leading time sharing investigators. Time sharing systems are likely to render obsolete systems that are not based on time sharing. Therefore, there is a legitimate worry that System/360 may not be a resounding success unless proper steps are taken." (PX 1194A, p. 1.)

He stated that "the commonest reason the customers give for rejecting System/360 for time-sharing is that there is not adequate hardware support for dynamic relocation", even though "dynamic relocation is not actually required for time sharing". (<u>Id.</u>, p. 3.)* IBM was being

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* This was also the view of Fred Brooks, chief architect of System/360, who held the opinion that dynamic relocation hardware "was unnecessary for time-sharing or any other purpose". (Brooks, Tr. 22743.) That is why such hardware was omitted from System/360. (See also Knaplund, Tr. 90532-33.)

told that

> "customers want dynamic relocation. It may be unnecessary and undesirable but we have not yet proved that this is so. The technical situation is very unclear and is changing rapidly on a month by month basis as technology advances." (Id., p. 4.)

Reviewing the "rejection of System/360" by those desiring time sharing, Rochester concluded:

> "There is much more at stake than these few prestige accounts. What is at stake is essentially all computing business, scientific and commercial . . . . we may find eventually that many of the best programmers will refuse to work at an installation that does not offer timesharing or offers inferior time sharing." (PX 1194A, pp. 2-3.)

He recommended that IBM "proceed with the design, construction and release of an advanced timesharing system," and that the work be done in public "so as to benefit from external criticism and so as to have a favorable sales effect". (Id., p. 1.)

Two days later, the Research group of the Task Force reached the same conclusion: "System/360 has been rejected or is about to be rejected by many of the important large-scale scientific users who are pioneering novel ways of using computers such as the 'computer utility'. This has been accompanied by a shift of attention to competitive equipment like the GE 635." (PX 2811, p. 1.) They also believed there was "a great deal more at stake":

> "The earlier concept of 'time-sharing' has now naturally led to the 'computing utility' concept. This means that computing capacity should be available right at the working place of the computer user by means of a terminal linked to a powerful central computer. . . . There is a very strong probability that the 'computing utility' will be the way of all scientific computing in a few years, and a good possibility that it will capture a substantial part of the commercial market as well. IBM cannot afford to overlook a development of this scope. We are currently in danger of losing all contact with the leading developers of this concept." (Id., pp. 2-3.)

The Research group recommended that "if IBM is to keep its present competitive position in the marketplace", IBM must

(a) "immediately undertake a long range study of the 'computer utility' concept";

(b) "undertake an immediate all-out educational effort to explain the capabilities of System/360 and its operating system for the multiprogramming applications involved in most teleprocessing and communications-oriented systems (where dynamic relocation is not required)";

(c) "undertake a project with the objective of offering and supporting a complex 'utility type' system requiring multiprogramming, multiprocessing and time-sharing with System/360"; and

(d) "to make this intent clear", announce "a multiplexor channel and hardware-aided dynamic core relocation capability <u>at once</u> for Models 60, 62 and 70". (PX 2811, pp. 4-5, emphasis in original.)

It was thought that only by implementing these recommendations would IBM be able to retain its "position of leadership which threatens to slip from us as a result of the independent development of the utility concept to which we have only belatedly directed our attention". (PX 2811, p. 7.)

In mid-September 1964, IBM's Scientific Computing Department reported on "remote scientific computing" to the Task Force:

"There exists in the market place a set of key leader accounts representative of the scientific market segment.

These accounts are invariably the innovative and experimentally-oriented accounts. They are the industry's spokesmen on the advanced state of the art in computing. They materially affect computer acquisition decisions in a variety of smaller establishments--both scientific and commercially oriented. . . .

". . . In general, the accounts in the set number over one hundred. They consist primarily of AEC computing laboratories, large University laboratories, large research laboratories of industrial companies, the independent non-profit laboratories, and certain aerospace establishments.

". . . .

"Today, a subset of this market, led by key university and certain closely related laboratories, has taken a fancy to the so-called area of remote computing. . . .

". . . .

"IBM's posture has been one of silence. In the remote scientific area we have been at a severe disadvantage because we have not made available sufficient information regarding our operating system for 360. It has not been stated to what degree the operating system will support time-sharing. We have also not stated what additional support, if any, will be available for time-sharing.

"Our time-sharing prospects require responses to the specific functions they have posed as requirements. The balance of the remote scientific community needs to know our responses in this regard as well as more detailed information about operating System/360.

"Certain accounts have already been lost. A small set of key accounts are right now in the process of evaluations leading to computer acquisition decisions. For every such case, decisions disadvantageous to IBM appear to be in the offering. In quantity, such losses do not appear to be large. In quality, they will have a tremendous impact upon a very large market segment. . . .

"If we do not respond on the time-sharing requirements in the near future, the time-sharing market will be largely lost to GE who has responded to this requirement. A large part of the balance of the remote scientific market will also be in jeopardy. . . ." (PX 2964A, pp. 4-6.)*

The report foresaw that the competitive threat would not be limited to GE:

> "We can expect similar emphasis on time-sharing system design from the other competitors. The experience of Burroughs with the D 825 and of Remington Rand with the M 490, 1218, and other special forms of real-time computers designed primarily for the military, have provided them with the experience necessary to develop well-honed second generation systems designed for general-purpose use. CDC has also had experience in the design of real-time systems. Furthermore, the system study efforts being conducted by CDC and ITEK at McDonnell Aircraft, General Dynamics and Lockheed, in the area of computer-aided design, will ultimately result in the announcement [sic] generally marketable equipment to compete with Alpine and, to a broader extent, the 2250 and its successors. The Digital Equipment Corporation is actively marketing the PDP-6 as a time-sharing system at extremely competitive prices. Although no real manifestation of intent has been made by RCA and Honeywell, the ultimate gravitation of the market toward general-purpose time-sharing systems will encourage all manufacturers to develop a product and support plan.
>
> ". . . The growing emphasis in the scientific and engineering market must ultimately effect [sic] the system selection process among so-called commercial users. . . .
>
> ". . . .
>
> "The advent of cost-justified, time-sharing business on centrally located systems should have an explosive effect on the service bureau business. This business is characterized today by the presence of a great many users located remotely from central facility. To some extent, the current business in service bureaus is limited by turnaround time. Most service bureau customers who install their own equipment do so because of the delays introduced by access to a centralized location and service." (Id., pp. R28-29.)

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* As we explain elsewhere, GE was at this time a corporation with corporate-wide annual revenues in excess of $5 billion--a "sleeping giant" to be sure, but one with the resources and technological capability to become a major force in the computer industry. (See below, pp. 488-90.)

In sum, the whole market, in all its dimensions, would be affected by the need for advanced time-sharing capability.*

The conclusions of the Task Force were buttressed by feedback from the marketplace.' For example, Hart testified that through the joint study activity which General Motors Research had with IBM,

> "we vigorously provided input to them about what our needs were and the importance of doing this job right, and what we believed was the right way to do it. . . . [w]e went to meetings and presented our case, and we, I suspect, did it loudly and with great conviction. Because, if we were going to provide a suitable time sharing environment to support our graphic consoles, then we needed to have certain capabilities available in order to be able to do that adequately." (Tr. 80278-79.)

In late 1964 or early 1965, Dr. Ivan Sutherland, Director of Information Processing Techniques for ARPA, contacted V. O. Wright of IBM "eight to twelve" times to discuss the topic of time sharing:

"He spoke words of encouragement, encouragement in the

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* The importance of time sharing to the computer market as a whole was perceived outside of IBM as well. For example, Project MAC and GE both believed that the computer field would evolve toward "an information utility". (Weil, Tr. 7116.) Various members of the computer field within the ARPA network (such as MIT, Stanford, Stanford Research Institute, Lincoln Laboratories, SDC, Rand Corporation and the University of California at Santa Barbara) believed that time sharing "was important" and should be pursued. (Perlis, Tr. 1968-69, 2043-44, 2054-55.) In 1965, Withington wrote that the "market for time-shared computer systems and applications" was "large and growing". He predicted that, within five years, such systems would represent a "significant part of the total computer market. In fact . . . the great bulk of the computer market. . . ." (PX 4830, p. 14.)

fact that he believed that IBM should pursue development of the timesharing concept in products and software as a matter of not only great importance to the United States government, but also of great importance to IBM and he simply encouraged and wanted to be kept aware, sort of as an insider, of how things were going on the project.

"[I]t was my understanding that his interests were the fact that he believed providing timesharing facilities to the Department of Defense contractors in design of new weapon systems, and use in other things, including health systems and so on, would, in fact, foster the use of computers, but more importantly from his standpoint, would assist in the solving of problems that these people in their research and development activity were confronted with and the use of computers would facilitate the solution of those problems at a more rapid rate and therefore accelerate the advancement of technology.

"[I]t was clear that he felt that two large companies, such as GE and IBM, pursuing developments in time sharing, was beneficial to the government, was beneficial to industry and, therefore, that he thought that was a good situation." (Wright, Tr. 13287-92.)*

IBM marketing people, too, were "raising an increasing amount of clamour, putting an increasing amount of pressure on the

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* Sutherland wrote the following on September 4, 1964, shortly after GE had been selected over IBM for Project MAC:

"Project MAC's decision in favor of G.E. has generated a very healthy spirit of competition between MIT/GE and IBM. In effect, Project MAC has stated publicly that the IBM product is inadequate and that MIT/G.E. can do better. MIT/G.E. must produce the best system they can in order to make good their claim. IBM must expend its best effort to show that its product can serve the needs of time-sharing. In fact, IBM has been slow in responding to the needs of interactive computer users; now we can expect IBM to show more interest in this field. Competition between IBM and MIT/G.E. is a good thing; it will stimulate rapid progress in the time-shared use of computers.

". . . .

marketing management of IBM" to provide "a product response that would let us be more responsive to our customers' requirements and to our customers' demand". (Wright, Tr. 12799.) By November 1964 Wright in the GEM region and others within IBM became concerned that the time-sharing movement would build "to a great ground swell", "impact" IBM's installed base of equipment and result in "a great deal of churning of the installed base, that is, the return of products that IBM had installed because of the requirement for a new capability in a computing system". (Wright, Tr. 12802-07.) According to Wright, he and his marketing colleagues were "trying to make sure that IBM was the leading producer, vendor, for data processing equipment and . . . that IBM did not fall behind". (Tr. 12807.) A response was needed "to the customers who were pushing us very hard to provide a product answer to their requirements." (Wright, Tr. 12807.) It was clear that others would provide that response if IBM did not. (Wright, Tr. 12843-45; PX 2964A, pp. R28-29.)

One of the catalysts for such response was the Lincoln Labs Request for Proposal which came in November 1964. (Wright,

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"ARPA must support Project MAC fully. The MIT personnel responsible for choosing G.E. equipment have made their best technical judgment. They are staking their professional reputations on their choice. In making a decision against IBM, they have stimulated IBM to new efforts. Were ARPA to reject the MIT decision, Project MAC would suffer a blow from which it might never recover, and IBM would be able to relax." (DX 894.)

Tr. 12813.) At the same time, an RFP was received from the University of Michigan for a "central, timesharing facility". (DX 895.) Watts Humphrey, IBM Director of Time-Sharing Systems, wrote to Learson on November 15, "[t]he list of accounts who have interest in Time Sharing is growing daily. . . . By the end of the year, I expect that this number will exceed thirty." (PX 1238A, p. 4.) Company prestige, as well as current and future business, was on the line. (PX 1191; PX 1246A.)

The messages from the field were heard by IBM management. Knaplund testified that reports from DPD in late fall of 1964 revealed that a number of "very influential and highly competent users"* agreed with the MIT analysis of System/360 and viewed dynamic relocation as being "crucially necessary" to a broad variety of new and advanced applications--a feature that would "accelerate and improve the efficiency of their internal system development and

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* These users included MIT's Lincoln Laboratory, General Motors Research, the University of Michigan, Carnegie Tech, Bell Labs, Rand Corporation, Stanford University and Ohio State University. (Knaplund, Tr. 90534; PX 2811, p. 1; PX 1194A, pp. 2-3.) IBM Chairman (then DPD President) Frank Cary testified concerning the Model 67 and time sharing:

> "[S]ome of our very, very best customers wanted it. . . .
>
> ". . . .
>
> ". . . I can just tell you that when customers . . . like AT&T and the Federal Government and the universities and General Motors Research . . . ask us to respond, we certainly at least try to respond to them. And we didn't undertake that with any thought that we weren't going to be able to do it." (Tr. 101808-09.)

programming activities". (Knaplund, Tr. 90534.) Knaplund, Hume, Learson, A. K. Watson and others concluded that "an intensive effort was urgently required to review the area of time-sharing and develop a plan for meeting this requirement". (Knaplund, Tr. 90534-35; Cary, Tr. 101808-09; PX 1246A.)

In November, a group reporting directly to T. V. Learson and A. K. Watson was set up under the leadership of Watts Humphrey to try to respond to the time-sharing requirement. V. O. Wright (who was made Director of Time Sharing Marketing) was called to Learson's home on the Saturday after Thanksgiving Day in 1964 and told to begin work that afternoon. According to Wright, Learson said that "the resources of the company were available to us for whatever we needed in order to move this development forward". (Tr. 12793-95, 12814-15; Knaplund, Tr. 90535; PX 1318.)

Starting in December 1964, IBM made time-sharing proposals to Lincoln Laboratory and "a limited number of other users in order to enhance our ability to learn and understand time sharing". (Wright, Tr. 12842-43.) According to Wright:

> "IBM at that point in time was looking at this whole development as sort of a learning vehicle or process, if you would. There were a great many things about time sharing capability in a computer facility that IBM did not understand . . . and we went about it on the basis that we wanted to develop a product that would satisfy Lincoln Laboratory and perhaps a few other selected customers, and that . . . development, would be used, then, as a learning process for IBM to understand what really a time sharing system ought to be, what the facilities and capabilities should be, both in hardware and in software." (Tr. 12825-26.)

IBM delivered its system to Lincoln Labs "four to five months later than had been originally proposed". Although it did not have all the functions originally proposed and did not perform as rapidly as had been anticipated, Lincoln Labs was able to use it as a time-sharing system. (Wright, Tr. 12829-33.) Wright believed, considering the fact that it was "the first of a development program", that Lincoln Labs was "reasonably satisfied with the product". They

> "expressed some dissatisfaction in the beginning, and as they continued to work with the product and we continued to work with them in the product, they became more satisfied and the expression of dissatisfaction was eliminated". (Wright, Tr. 12832-33.)

After the Lincoln Labs proposal there was a "great deal of demand" for IBM to propose similar products to others. (Wright, Tr. 12842.) Perlis testified that he and others at Carnegie Tech pressed IBM to provide "the same kind of time sharing service that MAC was developing" and were telling IBM that time sharing was "important" and "that what MIT and General Electric had joined together to do was the wave of the future". (Tr. 1963-69.) Others in the ARPA community did the same. (Perlis, Tr. 2054.)

IBM selected certain users who were believed to have "the capability of using a development system" and agreed to propose to "a limited number" in order to enhance its time-sharing knowledge. (Wright, Tr. 12842-43.) From January 1965 forward, IBM worked with a group of customers nicknamed the "inner six"--the University of Michigan, Lincoln Labs, Bell Labs, SDC, Carnegie Mellon University and General Motors. These institutions were selected to act as "consultant or adviser to the group developing the 67" because they were "the most knowledgeable and could make the greatest contribution to [IBM's] designing a product that would fit the requirements of [the] user community". (Wright, Tr. 12905-08; see also Hart, Tr. 80293.)

Although IBM had originally intended to propose to only six to eight customers "to enhance [its] experience base in the use of the product", that number was increased "because of the great pressure that built up in demand from users and from the IBM marketing organization". By October 1965, 63 proposals had been made.* (Wright, Tr. 12843.)

And IBM was still quite concerned that its competitors would steal a march:

> "[A] great many users . . . felt that time sharing offered them some additional capability that they needed. . . .
>
> "In some instances they would contact or write a letter to one of the IBM top senior executives. In other instances they would talk to their salesmen in their facilities, and so on, wanting a proposal, wanting to understand what IBM could do to satisfy this requirement.
>
> "And all during this period of time, in general, the industry was in a state of agitation because time sharing appeared that it might indeed be a new wave of the future from the standpoint of computing facilities for a company or an institution.

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* In early 1965, IBM received and responded to requests for proposals from NASA, Lewis and various other government agencies (including certain national security agencies). (Wright, Tr. 13316-24; DX 901.)

". . . .

"[T]here was clearly . . . an understanding that if IBM for some reason did not respond to this particular requirement of customers' need, . . . it was very likely that those customers might very well buy such capability from somebody else.

". . . .

"[T]he significance would be that IBM would lose business and that part of the installed base that IBM had at that point in time would disappear." (Wright, Tr. 12843-45.)

In March 1965, IBM announced the System/360 Models 64 and 66 "for limited bidding". (PX 6209.) With the availability of improved memory for the Model 65 in April, the Models 64 and 66 were withdrawn and replaced by the Model 67,* which was also released "for limited bidding". (PX 1427.) Wright, who was the Director of Time Sharing Marketing from November 1964 until fall 1965, agreed that "every time sharing system proposal made by the IBM Corporation during that time" received his close personal supervision. One or more people "with technical qualifications examined each such proposal . . . to ensure that IBM could provide those functions" and there was a Review Committee whose approval was required before the proposals were submitted. (Wright, Tr. 13334-35.)

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* The Model 67 was simply a Model 65 CPU, modified by the addition of a "Blaauw Box" (relocation hardware). (Wright, Tr. 13357; DX 898.) The Model 67 could be run as a Model 65 and "many" Model 67 users did so by running OS part of the time and TSS the rest of the time. (Brooks, Tr. 22760; PX 2029, p. 1.)

IBM was "very careful to be sure that all of our customers, the people who had orders, knew in fact the status of the program, what might be a problem, if it existed at that time, and how we were progressing." Moreover, because the customers involved were among the most sophisticated users, they "were able to understand the technical problems associated with the development effort". (Wright, Tr. 13336-37.) The customers "understood that the Model 67 was a research and development project and that things would change as they went along", but they were "willing to compromise on some of the things that we said would be included in the product and give them up if we could not produce them". (Wright, Tr. 12881-84, 13359.)

The Model 67 had its special bid restrictions removed and was announced in August 1965 for delivery in 1966, with the TSS operating system scheduled for delivery beginning in June 1967. (DX 898, p.2.)* The problems of developing TSS were substantially greater than IBM or the customers had foreseen. (Perlis, Tr. 1981-82; Knaplund, Tr. 90538; see also DX 13448.) Wright testified that when he left his job as Director of Time Sharing Marketing in November 1965, he believed there was "some" risk of slippage in the software, but "good progress was being made in the development of TSS" and

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* Product Test issued a "formal" non-concurrence with the announcement, although it believed the program was "in good shape". The non-concurrence was resolved by management. (Wright, Tr. 13352-54, 13667-68; Knaplund, Tr. 90536-37; McCarter, Tr. 88416-17.) The difficulties which the 67 eventually experienced were unrelated to Product Test's reasons for non-support. (McCarter, Tr. 88418.)

"the program would be accomplished . . . as it was described at the time". (Tr. 13360.) By July 1966, however, the number of lines of TSS code had "approximately doubled", largely because of "the fact that the degree of automatic operation of the system and particularly its ability to protect users from each other and from system failures is a great deal more complex than had been anticipated". However, the first release was still expected to be "relatively solid in terms of schedule". (PX 1826, p. 2.)

Problems continued to develop. In August 1966 IBM announced a delay of 45 days in the release of the initial TSS package. (PX 3471.) Further, in the fall of 1966, shortly after learning of performance difficulties with the TSS software, IBM made calls on its 360/67 customers to explain the situation and to inform them that certain functions were being decommitted and schedules delayed. (Wright, Tr. 12876-78, 13363-66; see also DX 897.) Wright testified that everybody had been informed and understood that this might occur:

> "All the customers understood that it was a development type of a project, it was a development of a system that was to some extent breaking new ground, . . . and everybody understood that there might be changes. . . ." (Tr. 12879, see also Tr. 13364-65.)

Hart testified that General Motors Research was kept fully informed of the problems that IBM was having with TSS. (Tr. 80294.)

In the meantime, GE was experiencing similar problems. GE's efforts at Project MAC were aimed at developing a software system called MULTICS, which was to be implemented on an advanced version of the 635, called the 645. (Weil, Tr. 7227-28.) GE announced the 645 to the public in the fall of 1965, when neither the machine nor the software was in existence. (Weil, Tr. 7232-35.) Before the end of 1966, GE withdrew the 645 from marketing because it

> "began to realize that what we had on our hands was a research project and not a product. . . . We were attempting to do something that had never been done before, and, in principle, we might end up discovering that it was not feasible. As it turned out, it was hard and slow, but it was feasible." (Weil, Tr. 7234.)

Weil described the GE 645 as "being in the research project stage" until 1969 or 1970. (Tr. 7234-35.) In fact, the GE-MIT MULTICS operating system was never delivered by GE; Honeywell, after the merger with GE, completed development of the software three years behind the original schedule. (Weil, Tr. 7232-33; Wright, Tr. 13375-76, 13673-74.) These problems arose because "the participants in the Project MAC effort underestimated the difficulty of successfully developing MULTICS". (Weil, Tr. 7232.) As GE's Weil testified:

> "The technical task that was being attempted was extremely sophisticated and many of the subjects were at the state of the art as it was then known, and it took a long time to iron out the details of implementing some of these important features." (Tr. 7232-33.)

The 645 was never delivered and Project MAC received, instead, a system designated the "636". (Wright, Tr. 13375-76.) Rather than providing GE with the "top-of-the-line prestige lustre" which had been expected, the 645 provided "very little to General

Electric except a drain on its resources". (Weil, Tr. 7236.)*

IBM did not give up on TSS or the Model 67.** Release 1 of TSS was made available by IBM in October 1967. (DX 3282A.) By April 1969, IBM had delivered a "substantially improved" version of TSS which was "considered to be an excellent software programming system". (Wright, Tr. 12842, 13375; DX 905; see also Hart, Tr. 80296-300, 81961-63; Cary, Tr. 101809.)†

The Model 67 was not widely accepted, and by year end 1970, only 52 Model 67s had been installed by customers. (DX 2609B, p. 182;†† see Cary, Tr. 101809.) However, the experience that IBM gained with the Model 67 and TSS proved invaluable. Evans testified that when he returned to SDD from FSD in 1969,ø he launched an effort

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* IBM's difficulties with TSS and GE's with MULTICS were hardly unique in the industry's development of large operating systems, particularly for time sharing. GE also encountered problems with its GECOS operating system. (Weil, Tr. 7215-19; see also Withington, Tr. 56727-31; below, pp. 501-03.) As we discuss below, so did many others. (See pp. 479, 568-72.)

** The magnitude of the task was so great, however, that IBM did consider withdrawing the Model 67 at one point. (PX 1955 (DX 13866).)

† That view was not universally held. Perlis testified that "TSS is working today", but that it never delivered the "work load" that Carnegie "expected that it should". (Perlis, Tr. 2118-19.)

†† We are aware that DX 2609B is not in evidence but we rely on it for the number of Model 67 installations because it is a sworn statement by an IBM corporate officer based upon IBM's accounting books and records.

ø Evans believed that his being sent to FSD was in some measure a punishment for failing to have dynamic address translation hardware incorporated into the design of System/360 from the start. (DX 4740: Evans, Tr. (Telex) 3950.)

to get dynamic address translation hardware, the hardware which is key to virtual memory systems,* put into the 370 plan. (PX 2487A, p. R2; DX 4740: Evans, Tr. (Telex) 3937-41.) Evans was successful, and virtual storage capability became a staple of all 370 systems announced after August 2, 1972. (Cary, Tr. 101809-10.) Moreover, virtual memory function was incorporated in 370 "in almost exactly the same way as the Model 67". (Case, Tr. 73403, 73612-13, 73578-79; Cary, Tr. 101809-10; see also PX 2487A, p. R2; DX 8066.) Thus, the Model 67 development produced hardware and software that became important elements of IBM's computer systems for the next ten years.

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* Virtual memory or virtual storage is a combination of hardware and software which allocates to the machine itself the task of moving data into and out of main storage from auxiliary storage. Virtual storage greatly simplifies the programmer's task because it relieves him from the burden of having to make sure that his data will fit into available main memory space at all times. For programming purposes, virtual storage gives auxiliary storage the appearance of being main memory. (DX 4740: Evans, Tr. (Telex) 3943-54.)

38. Educational Allowances. Universities had played a key role in the beginnings of EDP in the 1940s and 1950s ("[t]he first computers were conceived and built at universities . . ."(DX 5504, p. 15)), and a close working relationship had arisen between academicians and EDP manufacturers.* Also, during the 1950s and 1960s, many colleges and universities, supported in part by the National Science Foundation and other government agencies, greatly expanded their utilization of computers. (Plaintiff's Admissions, Set II, ¶ 641.2.)** The number of campus computing centers grew from 40 in 1957 to 400 in 1964 (DX 5504, p. 15), and, as the Rosser Report (DX 5504)≠ acknowl-

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* For example, as noted earlier, Eckert and Mauchly, the developers of ENIAC, did their early work at the Moore School of the University of Pennsylvania. (Eckert, Tr. 712-15.) John von Neumann, whose papers contributed to the development of the modern stored program concept, was a member of the Institute of Advanced Study at Princeton and later a consultant to IBM. (Hurd, Tr. 85614, 86599-600.) Herman Goldstine, one of von Neumann's closest collaborators, joined IBM around 1958 (Gomory, Tr. 98154), and became IBM's Director of Mathematical Science in IBM's Research Division. (JX 5, p. 57.) In more recent times, Phillip McC. Morse, Director of MIT's Computation Center, is a member of CDC's Board of Directors, and Harold Brown, President of the California Institute of Technology, is a member of IBM's Board of Directors. (PX 5779, p. 33; Morse, Tr. 30961.)

** As early as 1956, the Atomic Energy Commission was giving grants to universities in order to support the use of computers. (DX 5424, Pasta, pp. 11-13.) By 1963, at least eight government agencies contributed to the support of computers in colleges and universities: National Science Foundation, National Institutes of Health, Atomic Energy Commission, Advanced Research Projects Agency, NASA, Air Force Office of Scientific Research, U.S. Army Research Office and Office of Naval Research. (DX 5504, p. 43.)

≠ The Rosser Report, published in 1966, was the work of an ad hoc committee, the Committee on Uses of Computers, appointed by the National Academy of Sciences. J. Barclay Rosser of the U.S. Army Mathematics Research Center of the University of Wisconsin chaired the Committee. The Report estimated that in 1964, colleges and universities had about $250 million worth of computer equipment installed in those 400 centers. Universities' annual EDP budgets were comparable to the costs of running their libraries. (DX 5504, p. 15.)

edged, computers were becoming more and more important on the nation's campuses:

> "Campus computers are used by an increasing number of students either to do homework or laboratory problems, or to learn about the design and operation of computers themselves.
>
> "Campus computers, like laboratory equipment, are needed to do research. They increase the effectiveness of other scientific equipment and permit many scientific studies of a scope and depth heretofore unattainable." (DX 5504, p. 15.)

While in 1957 computer costs represented only 3% of all university research and development costs, by 1963 the percentage had more than tripled to 10.04%. (DX 5504; p. 66.)

But government funding was insufficient to support the growth in computing which universities were experiencing during that period. Computer equipment was expensive, and universities could not afford it without additional help. In 1963, for example, colleges and universities spent about $97 million on computers. About half of that came from federal sources, and colleges and universities themselves were able to pay for about 34%, a shortfall of 16% remained to be provided from other sources. (DX 5504, pp. 18, 21.)

In order to make up that shortfall, colleges and universities turned to computer equipment manufacturers for help. (Morse, Tr. 30965.)* The business equipment manufacturers had historically offered

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* DX 5462, a listing of Requests for Computing Hardware compiled by the National Science Foundation, lists 366 proposals from 175 educational institutions from 1957 to 1967 asking computer manufacturers for free or discounted equipment. (DX 5462, p. 20.)

special discounts to universities,* and that practice was continued. For example, when asked to explain why Burroughs offered educational discounts, Macdonald testified:

> "First of all, it appears that it's been an industry practice for a very long time. . . . [A]long with that, the educational institutions appear to have grown accustomed to this practice and remind us of it should we forget, and it is practiced by our major competitors and it seems to sort of satisfy the general social pressure that educational institutions should be treated in a kind of special category as far as pricing is concerned." (Tr. 6986.)

Thus, the pleas were generally successful:

> "In the recent past, operating costs for computer centers have increased too rapidly for the usual university financing. . . . This difficulty has been partly alleviated by the generous educational contributions offered by some of the manufacturers . . ." (DX 5504, p. 20.)

Helping universities acquire and use computers was clearly in the self-interest--or, as DeCarlo of IBM put it, "enlightened self-interest" (DX 7514, p. 8)**--of computer manufacturers. The use of computers at universites was an important means of gaining the widespread acceptance of the new technology. It offered the promise of overcoming some of the ignorance, fear and uncertainty about computers

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* For example, National Cash Register Co. offered educational discounts on cash registers and accounting machines at least as early as 1929. (DX 347, p. 2.) Similarly, Raymond Macdonald, chief executive officer of Burroughs, testified that the educational allowance "practice was in effect when I joined the business in [the] mid-1930s." (Tr. 6986.) IBM offered educational discounts in the mid-1930s on equipment to be used for teaching and research. (JX 28, ¶ 11.)

** According to DeCarlo, "The evolving patterns of corporate support of education predicate corporate giving on the basis of enlightened self-interest, a concept that serves to illuminate the mutual nature of corporation-education relationships. The long range interests of IBM and education coincide in important ways." (DX 7514, p. 8.)

by training the new generation in their use.

There were more direct potential impacts. The infant industry was suffering from an acute shortage of people who were trained in computing; educational discounts would help alleviate that shortage. According to the Rosser Report:

> "[Educational discounts were] first instituted because the manufacturers realized that they would have trouble selling computers unless people capable of using them were available. To encourage the training of such people, manufacturers gave discounts to schools offering courses related to computers; the more courses, the greater the discount." (DX 5504, p. 44.)

Also, as more and more people became knowledgeable about computing, additional applications for computers would inevitably be created, and the market would grow. The Rosser Report described that phenomenon as follows:

> "[U]niversities can draw upon the talents of their students, the best minds of each generation, at a time when these minds are alert, inquisitive, and full of fresh ideas. Because a university can bring these minds into contact with the computer in an atmosphere conducive to research and imaginative thinking, it can stimulate bold and original ideas for improving the computer and making better use of it. There is, therefore, great value in supporting such activity in universities." (DX 5504, pp. 28-30.)

In addition, some people believed that computer manufacturers would derive a positive public relations return from an active program in support of higher education. DeCarlo of IBM believed, for example, that "beyond fulfillment of 'corporate citizenship' responsibilities there is significant potential for public relations return on the education support investment". (DX 7514, p. 6.)*

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* Some people thought that such a "public relations return" would include students who, having been trained on computer equipment of a

For those reasons, IBM and other vendors offered a variety o: support to educational institutions. IBM offered educational allowances of varying percentages depending on whether the equipment was to be used for administrative or instructional purposes, and IBM also donated computer time to universities under circumstances that would ensure that the time would be made available to a wide variety of students.* In addition, manufacturers, especially CDC, offered research grants** (Norris, Tr. 5647), "buybacks" of computer time≠

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particular vendor, would later be inclined to favor that equipment. (See, e.g., Hangen, Tr. 10448-49; Rooney, Tr. 11880 ("[W]e felt it was advantageous to have the students in the university become acquainted with computers by first utilizing RCA equipment.").) Other evidence, however, suggests that any such advantage was more apparent than real. (See, e.g., Perlis, Tr. 2033; Morse, Tr. 30985; Andreini, Tr. 47880-82.) As Wright testified:

> "If you train a person on the use of a computer, he has an easy time going to some other manufacturer's computing system and adapting to that particular computing system. The fact that he was trained on an IBM system does not lock him into an IBM system and he is, therefore, able to handle another system." (Tr. 12910.)

* In the mid-1950s, IBM established data processing centers on the campuses of MIT and UCLA on the express condition that any student from any college in the Northeast could apply for time at the MIT center, and that similarly any student in the West could use the UCLA facility. (Hurd, Tr. 86421; see also Morse, Tr. 30965.) Almost 40 colleges and universities ultimately participated at the MIT center and over 60 participated at UCLA. (DX 7514, p. 33.)

** Norris of CDC defined a research grant as a situation in which "the educational institution pays the list price, but in a separate transaction we sponsor a particular research program at our expense". (Tr. 5647-48.)

≠ Norris said that a "buyback" meant that "Control Data had the right to use time on the machine for its own purpose in an amount equivalent to that expressed in terms of the monthly rental". (Tr. 5988.)

(Norris, Tr. 5988), and large cash contributions.* (Morse, Tr. 30980.)

Larger discounts for academic or instructional use than for administrative use were not uncommon, and were consistent with the desire of manufacturers to encourage the training of people knowledgeable in computing. The Rosser Report observed that:

> "There are numerous cases where computer companies have given support in the form of generous discounts on the rental or purchase price; in many cases, this has been done on the condition that some computer time be made available for instruction. This has ramifications similar to those arising from the NSF [National Science Foundation] support with its side condition." (DX 5504, p. 57.)

Looking toward the future, the report argued:

> "The computer manufacturers are gravely concerned with the question of education. For one thing, the shortage of programmers, referred to earlier, has a dampening effect on sales of computers. If the computer manufacturers could be assured that their educational discounts would really support education, rather than being used in good part as an indirect subsidy of government research, they would be disposed to return to the more liberal discounts of earlier days."** (DX 5504, p. 58.)

In restrospect, the educational allowance plainly accomplished the goal of supporting the growth of the industry, as well as

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* In the early 1970s, for example, CDC donated $5 million to MIT, payable over five years. (Morse, Tr. 30980.) Morse, head of MIT's Computation Center, was also a director of CDC but he testified that there was no connection between that fact and CDC's contribution. (Id.)

** The reference is to the Carnegie decision (PX 1088), a ruling by the Armed Services Board of Contract Appeals that universities had to pass educational discounts on to the government whenever computers acquired on such a discount were used in government-sponsored research. The Rosser Report criticized the implications and developing repercussions of the Carnegie decision and concluded: "In view of the pressing need for education in connection with computers at the present time, this tendency of government officials should be reversed." (DX 5504, p. 45.)

benefiting the society in general. In a draft report prepared for the National Science Foundation, Prof. W. F. Miller of Stanford University concluded that the educational allowance

> "was a very important form of support in the early years. It contributed immensely to the growth of the computing industry in the country. The computing industry grew in its most spectacular growth from the ground up. When the colleges and universities began to graduate engineers, scientists, business school graduates, etc., who had been introduced to computing through introductory courses and often had taken advanced courses in computing, they began to introduce computer methods into their respective businesses. This in turn stimulated the great demand for computers and the spectacular growth of the computer industry in the early and mid-1960s. There is no doubt that the colleges and universities who first introduced large teaching programs in computing would not have been able to support these educational courses on such an extensive scale without the benefit of the [educational allowance]." (DX 5500, p. 3.)

Similarly, the President's Science Advisory Committee, writing in a 1966 Report titled "Computers in Higher Education", observed that:

> "Great good has been done through donated computers, obsolescent computers, huge educational discounts, grants for the purchase of computers and the struggles of enthusiastic men with inadequate machines." (DX 5476, p. 18.)

Speaking of IBM's educational allowance program, Hurd testified that educational institutions and society in general benefited from educational allowances:

> "First, because of that educational allowance policy they were able to afford the installation of general purpose computer systems, and having afforded it, they were able to support their instructional programs, support their research programs, and as I have indicated in my testimony, increasingly the use of general purpose computers supported research not only in the physical sciences but in the social sciences and in the humanities. So in that sense the IBM educational allowance policy contributed to society in general because of the research results and the instructional results." (Tr. 86715.)

IBM's Educational Support Programs. IBM's support of education started with the beginnings of the company and it was originated and directed to a large degree by Thomas J. Watson, Sr. (DX 12150, pp. 17-18; DX 7514, p. 8.)

Watson had a very strong belief that IBM should support educational institutions because "'[t]here is no saturation point in education.'" (DX 12150, p. 18.) When IBM's SSEC became operational in 1948 (see pp. 24-25 above), Watson dedicated it to science and IBM allowed educational and research institutions to use the machine without charge. (Hurd, Tr. 86420.) At the dedication of the SSEC on January 27, 1948, Watson told the assembled guests:

> "It is with a mixed feeling of humility and confidence in the future . . . that I dedicate the IBM Selective Sequence Electronic Calculator to the use of science throughout the world." (DX 12150, p. 32.)

Mr. Watson's strong belief regarding IBM's support of education and the mutual benefits which would accrue was the basis for IBM's continuing policies in this area. As Dr. Hurd testified, IBM "hoped to benefit from the expansion in the understanding, uses and users of computing . . . and I believed that all suppliers of general purpose computers would benefit from its policies". (Tr. 86422.) He went on to comment: "they [educational institutions] were able to afford the installation of general purpose computer systems . . . to support their instructional programs . . . research programs . . . in the physical sciences . . . social sciences and in the humanities". (Tr. 86715.)

There are many examples of IBM's early support of educational and academic endeavors. For example, in 1924, Henry Wallace, who later became Vice President, used IBM punched card equipment which had been donated by IBM to Iowa State College, in order to do the research that led to his Ph.D. degree and later to the invention of hybrid corn. (Hurd, Tr. 86712.) During the 1930s, IBM supported Dr. Wallace Eckert's astronomical research at Columbia University and in 1945 established the Watson Laboratory at Columbia. (Hurd, Tr. 86713; DX 12150, pp. 11, 23.) In the 1940s, IBM supplied the machines that were used by the Carnegie Foundation for the Advancement of Teaching to evaluate test results from a nationwide survey. (Hurd, Tr. 86713.)

In October 1955, IBM announced an educational allowance program for the 650 computer. An allowance of 60% off the rental price was available to educational institutions that offered courses in both scientific computing and data processing. (JX 28, ¶ 12.) The 60% discount provided a great benefit to universities. Perlis testified:

> "The 60 per cent discount that IBM made available to universities opened up digital computing in the universities in the sense that almost no university was able to afford or at least thought they could find funds of the kind required to establish a digital computer laboratory until that discount became available, after which there were just a very large number of IBM computers, in particular IBM 650's finding their way into the universities and forming the focus of university computer centers." (Tr. 2009.)

That educational allowance policy was "absolutely" one of the "principa forces which enabled universities to become competent in computing as soon as they did". (Id.)

In May 1960, IBM announced that a 20% allowance would be offered on all of its EDP machines, systems and features, leased or purchased, used for administrative purposes, and that a 60% allowance would be available if that equipment was used for instructional purposes. (JX 28, ¶ 13.)*

IBM's allowance program remained relatively unchanged** until February 1963, when IBM abandoned the administrative use/instructional use distinction and reduced the 60% allowance to 20% on all new orders. (JX 28, ¶ 17.)

When System/360 was announced in 1964, IBM left the percentage of the educational allowance unchanged (at 20%) and made it available on System/360 equipment to colleges, universities and junior colleges. (JX 28, ¶ 19.) However, it soon became apparent that educational users who had second generation equipment installed under the much higher 60% allowance could not afford to take advantage of the price/performance improvement that System/360 offered because the educational allowance on System/360 was so much lower. (See, e.g., DX 12435, Armstrong, pp. 80-81.)

In addition the competition for the business of educational institutions was especially severe during the middle 1960s, and most of IBM's competition offered high educational discounts and other special arrangements such as lucrative research contracts. (See, e.g., Norris, Tr. 5647.) Macdonald of Burroughs said that on occasion

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* IBM estimated that in 1962, it would grant allowances worth $24 million. (DX 7514, p. 30.)

** Junior colleges and post-high school vocational institutions became eligible to receive educational allowances for certain equipment in 1961 and 1962 respectively. (JX 28, ¶¶ 15, 16.)

Burroughs' discount reached as high as 50% (Tr. 7534), and Norris of CDC testified:

> "[W]hen we first started the company, as I recall, educational discounts then were around 20 per cent. And then they increased, and at one period I recall their getting as high as 60 per cent." (Tr. 5648.)

In fact, CDC would often offer combinations of discounts, research contracts and buybacks in certain competitive situations. For example, at Battelle Institute, CDC offered a 20% educational discount on a CDC 6400, and in addition CDC gave Battelle $10,500 a month as a "buyback" of computer time. Similarly, at New York University, CDC offered a discount of $15,060 a month on a CDC 6600, and $14,400 as a "buyback". At the University of Illinois, CDC offered a 1604 computer for 13 months on what CDC called a "100% Rent-free consignment". (DX 278, pp. 1, 6; see also Norris, Tr. 5989-91, 5993-95.)

Plaintiff's witness Wright, a former Regional Director of Marketing for the GEM region in IBM's Data Processing Division, was asked whether IBM's educational allowance served any purpose from a marketing standpoint. He responded in part:

> "[A]ll vendors to some extent had educational allowances to my knowledge. All of the companies I have been associated with have an educational allowance and this, in turn, permitted IBM to compete for business in educational institutions, in addition to providing computering [sic] equipment at a lesser cost to those educational institutions." (Tr. 12958.)

As reported internally by IBM employees in 1964, Burroughs, CDC and GE were offering a wide range of discounts, from 20% to 60%, along with other significant considerations such as cash grants. (PX 2963, pp. 7, 9.)

During the period from 1965 to 1968, other computer manufacturers were successfully marketing computers to universities. For example, DEC reported that its computers were used at Yale University, MIT, Stanford University, University of California at Berkeley, Oxford University, Harvard University and University of Wisconsin, among others. (DX 13846, p. 6; DX 13847, p. 7.) SDS reported that users of its computers included Johns Hopkins University, Duke University, University of Delaware, Michigan State and UCLA. (DX 983, p. 10.) And Hewlett-Packard reported that colleges were using its equipment. (DX 11011, p. 10.)

As a result, IBM and its competitors frequently became involved in highly competitive situations at universities. (See, e.g., PX 1824 (Berkeley); PX 1468 (University of Pennsylvania); PX 1558 (University of Colorado).)

Even if IBM had discontinued its educational allowances altogether, it seems probable that other manufacturers would have continued them nevertheless,* and it is therefore hardly surprising that to some extent IBM considered such allowances a competitive necessity. As a result, in 1965, IBM raised slightly the educational allowance on System/360 computer equipment, and created a sliding scale of discounts ranging from 20% on the Model 30 CPU to 45% on the larger CPUs.

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* When asked what Burroughs would do if IBM were forced to discontinue its allowances, Macdonald said, "I believe we would consider it carefully, and were that to happen today I think we would probably continue the practice." (Tr. 6987.) Moreover, Macdonald said that "I suspect that for the remainder of the industry that the practice would continue." (Id.)

Even though that increase helped colleges and universities to acquire the newer System/360 computers, and even though it enabled IBM to be more competitive, a great debate ensued within IBM as to whether high educational discounts were the most appropriate way for IBM to support education.* Some favored continuing the discounts; some favored raising them; others favored lowering or even eliminating them. Still others favored massive efforts in support of education.

As examples of the differing opinions, T. V. Learson was quoted as saying:

> "We [IBM] have two objectives in this [E.A.] program: the first to get university customers back up to paying full rentals or as close to it as possible in the long-run; the second, to get more revenue in the short-run, i.e., 1966." (PX 1652, p. 1.)

Herman Goldstine, when he was Director of Scientific Development at DPD Headquarters, observed that "the educational allowance was originally introduced by IBM as a matter of enlightened self-interest and the expressed intention was to further the training of young people in the use of the computer." He went on to recommend "that we should substitute for the EA or for most of it a cash grants program or a value-received program. Perhaps we will always want a 5% discount for psychological reasons." (PX 1679, pp. 1, 2.) Armstrong took the position in November 1965 that the educational allowance program be

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* That debate was fueled by the Carnegie decision, referred to above, which had the effect of passing the manufacturer's discounts on to the government, a result which manufacturers had not intended.

left alone, i.e., unchanged from the March 1965 position. (PX 3871: Armstrong, pp. 145-46; see also Wright, Tr. 12912-13; compare PX 1661, p. 1.)

The result of the debate was a corporate decision gradually to reduce the allowance to 10%. (PX 1706, p. 2; PX 1745, p. 2; PX 1746, p. 2.) In 1966, the educational allowances on most equipment were reduced by about 10% of the price of the equipment. (JX 28, ¶ 26) as the first phase of the larger reduction. In 1969, the allowance was reduced to 10% as planned (JX 28, ¶ 29), where it remains today on most products.

39. IBM's Unbundling.

a. Introduction. Before discussing IBM's unbundling in 1969, it is useful to review briefly the causes and effects of bundling in the 1950s and 1960s. Bundling, as used in the EDP industry and with respect to IBM, is "the offering of a number of elements that are considered to be interrelated and necessary from a customer's point of view, in the computer field, under a single pricing plan, without detailing the pricing of the component elements themselves." (R. Bloch, Tr. 7603-04.) The elements which were offered without a separate price were non-hardware elements such as education, software, systems design, and maintenance.* (See above, pp. 56-67.) As described above (pp. 53, 56-67), the provision of such support services by manufacturers greatly facilitated the marketing of their equipment to users by reducing the users' risks in installing that new, unfamiliar, and expensive object, the computer. (See R. Bloch, Tr. 7751-54; Norris, Tr. 6058-59; McCollister, Tr. 11041-43; Welke, Tr. 17380-81,

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* Maintenance was included in the lease prices for equipment that the manufacturer continued to own and the user leased. Maintenance was priced separately for purchase customers. (See Spangle, Tr. 5094-97 (Honeywell); Macdonald, Tr. 6980 (Burroughs); Weil, Tr. 7087-88, 7099-100; R. Bloch, Tr. 7804 (GE); McCollister, Tr. 11461, 11476-77 (RCA).) Manufacturers have strong incentives to provide such maintenance in order to protect their property. (See Norris, Tr. 6069-70, McCollister, Tr. 11476-77; Vaughan, Tr. 21732-35.) The significance to the users in the early days of maintenance being included to lease customers, however, was similar to that of the bundling of other support services--it increased users' willingness to experiment with this new equipment and helped to assuage their fears and minimize their risks. (See Welke, Tr. 19225-28; see pp. 53-67 above.)

17343-46.)*

As a consequence, virtually "[a]ll the computer manufacturers marketed on a bundled basis" during the 1950s from the Univac I on. (Goetz, Tr. 17500-01; Spangle, Tr. 5092; R. Bloch, Tr. 7604; McCollister, Tr. 11042-43; see also Norris, Tr. 6066.)

At IBM, the provision of bundled support began before the installation or even the acquisition of a computer by the customer. Such support was viewed both inside and outside IBM as an essential part of the marketing effort. The IBM systems engineer (SE) was "part of the marketing team" (Akers, Tr. 96554-56) and would assist in the preparation of the proposal made to the customer. (Id.; Enfield,** Tr. 19908.) The IBM salesmen drew on them for technical support. It was the systems engineers who "had the implied responsibility of . . . developing systems to make sure that the

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* In formulating the provisions of the 1956 Consent Decree concerning IBM's obligations to customers that purchased equipment from IBM, the Department of Justice apparently recognized the benefit to users of the support provided by IBM without separate charge. The January 25, 1956 Final Judgment obligated IBM "to offer to render, without separate charge, to purchasers from it of tabulating or electronic data processing machines the same type of services, other than maintenance and repair services, which it renders without separate charge to lessees of the same types of machines". (U.S. v IBM, [1956] CCH Trade Cases § 68,245, Part VI, §(a), (S.D.N.Y. 1956).)

** At the time of his testimony in 1976, Enfield was President of The Computer Software Company. (Tr. 19841.) Between 1964 and 1969 Enfield was employed by IBM, first as a systems engineer and then as a Product Administrator in Data Processing Division headquarters. (Tr. 19843-44.)

machine was put to good use". (Welke,* Tr. 17009.) They worked with customers to define requirements and in system design, developing approaches to problems, also engaging in customer education and training and in programming. Such work would sometimes continue after installation. (Welke, Tr. 17007-10, 17069-70, 17372-73.) In short, the systems engineers were responsible for "making sure that the customer was indeed implementing the targeted applications, the business applications, and doing the job properly and being of whatever assistance we could to make sure that the machine was . . . performing properly". (Welke, Tr. 17010; Akers, Tr. 96555-56.)

Other firms in the industry also provided those types of services as part of their marketing efforts. McCollister testified that it was "normal for some fraction of the time of the [RCA] marketing force" to be dedicated to, for example, "[a]ssisting the customer with applications design and development, training . . . helping the customer plan expanded use of the system." (Tr. 9648-49.) McCollister regarded all the elements of the RCA "field organization" including

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* At the time of his testimony in 1976, Lawrence Welke was President of International Computer Programs, a firm providing "an information service to the computer software product marketplace" by publishing catalogs of software products and by conducting seminars on buying and selling software. (Welke, Tr. 17003-04.) Welke's first job in 1954 was with General Electric and he had the responsibility of installing a punch-card system in GE's production department. Between 1956 and 1963 Welke worked at IBM as a systems engineer for three years and as a salesman in the Data Processing Division for four years. Between 1963 and 1968 Welke was with a consulting firm and a bank as head of their automated customer services division. (Welke, Tr. 17004-07.)

"salespeople, maintenance people and systems analysts and programmers, technical people" as "a normal and as a necessary part of the successful sale and installation of computer equipment." (Tr. 11370-72.) In 1972 Ray Macdonald, President of Burroughs, stated that:

> "A major element of the marketing effort in our industry is support activities. It is important to note here that our industry's involvement with its products lasts throughout the lives of those products. It starts with semi-finished raw materials, continues through intermediate and final manufacturing processes, and extends to a full range of services in support of the product throughout its use.
>
> "At Burroughs, we developed a worldwide capability in excellent technical support of our products very early in the traditional product period. With the introduction of the computer, we have significantly extended our support operations by adding the new dimension of supporting the customer in his use of the product. This includes systems planning and installation support, and perhaps most important of all, the support of the customer in his application software requirements." (DX 426, p. 12; see DX 427, p. 4.)

Similarly, in 1961 NCR reported to its stockholders that its "marketing organization . . . provides necessary programming aids, training courses for the customer's employees, technical assistance on site preparation, and other supporting services of various kinds." (DX 402, p. 10.)

Obviously, the amount of SE services needed at a particular account varied and not in any simple way. As Akers testified, systems engineers at IBM "were a scarce resource within the branch office" so there was an attempt "to manage the technical talent in a way that was most beneficial in [IBM's] sales efforts and installation efforts with our customers." Systems engineers "were allocated on the basis of how much assistance a particular customer needed at a particular time; the degree of experience that the customer had;

whether or not that customer perhaps required additional educational effort because he or she was installing a new computer system or computer system for the first time. It was an effort to try to use that resource as productively as possible in pursuing the quota objectives that the branch office had." (Akers, Tr. 96555-57; see Enfield, Tr. 19878-79, 19886-88; DX 4793.) Systems engineers were assigned to customers on the basis of "who needed the work done and what had to be done to make it a successful installation". (Welke, Tr. 17017.)

Systems engineering services were provided to familiarize users with computers and to ensure that the user, if he chose to acquire a computer, used it properly to solve his problems. Such service relieved users from some of the risk of acquiring a computer in order to induce them to acquire it in the first place. But, in relieving customers of such risks, IBM, like other manufacturers, assumed them. By giving the users "a predictable cost that they could budget against" (Welke, Tr. 19225-26), the manufacturer took over the uncertainty in cost resulting from unforeseen variation in user needs.

Concomitantly, manufacturers stood to gain (by lower costs) if over time the customer required less or no assistance. In the long run, the reduction in customer needs would be accomplished in part, as it turned out, by the provision of increasingly sophisticated operating systems relieving customer programmers of a number of complex tasks, but it could also be accomplished in the short run by training customer personnel in the tasks which software had not yet taken over and in the use of the software-hardware combinations. Thus, according to the IBM "guidelines" concerning programming, "Systems Engineering personnel were to clearly encourage self-sufficiency among the customer [sic] in his programming capabilities with regard to application programs." (Enfield, Tr. 19862; see also Welke, Tr. 17373-75.) Such self-sufficiency "was a self-serving objective. The objective to enable the user to provide more of his own support would enable an SE to perform less of those functions", freeing the systems engineer for other assignments. It would also make the customer more efficient if he did not have to depend on others. (Enfield, Tr. 20249-50.)

In November 1962 Frank T. Cary, at the time Vice President of Field Operations for the Data Processing Division, put out guidelines to IBM executives, regional and local management and sales representatives and systems engineers saying that it was IBM's "responsibility" to provide to its customers "the assistance they need to install and obtain the results from the use of our equipment that we have outlined in our proposals to them". Among IBM's responsibilities were the "[e]ducation of customer personnel" and the provision of "[t]echnical guidance" in "the use" of IBM equipment and in "programming and testing". Similarly, in order to underscore to the recipients the extent to which IBM was committed to having the customer assume responsibility, the guidelines emphasized that it was the "customer's responsibility" to "[w]rite his own operating programs", "[w]ire the necessary control panels", "[o]perate the equipment" and "[p]rovide for the physical installation of the equipment". (DX 4793.) It is worth noting that these guidelines applied only to lease customers and to "the first user of purchased equipment" to whom IBM felt it to be its "responsibility to provide . . . the assistance they need to install and obtain the results from the use of our equipment that we have outlined in our proposals to them". (Id.) IBM, quite naturally, was making this marketing support available to its customers and not to users that acquired IBM equipment from other sources.

Ralph A. Pfeiffer, Jr.,* described IBM's philosophy as follows

> "What we were trying to do was to insure customer's profitable use of the equipment. The Manager has a certain stable of talents; he had a customer set that he had to support and he tried to make the most productive, efficient use of that cadre of personnel.
>
> "We are trying to supply a service to a customer. We are trying to have that customer make profitable use of his equipment. And if he is unable for some lack of whatever it might be, education in a certain area or a certain person who he relied on left and he was caught short, we try to supply that missing ingredient until he is able to handle it himself. We tried to train him.
>
> "We certainly were interested in having him be capable of running his own installation in a profitable way. Whatever that required in the way of training somebody or supplying that piece of education that was missing, I hope I operated accordingly." (Tr. 16019-20.)

The policy of building self-sufficiency in customers, however,

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*Mr. Pfeiffer is an IBM Senior Vice President and Chairman of the Board of IBM World Trade Americas/Far East Corporation. (DX 8074, pp. 42-43.) At the time of his testimony he was an IBM Vice President and the President of the Data Processing Division. (Tr. 2963-64.)

carried with it an end to the practice of not charging separately for such services. When enough customers became self-sufficient and when changes in hardware and software ceased to require them to be taught very new ways of operating, it would no longer make sense to bundle. By increasing self-sufficiency in customers, IBM created a growing group of customers who did not require the bundle. The exact date on which that group was sufficiently large that it made sense to un-bundle and provide the formerly bundled services at separate charges for those who wanted them is a matter of judgment. As we shall see, in IBM's judgment it came in 1969.

b. The Continued Demand For Bundling in the 1960s. During the 1960s, for the same reasons as in the 1950s, most users continued to prefer the bundled offering. (Welke, Tr. 19230; R. Bloch, Tr. 7751-54.) The demand for such support was not restricted to new customers unfamiliar with computers. Even in selling to "the large, established user", such services would be required "to some degree". "[T]here would always be areas which are unfamiliar to even a relatively sophisticated customer. The fact that he was graduating from some smaller system to say, a larger . . . system which might involve communications, this communications area would be the first time for that large customer. . . . So even with sophisticated customers these kinds of support were required." (Beard, Tr. 9944-46.)

The demand for support services continued in the 1960s as users were rapidly exploring new computer uses and as software improvements and architecture changes were occurring at a rapid rate.

As Beard testified:

> ". . . most of the customers we [RCA] were dealing with in the time frame of 1960 to 1970 were not thoroughly experienced in the use of data processing equipment. The field had gone through a very dynamic growth. It faced new technology, a new set of programs imposed upon the business organizations that used computers. So a lot of people felt they were on very shaky grounds. They were not sure of themselves." (Tr. 8497.)

New products and new ways of doing things were being introduced requiring customer training, programming and systems design services, imposing additional demands on the manufacturers. (McCollister, Tr. 9647-53; DX 69, pp. 3, 5; see also DX 98, p. 12.) As Withington observed in 1968:

> "Programmers and system analysts are in inadequate supply. This shortage has existed for years and shipments have nevertheless grown, but in one major respect the problem is worsening. The advanced, integrated applications many users wish to implement are novel and very complex and require much more creative, high-level system analysis than the simpler, second generation applications did. Since experienced system analysts are in the shortest supply of all, this pressure may have an increasing effect.
>
> "The increasing complexity of the third generation hardware and software (a necessary corollary to its increased capability) makes it difficult for the average user to understand and use. It may take longer than it used to for users to fully exploit the equipment they are currently installing: many users will not be able to use anything larger or more complex for a number of years." (PX 4833, p. 9.)

Thus, although users would eventually become familiar with the architecture of System/360, the sharp increase in complexity as users moved from second generation equipment to System/360 tended to offset the gains from previous experience. Users were being trained and retrained to use more complex equipment in increasingly sophisticated ways and the bundled IBM offerings were all the more important to the System/360 user. (See Welke, Tr. 19617-18.) For example, Welke testified that System/360 "represented a new level of hardware technology . . . it represented a new level of software technology with its systems software environment and the very way that you approach programming and processing. It caused a complete change in how people approached the task of data processing."* (Id.) In January 1964, F. P. Brooks, Jr., wrote that:

> "The breadth of System/360 and the number of innovations, particularly in gross systems concept, will require substantial lead time between announcement and proper installation. . . . The sheer amount of new abilities, new options, new specifications, and new prices will require time for the customer to assimilate. A major education program for IBM field personnel and customers must intervene between announcement and successful installation." (DX 1172, pp. 1-2; see also Withington, Tr. 56591-93; DX 4815.)

As we have seen in the discussion of System/360, all of this happened--and more--with the result that IBM was compelled to expend tremendous effort and expense to install and support System/360. As other third generation equipment began to appear, other manufacturers found requirements for support services growing as well. SDS told its stockholders in its 1965 Annual Report that

> "[t]he character of the computer market changed substantially last year as the result of advances in both the understanding of the technology and in the manner in which computers should

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* "By [1968] the marketplace had acclimated to these new hardware technologies and software technologies. By the same token, the product, the 360 system, particularly with reference to the software involved, the system software, had settled down and achieved a respectable semblance of predictability." (Welke, Tr. 19617-18.)

> be employed. . . . During the past year increasing emphasis has been placed by management on providing complete service to SDS customers both before and after installation. To this end, technical staffs and applications programming, systems engineering, customer training and maintenance have more than doubled in size and in the scope of their activities." (DX 981, pp. 4-5.)

Such increases continued for the next few years. (DX 982, p. 3; DX 983, pp. 16-17.)

Similarly, RCA found that the introduction and installation of its new Spectra series created large user demands for assistance. (McCollister, Tr. 9649-53, 11403-06.) NCR told its stockholders in early 1966:

> "As the trend toward fully integrated business systems gains momentum, NCR's opportunities for growth and greater profitability can be expected to increase proportionately. Full realization of these opportunities will require an aggressive continuation of the program of recent years. To this end, additional expenditures will be required not only for further product development efforts but also for training sales and service personnel and for providing the many supporting services essential to the successful marketing of advanced business systems." (DX 368, p. 3.)

It was a view which NCR was to reiterate as time went on. The following year, it stated:

> "Today, a . . . requirement for future success in the marketplace has arisen; that is the need for business equipment suppliers to provide additional guidance to customers in the utilization of new technologies for operating their businesses more profitably. For in the final analysis, the effectiveness of today's sophisticated information systems depends upon a full understanding of their potential at all levels of management. To this end, NCR's educational programs are being designed not only to prepare sales representatives to install advanced systems, but also to provide counsel and training in management sciences." (DX 370, p. 5; see also p. 19.)

In its 1967 report, just after the announcement on March 2, 1968, of its new Century series, NCR reiterated this position.

"In addition to offering outstanding equipment, meeting the demands of the market today also requires:

"1. Expert diagnosis of customers' current and future business information requirements, based on broad systems knowledge and experience.

"2. A complete range of supporting software, including standard programs for many applications and in-depth training of customer personnel.

"3. Continuing support of every installation, with upgrading of both system and equipment as customer requirements change.

"The company's marketing strategy is based on providing this full spectrum of customer services." (DX 366, p. 3.)

Similarly, one of Sperry Rand's major objectives in 1962 and 1963 was to "give increasing emphasis to our computer service and marketing". (DX 69, pp. 3, 5.) It was an "emphasis" which R. E. McDonald was to look back on in 1973 as "[o]ne of the main factors" behind Univac's success. (DX 98, p. 12; DX 65, p. 2.)

c. <u>IBM's Unbundling Announcement.</u> On December 6, 1968, IBM announced that it expected "to make changes in the way it charges for and supports its data processing equipment" during the following year. (PX 3390.) It announced its decision in detail on June 23, 1969, with the changes effective immediately for new orders and effective January 1, 1970, for customers with machines installed or on order. (PX 3351; PX 3352.) Basically, the announcement instituted charges for systems engineering services and education and for new "program products, as distinct from system control programming". (PX 3351, p. 4.) Programs then available from IBM's library continued to be available as in the past at no separate charge. IBM also offered to engage in contracts assuming "responsibility for the performance of specified tasks in the areas of systems design and analysis, application and program development and systems installation and evaluation". (Id.) No change was made in the way in which maintenance was provided, maintenance on purchased equipment continuing to be available at a fee and maintenance on IBM-owned equipment leased to users available without a separately stated charge. (PX 3351; PX 3352.) IBM also reduced its prices by 3%, stating that this reflected its "best approximation" of the expenses which would "no longer be provided for in prices of currently announced equipment". (PX 3351, pp. 1-2.)

There were a number of reasons for the announcement. First, IBM, like others, was feeling the strain of standing ready to supply services on demand without an extra charge in an increasingly complex environment. IBM "stated that--as a result of fast-changing data processing market conditions--the need for increasingly complex and comprehensive systems support is growing more rapidly than anticipated. In addition, new support requirements are arising from leasing companies and other owners of IBM equipment as they relocate and reapply their systems." Such demands for "new and additional forms of support services" were expected to continue to grow. (PX 3390, pp. 1-2; PX 3351, p. 3.) As would be expected in a company accepting the risks and burdens bundling entails, there was a recognition within IBM of the increasing costs of providing software and support. During the early and mid 1960s persons within IBM observed that programming expenditures were "skyrocketing" and "increasing dramatically" (PX 2804A, pp. 1, 2; PX 2805A, p. 1; PX 4053, p. 1), and attempts were made in 1966 to quantify the return to IBM on programming expenditures. (PX 1748, p. 11.) Cary testified that increasing demands of customers for education led to separate pricing of certain education offerings and that IBM was "always looking for ways of reducing the cost of systems engineering". (JX 57, p. 2.)

The general problem of cost escalation was magnified by the special problems associated with installation of System/360. As we have noted earlier, because of the unprecedented--and unanticipated--success of System/360, IBM had added new people to its marketing division. (See p. 372 above.) The training of such people, the support required by users to effect their conversion to the new and sophisticated operating system software associated with System/360, and the problems which IBM encountered with some of the 360 software caused IBM to devote an enormous portion of its resources to supporting the installation of System/360 and making sure that customers were able to do their work during the transition phase. (See pp. 369-72 above.) The result of this, however, was that levels of support far greater than ever before required were demanded of IBM. The cost of providing such support had to be borne directly by IBM itself, but in the long run, of course, it would have to be absorbed by IBM's data processing users.

At the same time, by 1969, in part as a result of IBM's policy of encouraging self-sufficiency, there had developed a group of relatively efficient and sophisticated users who would accept much more of the risks of computers and were willing to do much of the support in-house. As Welke testified:

> "The more sophisticated users, and the ones who had the best-run or the best-managed shops, for the most part were ready to accept the idea of unbundling, because I think they saw in it a chance to be more cost effective in their entire data processing operation." (Tr. 17172-73.)

T. J. Watson, Jr., testified:

> "We had some very sophisticated customers by this time, Lockheed, Boeing and others, who felt that they were better at performing some of these services than we were. They felt it onerous to pay for them when they, themselves, could do it in their opinion better." (Tr. 16602.)

Another reason for IBM's announcing unbundling in 1969 was that, by that time, the notion of charging for software and services had become relatively accepted because of the entry and success of software houses. (See below, pp. 851-65.) That had not always been true, however. From the early days of the computer industry up until the late 1960s software was generally looked upon as something other than property that could be appropriately charged for. "For the longest time, computer programs were looked upon as an intellectual product, but not necessarily having proprietary value." (Welke, Tr. 17361-62; see also DX 1096, pp. 1-2.) This led many people to believe that in fact most users were not willing to accept the notion of software as a "product" in the 1960s. (See Welke, Tr. 17093-95, 19180-82.) This view was both illustrated and reinforced by the free interchange of software that was characteristic of this period. (See below, pp. 856-58.) But, during the 1960s software houses began to charge for software products that competed with IBM's unpriced offerings and by 1969 "[t]he industry had developed to a point where many of those services were available, separately, and outside." (Watson, Tr. 16601; PX 3351, p. 3; see pp. 858-59 below.)* As a result, IBM began to believe that, for the first time, there might be business opportunities in selling software and services separately. (E.g., PX 3351, p. 3.) Under such circumstances, it was possible for IBM to stop offering such services, which it was finding "onerous", under the bundled system. IBM's Chairman testified that it "seemed like an appropriate time, from a business standpoint of view, to open the matter up in the way that we did". (Watson, Tr. 16602.)

Not surprisingly, customer reaction to IBM's unbundling announcement varied. Some relatively more sophisticated customers welcomed unbundling; others, generally the relatively unsophisticated, were less happy. Welke testified:

> "The initial reaction was--it varied. Some people were very happy with it. A good number of them that I came in contact with were anything from hostile to total disbelief as well.
>
> ". . . .
>
> "I think it depended on the sophistication of the user. The more sophisticated users, and the ones who had the best-run or the best-managed shops, for the most part were ready to accept the idea of unbundling, because I think they saw in it a chance to be more cost effective in their entire data processing operation.

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* One of the reasons for this was that industry practices had emerged which gave sellers some assurance of protection of proprietary programming from plagiarism. (Welke, Tr. 19211-13.) Welke testified that "many sellers" of software at one point, and "to a very limited degree" still, feared that their software would be plagiarized because of the ease with which programming can be copied and the inadequate protection

"The ones who didn't want the unbundling or who were against the idea I think in some cases were also the ones that were getting, . . . more than their normal share of IBM's support and systems engineering and programming as well." (Tr. 17172-73.)

Similarly:

"[U]sers, even in 1969, when they heard about unbundling, were reluctant to accept it or were hesitant and in some cases even hostile to the idea. At that point in time users were beginning to get a pretty good idea of what some of their cost elements were and the more sophisticated, more advanced users had a way of breaking out cost elements in their total computer operation, identifying them, and controlling them.

"But for a lot of users, there were still many, many unknowns in their data processing operation, things that they didn't know could happen, they had no way of anticipating, and I think they wanted the assurance that bundling, in effect, offered them, that one way or another, if and when the unknown occurred, they'd be covered. It was an insurance policy in many respects." (Welke, Tr. 19226.)

As might be expected, reactions of other manufacturers varied also. Bundling had been a practice desired by users. Users' needs changed over time as they became more sophisticated and self-sufficient but this was a continuous rather than a discrete process, and opinions, even in 1969, could very well differ as to whether the time had come to make the changeover. For many companies the decision whether or not to unbundle was not entirely a foregone conclusion.

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afforded software through patenting and copyrighting. (Tr. 19211-13.) This was recognized within IBM during the mid-1960s. In 1965 it was stated within IBM that "an overriding factor against unbundling [certain programming] is our present inability to protect the proprietary use of our programming systems". (PX 1651, p. 6.) In 1965, R. H. Bullen, then an IBM Vice President and Group Executive, wrote that: "We must settle on whether or not, and to what degree, we can protect programs before we can deal adequately with the question of selling them". (DX 1031.)

Spangle of Honeywell testified that Honeywell did not follow IBM's lead for a number of reasons. It was not set up administratively to charge for the separate items and enforce their collection throughout the field; it was not certain of the contractual arrangements it had with its existing customers; finally, Honeywell "hoped to gain some temporary market advantage . . . because we thought there would be quite a bit of resistance to this change by the customers and prospects, and that because of that we might be able to get some customers that we otherwise would not have been able to get". (Tr. 5086-87; see also Withington, Tr. 56786-87.)

Univac had similar reasons for not unbundling when IBM did. McDonald testified:

> "Actually, we felt that there would be considerable anxiety in the marketplace as the result of IBM's decision and announcement to unbundle, and we felt it would be to our competitive advantage to maintain our previous pricing policy so that we could go to the customers, potential customers of IBM, and say to them that we would offer you these services which we have in the past under the same pricing policy, and you know what you will be getting from us, and under the IBM unbundled pricing policy, only time will tell what your real prices will be; and I think this was effective, at least for a period of time.
>
> ". . . .
>
> "[W]e did see some increase in bookings over what we expected our bookings would have been had IBM not changed their policy . . . which we attributed to IBM's unbundling." (Tr. 2896-97.)

Similarly, McCollister of RCA "recommended that RCA should continue in the business by continuing to offer bundled services". He felt this to be "to the benefit of RCA in its relationship with its users . . . . [G]iving assistance to the user as required could lead to and usually did to a more effective use of that equipment by the user and gave RCA, therefore, a stronger installation and to the extent that the equipment was on rent, insured more completely a continuation of the rental income." It brought in more money than unbundling. Further, "I felt this had been a sound business policy for the IBM company for a long time and just because IBM . . . decided that they would change, I did not see at that time that this was a reason for the RCA company to change and do differently". "I believe the customers preferred the method which RCA had been following and which RCA elected to continue." (Tr. 11206-09.)

NCR went some distance in the direction of unbundling. On October 1, 1969, it stated its belief "that each user of its computer systems must be provided with a certain essential amount of software, systems support, and educational services if he is to successfully install the system and begin to benefit from his investment. NCR believes that this <u>basic</u> package of supporting services must be the responsibility of the equipment manufacturer." (DX 346, p. 1, emphasis in original.)* NCR recognized that there

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* NCR expressed the view in its 1969 report to stockholders that,

> "The deluge of new concepts and new equipment which has flooded the information processing industry in recent years points up dramatically the need for ever-greater customer support.
>
> ". . . .
>
> "Indeed, the growth of the industry will continue to depend in large measure upon its ability, through supporting services, to adapt these new concepts and equipment to the requirements of different organizations. Thus, during the 1970s increasing funds and effort will be devoted toward broadening the spectrum of customer assistance." (DX 367, pp. 19-20.)

would be considerable variance in the level of support required by different customers and stated that "it will continue to be NCR's policy to provide, as part of the basic hardware price, that amount of software and support which will realistically insure that a prudent user will be able to install and successfully utilize his NCR computer system". An allowance, based on the size of the system amounting to "approximately 30 man-days of support for each $1,000 of monthly rental" was to be provided with support above that level billed separately. The same principle was to apply to educational support and software "including both applied programs and computer languages". (Hangen, Tr. 10721-24; DX 346.)

On January 1, 1970, however, NCR announced a change in its policy stating:

> "After further evaluation, it has been decided not to price all basic and applied software and not to establish an allowance against which such chargeable software would be applied. The NCR software pricing plan will be to continue to establish pricing for software products on a selective basis, considering the value to the customer, uniqueness, and other factors." (DX 386, p. 2, emphasis in original.)

There was much less disagreement in 1969 and 1970 on the question of whether or not operating systems or systems control programming should be unbundled.* IBM did not unbundle such programming, stating: "System control programming is an essential part

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* By the early 1970s only CDC had unbundled its operating system. (Norris, Tr. 5647; Goetz, Tr. 17530.)

of a data processing system. It is fundamental to the operation and maintenance of the system and will be made available as part of the system." (PX 3351, p. 4; see also PX 2454, p. 1; PX 3352, p. 5.)

The fact that operating systems were essential was widely recognized. Enfield testified that he did not "see how" a supplier of computer systems could market its equipment without making available some form of an operating system, at least following the introduction of System/360, by either producing the operating system itself or arranging for it from some external source. (Tr. 20740-41, 21074.) Welke testified to the same effect. (Tr. 19223.) Dr. Perlis of Yale testified that

> "operating systems are . . . indigenous to all major computers at the present time. They manage the computer resources and they really could be part of the hardware except that their functions are not well enough understood at the present time to make it economically feasible to put it into hardware". (Tr. 1344.)

According to Perlis, operating systems are "crucial to the successful operation of almost every computer around today". (Tr. 1348.) As a result, operating systems are "typically" designed for a particular fit with a particular computer, because "[t]hey depend very strongly on the particular resources and the way those resources are organized in a particular machine, and they do this so that they can achieve the most efficient operation possible . . . to take maximum advantage of the idiosyncrasies of the hardware". (Perlis, Tr. 1986.) Thus, Withington testified that hardware and software "are now necessarily designed as one, designed to execute from the same architecture". (Tr. 55919-20; see also DX 491, p. 5.)

Hence, separate pricing of operating systems would require "arbitrary allocations". (Withington, Tr. 56798.) Indeed, Withington wrote in June 1969, shortly before IBM's June 23 unbundling announcement, that systems software was "essential to the operation of modern computers and is designed contemporaneously with the machines. It is not possible to separate its development costs from those of the computers themselves, nor is it possible for the machine to operate without some version of the operating system". He concluded that this was a "complex area" and that "basic skeletons of the operating systems" were, at that time, "likely to be provided free with every machine . . . because there is no rational way to separate them". (PX 4834, p. 11.)

Ray Macdonald of Burroughs testified:

> "[W]e had extensive discussions on systems software, and I believe that our conclusion after some experimentation, and quite a bit of back and forth debate, was that the systems software that I have described is in fact an inseparable part of the system for the average user.
>
> "Now there may be the very unusual user which represents an extremely small portion of the total market who may . . . have the sophistication to consider a different mix or different system software for his own purposes, but first of all, I think this is a very, very small portion of the total market, and certainly not suitable for the vast majority of the market." (Tr. 6977-78.)

Thus, as the 1960s ended IBM had embarked on a course of separately pricing certain of its software and services. As we shall see, IBM continued on this course during the 1970s, separately pricing increasing amounts of its software and services in response to rapidly changing market requirements and technological advance.

40. Sperry Rand/Univac. Although Sperry Rand's Univac Division entered the second half of the 1960s lagging substantially behind the industry leaders in the areas of product compatibility and storage technology, it was able, by the end of the decade, to reestablish itself as a major force in EDP, logging substantial gains in revenues, organization and technology.

a. Univac's Problems in 1964. Univac, in 1964, was in a state of some disarray. It was in the midst of a succession of presidents (Eckert, Tr. 1008-13; McDonald, Tr. 3785-88)* and was "still suffering" from the "great drawback" of its "inability to assemble a smoothly working, reasonably permanent management team". (PX 4829, p. 20.) Additionally, despite the suggestion of Dr. Eckert** that Univac, like IBM, should concentrate on a single product line (DX 10; Eckert, Tr. 1014-17), Univac had manufactured and was still marketing several incompatible product lines (represented in 1964 by the 490, the Univac III and the 1107), each requiring different software. Moreover, Univac had failed to provide successors to its obsolete products. (See PX 4829, p. 20; DX 8, pp. 1-2; DX 10; DX 14, p. 1.)

In 1964, "after it had become apparent to the rest of the industry that magnetic disks were superior", Sperry was still marketing its FASTRAND drum instead of quickly proceeding with disk development,

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* R. E. McDonald was President of the Univac Division from 1966 to 1971. (McDonald, Tr. 2769, 2776-78.)

** J. P. Eckert was a Vice President of the Univac Division and technical advisor to the President of Sperry Rand at the time of his testimony, having held that position from "about 1960". (Eckert, Tr. 710.)

a delay which had a substantial adverse effect on the marketing of its computer systems. (Withington, Tr. 56455, 56485-87.) Consequently, Univac was compelled to purchase disks from other suppliers "for a while".* (Withington, Tr. 56243-44.)

Univac's financial results during the first half of the decade were not particularly encouraging. In 1962, the corporation had found that "the rate of technological obsolescence" required it to write down the value of its older EDP equipment by more than $50 million, and to accelerate the depreciation of its newer models. (DX 69, p. 3.) In 1964, Univac was "losing money" (McDonald, Tr. 3813) and experiencing a relatively slow rate of revenue growth. (14.8% compound growth rate from 1960-64 compared to 27.4% from 1956 to 1960.) (See DX 8224, p. 624.)

Notwithstanding its limited success, Sperry reported to its shareholders in its 1965 Annual Report:

> "Data processing is a dynamic industry, having great growth potential. It has established a place in the world's economy that is essential and will continue to grow. Such dependence upon any industry in the past has not only led to growth but also profitability. Therefore, we have determined that we will remain in and grow with the data processing business." (DX 13983, p. 6.)

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* IBM employees reported, in 1968, that suppliers of disk drives to Univac included Vermont Research, Bryant, Data Disc and Memorex. (PX 2267B, p. 27.) Univac continued to purchase disk drives from Memorex through 1970 (Guzy, Tr. 33170-71), and from CalComp through 1973. (PX 5584, p. 16.) It also purchased disk drives from Peripheral Systems Corp. in 1969. (DX 1302, p. 1.)

According to McDonald, during the period from 1963 to 1971 Univac concentrated its marketing efforts on the Federal government and airline reservations users. (Tr. 2890-91.) The Federal government was a very important customer for Univac in the 1960s, as it was for most of the industry; Sperry reported that in the fiscal year which ended March 31, 1964, for example, the Navy had ordered four 490 systems for world-wide inventory control, the Marine Corps had ordered three Univac III systems for similar applications and the Air Force had "ordered more than 150 UNIVAC 1050-II systems, as well as three UNIVAC 1107's for logistic control purposes". (DX 13913, p. 16.) The Air Force order alone was, as Withington noted, "large enough to cause a bulge in shipment statistics". (PX 4830, p. 22.) During the 1960s Univac claimed "a complete array of computers" for the military. In its 1964 Annual Report, Sperry Rand contended that "no other company in the industry [could] match this range". (DX 13913, p. 12.) Several computer systems were offered by Sperry Rand to satisfy shipboard, airborne, van-mounted and aerospace military and space requirements.* Univac was the prime supplier of the militarized AN/UYK-5 & 7** which were the standard milspec computers for the U. S. Navy. Univac also had a broad range of

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* Sperry Rand also had large commitments to the space program. For example, eleven Univac 1218 systems were to be delivered in 1964 to NASA tracking sites to assist in tracking the Gemini Capsule. A Univac 1218 was selected for the "mobile-wing, Limited-warfare intelligence complex". (DX 13913, p. 12.)

** The AN/UYK 7, a third-generation computer, used a general purpose software package called Gipsy, developed by the Naval Electronics Laboratory in San Diego. Gipsy provided the capabilities of a master control and data base handling program with a maximum degree of hardware independence. (DX 5117, p. 1.)

computers oriented to Navy milspec requirements which were in popular use aboard Navy vessels, performing a wide variety of applications. For example, the Naval Tactical Data System (NTDS) application aboard the U. S. S. Enterprise had a Univac USQ20 (1206) as their central computers. (DX 69, pp. 12-14.) In addition, the AN/UYK-5 computers were used on Navy vessels to process maintenance records, supply and accounting applications. (DX 5123, p. 3.) The Marine Corps used the Sperry Rand 1005 systems (AN/UYK-5 [V]) for their field van-mounted applications. Van-mounted 1005s were also used by the Army in their PERMACAPS and DLOGS systems in Germany, Vietnam, Korea and around the United States. (DX 5410, Fullerton, pp. 36-37.) At the White Sands Missile Range (WSMR) in New Mexico the Sperry Rand 1218* was used for a variety of applications including: missile guidance and tracking, data reduction and analysis, simulation, communications, logistics management, and satellite tracking. (Plaintiff's Admissions, Set II, ¶ 768.0-.4.) The Univac 1108 at WSMR was also used for missile guidance and tracking. (Id., ¶ 748.2-.4.)

The Naval Electronics Laboratory in San Diego acquired: 1 IBM 360/65; 1 CDC 8090; 1 Sperry Rand 1230; 5 Sperry Rand USQ20s (CP 642A/B); and 1 Sperry Rand AN/UYK-7 (CP 890.) (Id., ¶ 702.0.) As of 1974, applications of a general data processing nature previously processed on the Univac CP-667, USQ-17 and USQ-20 computers were to be transferred to the IBM System/360 Model 65 along with those that had been run on the two CDC 1604s. (Id., ¶ 702.15.)

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* The militarized 1218 and the commercial UNIVAC 418 are identical in design and the mainframes do not vary at all. (DX 9088.)

The Department of Navy reported the use of Sperry Rand AN/USQ-20s, AN/UYK-5s, Sperry Rand 1219s, and a Sperry Rand AN/USQ-17 for the Navy Management Information System for Education and Training. (DX 2992, pp. 592-93, 1123.)

In the area of airline reservations, British European Airways ordered a 490 in 1964 (DX 13913, p. 13); two years later, in fiscal 1966, Univac reported that it had been awarded the "biggest commercial computer contract ever awarded", a $39 million contract from United Airlines, "to design and build a computerized information system that [would] handle United's needs through 1975". (DX 61, p. 9.) As it turned out, Univac was unsuccessful in its bid to meet United's requirements, and the effort was "aborted" in 1970, with United Airlines moving to an IBM system.* (O'Neill, Tr. 76015-17, 76231-32.)

b. <u>The 1108.</u> The United Airlines system was to have been "based on Univac's 1108's". (O'Neill, Tr. 76231.) This computer, introduced in 1964 (DX 13983, p. 14), was compatible with the thin-film 1107, and was intended for Univac's "large-scale users". (DX 14, p. 1.) Withington viewed the 1108 as "technically impressive", claiming that its "very fast control memory" marked "the first significant appearance of integrated circuits in commercial computers . . . ." (PX 4829, p. 20.) The 1108-II, a "time-shared version" of the

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* "The reason that United decided to terminate that activity was that they concluded that the system being developed [for] United at Univac would not accommodate their projected volume. They subsequently installed IBM 360/65s, and later installed IBM 195s for their passenger service system." (O'Neill, Tr. 76016-17.)

1108 was introduced in 1965. (PX 4830, p. 22.) The 1108 was not delivered in volume until late 1966. (PX 4832, p. 18.) By 1967, the 1108 "accounted for about half the value of Sperry Rand's shipments". (PX 4833, p. 17.)

Univac continued to develop and extend its 1108 system and related machines through the late 1960s. Univac, in fiscal 1969, announced the 1106; "a smaller, compatible version of the 1108 system". (DX 3271, p. 5.) In 1967, Univac entered "the data services field with a service bureau network of 1108's directly connected to small computers on users' premises". (PX 4833, p. 17.)

Univac 1108s were employed in a wide variety of commercial contexts. The 1968 Sperry Annual Report showed a picture of the Univac 1108 scheduling trains for the French National Railway. (DX 13914, p. 5.) In addition to United's reservation system, Fuji Bank Ltd., Tokyo, in 1969 inaugurated a nationwide on-line banking system using an 1108, according to the Sperry Rand 1969 Annual Report (DX 3271, p. 7); and the Sun Oil Company ordered an 1108 system in 1968 for use in processing business and scientific problems (DX 13914, p. 16), to name but a few examples. As Sperry management noted in its 1970 report:

> ". . . The Univac large-scale computer systems--especially the 1100 series--are acknowledged to be the most versatile processors available. The UNIVAC 1108 and 1106 systems, in addition to having unparalleled capability for scientific and engineering applications, have gained wide acceptance among commercial/industrial users for business

data processing and communications tasks." (DX 13915, p. 5.)*

In March 1969, Sperry Rand management reported that "the backlog for Univac 1108 computer systems continues at a high level. . . . It provides the Company with an entree into the market for management information systems because of the computer's communications and multiprocessing capabilities in both business and scientific applications". (DX 3271, p. 5.)

Development of the 1108 was not without its problems, however; the 1108 operating system, EXEC-VIII, had "major problems in its initial stages". (J. Jones, Tr. 79631; PX 4834, p. 25.) These problems, similar to those encountered by other manufacturers with complex operating systems during the 1960s (see Perlis, Tr. 2002-03; Weil, Tr. 7217-19; McCollister, Tr. 9694-97; Rooney, Tr. 12132-36, 12349-50; Conrad, Tr. 14088-89; Withington, Tr. 56727-31), came relatively later for Sperry Rand "because it was not attempting to offer systems programs as complex and advanced as the other competitors were". (Withington, Tr. 56736.) During the late 1960s, Univac failed to deliver operating systems which completely met their advertised

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* NASA's Marshall Space Flight Center (MSFC) Computation Laboratory utilized 1108s to perform both "scientific data processing" and "administrative data processing". (Plaintiff's Admissions, Set IV, ¶ 386.0.) The Slidell Computer Complex at Marshall also used two 1108 systems for rocket stage design work, scientific applications and "some administrative data processing". (Plaintiff's Admissions, Set IV, ¶¶ 390.0, 392.0, 394.1, 401.0.) Five Univac 1108s were installed at the White Sands Missile Range (WSMR), utilized by the Army, Navy, and Air Force: two of the 1108s are employed in real-time missile performance computations; two others provide back-up, batch processing of test data and remote time-sharing ability; and the fifth is used for batch processing of classified data. (Plaintiff's Admissions, Set II, ¶¶ 746.4, 748.0-.7.)

capabilities and, indeed, EXEC-VIII was delayed at least two or three years, not meeting its advertised capabilities until sometime in the early 1970s.* (Perlis, Tr. 2003; Withington, Tr. 56737.)

c. <u>The Product Line Task Force.</u> The 1108, though successful, was not an answer to Univac's need for a compatible product line. As we have seen, it was announced at approximately the same time that Eckert, in his capacity as head of the Gemini Committee, was calling for unification of Univac's dissimilar product lines. In 1965, in the wake of IBM's System/360 announcement, Frank Forster, Univac's President from July 1964 to early 1966 (DX 13983, p. 6; DX 61, pp. 2-3), set up a Product Line Task Force to review Univac products and to help him make decisions about their future. (McDonald, Tr. 3804-05; see also DX 13.)

The task force, in February 1965, reported that it believed that Univac's manufacturing costs were higher than those of IBM, and that:

> "IBM's heavy investment in product research is beginning to bear fruit. Its developments in circuits, microprogramming techniques, memories, and mass storage suggest that for the first time in the short history of the industry, IBM has acquired a definite technological leadership; this, together with our cost situation, may leave us little to sell. (DX 15, p. 2.)

In its next report, issued in March 1965, the task force observed that both Honeywell and RCA had committed themselves to the production of integrated computer families (the Honeywell 200 series and RCA's

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* As a result of the delay in developing EXEC-VIII, NASA, for example, was able to renegotiate its contract with Univac to include the grant of free computer time as a "slippage" penalty. (DX 5654, pp. 114-15, 231-32.)

Spectra 70 line) in the "tailwind created by . . . IBM". (DX 16, p. 2.) The report quoted the editor of Datamation:

> "UNIVAC is the big question mark . . . every month until a new line is announced weakens their chances of success . . . and it's not clear they'll offer a complete line at all. Anything less could relegate them to the second division." (Feb., 1965, p. 88.) (Id.)

Nonetheless, the task force was unsure whether Univac should try to match IBM's 360 or take some other action. Specifically, it expressed the concern

> "that the RCA and Honeywell moves, although based on clever sales strategies, may not make such good sense financially. Both are based on the assumption that now that IBM has made its move, the pace of obsolescence will slow down, and longer writeoffs will be possible than in the past. It is our opinion that in about five years this assumption will prove to be catastrophic to anyone who bases his product line on it." (Id.)

Ultimately, Univac decided not to introduce a full spectrum product line but to introduce only three machines, called models A, B and C. In consonance with its "concern" about future technological developments rendering obsolete an entire product line, the task force called for accelerating development of the model at the low end of the line, the model A, which was to be a 360-compatible processor targeted between the 360/20 and 360/30, to take advantage of the "large and barely exploited market for a low-priced scientific computer". (Id., pp. 2-3.) The task force observed, however, that:

> "The announcement of Model A will have an effect on the whole product line, all the way up to the 1108A. Regardless of what is claimed, the fact that model A contains the 360 repertoire will tell the world that our other products may be dead ends". (Id., p. 5.)

d. <u>The 9000 Series.</u> The task force had been convened to consider Univac's product strategy nearly three years after IBM's SPREAD Committee report; its reports appeared nearly a year after the announcement of System/360. (DX 16, p. 1.) Univac finally announced its third generation compatible computer family, the 9000 series (corresponding to the previously mentioned models A, B and C) in the spring of 1966. Called a "line of small and medium-sized computer systems", Univac's initial offering included "the 9200, a low-cost, internally programmed punch-card system, and the 9300, a high-performance card and tape system". (DX 70, p. 9.) While the 9000 "aimed at compatibility" with IBM's 360 (Eckert, Tr. 908), it was not truly compatible:

> "[A] new line, compatible with IBM 360 coding . . . would have probably solved the problem. While the 9200, 9300 and 9400 are IBM like in their order code, they are not enough alike to do us any real good. We have had loads of people prove to us why we can't be IBM compatible and very little real effort to be IBM compatible, either in our software or our hardware efforts." (DX 10, p. 1; see also McDonald, Tr. 3803-04.)

The 9000 series was upward but not downward compatible among the three models. Thus, "if a person had programmed something for some of these smaller machines he could use it in one of the larger machines but not the other way around." (Eckert, Tr. 906-07.) It also was not compatible with the 1100 series. (Eckert, Tr. 908.)

The third machine of the line, the Model 9400, was first announced in January 1968 (DX 13914, p. 6), and delivered in 1970 "from factories in the United States, West Germany and Japan". (DX

3271, p. 7.) The 9000 series was intended to "enable smaller companies to benefit from the advantages of computer power. . . . Typical customers [were] a savings and loan association in Kansas City, an aviation company in California and a wholesale grocer near Philadelphia." (DX 13914, p. 16.)

Univac both manufactured its own peripherals and purchased peripherals from others, remarketing them as part of its computer systems.* For a short period, it marketed to other manufacturers its peripheral devices which in turn were remarketed as part of other systems. (McDonald, Tr. 4053-55.) Further, its own products were used as part of systems in another way. The 9000 series, for example, were sometimes used as terminals to other manufacturers' systems. (McDonald, Tr. 3969; Withington, Tr. 56981.) As a 1970 Univac advertisement said:

> "They are widely used as either central site systems or terminal systems. As terminals they may be upgraded, without reprogramming, in low-cost steps to grow with your processing needs." (DX 13939, p. 176.)

In addition to acquiring peripherals from other manufacturers, Univac contracted with software houses to have work done when it did not have sufficient in-house capability to meet its requirements and did not wish to expand internally to meet a peak

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* For example, Univac purchased tape drives from Ampex (Ashbridge, Tr. 34851) and disk drives from Memorex, Calcomp and Peripheral Systems. (Guzy, Tr. 33170-71; PX 5584, p. 16; DX 1302, p. 1.) In 1968, IBM employees reported that Univac also purchased disk drives from Vermont Research, Bryant and Data Disc and tape drives from Potter Instruments and OKI. (PX 2267B, p. 27.)

load. (Eckert, Tr. 915-16.) McDonald testified that Univac purchased "software assistance from the Computer Sciences Corporation and also from University Computer Company". (Tr. 4024.)

Univac both leased and sold its EDP equipment. McDonald wrote in 1967 that:

> "[a]pproximately 50 per cent of the Division's products are sold outright with the remainder leased by customers on a one-year to five-year basis." (PX 1, p. 3.)

Univac provided support services to its customers as well. (McDonald, Tr. 2893-96.) McDonald testified that Univac had to provide these services if it "were to compete successfully", since IBM did so. (Tr. 2895-96.) However, Univac did not unbundle when IBM did in 1969, because:

> "[W]e felt that there would be considerable anxiety in the marketplace . . . and we felt that it would be to our competitive advantage to maintain our previous pricing policy . . . and I think this was effective, at least for a period of time." (McDonald, Tr. 2896.)

McDonald testified that Univac's pricing policy between 1963 and 1971 was "to provide the potential customer with a system that would perform his requirements at a price that would generally be 10 percent, as a rule of thumb, below the price offered by IBM", not taking into account the performance of associated peripheral devices. (Tr. 2883-84; 4190-91.) Univac attempted to set its products' price/performance between IBM's products, much as RCA had done with its Spectra series. (McDonald, Tr. 4182-83.) Considering that Univac's 9000 series was announced two years after System/360, Univac's pricing approach was perfectly understandable.

IBM was not the only competitor about which Univac was concerned, however. While McDonald, in 1967, identified "eight major hardware manufacturers" who were "[a]t the hard core of the industry" [IBM, Univac, CDC, RCA, GE, Honeywell, Burroughs and NCR] (PX 1, pp. 6, 12; see also McDonald, Tr. 2804-06), he recognized that:

> "[b]y the 1960's, there were up to 50 major suppliers of automatic computing digital and analog computers and data processors. Over 700 organizations with some 30,000 persons were engaged in one part or another of the computer field." (PX 1, p. 1.)

These included peripheral manufacturers, software suppliers, service centers, and leasing companies. (Id., p. 12.)

In the middle 1960s Univac management became "concerned" about leasing companies. Forster wrote to McDonald in 1966, stating that he had:

> "some apprehension and also some prejudice in that I consider them to be parasitic. . . . If computers do not stay on rental, since they have no loyalty to any particular equipment their manner of disposal could be damaging." (DX 78.)

Univac's concern about the "manner of disposal" of leasing company equipment was that the leasing company would at some later time market it at very low prices, in effect "dumping it" on the market, knocking Univac's own equipment out of customer installations. (McDonald, Tr. 4017; DX 76.)

Univac responded to this concern. In January 1969, management approved revisions in Univac's long-term lease plan which were designed to "decrease future vulnerability" to third-party leasing companies and which included the adoption of step-down payment plans for long-term leases and price-cutting of five-year lease rates for Univac's "most profitable systems". (McDonald, Tr. 3988; DX 76, p. 5.)

e. <u>Univac's Success in the Late 1960s.</u> Despite the fact that Univac did not offer a single compatible family with the breadth and compatibility of the IBM 360, it experienced substantial growth in its EDP business during that time. At the end of 1965, prior to volume shipments of the 1108 or the announcement of the 9000 Series, Univac's U.S. EDP revenues were $203 million; as of year end 1970, its U.S. EDP revenues were $478 million. (DX 8224, p. 624.) McDonald estimated in 1974 that "revenue growth since fiscal 1965 [had] been 284%, or a 16% compound annual growth rate--in excess of that of the computer industry as a whole". (McDonald, Tr. 3867-68; DX 71, p. 7.) By fiscal 1969, the Univac division had become "the largest contributor to [Sperry's] revenues and earnings".* (DX 3271, p. 2.)

Univac's growth was not limited to the United States. From at least the 1960s onward Univac offered a single worldwide product line. (Withington, Tr. 57602-03.) Thus, in 1967 Univac's International Division conducted operations through 32 subsidiaries and distributors in Canada, Central and South America, Europe and the Far East. Sales and service offices were situated in Belgium, England, France, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland, Australia, Brazil, Canada, Mexico, Argentina, Colombia

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* Withington echoed the turn-around:

> "The Univac Division became the largest single contributor to the profits of the corporation (it seems only a short time ago that Univac was castigated as the largest single drain on them!)." (PX 4834, p. 24.)

and Venezuela. (PX 1, p. 4; see also McDonald, Tr. 3839-42.) McDonald predicted in 1967 that "overseas markets will grow at a more rapid rate than that of domestic markets . . . . UNIVAC seriously intends to participate in the rapidly developing European market" and "will routinely work across many international boundaries". (PX 1, pp. 5-6.) For 1970 Univac reported that its "international business [was] growing at an even higher rate than the domestic operations". (DX 13915, p. 7.)

Univac made great strides in the last half of the 1960s despite its slow start in undertaking a compatible family of products and its reluctance to accept disk technology. McDonald recognized what the problem had been and what would be required to solve it:

> "Planning will be a requisite to survival on the basis upon which profitable business development can be structured. . . . The combined magnitude of both opportunity and risk superimposed upon the rapidly changing pace of the industry will rule out success based upon 'seat of the pants' decision-making. The old technique of fumble and correct errors is out. There will not be time in the future to recover from serious mistakes without suffering severe penalties. We, therefore, must measure daily events against a flexible, preconceived plan of action in order to react in a timely fashion, competitively. Hard planning will be a part of daily activity. It will not be a luxury in the future.
>
> "This is the precise area of one of UNIVAC's greatest past weaknesses. It is an area which has received concentrated attention since 1964 and will continue to receive emphasis in the future." (PX 1, p. 7.)

Finally, Univac was back on its way to becoming a successful computer company.

41. <u>General Electric.</u> At the time of IBM's announcement of System/360, General Electric was (as it still is) a large corporation. From that time to the end of the 1960s, it was always in the top six of the Fortune 500. (R. Jones, Tr. 8754.) Its corporate-wide revenue grew from $5.1 billion in 1964 to $8.4 billion in 1969. (DX 13667, p. 1; DX 556, p. 2.) IBM's corporate revenue in 1964 was $3.2 billion (PX 5771, p. 3) and $7.2 billion in 1969. (DX 3364, p. 5.) GE was larger than IBM throughout the entire period. (DX 556, p. 28; DX 3364, pp. 59-60.) However, whereas most of IBM's domestic revenue during the period 1964-1969 came from its EDP business (see DX 3811; DX 3364, pp. 47, 48, 53, 54; PX 5771, pp. 32, 36; DX 13677, pp. 33, 37; DX 13678, pp. 33, 37; DX 13679, pp. 33, 37; DX 13680, pp. 45, 46, 53, 54), virtually none of GE's did. As the chart below shows, at no time during the period 1964-1969 was GE's U. S. EDP revenue more than 3-1/2% of its total U. S. revenue. (See Weil, Tr. 7260.)*

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* Plaintiff called four witnesses who testified about the GE computer business. They were John W. Weil, who was in GE's computer business from 1963 through 1970, as Manager of Engineering from 1964 through 1966 and Manager of Advanced Systems and Technology Operation thereafter (Weil, Tr. 7003, 7007-08, 7072); John L. Ingersoll, who was involved with GE's computer business from 1967 to 1970 as a financial manager and a staff member of the Ventures Task Force (Ingersoll, Tr. 8042-43, 8097); Richard M. Bloch, who was Manager of the Advanced Systems Division of GE from November 1968 to mid-1971 (R. Bloch, Tr. 7615-16, 7755, 7777); and Reginald H. Jones, who held top management positions at GE beginning in 1961 and became Chairman of the Board in December 1972. (R. Jones, Tr. 8752-53.)

Year	GE Total U.S. Revenue	GE U.S. EDP Revenue	% GE U.S. EDP to GE Total U.S.
	(in millions)		
1964	$4011.5	$ 53.4	1.3
1965	4952.6	66.5	1.4
1966	5698.3	99.0	1.7
1967	6129.2	143.1	2.3
1968	6664.6	180.0	2.7
1969	6638.0	219.6	3.3

(PX 326 (DX 13668, pp. B, 3); PX 327, pp. 2, 36; PX 328, pp. 2, 23; DX 556, pp. 2, 18; DX 8224, p. 6; DX 8631, pp. 31, 37; DX 13667, pp. B, 14; DX 13669, pp. 3, 4; DX 14484, p. R1; DX 7320.)

In 1963, computers were a part of the "industrial components and materials area" at GE which accounted for 28% of GE's revenues in 1963. That area also included advanced controls for machine tools, Lexan plastics, silicone chemicals, component motors, appliance controls and lamp ballasts. The remainder of GE's business was derived from consumer goods (26% of revenue), including appliances, television, and lamps, among others; heavy capital goods (24%), including diesel electric locomotives and power generating and transmitting equipment; and defense sales (22%), including jet engines and missile guidance systems. (PX 325, p. 10.)

Notwithstanding the small part played by computers in the GE hierarchy, GE had to be considered one of the most significant of IBM's competitors in the computer industry in the 1960s because, as

Richard M. Bloch, who joined GE in 1968 as the Manager of the Advanced Systems Division, testified, GE "was probably the greatest electrical and electronic technical organization, technically oriented organization in the world, and with very strong financial resources". (R. Bloch, Tr. 7615-17.) Similarly, in 1964 Withington wrote: "GE's long-term potential must be considered greater than that of any IBM competitor". (PX 4829, p. 19.) John W. Weil, who was the manager of engineering for GE's Computer Department from 1964 to 1966 and thereafter the Manager of GE's Advanced Systems and Technology Operation until 1970, testified that he believed that "GE had the resources and technological capability to become a major force in the computer industry". (Weil, Tr. 7007-08, 7072, 7173.) With all that technological potential and financial power, GE was called the "sleeping giant". (R. Bloch, Tr. 7788-89; PX 353, p. 43.)

But, in the computer field at least, the "sleeping giant" never woke up. Its efforts in computers in the 1960s ended with the sale of most of its computer business to Honeywell in the merger that created Honeywell Information Systems. The story of how GE failed to capitalize on its advantages and succeed is the story of lack of corporate commitment, inadequate management and a failure to keep up with the demands of the market as technology and competition advanced.

a. <u>The GE 400 Series.</u> During the year 1963, GE was marketing the GE 100 and 210 computers for banking applications (they were derived from the ERMA machine), the 304 (under license from NCR) and the 225. (Weil, Tr. 7005-06; see above at pp. 205-07.) In December 1963 GE announced its 400 series. (DX 488; DX 490.) That series had evolved from work done in the Computer Department in Phoenix in the early 1960s. (Weil, Tr. 7238-39.) The 400 series was called the "GE line of the future which would be compatible throughout". (PX 353, p. 44.) The 400 line was aimed at, among others, IBM 1401 users. (Weil, Tr. 7031-35.)* According to Weil, the GE 400 series (which was not compatible with the 200 series) "was intended primarily for business data processing users, although it did have some features that could support engineering and scientific calculations, but strictly as a secondary objective". (Weil, Tr. 7018, 7038.)

However, within a few years after the announcement of IBM's System/360, "the distinction between a scientific computer and a business computer . . . had been erased". (Weil, Tr. 7188-89.) GE was marketing the 400 for both scientific and business applications: "Can scientists and businessmen be happy with the same computer? Ask about a GE-400. Many installations have proved the GE-400 can handle engineering and scientific problems as easily as business problems." "So you see the GE-400's don't _just_ mean business. They now offer you the broadest capabilities available today

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* GE offered a "1401 simulator [with the 400 line], a piece of software which . . . had some hardware assistance which permitted programs from IBM 1401[s] either to be run or to be converted easily to the 400". (Weil, Tr. 7031-32.)

on a medium scale information system--all the way from everyday business runs to complex scientific problems." (DX 489.) The reason for this marketing change was, according to Weil, that "[a]s of 1967, the [IBM] 360 had been on the market for three years and the market in the middle range . . . of computers was now much more homogenized between business and scientific than it had been earlier, and the GE 400 was hence sold as much as you could to a broad market encompassing the middle class of . . . engineering and commercial applications, both." (Weil, Tr. 7263.) "[S]o long as the scale of problem is suitable to the machine the machine could do either business or scientific work. The distinction between those two in this class of machine had largely been erased by that time." (Weil, Tr. 7264.)

According to internal IBM reports, GE also reacted to IBM's 360 announcement by reducing the price of the 400 CPUs between 8% and 17% and the tape drives and their controllers between 14% and 27%. (PX 2966, p. 3.)* The IBM Commercial Analysis Department reported that "[t]he price reduction gives the GE 400 a price/ performance advantage over comparable System/360 configurations. The improved price performance of the GE 400, coupled with 4-6

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* See also DX 1525, p. 1 (7/29/64): "GE has not officially reduced prices, but they are selling their 400 line at 18% off. They have also reduced their extra shift to a 10% charge"; and PX 320, p. 16 (6/23/64): "The 400 line is a competitive offering today, but will require some revision if it is to remain competitive in the direct access market, and in the mixed business and scientific environment of two years from now."

months delivery, demonstrable hardware, and programming support makes the GE 400 extremely competitive with IBM's commercial product line." (Id.) This Commercial Analysis report evoked disagreement within IBM as to the effect of the GE price reduction. Knaplund "felt that, while in some applications the price reduction did indeed give the GE 100 [sic] a slight advantage, basically and broadly the reason for the competitive announcement was that our 360 put them under pressure and they had to reduce the 400 for them to stay competitive". As a result, IBM's President, A. L. Williams, chided the President of the Data Processing Division, F. T. Cary, for disseminating reports that were "unduly negative". (PX 2966, pp. R-1, R-2.)

GE initially announced four models in its 400 line of "compatibles"; in fact, however, only two were ever delivered. (PX 353, p. 44.) Subsequent GE product announcements (the 600 and 100 series) were not compatible with the 400 series. (Id.) In 1970, GE cited the failure to deliver all the 400 models which had been announced, as well as the incompatibility between 400 and 600 series computers, as yet another reason why GE developed an "image of fail[ing] to follow through" in EDP. (Id., pp. 43-44.)

b. The GE 600 Series. GE announced its 600 series in July 1964, after the announcement of System/360. (Weil, Tr. 7197-98; DX 491, p. 1.) At that time the 600 Series consisted of the GE 625 and 635, which differed only in memory speed. Later, GE announced the 615, a "special configuration, slower memory speed version of the same 625/635 system", the 645, "associated with MIT in Project MAC", discussed below, and, eventually, the 655 which reimplemented the 625/635 in higher speed integrated circuits. (Weil, Tr. 7198.)

The GE 600 series also included "several compatible but physically different military versions". (PX 4829, p. 18.) In a report on the 600 series, Withington wrote that the 600 series (and the 400) show "the same design emphasis on well-balanced, practical, but unspectacular systems. There are no technological innovations, and their basic speeds and specifications are no more than comparable to those of their competitors." (Id.) Internal IBM documents reported that GE was offering the 635 "at no extra shift charge". (DX 1525, p. 1.) When GE compared the 600 line against the announced IBM 360, it concluded that "depending upon exactly which model and details of usage and configuration, the 600 is either just a little more favorable or just a little less favorable than comparable members of the 360 series". (PX 320, p. 16.) As we have seen, however, IBM had made its own analyses of the competitive reactions to System/360 and improved its price/ performance with the 360/65 before delivery. (See pp. 389-90 above.)

However, the 600 line was not as technically advanced as the System/360. Weil classified the 600 series as a "second generation solid-state computer". (Tr. 7192.) Moreover, in peripherals the 600 series suffered in comparison to the IBM 360:

"At present, GE's systems are somewhat handicapped because their peripheral equipment (particularly random-access file storage devices) is in some respects inferior to IBM's. GE says it is moving actively to remedy this and to equal IBM's peripheral equipment with products of its own manufacture." (PX 4829, p. 19.)

Nevertheless, according to Weil, the initial customer acceptance of the 625 and 635 were "extremely good, well beyond our expectations". (Tr. 7206.)

One of the reasons for this was GE's success with users of the IBM 7090/7094 computers. GE had "carefully targeted as one of the markets for the GE 600 system the installed base of IBM's 7090's and 7094's" because the 7090/7094 "was at that time by far the leading scientific and engineering computer in the field, it had the largest number of such systems, so it was a large enough target". Further, since GE was itself a large user of the 7090/7094, the "members of these computer installations played a leading role among the user community of the 7090s and 7094s, so that . . . we had an enormous resource to draw on who understood that market and the needs of that user very well". (Weil, Tr. 7026-27.)

GE "designed the 600 system to feel as familiar as possible to a 7090 or 7094 user". Among other things, its peripheral equipment could accept both media and format from such users and its software represented "a compatible superset, a software that would include the capabilities of what the user already had but would give him further extensions". (Weil, Tr. 7029.) To aid conversion, GE provided a piece of hardware "called a 7090 Simulator, so that a user who purchased this piece of hardware and put it in his system could in fact run programs from the 7090 or 7094 without modification, or at least that was the hope. Most of the time it succeeded." (Weil, Tr. 7030.)

As a consequence, when IBM announced its 360 line as incompatible with its own earlier series, the computer group at GE was "initially at least overjoyed with what had occurred because it meant right at the time we were introducing a system designed to displace 7090's and 7094's, IBM had itself abandoned the 7094 and 7090 computer series and brought out an entirely different computer series, and it was our belief at that time that it would be easier, if you were a user, to convert from the 7090/7094 to the 600 series than it would be to convert to IBM's new 360 series. We regarded that as a fortuitous occurrence and potentially to our advantage." (Weil, Tr. 7060-61.) The user of the 7094 was "forced . . . to either go to a 360 or to some other competitive system, and we were sitting there with a system designed to make that conversion as easy as possible." (Weil, Tr. 7062.) That, of course, was one of the risks that IBM was taking with the 360, and by 1964 GE with its 400 and 600 and Honeywell with its 200 were attempting to take advantage of the 360's incompatibility with previous IBM lines.

Weil testified that GE was "relatively successful in converting user programs from the 7094 and 7090 to our 600 line" and that "our users found the conversion to involve work but to be within reasonable difficulty". "I don't really think we found a lot more difficulty . . . than we anticipated." (Tr. 7037-38.) Weil estimated that GE acquired between 10% and 20% of the IBM 7090/94 base. (Tr. 7269.)

In addition to providing compatibility with the 7090/7094, the GE 600 (as had the 400) provided a compatibility feature which assisted conversion from the IBM 1401 to the 600 line. This would enable users who had previously used 1401s as off-line devices in conjunction with the 7090 or 7094 (e.g., tape to printer, peripheral operations) to move both the applications previously done on the 7090/94 and the off-line functions run on the 1401 onto a single computer in the 600 line. (Weil, Tr. 7031, 7034-35.)

The GE 600 series marketing strategy probably was based in part on the ability of the 7090 users who leased the 7090 to terminate their lease in a relatively short time and send the IBM equipment which they were using back to IBM. (Weil, Tr. 7207.) In Weil's judgment, "the GE 600 competed well with the IBM 7094". (Tr. 7212.)

Naturally, in competing for conversion of the 7090/94 customer as well as for other business, GE was competing against the newer System/360 IBM computers as well. Weil testified that "generally we were competing with the upper end of the 360 spectrum as it then existed. That would include occasionally the Model 50 but primarily the various models of the 60's and occasionally the 70's within the IBM 360 family". (Tr. 7207.) The restricted configuration 615 may also have competed with the 360/40. (Weil, Tr. 7209; see also Tr. 7215.) Still later, in about 1970, the 600 series competed against the 370/145, 155 and (less frequently) the 165. (Weil, Tr.

7210-11, 7215.)

In "targeting" the 600 line against the 7090/94, GE in part paid a price for its success. Weil testified that the GE 600 competed with the 360/65 "perhaps less well" than with the 7094 "because it was very specifically targeted at the 7090/7094". (Tr. 7212.)

GE described its 600 line as a "family of large-scale computers for business, scientific and real-time use" (DX 491, p. 1) and as "a new, advanced, high-performance, large-scale computer for use in business, scientific, and real-time applications--complete with all software". (DX 492B, p. 3.) Weil testified, however, that the line was originally intended "primarily for engineering and scientific computation, but with specific features that would make it attractive as well for business and commercial application, but that in this case was the secondary market". (Weil, Tr. 7019.) "While the machine was basically a scientific machine derived from the 7090/7094 we were trying to replace, we also included extensive character manipulation facilities, which would have been typical of earlier business machines, commercially oriented machines, and was a part of the support we built into the machine--there were other such supports--part of the support we built into the machine for a COBOL compiler to make it attractive to business applications". (Weil, Tr. 7192.) GE "had the ability to use the growing low cost of logic to provide a number of features aimed at these several markets" (id.), reflecting the fact that "since the early sixties it really hasn't been economically important to design a computer system only for business or only for scientific applications, except at the extreme ends of this spectrum, where you were trying to do as much scientific calculation as you possibly can within the limits of the technology". (Weil, Tr. 7190.) Thus, GE's "intentions" with respect to the scientific marketing emphasis of the 600 series were differences of degree, not of kind. The perception at the time was that the 600 series, like the 360, would compete in all application areas.

Thus, Withington in 1964 wrote: "GE also believes (and we agree) that in the large-computer area there are no longer significant distinctions between scientific and business machines, so the potential market for the 600 series and its successors is very large". (PX 4829, pp. 18-19.) He also wrote:

> "GE's product line, then, is more analagous [sic] to IBM's than that of any other competitor. GE hopes to compete not by being different, but by doing the same things better: by providing a combination of hardware, software, price, and customer service which will appear superior. No competitor desiring a rapid increase in market share and profitability could afford to follow this approach. However, GE has repeatedly stated that its intention is to build a solid and major position in the computer industry: its approach is consonant with this goal." (Id., p. 18.)

And Weil made clear that the 600 was marketed after its announcement for both business and scientific applications: "[A]s the 600 was sold, as it went on in its lifetime, it was sold more and more to organizations that were more business-oriented and less scientific-oriented, partly as a result of bringing it down to the 615 . . . which was more in the territory of more business installations, and partly because we found there were many more business customers out there than were scientific customers for our class of system." "[T]he customer base that we built up became more and more business-oriented with time." (Weil, Tr. 7270-72; see PX 328, p. 21.)

Weil testified that the 600 also had capabilities for real time applications, which later turned out to be very useful for time sharing (discussed below) although those capabilities "were used by very few of the actual users that we sold the machine to". These real time capabilities were "a direct reflection of the military parentage of the central processor and the memory controller portion of the 600 system". (Tr. 7192-93.) In particular, the development of the 600 line drew on the work which had been done for the GE M-236 military computer by the Heavy Military Electronics Department in Syracuse.* (Weil, Tr. 7178-79, see Tr. 7301-02.) Among the real time uses of the GE 600 were the data reduction and monitoring done in connection with the Apollo launch system. (Weil, Tr. 7200; DX 556, p. 5.)

Even with the initial announcement of the 600 series, GE was thinking about the importance of time sharing as an emerging area. In July of 1964, in an internal GE publication, the General

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* Weil testified that "for the hardware aspects of the central processing units", the componentry, skills and the manufacturing facilities required today to produce the central processing unit are essentially the same whether one is speaking of a computer which is used for scientific, commercial or process control application. (Tr. 7191.)

Manager of the Computer Department was touting the 600's ability to permit "a large number of low-cost remote stations [to be] connected . . . by common carrier lines, thus permitting many people access to the computer's problem solving skills. The need for many small computers on college campuses, large government installations, or in widely-dispersed manufacturing organizations might thus be eliminated." (DX 491, p. 1.) While "the system had a number of features in its peripherals and architecture which would make this possible . . . at the time of this announcement we [GE] did not supply a system that could support such an application". The hardware features included "an excellent form of memory protection to isolate the system software from whatever users may be doing and to provide memory relocation features so we could accommodate a number of different programs in the system at the same time". As we shall see, the 600 was subsequently used in this way--as a time-sharing system. (Weil, Tr. 7199-203.)*

Notwithstanding the attractiveness of the 600 series conceptually, GE encountered difficulties in delivering the 625 and 635. Weil testified that:

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* As Weil explained, at the time it was thought that a single, central, shared computer was more efficient than a number of smaller, stand-alone computers. (Tr. 7203-04, 7254.) Thus, the 625 and 635 were "actively marketed for remote batch applications" as a centralized system in which it was contemplated that remote batch terminals would replace earlier smaller stand-alone systems. (Weil, Tr. 7252-54.) In the 1970s with lower and lower hardware costs, the trend turned the other way with many people believing that a number of smaller computers were more efficient than a single large computer. (See below at pp. 1276-86, 1339-40, 1448-59, 1510-16.)

> "We were attempting to bring to market simultaneously a new central hardware system, a new processor system, a new set of peripherals, and an entire new set of software.
>
> "On top of that this was the first time that General Electric had ever attempted to put together and market so large a system, and as a result of all of those factors at once, we had a great deal of difficulty making the systems perform to our customer's and our own satisfaction in the field. A combined set of hardware difficulties and software difficulties",

including

> ". . . a lot of difficulty with the magnetic tape units, we had some unreliability in the memories we were using",

and, because of the size and complexity of the system,

> "one of the difficulties we had was when something went wrong we had the problem of telling just what had gone wrong in this roomful of equipment, so diagnosis was a problem for us as well." (Tr. 7215-16.)

The difficulty with the software "centered around the operating system called GECOS, which was . . a comprehensive operating supervisor", among the first of such systems. "[I]t was ambitious in its design. We had a great deal of difficulty in getting it built, made reliable and made efficient." (Weil, Tr. 7216-17.)

There were three versions of GECOS. GECOS I, which had originally been intended for the 625 and 635, was never brought to the field.

> "It died in our test rooms because it was clear that it was sufficiently scrambled up internally that it would not make a good product, and so GECOS II was constructed to take its place using the lessons that we had learned on GECOS I.
>
> "GECOS II was the first version of GECOS that was sent to the field, and while it had a good deal of difficulty when it went to the field, eventually, with much patching and baling wire, was made to operate satisfactorily.

"GECOS III was initiated at that same--at the time period that GECOS II was in the field again to make use of the lessons we had in bringing GECOS II to the field, to reflect them back in what we hoped then would be a clean design and a clean product, so that GECOS III would incorporate the lessons of our field experience.

"It was started and it was brought to the field much later, I believe around 1968 . . . ." (Weil, Tr. 7217-18.)

Weil echoed the theme of many computer people during the 1960s when he said that GE's problems resulted at least in part because it was attempting to develop a state-of-the-art software system. (Tr. 7217-19; see Perlis, Tr. 2001-04; McCollister, Tr. 9694-97, 9706-08; Rooney, Tr. 12132-36, 12349-50, 12358; Conrad, Tr. 14088-89, 14133; Withington, Tr. 56727-30.)

The difficulties encountered with the 625 and the 635 did not result in slippages in delivery dates although Weil testified that "perhaps they should have. The difficulties occurred much too often out in the customers' installations." (Tr. 7220-21.)

In late 1966 or early 1967, the 600 series systems were withdrawn from the market and "put into . . . hibernation" ("it was put to sleep for the winter"). GE continued to support the systems already sold but did not actively seek new sales. That winter sleep period lasted for at least a year or two, and the systems were not marketed again until 1968. (Weil, Tr. 7221-22.)

In the fast-moving computer business, withdrawal is a mistake. Whereas IBM, when confronted with similar difficulties, put all of its effort into solving them and keeping its customers satisfied (see above at pp. 371-72), GE withdrew. Weil said that "the hibernation of the 600 was a mistake"; "it led to a considerable undermining in the confidence of General Electric's offering of this class of system" and adversely affected GE's image in the computer industry. Weil explained why:

> "When you buy a computer system, you are expecting a great deal from the man who -- the company that supplies it to you. You want to make sure that they will still be in business; that they will stand behind any difficulties that your system has had, and that they will make it do what they told you it was going to do. And any indications that people were backing away from such a full commitment would surely reduce a customer's confidence in that particular vendor." (Tr. 7224-25.)*

Withington also testified "that the inability of the General Electric Corporation to deliver operating systems [including GECOS and MULTICS] which completely met their advertised capabilities hurt the credibility of General Electric." (Tr. 56754, 56727-28.)

There were direct financial consequences as well. In 1966 GE reported that "in the information systems business, current operating losses were higher than projected because of difficulties involved in meeting a very sharp increase in shipments, and because of expenses in integrating worldwide product offerings. Substantially increased costs were also encountered in getting some new systems into operation." (PX 327, p. 9.) John L. Ingersoll, who had been Financial Manager of GE's information systems business in the late sixties, testified that from 1965 to 1968 GE's difficulties with the

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* Withington, when he testified, emphasized that the customer's relationship with a computer systems vendor depended on the customer's understanding that the vendor was "credible"--that is, that "a given manufacturer is a good one to be associated with . . . over time". (Tr. 55735-36, 57671-72.)

625 and 635 "were a major element in the financial results experienced by that segment of GE". (Tr. 8339.)

Such difficulties, experienced with the first computers and software of the 600 line, were aggravated when it came to the development of time sharing.

c. Time Sharing. GE was involved in "two somewhat separate threads" in the development of time sharing. (Weil, Tr. 7106.) The first of these, developed by Dartmouth with some help from GE, was "a very effective small time sharing system which we then brought into our engineering organization and eventually modified, documented and offered as a product . . . initially on a system derived from the 225, later on a system derived from the 235, and eventually, very related, conceptually related systems were offered on the 400 line and on the 600 line". Weil believed that this was the first commercial time-sharing offering. (Tr. 7106-07.)

That system was "independent of the separate path which involved the more ambitious, technically, time sharing system based upon the 645 and the MULTICS software". (Weil, Tr. 7106-07.) That more ambitious development involved Bell Labs and M.I.T. (Weil, Tr. 7108, 7225-26, 7231.)

Early in 1964, the Project MAC organization at M.I.T., which had already developed a time-sharing system (CTSS) on a pair of IBM 7090s (Brooks, Tr. 22739-40; Perlis, Tr. 1881, Weil, Tr. 7226-27), was "interested in developing an extremely advanced time sharing system". It approached a number of manufacturers "for a cooperative effort in that development". (Weil, Tr. 7108.) General Electric proposed to Project MAC a version of the 635 system, which "would be modified in accordance with some of the discussions we had had with them, and which would provide then a hardware base for the advanced time sharing system they wished to develop." In addition, GE "proposed working jointly with them in the development of the software that would reside on that hardware." (Weil, Tr. 7111-12.)

In the summer of 1964, Project MAC selected GE over bids from IBM, DEC (who did place a $1 million peripheral processor, however), and others. (PX 2961, pp. 1, 3.) IBM believed that its rejection was due, at least in part, to the fact that it had proposed to implement time sharing without dynamic relocation hardware. (Knaplund, Tr. 90533-35.) Weil confirmed that GE believed that "certain aspects of the 600 architesture [sic], the 600 system, as laid out, were more amenable to some of the things that MIT wanted to do than were either the 7094 based system or the 360 based system". "[W]e had a good meeting of minds, a good agreement on philosophy with the Project MAC team." (Tr. 7115.) Project MAC and GE--and others in the industry--believed that computer systems were evolving toward "an information utility" based on the time-sharing concept which would be of crucial importance to the future of computing. (Weil, Tr. 7116, 7251-52, 7254-55; see Perlis, Tr. 2117-18; PX 320, pp. 9-10.) Wright, Director of Time Sharing Marketing for IBM from 1964 to 1965, summarized his eight or twelve conversations with Dr. Ivan Sutherland, the Director of Information Processing

Techniques for the Department of Defense's Advanced Research Projects Agency (which funded Project MAC) (Tr. 13287-90) as follows:

> "Ivan Sutherland was essentially exploring what IBM was doing in the timesharing field. . . . I think that he was trying to convince himself whether or not we were serious, whether or not we intended to follow through with a degree of urgency in the project.
>
> "He spoke words of encouragement, encouragement in the fact that he believed that IBM should pursue development of the time sharing concept in products and software as a matter of not only great importance to the United States government, but also of great importance to IBM and he simply encouraged and wanted to be kept aware, sort of as an insider, of how things were going on the project.
>
> "[I]t was my understanding that his interests were the fact that he believed providing time sharing facilities to the Department of Defense contractors in design of new weapon systems, and use in other things, including health systems and so on, would, in fact, foster the use of computers, but, more importantly from his standpoint, would assist in the solving of problems that these people in their research and development activity were confronted with and the use of computers would facilitate the solution of those problems at a more rapid rate and, therefore, accelerate the advancement of technology.
>
> ". . . .
>
> "[I]t was clear that he felt that two large companies, such as GE and IBM, pursuing developments in time sharing, was beneficial to the government, was beneficial to industry and, therefore, that he thought that was a good situation." (Tr. 13290-92.)

As shown above (at pp. 417-36), many people within IBM also believed that the time-sharing computer utility concept might well be the wave of the future and failure to respond to competitive thrusts in this area--especially by a competitor with the power and potential of General Electric--might relegate IBM to a secondary position in the future. Thus, for example, in September 1964, responding to the loss of Project MAC and of other important accounts in the time-sharing area, Nat Rochester, a member of IBM's Time Sharing Task Force, concluded: "There is much more at stake than these few prestige accounts. What is at stake is essentially all computing business, scientific and commercial. . . ." (PX 1194A, pp. 2-3.) Two days later, the Research Group of the Time Sharing Task Force wrote:

> "There is a very strong probability that the 'computing utility' will be _the_ way of all scientific computing in a few years,and a good possibility that it will capture a substantial part of the commercial market as well. IBM cannot afford to overlook a development of this scope. _We are currently in danger of losing all contact with the leading developers of this concept._" (PX 2811, p. R-3; emphasis in original.)

Similar thoughts were expressed by other groups within IBM. The Scientific Computing Department reporting on "remote scientific computing" urged:

> "Certain accounts have already been lost. A small set of key accounts are right now in the process of evaluations leading to computer acquisition decisions. For every such case, decisions disadvantageous to IBM appear to be in the offering. In quantity, such losses do not appear to be large. In quality, they will have a tremendous impact upon a very large market segment.
>
> ". . . .
>
> "If we do not respond on the time-sharing requirements in the near future, the time-sharing market will be largely lost to GE who has responded to this requirement. A large part of the balance of the remote scientific market will also be in jeopardy." (PX 2964A, pp. 4-6.)

Wright put it concisely:

> "And all during this period of time, in general, the industry was in a state of agitation because time sharing appeared that it might indeed be a new wave of the future from the standpoint of computing facilities for a company or an institution.
>
> ". . . .

"So there was clearly, you know, an understanding that if IBM for some reason did not respond to this particular requirement of customers' need, demands of the customer, it was very likely that those customers might very well buy such capability from somebody else.

". . . .

"[T]he significance would be that IBM would lose business and that part of the installed base that IBM had at that point in time would disappear." (Wright, Tr. 12843-45.)

In addition to being in the forefront of the new wave, GE expected two additional benefits from its work with Project MAC. First, "it was an opportunity for us to work with one of the organizations that was widely regarded as an advanced thought leader in the field, hence, we hoped to benefit technically from that work, but also because it was based upon 600 line hardware, even though it was largely incompatible with the 625/635, it would nonetheless provide a reflection on the 635 and 625 hardware in the minds of our prospective customers, so that the customers would feel that the machines they were buying were related to and that he might someday look forward to growing into the kind of applications that MIT and GE were developing on the 645". Second, "it lent an aura of advancement to the rest of our commercial offerings." (Weil, Tr. 7122-23.)

GE and M.I.T. were not the only participants in Project MAC. Bell Labs was also to be involved in the development of the MULTICS system, "a system, hardware and software together, for carrying out a very advanced form of time sharing, a multiple access to extensive system facilities". (Weil, Tr. 7225-26, 7231.)

The first GE system installed at M.I.T. was a GE 635, which was "used as a development facility, but the project was aimed . . . at developing the MULTICS system, and a part of the MULTICS system was a special expanded version of the 635, which was later termed the 645." The 645 involved "major extensions to the central processor, primarily having to do with the way in which memory was addressed and accessed." "[T]here were hardware protection features" and a "high capacity input/output controller". "A very advanced form of dynamic relocation was included in the 645." (Weil, Tr. 7227-28.)

In the fall of 1965, GE announced the 645 as a product at the Fall Joint Computer Conference. (Weil, Tr. 7233.) In December it announced that it was working toward the "broad commercial availability" of the 645 system. (PX 326 (DX 13668, p. 15).)* However, within a year of the December 1965 announcement, the 645 was withdrawn "because we began to realize that what we had on our hands was a research project and not a product. . . . We were attempting to do something that had never been done before, and, in principle, we might end up discovering that it was not feasible. As it turned out, it was hard and slow, but it was feasible." Weil described the GE 645 as "being in the research project stage" until 1969 or 1970. (Weil, Tr. 7234.)

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* GE had already bid a version of what came to be the 645 to GM Research along with time-sharing software, graphic console and devices. Neither the hardware nor the software existed at the time, and the consoles were to be modified versions of those already being marketed for military applications. (Hart, Tr. 80284-87.)

At the time of the public announcement of the 645, the software had not been developed and the 645 itself was not in existence. General Electric never offered the 645 again as a product. (Weil, Tr. 7234-35.)

While the 645 was intended "to provide a top-of-the-line prestige luster to the 600 line and to our other products, and also to be a prototype for future sophisticated time sharing systems", as it turned out, "because of its lateness and its difficulty, it represented very little to General Electric except a drain on its resources" (Weil, Tr. 7236) although "some of the features that were pioneered in the 645 have since appeared elsewhere". (Weil, Tr. 7237.) Despite the potential which it had for future success, GE never put its principal marketing thrust on the GE 645. (Weil, Tr. 7236.) The 645 was never delivered, and Project MAC received a system designated a "636". (Wright, Tr. 13375-76.)

Although Weil and others believed in 1964 and 1965 that the MULTICS system "could be technically feasibly designed", the participants in the Project MAC effort "underestimated the difficulty of successfully developing MULTICS". (Weil, Tr. 7232.) "[T]he system operated in the way that [it] was originally intended about three years behind its own schedule." Weil testified that this was a consequence, first of the difficulties of cooperation among M.I.T., Bell Labs and GE, and, secondly, because "the technical task that was being attempted was extremely sophisticated and many of the subjects were at the state of the art as it was then known, and it took a long time to iron out the details of implementing some of these important features". (Weil, Tr. 7233.) Such problems occurred in other state-of-the-art software efforts, including those of IBM. (Perlis, Tr. 2001-04; McCollister, Tr. 9694-97, 9706-08; Rooney, Tr. 12132-36, 12349-50, 12358; Conrad, Tr. 14088-89, 14133; Currie, Tr. 15704-06; Withington, Tr. 56727-30.)

d. False Starts. On a number of other occasions during the 1960s, GE began development of product lines which were cancelled or greatly reduced.

Weil testified that in the early 1960s, a series known as WXYZ was in development in Phoenix. "WXYZ was a series of four systems of which the Z was to be the most powerful." By the time Weil became familiar with it, "only the X and the Y were under serious development". After "considerable evolution", the X eventually became the GE 400. "The Y was to be a rather sophisticated, larger system, but it was cancelled at the end of 1962 and its place in the market spectrum was eventually covered by the beginning of the 600 project." Neither the W nor the Z was ever delivered. (Weil, Tr. 7238-39.)

Following the announcement of the 600 series computers, GE considered a series of new product lines. An important event which triggered these lines was the acquisition of overseas affiliates, the Bull Company in France and the Olivetti Electronics Division (later known as GE Information Systems Italia) in Italy. (Weil, Tr. 7239; see also PX 326 (DX 13668, pp. 3, 15); PX 328, p. 18.)

According to Weil, GE at that time was interested in producing "a world-wide product line which would cover the main portions of the product spectrum", and as a result a series of product lines were conceived. (Tr. 7239-40.)

The first such line, the GE 100 line, was conceived during the tenure of Dr. Louis Rader. Rader joined GE in 1964 as Vice President and General Manager of the Industrial Electronics Division and took over the GE Information Systems Division which was formed in 1965. (DX 13668, pp. 15, 33.) The GE 100 line consisted primarily of three sets of processors which were to be manufactured in Italy, France and the United States and which GE intended to market throughout the world. (Weil, Tr. 7240.) In 1966, Rader was transferred from the Information Systems Division to become General Manager of a new division, the Industrial Process Control Division. (PX 327, pp. 9, 33.) Despite the fact that several study groups recommended proceeding with the 100 line, Hershner Cross, who took over from Rader as General Manager of the Information Systems Division in 1966 "overruled all the study groups and decided that the 100 line would be abandoned". Cross did this "at the same time that he put the 600 into hibernation." (Weil, Tr. 7223-24, 7240-41; PX 327, pp. 9, 33.)*

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* Weil testified that the GE Italian computer operation pursued the 100 line after the decision was made not to proceed domestically. The lower members of the line manufactured in Italy had their names changed several times and were brought to market originally as the 115 and later as "successive members of a moderately effective, low priced business system". (Weil, Tr. 7241.) The GE Italian operation pursued the 100 line despite Cross's edict because "they had a strong general manager". (Weil, Tr. 7242.)

After cancellation of the 100 line, GE began to consider different new product lines.

> "Upon cancellation of the 100 line, one of the measures that was taken was to initiate a study centered in France, but with worldwide participation, to spec out a more advanced line than the 100 line that would serve the same general purpose.
>
> "This project, known as Project Charley, met in Paris for a period of a number of months, but nothing broader came out of that beyond a book of proposed specifications.
>
> "At that point there were some management and personnel changes in General Electric and it was about at this juncture that John Haanstra came to General Electric, and he initiated the development of another line of computers, again to be worldwide and again to serve a broad spectrum.
>
> "Eventually this line of machines was known as the ERW line . . . ." (Weil, Tr. 7242.)

The ERW line began in late 1966 and "lingered on for a while after that, but its principal effort was for eight or nine months, beginning in the fall of '66, into the spring of '67". After that,

> "John Haanstra's responsibilities were changed and he was put in charge of the Phoenix operation. He lost his personal identification with this worldwide product line and instead became a champion of what was going on in Phoenix, which of course was very heavily the 600.
>
> "The ERW line was largely leaderless for a period of time . . . .
>
> "Then Dick Bloch came to General Electric and he instituted a line, I believe initially called the 700 line and eventually called APL, which was his conception of a worldwide, broad spectrum computer line." (Weil, Tr. 7243.)

This was in 1968. (R. Bloch, Tr. 7615-16, 7755.) Haanstra, who had been recruited from IBM to lead the GE computer operations in 1968, was moved to Phoenix less than a year later, then was killed in a plane crash in 1969, and none of these projects ever resulted in delivered products. (Weil, Tr. 7242-46; R. Bloch, Tr. 7756.)

Bloch, who came to General Electric from Honeywell via Auerbach Corporation in 1968 and succeeded Haanstra as General Manager of the Advanced Development and Resources Planning Division, testified that when he arrived, there had been "several starts in the direction of an advanced product line". (Tr. 7592, 7611, 7757; PX 327, p. 28.) According to Bloch, while there were "some very, very excellent developments afoot", the operation was poorly organized and "one would have wondered how this would ever be put together into a line". (Tr. 7757-58.) One problem was that there were various development activities under way under different auspices throughout the company. (R. Bloch, Tr. 7759.)

> "GE previously was typified to me as a company of great potential in terms of spot accomplishments in various areas--software, hardware, new attacks, in concept and in hardware too. But the real question was, how was it all going to be put together? That was one side of it. The other side of it was that nobody thought about the total plan, the total objective, what this business data processing world was all about." (R. Bloch, Tr. 7759.)

Thus, Bloch believed "the decentralized organizational approach of General Electric adversely affected their attempt to develop an integrated line of computer products", and individual departments took over responsibilities for obsolescent lines, promoting their own interests. (Tr. 7759-60.) The problem was that GE, unlike IBM, was unable to tie together under central control this disparate collection of products produced and marketed throughout the world.* What Bloch called GE's "decentralized organizational approach" was a substantial part of its downfall.

e. The Management of GE's Computer Operation. General Electric encountered substantial difficulties in managing its computer operation. It had a revolving door of management personnel running its computer business during the period 1964-1970. During that time frame GE ran through a progression of managers and other key personnel whose jobs constantly changed and who were succeeded by people with little computer experience.** The result was that

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* The following statement from the 1968 GE Annual Report summarized the GE computer equipment business as of that date.

> "On a world basis, General Electric offers five product lines, starting with the small-scale GE-50 series, produced by Bull-General Electric in France. The Italian operation produces the 100 series, and in 1968 introduced a more powerful system, the GE-130. The US-designed 200 series continued to hold wide acceptance for its dependable computing power. The GE-400 line of medium-scale systems is produced in the U.S. and France and in Japan under a licensing agreement." (PX 328, p. 18.)

** In July 1963, the Computer Department was headed by Harrison Van Aken, who reported to the General Manager of the Industrial Electronics Division. (Weil, Tr. 7085; PX 320, pp. 1, 2, 19; DX 485; DX 491.) In 1964, Dr. Louis T. Rader was hired to be in charge of GE's worldwide computer activities. He was named Vice President and General Manager of the Industrial Electronics Divison and reported to Hershner Cross, Vice President and Group Executive of the Industrial Group. (J. Jones, Tr. 79357-58; DX 13667, p. 31.) In 1965, General Electric realigned its organization and formed an Industrial and Information Group headed by Cross. Within that group was the Information Systems Division, headed by Rader. (DX 13668, pp. 15, 33.) In 1966, still another new division was formed, called the Industrial Process Control Division, and Rader was transferred from the Information Systems Division to the new division to become its General Manager. Cross remained group executive of the Industrial and Information Group and at the same time served as Acting General Manager of the Information Systems Division. (Weil, Tr. 7223-24; PX 327, pp. 9, 33.) Early in 1967, J. Stanford Smith, formerly Vice projects begun were abandoned and no continuity of purpose or product development existed. But the problems went deeper than that.

According to Weil, one of the "major mistakes" which GE made in managing its computer business, stemmed from GE's "very strong" belief

> "in the philosophy of professional management. This basically is that management is a profession and a good manager can manage any kind of business.
>
> "This in fact works quite well for a mature or gradually declining business, where a man put into a business can model his behavior upon that of his predecessor's and then make adjustments as he learns what's really going on. In a rapidly evolving business, however, his predecessor's behavior, especially if it was unsuccessful, is a very poor model. And since he knows nothing about the business, he is a professional manager and came from Toasters or Welding, or whatever it may be, elsewhere in the General Electric Company, he really could not understand what he was managing.

President of Marketing and Public Relations Services, became the General Manager of the Information Systems Division. (DX 13668, p. 33; PX 327, p. 33.) In January 1968, GE again changed its organization, going from 5 groups to 10 groups and from 29 divisions to 46 divisions. Hershner Cross's Industrial and Information Group was split into two groups. Cross remained Vice President and Group Executive, heading up the Industrial Group which included the Industrial Process Control Division led by Rader. Smith was promoted to Vice President and Group Executive in charge of the Information Systems Group, and John Haanstra, who had recently come from IBM, became General Manager of the Advanced Development and Resources Planning Division within that group. (R. Bloch, Tr. 7755-56; DX 13669, pp. 27-29.) In 1968, Haanstra became General Manager of the Information Systems Equipment Division (PX 328, p. 28) and Richard M. Bloch replaced Haanstra as General Manager of the Advanced Development and Resources Planning Division (later the Advanced Systems Division). (R. Bloch, Tr. 7623-25; PX 328, p. 28; DX 556, p. 30.) In early 1969, Hilliard W. Paige, who was Vice President and Group Executive of the Aerospace Group, replaced Smith as head of the Information Systems Group. (PX 328, p. 27; DX 556, p. 29.) Later that year, J. F. Burlingame succeeded Haanstra, who was killed in a plane crash, as Vice President of the Information Systems Equipment Division. (DX 556, p. 30.)

". . . .

"But if you have a series of these managers above each other, they feel they are in trouble, they now must do something. What can they do? They do not understand the business well. So the only thing they can do is to replace the man working for them.

"So the net result of this was, as we got into difficulties, especially in bringing the 600 to market thereafter, we had a sequence of people running General Electric's computer business, none of whom, except when we come to Dick Bloch and John Haanstra--and, again, they were not in charge of the computer business but were key people--none of whom were experts in the computer business. Furthermore, we had a new one every eighteen months or so.

"So that General Electric never developed experienced management that understood the computer business, and I believe this was a major part of why General Electric never learned how to manage the business properly." (Tr. 7247-49.)

This philosophy led to General Electric having "a great deal of difficulty . . . in entering dramatically new fields", although it was "extremely successful in managing mature businesses and declining business". (Weil, Tr. 7259.) This is undoubtedly associated with GE's decision, discussed below, to remain with its "core" businesses rather than continuing in computers.

GE's management problems were perceived outside of GE as well. Withington testified:

"I recall that General Electric, consistent with its policy of rotating managers between divisions, changed the senior management of its computer systems business at intervals of approximately three years and I recall feeling that this was a poor practice as the incoming managers rarely understood much about the business at the time they would take it over." (Tr. 56731.)

John Jones, of Southern Railway, testified that although Southern Railway was a "very large customer of General Electric" in other areas, Southern Railway "did not seriously consider their computer equipment". (Tr. 79352.) In the middle to late 1960s, Jones reached the conclusion "that General Electric was not a viable competitor, not one that I would consider selecting in the environment that I was in at the Southern Railway Company and with the project that I had before me to complete". (Tr. 79353-55.) He testified:

> "[T]hrough personal knowledge at several levels in the company, I was at least to some extent aware of the activities of the Computer Division of General Electric, and it was my view that there were some serious problems in terms of how they were managing that function, and it was my concern that I would not be able to obtain the support and continuing responsiveness from General Electric that I would judge to be critical in the system that we were considering installing.
>
> "As a result of those concerns, despite the fact that we had been a large customer of General Electric in other areas, it was my conclusion that I did not want to take on the risk of, or what I perceived to be a risk, of considering installing General Electric equipment." (Tr. 79354-55.)

Jones' views crystallized in middle to late 1967 (id.), about the same time that General Electric's difficulties were being made public in the form of the "hibernation" of the 600 system.* (Weil, Tr. 7221-22.)

In 1970, GE's future product plans (then known as APL) recognized that among the "negative factors" which affected GE's image in the computer industry were (a) GE's "management indecision and replacement", (b) GE's "professional manager" image, (c) GE's

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* Jones based his views on his personal contact with General Electric at the time. (J. Jones, Tr. 79355-60.)

"lack of long-term commitment" and (d) GE's "loss of key personnel". (PX 353, p. 45.)

Rotation of management meant a lack of continuity in decision making over time, but another difficulty, as already observed, was decentralization of decision-making responsibility at the same point in time. Bloch testified that

> "GE operated in a decentralized fashion, with profit centers usually at the departmental level, and for reasons which I do not pretend to comprehend, the top management of the company allowed these growths to occur of quite competent, in their own right, groups, both here and overseas.
>
> "Overseas, of course, one can understand some of that, because there was outright acquisition. But even here there were a multiplicity of centers and there was a proliferation of activity; multiple peripheral devices of the same general character being developed at different places at the same time; a lack of coordination from any central area whatsoever.
>
> "Our plan was, indeed, to make use of the facilities worldwide but to have it completely controlled and specified, all standards set, from the central operation in New York. And this was a new philosophy to them entirely. And if this was indeed a new philosophy to them, then I can understand why they had problems earlier." (Tr. 7646-47.)

Bloch had "no question" in his mind that "the decentralized organizational approach of General Electric adversely affected their attempt to develop an integrated line of computer products". He encountered "substantial resistance" to his attempt to limit the decentralization. (R. Bloch, Tr. 7759-61.) GE's decentralization of responsibility within computers reflected its general management philosophy. GE's 1968 Annual Report stated that "General Electric had 170 decentralized operating departments focusing on separate aspects of world markets in 1968. Its production ranged over some

3,000 different categories of products and 200,000 different models and sizes." (PX 328, p. 7.)

The Computer Department was always buried deep in the organizational structure. Back in 1963, the Computer Department had been within the Industrial Electronics Division which in turn was part of the Industrial Group. Weil testified that there were "something approaching a hundred" departments in GE at that time. (Tr. 7153-54; DX 485.) In 1968, GE formed the Information Systems Group, one of ten groups containing 50 to 60 divisions and, in turn, 130 or 140 separate departments. (R. Jones, Tr. 8794-95.) Because computers had been so far down in its organizational structure and because it had so many other products to attend to, GE failed to mobilize its resources in computers to the extent necessary. Weil testified that among the "major mistakes which GE made in the management of its computer business" were two which related to this. First,

> "a lot of ambitious and difficult tasks were attempted which turned out to be more difficult and more ambitious perhaps than was appreciated when we started.
>
> "Secondly, General Electric was never fully committed to its computer business. It was always a business . . . that General Electric could live without. So that if troubles came or budgets were suddenly bigger than had been expected, there was always this reconsideration of 'Is this really a business we want to be in? And how do we prevent this from draining the profits of our other businesses?' It was not the strong commitment felt by those of us actually in the computer business of General Electric." (Tr. 7247-48.)

He testified that there were differences, for example, between GE's commitment to the computer industry and its commitment to the atomic power business to which it "manifested a greater commitment to success". Nuclear power was regarded as "an adjunct to that core of business of the company" consisting of the supplying of power generation equipment. "It was clear that the mission of the nuclear power business was: We don't know whether there is a business, but if there will be a nuclear power business, you will be one of the leading competitors." On the other hand, the "equivalent charge" for the computer business would have been, "We are sure there will be a computer business, now you must demonstrate that you can compete." (Weil, Tr. 7174-76.)

Similarly, Bloch testified that, when he joined GE in 1968:

> "They were in the business. They had been in for some period of time furnishing general purpose computing equipment. My feeling was, however, that it was always tainted with some tentativeness or speculativeness on the part of the company as a long term commitment to the field. My feeling was that if it turned out to be a great success, the company would be delighted; if it turned out not to be a great success, the company could extinguish parts or all of its activity in the field without necessarily any great remorse." (Tr. 7623-24, 7616.)

Reginald H. Jones, Chairman of the Board and Chief Executive Officer of GE at the time of his testimony and a member of the Ventures Task Force which recommended GE's exit, as described below, testified that he (and his predecessor, Fred J. Borch*) had agreed with their predecessor, GE's former Chairman, Ralph Cordiner, who said about GE's computer business: "General Electric's mistake was

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* Fred J. Borch was Jones' predecessor (R. Jones, Tr. 8752), not his "successor" as Jones mistakenly says at Tr. 8870.

that it failed to realize the opportunity and therefore made an inadequate allocation of resources, both human and physical, to the business". (Tr. 8869-70, 8751, 8752.)

Jones testified that "as early as the 1950's, if we had increased substantially the technical manpower assigned to the business, if we had increased at that time the financial resources required for the business, they would have been much smaller in terms of absolute numbers than they would have been, let's say, some fifteen years later." (Tr. 8875.) Jones said: "We never did make the allocation of resources to the business that were warranted." (Tr. 8874.) The contrast with both IBM's commitment to the business in the 1950s and its investment and risk-taking with System/360 in the 1960s is striking.

f. <u>GE's Position in the Late Sixties.</u> In 1964, General Electric obtained approximately half of Compagnie Bull General Electric and Societe Industrielle Bull General Electric for $43 million. (DX 13667, p. 16.) By the time of the Honeywell merger, revenue of the Bull companies was $206 million. (DX 554, p. 10.) In 1965, General Electric acquired the majority interest in Olivetti-General Electric for about $12 million. This subsidiary was formed from the electronic data processing business and the electronics laboratory of Olivetti of Italy. (DX 13668, p. 3.) In 1968, General Electric changed the name of Olivetti-General Electric to General Electric Information Systems Italia when it secured full ownership of the Italian-based computer affiliate. By

1968, General Electric had research, engineering and manufacturing facilities at 13 locations in five countries with a worldwide sales and service organization of 8,000 employees. (PX 328, p. 18.) As has been noted, the Bull subsidiary produced the GE-50 series and the 400 series* and the Italian subsidiary produced the 100 series and the 130. (PX 328, p. 18.) In 1968, General Electric also broadened its line of input/output and storage devices and extended its time-sharing services. By the end of that year, more than 50 GE time-sharing systems were in place serving about 100,000 customers in 17 countries around the world. GE reported that this area of the business was "growing even faster than the computer equipment sector". (PX 328, pp. 18, 21.)

GE also reported that "the company's investments in computer technology have given us an expanded worldwide base in what has been characterized as the world's fastest growing business. Again, our developing capability to serve this industry is leading to further new opportunities." (Id., pp. 3-4.)

GE's 1968 sales of information systems were "well above those of 1967 and with operating losses substantially reduced". (Id., p. 18.) For the year ended December 31, 1969, the General Electric computer operations which Honeywell acquired showed a profit. (Ingersoll, Tr. 8329-30; DX 554, p. 9.) Those operations continued to show a profit for Honeywell in 1970. (DX 148, p. 1;

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* The 400 was also produced in Japan and the United States. (PX 328, p. 18.)

DX 13977.)

In 1969, GE announced the GE-655, "the most powerful member of the large-scale GE-600 line" which had "had its best year in shipments and orders". According to the GE 1969 Annual Report, the GE-400 line also had a successful year. (DX 556, p. 13.)

Despite these improvements, GE was still in trouble. Yet, if GE "did not appreciate the problem that was building in the late Sixties" (R. Jones, Tr. 8876), others did. Withington wrote in 1969:

> "During 1968, General Electric was able to demonstrate completely successful operation of its GECOS-III operating system for the 625 and 635 computers. . . . The 625 and 635 (recently joined by a smaller 615) are continuing to sell largely because of the success of GECOS-III, but the machines themselves are obsolescent from the point of view of cost-effectiveness. It is to be presumed that General Electric has in development compatible successor machines which can capitalize on GECOS-III, but which will show better performance. When this new line is announced, General Electric will be in a position to make a strong resurgence in the large machine area." (PX 4834, p. 29.)

Withington judged the GE-400 line "obsolescent" as well and said, "General Electric's future position is dependent on the timing and success of the new line." (Id.) As we have seen, GE had made several false starts to the development of "compatible successor machines" and was not, in fact, "in a position to make a strong resurgence".

As of 1969, GE had several incompatible lines, which had been "developed at different times in different places, and to a great extent under different management". (R. Bloch, Tr. 7787-88; PX 328, p. 18.) Bloch, who came to GE in 1968, concluded that the

GE 100, 200 and 400 series computers

> "were beyond their useful time in terms of state of the art. They were in place doing their work, except that we were simply facing the natural problem of the field, and that is with time. You get to a point in which the price/performance is so improved over equipment of days of yore that it is clear that those users are going to move to new equipment, and either you are going to provide that new equipment or your competitors are going to provide it." (Tr. 7761-62.)

As Jones put it: "You had to bring out something that would exceed the price/performance of the existing competition because you knew full well that they were going to be moving ahead of you. It is a constant leap frogging game." (Tr. 8866-67.)

Bloch testified that although the larger 600 series had come out more recently than the other lines, the importance of smaller systems "far outweighed the significance of that 600 series, looking toward the future". This was because Bloch foresaw a tendency toward increasing decentralization and smaller processors, "which are smaller physically, they are smaller dollarwise, but they certainly aren't smaller in terms of power when contrasted with the earlier days". (R. Bloch, Tr. 7762-67.) Thus, while the 600 "would be more appropriate for extremely large, powerful systems that are meant to be operated on a highly centralized basis", Bloch felt that GE needed to pay more attention to the smaller members of the line. (R. Bloch, Tr. 7768; see Weil, Tr. 7252-54.)

The Ventures Task Force, organized in late 1969 to consider GE's future in the computer business, reported in April 1970 that "most current product lines are obsolete" and that GE had a "lagging technical position in mainframes, peripherals and manufacturing process technology". (PX 331A, p. 18.)

This was not a secret held within GE. GE's reputation in the computer industry had suffered badly from its management failures and product obsolescence. Thus, the Advanced Product Line Master Plan in January 1970 recognized that GE's image in the computer industry was poor:

> "General Electric has the reputation of the 'sleeping giant' of the information systems industry, with vast capabilities and resources which have yet to be marshalled for a determined attack on IBM.
>
> "GE's image is one of failure to follow through, as characterized by:
>
> " . An enviable image in the banking industry was built through the success of the ERMA project and GE's leadership in development of Magnetic Ink Character Recognition standards. This image was subsequently lost due to neglect.
>
> " . In 1963, GE assumed a leadership position in the area of communication systems and communications control concepts with the announcement of the DATANET-30. Subsequently, GE has lost its leadership in the field by not following up with any improvements until the recent announcements in 1969.
>
> " . In the area of system capability, GE coined the phrase, 'The Compatibles'. When the GE-400 line was introduced, it was characterized as the GE line of the future which would be compatible throughout. Although GE announced four members (GE-425, GE-435, GE-455, GE-465) of this line, it delivered only two.
>
> " . Since announcement of the GE-400 line, GE has made two other major line announcements: the GE-600 line, which is not compatible with the GE-400 line; and the GE-100 line, which is compatible with neither. In fact, GE currently supports seven mutually incompatible product lines.
>
> " . In 1964, GE recognized the way of the future by an aggressive advertising and promotional campaign with regard to direct access. It indicated that direct

access was the way of the future and announced a line of disc storage devices to support this assertion. Since then GE has not followed through on this commitment even though the initial prognostications proved to be accurate.

"A brief summary of GE's image with respect to the various product lines includes:

"GAMMA 10--an ideal model for a beginner.

"GE-50--excellent for new users, but no compatible upgrade.

"GAMMA 30--an obsolete machine with no compatible upgrade.

"GE-200--an obsolete line with no compatible upgrade.

"GE-100--a good family of products.

"GE-400--a relatively obsolete line with no compatible upgrade.

"GE-600--a reasonably good line with a need for a higher member (a la the GE-655). Good operating system software--among the best in the industry.

"As long as the user is able to remain within a given one of the seven product lines, he is reasonably satisfied.

"Measures of customer loyalty appear to fluctuate from year to year, but are generally below IBM and appear to be consistently below the industry average. This loyalty is understandably low when customers must move up from the product line which they are currently utilizing." (PX 353, pp. 43-44, footnote omitted.)

Unlike IBM which had integrated its product line in 1964 with a single compatible line conceived, developed and marketed on a worldwide basis, GE in 1969 still had several incompatible lines with fragmented development and inadequate worldwide coordination.

g. <u>The Advanced Product Line (APL).</u> Plainly, if GE was to overcome its problems, it needed a new product line. This was to be Bloch's task when he joined the company in 1968. (R. Bloch, Tr.

7757.)

This new line, "initially called the 700 line and eventually called APL . . . was his conception of a worldwide, broad spectrum computer line". (Weil, Tr. 7243.) It was to be "a single integrated line to be marketed on a worldwide basis". (R. Bloch, Tr. 7798; Ingersoll, Tr. 8104.) GE's plan was to achieve the "number two position" in the field:

> "We could not also see a company such as GE being satisfied with a $50,000,000 business, say, in some convenient corner of the field, even if it were able to make a profit there, which might indeed happen, because a business that size is insignificant in the GE scheme of things." (R. Bloch, Tr. 7648-49, 7799.)

As a result of this goal, GE's APL was to be "an attack" "across the board". The new line was to "attack" everything from the $500-a-month rental to the $70,000- or $80,000-a-month rental, which, as Bloch put it, "is a tremendous range", "well over 90 percent of the total range". Of course, GE was attacking IBM and "in particular attacking the IBM 360 series, and not only the 360 series, but what we surmised was coming soon, and which became the 370 series." (R. Bloch, Tr. 7647-48.) Bloch testified that, had the APL line ever been completed, it would have been a "more ambitious . . . or broader, more comprehensive, line than any that was in existence in the year 1970--or '69 . . . with the exception of IBM". (Tr. 7803.)

Bloch felt a sense of urgency about this mission and sent a telegram to various parts of the GE computer organization (including Haanstra in Phoenix and Weil in Bridgeport) creating a special task force. (DX 540.) Bloch testified that he felt the situation was urgent because

> "the company was on a timetable if it was to enter the field in a fashion which I thought was necessary, which meant that we had to fix the specifications, characteristics, and get the assignments made, development of assignments and so on, throughout the world, certainly before the end of that calendar year. . . .
>
> "The importance was simply that of time costing the company its future position in the field. By delaying the time at which we could announce and ship these systems, we would be, it was my feeling and generally agreed, losing some of our current base.
>
> "Secondly, IBM was, I thought, much more vulnerable at the earlier time within this period, that is, in the earlier seventies, and that every month that could be compressed with respect to the schedule meant an ability to tackle IBM more readily and to preserve our customers . . . the present GE CPL [current product line] customers who had obsoleting equipment. And there was the danger, thus, of their moving elsewhere." (Tr. 7792-93.)

The APL line was not to be compatible with the earlier GE lines. (R. Bloch, Tr. 7873; see also PX 353, p. 119.) Users of earlier GE lines converting to APL would encounter conversion problems of the same kind that an IBM user would in converting to APL--and GE, of course, would have faced the same problem IBM was confronted with in 1964 when it announced 360. It was planned that about 35% of anticipated worldwide shipments would be made to users of earlier GE lines, with another 35% to be shipped to users of competitive systems, chiefly IBM. The remainder were to go to new users. (PX 353, pp. 53-54, 57.) To effect the necessary conversions, GE planned to offer various emulation and conversion aids. (R. Bloch, Tr. 7881-84; PX 353, pp. 53, 62-63, 67, 118, 119, 164-65, 171, 175, 178, 179.)

In order to induce IBM users to convert, the APL line had as primary targets, "the 360/20, 25 and, to some extent, the 30 and, to still a lesser extent, the higher level machines in the IBM line, and also another IBM line". (R. Bloch, Tr. 7663-64, 7866.) GE targeted these users because of the difficulties that the users of the lower machines in the IBM line would have in converting from DOS to OS/360 (R. Bloch, Tr. 7867-68) and the fact that most of the programs written for such systems were written in higher level languages. (R. Bloch, Tr. 7868-72, 7880; PX 353, p. 64.)

Bloch testified that he and "the top programming experts" at GE believed that the conversion objectives of the APL could be achieved, although it was "an extremely ambitious task". (Tr. 7889-90.)

To induce IBM's users to move to the new GE systems, a price/performance advantage of 20 to 40 percent against the 360 was thought to be required, and Bloch thought that it would be necessary for GE to match IBM's peripherals as well. (R. Bloch, Tr. 7654-59.) Basically, what GE was intending to do was to duplicate IBM's 360 plan of attack some five or more years after its announcement.

The strategy for APL preferred by the GE Information Systems Group was the "A-F strategy" providing for the offering of the entire line at once, a "full across-the-board strategy", with shipments beginning in early 1973. This would have required an $858 million expenditure before taxes, with an after-tax investment of $429 million for the years 1970-1975. (R. Bloch, Tr. 7695-96; PX 362, p. 4.) Roughly half of the required investment was the financing that would be required for the 80 percent of the APL line that was expected to be leased by customers. As Bloch testified, it presumed a successful APL with a large number of systems on lease: "It is one of the prices you pay for success." (Tr. 7699.) "And from my view, once those machines were out in the marketplace, we were going to keep them out there, which meant tremendous income coming at a later time." (Tr. 7929.) "[I]n no sense did I consider 858 to be the exposure of the company." (Tr. 7703.)

Indeed, Ingersoll testified that, during the period when he was associated with the Ventures Task Force, it was "a general assumption" that the announcement of APL would have the overall effect of increasing revenue and income from GE's current product line during the years immediately following 1969, with an increase of $177 million from the combined product lines in 1970-1975 (Ingersoll, Tr. 8378-82; PX 362, p. 10), a positive effect not taken into account in the $858 million investment estimate. (R. Bloch, Tr. 7935-36; see also PX 362, p. 10.) Substantial net profits were expected to be earned in the late 1970s, after which a successor to the APL was contemplated. (R. Bloch, Tr. 7908-10; PX 362, p. 5.)

The APL plan, then, was an ambitious one, requiring large expenditures. It contemplated an across-the-board attack, even though profits might have been made in a "$50 million business" without such an attack. Further, it had to be pursued immediately. In the event, it became just another false start.

h. <u>The Ventures Task Force and the Decision to Disengage.</u> The Ventures Task Force was formed by GE Chairman Fred J. Borch in the last quarter of 1969. It was asked to review GE's computer business, commercial jet engine business, and nuclear energy business. Its mission was "to analyze those businesses and to present to the corporate executive office some plans that would outline the alternates and options available to the corporation with respect to those specific businesses". (R. Jones, Tr. 8756-57.)

In particular, the Task Force stated in its report that Mr. Borch "specifically impressed upon us the urgency of our finding some way to arrest the heavy continuing drain on our assets resulting from these major new ventures". (PX 331-A, p. 5.)* The Task Force "adopted two broad criteria as the bases for our efforts to evaluate each available strategy; the risks and potential rewards inherent in each strategy and impact of each strategy on corporate earnings". (<u>Id.</u>, p. 6.)

Corporate earnings were a problem. GE's earnings per share had "plateaued" from 1965 to 1969, creating "a dismal record". (PX 331-A, p. 5; see also DX 550, DX 551.) The 1969 earnings had declined due to an "extensive strike". (Ingersoll, Tr. 8266-67; see also PX 331-A, p. 5; DX 556, p. 3.) As a result, the GE stock price had declined 34% from 1965 through 1969, compared to a decline of 17% for the Dow Jones Industrial Average, 8% for Westinghouse, and an increase of 3% for the Standard & Poor's Industrials. As the Task Force put it: "Stockholder impatience is indeed understandable."

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* "Major new ventures" were distinguished from GE's "core" businesses. (<u>Id.</u>)

(PX 331-A, pp. 5-6.)

The members of the Ventures Task Force, Jones, Jack McKitterick, and Robert Estes were corporate officers, but not one of them had had any responsibility for the computer business or the GE Information Systems Group.* (Ingersoll, Tr. 8267-69.) The Ventures Task Force studied the companies that GE met in the marketplace only "in a superficial way" in order to understand the strategy, types of equipment, and the "markets" attempted to be served by "each of the major entrants in the business".** (R. Jones, Tr. 8778-79.)

Jones testified that the Task Force was a "part time" assignment for its members. He characterized the thoroughness or completeness of the work done by the Ventures Task Force in the following way:

> "When you look back and think that we worked together for a very limited number of weeks, and when you recognize that the computer industry is a very complex business, and when you recognize also the fact that none of us had any experience in the computer business before we went into this, certainly it was not an exhaustive analysis of the computer business. It was an analysis that I think developed a fair comprehension of General Electric's position in the computer business, but I wouldn't characterize it as an in-depth study." (Tr. 8767-68.)

Of the three new "ventures"--computers, jet engines, and nuclear energy--the Ventures Task Force studied computers first.

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* At the time of their Task Force assignment, Jones was Vice President of Finance, McKitterick was Vice President of Corporate Planning and Estes was Vice President, Secretary and General Counsel. (Ingersoll, Tr. 8267-69.)

** The Task Force studied IBM, NCR, CDC, Honeywell, Burroughs, Univac, Xerox, ICL, Siemens, and several Japanese companies. (R. Jones, Tr. 8778.)

This was because, as Jones testified, GE was "in a position in nuclear where we had so many contractual commitments that our options and our alternates were rather restricted. The same thing held to a lesser degree in the commercial aircraft engine business, whereas in the computer business it seemed to us that we had a good deal more freedom to select from a rather wide range of alternates and options as to the future course of the business". This was so because the computer business "did not have long-range, long-standing contractual commitments to deliver product[s] over an extended period of years". (Tr. 8758-59.)

The Ventures Task Force "attempted to evaluate the risks associated with the APL plans . . . from a broad business standpoint. . . . [It] did not undertake to verify the accuracy of specific details of the cost estimates, for example." (Ingersoll, Tr. 8431.)

The Task Force ultimately reached the conclusion that GE should "disengage by combining its computer business with that of some other computer manufacturer" (R. Jones, Tr. 8801) despite the fact that it found that in the computer market "great size and very rapid growth make for a challenging opportunity" with the U.S. and European businesses projected to double in the next five years. (PX 331-A, p. 9.) It listed a number of negative factors affecting GE: "substantial operating losses", "heavy debt obligations and interest burden", "obsolete product lines", and "poor reputation and image" (PX 331-A, p. 49), and stated that GE had

> "Limited technical strength other than in data management and multi-processing software and communication equipment.

"Major product lines obsolete, complete but incompatible. Not vertically integrated. Weak in peripherals, mass storage and terminals." (PX 371-A, p. 39.)

Among listed "Critical Future Problems" were

"Across the board system obsolescence.

"Vulnerability of PARC [installed base] to competition--lack of specialization. Customer loyalty now under 80%, lowest of any competitor.

"Lagging technical position in main frames, peripherals, and manufacturing process technology." (Id., p. 40.)

Its installed base was termed "already obsolete and vulnerable with the conclusion: "Time is not on our side." (PX 331-A, p. 20.) The Task Force stated that "we need to be realistic about the relatively poor reputation and image we enjoy as a computer equipment manufacturer". (Id., p. 34.)

Jones concluded: "[W]e were not doing the job that was satisfying the customer to the extent that certain competitors were." (Tr. 8886-87.)*

The Task Force evaluated the APL plan. It concluded that that plan

"conceptually recognizes the current needs of the business and presents a goal that, if realized, would indeed place the company in a strong position in the business computer field. It is our conclusion, however, that the APL entails very high risks, and that it is doubtful that it could be kept to time,

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* Jones also testified: "[I]t is my experience that in business you succeed when you satisfy a customer and when you do it in terms of giving values that are highly satisfactory from the standpoint of the customer. And I use 'value' in the sense of conveying reasonable price, quality of product, features of product and performance, overall performance of product." (Tr. 8868.)

> cost and system performance schedules. Even if General Electric were in a position to undertake such an ambitious program, we would not recommend that it invest the requested sums in such a hazardous project predicated on an all-out attack on IBM, one of the world's strongest corporations.
>
> "Faced with the lack of earnings growth, but seeking to retain its image as a growth company, General Electric cannot, in our opinion, undertake <u>any</u> half-billion dollar venture, such as APL that produces substantial immediate net income losses." (PX 331-A, p. 7, emphasis in original.)

The APL plan, according to the Task Force, called for a fourfold expansion in GE total shipments in six years with an expansion of 60% to 70% per year of its sales force and "even so, productivity of GE['s] sales force must be twice as great per man as that of IBM". (*Id.*, p. 28.)

Jones testified that one of the reasons that the Ventures Task Force "felt that the APL plan was one fraught with risk" was that it called for technology beyond the current state of the art, which required "invention by schedule in order to achieve its objectives". (Tr. 8769.) If it "had not been so ambitious in a technological sense and in a timing sense it might have been a somewhat better plan. It might have had a chance of acceptance." (R. Jones, Tr. 8790.)

In fact, Weil testified that by late 1969, APL was not "well along" in its design and development and that "the software was still in fairly early specification form". (Tr. 7244-45.) At the time of the Ventures Task Force "detailed engineering specifications" and "firm cost estimates" were not available. (Ingersoll, Tr. 8370; see also R. Jones, Tr. 8768; PX 363, p. 15.)

Yet the world would not wait for GE to come up with its

360. Jones testified that "it was our experience that every time we went out to sell a computer there were a lot of other people knocking on the customer's door, attempting to sell him a computer. In that sense it was highly competitive." (Tr. 8861.) He testified that "it was the opinion of the Ventures Task Force that some of the companies in the field would find it necessary to combine . . . that the [business computer systems] business was competitive . . . and that it would continue to be competitive and it would be those competitive pressures that would cause some combinations to take place in the field." (Tr. 8864-65.) General Electric believed "that one of the characteristics of the business computer systems business was that competition constantly forced suppliers to come out with better products at lower prices in order to keep the customers that they had and to get new customers". (R. Jones, Tr. 8865.)

The Ventures Task Force called IBM "a moving target" which Ingersoll interpreted to mean that "we at General Electric should assume that IBM would not be a stationary object, it would be a dynamic situation, and the conditions . . . might well change". "[I]t was in effect a high risk to assume that the conditions and evaluations . . . would remain constant, that is, that the comparisons would be subject to change as IBM made plans and introduced its own products." (Ingersoll, Tr. 8128-29; PX 363, p. 15.) Similarly, the Ventures Task Force and its support staff felt that "it was a high risk assumption" to assume that competitors other than IBM "would stand still with respect to market share". (Ingersoll, Tr. 8127.)

As a result, Jones testified that the Ventures Task Force concluded "that the life of a family of computers was quite limited", something in the range of four to six years, "and that you did not bring out a family of products that simply met the price/performance characteristics of the then existing competition. You had to bring out something that would exceed the price/performance of the existing competition because you knew full well that they were going to be moving ahead of you. It is a constant leap frogging game." (Tr. 8866-67.) It was a lesson which GE learned too late and IBM had learned well before. (See PX 1077;* DX 4806;** pp. 493-94, 531 above

Indeed, the APL plan itself stated in January 1970:

> "One of the key aspects of technology in the computer field is its high rate of obsolescence. Never in the history of technology has the pressure of competition and the lure of highly rewarding markets created such a dynamic evolution. While this characteristic is forcing rapid technological progress, it is, at the same time, imposing on the computer manufacturer a heavy financial burden and the necessity of planning products with a narrow margin for error." (PX 353, p. 23.)

The Ventures Task Force, of course, had not been called together simply to consider computers. Ingersoll testified that he

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* Thomas J. Watson, Jr.: "I believe that whenever we make a new machine announcement, we should set up a future date at which point we can reasonably assume that a competitor's article of greater capability will be announced. We should then target our own development program to produce a better machine on or before that date." (PX 1077, p. 2.)

** Thomas J. Watson, Jr.: "I think it important to note, however, since we seem to have suffered for a few months or even years because our machines predated the effective competitive machines now in the marketplace, that we now make these machines good enough so they will not be just equal to competition, for I am sure that once they are announced our competitors will immediately try to better them. This is all to the good and I am for competition, but I want our new line to last long enough so we do not go in the red." (DX 4806.)

believed that GE's management was concerned with improving the profitability of the company as a whole, based in part on the experience of the late 1960s in terms of stationary and then declining earnings. It was therefore concerned with the immediate impact of APL on GE's earnings which impact, from 1970 to 1975, the APL plan had projected to be negative. (Ingersoll, Tr. 8271-72.)

The Ventures Task Force concluded that "General Electric can ill afford the financial resources needed for an all-out drive for position in this industry, basically because of the needs of other businesses within its scope". (PX 371-A, p. 73.) The "core" businesses needed "more rather than less support, and the company's immediate earnings goals can only be met from these businesses". (Id., p. 76.)

As Jones testified:

> "At that point in time we had these two tigers by the tail other than computers--that is, jet engines and nuclear--and we had this host of other ventures that we were trying very hard to bring on, all of them spun out of this common technology of our electrical industry and electronics industry.
>
> "We were increasing or had been increasing our debt substantially through this period, so that our debt-to-capital ratio has been climbing. And we just said, you know, there is a breaking point where we will lose our triple A rating as a corporation if we continue to pile on debt and if we continue to try to do all these things that we have got on our plate right now.
>
> "This was the one where we had you might say the least commitment . . . in terms of contractual commitments." (Tr. 8831-32.)

The Ventures Task Force also had concluded that:

> "For the first time in our generation, at least, we face the necessity for an allocation of corporate resources which are

not adequate to meet all of our readily identifiable needs--during a period when the company is under special pressure to demonstrate its ability to grow earnings. The general economic climate is not favorable; the capital markets are severely depressed; credit is costly and may be assumed to become progressively less available; inflation has forced higher labor costs on the company following the longest strike in the company's history." (PX 371-A, pp. 75-76, see also pp. 7, 10; PX 331-A, p. 7.)

GE could not do everything at once: "[W]e can't afford to back every horse. We just don't have limitless resources." (R. Jones, Tr. 8843.)

Disengagement in nuclear energy and jet engines was "not an available option" because of GE's contractual commitments. (PX 371-A, p. 76.) While nuclear reactors were considered part of GE's "core business" ("essentially those that dealt with the generation, transmission, and distribution of the electrical energy in terms of the equipment to do all those jobs, plus the equipment that would utilize electrical energy") and jet engines were considered "a spin-off of the core, but . . . very closely related", General Electric never "viewed the computer business as being part of its basic core". (R. Jones, Tr. 8838-41.)*

The Ventures Task Force did consider the possibility of retrenchment, rather than withdrawal, with such retrenchment taking the form of moving to a more specialized product line. However, it was decided that this was not an optimal strategy for General Electric,

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* It is instructive that in its "core business", nuclear reactors, GE had invested for 20 years without making a profit. (Ingersoll, Tr. 8288-91.)

although it would have required less investment money. (Ingersoll, Tr. 8144-45, 8150-51, 8188-89; R. Jones, Tr. 8801, 8881-83, 8796-97.) As Jones testified, this was in part because:

> "We had sold our equipment to almost every market. We had not concentrated on banking or manufacturing or retailing. We had either of our own manufacture or through resale a substantial and wide ranging line of peripherals, and because our product offerings over time had been so eclectic, we felt that if we were to withdraw to the role of a specialist, we would be in effect abdicating many of the customers and many of the markets that we had been serving.
>
> "Of course, the result of that would be a substantial reduction in our overall market opportunities." (Tr. 8797.)

The decision was made to merge a large part of the business with Honeywell by both companies transferring their business computer operations to a new Honeywell subsidiary. (DX 555, p. 3.) GE retained an interest in the new company and, as is detailed below, successfully continued its "own independent development of businesses in the promising areas of process computers, computer time-sharing and data communications equipment."* (Id.) (See pp. 544-46 below.)

As we have seen, the GE decision to disengage was taken in part because of past GE mistakes and in part because General Electric had other fish to fry.**

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* GE would have liked to have taken a controlling interest in the new venture but feared the disapproval of the Antitrust Division. (See Ingersoll, Tr. 8242, 8252-53; DX 7259, Borch, pp. 13-14.)

** Jones testified that he "personally knew of no acts or activities of IBM that would have caused our disengagement", and none were brought to his attention during the activities of the Ventures Task Force. (Tr. 8867-68.)

Could General Electric have succeeded had it remained? Bloch testified that he thought GE had the resources necessary to become "a clear No. 2 in the supply of computer systems used for business data processing purposes". He "felt at the time that it was a mistake" not to implement the APL. (Tr. 7811.) Withington, who, unlike Bloch, was not personally involved, testified that GE had sufficient assets to be successful if it chose to invest them in the general purpose computer systems business. (Tr. 56732.)

Indeed, General Electric did not have much trouble raising money in the years after 1970. From 1970 to 1974, it raised approximately $625 million by long-term debt. (DX 553.) It chose to invest those funds elsewhere.

i. Did GE Lose Money? It is questionable whether GE lost much, if any, money in the course of its computer operations or, at least, whether it would have lost money thenceforward had it not sold part of its operations to Honeywell.

A report by Peat, Marwick & Mitchell, General Electric's outside auditors, showed that GE's domestic business computer operations lost approximately $163 million in the period 1957 through September 1970. (PX 380; see Ingersoll, Tr. 8353-56.) Jones testified that this accorded with his recollection. (Tr. 8756.) Ingersoll testified that this figure included allocation of corporate overhead expense to GE's domestic business computer operation, involving expenses which continued after the transfer to Honeywell and which were not directly incurred in the operation of GE's domestic computer operations. (Such allocation amounted to 10% to 15%.) (Ingersoll, Tr. 8359-60, 8365-66.)

Further, Ingersoll testified that PX 380 "reflects the cost of developing the equipment incurred by the Domestic Business Computer Operations that were subsequently transferred to Honeywell--the development, that is, through the date of the transfer". (Tr. 8377-78.)

Hence, in order to evaluate whether GE would have ultimately made losses had it not sold part of its operations to Honeywell, one must consider the profit stream which would have resulted from those sunk expenses. As Ingersoll testified, "because of the relatively long life of computer equipment, . . . in order to properly evaluate the total results one should look toward the full life of the equipment". He agreed that it is "generally true that in the development, manufacture and marketing of new lines of computer equipment that losses are sustained in the early years and profits derived in later years". (Tr. 8199-200.)

According to GE's proxy statement, that portion of GE's computer operations which was sold to Honeywell had an after-tax profit for 1969. (DX 554, p. 9; see Ingersoll, Tr. 8329-30.). Further, in December 1969, GE's Information Systems Group estimated that the net income from its current computer product lines for the years 1970 to 1975 would be $173 million (this estimate also included a positive impact of APL on current products). (PX 362, p. 10; see Ingersoll, Tr. 8378-79.). The Ventures Task Force in April 1970 estimated that the current product line would bring in $821 million in revenue and $164 million in net income in the years following 1969, regardless of APL (it was evaluating the business from the point of view of a prospective buyer). (PX 331-A, p. 32; see Ingersoll, Tr. 8376-77.)

The terms of the sale, which was announced on May 20, 1970 (PX 323 (DX 14502)), were as follows. The two companies formed Honeywell Information Systems (HIS) and GE received an 18-1/2 percent interest in it. In addition, GE received 1.5 million shares of Honeywell common stock and $110 million of Honeywell subordinated notes (later converted to additional shares of Honeywell common). (DX 555, pp. 22-24; see Ingersoll, Tr. 8393-96; DX 14073, p. 32.) At the time GE recorded a profit of $1.7 million on the transaction. That amount was quite conservative, GE having undervalued its minority interest and the value of its Honeywell stock. (DX 555, pp. 26, 31.) Ingersoll testified that the market value of the 1.5 million shares of Honeywell stock received by GE was "in the neighborhood of $130 million". (Tr. 8388-89.) In addition to that and the $110 million in notes, Ingersoll testified that GE valued its minority interest in HIS at "approximately $32 million", "substantially less than the net book value of that minority interest as determined by Honeywell" which valued it at "at least a hundred million dollars". (Tr. 8393-96.) In fact, the 1,500,000 shares of Honeywell stock had an average market value of about $120 million as of the last quarter of 1970, based upon the average between the high and low prices at which it traded during that period. (DX 555, p. 31; DX 14064, p. 164.) In 1971, GE received 1,025,432 shares of Honeywell stock in exchange for the $110 million in notes. (DX 14073, p. 32.) Those shares had an average market value of about $113.2 million in 1971. (DX 14130, p. 164; DX 14131, p. 172; DX 14132, p. 172; DX 14133, p. 173.)* In 1976, GE exchanged about one-third of its interest in HIS for 800,000 shares of Honeywell stock and, in 1977, the remaining two-thirds of another 1,400,000 shares. (DX 13980, p. 40; DX 13981, p. 40.) The Honeywell stock received in 1976 had an average market value in that year of about $35.6 million (DX 14062, pp. 2, 4, 6, 8); the stock received in 1977 had an average market value in that year of about $68.5 million. (DX 14063, pp. 2, 4, 6, 8.) GE sold the Honeywell stock over the years, disposing of the last in 1978. (DX 13981, p. 40; DX 13887, p. 40.)

Taking all these things into account, even allowing for the difference in timing and inflation between the expenditures made in the early sixties and the returns received from the Honeywell sale, GE appears to have been a net gainer in the computer industry.

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* As used herein, the average price of Honeywell stock in a given year is the average of the high and low prices at which it traded during that year.

42. RCA. As we have seen, the 1950s were a stagnant period for RCA's computer business. During the early 1960s RCA experienced several problems that continued to retard its growth in computers, in particular the failure of the 601 and its on again-off again peripherals development. (See pp. 196-207 above.) Toward the middle of 1963, RCA had stopped marketing the failed 601; the 501 was "starting to decline" and RCA was marketing only one computer model, the 301. (McCollister, Tr. 9622.)* RCA then announced its 3301 computer system.

a. RCA 3301. The RCA 3301 was announced on August 20, 1963. (DX 580, p. 1.) The 3301 was an "interim product", designed and marketed by RCA "to round out our overall product program . . . [by] tak[ing] the place of the 601". (McCollister, Tr. 9247, 9622.) The 3301

> "was not a new design. It wasn't intended to be the foundation of a future line of products; rather, it was a product that we could develop relatively quickly, at relatively low engineering expense,[**] that would

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* E. S. McCollister joined RCA in 1961 as Vice President of Marketing for the computer division. He held that or a similar position until December 1971 when he left RCA. He then joined the Burroughs Corporation in January 1972. (McCollister, Tr. 9161-62.)

** McCollister recalled that the engineering development cost for the 3301 was "in the order of about $2 million for the processor and for the associated control units". (McCollister, Tr. 9623.)

> give us an additional offering to take the place of the 601, and that in a sense would give us time to get on with a complete new product program in the longer range future." (McCollister, Tr. 9622-23.)

RCA described the 3301 as an "all purpose computer" that "features advanced communications devices and arithmetic circuitry to make it equally powerful for scientific equation solving, super fast business data processing, instantaneous (real-time) management control, and high-speed data communications". (DX 580, p. 1; see also Beard, Tr. 8994-95.)* In addition, the 3301 could perform applications "which were in other circumstances performed by multiple installations of special purpose computers". (Beard, Tr. 8994-95.)**

While a more successful product than the 601, the 3301's success was limited for two reasons: poor peripherals and its "eclipse" by the announcement of the Spectra 70 series less than a year and a half later. (Beard, Tr. 8458-60, 10276, 10307.)

RCA had been beset by problems with the peripherals used on its 501 and 301 systems. (See above, pp. 195, 201.) The peripherals on the 3301 "prevented the computer system from achieving its full throughput capabilities". (Beard, Tr. 10276.) Although RCA had resumed manufacturing its own peripherals in 1962 (see above, p.

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* The 3301 was not as versatile, however, as System/360. (Beard, Tr. 10266.)

** A. D. Beard, Chief Engineer of the RCA computer division from 1962 until 1970 (Beard, Tr. 8447-51), used the term "special purpose computer" to mean "real time" computers such as SAGE (Tr. 8995-97), "communication equipments", and "small and medium sized scientific computers". (Beard, Tr. 8996.)

202), time and continuity of effort had been lost and RCA was largely "constrained to live with the peripherals that were then existing on the 301 or which could be made available from outside suppliers". (Beard, Tr. 9004, 10307; see also McCollister, Tr. 9622-23.)*

RCA also experienced problems with a peripheral unit of its own manufacture, the RACE mass storage unit. The RACE unit was a storage device that used magnetic cards.** Those cards

> "had to be extracted from a magazine, put in a channel that carried it to a revolving drum, held on the drum while it rotated past a reading head, where the information was read or reported, and then the card had to be returned to the magazine from whence it came.
>
> "And this was a very, very complex mechanism and a very difficult technical task." (McCollister, Tr. 9657.)

RACE was designed to provide random access storage for the 3301. Compared to IBM's 2311 disk drive,≠ announced by IBM with System/360 in April 1964, RACE was "much smaller" in terms of storage, but "considerably faster" in terms of access time. Thus, for the application mix of some users, RACE, when operating properly, would be superior to a disk drive and under other circumstances, the disk

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* According to McCollister, "In the 3301 [RCA] used a card reader from Uptime, we used the ICL, or ICT I believe it was at the time, a hundred-card-a-minute punch, we used the Anelex printer, of which we bought the complete printer sub-system from Anelex." (Tr. 9622-23.)

** The RACE unit came in two models, the 3488 to be used with the 3301 processor and the 568 for the later Spectra series. (McCollister, Tr. 9656-57.)

≠ RCA did not have a disk product of its own to offer with the 3301. (Beard, Tr. 9046.)

drive was superior. (Beard, Tr. 9046-47.)

The major problem with RACE was that it was not reliable. Thus, Withington classified RACE as "a major product failure" (Tr. 56511), and McCollister explained why:

> "[T]he cards wore out . . . the cards were damaged in transit . . . sometimes there was a failure to select the proper card . . . it was a tedious process to replace a card in the file when it was beginning to wear out and, indeed, to detect when it was beginning to wear out." (Tr. 9658.)

Moreover, even when operational the RACE unit was "unable to meet the speed of accessibility that had originally been specified in the product". (McCollister, Tr. 9658.)

Second, the success of the 3301 was limited by RCA's introduction of a new series only a little more than a year after the 3301 was announced. RCA's announcement of its Spectra 70 series in December 1964 "eclipsed" and "superseded" the 3301. (Beard, Tr. 8458-59; PX 4830, p. 25.) Thus, potential customers of the 3301 were encouraged to obtain Spectra 70 series. For example, RCA provided emulation of the 301 on the Spectra 70 but not on the 3301. (PX 4830, p. 25.) Another sign to RCA's users that the 3301 was a dead-end machine was RCA's failure to provide a "growth machine" for users of the 3301.* (Beard, Tr. 9986-87.) Because RCA provided no emulation from the 3301 to Spectra 70 or to any other system, 3301 users had

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* A "growth machine" is one "which allows the programs to be moved from the predecessor machine to the growth machine [with] a minimum of re-programming effort". (Beard, Tr. 9986-87.)

nowhere to go in the RCA line without converting their programs. (Beard, Tr. 8458-59, 10235.)

b. The Spectra 70 Series. IBM announced its System/360 on April 7, 1964. Beginning "shortly" after the announcement, RCA formulated the "design specifications" for its Spectra series. Those specifications were done "in [a] preliminary fashion" around July or August of 1964. (McCollister, Tr. 9624.)

The Spectra 70 series eventually comprised eight models--the 70/15, 70/25, 70/35, 70/45, 70/46, 70/55, 70/60 and 70/61. The sizes of the processors increased in numerical order, and the 70/46 and 70/61 were intended to offer time-sharing capabilities. In December 1964 RCA announced the 70/15, 70/25, 70/45 and 70/55. (Beard, Tr. 8483-85; McCollister, Tr. 9635-36; DX 669, p. 11.) The 70/35 was announced in September 1965 (DX 670, p. 16); the 70/46 was announced in 1967 (PX 338, p. 22); the 70/60 and 70/61 were not announced until 1969 (DX 674, pp. 8-9).

No prototype of any of the systems was in existence at the time of the announcement. A prototype of the first machine was not built until the middle of 1965 at which time prototypes of most of the control units were also built. (McCollister, Tr. 9635-36.)*

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* During 1965 through 1966 several new peripherals were also designed. (McCollister, Tr. 9635-36.) During 1965 and 1966 RCA's total engineering budget for software and hardware was approximately $15 million annually, out of which came engineering expenditures for the support of older products as well. (McCollister, Tr. 9634-35.) Compare the status of RCA's Spectra at announcement with that of IBM's System/360: By the time of the IBM 360 announcement there were prototypes of all models of the processors. (Brooks, Tr.

Deliveries of the "small systems" began in 1965 and the "larger systems" in 1966. (Beard, Tr. 8460.)

Four aspects of the Spectra 70 series are particularly important: its attempt at compatibility with System/360, its ability to perform commercial and scientific applications, the problems RCA encountered and the success of the Spectra 70 series.

(i) Compatibility with System/360. In a decision that affected both the Spectra 70 and its succeeding RCA Series, RCA decided to make its Spectra 70 series compatible, that is, able to use the same application programs with little or no modification, with IBM's 360 systems.

By making its Spectra 70 compatible with IBM's System/360 RCA hoped to be able to persuade substantial numbers of 360 users to move to the Spectra series. (Beard, Tr. 8461-63; McCollister, Tr. 9269-70; Rooney,* Tr. 12117.) In particular, RCA expected to target

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22695-6; Hughes, Tr. 33995.) Most of the processors and some of the peripheral equipment were in the early stages of product test (McCarter, Tr. 88382-83; JX 38, ¶ 19); all, or almost all, the memories had undergone technical evaluation testing (Brooks, Tr. 22699); microprogramming and multiprogramming had been tested on the Model 40 (McCarter, Tr. 88382-83); four estimating, forecasting and pricing cycles had been completed; and the "componentry, systems and product testing program already completed . . . [was] more extensive than the entire program ever [previously] undertaken for a system". (DX 1172, p. 2; see also DX 1165.)

* J. W. Rooney joined RCA as Vice President for Marketing Operations in 1969. He became the Vice President of Marketing for the Computer Systems Division in 1970 and was President of the Division from 1971 until he left to go to Itel in 1972. (Rooney, Tr. 11687-88.)

its marketing efforts at those 360 users who wanted to obtain larger or more functional equipment. (Beard, Tr. 8526-28.*) To those users RCA wanted to offer better price/performance on its Spectra 70 equipment than IBM did on its 360 equipment and thus persuade the user to acquire Spectra 70 equipment. (Beard, Tr. 10103; Rooney, Tr. 12117.)

Thus, during this period RCA attempted to offer a price/performance advantage of between 15% and 20% over IBM's systems. (Beard, Tr. 8493-94, 10095; Rooney, Tr. 11826; see also Wright,** Tr. 13083.) RCA's pricing methodology was the direct result of RCA's strategy to be compatible with IBM and to go after IBM users.

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* RCA believed that compatibility had become a more useful marketing tool after introduction of 360. Prior to 360 RCA had a "sales opportunity" whenever a customer wanted to go to another computer because:

> "As the computer industry evolved, ordinarily even in moving within the line of one manufacturer, within the line of IBM, there was conversion that was necessary. And since a customer was facing . . . a conversion in the case of IBM, we could argue it won't be any more difficult to convert to RCA." (McCollister, Tr. 9273-77.)

Since users of 360 would be able to move up to a larger IBM 360 computer "relatively easily", it would be to RCA's advantage "to make it almost as easy as we could for the customer to move to the RCA product line as to move up within the IBM product line". (McCollister, Tr. 9273-75.)

** V. O. Wright joined RCA as Vice President and Regional Manager of Federal Government Marketing in the Computer Division in 1970, became head of Systems Development in 1971 and left in 1972 to go to Amdahl. (Wright, Tr. 12785.)

"[I]f you are going head to head with a competitor, such as IBM, and you essentially are going to offer the same function and if the competitor is in a stronger position in the marketplace than you are, you would offer a price advantage to move your product." (Rooney, Tr. 12415, see also Tr. 12414, 12420-21.)

The pricing methodology was based upon two assumptions:

(1) RCA assumed that in many cases Spectra would be offered to displace existing IBM computers and some inducement would have to be offered to persuade the IBM user to go to the trouble of replacing his existing IBM computers and install Spectras (Beard, Tr. 10103; Wright, 13083-84)*; and

(2) Spectra was delivered one to two years after IBM's System/360, and customers expected a new offering to have a price/performance advantage over older computers. (Beard, Tr. 10103-05.)

If RCA had not adopted the compatibility strategy, other pricing strategies would have been available:

"If you did not have compatibility, you would be going with your own product line, which would have its own unique characteristics and functional capabilities.

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* This "was needed in order to compete with IBM and in order to obtain business from people who were currently using IBM systems, to displace IBM systems. If a customer has a fairly substantial investment in software, he has to have some reason and some motivation to move to another vendor, and we felt that that was the margin of motivation that was needed to get them to move." (Wright, Tr. 13083-84.)

"If you felt that you were matched in those unique capabilities and functions by IBM, you would probably price your products for comparable systems in the same range but not necessarily under IBM.

"If you felt you had a unique product, then you would not be guided by IBM's pricing policies. You would then price based upon your analysis of what the market would bear for that functional capability." (Rooney, Tr. 12421.)

RCA employed the technique of "straddling", placing its machines in terms of performance "approximately midway between a pair of IBM machines". (Beard, Tr. 10106-07, 10113, 10121-22, see also Tr. 10097-99.)

"Generally what was done was to pick what appeared to be the most commonly used configurations of equipments: so many tape drives for a small system, so many tape drives for a large system, and so forth, to pick several of what were considered to be representative points around which you would expect a large number of customers to cluster.

"Based on that simplified set of system considerations--that is, not taking all the possible combinations into account, but some of the most probable ones--evaluations were made on a system basis, that is, not only the speed capabilities of the main processor but also what range of peripheral speeds you would put on each of these system configurations, determine what the relative overall performance advantage or disadvantage was, and set the prices accordingly.

". . . [T]here would be some possible configurations whereby you would not meet your price/performance goal of 15 to 20 percent; you would only meet them on the specific points that you had evaluated.

"There would be some cases where you would exceed that price/performance advantage. There would be other cases where perhaps the advantage would go the other way." (Beard, Tr. 10092-93; see also Rooney, Tr. 12129-31.)*

As discussed at greater length below, RCA's attempt to offer better value to the customer than System/360 failed even though it may have been able to announce that it provided more throughput per dollar (better price/performance) than some of the 360 systems with which it competed.

RCA also believed that the compatibility strategy would have a good chance for success because it could take advantage of the situation where IBM users were leasing from IBM on a short-term basis, which leases could readily be terminated and RCA equipment substituted. (Beard, Tr. 10073; see also Rooney, Tr. 12126-27.)

A number of arguments against the compatibility strategy were raised at RCA:

First, if IBM customers could switch easily to RCA machines, then RCA customers could also switch easily to IBM machines. Beard called this a "two edged sword". However, RCA felt that it "had more to gain . . . than to lose" because IBM had many more existing customers than did RCA. (Beard, Tr. 8519-20; see also Rooney, Tr. 11857.)

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* Thus, the Spectra 45 was placed between the System/360 Model 40 and the Model 50, and the Spectra enjoyed a price/ performance advantage over the 360 Model 40. However, the performance of the 360/50 was superior to the Spectra 45. The same was true with respect to the comparison between the Spectra 55 and the System/360 Models 50 and 65. (Beard, Tr. 10106-07, see also Tr. 10097-99.) The Spectra 45 and 55 were bid against the IBM System/360 Models 50 and 65. (Beard, Tr. 10113, 10121-22.)

Second, the similarity between Spectra and 360 "sharpened the comparisons" between RCA and IBM, making it "easier for the customer to analyze and quantify the differences" and putting "RCA in a position where its products could easily be criticized versus what IBM was offering. . . . If there were any deficiencies on RCA's part they would probably stand out as weaknesses." (Beard, Tr. 8526.)

Third, RCA could have chosen "the most natural alternative . . . an extension of the 301, 3301 systems". This would have provided two advantages to RCA: it would have given it "a certain advantage" in marketing to the existing 3301 user base, because of the "software investment that [the users] had made in those machines". (Beard, Tr. 8524-26.)* And it might have enabled RCA to provide a "superior architecture to what IBM had chosen".** (Beard, Tr. 8524-26.)

RCA considered this important decision only briefly. McCollister testified that "because of the press of time in this case,

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* As noted above, RCA chose to forego this "advantage" and did not provide any emulation on the Spectra 70 series for the 3301 user.

** According to Beard this possibility did not seem to be very likely:

> "However, I think most of us felt that it really didn't make that much difference to the customer what particular machine instructions were made available; that the 360 set was a complete set, it included most of the things we had thought of and perhaps some that we had not thought of; there were some things that were missing, but these were secondary in our minds." (Tr. 8524-26.)

I am not even sure that there was a formal product proposal". (Tr. 9630-32.) The compatibility arguments prevailed, and two or three weeks after the announcement of System/360, RCA decided to make its Spectra series "as compatible with the 360 as the circumstances permitted". (McCollister, Tr. 9273.)

With the compatibility approach that RCA chose, its Spectra series had the same instruction set, instruction format and word length as 360. However, "in terms of the engineering implementation of this architecture, it was quite different between RCA and IBM. . . . . If you took these machines apart, they were totally different machines . . . RCA used a completely different set of components." (McCollister, Tr. 9644-45.)

(ii) <u>Commercial and Scientific Ability of Spectra 70 Series.</u> As discussed above (see pp. 290-96), IBM's System/360 was aimed at all users regardless of application. Initially, RCA planned to market the Spectra systems for "commercial as distinct from scientific purposes . . . it was a stated strategy to all of our marketing people that we were selling to the business environment and precisely said that we did not have a computer to compete in the scientific arena". (Rooney, Tr. 11802-03; see also Beard, Tr. 8460.)

While RCA initially chose to concentrate on marketing to users who used computers for commercial applications, the design of the Spectra, as with IBM's 360, was flexible enough to be used for many purposes. Beard wrote in 1965 that among the "salient points" incorporated in the "basic design philosophy of the RCA Spectra 70

Series" was a "versatility for handling data processing, real time, and scientific applications from the small user to the very large". (DX 617, p. 2; see Beard, Tr. 9099-100.) Beard testified that the "primary reason" for making that a "salient feature of the design philosophy of the Spectra 70" was:

> "We felt that as the customer world became more sophisticated that there would be a consolidation in the computer type operations of more than one type of function and therefore this versatility, which allowed for engineering and scientific type problems, communications problems, data processing, batch problems, information control systems . . . could be merged into one computer complex.
>
> "It may be a relatively small computer, if the operation is a small one. It could be a very large computer, if the operation had a large volume of data to be processed. There would be configurations where reliability was extremely important and it would be necessary to have multiple processors in order to have redundancy in the system.
>
> "It would be an advantage, from what we saw in the field emerging, for the hardware as well as the software to accommodate these various functions in one system as opposed to having distinct unique systems for each of those functions." (Tr. 9100-01.)

Very soon after the initial delivery of the Spectra, the consolidation of the various types of functions which was anticipated in "the design philosophy of the Spectra 70" had come to pass with "some of the more advanced customers . . . ready for these types of systems in the latter half of the sixties, and certainly that trend has continued into the seventies". (Beard, Tr. 9101-02.) By 1970 RCA was advertising the versatility of the Spectra 70:

> "The emergence of third generation equipment with increased speed and storage capacity has brought us to the realization that scientific applications are

within reach of almost every computer user. In the past these applications were confined to the big and expensive machines.

* * *

"For all your data problems--from simple accounting to management science programs--Spectra 70 offers a complete systems approach.

"Linear programming . . . statistical analysis . . . simulation . . . automatic machine tool control . . . all are key elements of management science operations. Spectra 70 handles these applications and your normal data processing at the same time." (DX 619, pp. 1, 39, emphasis in original.)*

To assist its customers RCA offered its "Systems Scientific Services":

"Systems Scientific Services provide a broad range of support to RCA customers in software areas.

"By supplying generalized scientific, statistical, simulation, and mathematical software, Systems Scientific Services assist the user in achieving efficient use of his system . . . right at the start.

"Also available are scientifically oriented programming systems." (Id., p. B.)

(iii) Problems with Spectra 70 Series. The Spectra 70 series suffered from various problems that hurt its performance in the marketplace. Much of the equipment of the Spectra 70 series suffered from reliability problems which users took into account in choosing

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* RCA also explained the new field of management science:

"Along with the advancement in equipment, the technology and management science has made significant advances to the point that it is an integral part of modern, efficient, organizational management.

"Management science has a broad definition that includes mathematical, statistical, and operation research techniques that aid in effective decision making on the part of management." (DX 619, p. 1.)

between RCA and IBM computers. (Rooney, Tr. 12190-91.) Rooney complained about RCA's equipment as late as June 1970:

> "RCA equipment apparently requires larger amounts of dedicated preventive maintenance time than that of our main competitor, IBM. Customers that have both our equipment and IBM equipment are aware of this, and this works to our detriment in the marketplace." (DX 621; see also Rooney, Tr. 12186, 12202-03.)

Moreover, according to Rooney, RCA's equipment was

> "apparently more sensitive to environmental fluctuations than that of competition, particularly to IBM. This makes our customers somewhat sensitive to the differences between our maintenance policies and theirs. I am told, for example, the 360/30's can be left without any maintenance whatsoever for weeks on end. Yet, most of our systems require that we take the system from the customer for periods of time every day." (DX 621; see also Rooney, Tr. 12145-48.)

For example, RCA's disks were "more sensitive to air conditioning" than those of IBM, "so, if you did not have the adequate amount of air conditioning, that could lead to the need for more preventive maintenance". (Rooney, Tr. 12197-201.)

RCA suffered problems during the installation of the Spectras. In that regard Rooney testified that:

> "RCA equipment was more difficult to install because of certain environmental factors. I remember the RCA equipment required more air-conditioning and power and I remember a problem of size, physical size of the units being involved, in terms of: if we replaced IBM, certain of our units would require more physical floor size than IBM equipment." (Rooney, Tr. 12175-76.)

These problems made it harder for RCA than for IBM to install its equipment. (Rooney, Tr. 12204-05; DX 620.) It was reported to Rooney in 1970 that:

"In the area of installation, the RCA-IBM comparison is not restricted to just power and air-conditioning requirements. The problems are more profound, and bear directly on the equipment designed.

"The installation of RCA data processing equipment has historically been more difficult and more time consuming than that of our competition, particularly IBM's. Since the RCA marketing strategy is to sell to the IBM replacement market, the installation of RCA equipment is constantly being compared against IBM in an unfavorable light." (DX 620; see Rooney, Tr. 12205-06.)

During 1968 a portion of the marketing force was diverted from seeking new business to coping with problems of installation. At that time the marketing force was

"very, very heavily occupied in working with existing customers on the installation of equipments which has [sic] been ordered at an earlier time. . . . [D]uring the year 1968 about 75 percent of [the time of] the marketing organization . . . was devoted to working with existing customers as opposed to seeking new business. . . . And this made very heavy demands upon the time and capabilities of our field marketing organization, and this impacted to some degree our ability to get new orders." (McCollister, Tr. 9647-50, 9653.)

RCA also found that its marketing force had to take time out from their normal selling efforts to deal with "[t]he problems of training customers in the programming of the equipment, in working with the customer in the installation of the equipment and the conversion of his system of processing work to this new method". (McCollister, Tr. 9649-50.)*

* The amount of effort expended by the marketing force on customer training was related to the fact that "the Spectra 70 equipment was new to the user". There was a demand for the services of the marketing organization to deal with problems in systems programming for Spectra because there were new programming products and, as McCollister

In addition to the problems that pervaded the entire Spectra line, RCA experienced problems which were uniquely associated with particular models. Those problems caused the Spectra product line to vary greatly in its degree of success.

<u>The Spectra 70/15 and 70/25.</u> First deliveries of the smallest computers in the Spectra series, Spectra 15 and 25, were made toward the end of 1965. (McCollister, Tr. 9640.) The 70/15 and 70/25 had less function than the rest of the Spectra line. This permitted them to be brought out earlier (Beard, Tr. 8460):

> "They did not use integrated circuits . . . [i]t was a means of protecting us against any risks that there might be in the use of integrated circuits in the larger systems.
>
> "Secondly, we felt that there might be some customers who are interested in a system that did not have a complete instruction set and was simpler to operate." (McCollister, Tr. 9719.)

The 70/15 and 70/25 were "relatively poor competitors" (Beard, Tr. 10110) and thus not very successful. (McCollister, Tr. 9642.) The lack of a complete instruction set--one of the reasons why the 70/15 and 70/25 were introduced--and the limited capability of the systems were two of the liabilities of the 70/15 and 70/25:

> "It turned out that most customers wanted the systems which had the more complete capabilities, and also the 70/15 and 70/25 did not have the communications capabilities that the larger systems had and they did not have the programming language capabilities that

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put it, "the experience of the industry in general is that there is always work to be done on new programming products". (Tr. 9651-52.)

the larger systems had". (McCollister, Tr. 9719.) In addition, "there was no COBOL capability provided at all" on the 70/15 and 70/25 (McCollister, Tr. 9730-31), which was anomalous since the 70/15 and 70/25 processors "in general left out the scientific type of instructions, and concentrated primarily on the data processing instructions". (Beard, Tr. 9071-73.)

In November of 1968 the product planning organization of the RCA computer division* made a similar observation:

> "[T]he Spectra 70/15 and 70/25, are basically sound processors, however, minimal software, no communication facilities, no random access hardware or software facilities and the lack of slow speed/low cost card and print devices were the prime reasons for poor competitive position." (PX 127, p. 77.)

The 70/15s and 70/25s were also hurt by RCA's absence of "marketing emphasis". (McCollister, Tr. 9729.) McCollister testified that the competitive position of these two systems "really wasn't that important to the RCA computer division". They were "insurance policies" using "existing technology that we could bring to market, deliver to customers before we could deliver the larger systems". (McCollister, Tr. 9740-41.) As a result RCA put little effort into marketing the 70/15s and 70/25s:

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* During the period 1964-1972 the RCA computer division had three different names: from 1964 to 1968 it was called the "EDP Division"; from 1968 to 1970 it was called the "Information Systems Division"; and after 1970 it was called the "Computer Systems Division". Here it will generally be referred to as the "computer division" or "Computer Systems Division" unless appearing in a quotation.

"These were relatively low cost, low margin systems, and when we had a finite amount of marketing field manpower, it made better economic sense for us to concentrate on the larger systems, where we had larger unit sales value." (McCollister, Tr. 9724-25.)*

The shipments of 70/15s and 70/25s turned out to "trivial". (McCollister, Tr. 11355.) And RCA produced the 70/15s and 70/25s "only during part of the total life cycle of the Spectra 70 family". (Id.)

The Spectra 70/35, 70/45 and 70/55. The Spectra 70/35, 70/45 and 70/55 were larger processors than the 70/15 and 70/25. Deliveries of those systems were about "fifteen months or so behind IBM".** (McCollister, Tr. 9646.) The 70/45 turned out to be the "most successful" of RCA's Spectra series.≠ (McCollister, Tr. 9665.) The 70/55 was less successful than the 70/45. It suffered from several problems:

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* In distinct contrast to the RCA lassitude with the low end of its line, IBM constantly attempted to grow the market with its low end computers. Thus, the 1401 (announced in 1959) and the 360/20 (announced in 1964) were the largest-selling IBM systems of their time. (See above, pp. 141-42, 399.)

** The Spectra 45 was first installed in July or August 1966 and the Spectra 55 first installed toward the end of that year. Deliveries in quantity of the 70/45 began in 1967. (McCollister, Tr. 9640-42.)

≠Beard wrote in 1965 (and testified as to the accuracy of his statement) that "the Spectra 70/45 is a medium-scale processor with a high performance capability for business, scientific, communications, and real-time applications", giving airline reservations or brokerage quotations as forms of real-time applications. (Beard, Tr. 9080-81; DX 617, p. 7.)

(1) The 70/55 "had serious memory problems. . . . We would get repeated errors in memory due to technical failure in the memory itself and this would bring the system down. [We] had a great deal of difficulty in maintaining the gear and keeping it up." (Rooney, Tr. 12139.) In fact, "there was some exchange of memories . . . some early number of the first machines had to have their memories replaced." (Beard, Tr. 10111-12.)

(2) RCA experienced "manufacturing problems with the [70/]55s, which gave us an unusual amount of field maintenance attention during the first year". (Beard, Tr. 10112.)

(3) The 70/55 was difficult to install and relocate. (DX 620, pp. 1, 3-4.)

(4) The 70/55 came out approximately a year after the 70/45 and tended to be "eclipsed" by the 70/60 and 70/61 which RCA brought out shortly thereafter. (Beard, Tr. 10109-10.)

(5) The 70/55 was hurt because it did not offer any emulation capability. Notwithstanding the fact that emulation capability was important to the success of the 70/45 system, the Spectra 55 did not emulate anything. (Beard, Tr. 10109, 10233.)

The result of these failures of the 70/55 had a "dampening effect on the [RCA] sales force" and led to customer cancellations. (Beard, Tr. 10111-12; see McCollister, Tr. 11216.)

While the 70/35 provided for emulation of the 301, that emulation "did not work successfully because the Spectra 35 was priced at such a high price that it was not a logical move for the 301 user to move up to the Spectra 35 system. . . . [Thus,] 301 users did not move up to the Spectra 35". (Rooney, Tr. 12137-39.)

<u>The Spectra 70/46, 70/60 and 70/61.</u> RCA's 1969 Annual Report described the 70/60 as a

> "[l]arge-scale . . . batch processor, which is designed to handle retail credit and reservation systems, automate production control, and service government and industry data banks." (DX 674, p. 8.)

The 70/46 and 70/61 were time-sharing systems. RCA began its work on time sharing during 1967 by attempting with the 70/46 "an expansion of the 70/45". (McCollister, Tr. 9673-74; DX 672, p. 21.) McCollister testified that the hardware for the 70/46 was "in its elements identical" with that of the 70/45 with "the addition of some faster registers in the machine". He estimated the hardware development effort of the 70/46 was "in the order of $2 million . . . because we made so much use of what was already existing in the 70/45". (McCollister, Tr. 9679.) The Spectra 70/61 had a comparable relationship to the 70/60 in terms of design approach as the 70/46 had to the 70/45. (McCollister, Tr. 9680.)

RCA, like GE and IBM (see above, pp. 417-18, 505-06), went into computer time sharing because of the changing demands of the industry. The introduction of the 70/61 "was in response to accelerating industry shift from traditional batch processing to remote computing, a system in which a large central computer accepts and almost simultaneously feeds back data to numerous remote terminals". (DX 674, p. 8.)

As a result of "[t]he growing acceptance of remote computing", RCA foresaw "excellent potential for sales of data communications terminals and other peripheral equipment as well as for computer hardware" and expanded its manufacturing capabilities for peripheral computer equipment. (Id.)

However, orders for the 70/46 and 70/61 during the years 1969-1971 were "less than had been projected in the forecasts because . . . the 70/46 had originally been planned as a system from which to gain experience with this class of product". (McCollister, Tr. 9694.) The marketing forecast was "excessively optimistic". (McCollister, Tr. 9695.)

RCA, like GE and IBM, ran into substantial difficulties developing the time-sharing software. RCA's time-sharing software was called the Time Sharing Operating System (TSOS).* The development of TSOS was "[b]y far the largest software development or largest programming system" that RCA's computer division had undertaken. (McCollister, Tr. 9697.)

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* At a later time TSOS was known as VMOS. (McCollister, Tr. 9717-18.)

Despite this effort RCA had

> "[i]mportant difficulties with . . . TSOS-VMOS which substantially impaired, certainly in early installations, the performance of the system as a whole, which includes both hardware and software." (McCollister, Tr. 9710-11.)

The problem with TSOS was that "there were bugs in it, which took time to get rid of, and it was late, as far as providing functions specified were concerned". (McCollister, Tr. 9694.)* Similarly, Rooney, who joined RCA in 1969 and was President of the Computer Systems Division in 1971 and 1972, testified that:

> "The Time Sharing Operating System was a form of virtual memory system that had a great deal of functional capability to offer, that was new and unique in the marketplace, but its reliability in performance was extremely poor and we had not achieved a high degree of reliability with that system while I was at RCA.
>
> ". . . .
>
> "The system was referred to as bombed out. There would be a problem. It would essentially go down. There had been a malfunction in the hardware, but in essence it was what was referred to as a bug in the program of the operating system, but it was not able to cope with handling certain data, as it was specified to handle it." (Rooney, Tr. 12132-34.)

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* McCollister observed that developing time-sharing software was difficult "for other manufacturers attempting [it]" as well as for RCA. (McCollister, Tr. 9694.) He added:

> "The history of the computer industry is filled with examples of difficulty that every manufacturer has had with the introduction and initial installation of new products, either hardware or software. This is a normal way of life.
>
> "[S]oftware, in particular, is a complex technical

As a result:

> "It was available to the user, but there were a great many periods of down time and, also, if you were operating with terminals, the response of the system would be very slow in a timesharing mode." (Rooney, Tr. 12134.)

In July 1971, Rooney identified "inadequate software" as among the "functional capabilities which detracted from [Spectra's] ability to meet its product objectives". (DX 11101, p. 1.)* While the performance of TSOS/VMOS improved "as time went on" (McCollister, Tr. 9718), development work on TSOS continued until RCA left the computer business. (McCollister, Tr. 9674.)

> task, and very large programming systems have literally hundreds of thousands of instructions in them between which there is interaction, and sometimes you don't know whether or not there is a fault until for the first time a particular combination occurs, and it is very difficult to develop this total mass of logic and to make certain that it is all correct at the time you turn it over to a user of equipment. This is a common experience within the computer industry.
>
> "For another reason, competitive conditions in the industry have been such that the manufacturers are always under extreme pressure to get out a new set of equipment and get it into the marketplace and get it installed as quickly as they can." (McCollister, Tr. 9696-97.)

* We are aware that this document is not in evidence; however, we believe it is reliable and rely on it because it was written by a person with knowledge of the facts (J. W. Rooney, President of RCA's Computer Systems Division) contemporaneously with the events described and confirms Mr. Rooney's trial testimony on the same subject. (See Tr. 12131-37.)

Other Product Problems. In addition to problems with its processing units, RCA experienced problems with the operating software (in addition to time-sharing software), random access memory units, card readers and memory stacks on Spectra 70. These problems created substantial problems for RCA in its marketing of Spectra. As Beard testified, in addition to looking at the price/performance or throughput claims of RCA, a user to determine the value of a computer system

> "would be looking primarily at the total system service that he would be supplied with, not only the effectiveness of the hardware to perform his requirements, but what software would be made available, and how effective the software was, the caliber of the maintenance organization to maintain the equipment once it was installed, his impression as to how well he would be supported by the vendor on future applications which he had not yet fully defined in his own mind in terms of new equipments, new software." (Tr. 10090.)

In addition, the user would take into account the relative functional capabilities of the peripheral equipment offered by competing systems. (Id.) When compared to IBM, the overall "value" of Spectra to the user did not match IBM's 360.

TDOS. For its Spectra systems from the Spectra 45 up, RCA had an operating system called TDOS. Rooney testified:

> "When it was announced it was a good system, but RCA did not continue to improve upon it at the same pace as IBM improved upon their OS. Our system, while performing satisfactorily in terms of reliability, did call for a lot more operator intervention in terms of performing the work than the OS system.
>
> "I made a strong plea for an improved system called OS 70, which was under development, to be used on the RCA 6. That system was decommitted in the early part of 1971.

> "By 'decommitted' I mean it was never brought to the market.
>
> ". . . .
>
> "The people responsible for putting the system together felt that they couldn't do it in the time frame that had been asked for". (Rooney, Tr. 12135-37.)

<u>Peripherals and Memory Stacks.</u> As discussed, RCA introduced its RACE file during 1964, and it suffered from various problems. (See above, pp. 549-50.) RCA marketed the RACE with its Spectra series and continued to market it actively into 1968 at which time it

> "was impacted by the progressive development of disk file technology. Disk files were more reliable devices. There were fewer things to make mechanical trouble in them. They had a faster access time and a faster transfer rate of information from the medium into the processor, and as the cost performance characteristics of disk files improved, the relative advantage and cost performance of the so-called RACE unit was reduced, until you reached the point where, for most applications, a disk file, as illustrated by the 2314, was a preferred approach." (McCollister, Tr. 9659-60.)

During the middle 1960s RCA still was not producing disk drives. To meet the demand from users for disk drives, RCA purchased IBM 2311 and then CDC 2311-type disk drives for use with the early deliveries of the Spectra 45 and 55 in 1967. (Beard, Tr. 9935.) RCA did not deliver its own 2311-type disk drive until the end of 1967 or beginning of 1968, a year and a half after its first Spectra deliveries. (Beard, Tr. 9913.)

When IBM began deliveries of its 2314 disk drive, RCA found that its marketing people "were under a handicap in selling the Spectra

70 Systems. We did not have a comparable product to the IBM 2314 at the time." (Beard, Tr. 8575.)

RCA's development of a 2314 equivalent was hampered by the departure of the group of persons who had worked on development of its 2311-type disk drive in 1967-68 to form another company, which was called Linnell Electronics.* The departure of those persons impaired RCA's ability to develop new disk drives. (Beard, Tr. 9924-28.) During 1968 RCA determined that Memorex was ahead of RCA in disk drive technology, and RCA contracted to have Memorex supply RCA with its "first year or year and a half supply of disks". Obtaining disk drives from Memorex "cost additional money" because RCA "had in parallel [its] own development going on which was going to be about a year later than Memorex's". However, RCA could not afford to wait the additional year because it was "losing too many sales" to IBM "for the lack of it". (Beard, Tr. 8574-75.)

RCA supplied its own controller for the Memorex 2314-type drives (Beard, Tr. 10254-55), developing it at an engineering cost of about $500,000. (Beard, Tr. 10246.) RCA started to work on a 2314-type product as a "full design project" in 1968 (Beard, Tr. 9922) and delivered the first units to customers "around the latter part of 1969 to perhaps mid-1970". (Beard, Tr. 9915.) The fact that RCA "was not able to produce on its own or to duplicate the 2311 or the 2314 disk

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* In 1968 Linnell was manufacturing IBM-compatible 2311-type disk drives for use with System/360. (DX 12543.) By 1972 it was manufacturing 2314-type compatible disk drives as well. Both drives were marketed by Bryant Computer Products. (DX 4556, p. 2.)

drives until very much after the IBM delivery" hurt RCA. (Rooney, Tr. 12123, 12192-94.) Disk drives offered "a functional capability very much needed in terms of price/performance in the competitive marketplace and without that capability you were in a weak competitive situation against IBM". (Rooney, Tr. 12192-94.) Thus, in July 1971 Rooney wrote that "the lack of a 2314 competitive device until late in the product life" was one of the "many functional capabilities which detracted from [Spectra's] ability to meet its product objectives". (DX 11101, p. 1.)

RCA also had initial difficulties with the card reader on its Spectra series. The difficulties were corrected only at the cost of making it a "very high cost product". (McCollister, Tr. 9604.)

One of the most severe problems faced by RCA was that of providing reliable memory stacks in 1967 and 1968. This problem cost RCA as much as $10 million and caused J. R. Bradburn, Executive Vice President of the computer division, to write to R. W. Sarnoff, President and Chief Executive Officer of RCA (PX 338, p. 49) in December 1968 recommending that the Memory Products Division be transferred to his division:

> "Modern computing and data processing systems consist in essence of input/output peripheral equipment, control, and memory. Development of complete competitive systems involve [sic] simultaneous, continuous, and coordinated development of all components. The single most important element of this overall development is memory.
>
> "Development processes must involve more than theoretical analysis and its immediate physical embodiment. A thorough understanding and consideration

of mechanical design, reliability, manufacturability, and maintainability of a complete memory system is required. Nothing less can meet competition today. . . .

"The present organizational structure within RCA is not conducive to efficient operation or to meeting these requirements. It does not bring to bear upon the decision making process the needed emphasis or the proper sense of order of importance adequate to meet the needs both in the short and long runs.

". . . [This] is what has been demonstrated by the inordinate difficulties encountered in trying to provide reliable memory stacks for our computer shipments in 1967 and 1968. Poor stacks may have cost us as much as $10,000,000 in those two years. Additionally, our problem is portrayed by what has been inadequate provisioning in the engineering budgets of Memory Products." (DX 840, p. 1.)

(iv) <u>RCA Success with the Spectra 70 Series.</u> Despite the numerous problems experienced by the Spectra 70 series, during the period of its life (1965-1969) RCA enjoyed considerable success with its computer business. McCollister testified that:

"1966, '67, '68 and '69 were generally periods of steady and encouraging growth, and we were operating for the most part during this period at pretty much a breakeven, although in the year 1966, because we had a heavy installation workload, we upped the budget of the marketing organization, which threw us back into the red, and in the following year or two we began to increase the amount of money going into the engineering organization.

"But I would say that beginning in 1965 through the year 1969 we were making what appeared to be encouraging progress. We did have an ability to compete within our particular scope of operations and the corporation was encouraged about the long term outlook for the Division." (Tr. 9246-48.)

RCA's annual reports confirm McCollister's assessment: In 1964 RCA reported that its "gross computer sales and rentals" were higher than $100 million, having grown from $14.6 million in 1960. "RCA's total data processing business earned a profit for the full year." (DX 669, p. 2.)

In 1965 RCA reported that its profits in the computer business continued and "the potential for future profits was enhanced by the booking in 1965 of orders for 92 percent more computer systems than in the preceding year. By 1970, profits from the data processing business . . . are expected to become a highly significant factor in RCA's total earnings." (DX 670, p. 7.)

In 1966 RCA reported that "domestic orders for RCA computers and their associated equipment rose by 53 percent over the 1965 level". During 1966, with Spectra deliveries beginning, RCA enlarged its field marketing force by 45 percent, planned for another 35 percent increase in 1967, and "boosted production capacity by 75 per cent to fulfill the growing demand for Spectra 70 computers and other data processing equipment". (DX 671, pp. 4, 15.) RCA reported that a loss in its computer business in 1966 was caused by an increase in leasing as opposed to purchasing by customers.* (Id., p. 4.)

In its 1967 Annual Report RCA reported that:

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* Concerning the change in favor of leasing by customers RCA reported that:

> "The increase in lease transactions was common throughout the computer industry and reflected in part the tightness of the money market. While tending to promote long-range stability by spreading income over the period of lease, it reduced immediate income. This trend, as well as increased spending for future growth, contributed to a loss in RCA's computer business for 1966."

"Our computer business continues to grow at a faster rate than that of the industry as a whole. However, because most of our equipment is leased, rather than sold outright, income is necessarily delayed. In 1967, this situation placed us once more in a loss position, but we look upon this as an investment in future profits and we look forward with confidence to the period when our data processing activity will become one of the most importan parts of our business, surpassing even color television." (PX 338, p. 5.)

In 1969 RCA reported:

"Domestic bookings of RCA computers were more than 40 per cent greater than in 1968 and represented nearly a threefold growth in the past five years.

". . . .

"As the decade ended, our backlog of computer orders was 30 percent higher than a year ago. The trend toward remote computing systems as well as the mushrooming of data processing applications make the outlook for the '70s very promising. We expect the dollar value of our information system shipments to increase significantly during the 1970's and to approach $1 billion annually.

". . . .

"While total revenue from sale and lease of computers rose 23 per cent during 1969, RCA's computer operations remained in a loss position. This deficit is largely the result of expenditures aimed at future growth, which include the building up of our marketing forces and expansion of software and other aspects of the business." (DX 674, pp. 8-9.)

During the period 1965-1969, RCA's U.S. EDP revenue rose from about $89 million to approximately $211 million. (DX 8224, p. 2.

RCA added:

"A pattern of fluctuating profits and occasional losses is to be expected in the development of a strong base for the future in this complex and competitive field." (DX 671, p. 4.)

c. RCA Computer Systems Division 1969-1971. The story of RCA's involvement in computers at the end of the 1960s into the early 1970s has three parts:

First, the change in personnel at the corporate level and in the computer division during that time frame and resulting changes in goals of the computer business;

Second, the decision to develop and the consequences of the RCA Series; and

Third, the problems that resulted from the preceding two decisions.

(i) Changes in Management Personnel and Goals. On January 1, 1968, Robert Sarnoff became Chief Executive Officer of RCA while continuing as President; his father, David Sarnoff, continued as Chairman of the Board. (PX 338, p. 49.) During 1968 Chase Morsey, Jr. left Ford and joined RCA as Vice President of Marketing, and the next year became an Executive Vice President of RCA. (McCollister, Tr. 11156-57; PX 338, p. 49; PX 339, p. 49.) In 1970 Robert Sarnoff replaced his father as Chairman of the Board (DX 674, p. 36), and in 1971 A. L. Conrad became President and Chief Operating Officer. (PX 341, p. 38.) Conrad had worked his way up through the RCA Service Company (PX 400) which, "[i]n addition to its work for the government and in education, the Service Company install[ed] and maintain[ed] home-entertainment products, commercial electronic systems, and business and industrial equipment". (DX 677, p. 13.)*

At the time Robert Sarnoff became RCA's Chief Executive Officer, RCA underwent a change in its corporate philosophy. In its 1968 Annual Report RCA reported that:

> "In its formative years, RCA's growth depended primarily on a single product or service.
>
> ". . . .
>
> "The word that best characterizes the modern RCA is diversity. An almost even balance has been achieved between manufacturing and service operations, and the well-being of your company no longer hinges upon any single activity. Carefully planned diversification has moved us into new areas of enterprise, such as vehicle rentals through The Hertz Corporation and book publishing through Random House. New businesses have been created from within, such as the Information Systems Division". (PX 339, p. 11.)

RCA's desire for diversity caused it to acquire many different and unrelated businesses. Starting in 1966, RCA acquired the Hertz Corporation (automobile rentals); Random House and Ballantine Books (book publishing); Coronet Industries (carpets); Banquet Foods (frozen foods); Oriel Foods and Morris & David Jones (wholesale food distributors in the United Kingdom); Cushman & Wakefield (real

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* RCA's changes in higher management have continued to the present. On December 31, 1975 Sarnoff resigned as Chairman of the Board of RCA. (DX 951, p. 36.) He was replaced as Chairman during 1976 by Conrad who remained as President. (DX 13852, p. 37.) In September 1976, Conrad resigned as both President and Chairman, and Edgar Griffiths replaced him as President, while the position of Chairman remained vacant. (Id.) On January 1, 1980 Griffiths filled the vacant position of Chairman and Maurice Valente became President. (DX 13902, p. 48.) In June 1980 Valente was forced to resign as President, and RCA abolished the position and created an Office of the Chairman consisting of Mr. Griffiths and five other current executives. (DX 13861.)

estate); Alaska Communications System (communications); and a color tube manufacturer in the United Kingdom. (Conrad, Tr. 14002-05; DX 671, p. 5; DX 674, p. 21; DX 677, pp. 14-19.)*

During that period it entered several new businesses including the domestic common carrier satellite business. It also undertook significant new investments in Colortrak (an advanced color television receiver), SelectaVision, VideoDisc, Global Communications and the RCA Service Company (related to lease and maintenance services for private telephone systems). (Conrad, Tr. 14002-05.)

Thus, by 1971 RCA was a conglomerate engaged in a large variety of different fields including home appliances, televisions, radios, recording devices, federal defense contracts, communications services, broadcasting, automobile rentals, food, carpets, books, records, and real estate--and computers. (Rooney, Tr. 12022-24.)

During the 1966-76 period, the chief executive officers of various RCA divisions and subsidiaries, including Banquet Foods, Coronet, Hertz, Random House and Global Communications, were directors of the RCA Corporation. No officer of the computer division was a member of the RCA Board of Directors during this period. (Conrad, Tr. 14027-28; PX 339, p. 49.) In 1971 revenues from the operations of the RCA Computer Division represented less than 10% of RCA's

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* By 1979 RCA had sold Alaska Communications System and Cushman and Wakefield. (DX 951, p. 17; DX 13902, p. 14.) As of 1980, RCA had sold Random House and was trying to sell Banquet Foods. (DX 13860.)

corporate revenues--$270 million out of $3 billion. (Rooney, Tr. 12025.)

At this time changes were also occurring in the personnel and goals of RCA's computer division. During 1969 and 1970 RCA hired people from IBM to manage parts of the computer division. For example, L. Edwin Donegan, Jr., became Vice President of Sales in 1969 and General Manager in 1970. (McCollister, Tr. 11590.) Joseph W. Rooney came from IBM in 1969 and after a brief corporate staff job became Vice President of Marketing; in 1971 he was President of the Computer Systems Division. (Rooney, Tr. 11687-88.) V. Orville Wright was hired in 1970 and the next year was head of Systems Development. (Wright, Tr. 12785.) Sam Adams was responsible for business planning. Bill Acker was put in charge of the financial operation. (McCollister, Tr. 11590.)

The goals of the computer division changed with the new corporate and computer division management during this time. Until Robert Sarnoff took over in 1968, the RCA computer division had placed its emphasis on accomplishing its business plans and obtaining moderate growth, an emphasis which McCollister considered "correct". (Tr. 11156-57.)*

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* Withington similarly identified and endorsed RCA's emphasis during that time:

> "In 1965, the RCA strategy was to offer a line of general purpose computer systems . . . with instruction set compatibility to IBM processors, . . . and to grow at a modest rate commensurate with maintaining profitability at all times.

In 1968 RCA changed its emphasis to one of quickly obtaining a larger market share. McCollister attributed this change to the newly-arrived Chase Morsey,* and testified that the change was not "beneficial" to the computer division because:

> "It tended to place the emphasis upon increasing market share and relatively deemphasize control of expenses and achieving a profit, and the end result is that the expenses in the RCA Computer Division mounted to the point where they contributed significantly to RCA's withdrawal from the business.
>
> "In other words, you place the emphasis upon share of market and you tend to deemphasize some of the other important aspects of running a successful business, and share of market is only one consideration". (Tr. 11158.)

In its 1970 Annual Report RCA reported that:

> "Our highest priorities today are the establishment of a profitable computer business and the capture of the domestic industry's No. 2 position. RCA has made a greater investment in this effort than in any prior venture in its history, and we are convinced that the returns will be substantial". (PX 340, p. 3.)

This change in strategy was visible outside RCA. Withington testified that:

> "That was RCA's historic strategy since the announcement of the Spectra 70 series, . . . the system seemed versatile and attractive, and I saw no reason why RCA could not continue growing at a modest rate and increase its total market and perhaps even its market share on the basis of its current offering". (Tr. 56702-03.)

* McCollister believed that, having come from the Ford Motor Company, Morsey "was very conscious of share of market statistics and he was also influential, and this caused the division to give increasing recognition to share of market as such". McCollister regarded Morsey's emphasis on share figures as "exaggerated" and "a legacy from his experience in the automobile industry". (Tr. 11156-58.)

". . . RCA's new strategy involved attempting to grow very sharply in market share from the position they were in by means of attempting to capture IBM's customers in the processes of evolving from the 360 series to the 370 series . . . RCA's new strategy involved expanding its operation in every respect,[* field organization, the manufacturing capability, and the engineering force, at a substantial increase in cost; and more importantly, it involved the anticipation of incurring the manufacturing costs of a very large number for RCA of new systems in a short time. . . . These financial requirements would inevitably cause a lack of profitability for a period". (Tr. 56707-09.)

It was this change in strategy that led directly to the ill-fated RCA Series.

(ii) The RCA Series. During the 1968 time frame RCA realized that if it was to achieve its new growth objectives it would need successor systems to the Spectra series. Unfortunately, RCA was undecided about what successor products to develop. McCollister testified:

"In looking at the next family or generation of equipment beyond Spectra, there was a lengthy debate between the people responsible for programming systems, that is, the so-called software organization, and the people responsible for hardware or equipment specifications, and perhaps the engineering organization as well, as to exactly what the nature of this product should be." (Tr. 9809.)

RCA made two starts at developing a successor product line. The first attempt, referred to at trial as the X series, was decommitted in 1969 for two reasons: first, RCA felt that it could

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* For example, during 1971 the computer division expanded its operations: it opened a sales office in the United Kingdom to market RCA computer products in Europe (Rooney, Tr. 12365) and it constructed a new manufacturing site in Marlboro, Massachusetts. (McCollister, Tr. 10963-65.)

not meet what it predicted to be IBM's announcement of 370*; second, the series included

> "[a]n architectural problem [in] that they doubted they would ever be able to complete the product line without a major restructuring of their whole development program. . . . My understanding at the time was that they could not build it at all if they had developed it or had set up the architecture". (Rooney, Tr. 12225-26.)

The second attempt at a successor to the Spectra was the New Technology System (NTS). The NTS was originally scheduled for announcement in early 1971. However, "[t]here was a slippage in that program and it was subsequently put off for announcement for approximately 18 months as a result of development problems within RCA itself". (Wright, Tr. 13173.)

RCA made only "marginally small" investments in NTS. (Withington, Tr. 57079.)** It appeared that NTS, if announced as it was being developed, would have encountered competitive difficulties. Withington testified:

> "The basic reason for my concern was that I believed at the time that IBM would introduce a new family of general purpose computer systems in the time frame 1973 to 1977, which was the time frame in which RCA's NTS computer systems were to be shipped.

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* This prediction was based on "intelligence" from people who had worked at IBM and from trade journals. Based on this intelligence, RCA understood that IBM announcements would begin in the second or third quarter of 1970, with larger models announced first, and announcements continuing throughout 1970 until the lower models of the line would be announced at the beginning of the 1971 period. Shipments were anticipated to be 12 months later. (Rooney, Tr. 12225-29.)

** During this time RCA hired A.D. Little to review RCA's product and marketing strategies in its computer business. (Rooney, Tr. 11814.) On behalf of A.D. Little, Withington made suggestions and wrote a report. (DX 2666.)

"I believed that the nature and functionality of the NTS line would be inadequate to meet the needs of customers who were IBM users or who would otherwise consider IBM systems during that time frame."* (Tr. 56715-16.)

Withington told RCA that "a revision and acceleration of the product plan would be necessary if RCA would have . . . '[a] good chance of attaining the desired market share'".** (Tr. 56716;

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* Withington listed the ways in which the NTS line would be "inadequate in terms of functionality":

> "I noted that RCA's NTS line involved only monoprocessors rather than multiprocessors. I noted there would be no small satellite processors, and I noted that NTS was to be aimed at the medium monoprocessor market segment, this meaning in terms of price range, and noted my belief that the IBM customers would be migrating from the medium monoprocessor market segment to large multiprocessors to obtain the advantages of centralization.
>
> ". . . .
>
> "I foresaw that the IBM systems of the 1973 to 1977 range would be equipped with multiprocessing, satellite systems, virtual memory, and fail-soft, of which all but the latter were in fact announced; and that there would be a trend toward centralization, which did take place.
>
> "Since RCA's NTS line did not fit with either that functionality or that trend, I believe that was the entire reason for my concern". (Tr. 56715-16.)

** He recommended that RCA embark on a development program for a satellite processor and on a "comprehensive terminal plan" because "an adequate line of inquiry interactive and remote batch terminals must be offered with network systems": because of their "visibility" and large numbers, "terminals may dominate users' selections". The existence of a terminal product line for RCA "might very well" have made a difference in the success of the NTS plan because "the profitability of the computer business as a whole might have been greatly enhanced" if RCA had had excellent terminals. (Tr. 56718-20; DX 2666, pp. 5, 15-16.)

see also DX 2666, p. 5.)

During 1969 and 1970, RCA looked at other ways to replace its Spectra Series:

> "One was to specialize in just one or a few industries and to market in no other than those few industries. Another alternative was to select an individual niche in the product line by rental size where we could market exclusively products in that area". (Rooney, Tr. 11820-21.)

At this point, during 1970, RCA had several alternative ways it would proceed in the computer business: it could continue to market the Spectra 70 series until NTS, or some other more advanced product line was developed; it could specialize in a particular product area or it could market what became the RCA Series. The latter option--the RCA Series--was chosen for several reasons:

(1) The new management of the RCA Computer Systems Division wanted to stop marketing the Spectra and to market its own line of products:

> "The then management of the Division wanted to have a product line that would be associated with their management era or period, as opposed to a product line which was associated with an earlier management era". (McCollister, Tr. 9837-38.)

It also thought that a new product line would have a "psychological influence" on the "marketplace". (McCollister, Tr. 9816-17.)

(2) RCA also believed that it could not continue to sell the Spectra series in the face of the price/performance improvements offered by IBM with its System/370. According

to Rooney, if RCA had not been "selling against IBM" it could have continued to offer the Spectra series. (Tr. 12234-36.)

(3) Because of its desire for a large market share RCA rejected the idea of focusing on particular product areas:

> "[A]t a meeting I attended, [A.D. Little] presented the concept that you had to have a broad product line because you could not possibly sell enough share of any particular product category to achieve this goal and that strategy was accepted as being valid" by "[t]he management of the Computer Systems Group as well as corporate management". (Rooney, Tr. 11814.)

(4) RCA believed that it could equal or better the price/performance of the IBM 370 systems and take away IBM users by introducing the RCA Series:

> "We were faced with a pending IBM announcement; we knew that the IBM announcement would offer their clients improved price/performance; we had just had the X series decommitted; and our objective was to grow to 10 percent share of the market. And we felt that we had to therefore maintain our original strategy of going after the IBM base. And after many discussions, it was concluded that by putting in the new memory capability we would be able to bring the cost of these systems down, so that we could offer a price competitive system--price/performance competitive system with IBM's 370. And since it was following the Spectra architecture, conceptually it would be the same strategy as IBM was employing, that is, utilizing the existing software for the next generation of equipment". (Rooney, Tr. 12242-43.)

The RCA Series was announced on September 15, 1970, three months after the first announcement of IBM's System/370. (Wright, Tr. 13175-76.) The RCA Series consisted of four models "of small-to-medium-class computers--RCA 2, 3, 6 and 7". (PX 340, p. 17.)

RCA described the RCA Series as "offering more power and memory for the dollar than present third-generation systems". (DX 675

p. 16.) While the RCA Series had new memories, "under the covers, the RCA Series was essentially the Spectra 70". (McCollister, Tr. 9819-20.) McCollister described the RCA Series:

> "[I]t was a restyled product line. There was a new set of covers, the frames were the same, and it was essentially a cosmetic treatment of the existing Spectra 70 Series with new model numbers and new pricing.
>
> "There may have been some minor improvements. But fundamentally the product was not changed from the Spectra 70." (Tr. 9816-17, see Tr. 9819-20.)

RCA's computer division management devised "an elaborate strategy" to make the RCA Series succeed:

> "There was a very elaborate strategy at the time as to where these units of the RCA series would fall against the IBM either 360 or 370, either as it had been announced or was expected to be announced, and I think there was a fallacious expectation that in this elaborate strategy that the RCA series would fall at a certain point within the IBM product line spectrum and that IBM would be unwilling to disturb the equilibrium of that product spectrum and, therefore, negate the rationale of the RCA product concept." (McCollister, Tr. 9837-38.)

Under this "elaborate strategy" the RCA Series would "intercept" the System/370. "Certainly there was a great deal of effort and much paperwork and many presentations with respect to this rationale". (McCollister, Tr. 9838.) Similarly, Rooney testified that in 1969-1971 "we had a term called intercept strategy, which implied intercepting the upward migration of the IBM client base with RCA equipment". (Tr. 11811-12.)

The "elaborate strategy" failed.* The RCA Series was a

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* At the time of the decision Withington cautioned RCA about the RCA Series. He testified:

"major product failure" and "a mistake" (McCollister, Tr. 9819-20; Wright, Tr. 13577-78; Withington, Tr. 56454-55.) The RCA Series failed in two respects: (1) instead of "intercepting" System/370, it "intercepted" RCA's own Spectra 70 series, and (2) it had substantial technological problems.

Interception of the Spectra 70. The witnesses used different words but all said the same thing: by introducing the RCA Series, RCA "obsoleted", "intercepted" and "blew . . . out of the water" its Spectra 70 series. (McCollister, Tr. 9838-39; Withington, Tr. 56720.) Withington explained what happened:

> "[A] great number of present Spectra 70 users renting . . . their systems, did indeed order the new RCA Series and indicate their intention to return their Spectra 70s, and that phenomenon indicated immediately that the financial impact of the new series would be more negative than planned". (Withington, Tr. 56711; see also PX 4836, p. 23.)

So did McCollister:

> "[A] customer had everything to gain by ordering an RCA series and returning the Spectra 70. He got a brand new

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"I remember indicating my concern to RCA management at that time about the likelihood that the new RCA Series would cause a general replacement of rented Spectra 70 machines in the field, and that this would cause more negative financial results than they were expecting. And I remember being uncertain about the degree to which IBM customers would be willing to convert quickly and in large numbers to the RCA Series". (Withington, Tr. 56710.)

Withington "did not reach a firm conclusion at that time that failure was inevitable". He testified that the strategy might have been successful "if it had been carried out differently with different prices for the machines, with less effort to grow suddenly, and with more effort on functional improvements in the product line". (Tr. 56710-11.)

machine. It cost him maybe 15 percent less or so and why not?" (McCollister, Tr. 9837-39.)

The interception of the Spectra by the RCA Series seriously hurt RCA in several respects. First, it reduced RCA's rental income because rents for the RCA Series were lower than for the Spectra. McCollister testified:

> "[T]he announcement of the so-called RCA Series of equipments as replacement to Spectra 70, which offered new equipment under different model numbers, which was technically essentially unchanged from the previous equipments, but which was offered at a lower price than previous equipments, meaning those equipments which were in that rental base . . . hastened the return of those equipments from the rental base to the manufacturer.
>
> "The effect was that it hastened the return of equipment that was then installed with customers on a rental basis because the customer could get a newly manufactured machine of equal ability, a new appearance and at a lesser price than he had been paying for the one which he already had installed". (Tr. 11491-94.)

Second, RCA was forced to build more RCA Series machines while it built up an inventory of returned RCA Spectra 70's. Wright described the situation confronting RCA:

> "You therefore were confronted with the building of new products by the manufacturing organization and shipping those products to the installed customer base, and in many, many instances, because there was improved price/performance in the RCA Series over the Spectra series, you replace your own equipment and you got the Spectra series of systems equipment back. In many instances the cost of manufacturing had not been fully amortized, and that would have an effect upon both your cash requirements and also upon your P&L". (Tr. 13577-78.)*

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* The fact that the cost of manufacturing had not been fully amortized would indeed have an effect upon the profit and loss statement. However, since those costs were sunk, the failure to amortize them fully could not directly affect the cash flow. Cash flow would be affected, of course, as McCollister testified (see

McCollister testified that RCA found itself with:

> "[o]rders for the RCA Series which required a manufacturing investment, in the product being placed out on rental for the most part, which drew capital from the corporation to do this, and it resulted in the displacement of existing Spectra 70 processors in many cases before they had been fully depreciated". (Tr. 9818.)

He added that:

> "This tended to build up an inventory of the equipment which was returned by the customers, the rental income from that equipment ceased and the company was faced with the requirement to invest money in new equipment to place in the customer's office to take the place of that which was sent back or returned". (Tr. 11491-94.)

In addition, the early returns of the Spectra 70s:

> "[h]ad serious adverse financial effect upon the Divison because it did not permit us to follow a plan or have a strategy which would maximize the return from the investment in Spectra 70 equipments." (Tr. 9838-39.)

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above), by cessation of rentals from the returned machines and the necessity to spend money to manufacture the new ones.

The problems of returned Spectra 70 systems were such that RCA established a Returns Task Force, which made its presentation in early August 1971 and, considering both returns experienced to date and those which were forecasted, concluded that "approximately 70 percent of the returns were being caused by RCA's replacement of Spectra series with RCA equipment". Approximately 18 percent were losses to competition and about 12 percent due to economic problems. (Rooney, Tr. 12275-77; Wright, Tr. 13581-83; DX 873, p. 24.) These early returns particularly hurt RCA's profit and loss statements by forcing RCA to write off the undepreciated asset value of its "accrued equity contracts". (McCollister, Tr. 9820-21.) These contracts were arrangements in which the customer leased the equipment for five years, making equal monthly payments over that period, but RCA took 70 percent of the revenue that it expected to achieve into its profit and loss statement in the first year of the contract. (Wright, Tr. 13589-96.) When the RCA series was announced, some equipment under accrued equity contracts was returned prematurely (according to McCollister) because the manager of the division "was anxious to make a showing with respect to the success of this new product line" and had "an inclination to allow customers to return Spectra 70 equipments prematurely for the sake of being able to cite an order for a machine in the new product line". (McCollister, Tr. 9820-21.) This meant that debits against current revenue had to be recognized when machines were returned before earning the revenue already reported in prior years.

Technological Problems of the RCA Series. The RCA Series suffered from technological deficiencies that hampered its success:

> "Because you were in a sense perpetuating technology that was five years old, you were making a new investment in five-year old technology, and the pace of technology in the industry, in it [sic] cost effectiveness characteristics, is such that when you bring out a product line you cannot afford not to take advantage of improvements in cost performance and capabilities up to the time that you bring out that equipment.
>
> "That is certainly one aspect of the problem, that it resulted in new investment in old technology when better technologies were available at that time". (McCollister, Tr. 9819-20.)

In addition to the general technological staleness of the RCA Series, particular products were deficient in various ways. Peripherals continued to be a problem. By 1970 RCA was "[t]wo to three years" behind IBM in the development of peripherals.* (Rooney, Tr. 12247-48.) More specifically, RCA was hindered by its failure to have a disk drive competitive to the IBM 3330, which had been announced in June 1970 with System/370. In 1971 Rooney reported that RCA still suffered from its:

> "[i]nability to provide a 3330 competitive device until some 19 months after IBM's delivery of its 3330 unit. I feel both of these items are of major importance to the success of our RCA series marketing efforts and should be resolved. In particular, I am concerned we may suffer the same exposure we have faced with the 70/564 and 70/590 disc programs if we are not able to accelerate the present delivery schedule for our 8580 unit." (DX 11101, p. 2.)

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* Rooney added that there had been a pattern in the RCA experience up to 1970 of producing essentially carbon copies of IBM's peripheral equipment two or three or more years late, either by developing that equipment themselves or by acquiring that equipment from other equipment manufacturers. It was one of his goals in 1970 to try to do something to overcome that disadvantage. (Rooney, Tr. 12249-50, 12252-53.)

And in July 1971, RCA's computer division monthly report stated that "sales of the RCA 6 and 7 have been and will continue to be hampered by the large delivery differential between the RCA 8580 [disk drive] (March 1973) and the IBM 3330 (August 1971)". (DX 11099, p. 5.) By then RCA was arranging to purchase the 3330 on an OEM basis from IBM. (See DX 937.)

In mid-1970 RCA established a Peripheral Task Force to try to do something about its problem with peripherals. (Rooney, Tr. 12249-53.) On July 16, 1970, L. E. Donegan, Jr., Division Vice President and General Manager of the Computer Division, wrote to W. W. Acker in Finance and Administration concerning the activities of the Peripheral Task Force:

> "Conceptually, the thing we must begin doing and you should attack it across the board in all peripheral areas, is get away from the pattern of producing carbon copies of IBM's peripherals, one generation late. Now that we have our hands on some very good IBM intelligence we should attempt to leap-frog and get ourselves to within 12 months of their delivered peripheral capability.
>
> ". . . the tape units that we are presently developing in Marlboro are competitive in price performance and specifications with Third Generation IBM tape stations and most likely will be non-competitive once IBM makes its new tape family announcements. We must keep this from happening." (DX 862.)

RCA's problems with software also continued into the RCA Series. VMOS 4, an operating system to be used with the RCA 3 and RCA 7, was announced in September 1970. (Rooney, Tr. 12335.) By December 1970 it appeared that there would be a 6-9 month slippage in the delivery of VMOS 4. According to A. L. Fazio, RCA's Manager of Virtual Memory Systems, such slippage would be a "product disaster" causing RCA to lose about $3.5 million from delayed installations and approximately $2.1 million points (dollars in monthly rental) from current and future prospects. (DX 872, pp. A, B, C.)

The slippage occurred and was "significant". (Rooney, Tr. 12349-50.) Because of that slippage RCA lost $3.5 million in revenue and marketed about 40 systems--20 RCA 3s and 20 RCA 7s--less than it would have during 1971 through 1973.*

(iii) Computer Systems Division's Problems--Early 1970s. 1970 was "essentially" a breakeven year for the RCA Computer Systems Division. At the time RCA projected that 1971 would also be "breakeven", with 1972 showing a $25 million and 1973 a $50 million "pre-tax operating profit". (McCollister, Tr. 9814-15.) A five-year business plan drawn up by the Computer Systems Division in late 1970 provided for "a breakeven position in 1971". (PX 208, p. 1.) In its 1970 Annual Report RCA painted a similar picture for its shareholders:

> "This investment has already resulted in a more rapid growth rate for RCA than for the domestic industry as a whole. In 1970, the value of RCA's net domestic shipments rose by more than 50 percent, while that of the industry fell by more than 20 percent. Among the factors responsible for RCA's progress was a decision to continue increasing the computer marketing force during a period when many others in the industry were retrenching as a result of the weakness of the economy.

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* The purchase revenue on each RCA 3 sale lost would have been $1 million and on each RCA 7 sale lost would have been $2 million. (If rented, monthly revenue would have been 1/50th of the sales price.) (Rooney, Tr. 12352-53.)

"Our computer revenue this year will be more than double that of five years ago, and we continue on target toward a profit crossover in computers in the early 1970's". (PX 340, p. 3.)

However, during the beginning and middle of 1971 it was becoming apparent that those plans for the Computer Systems Division would not be met, and that the Division would be far less successful:

(1) In late January 1971, Robert Sarnoff was informed by RCA's auditors, Arthur Young & Co., of a "major . . . change in operating results of the Computer Systems Division in the 1971 business plan", and he asked for an analysis of the problem. Arthur Young responded by a letter dated February 24, 1971. (DX 11108, p. 1.)

(2) In April 1971 RCA revised its business plan for the Computer Systems Division. That plan reduced the prediction of revenue for the Division set forth in the December 1970 plan from $323 million to $261 million. The revised plan predicted an anticipated pretax loss in 1971 of $37 million. (DX 952, pp. 7-8, 12.)

(3) On April 23, 1971, H. L. Letts, RCA's Senior Financial Officer wrote to Sarnoff that the magnitude of the Division's problems raised serious long-term concern about the business and suggested reappraisal of the Division's objectives. He suggested that a task force be set up to study the Division and its objectives. (DX 952, pp. 1, 2.)

(4) By June 1971 a task force comprising six persons from Arthur Young and the RCA Auditing Staff had reported

on the problems of the Computer Systems Division. Morsey sent this report to Sarnoff and Conrad with a cover memorandum stating that "the Computer Systems 1971 loss could deteriorate significantly from Business Plan levels". (DX 955, p. A.)

(5) During 1971:

> "[I]t became apparent that there would be a loss in magnitude of $30 million or $35 million, a loss that eventually rose to the area of $50 million or $60 million, and this of course was an enormous difference from what had been anticipated at the beginning of that year." (McCollister, Tr. 9814-15.)

(6) By the middle of 1971 problems at RCA "put in question the anticipated revenue, and in turn opened the question in my mind as to . . . profitability . . . in the remainder of 1971". (Conrad, Tr. 14125.)

Those and other participants in or observers of RCA's computer business pointed to many problems in RCA's Computer Systems Division that would cause its anticipated losses. A discussion of each follows:

<u>Declining Revenues.</u> The higher-than-anticipated returns from Spectra equipment ($155 million as opposed to $90 million) resulted in a reduction of expected net shipments (even though there was an increase in gross shipments) from $230 million to $186 million. RCA's 1971 Business Plan stated that:

> "[t]he returns implications of RCA's first introduction of . . . the RCA series compatible with the Spectra series . . . were not fully reflected in the first plan. . . . There has also been greater migration than expected from the old to the new series. . . . The increased dependence on the RCA series

has a profound impact on revenue projections and attendant risk, since product will not be available until second half of 1971". (DX 952, pp. 7-8.)

Expenses Too High. RCA's revised plan in April 1971 suggested possibilities of actions "to minimize corporate investment until development of larger revenue base is obtained", including the deferral of the Marlboro office building, "improved asset utilization and management", "further expense reductions" and a possible merger with or sale to another company. (DX 952, p. 21)

McCollister attributed RCA's losses to the fact that "there was a substantial increase in expense, and that revenues were not increasing, and that revenues had been seriously overforecast." An example was the construction of the Marlboro facility in 1971. "The relocation of the offices, the executive office and the construction of the office building under the circumstances was . . . a mistake. . . . [It] was an expenditure which could have been deferred". (McCollister, Tr. 10964-65, see also 9814-16.)*

RCA also "had a very serious problem relative to manufacturing costs". According to Wright:

> "It stemmed from several sources. One was the fact that the manufacturing process in RCA was not as fully automated as I had seen it automated in IBM manufacturing.
>
> "RCA was not devoting sufficient attention in engineering a product to the matter of cost. They tended to engineer the product to get it built, but ignored what it might cost to build it after it was engineered.

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* The expenditure for Marlboro amounted to about $25 million for capital facilities, not including relocation expenses. (McCollister, Tr. 10966-67.) McCollister also testified that the 1971 opening of RCA's sales office in the United Kingdom was "a mistake" because "it was an investment which would, if ever, be financially rewarding only at some point in the future". (Tr. 10965.)

"There was no value engineering work going on after the product was developed to reduce its cost within the manufacturing organization. Those types of things.

"The cost, as I recall it, when I first got involved in that, which would have been early in 1971 . . . was running at that point in time about 42 percent of revenue." (Wright, Tr. 13559-60.)*

<u>Poor Organization and Unreliable Information.</u> The Arthur Young report to Robert Sarnoff in February 1971 reported:

"The basic failure to develop acceptable planning information in the division involved the lack of a reliable information base, principally relating to revenues, from which plans could be developed and current performance measured. This situation was aggravated by communications gaps which developed in a period of organizational change. Planning responsibilities and assignments were not clearly defined. As an example, the financial group was divided early in 1970; moves to upgrade the remaining group were less than successful. Preparing for the move to Marlboro was probably a further complication." (DX 11108, p. 1.)

The Returns Task Force in 1971 reported that the Computer Systems Division suffered from the inadequate tracking of computer equipment:

"1. No single, reputable data base for customer/equipment information.

"2. No two data sources agree.

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* Wright recalled the comparable figure for IBM's manufacturing cost as a percent of revenue as "on the order of 14 to 15 percent" and "in certain other products, such as the CPU alone . . . substantially under that". RCA looked at other companies besides IBM and concluded that Sperry Rand's manufacturing cost "was running about 24 percent of revenue," and Burroughs "was about 21 percent of revenue." (Tr. 13560-61) When Wright got to RCA he "took several steps to reduce those manufacturing costs." (Wright, Tr. 13563) For example, RCA substituted "high quality plastic" covers for the "very heavy steel gauge covers" it was using at 15% of the cost. (Wright, Tr. 13564.) This and other cost cutting measures reduced manufacturing costs by "8 percentage points as it would relate to revenue". (Wright, Tr. 13566.)

"3. Regular field inputs to data bases are clearly modulated by quota objectives bias.

"4. Recourse to the field for instant surveys leaves them short on time, us long on dependence--in our survey we check out at about 85% accuracy.

"Conclusions: Forecast based upon CS Data Bases and field surveys inherit a builtin error factor of ± 20%." (DX 873, p. 33.)

Inadequate Financial Controls. A study of the Computer Systems Division in the summer of 1971 reported:

"It has become apparent that CSD has not had adequate financial controls and analytical capability. Because of the complexity of the computer business in terms of revenue and cost forecasting, the interaction between generations of equipment, and the requirement for large, direct sales force, the control and analytical needs are greater in CSD than in most other businesses. These controls and analytical skills have clearly not been adequate in the division in the past. Moreover, despite some awareness of problems developing, Corporate Finance did not provide the required support or leadership to the division in up-grading the controls and basic capability. If some of these problems had been made clearer earlier, the business might have been conducted in a different manner." (PX 349, pp. 6-7.)

The lack of financial controls resulted in RCA's inventory being overvalued,* past due accounts receivables

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* The 1971 Study of the Computer Systems Division reported:

"It has recently become apparent that a significant portion of Computer Systems inventory may be overvalued. Although it is not possible to identify at this time the extent of the problem, major writedowns will be required on video data terminals, Spectra 45 Mod 1, disc drives and other computer equipment. Available reserves may not be adequate." (PX 349, pp. 6-7.)

with significant amounts being prematurely written off,* and questionable orders being booked.**

Product Deliveries. Because of product problems forecasts of RCA Series shipments were not met. For example:

> "In the June 2 presentation, the 1971 business plan assumed shipment of sixty RCA 6 series in 1971. As of mid-July, Computer Systems indicated that the best estimate of RCA 6 shipments for 1971 was fifteen. A similar decline has occurred in the case of the RCA 7.

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* The report from Arthur Young observed:

> "We believe that one of the most critical financial problems facing Computer Systems is with its accounts receivable. Of approximately $27 million of billed receivables, close to 50% ($13 million) are past due, and $3.3 million or 68% past due in Magnetic Products, Memory Products and Graphic Systems.
>
> "This situation has been caused by many factors. A primary cause has been improper communication and incomplete data flow between the field and Headquarters, and within the Headquarters. . . .
>
> "Since many of the past due receivables are disputed items, a significant portion of the receivables are being written off or reversed, rather than cash being collected. Credits to receivables have been averaging $3 million a month for the past twelve months ($37 million). Receivable reversals in May totalled $4.4 million, $2 million of which were netted directly against revenues. A limited two-week test of Task Force collection results on receivables past due over 90 days indicated that 40% were being reversed and only 60% collected in cash." (DX 955, p. 2; see also DX 11106, p. 1.)

** The 1971 Study of the Computer Systems Division reported:

> "A recently completed audit report indicates that one-third of the bookings represent questionable items. . . . This problem is compounded by the fact that a portion of sales commissions are paid at the time an order is booked and, therefore, salesmen may have been overpaid to the extent that the bookings are not firm. (PX 349, pp. 6-7.)

". . . .

"Despite assurances that time-sharing software problems had been solved last fall, software availability continues to be a severe problem. . . ." (PX 349, pp. 6-7.)

RCA Series Impact. The NTS series appeared to be likely to impact the RCA Series:

"Based on expected introduction dates for the NTS series, it appears possible that a six-year life for the RCA series will not be achieved. A shorter system life would result in significantly greater write-downs in 1971 and future years. This impact could be anticipated by increasing the obsolescence reserve or accelerating depreciation but either of these actions would cause additional losses in the shorter term." (PX 349, p. 7.)

Changes in Accounting Procedures. As noted above, premature returns of products placed under "accrued equity" contracts forced RCA to take debits against current revenue. (Wright, Tr. 13589-91.) A draft release of the Accounting Principles Board "put in question the accounting practices being applied within RCA to the Accrued Equity lease".* (Conrad, Tr. 14057-58.) The effect of a retroactive change in accounting practice would be large, involving a total effect of a $53.6 million reduction in revenue for 1971 and a $104 million reduction in 1972 with a "substantial negative effect on the P&L

* This was the same ruling which affected Telex and Memorex and which would have required RCA to treat such transactions as leases rather than sales, ceasing its practice of taking 70 percent of the revenues to be received over five years as revenues received in the initial year of the contract. (Wright, Tr. 13590.)

performance of Computer Systems in 1971 . . . and even greater negative effect in 1972". (DX 956, pp. 5-6; see Conrad, Tr. 14058-65, 14069-70.)

The Economy. RCA's computer business was hurt by the poor state of the economy in 1970 and 1971. "The economic situation for the computer business in 1970 was quite bad. . . . Shipments that year were down some 20 percent from the previous year." (Rooney, Tr. 12264.) The economic situation increased the number of returns of computer equipment that RCA experienced. (Rooney, Tr. 12682.) The Returns Task Force estimated that 12 percent of the returns of the Spectra in 1971 were due to the poor state of the economy. (DX 873, p. 24.)

Increased Competition. During the late 1960s and early 1970s increased competition hurt RCA's computer business. While RCA was putting out its old technology RCA Series, IBM was introducing a series based on new technology. As discussed above, prior to the announcement of that new IBM series RCA had attempted to predict the price/performance of IBM's anticipated new line in setting up its strategy. When the 370 systems were announced in mid 1970, RCA found that its predictions for the 370/155, 370/165 and 3330 disk drive were "accurate". Its predictions for the 370/135 and 370/145, however, were "off target". RCA had anticipated that the price of the 370/145 would be 5 to 10 percent higher than the

RCA 6 price; as announced, however, in September 1970 the 145 was priced approximately the same as the RCA 6. The 370/135 also came out with better price/performance than RCA had anticipated. The result of the inaccurate predictions were less sales for the Spectra 6 and 2 because those systems were not as price/performance competitive as RCA believed they would be. (Rooney, Tr. 11910-11, 11913-14, 11922-23, 12583-90, 12649-50; PX 349, pp. 6-7.)

Moreover, Rooney testified that all of the significant technological innovations in 1970 were achieved by the IBM Corporation. (Tr. 12048-60.) Those included the 3330 disk drive, which "brought to users significantly improved price/performance, capability of storing and retrieving data on disks at much faster speeds than [previously]" (Rooney, Tr. 12049); semiconductor memory, which "reduce[d] the cost to the user in terms of the amount of money he would have to pay for memory . . . [and gave] the ability to have potentially much higher speed" (Rooney, Tr. 12050-51, see Tr. 11923); microprogramming, which allowed the user to "improve the speed" with which he would process different applications and made it possible for computers to more readily perform the instruction sets of other computers (Rooney, Tr. 12056-57); and the 3211 high-speed printer. (Rooney, Tr. 12058-59.) Rooney agreed each of the "significant innovations" attributable to IBM gave IBM "a competitive advantage in marketing commercial data processing systems." (Tr. 12060.)

RCA's competition was not limited to IBM. Competition from other sources was also increasing. A "Computer Industry Survey" prepared by RCA in February 1970 listed 102 companies (other than IBM) offering "computers", "peripherals and components", and "software and services". (DX 11107, pp. 4-6.) RCA was experiencing increased competition from peripheral manufacturers. Wright, who was Chairman of the Peripheral Task Force in 1970, testified that the Task Force was "surprised" and "shocked" by the number of users using, or intending to acquire, non-RCA equipment as part of RCA systems. This indicated to him that users "had learned that it was possible for them to achieve certain benefits by procuring and mixing boxes from different manufacturers in the same system". (Wright, Tr. 13555-57; see also DX 852, pp. 14, 17, 19-20.) By July 1971 RCA's Data Processing Division monthly report listed among "significant problem areas":

> "Independent peripheral manufacturers, i.e., Potter, Singer, have been waging extensive sales campaigns at selected customer sites. For example, Singer/Frieden [sic] has proposed a plug to plug capability for replacement of the 70/564 Discs at California Dept. of Justice." (DX 11099, p. 4; see also Beard, Tr. 9021.)

RCA also experienced increased competition from third-party leasing companies and the same July monthly report said that "discounts being offered on 360 systems by third party leasing companies have [among other things] accounted for the slowdown on the demand for RCA Series systems".* (DX 11099, p. 5; see McCollister, Tr. 9290-92.)

d. RCA's Decision To Sell Its Computer Business To Sperry Rand. It was clear by the middle of 1971 that RCA's computer business had been hurt substantially by management errors, particularly by the introduction of the RCA Series. Yet it was not clear that RCA needed, or even wished, to sell its computer business. In 1971, according to Conrad, RCA's management had "a very strong commitment" to its computer business. Indeed, in July 1971, Conrad, speaking by videotape to a Computer Systems Division marketing management meeting, tried to dispel rumors that RCA would exit the business. He spoke "in substance" as follows:

> "As RCA's new President and Chief Operating Officer, let me assure you that the goals of your division, as enunciated so frequently in the past by Bob Sarnoff, are not changed. They remain faithful to his often expressed determination -- to achieve for RCA a profitable, long-range computer operation.
>
> "Every member of RCA's corporate management team stands behind that commitment. Contrary to rumors, RCA

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* McCollister testified that "the impetus for the conception and the development of the use of" the accrued equity contract, described above, "came about to some considerable measure because of the presence of leasing companies in the marketplace". (Tr. 9805.) Such contract began to be used extensively toward the end of 1969 to the early part of 1970. (McCollister, Tr. 11088, see also Tr. 9804.) By 1970 between 50% to 60% of the new contracts written were of this type. (McCollister, Tr. 9806-07.)

has no plans whatsoever to sell its computer operations. As we informed the New York Stock Exchange less than two weeks ago, these rumors are old hat. They've been circulated in the past. They were unfounded then. They are unfounded now.

"Neither rumors nor setbacks will undermine our commitment to computers. We faced them before--as we did in color television. We believe computers can do for our company in the Seventies what color did in the Sixties.

"On a personal note, I had an opportunity last week to express my personal commitment to RCA's computer business. I heard that rumors about RCA selling its computer business had caused the president of a mid-western railroad to revoke his order for an RCA computer. So I picked up the phone and called him directly. I told him exactly what I have just told you. And I've now been informed that the order has been reinstated." (PX 192, pp. 3-4; see Conrad, Tr. 13939-40.)

He added: "We are making a greater investment in the computer business than in any prior venture in our history. This is a measure of our confidence that RCA systems and products will effectively meet competitive challenges in the decade ahead." (PX 192, p. 2.)

By September, however, RCA's view of its participation in the computer industry had changed.* A group of executives consisting of Conrad, Sarnoff, Morsey and R. L.

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* In Conrad's "judgment" the internal discussions in RCA's management concerning staying or exiting from the computer systems business "really began in August of 1971". (Conrad, Tr. 13942.) On August 27, he and Sarnoff received reports concerning the status of RCA's computer business. (See PX 201; PX 349.)

Werner* (Conrad, Tr. 13942-44) met on September 16, 1971, for an hour and a half and decided to recommend to the RCA Board of Directors that RCA exit from the business. None of these four had ever had direct responsibility for the RCA computer division or had even worked in it. The Board of Directors adopted their recommendation on the following day.** (Conrad, Tr. 13942-43, 13948, 14145.)

The decision to sell the computer business came as a "surprise" to persons working in the Computer Systems Division. (Rooney, Tr. 12369; Wright, Tr. 13172, 13570-71.) RCA's management had not consulted with Wright, Donegan (Vice President and General Manager of the Division), Rooney or, to Rooney's knowledge, anyone else in the Computer Systems Division. (Rooney, Tr. 12368-71; Wright, Tr. 13572.)

The basis for the Board's decision to sell its business was that if anticipated losses of $137 to $187 million in the Computer Systems Division over the period

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* Werner was RCA's general counsel. (PX 341, p. 38.) He retired as general counsel during March 1978 and continued as a director until 1979, when he did not stand for reelection. (DX 13853, p. 41; DX 13902, p. 48.) Conrad left RCA in 1976 (DX 13852, p. 37), and Morsey left in 1973. (DX 678, p. 40.)

** At the directors' meeting the recommendation was embodied in a memorandum (PX 208, p. 8), which Morsey read to the Board of Directors. (Conrad, Tr. 14072.)

1971-1976 materialized, that would cause a need for a greater investment in computers than RCA chose to make. The amount of the investment required over the 1971-1976 period was estimated to be $702 million. (PX 208, pp. 4-5.) The amount was disputed, however, even within RCA, and some thought the figure was overstated by $100 to $200 million.*

Competing with the computer division for investment funds were the many other divisions in the RCA Corporation. The needs of those other divisions for investment funds also were greater than had been expected; a "preliminary evaluation" showed that "new funds required" during 1971-1976 "may exceed $1 billion" for the corporation as a

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* Julius Koppelman, the financial vice president of the Computer Systems Group, believed that the $702 million figure was in error by a very large amount. He, of course, had not been consulted before September 17. (Rooney, Tr. 12370-71.) Wright testified that:

> "Julius Koppelman . . . subsequently had occasion to look at those financial numbers that had been put together by the corporate staff and submitted to the board, and Mr. Koppelmann told me that there had been a serious error in those calculations on the order of a hundred million dollars, where it was overstated as far as the amount of cash that was required, and that this had been caused primarily as a result of the corporate financial people not understanding certain of the contractual terms and conditions that we had with customers on certain of the equipment that we had installed." (Tr. 13572-73.)

Similarly, Rooney testified that he was told by Donegan "that Mr. Koppelmann . . . told him that there was an error of some $200 million in those numbers . . . in overestimating the capital requirements of the business." (Tr. 12371-74.)

whole. (PX 208, p. 5.)

It was against that background that RCA made its decision. It considered whether to proceed with the magnitude of investments contemplated both in computers and other areas, and believed that "if earnings growth can be maintained at an annual rate of 10%-15%, the Company can raise needed funds". However, if RCA earnings were only to grow "at a rate similar to GNP (7%)" or if a recession were to occur "the resulting reduction in RCA's overall profit position could bring considerable pressure on obtaining the $1 billion outside financing required". There could be "severe financing problems". Major losses in computers would add to the difficulties. (PX 208, p. 6.)

Conrad testified that he believed that RCA could have raised the necessary capital to finance the projects that the Computer Systems Division had in mind at the time, could have reached its goal of achieving 10% of some defined market, and would at some point in time have been profitable. (Conrad, Tr. 14047-48, see also Tr. 13944-47.)

Similarly, Rooney--who as a member of the Computer Systems Division had not been consulted prior to the decision--testified that he believed that RCA could have been successful in displacing IBM products in the 1970s had it been allowed to continue in the business. (Tr. 12094.)

Withington, who had advised RCA's Computer Systems

Division a year earlier, believed that RCA could have been successful in the computer business had it chosen a different, less adventurous, strategy and remained profitable while growing more slowly. (Withington, Tr. 56711, 56720-21.)

RCA considered what actions could be taken to mitigate the risk that it would need a large amount of financing if it stayed on its present strategy in computers. One alternative mentioned was to

> "reduce investments in other new businesses such as the Supermarket project, the French Color Tube venture, SelectaVision, etc., thereby substantially reducing outside financing requirements. Even in this case, if profits were to grow at 7%, or if a recession were to occur, it is likely that the major financing which would still be required for CSD could only be obtained at higher interest rates and more restrictive terms. In addition, RCA would in this case be relying even more directly on the ultimate success of CSD by passing up other, perhaps more attractive opportunities." (PX 208, p. 6.)

Another alternative would be to keep the computer business but "to substantially reduce the size and scope of the computer operation" by limiting it to certain narrow market areas. However, it was believed that this would reduce revenue as well as expenses and "while cash requirements would be reduced substantially, it is questionable whether the business would ever attain economic viability". (Id., p. 6.*) As a result, "the additional investment required in

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* Other alternatives mentioned were to cut dividends and sell surplus real estate and "marginal business". (PX 208, p. 6.)

CSD no longer appears to be a prudent financial risk". (Id., p. 7.)

A major concern was that if there were a downturn in the economy in the mid-1970s, "the many healthy and vital parts of the rest of RCA could be hindered" because of the "high level of outside financing" required for computers "as well as the other parts of RCA". "While the computer industry is an attractive and growing business--although at a slightly lower level than originally anticipated--the profits to be gained by RCA from this business, in relation to the total investment required, do not appear to be consistent with sound financial planning". (Id.)

In addition, the memorandum said that given RCA's position in the computer business "[t]he manpower and financial resources of IBM, including the size and strength of the marketing, research and development organizations, are such that achieving market share growth as well as acceptable profitability, is extremely difficult". (PX 208, p. 7.) Thus:

> "In summary, the computer business currently accounts for about 6 percent of RCA's total revenues. While it could represent a growing segment of the Company's operations, it is unlikely to ever exceed perhaps 10-15 percent of total RCA volume. Continued commitment to computers, however, could lead to severe financing problems for the Company and may contribute to restricted growth in other operations. On balance, it is believed that the risk does not justify the potential reward. Therefore, withdrawal from the mainframe computer and peripheral equipment business is recommended." (PX 208, p. 8.)

Similarly, Conrad testified that RCA left the computer business because:

> "[W]e believed that we could apply the resources employed in the computer business better in other opportunities within RCA, which would lead to profit at an earlier time with greater assurances." (Conrad, Tr. 13933-34; see also PX 217, pp. 2-5; Conrad, Tr. 13989-94.)*

All the participants and observers of RCA's decision to sell its computer division agreed that RCA's decision was voluntary, and "nothing IBM did or any other company forced us or caused us to exit the business per se". (Conrad, Tr. 14046; see also PX 217, p. 5; Rooney, Tr. 12387; Wright, Tr. 13630-31.)

After September 17, 1971, RCA negotiated with Sperry Rand and with Mohawk Data Sciences concerning the sale of its computer business, as well as having meetings with several other companies, including Burroughs, Xerox and Memorex. It sold the division to Sperry Rand.** (Conrad, Tr. 13953-54, 13968-70; PX 402.) In its presentations to

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* Among the projects in which RCA believed it could invest its money with more opportunity for profit than the computer business, the principal ones were Alaska Communications, the Global Communications Company, SelectaVision, and VideoDisc. (Conrad, Tr. 14046-48.) By 1978 RCA had sold Alaska Communications. (DX 13854, p. 15.)

** During the period subsequent to 1966 RCA also withdrew from many businesses in addition to the business of its Computer Systems Division. Those businesses include: the manufacturing and marketing of radios, phonographs and stereo equipment; the manufacturing of radio tubes; a color picture tube prospective purchasers, RCA estimated that the "After Tax Cash Contribution" of its lease base for the period 1972 through 1974 would be $193 million assuming no residual value. (PX 405A, p. 8.) It sold its computer division to Sperry for approximately $137 million. (Conrad, Tr. 14130.)

RCA reported that it lost approximately $241 million before taxes on its computer systems operations for the years 1958-1971*. (PX 410.)

In September 1971 RCA set up a reserve of $490 million pretax, $250 million after tax, to cover prospective losses in connection with the sale of its computer division. The losses that were anticipated related to disposition of assets "such as inventory, receivables, plant", "discharge of claims and obligations for commitments to employees for

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joint venture with Thorn Electrical Industries; Meyer Bros. Parking Services; United Exposition Services (a subsidiary of Hertz that engaged in services related to exhibitions); Cushman & Wakefield; the design, manufacture and sale of microwave communications transmitters, receivers and multiplex equipment in the United States; electron microscopes; Service America, which offered to service televisions of all manufacturers; RCA Alascom; and Random House. By 1980 Banquet Foods was also up for sale. (Conrad, Tr. 14022-27; DX 13854, p. 15; DX 13860, p. 8; DX 13902, pp. 2, 36-37.)

* RCA's losses in the late sixties had "to do with the investment that we felt we had to make and the engineering and programming for future profitability in order to grow in the business", as well as to RCA's accounting for leases. "[P]rofitability was governed primarily by the rate at which RCA determined that it would like to grow", about 20% a year, "somewhat faster than the general growth of the market". (Beard, Tr. 8535-38.)

severance and release", and other purposes. In December 1973 a review indicated that the disposition was going better than expected and the reserve was reduced by $78 million, leaving a pretax reserve of $412 million. (Smith, Tr. 14247-48.)

e. <u>After the Sale to Sperry Rand.</u> The story of RCA's participation in the computer industry after the 1971 sale to Sperry Rand has two parts: RCA's activities and Sperry Rand's success with the computer division it purchased from RCA.

(i) <u>RCA's Activities.</u> As it had planned, RCA invested heavily in other businesses in the 1970s. Conrad testified that from 1972 through the end of 1976, RCA invested approximately $130 million in satellite communications (Tr. 14009-10), more than $250 million in the same period in Global Communications (Tr. 14011-12), approximately $200 million annually in the purchase of automobiles for Hertz (Tr. 14102-06), and $150 million in Alaska Communications. (Tr. 14008-09.)

RCA also continued in or entered computer-related businesses. Conrad testified that:

> "In our Solid State Division, we manufacture, design, engineer and manufacture integrated circuit devices called microprocessor chips, which can be and are used in data processing applications, as well as communications applications.
>
> "We also continue to offer and perform service on a variety of data processing or reservation system terminals, which are owned by others.
>
> "We continue to from time to time design, develop

and manufacture special processors which are sold to the government in conjunction with tracking devices, such as radar." (Tr. 14048-49, see also Tr. 14157-58.)

(ii) Sperry Rand's Success with RCA's Computer Systems Division. Sperry believed that its acquisition of RCA's Computer Systems Division was "a sound business" and a "wise" decision. (McDonald, Tr. 3873-74; DX 63, p. 1; DX 71, p. 9.) In its 1973 Annual Report Sperry reported:

> "More than 90% of these RCA customers remained with us, and more than $130 million in new equipment was shipped to these users during calendar year 1972. We are continuing to build 'bridges' between the RCA systems and Sperry Univac's line, and we are confident that many of these customers will eventually convert to Sperry Univac's systems." (DX 63, p. 1.)

In December 1974, 77% of the original RCA customers acquired by Univac were still using their RCA equipment and 5% of the original customers had moved to Univac systems, and the RCA equipment had yielded a "revenue stream (sales, rentals and maintenance) for 3 years of approximately $370 million". Univac believed that "these benefits will certainly not end at this point". (DX 68, pp. 11-12.) By May 1975, approximately 76% of the RCA equipment acquired by Univac was still on rent. (McDonald, Tr. 4045-46.)

f. Conclusion. Like General Electric, RCA was a large company with a small computer business. In the last full year before its sale to Sperry Rand, RCA's U.S. EDP revenue was $226 million. (DX 8224, p. 2.) RCA's venture into computers was a failure; but it need not have been. As we have seen, despite RCA's great technological capability in the 1950s, RCA only placed nine computers in that decade. RCA's inactivity in the 1950s and early 1960s cost them dearly. But RCA still could have succeeded. The Spectra, patterned after IBM's 360 was a mixed success. Reliability problems and inadequate peripherals limited the acceptance of the systems. But even then had RCA understood the need to push ahead with technological development, to commit its ample resources to new, more advanced follow-on systems, it could have succeeded.

Instead, it introduced the RCA Series--yesterday's technology at lower prices--and it chose that vehicle to spearhead its drive to "gain market share" and "become number 2 in the industry". But the RCA Series could not compete with the more advanced products of IBM and others and was a "major product failure", blowing the Spectra series "out of the water".

At the same time, the management of RCA changed hands and the company sought to transform itself into a conglomerate. The result of its conglomeration was that all the various corporate mouths needed feeding at once and as the company entered the recession of the early 1970s, it found itself stretched too thin to pay adequate attention or commit sufficient resources to save the computer business from the RCA Series debacle.

In sum, the story of RCA, like the story of General Electric, is the story of missed opportunity, bad management and product failures.

43. Honeywell. The history of Honeywell during the period 1964-1970 was built on the success of the Honeywell 200--a product which gave birth to a compatible family of computer systems and in turn sparked expansion of Honeywell's peripheral line and service capabilities. Despite some difficulties along the way, Honeywell ended the sixties with a large and successful array of electronic data processing products and services with rising revenues and profits derived from them.

a. The 200 Series. In December 1963 Honeywell had announced its 200 computer system, along with an "automatic program conversion package, called 'Liberator'". (DX 198, pp. 25-26.) Richard Bloch, who led the Honeywell team that designed the 200 (Tr. 7886), testified to the strategy behind it:*

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* Richard Bloch, who was Vice President for Product Planning at Honeywell for most of the period he was there, 1955 through 1967, testified about Honeywell. His duties as Vice President were to develop product, pricing and marketing strategies for the products of the EDP Division. (Tr. 7575-76.)

James H. Binger and Clarence W. Spangle were the other witnesses who testified about Honeywell. James H. Binger was Chairman of the Executive Committee of Honeywell, Inc., when called to testify. (Tr. 4489.) An employee of Honeywell since 1943, he became chief executive officer of Honeywell in 1964 and held that post for the following decade; starting in 1965 he was also Chairman of the Board of Directors. (Tr. 4489-90.)

Clarence W. Spangle was President of Honeywell Information Systems and Executive Vice President of Honeywell, Inc. in 1975. (Tr. 4882.) Spangle, too, had been with Honeywell since the 1940s. (Id.) From 1965 through 1969, Mr. Spangle was Vice President and General Manager of Honeywell's Electronic Data Processing Division, responsible for marketing, manufacturing and development of data processing systems. (Tr. 4887-89.)

> "[T]he 200 was conceived to represent a next step for 1400 Series users in the IBM line, and we really designed that machine from the outset to be attractive to that user community.
>
> "One of the attractive features had to be a means of getting the user to bring his programs on to the new machine, and that required conversion facilities and conversion offerings, which we intended and indeed did develop." (Tr. 7578.)

Honeywell felt this strategy would give it an "accelerated move into the [general purpose business data processing] field, which we needed." (R. Bloch, Tr. 7585-86.) In 1963 Honeywell's EDP revenues were only 4% of its total revenues, and it had yet to make a profit in that area. (DX 132, p. 11; DX 198, pp. 4-5; DX 8224, p. 387; DX 14484, p. R1; DX 8631, pp. 31, 37.)

The 200 was designed to make conversion from the IBM 1400 series as easy as possible. (Binger, Tr. 4823; R. Bloch, Tr. 7886.) An effort was made to replicate closely the file structure, media and formatting of the 1400 (R. Bloch, Tr. 7605-06; Spangle, Tr. 5025) and the LIBERATOR conversion aid was developed. (R. Bloch, Tr. 7606.) The LIBERATOR enabled 1401 programs to be converted to 200 series programs by means of assembly language and object code translators. (Id.; Goetz, Tr. 17652-53.) Because the conversion required only a very small amount of manual intervention, it resulted in a high degree of efficiency. (Spangle, Tr. 5021-22; Goetz, Tr. 17652; see also R. Bloch, Tr. 7888-89.)

The LIBERATOR successfully accomplished the conversion for which it was designed. (Binger, Tr. 4823; R. Bloch, Tr. 7888-89; see also Goetz, Tr. 18780-81.) Thus, the 200 offered users both an easy conversion method* and price/performance superior to its competitors, including the 1401. (McCollister, Tr. 11237, 11365-66; Evans, Tr. 101187-88; PX 6204, p. 4; DX 167.) Both of these characteristics led the Honeywell 200 to enormous success. (R. Bloch, Tr. 7602-03, 7888; McCollister, Tr. 11235-36; Withington, Tr. 55863-67; J. Jones, Tr. 78989-95.) Withington wrote in October 1964 that Honeywell had obtained many hundreds of orders for the 200, and that no computer manufacturer was gaining ground as fast as Honeywell. (PX 4829, pp. 20-21.) IBM reports called the 200 an "outstanding success", allowing Honeywell to expand its marketing and other personnel and to turn a profit for its EDP Division. (PX 3481, p. 69.) McCollister testified that Honeywell expanded its sales force during the early sixties so that by 1965 Honeywell had 50 to 75 percent more people than did RCA, although the two companies had started the sixties equal. (Tr. 10962-63.) Sales were made to all kinds of customers; Gordon Brown testified that as a Honeywell marketing representative he sold 200s to an insurance company, an aircraft company and a service bureau; Honeywell reported sales to the Internal Revenue Service and to U.S. Air Force Major Air Commands. (G. Brown, Tr. 50985; DX 13349, p. 27.)

Within IBM, the Honeywell 200 announcement provoked heated discussion on how soon IBM was going to come up with a better performing product with which to respond. Immediately following the

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* The 200 was also compatible with "most widely used small computers". (DX 167; DX 198, p. 26.)

announcement, T. V. Learson, IBM's Senior Vice President, wrote to T. J. Watson, Jr., its Chairman, and A. L. Williams, its President, that the Honeywell announcement was "even more difficult than we anticipated". (PX 1079.) Shortly thereafter, M. T. Hague, IBM Director of Market Programs, wrote to Dr. J. W. Gibson, IBM Vice-President and Group Executive, that the 200 "represents the most severe threat to IBM in our history". (PX 3912.) Evans testified that the marketing force and others dealing with the 200 regarded it as a real challenge to IBM (Tr. 101186), and both he and Knaplund testified that the marketing organization put a lot of pressure on the development organization to announce the 360/30 as soon as possible in reaction to the 200. (Knaplund, Tr. 90475; Evans, Tr. 101190.) On January 28, W. C. Hume, President of the Data Processing Division, wrote to Dr. Gibson:

> "We must have an answer to this system immediately . . . . The best solution to this problem . . . is a 101-H [360/30] machine with a competitive price to the H-200 and a performance equal to or greater than the H-200, ready for announcement by mid-February." (PX 1090; see pp. 353-57 above.)

Of course, by April 1964 IBM was able to respond to the H-200 with the 360/30--which was two or three times more powerful than IBM's 1401 at less than one and a half times the price. (Hughes, Tr. 33924; JX 38, p. 33; DX 573, p. 6; see pp. 280-31 above.) Despite the announcement, Honeywell continued its successful course. In December 1964 T. V. Learson wrote to T. J. Watson, Jr. that "the

Honeywell 200 story" had led to 300 losses to date for tape-oriented systems, with 1,000 such situations in the doubtful category, 40% of which he estimated as losses. (PX 1288, p. 2.)

Honeywell spent the remainder of the decade enlarging on and solidifying the 200's success. In a 1969 speech, Binger outlined his strategy:

> "In the beginning we made a conscious decision and adopted a strategy to compete in a broad segment of the computer marketplace, and to make significant penetration through a wide array of products and services. Our highly successful Series 200 computer line is the prime example of this strategy." (DX 132, p. 12.)

In June 1964, after IBM's announcement of System/360, Honeywell announced the 2200 and followed it in February 1965 with three other compatible new members of the Series 200, giving it a "family of computer systems": the 120, the 1200, the 2200 and the 4200. Honeywell stated that "[t]he family concept of these new systems gives our customers the assurance that they can meet problems of growth by expanding through an extended range of central processors, continuing to use the peripheral equipment already in their EDP system."* (DX 13849, p. 27.) The 200 series was also, through hardware design and programming adaptations, "accessible to [Honeywell's] 400 and 800 [users] who can shift to the higher levels of the newer series with a minimum of adjustment, and with the protection of a substantial part of their prior

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* The compatibility of the 200 family meant each model was also compatible with the IBM 1401. (Withington, Tr. 56375-76.)

programming and file investment." (DX 199, p. 32.)

Spangle testified that the 200 line was priced so that the three-year lease prices would be "roughly equal to those of IBM for equivalent price/performance on a system basis", with the one-year price "slightly above that of IBM" and the five-year price "5 to 10 percent below the one-year price of IBM". The consideration of what the price should be was based on the price for the system, although the individual elements of the system were priced individually. (Spangle, Tr. 5056.)

According to Richard Bloch, Honeywell gauged its pricing "against the nearest competitive IBM line or the IBM equipment which we were hoping to supersede, to a lesser extent some of the other competition" because "if we were to increase our penetration of the market we would obviously have to take away some of the captive business that was presently in IBM's hands". (Tr. 7596-97.) Honeywell priced its product so that it demonstrated performance advantage over IBM "that might be measurable in tens of percent" with a price equal to or less than the IBM price. Where, on the other hand, Honeywell felt that it did not have any substantial performance advantage, it considered that it would certainly have to have a significant price advantage. This meant 90% or less than the IBM price. However, there was no "automatic rule of thumb". (R. Bloch, Tr. 7599-601.)

As IBM improved the capabilities of its 360 line (see pp. above), so did Honeywell with further improvement of the capabilities of the 200 family through peripheral and software announcements. A number of new products, both hardware and software, were announced for the Series 200 line at the end of 1966, covering mass storage, data communications and expanded multiprogramming, including four magnetic disk devices for "random access information storage and retrieval"* and a number of terminal devices. (DX 199, p. 31.)

The tempo of announcements accelerated as the decade went on. In its 1967 Annual Report, Honeywell stated:

> "Product lines of the Electronic Data Processing and Computer Control Divisions[**] are being broadened continuously to assure competitiveness. In 1967, for example, more than a hundred hardware and software products and product modifications were added to the Series 200 EDP line and the control computer line." (DX 200, p. 31.)

Binger and Bloch testified that Honeywell's competitors in the 1960s were IBM, Sperry Rand, RCA, Burroughs, GE, CDC, NCR and DEC. (Binger, Tr. 4527, 4593-94; R. Bloch, Tr. 7592-94; see also Spangle, Tr. 4933-34.) SDS was a competitor "to a limited extent". (Binger, Tr. 4515.) Honeywell also faced efforts by Fujitsu, Philips and Nixdorf to sell their computer equipment in the United States. (Binger, Tr. 4516-17.)≁

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* These were acquired OEM from CDC. (See below, p. 628.)

** See below, p. 633.

≁ Other foreign competition was encountered, too; for example, Honeywel] bid against Siemens, among others, in 1968, for an accounting and payroll system for the U.S. Army. (DX 7556.)

Honeywell's 200 series was sufficiently popular to be marketed by leasing companies. Thus, Leasco dealt in Honeywell equipment before 1967 (Spain, Tr. 88749) and Finalco was leasing Honeywell 200s and 1200s, a fact which made Patton, a Honeywell Regional Sales Manager, "a little nervous over what could happen if those systems come off lease". (Spangle, Tr. 5191-92; DX 161A.) Transamerica also leased Honeywell equipment in the late 1960s. (Spangle, Tr. 5190.)

b. Problems and Solutions.

(i) Other Systems. Honeywell was not without problems over this period, though. One of these was the 8200 computer system, which was planned to be the most powerful computer system in the 200 series. (DX 13849, p. 27.) The Honeywell 8200 was announced in 1965. (Id.) It was intended to bring together the Honeywell 200 line and the Honeywell 800 line, the latter of which was installed at that time at about a hundred different sites. (Spangle, Tr. 4997.)

"At the time of the announcement the development of the machine had not begun. And as the development was undertaken, it turned out to be much more difficult to do those things than had been anticipated," and Honeywell spent large amounts of money, more than it had planned, to develop the equipment and to develop the software to supply with the equipment. (Id.)

Honeywell was not able to achieve the objective of having that system be an upgrade path for the 200 line so, according to Spangle, "its market became limited really to those 800 customers who wanted to continue largely in the batch processing mode and wanted higher throughput". (Spangle, Tr. 4997-98.)

As a result of all this, Honeywell was able to ship only about 40 of these machines which Spangle testified was not enough to make the whole investment and development worthwhile. The particular problem that caused the 8200 to fall short of its objective was the need for two operating systems in one computer system--Honeywell could not get it to work. (Spangle, Tr. 4998.)

Honeywell tried to aid its customers with 800 systems installed in another way--by the provision of a larger system which was compatible only with the 800. Thus, it announced the 1800 in 1962. (See p. 189 above.) However, according to Withington, the 1800, designed to accommodate the growth needs of the 800 users, "sold in only very small amounts". He attributed this to the fact that the IBM 360 and GE 600 series, available at the same time, "were regarded as superior to the Honeywell 1800 by users and Honeywell users who outgrew their Honeywell 800 apparently more frequently left Honeywell for a competitor than accepted the 1800 instead". The 360 and GE 600 systems were felt to be superior to the Honeywell 1800 "because they offered early versions of operating systems whose primary initial virtue was to permit multiple programming . . . plus automatic control of peripheral equipment in ways which would simplify the users' programming requirements". (Tr. 56491-93.)

(ii) Peripherals. In the early sixties, Honeywell still believed that magnetic card devices would be competitively superior to magnetic disk drives. It had under development magnetic card devices which had been announced to customers. However, the slow speed and unreliability of the card devices caused difficulties and hurt Honeywell in its marketing of systems. (Withington, Tr. 56494-95.) Finally, the effort was dropped, termed in IBM reports "a dismal failure". (PX 3481, pp. 75-76.)

Honeywell made its decision to abandon the magnetic card mass storage devices following IBM's announcement of the 2311 disk drive for the System/360. Withington testified that this was "a major change for Honeywell, because at the time there was no expenditure whatever for disk drive development, all of the mass storage development efforts being put into the magnetic card devices, so Honeywell had to start a new effort from scratch and also search the industry for OEM sources for suitable disk drives". (Withington, Tr. 58562-63.) By 1967 CDC was shipping its 9492 disk file to Honeywell, who then became its principal customer for CDC 9433 and 9434 disk drives, taking in excess of 4,700 units. (G. Brown, Tr. 51033-34, 51056-57.) Honeywell began to manufacture its own disk packs in 1967, but continued to purchase the drives. (G. Brown, Tr. 51056-57; DX 200, p. 31.)

Honeywell had already begun efforts to produce itself all of the peripheral devices contained in its EDP systems in the mid-sixties. (DX 13849, p. 28.) During 1965 it started deliveries of its own card reader, and was about to start shipment of its own card punches. (DX 13849, p. 28.) Prior to 1965 Honeywell purchased IBM card readers and card punches and offered them with its own computer systems, including the 200. It planned, however, in that time period, to develop its own manufacturing capability in punch card equipment, a decision which was accelerated by the announcement in late 1964 that IBM would no longer lease such equipment to Honeywell and other manufacturers planning to re-lease them to customers but would only sell. (Binger, Tr. 4512-13, 4549-50; Spangle, Tr. 5102-07.)

During 1965 Honeywell introduced new models of printers and tape transports and started deliveries of a variety of communications terminals as well. (DX 13849, p. 28.) However, it continued to acquire software or software development from outside companies. (Spangle, Tr. 5092-94.) Contrary to IBM's full-scale entry into the manufacture of its own components in 1961 (see pp. 282-90 above), Honeywell divested itself of its component operations in 1965, stating it "felt that we should concentrate our attention on electronic end products rather than components of this type. We intend to rely on the numerous well qualified suppliers of semiconductor devices for our substantial requirements." (DX 13849, p. 6.)*

* Honeywell reentered the development and manufacture of componentry in 1969 with the announcement of a new integrated circuit development center. (DX 123, p. 41.)

c. Marketing Practices. Starting in 1965 Honeywell offered three- and five-year lease plans for systems and peripherals. (Spangle, Tr. 4953; Brown, Tr. 52613; Withington, Tr. 56624.) Under Honeywell's five-year lease plan, the customer could change his configuration within certain limits without penalty. (Spangle, Tr. 5529-30.) According to Honeywell's 1965 Annual Report, "the extended lease terms for our new generation equipment have been well received by our customers with the result that a substantial percentage of the present leases are being lengthened to five years. Use of extended lease terms by both present and future customers permits computer users to benefit from the new level of technological stability which now exists". (DX 13849 , p. 5.) In 1967 nearly 70 percent of "commercial" Series 200 contracts signed were for five-year periods. (DX 200, p. 32.)

Bloch testified that during his tenure at Honeywell, (1955-1967), 80 to 90 percent of Honeywell's computer systems were leased. This was dictated "pretty much" by the customer. (Tr. 7673, 7675-76.) Honeywell developed a sale and leaseback method of financing these leases in 1966. Honeywell would arrange with some lending organizations--"usually these were syndicates put together by someone; like say, the First National City Bank did one group"--whereby it would sell them an amount of installed equipment and then lease it back from them. They would give Honeywell the cash for the equipment and then it would pay them in installments until it had paid back the amount of the cash advance plus a financing charge. (Spangle, Tr. 5076-77.) According to Spangle, this "improved our profit and loss statement" and produced "more cash with which to operate". (Id.)

The sale and leaseback method continued until 1967, when a wholly-owned subsidiary called Honeywell Finance was set up. That subsidiary "was able to accomplish much of the benefits of the sales and leaseback transaction in so far as creating or attracting cash and capital . . . although it did not have the effect of accelerating the profit from the lease part of it as the sale and leaseback transaction did". It did, however, preserve the residual value of the equipment for Honeywell. (Spangle, Tr. 5082.) Honeywell Finance borrowed money from banks and investors through commercial paper issuance and through the issuance of long term and medium term bonds, on the security of the receivables from Honeywell's rental contracts. The loan proceeds were passed through to Honeywell. (Spangle, Tr. 5082-84.) Honeywell's initial investment in this subsidiary was $15,000,000, half in a subordinated loan and half in common stock. A $60,000,000 line of bank credit was established of which $23,350,000 was being utilized at year end 1967. (DX 200, p. 9.)

During the middle and late 1960s, Honeywell supplied educational courses for customers, programming support, operating systems and application software without separate charge. (Spangle, Tr. 5084-86.) Bloch testified that this was due to "the dictates of the marketplace . . . the traditional way in which these services and equipments were being offered from the time that the field had begun". (Tr. 7604.) When IBM announced its unbundling decision in 1969, Honeywell conducted a study to decide what action to take. The study recommended that Honeywell not follow IBM. Spangle testified that there were several reasons for this:

(1) Honeywell was not set up administratively to handle the charge for all these separate items and to enforce their collection throughout the field;

(2) it was not certain of the "contractual arrangement" it had with its customers, and was concerned that some customers would feel that it had contracted to furnish the items which might otherwise be unbundled;

(3) it also "hoped to gain some temporary market advantage . . . because we thought there would be quite a bit of resistance to this change by the customers and prospects, and that because of that we might be able to get some customers that we otherwise would not have been able to get". (Spangle, Tr. 5086-89.)

Instead of unbundling, Honeywell increased its prices slightly, since it believed that IBM's change would be regarded as a price increase. (Spangle, Tr. 5089.) Honeywell then began to advertise its "package pricing" as its "same old bundle of joy . . . once in a while you move ahead just by standing still". (DX 13713.)

d. Product and Service Acquisitions and Expansion. Prior to 1966 Honeywell had developed a series of small, high-speed general purpose digital computers to enhance its capability to provide control systems integrated with instrumentation of its own manufacture, a related business which Honeywell had been involved in for many years. (DX 13849, p. 20.) In 1966 Honeywell acquired the Computer Control Company, which at that time was a leading manufacturer of such small, high-performance hardware,* and established it as Honeywell's Computer Control Division. (DX 199, p. 3.) The Computer Control Company products included the DDP-116, DDP-416 and DDP-516 computer systems and line of memories. (DX 199, p. 32.) The computer systems were used by customers at the time in communications switching, engineering and scientific applications. They were also offered to OEMs, who built systems for typesetting, plotting and freight yard distribution applications. (Id.)

Honeywell applied the "advanced digital techniques" gathered from the acquisition of Computer Control to its own products in the industrial process control area (see, e.g., DX 200, p. 24) as well as to other areas of data processing. For example, the DDP-516 was offered for time sharing, communications and medical applications. (DX 7561, pp. 5, 9, 10.) The 516 was made available for use aboard ships, aircraft and vans. The modified DDP-516s had all the capabilities of the standard commercial version--software, price, delivery,

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* See, e.g., DX 4917, a 1965 letter from John P. Abbadessa, Controller of the U.S. Atomic Energy Commission, to a number of computer manufacturers requesting that the AEC's Oak Ridge National Laboratory be accorded the benefits of the manufacturers' educational allowance policy. The recipients were CDC, GE, RCA, Honeywell, IBM, Burrougns, Sperry Rand, SDS, Philco, Bunker Ramo and Computer Control Company.

flexibility and proven design--while meeting the operational requirements of military, marine and other users. (DX 7727.) Ruggedized DDP-516s were used by the Coast Guard to gather data for weather forecasting. (DX 7561, p. 10; DX 9087.)* American Airlines used 516s to control IBM 1977 terminals within its passenger services system. (O'Neill, Tr. 76000.) The 116 was sold to Bunker Ramo for the "control and filing of up-to-the-minute freight booking information" on airline passenger planes. (DX 5789.) The 116 was also used as part of a railroad car classification system by Westinghouse Air Brake Company and in process control applications by the Brown and Williamson Tobacco Corp. (Id., p. 7.)

In 1969 Honeywell introduced its first expansion of the old DDP line: the Honeywell 316. Honeywell called the 316 a "minicomputer"** and a "general purpose digital computer". (DX 123, pp. 1-2.) The 316 had a full line of peripherals and was offered for real-time control, data acquisition and communications applications, and as a front end for commercial computers made by others. (DX 7583.)

Honeywell later incorporated these smaller computers into larger computer systems offered by it and offered them for business

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* The Honeywell press release stated that "using a general purpose machine rather than specially designed systems formerly employed will let the Coast Guard apply computers to many of its activities at sea". (DX 9087.) We recognize that this press release is not in evidence, but we rely on it both because it represents a contemporaneous statement by Honeywell describing its products and because the facts involved are independently corroborated by DX 7561.

** Spangle testified that a "minicomputer" is a "small general purpose computer, and small is a relative term, smaller than other computers." (Tr. 4916.)

data processing. It also sold these same smaller computers to its Control Systems Division for incorporation into systems which they in turn resold, and to outside buyers for use in specialized systems. (Binger, Tr. 4540-42, 4689-91; Spangle, Tr. 4916-18, 4930.)

Early in 1968 Honeywell combined its EDP Division and Computer Control Division into the Computer and Communications Group, to "bring into one organization those related activities that are essential to the computer and computer-oriented business". The new group was given the mission to involve Honeywell in the "total information systems market". (DX 201, p. 31.)*

In the late sixties Honeywell expanded its EDP services offerings too. It organized an Information Services Division, offering "a broad range of integrated remote access computing services and contract software, as well as general data processing and continued improved services for Honeywell EDP customers". Sixteen data centers were opened around the country. (DX 123, p. 33.) The centers used a Honeywell 1648 for time sharing. This system was comprised of several Series 16 computers and was introduced by the Computer Control Division. (Id.) According to Binger, the 1648 competed with the IBM 360/25 and 360/30, the DEC PDP 10 and TSS/8 (based on the PDP 8), and the Hewlett-Packard 2000 A and B. (Binger, Tr. 4593-94.)

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* This Group was Honeywell's contribution to Honeywell Information Systems, the newly formed subsidiary of Honeywell which was merged with part of General Electric's computer operations. (Binger, Tr. 4531.)

In sum, Honeywell's EDP operations grew steadily throughout the 1960s. Honeywell entered the EDP business overseas in 1964 (DX 132, p. 11) and its international EDP operations more than doubled in 1965. Manufacturing of the 200 series in Scotland also began in 1965. (DX 13849, pp. 28-29.) Its Series 16 was manufactured in the Scottish plant and in Japan by its licensee the Nippon Electric Company. (DX 201, p. 36.) Honeywell had been rapidly building its international computer sales force (DX 132, p. 13); by 1965 marketing and service organizations existed in Australia, Canada and Western Europe (DX 201, p. 36) and by 1969 Honeywell people served 95 percent of the "world's computer market". (DX 132, p. 13.)

By the end of 1969 Honeywell reported that its Computer and Communications Group continued to be the fastest growing area of its business; in fact, its computer and communications business was growing faster than the industry, and its rate of profitability increase was exceeding its growth rate. (DX 123, pp. 7, 28.) Revenues for the first nine months of 1969 increased 33.5 percent over the comparable period in 1968. (DX 132, p. 11.) Binger stated in a speech given in 1969 that domestic computer operations had been profitable for four years and overseas operations for two (id; see also DX 123, p. 7); indeed, the computer business was "solidly profitable". Binger thought that the only possible factor limiting Honeywell's growth was the shortage of qualified people:

> ". . . we are not technology limited, we are not capital limited, we are not basically market limited. We may at some point be people limited to some extent." (DX 132, p. 17; see Binger, Tr. 4818-20.)

In 1969 the Computer and Communications Group employed 24,000 people worldwide, compared with 18,000 a year before. Over one-half of Honeywell's research, development and engineering dollars were spent in the computing area. (DX 123, p. 33.) Between 1963 and 1969 Honeywell's domestic EDP revenues had increased from $27 million to $210.8 million, a more than sevenfold increase in seven years. (DX 8224, p. 387; DX 14484, p. 1; DX 8631, pp. 31, 37.)

44. Burroughs. The story of Burroughs in the period 1964 to 1970 is one of a company that turned itself around, going from predictions of failure to success. A slow starter in computers, by 1964 Burroughs had still not transformed itself into much of a computer company, having developed and marketed relatively few EDP products. (See above, pp. 227-28 .) Beginning in 1964 Burroughs shook up its operations, reduced expenses and, while remaining profitable, increased its investments in research and development. The results were a proliferation of new products, substantial growth and increased profitability over the decade.

a. Burroughs in 1964: Problems and Changes. Burroughs' situation in 1964 did not look promising for future growth in the computer industry. Indeed, as R. W. Macdonald* wrote in 1975:

> "[I]n 1964, some analysts who observed the developing computer industry, had serious doubts about the ability of Burroughs to survive in the new environment as a computer company. Even some members of our own Board of Directors were concerned, and a highly respected financial journal predicted flatly that Burroughs either would have to merge into another company or fail." (DX 427, p. 2.)

Those serious doubts were based on two factors: Burroughs' mediocre record in computers and the perceived strength of its competition.

Burroughs' record in computers as of 1964 was not strong.

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* R. W. Macdonald, a director of Burroughs since 1959, in 1964 became Executive Vice President, in 1966 became President and Chief Operating Officer and in 1967 became President and Chief Executive Officer. (Tr. 6882-83.) Macdonald testified at trial by deposition.

It had begun, but had not completed, the "major transformation" from mechanical office equipment to electronic computer technology. (DX 427, pp. 3-4; see above, pp. 227-28.) Its computer product line was limited, consisting mainly of the B 200, B 5000 and D 825 computers. (See above, p. 227.) Its financial record since 1961 had been poor; its revenues had "remained on a plateau" and its earnings were "unsatisfactory". (DX 427, p. 3.)

The doubts about Burroughs' future were also based on the "size, profitability and technical achievements" of the "many companies [who] had aspirations to be mainframe manufacturers". Regarding the size of those companies, Macdonald wrote:

> "We faced giants such as RCA, with 1964 revenues of over $2 billion; Honeywell, with over $600 million; Sperry Rand, with its Univac Division, with $1.3 billion. IBM in those days had revenues of over $3 billion, but IBM was not the largest company we faced in terms of total revenues. General Electric, with serious intentions and a major program in computers, already was an industrial giant with revenues in excess of $5 billion." (DX 427, p. 3.)

In contrast Burroughs' total annual worldwide revenues were less than $400 million. (DX 10260, p. 22.)

With regard to technical achievements, Macdonald wrote that by 1964 IBM was "well on their way to development of a truly impressive research and development capability" and "General Electric had been exploring the uses of the electron for years in both electrical and electronic applications". By contrast:

> "Although [Burroughs] had been engaged in electronic research and had achieved initial success with a few very advanced new products, the products on which our revenue and profits depended remained primarily mechanical." (DX 427, p. 3.)

Starting in 1964 and continuing through the 1960s Burroughs set about to achieve its objective of "profitable growth" and "moderate growth commensurate with maintaining profitability" in computers. (Withington, Tr. 56732; DX 10262, p. 6.) As a first step, in 1964 Burroughs' President Ray Eppert formed the Profit Improvement Committee. The Committee was to consider reorganization "with respect to all aspects of marketing, manufacturing and engineering operations, and the establishment of clear product development objectives". Its "primary charge was the swift improvement of the company's profitability". (DX 427, p. 5.)

The changes instituted by this Committee (of which Macdonald was a member) and further changes instituted by Macdonald, who, in 1964 was given "broad administrative responsibilities" (DX 10260, p. 4) and in 1966 became Chief Operating Officer (Tr. 6883), were intended to accomplish two things: first, reduced expenses, and second, improved development of computer products. (Macdonald, Tr. 6883-91; DX 427, pp. 7-8.)

(i) <u>Reduction of Expenses.</u> The Profit Improvement Committee found that Burroughs' "'problems' lay in the efficiency of its operations" and not in "spending levels associated with research and development". The Committee instituted several changes* to

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* These changes contrast with the policies implemented at RCA during the late 1960s. At RCA expenses increased, the importance of financial controls was not emphasized, product development was not encouraged, and market share rather than profitability was considered the goal. (See pp. 581-89 above.)

increase efficiency:

First, the productivity of the sales force was increased. To do this, the Committee reduced salaries and commissions for salesmen, reorganized the sales organization* and moved unproductive salesmen out of the division. Burroughs found that:

> "The combined effect of these organizational changes gave us the equivalent of adding 500 highly productive salesmen--with no increase in budget costs." (DX 427, p. 7.)**

Second, the Committee found that manufacturing costs "had been increasing as a percentage of revenue every year for ten years", and the Committee undertook to reduce those costs. It did this by reducing the number of managers at its plants, specializing the plants by products, introducing a series of financial controls, designating each marketing district a "profit center", modernizing existing facilities and building 17 new plants. With these changes, by 1966 manufacturing costs were reduced by more than five percent of revenue and continued downward in ensuing years. (DX 427, pp. 7-8.)

Those reductions of expenses soon benefited Burroughs:

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* Burroughs created additional sales offices, established sales zones, reduced the number of salesmen reporting to each manager, and gave each manager a personal sales territory to cover. (DX 427, pp. 6-7.)

** In its 1965 Annual Report Burroughs reported that its "marketing realignment program [had] contributed to the sales success of Burroughs' business machines and systems and improved profitability of the Corporation in 1965". (DX 10261, p. 8.)

> "The combined effect of these major changes, along with reductions in marketing and G&A expenses and other economies resulting from stricter overall control, produced an increase in net earnings of over 200 percent in two years, from $10 million in 1964, to $31 million in 1966." (DX 427, p. 8.)

(ii) Increased Product Development. As a threshold matter the Profit Improvement Committee decided that Burroughs' lack of profitability did not result from too much spending for research and development. (DX 427, p. 6.) In fact, the reduction of expenses discussed above allowed increased expenditures in research and development:

> "Removal of these excesses resulted in greater profitability, which in turn made more money available for research and development, allowing us to spend more in engineering, leading to further cost reductions. Since 1964, we have increased our commitment to R and D each year. . . ." (DX 427, p. 8.)

In 1964 Macdonald began to have "greater influence" in Burroughs and his "principal activity was to utilize these resources and developments to a much greater degree than they had in the past". In addition, he made sure that Burroughs would "pay a great deal of attention to product development". (Macdonald, Tr. 6886.)

Burroughs pressed ahead with its computer developments in two ways: First, it expanded its "product program to become more of a full range company". (Macdonald, Tr. 6888-89.) Second, it offered greater capability and increased the diversity of its computer products. (Macdonald, Tr. 6889-90.) The addition of new products, in turn, made more money available for research and development, as Macdonald explained:

"In 1964 we were operating on a research budget, an R and D budget of approximately sixteen million dollars and as we expanded our business we were able to afford an expanded R and D budget and as we were able to do this we expanded the range of products which we felt we could successfully undertake . . . . (Tr. 6889.)

By 1969 Burroughs' annual spending in research and development had doubled to $35 million. (DX 10285, p. 3.)

The changes that Burroughs began in the mid-1960s, particularly its increased research and development and improved manufacturing capabilities, required new investment. Macdonald described those investments between 1965 and 1972:

"Since 1965, Burroughs had spent some $250 million in R&D. These funds came entirely from our own resources and were used for the development of our commercial and trademark product line.

"Over the same period, we have also invested just over one billion dollars to expand the manufacturing and marketing facilities to sell the products resulting from this R&D expenditure. Approximately $750 million of this represented a marketing investment. It went for facilities, inventory, receivables and lease funding. The remaining $250 million was for manufacturing facilities, men, machinery and equipment. I should also point out that this billion dollars was in addition to the $500 million that we had already invested by the end of 1965. Of the billion dollars invested over the last seven years, $250 million was generated through retained earnings and the remaining $750 million was raised in the financial markets through loans and equity issues." (DX 426, pp. 19-20.)

b. Computer Developments 1964 - 1969. Burroughs moved to extend both the breadth of its product line and to increase the capabilities offered by its computer products and by the end of 1969 had succeeded in adding many new products. This discussion traces the development of Burroughs' computer products in three parts: its 500 Systems, its smaller computers and its peripheral products.

(i) The 500 Systems Family. An important factor in Burroughs' success during the 1960s was the success of its 500 Systems family. Nine systems in that family were eventually announced: the B 500,* B 2500, B 3500, B 4500, B 5500, B 6500, B 7500, B 8300** and B 8500. Because of problems that Burroughs, in common with other manufacturers, experienced with its larger machines, the B 7500, B 8300, B 8500 were either not delivered or not operational at customer locations, and the B 6500 was delivered late. The B 4500 was also never delivered. (PX 5048-D (DX 14506), Pierce, p. 62.) Still, by 1969 Burroughs was able to report that "this family of balanced general purpose commercial data processors have helped the Corporation establish an excellent position in the EDP market". (DX 10264, p. 5.) However, while Burroughs promoted the 500 Systems as a "family", they were not machine-language compatible as was the IBM 360, but were only compatible through the use of higher level languages. (PX 5525-A, p. 218; DX 10264, pp. 6, 8.)

Four months after IBM announced its System/360, Burroughs in August 1964 announced the first member of the "500" System family, the B 5500. (DX 13920.)/ Burroughs described the B 5500 as a

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* Burroughs sometimes promoted the B 500 as part of the 500 Systems (DX 10264, p. 6); it was, however, more closely related to the B 200 and B 300 and is discussed in that section.

** Burroughs did not describe the B 8300 as a member of the 500 Systems family. However, it was closely related to the B 8500 and is therefore discussed in this section.

/ Withington commented that, by announcing only one new model, Burroughs had not "attempted to answer System/360 across the board". (PX 4829, p. 22.)

"modular data processing system of advanced design for both commercial and scientific applications in the medium to large scale categories". (DX 10260, p. 12.) Burroughs reported that it had "up to three times more productivity than its predecessor, the B 5000". (Id.)

B 5500s were indeed used for commercial and scientific applications, as well as in aid of the space program. During 1964 a B 5500 "joined the famous Atlas ground guidance computer in the nation's space program" and was used to track the Saturn missile. Two Burroughs' B 5500s were also used in "tabulating and projecting national election results for the American Broadcasting Company". Those B 5500 Systems "operated in the same manner for the election as all Burroughs' computers do in projecting business trends, statistics, competitors' activities and other information on which managements make decisions". (Id.) By 1965 Burroughs reported that its orders for the B 5500 had exceeded forecast and "included many diverse applications in national and state governments, advertising, manufacturing, shipbuilding and research". (DX 10261, p. 9.)

During 1965 Burroughs' Defense, Space and Special Systems Group* announced the B 8500. The B 8500 was marketed for "high

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* Burroughs had two groups that marketed computers, its Business Machines and Defense, Space and Special Systems Groups. In 1968 Burroughs described the functions of its Defense, Space and Special Systems Group:

> "The Defense, Space and Special Systems Group produces and markets special data processing systems and advanced products for the military and other government agencies. It manufactures

volume, time-sharing, on-line business, scientific and government applications" and provided for "management information processing, including the full complement of business data processing, reporting and message handling as well as centralized or decentralized scien-

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> super-computer systems for government, commercial, educational and scientific applications. The Group also produces visual display systems, memory systems and electronic components." (DX 10263, p. 17.)

The relationship between the Defense, Space and Special Systems Group and Burroughs' commercial business was close and involved, marketing and designing the same or similar products. Burroughs described the relationship in its 1964 Annual Report:

> "[t]he Corporation's programs for various military and civilian agencies, coupled with large investments of its own in research and development, have yielded important technological advances which are being utilized in Burroughs' commercial data processing systems and accounting machines as well as in defense and space projects". (DX 10260, p. 19.)

Similarly, in its 1965 Annual Report, it stated that:

> "[t]he Defense and Space Group was expanded in 1965 to include the development, production and marketing of custom-built large-scale electronic data processing systems for commercial, industrial and special applications. These systems to a great degree now parallel the requirements of high performance computers employed in major defense and space programs where Burroughs has had many years of successful experience." (DX 10261, p. 17.)

Products designed and marketed commercially often were later modified or further developed and marketed for military use, and vice versa. For example, the B 5000, the foundation for the subsequent "500" product line, grew out of military work (the Burroughs D-825). (Withington, Tr. 55976-77, 58527-28.) And when the Defense, Space and Special Systems Group was awarded a contract to produce a mobile communications system for use by the U.S. Army, it modified four B 3500 computer systems which had been developed by the Business Machines Group. (DX 10716, p. 8; DX 13665, p. 19.)

At the end of 1968 the Defense, Space and Special Systems Group took over the responsibility of marketing, in addition to specially designed equipment, all of Burroughs computer products to the Federal government. (DX 13665, p. 19.)

tific and engineering computations". According to Burroughs, the B 8500 was a "logical extension" of the concepts of "modularity, multiprocessing and automatic scheduling programs used with the B 5500 and D 800 series systems.* The B 8500 also made use of monolithic integrated circuits. (DX 10261, p. 17.)

By 1967 Burroughs reported that:

> "Broadening customer interest in the giant self-regulating B 8500 system confirms the importance Burroughs has given the development and production of this supercomputer. It has the unique ability to multiprocess a number of batches of accounting routines, solve engineering and scientific problems, and deal with transactions as they occur, all at the same time. The interest of potential users in the B 8500 has greatly increased for on-line, real-time business and scientific applications." (DX 10263, p. 9.)

However, Burroughs experienced problems developing the B 8500, and none was ever delivered. (Perlis, Tr. 2001-02; PX 5048-D (DX 14506), Pierce, p. 62.)

It was not until 1966 that Burroughs began to turn its 500 Systems into a family of computer systems somewhat comparable in breadth to IBM's System/360. In that year Burroughs introduced three new "members of the 500 systems", the B 6500, the B 2500 and B 3500. (DX 10262, p. 8.)

Burroughs reported that the B 6500 was "taking [its] place" between the "medium-sized" B 5500 and the "giant" B 8500.

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* The D 800 series included the D 825, a computer developed for the military. (See above, p. 227.) Macdonald testified that a good deal of the B 8500s "architectural concept came from the 825" and it "was intended to be an enlargement and in terms of size and speed from the generation of equipment which was the D825". (Tr. 7556-57.)

The B 6500 central processors employed monolithic integrated circuitry throughout; had core or thin-film main memories; were "equipped for true multiprocessing, parallel processing, and real-time and time-sharing operations", and had a "comprehensive, automatic operating system for program control, completely coordinated with the hardware elements". (DX 10262, p. 8.)

The B 6500 was not delivered until 1969. (DX 10264, p. 8.) Even then its "full development" was delayed by problems in its system software. (DX 3269, p. 3.) Burroughs reported that it had corrected those problems in 1971. (Id.)

The B 2500 and B 3500 were released for sale in April 1966. (DX 10262, p. 3.) Demonstrations for these systems "were made on a broad range of business applications programmed in COBOL, including remote processing and multiprocessing under the automatic control of the Master Control Program". (Id.) Burroughs reported these systems would be sold "in the medium-priced range". (Id., p. 8.) By 1967 Burroughs reported that it had received "an impressive number of orders" for the B 2500 and B 3500 from users in "such diverse fields as finance, manufacturing, government, retailing, insurance and publishing". (DX 10263, p. 9.)

In 1967 Burroughs announced the B 7500. Burroughs reported that its release "stimulated interest in other EDP products and strengthened the Company's position in this highly competitive field". (DX 10263, p. 11.) However, the B 7500 was never delivered. (PX 5048-D (DX 14506), Pierce, p. 62.)

In its 1968 Annual Report Burroughs reported that during 1968 it had installed the B 8300, "part of the B 8500 development program", to provide "a central passenger reservation system for a major world airline". That installation used "three central processors functioning under the automatic control of a single software operating system"; there were more than 2700 input and display terminals throughout the United States with keyboard input and cathode ray tubes "to display data transmitted to and received from the computer". (DX 13665, pp. 3, 5.)

The airline at which Burroughs installed its B 8300s was Trans World Airways (TWA). (O'Neill, Tr. 76014.) The B 8300s at TWA were never operational, however, because the B 8300s "could not accommodate the projected workload" and Burroughs "had not demonstrated adequate availability or reliability of the system". (O'Neill, Tr. 76015.) The effort was terminated, and in late 1970 TWA sued Burroughs for non-delivery of the B 8300. (O'Neill, Tr. 76015.)* In 1971 TWA installed one IBM 360/75 and two IBM 360/65s to perform the reservations function.** (O'Neill, Tr. 76013-14.)

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* The litigation was settled in October 1972 with Burroughs agreeing to assume certain payments to a leasing company and either to make equipment available or to pay a sum of money to TWA. As a result of the settlement, Burroughs' earnings were reduced by $4,813,000 net of taxes. (DX 10265, p. 42.)

** Burroughs was not the only company that had difficulty installing an airline passenger reservation system during the 1960s. Sperry Rand was also unsuccessful at installing such a system at United Airlines. United, like TWA, then acquired IBM equipment. (O'Neill, Tr. 76015-17, 76231-32.)

By 1969 Burroughs reported that the production of its "'500 Systems' reached an all-time high during the year". Burroughs described some of the reasons for the success of the 500 Systems:

> "Our systems software provides self-regulated operation which assures Burroughs customers of maximum work output through the techniques of multiprogramming in which a number of different programs are handled at one time. In the larger systems, simultaneous parallel processing of programs is achieved by use of multiple central processors. Another important advantage to users of our medium and large systems is a modular architecture which enables them to add processors and increase main memory and input/output capacity in increments as needs expand. Upward compatibility--from one '500' Systems computer to the next largest in size--is assured through the use of higher level programming languages. COBOL is used for business applications on the entire range of computers. For engineering and scientific applications, FORTRAN is used on the medium-scale B 3500 and B 5500 and the large-scale B 6500 and B 8500, and ALGOL on the B 5500, B 6500 and B 8500. PL 1 will be available on the large systems and other special languages will be added as they are required." (DX 10264, pp. 6-8.)*

These characteristics, of course, were much the same as those IBM had earlier employed successfully in its System/360.

(ii) Smaller Computers. Burroughs marketed its smaller computers in three lines: its line of B 200 successors, its E Series and the L/TC Line.

Burroughs had introduced the B 200 in 1961. (PX 5525A, p. 53; see above, p. 227.) In early 1965 Burroughs introduced

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* Burroughs reported that it had been able to obtain a design advantage with the Burroughs 500 systems:

> "[w]ith the Burroughs 500 Systems, the corporation gained an advantage by developing the software and hardware in parallel. Engineers in these two areas combined their efforts as the systems were developed, closing the time lag between installation and complete usefulness of the system to the customer. This advantage also insures the user maximum performance of the complete system." (DX 10262, p. 10.)

its B 300 data processing system which was compatible with B 200. Burroughs reported that the B 300 included on-line capacity and that its "modular design provides for the simultaneous use of more than one B 300 processor with a single disk file system". (DX 10260, p. 12.) By 1966 Burroughs reported that the B 200 and B 300 computers had been:

> "[l]eased or purchased by customers in many fields including transportation, data processing services, photo supplies, utilities, insurance, publishing, brewing, school systems, manufacturing, baking, textile milling, property management, retailing, wholesaling, distributing, government and public service, research and finance." (DX 10262, p. 12.)

In 1965 Burroughs introduced the B 340 bank data processing system which was smaller than, although compatible with, the B 300 system. (DX 10263, p. 11.) During 1968 Burroughs introduced its B 500 computer. The B 500 had an automatic operating system and used COBOL. While promoted by Burroughs as a "member of the '500' Systems EDP family", the 500 was compatible in assembly language with the B 100, B 200 and B 300 systems but was compatible only through the use of COBOL with the 500 Systems. (DX 13665, p. 5.)

During 1964 Burroughs brought out its E 2100 computer. (DX 10260, p. 8.) Between 1964 and 1970 it added to the E Series with the E 3000, E 5000, E 6000 and E 8000. (DX 10263, p. 11; DX 10264, p. 18.) The E Series were small solid state computers with electronic logic and data storage. (DX 10260, p. 9; DX 10264, p. 18.) On the larger E Series computers, the E 6000 and E 8000, COBOL was available. (DX 10264, p. 18.)

In 1968 Burroughs took a major step forward with the announcement of its TC 500 terminal computer. (DX 13665, pp. 1, 7.) The TC 500 was characterized by John Jones of Southern Railway as the first "intelligent terminal", that is, the "first programmable terminal . . . that had in it a processor, a general purpose processor with memory and input and output, that could be programmed to perform in some way as the user desired as opposed to being hard wired". (Tr. 79044-45.) The TC 500:

> "[h]ad a keyboard for an operator to input data and a printer on which data could be printed, a character printer, and a processor inside of it which could be programmed to give that device any particular characteristics in its operation, as well as do other processing of the data as it was entered or before it was printed." (Tr. 79044.)

Burroughs similarly described the TC 500 in its Annual Report:

> "An internally programmed computer using integrated circuitry and disk memory, the TC 500 can operate as a data communications terminal on-line to a central computer, or function off-line independently. . . . In addition to data communications, they can edit and format information and perform functions which previously had to be handled by the central computer." (DX 13665, p. 7.)

In 1969 Burroughs introduced its TC 700 and TC 310 terminal computers. The "TC 500 and TC 700 have their own computing and memory capabilities. They also edit and format information for most economical transmission to a central system. The TC 310, in multiples, is connected to a data controller which then performs the formatting and other necessary operations prior to data transmission." (DX 10264, p. 14.)

Also resulting from the same engineering as the TC computers was the L 2000 computer. Introduced in 1969, the L 2000 was a computer, designed for billing, as to which "the addition of a data communications unit converts it to a terminal computer able to communicate with a central computer system". (DX 10264, p. 18.) COBOL was available for the L 2000. (Id.)

Macdonald described the L/TC series as follows:

> "These internally programmed machines are programmed in COBOL and can operate under operator control or under program control.
>
> ". . . .
>
> "These small systems are, in terms of what they can perform, small full-scale computers." (DX 10285, p. 6.)

(iii) Peripherals. During the years from 1964 through 1969 Burroughs improved upon its existing peripheral equipment. It introduced several models of improved card readers, printers, sorter-readers, tape transports, multi-tape listers, and tape drives. (DX 10261, p. 11; DX 10264, p. 10.)

By 1964 Burroughs had developed and was marketing a disk file with a head-per-track. (Withington, Tr. 56244; DX 10260, p. 10.) This head-per-track file had a slightly faster access time and a slightly higher cost per unit of storage than the movable head devices. (Withington, Tr. 56244-45.) During the mid-1960s Burroughs found that its disk drive was "a significant factor in the growth of the Company's business in EDP systems". (DX 13665, p. 5; see also PX 4834, p. 31.)

However, in 1962 when IBM introduced its 1311 disk drive with a removable disk pack, Burroughs did not offer a disk drive with a similar removable pack, nor did Burroughs offer such a disk drive after IBM followed this announcement with the introduction of the 2311 and 2314 disk drives. Where Burroughs' customers wanted the advantages of a removable disk pack, Burroughs sought to convince them to keep their files on magnetic tape and to load and unload the files on to the Burroughs' fixed pack drives. (Withington, Tr. 58802.) Finally, in the late 1960s, Burroughs arranged to acquire disk drives with removable disk packs from Century Data, and in 1970 it began marketing those disk drives as part of its computer systems. (PX 4445, pp. 7-8; DX 10716, p. 12.)

Burroughs introduced new peripheral equipment during the 1960s. In 1969 Burroughs introduced a new electronic reader/sorter which handled documents both optically and magnetically encoded and a new computer-output-to-microfilm system. It also announced three new encoding devices: the Series N keyboard-to-magnetic tape data encoding machine; the A 149 peripheral card punch, the A 150 keypunch, and the A 160 verifier for punched card encoding; and the Series S "general purpose character encoding machines . . . designed to encode unit documents . . . to facilitate electronic reading by high-speed recognition equipment". (DX 10264, pp. 10-14.)

c. Burroughs at the End of the 1960s. By the end of the decade the changes Burroughs had instituted in 1964 had begun to achieve Burroughs' objective of "profitable growth". (DX 427, p. 8.) Burroughs had reduced costs and increased efficiency in its manufacturing and marketing operations (DX 427, pp. 6-8), and it had increased its expenditures in research and development. (Macdonald, Tr. 6889; DX 427, p. 8; DX 10264, pp. 4, 6.) Aided by those changes, Burroughs had expanded its product line in terms of both range and the capabilities offered. From a few mid-size computers in 1964, Burroughs delivered several complete lines of computer systems ranging from small (E Series; L/TC Series) to very large (B 6500) by 1969. Its numerous new product offerings were reflected in its 1969 Annual Report which described its "broad line of products for the data recording, computing and processing market" including:

> "[c]omputer systems, memory sub-systems, peripheral input and output equipment, data encoding equipment, data communications terminals, accounting systems, calculators and adding machines, business forms and office supplies, custom-designed electronic systems, and data display devices. This extensive range of products represents one of Burroughs basic strengths for continued growth in the rapidly expanding data processing industry." (DX 10264, p. 2.)

And Burroughs was also continuing its technological development in intelligent terminals, an area that would become very important in the 1970s. (See DX 10264, p. 14.)

It was clear that Burroughs' management understood the close interrelationship of its extensive product line. In a 1969 presentation to the New York Society of Security Analysts, Ray Macdonald stated, concerning the relationship among various computer products, that:

> "In 1967, I said that when I had the next opportunity of addressing this group we might refer to electronic accounting machines, electronic accounting systems, terminal units and electronic computers as one continuous market from small machine to giant computer. This blending of several markets into a single broad market has now become more evident." (DX 10285, p. 5.)

Burroughs' financial results, in turn, reflected the proliferation of its computer products. From 1964 to 1969 Burroughs' total corporate revenues did not quite double, increasing from $392 million to $759 million. During the same time its domestic EDP revenues increased from $61 million to $260 million and its corporate profits jumped 500 percent. (DX 8224, p. 1; DX 10260, p. 5; DX 10264, p. 5.)

Writing in 1975, Macdonald looked back on the results of the changes that Burroughs had instituted in 1964:

> "Our revenue has doubled every five years, and today, at $1.5 billion, is four times its level of ten years ago.
>
> "Our net earnings have increased by 14 times during the 10-year period, and this is the best record of growth in the mainframe computer industry.
>
> "Our manpower worldwide has increased from about 34,000 to more than 51,500. We are operating 54 plants in ten countries and two more plants are under construction." (DX 427, pp. 2-3.)

By the beginning of 1970 Burroughs had made up much of the ground it had lost during the 1950s and early 1960s, and was well situated for even greater success in the 1970s.

45. National Cash Register. Historically, National Cash Register (NCR) was a company that had concentrated on marketing its "traditional products"--cash registers, accounting machines and adding machines--to customers engaged in retailing and banking. (DX 344, p. 1; DX 372, p. 1; see pp. 229-31, 236 above.) By the beginning of 1964, while continuing to concentrate on customers in those areas, NCR had introduced and was marketing two models of its second generation 351 computer system which had been announced in the early 1960s. (DX 344, p. 14; DX 382, pp. 3, 10.) At the same time NCR was actively expanding "the functions of its traditional products". (See above p. 241; DX 344, p. 1.) In 1964 NCR's domestic EDP revenues ($46.3 million) accounted for only about 13 percent of its total domestic revenues. (DX 361, p. 22; DX 8224, p. 3.)

The story of NCR in the years between 1964 and 1970 is that of a company wishing to maintain its traditional business and only gradually adding the increased capability offered by computers. This desire gradually to develop computers to support its traditional business was expressed by the President of NCR, Robert S. Oelman,* in a November 1964 speech. He stated that the company had "recently" undergone "the most significant change in [its] long history . . . the advent of electronic data processing." (DX 342, pp. 2-3.) However,

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* Oelman, along with J. J. Hangen, were the two witnesses called by plaintiff from NCR. From 1964 until he left NCR in 1973, Oelman was Chairman and Chief Executive Officer of NCR (Tr. 6117), and from 1964 until 1972 Hangen was Vice President of Finance. (Tr. 6233.) At the time he testified Hangen was Senior Vice President of Corporate Affairs for NCR. (Tr. 6239.)

Oelman explained that this change did not mean the demise of NCR's "traditional products"--cash registers, accounting machines and adding machines--for two reasons: First, the traditional products were "being integrated" into electronic data processing systems; the traditional products serve as an "input medium" for data and are tied into "the mainstream of the data processing revolution". Second, NCR could use "new technologies to add important machine features and to improve overall performance" of its traditional products. (Id., pp. 3-6.)

Thus, NCR, rather than recognizing that computers were going to obsolete its "traditional business" (as IBM had in the 1950s) and committing itself to the new technology, chose to split its resources between computers and its traditional cash register and accounting machine products. (See, e.g., DX 361, p. 1; DX 370, p. 16.) In its 1966 Annual Report NCR reported that:

> "The Company's R&D program is designed to achieve two basic objectives:
>
> "1. To improve NCR's traditional position of leadership in the control register, accounting machine and adding machine markets;
>
> "2. To gain for the Company an increasing share of the rapidly growing market for computer systems and related equipment." (DX 370, p. 16.)

Outside observers also reported on NCR's desire to proceed gradually in computers. Withington described NCR as following a plan during the 1960s to proceed "methodically" in computers by using computers "to complement its existing product and marketing positions". NCR did this because "[t]he risks and investments involved in introducing highly innovative products to rapidly achieve a major share of computer shipments do not appeal to NCR, and that as long as the company's overall position, growth, and profit objectives are supported the company's computer market share is not a primary objective." (PX 4834, p. 34.)

Similarly, an analysis of NCR by IBM employees in IBM's Market Evaluation Department observed that in 1967 NCR was "still in the process of establishing itself in computers [and its] management is not prone to risk ventures". (PX 2050, p. 4.)

Developments at NCR during the period from 1964 to 1970 show a company improving its products gradually and trying to avoid taking the risks of producing innovative products. From 1964 to 1968 NCR introduced only a few improvements to its second generation equipment. During the summer of 1964, NCR announced a follow-on member of the 315 family, the 315 Rod Memory Computer (RMC). (DX 361, p. 14; DX 401, p. 2.) The 315 RMC used thin-film memory technology and was compatible with other computers in the 315 line. (Hangen, Tr. 6314; DX 361, p. 14.) Multiprogramming for the 315 RMC was announced during 1966. (DX 370, p. 16.) During 1965 NCR announced the Series 500 computer, a general purpose computer which attempted to combine "magnetic ledger bookkeeping with various combinations of punched card, punched paper tape or optical equipment". (Hangen, Tr. 10402; DX 361, p. 13.)

NCR also continued to make changes to its existing products. Despite the fact that the CRAM file had been superseded by the disk drive (discussed above at p. 235; see Withington, Tr. 56469-70, 56511), in 1966 NCR announced a more powerful version of that product (DX 370, p. 16) rather than replace it entirely with disk drives.

Following the trend started by System/360, NCR reported in 1966 that it was increasing the modularity offered by its 315 computer family:

> "When NCR announced the 315 computer family, four basic processors, three memory sizes, and 12 peripherals were offered. Today, 315 users have a choice of nine different processors, eight memory combinations and some 60 peripheral units. Expansion of this flexible computer series in 1965 included three new magnetic tape units, three new high-speed printers and a new communications controller. This latter device permits up to 100 communication lines serving input or output devices to be linked directly to a 315. It greatly extends the power of the system to receive inquiries from remote locations and transmit answers." (DX 368, p. 6.)

It was not until March 5, 1968, almost four years after IBM's announcement of System/360, that NCR introduced its third generation computers, the Century Series. The first models announced were the Century 100 and 200, and NCR stated that it intended soon to announce a Century 400 which would be capable of performing time sharing. (DX 348, p. 1.)

The Century 200 was "designed for batch, real-time, and scientific processing". (DX 469, p. 2.) NCR offered the Century 100 and 200 Systems, in addition to sale, on one, three or five year rental terms.* (DX 348, pp. 1-2.) Each system was marketed with a minimum amount of main memory, a card reader or paper tape reader, printer and disk drive. (DX 348, p. 1.) Other available peripherals included CRAM, a MICR sorter-reader, an optical journal reader, punched card units, and visual display units. (DX 421, p. 17; DX

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* By April 30, 1969, over half of the orders for the Century Series were for a five-year term. (DX 372, p. 4.)

469, p. 14.)

NCR promoted the Century Series as its "most important new line of products" (DX 366, p. A), asserting that it incorporated many advances over its previous machines, including:

(1) The Century Series continued the use of thin-film main memory introduced on the 315 RMC. NCR called this an "important 'first'", making the performance of the thin-film memory available at a lower cost. (DX 366, p. 5.) Within about a year after the announcement of the Century Series, NCR replaced the thin-film memory with core memory. (Hangen, Tr. 6329-30.)

(2) The Century Series used integrated circuits "throughout all Century computers and peripherals". (DX 366, p. 6.)

(3) The Century Series provided for "complete upward compatability" so that "as a user's needs increase, more powerful processors can replace original units as required". (Id., p. 8.)

(4) The Century Series included more advanced peripherals--including, for the first time, disk drives: "The philosophy" of the Century Series "is that the disc concept is an integral part of all members of the family". The Series also included a new high-speed printer and, yet again, an improved CRAM unit. (Id., pp. 6-7.)

(5) The Century Series had the capability to use both

COBOL and FORTRAN* programs among others.**

(6) The Century Series provided for standardization in design including standard cabinet frames and panels, power supplies and cable connections. It also provided for standard interfaces so that "the many peripheral units available with Century processors can 'interface' simply, and in a wide variety of configurations". (Id., p. 7.)

Of course, while these features represented improvements over NCR's prior products, all these features, with the exception of the soon to be discontinued thin-film memory, had been included in IBM's System/360 four years earlier.⁄

In its Annual Report for 1968, NCR announced its marketing plans for the Century Series:

> "Over the years NCR has established itself as a leading supplier of business systems to thousands of manufacturing concerns, construction companies, wholesalers, schools, hospitals, utilities, hotels and motels, business service firms, and local, state and federal government offices.

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* According to Hangen, FORTRAN would be used by NCR users to perform scientific applications. (Tr. 10604.)

** On software development, NCR reported:

> "Basic computer operating software as well as standard application programs have been prepared concurrently with equipment development. This has insured full program compatibility, plus a proper balance between 'hardware' and 'software' capabilities." (DX 366, p. 10.)

⁄ During this period, perhaps because of NCR's late response to System/360, NCR "as a general rule . . . attempt[ed] to price [its] products slightly less than the comparable IBM system", that is, "5 to 10 percent less". (Hangen, Tr. 6350-51.)

"The advent of the Century Series computer family has multiplied the company's opportunities in these fields. As users of NCR accounting machines grow and their data processing requirements increase, a Century 100 computer system can meet these greater needs just as the Century 200 can serve the larger organization. At the same time however, with thousands of new small businesses being established each year, the market for accounting machines has continued to grow."

* * *

"The largest single market for computer systems is in manufacturing. One out of every four Century Series computers currently on order, for example, is scheduled for use in this area." (DX 340A, p. 8.)

Hangen, then Vice President of Finance (Tr. 6233), emphasized in April 1969 the opportunity Century afforded to broaden NCR's marketing thrust:

"Although we intend to continue our close relationships with the retailing and financial industries, the Century allows us to broaden our marketing thrust. We are offering specialized Century programs for the Educational, Hospital, Local Government (including Law Enforcement), and Distribution Industries." (DX 372, pp. 3-4.)

He added that the majority of orders received for the Century were from "non-banking, non-retail industries". (DX 372, p. 4.)

The Century Series was "largely responsible" for the fact that in 1968 NCR's domestic orders for computers increased 98% over the prior years. The result of the increase was that "for the first time domestic orders for computer equipment exceeded those for either cash registers or accounting machines." (DX. 340A, p. 2.) To meet the demand NCR expanded the Electronics Division plant facilities by 50%

and planned a further increase in 1969. (DX 340A, p. 2.)*

The large increase in orders had an "adverse impact" on NCR's earnings during 1968 as the 1968 Annual Report explained:

> "Users of computer systems generally prefer to rent rather than buy such equipment. Thus, the introduction of a major new computer family such as the Century Series tends to have an adverse impact on earnings initially, since the company must immediately bear production startup, software, training and depreciation expenses although revenue from rental installations is received only over a period of years." (DX 340A, pp. 2-3.)

NCR went on to assure its stockholders that in future years there would be "a highly favorable effect on earnings". (DX 340A, pp. 2-3.) Ninety percent of the Century Series systems marketed were in fact leased. (Hangen, Tr. 6358-59.)

Throughout the 1960s, NCR understood the importance of support services--customer training, maintenance, systems design--in marketing computer products. It stated in its 1964 Annual Report that:

> "The user of an NCR business system buys considerably more than the machine units which make up that system. In every case, an NCR systems specialist and in many instances teams of specialists design the most efficient system possible to meet the customer's current and future needs, then thoroughly train the user's staff in its use. After the system is operational, further counseling and assistance including dependable maintenance are provided." (DX 361, p. 8.)

Similarly, it stated in its 1966 Report that:

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* The Century 100 was first shipped in the fall of 1968 (DX 340A, p. B), and the Century 200 was first shipped in June or July 1969. (Hangen, Tr. 6328.)

"Today, a . . . requirement for future success in the marketplace has arisen; that is the need for business equipment suppliers to provide additional guidance to customers in utilization of new technologies for operating their businesses more profitably. For in the final analysis, the effectiveness of today's sophisticated information systems depends upon a full understanding of their potential at all levels of management. To this end NCR's educational programs are being designed not only to prepare sales representatives to install advanced systems, but also to provide counsel and training in management sciences." (DX 370, p. 5.)

And, with the introduction of its Century System it realized that customers needed even more support. In its 1969 Annual Report, it stated:

"Marketing requirements of the business equipment industry have changed significantly in recent years. In recognition of this, the company has taken various steps to provide the greater degree of support which customers need and expect." (DX 367, p. 4.)

After IBM announced its "unbundling" in June 1969, NCR's Pricing Committee decided whether to make any changes in its pricing of support services. (Hangen, Tr. 6364.) Recognizing that there would be problems, "particularly [in] customer relations", the Pricing Committee did not take any immediate action. (Hangen, Tr. 6393.) On October 1, 1969, NCR announced a change in its pricing structure. (DX 346.) The announcement stated in part:

"NCR believes that each user of its computer systems must be provided with a certain essential amount of software, systems support, and educational services if he is to successfully install the system and begin to benefit from his investment. NCR believes that this basic package of supporting services must be the responsibility of the equipment manufacturer.

"In addition, NCR recognizes that there is considerable variance in the level of support required by different customers. This is a function of the capabilities of the customer's internal EDP staff and of the scope and complexity of the applications to be installed.

"Accordingly, it will continue to be NCR's policy to provide, as part of the basic hardware price, that amount of software and support which will realistically insure that a prudent user will be able to install and successfully utilize his NCR computer system.

". . . .

"Software and support services requested above the level which is included in the basic hardware price will be separately priced." (DX 346, p. 1, emphasis in original.)

NCR did not change basic hardware prices when it started to charge separately for those support services. (Hangen, Tr. 6365.)

On January 1, 1970, however, NCR partially reversed its unbundling decision and announced:

"After further evaluation, it has been decided <u>not</u> to price all basic and applied software and <u>not</u> to establish an allowance against which such chargeable software would be applied. The NCR software pricing plan will be to continue to establish pricing for software products on a <u>selective</u> basis, considering the value to the customer, uniqueness, and other factors. This approach creates an allowance effect since the more basic software offerings will not be priced." (DX 386, p. 2, emphasis in original.)

NCR's computer data center business, begun in 1960, expanded during the 1960s, so that by 1968 there were 69 centers worldwide. Many customers of NCR's data centers used NCR cash registers, accounting machines or adding machines to produce "punched paper tape or machine readable 'optical' figures as a by-product of normal operation." The customers then sent the output media to NCR's data center for processing. (DX 340A, p. 10.) The data centers were "NCR's most successful effort in the data processing business" in the 1960s, according to Withington (PX 4832, p. 22), and, in addition, proved to be a "powerful stimulus to the sale and rental of data capturing" devices. (DX 340A, p. 3.)

NCR's use of its traditional products as input devices for its data center computers was an example of NCR's attempt to integrate its traditional products with its computer systems. In 1963 NCR reported that those products could be used with computers in several ways:

> "Many different types of cash registers, accounting machines, adding machines and other peripheral units are available as basic input devices for [computer] systems. Some of these machines communicate with computers by means of punched tape or punched cards. Others record transactions or other data in slightly stylized print which can be read by optical or magnetic scanning machines. Still others can be cabled directly 'on-line' to NCR electronic data processing systems." (DX 344, p. 3.)

NCR did very little, however, in terms of developing and marketing on-line systems during the 1960s. During May 1969 H. M. Keller, NCR's Manager of Terminal Communications Products, wrote that in terminal and communication products NCR did "not have a great choice to offer our prospects", and he listed only one on-line device, the 42-500, a bank tellers' console. (DX 719, p. 1, see Oelman, Tr. 6164.) Keller noted, however, that a change had recently occurred in NCR's commitment to on-line devices:

> "Before we knew that our Company committed itself to creating and offering terminal devices for many, many purposes, we may have had reasons for not encouraging sales of on-line systems. Now that we know that NCR is committed, each of us must help to penetrate the on-line field." (DX 719, p. 1.)

In support of that commitment NCR was investing "tremendous sums of money in developing" terminal and communications devices. Keller predicted that:

> "To quite some extent, our future success in the terminal field will depend upon our success with computer sales and installations. On the other hand, the availability of a complete range of terminals will certainly further enhance our CENTURY sales." (DX 719, p. 1.)

NCR made a similar prediction concerning terminals in its 1969 Annual Report:

> "More and more people will be brought into direct communications with computers through a variety of data terminals and data display devices. In fact, it is anticipated that by 1975 users of data processing systems will be investing as much or more in data terminals and related communications equipment as in the central computer itself. This will create major new opportunities for the business equipment industry and particularly for companies such as NCR which has extensive experience in data entry devices." (DX 367, pp. 9-10.)

And:

> "A decade ago, almost all business machines were sold as free-standing equipment. Today, many of these products as well as entirely new types of equipment are linked together as "total" systems to meet individual customer needs. Such systems often include arrays of compatible computer equipment including communications networks." (DX 367, p. 19.)

Those predictions turned out to be accurate. During the 1970s, NCR found that "the capabilities and price/performance of its terminals [were] an important factor in convincing users to take NCR computer systems." (Oelman, Tr. 6183; see also below pp. 998-99.)

By 1970 it was plain that NCR had proceeded "methodically" in the computer business, avoiding risks but avoiding also the great success that comes with successful risk-taking. Between 1964 and 1970, NCR's most significant development was the introduction of two models (the Century 100 and 200) of a system the principal features of which had been available on IBM's System/360 delivered three years earlier. With this gradual development, however, NCR reduced the chances that it would be a failure like GE and RCA and found itself positioned to turn the corner in the 1970s, which it ultimately did. NCR's domestic EDP revenues for the year 1969 were $179,298,000, over five times its U.S. EDP revenues in 1963. (DX 8224, p. 3.) Even with that growth, NCR's domestic EDP revenues accounted for only 26 percent of NCR's total domestic revenues but double what it had in 1963. (DX 367, p. 6.)

46. <u>Control Data Corporation (CDC).</u> The period from 1963 to 1969 was one of rapid expansion for CDC. It added to its two principal product lines, the 3000 and 6000 series; it expanded the applications capabilities of its computers to include not only a scientific emphasis but also business-oriented software; for the first time, it developed, manufactured and marketed a broad line of peripheral equipment, including OEM sales to other companies and IBM plug-compatible equipment; it expanded its overseas operations; it made a large number of acquisitions, including, most importantly that of Commercial Credit Corporation, a large financial services company; and, finally, it greatly expanded its data center business. CDC's total EDP revenues grew from $85 million in 1963 to $570 million in 1969. (DX 298.) Its U.S. EDP revenues grew from $88 million in 1964 to $458 million in 1969. (DX 8224, p. 5.) Its assets increased from $71 million in 1963 to $761 million in 1969. (DX 302.) To finance that expansion, at least in part, CDC raised over $767 million between 1963 and 1969 through equity and long-term debt financings. (DX 300.)

The discussion below focuses on five principal areas of CDC's growth during the 1963-1969 period: First, CDC's major product announcements, including, principally, its 6000 and 3000 series, and their success; second, the increasing use of CDC computers to perform both scientific and commercial applications; third, CDC's expanding peripheral equipment offerings, both as attachments to CDC systems and as OEM products sold to other companies; fourth, the expansion of CDC's data centers; and, fifth, the way in which CDC's growth took place, *i.e.*, by vertical integration and acquisition.

a. CDC's 6000 and 3000 Series Offerings (1963-1969).

(i) The 6000 Series. CDC's most important product in the 1960s was undoubtedly the 6600 computer, announced in July 1962 in connection with a contract let by the Atomic Energy Commission's Lawrence Livermore Laboratory, and first delivered in September 1964 (seven months later than the date contracted for). (JX 10, ¶ 4.) CDC Chairman and Chief Executive Officer William Norris* described the 6600 as a "very great risk" since "it was a trip into the unknown" and

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* William Norris was one of the four founders of Control Data in July 1957. (Tr. 5604.) In August 1957 he was elected to the Board of Directors and to the position of President of CDC. In 1958-59 he assumed the additional title of Chairman of the Board of CDC. At the time of his testimony in 1975, Mr. Norris had been Chairman and Chief Executive Officer of CDC for over seventeen years. (Tr. 5596-97; PX 355, pp. 11-29.) Prior to the formation of CDC, Mr. Norris was General Manager of the Univac Division of Sperry Rand. (Tr. 5603.)

R. D. Schmidt joined CDC in 1962 as a salesman. At the time of his testimony, Mr. Schmidt was a member of the Board of Directors of CDC, Executive Vice President of the corporation and Chairman of its Export Strategy Committee. (Tr. 27199-201.)

J. W. Lacey had been employed by CDC for approximately fifteen years at the time of his testimony, and held the position of Senior Vice President of Corporate Plans and Development. In addition, he was Chairman of CDC's Operations Committee and a member of the Board of Directors of CDC's Commercial Credit Corporation subsidiary. (Tr. 6552-53.)

Gordon Brown, at the time of his testimony, was Senior Vice President of Marketing and Planning for CDC's Peripheral Products Company. (Tr. 50977-78.)

H. W. Forrest testified by deposition. (DX 13526.) Forrest worked in the Univac Division of Sperry Rand under Norris and moved with Norris to CDC. (*Id.*, pp. 42-44.) At the time he was deposed, Forrest was Senior Vice President, Government Relations, for CDC. (*Id.*, p. 4.)

testified that CDC was "betting the future of the company" on it. (Norris, Tr. 5616.) But, as did IBM with System/360, CDC received considerable returns on its "bet". Despite early problems with the 6600, CDC ultimately was successful with it and with the other 6000 Series computers. (See Norris, Tr. 5849-51.)

On December 15, 1964, some eight months after IBM's System/ 360 announcement, CDC formally announced the "6000 Series", then consisting of the compatible 6400, 6600 and 6800 computers.* (DX 319.) In the announcement press release, Norris described the 6000 Series as "the industry's most extensive product line of super-scale computers . . . provid[ing] business, industry, science and government users the most comprehensive range of software and system compatibility ever announced in the computer industry." (DX 319, p. 1.) Purchase prices for typical 6000 Series systems were announced as ranging "from less than $1 million to several million" with rental prices from $25,000 to $150,000 or more per month.** (DX 319, p. 3.)

By the end of 1964, CDC had received "possibly five or six" orders for the 6600 (Norris, Tr. 5624), although top officials at IBM had believed as early as the Fall of 1963 that as many as 10 accounts were then planning to order CDC 6600s. (JX 10, ¶ 9.) Deliveries of the 6600 were delayed, however, due to unanticipated technological

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* The 6800, however, was never delivered. (Norris, Tr. 5967; JX 10, ¶ 34.)

** CDC later announced two more models of the 6000 Series, the 6500, announced in March 1967, and the 6700, announced in May 1969. (PX 355, pp. 36-37; see Norris, Tr. 5626.) Norris described the 6500 as "actually two 6400's connected together" and the 6700 as "somewhat more powerful", being "basically two 6600s." (Tr. 5626.)

problems in 1964, 1965 and 1966. (See JX 10, ¶ 34; Norris, Tr. 5853-54.) By 1966 CDC had solved its technological problems and reported to its stockholders on the problems which had occurred in its development of large systems:

> ". . . The development and manufacture of very large computers are extremely difficult,and severe technical problems are inherent in the process. In a past stockholder report, it was emphasized that estimating completion dates of very large computer developments is becoming increasingly difficult. Last year at this time we believed we had found solutions to the major technical problems in connection with the 6600. Experience since then has proven that, while this was generally true, the estimate was in error on the time and effort required to make the necessary changes in the equipment and programs. The process took longer than anticipated; as a result, we incurred increased penalties for late delivery and retrofit costs." (DX 13839, p. 2.)

CDC also found it difficult to establish a price for the 6600. In April 1964, CDC submitted 6600 proposals to the Bettis Atomic Power Laboratory (BAPL) and the Knolls Atomic Power Laboratory (KAPL), in competition with IBM, Burroughs, Philco and Sperry Rand proposals.* (JX 10, ¶ 12; Norris, Tr. 5620; DX 4960, p. 5.) The bidding process was highly competitive. Initially, BAPL and KAPL selected CDC and Burroughs respectively. Later, however, both BAPL and KAPL changed their selections to IBM. (JX 10, ¶ 12.)

Six months later, CDC was told by the Government that it was interested in reopening the BAPL and KAPL negotiations if CDC was prepared "to sharpen [its] pencils". (Norris, Tr. 5620.) According to CDC Chairman Norris, BAPL and KAPL then misled CDC "in a deliberate manner" as to the terms of the IBM offering, telling CDC "that IBM had

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* IBM proposed 360/90's, with the interim installation of Model 70s until the 90s were ready for delivery. (JX 10, ¶ 12.)

offered a computer at four times the power of the 6600 at a lower price", as well as misrepresenting the date at which IBM could deliver its equipment. (Norris, Tr. 5970-73; PX 367, p. 5.) CDC made an "unsolicited proposal" to BAPL and KAPL in late February 1965 "at a price substantially lower than that previously proposed by CDC and substantially lower than the price proposed by IBM."* (JX 10, ¶ 12; DX 324.) CDC "proposed a combination deal which would involve replacing the 6600 within some period of time . . . with the computer that would be much more powerful than the 6600, . . . the 6800, and at the time the 6800 was delivered, that we [CDC] would take back in trade the 6600." (Norris, Tr. 5621.)**

CDC, "unfortunately" according to Norris, ultimately won the BAPL and KAPL contracts. (Tr. 5963, 5976; JX 10, ¶ 12.) Moreover, it was unable to meet the delivery dates and, as a result, was required to

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* CDC had earlier reduced the price on the 6600 because of "substantial reductions in prices of component parts (transistors, diodes, etc.) which . . . occurred in [1963 and 1964]". (DX 13838, p. 4; Schmidt, Tr. 27416.)

** One other aspect of CDC's pricing policies is worthy of note. Both Norris and Lacey testified that, as a general rule, CDC set the prices for its computer systems five to ten percent below IBM's prices. (Norris, Tr. 5653; Lacey, Tr. 6567-70.) According to Lacey, this was "[b]ecause our [CDC's] experience tells us that if we on a grand average basis go significantly higher than that, that our opportunity for business rapidly diminishes". (Tr. 6573.) CDC considers the "prices of all manufacturers but principally the prices of IBM and, secondarily, of other manufacturers". (Lacey, Tr. 6569.) Norris and Lacey admitted, however, that it is extremely difficult to compare accurately the performance of the system of one manufacturer as against that of another manufacturer. (Norris, Tr. 6038-40; Lacey, Tr. 6800-01.) Norris testified that computer companies compete on the basis of a variety of factors other than price; reliability is a factor, for example. (Norris, Tr. 6040-41.)

pay substantial penalties which further reduced its effective price. The final settlement was "substantially disadvantageous to Control Data". (Norris, Tr. 5976-78.) For a time, difficulties with the 6600 adversely affected CDC. According to Norris:

> "We were losing money as a company in 1966/1967 primarily because of problems with the 6600 computer. Frankly, there was a great deal of conflict in top management in 1966 over whether we should press forward or retrench--closing down data centers was high on the list of retrenchment possibilities. The decision was made to press on, however there were some deserters in top management as a result--they were afraid that the ship was sinking." (DX 284, p. 6; see also Norris, Tr. 5678-79.)

Mr. Norris also testified that CDC "had to rush into the 6600" because it had been "literally clobbered by IBM competition" to CDC's earlier 1604 computer system, and that with the 6600, CDC again faced the "enormous impact of competition from IBM". (Tr. 5625.)* Ultimately, however, the 6600--and the 6000 Series in general--proved to be "particularly" successful for CDC. (See Norris, Tr. 5849-51.)** In 1969, for example, CDC successfully bid for an Air Force procurement to replace Univac and IBM equipment with 12 or 13 6000 Series machines,

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* Such militant language by persons speaking for firms in a competitive environment is not uncommon. For example, CDC's chief development engineer for the 6000 Series, Vice President Seymour Cray, at CDC's June 1963 corporate planning meeting, urged that CDC announce the 6600 and a successor in order to "slug" IBM because, in his opinion, IBM had "made a mistake by putting all [its] eggs in an integrated circuit basket". (DX 13526, Forrest, pp. 748-750.)

** CDC received more than $286 million in revenue and more than $185 million in gross profits from the 6600 computer systems during the period 1964-1972. CDC's gross profits on the 6600 exceeded its gross profit objective which was set to yield a reasonable rate of return on investment and a reasonable net profit at the bottom line. (DX 1185, pp. 3-5.) We are aware that DX 1185 is an offer of proof and not evidence; however, we rely on this offer of proof because it is consistent with the other evidence about the success of the 6600 systems and the growth of CDC.

including several 6600s. The contract was for systems "to handle the entire inventory scheduling acquisition of spare parts for the Air Force Logistics Committee" and its aggregate value to CDC was approximately $40 million. (Schmidt, Tr. 27469-76.)

CDC finally manufactured 94 6600/6700* computers (as compared to some 17 360/90s manufactured by IBM, including four for use within IBM) and a total of 215 CDC 6000 Series computers. (JX 10, ¶¶ 35, 36.)

In the late 1960s, as a successor to the 6600 and a replacement for the never-delivered 6800, CDC developed the 7600 computer, which it officially announced in December 1968 and first delivered the following month--more than 21 months after the first committed delivery date for a 6800 and seven months later than the delivery date called for in the first contract using the machine designation "7600". (Norris, Tr. 5628; JX 10, ¶ 34; PX 355, p. 39.) Norris characterized the 7600 as "several times more powerful than the 6600 and it addresses the same market". (Tr. 5628.) CDC installed its first two 7600 computer systems during 1969 (DX 13843, p. 4) and in that same year, CDC Vice President J. W. Lacey, speaking to a CDC graduate orientation class, described CDC's success as follows:

> "[W]e have a world-wide leading position in large computers today. That position is widely recognized. Since 1964, with the delivery of the first 6600 Computer, followed recently by the 7600 Computer, Control Data has dominated this market. Second, there is a rapidly increasing trend towards very large computers used in data processing networks in which many users share the enormous power of machines like the 6600, and away from medium sized and small sized stand-alone computers. . . ." (DX 438, p. 7.)

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* The 6700, announced in May 1969, was "basically two 6600's". (PX 355, p. 37; Norris, Tr. 5626.)

Looking to the future of the company, Lacey said "[w]e believe that our position today and the direction we are giving our business puts us in an outstanding posture to share in the explosive future growth of our industry". (Id., p. 13; see also Lacey, Tr. 6676-77.)

(ii) The 3000 Series. The 6000 Series was not the only product line developed by CDC in the 1960s. CDC also significantly expanded its 3000 Series. In September 1963, CDC announced its 3200 computer; in January 1964, it announced the 3400. (PX 355, p. 34; Norris, Tr. 5627.) Norris testified that the 3200 competed with "IBM, Univac, Burroughs, NCR to an extent, and possibly SDS". (Tr. 5627.)

1965 saw the continued expansion of CDC's 3000 Series. The 3300 was announced in November 1965 and delivered in that same month. (PX 355, p. 35.) Norris described the 3300 as CDC's "entry into timesharing. And, again, I think it had some added features for business data processing. And it was a considerably lower-priced machine than, say, the 6600. It was what you term then a medium-size computer." (Tr. 5627-28.) According to Norris, it competed with "IBM, Univac, Burroughs, SDS and NCR." (Id.)

The 3500 was announced in November 1965, although it was not delivered until 1969. (PX 355, pp. 35-36.) Norris testified that it was "essentially the same computer" as the 3300 except for the use of integrated circuits and "somewhat larger memory options". (Tr. 5628.)

In 1967, CDC announced its 3150 computer, the smallest of the 3000 Series, stating that it "provides a complete business and scientific information handling capability with a minimum of hardware and software. The 3150 provides maximum throughput at low initial cost to the user and the capability for him to expand upward as his information handling needs grow." (DX 13840, p. 8.)

The 3000 Series was a substantial success for CDC, without, in large part, the start-up problems that beset the 6000 Series. Indeed, as early as 1966, CDC was able to describe its 3200--which was introduced little more than two years earlier--as "highly successful". (DX 13839, p. 5.) And in 1968 CDC reported to its stockholders that "orders for our 3000 product line continue to increase-both in the number of systems ordered and in average dollar value." (DX 13842, p. 2.) The 3000 Series was successfully marketed for applications in manufacturing, general business data processing, education, medicine, data services and the brokerage business. (DX 13843, p. 4.) Moreover, it gave CDC a lower-priced alternative to the expensive 6000 Series computers.

b. <u>CDC's Expansion into Commercial Data Processing.</u> As the decade began, CDC perceived itself as offering large, "scientific" computers. Very quickly, however, CDC learned that the distinction between scientific and commercial data processing--if indeed there ever was on--had blurred almost to the vanishing point, and by the end of the 1960s, CDC estimated that fully 40 percent of its business came from "pure business data processing". (Schmidt, Tr. 27476-78.)

CDC's Chairman Norris described CDC in the early and mid-1960s as "a supplier of large-scale digital computers to scientific and engineering applications". (Tr. 5624.) Norris also testified that, at the time of its announcement in 1962, CDC thought that the 6600 "would be unique to a great extent . . . it being so much more powerful and so well-suited to scientific work, it would just be outstanding in the eyes of those laboratories that have these very large scientific problems". (Tr. 5617-18.)

CDC Vice President, Gordon Brown, described the entire 6000 Series as announced as

> "very definitely a scientific line of computers, and therefore, the analyses that we did showed that the strength of the 6000 product line prevailed . . . over IBM and Univac in most typical environments; and, on the other hand, proved to be deficient when it was employed in an environment requiring a lot of input/output of data, or commercial type requirement [because] the architecture of the 6000 series was designed with the scientific user in mind. It had a large, fast, central processor with a number of auxiliary processors to handle the input/output functions. And it had a large, very fast disk storage capability associated with it." (Tr. 50996.)

By October 1965, however, the CDC Executive Council* had recognized that there were no longer separate markets for scientific and business data processing. (DX 276; see Norris, Tr. 6002-06; Tr. 6081-82.) Thus, between 1964 and 1968, according to Brown, "gradually additional capabilities were added to the 6000 computer system, and these included COBOL compilers of sort and merge packages and the ability to handle permanent files as opposed to using the input/output devices as auxiliary storage or temporary storage of data files." (Tr. 53064-65.)

Similarly, CDC Vice President Schmidt testified that although

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* Lacey described the CDC Executive Council as "responsible for advising our Chief Executive Officer concerning major business questions". (Tr. 6556.)

"[i]n the early stages of the 6000 marketing effort, we aimed at primarily the scientific applications . . . that has changed." The change "started with the coding of a COBOL compiler for the 6000 Series and the 6600 specifically." (Tr. 27457.) CDC described the introduction of a COBOL compiler for its 6000 Series in 1967 as "an important achievement, for we are now able to provide our customers with the full power of our super computers to handle the broad scope of their data processing problems." (DX 13841, p. 4.) Then came the development of application programs for the 6000 Series in COBOL and the sale of "some limited number of [business] applications, usually in conjunction with primary scientific applications." By 1968, CDC had sold 6000 Series systems in Mexico "which were devoted primarily to business data processing, using that COBOL compiler and the COBOL application programs." And in other situations, customers with business applications as well as scientific applications ordered a 6600 system to do both. (Schmidt, Tr. 27457-58.)

The primary impetus for the broadened use of the 6000 Series came from customers who wished to have a single machine capable of performing both commercial and scientific applications--one of the primary reasons that led IBM to develop with System/360 the capability to do both applications equally well. (Norris, Tr. 5618; see JX 38, pp. 27-29; see pp. 290-96 above.) As Norris testified:

> "We found that there were large companies who, while the majority of the work that they wished to do was of an engineering and scientific nature, still they had a certain amount of business data processing and that they preferred to have only one computer as opposed to having two computers, one for scientific and the other for business.

> "So, we set about to broaden out the software which was available with the 6600 so that we could meet the requirements of those customers where the bulk of the work was still scientific but still the 6600 would do the business data processing well enough so that the customer only had to have the one computer." (Tr. 5618.)

While CDC also introduced the 3000 initially as "basically scientific", it realized from the outset that the 3000 Series "had a little bit more versatility as a business data processing machine than the 6600". (Norris, Tr. 5627.) Over time, CDC added hardware features and software packages to enhance the 3000 Series desirability for business applications. (Brown, Tr. 50990-91.)

Among the uses of the 3200 during the first years of that system's life were: medical research and training and use in "flight-testing ground stations" (DX 13838, p. 7); and use in combination with a 3600 "to integrate the computing and business data processing" for the 57 associate companies of Phillips, the Dutch manufacturer. (Id., p. 9.)

In 1965, CDC announced the 3300 which, according to Norris, "had some added features for business data processing." (Tr. 5627; PX 355, p. 35.) In its 1967 Annual Report, CDC stated that "the variety of applications being handled by the 3300 include production scheduling, labor analysis, data communication, inventory control, engineering computations, and general business data processing." (DX 13840, p. 8.) And by 1966, according to Brown, "the 3000 product line . . . was evolving to a . . . better balanced product line between both the scientific and the commercial users. The initial base of customers had largely been scientific users, and many of them were starting to expand their applications for commercial usage." (Tr. 50997, see Tr. 50990.)

c. <u>CDC's Expanding Peripheral Business.</u> In its early years, CDC did not manufacture its own peripheral equipment. (Norris, Tr. 5609; see PX 6066, p. 1.) In the 1963-1969 period, however, CDC began to manufacture peripheral equipment not only for attachment to its own processors but also as an OEM supplier for other EDP companies. In addition, CDC laid the foundation for its later very successful entry into the IBM plug compatible peripherals business.

By the early 1960s, CDC had recognized that the sale of peripheral equipment was potentially a highly profitable opportunity and therefore began to expand its peripheral offerings. For example, in 1964, in its news release announcing the 6000 Series, Norris stated:

> "[N]umerous peripheral devices . . . are under development and will be announced over the next two years to complete the implementation of products required for total management information systems. These peripheral devices include:
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> "Disk files--not only low-cost units but very sophisticated, high capacity, low access time, extremely high transfer rate, mass memories.
>
> "Mass core memory.
>
> "Remote terminals and processors for on-line man/machine interaction.
>
> "Optical character recognition readers.
>
> "Line of visual displays.
>
> "Line printers, card punches and readers."
> (DX 319, p. 3.)

In 1965, CDC acquired Data Display, Inc., a manufacturer of "electronic display peripheral equipment". (PX 355, p. 5; DX 296.) In

1965, CDC announced its 852 disk drive which was "in many ways like the IBM 1311". It was marketed "in a very modest way" on an OEM basis to GE and Honeywell in Europe (Brown, Tr. 51015-17) because "there was very little market demand for this type of product at the time, and CDC was just beginning to build and staff an effective market and service organization." (Brown, Tr. 51015-51017.)

In 1966, CDC announced its 9433/34 disk drive--an IBM 2311-type device, although it was not media compatible with the 2311 drive--on an OEM basis, with first shipments occurring in 1967. CDC's principal OEM customers for the 9433/34 were Honeywell, GE and RCA, as well as ICL in Great Britain and Siemens in Germany.* CDC eventually sold some 16,000 9433/34 drives in the late 1960s on an OEM basis, at prices less than one-half that of the IBM 2311. (Brown, Tr. 51056-58.) The development and marketing of such IBM-type devices, of course, foreshadowed CDC's later decision to produce IBM plug-compatible peripherals. (See Brown, Tr. 51063-67.)

In the 1966-67 time frame CDC also began to market peripherals originally designed for its 6000 Series on an OEM basis, such as the 6638 disk file, which was sold to Honeywell, ICL and GE as the 9490.**

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* CDC stated its view of the computer market in its 1965 annual report as follows:

> "We view the computer market as a world market, and plan our organization and operations to maximize our abilities to best satisfy our customers in that market." (DX 14214, p. 5; emphasis in original.)

** Less than 40 9490 disk files were shipped, however, according to Brown, because there was not a large market at that time for that type of fixed non-removable storage disk device and because not many OEM customers had channels that could take the high data rate of the 9490. (Tr. 51033-34.)

(Brown, Tr. 51032-34.) In 1967, CDC introduced a new line printer, new tape transports, a card read-punch, a magnetic drum storage unit and several new versions of electronic display terminals. (DX 13840, p. 8.)

During 1968, CDC added to its peripherals product line "a 5 billion bit disk file, a 1200 line per minute printer, and a new generation of tape transports". (DX 13841, p. 8.) At the same time, it informed its stockholders that "[i]ndependent suppliers and the in-house developments of major computer manufacturers do and can be expected to continue to intensify competition." (Id., p. 8.)

And in 1969, CDC introduced six more new peripheral products: a disk storage unit, two printers, a card reader, a display terminal, and a drum device. (DX 13843, p. 6.) Also, CDC announced an IBM 2314-type device in 1969 for use with CDC's 3000 Series, 6000 Series and CYBER 70 product lines. (Brown, Tr. 51068-69.)

By the end of the 1960s, CDC "had made major investments in technology in most of the principal peripheral areas. This started with the development of subsystems for use in [CDC's] own computers and carried through most of the Sixties . . . into the development of a fairly large base of OEM business." (Brown, Tr. 51212; DX 438, p. 12.)

d. Data Centers. CDC also greatly expanded the data center (service bureau) portion of its business in the 1963-1969 period. In 1964, for example, CDC had six data centers. (DX 13838, p. 8.) By 1969, it had more than 40 "throughout the world". (DX 13843, p. 6.)

The six data centers operated by CDC as of 1964 used CDC 3600 and 1604-A computer systems, forming a network--later known as CYBERNET--"tied together by Bell System Data-phones" and "providing complete data processing services to commercial and government users on a contract basis." (DX 284, p. 4; DX 13838, p. 8.) Typical of the many applications processed at the centers were "Operations Research applications", "traffic surveying and planning", "Hospital data processing" and "school scheduling and grade reporting". (DX 13838, p. 8.)

By 1965, CDC had seven data centers and had begun its "network development". (DX 284, p. 4.) However, "[e]xcept for brief periods in the mid-60's, data centers in the aggregate operated at a loss until 1972 because [CDC] kept pouring money into expansion". (Id.)* Norris, in a draft of a speech in 1973, cited this as an example of CDC's "willingness to take risks". (Id.)

In the fiscal year ending June 30, 1968, CDC acquired C-E-I-R, a company which offered computer programming and other professional data processing services, and Pacific Technical Analysts, Inc., claimed to be "the largest and most capable programming and service center company serving the Western Pacific area". (DX 13841, p. 2.) By the end of fiscal 1968, CDC was operating over 30 data centers worldwide and offering "an extensive inventory" of application programs. (DX 13841, p. 7.)

In 1969, CDC offered the following description of its CYBERNET network of data centers:

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* Accounting losses which result from expenditures made for the purpose of achieving later returns, are, of course, not truly economic losses but rather investments.

"Through the highly advanced CYBERNET service, customers have convenient access to the cost/performance advantages offered by both the CDC 3300 and 6600 computers without having to make large capital outlays." (DX 13843, p. 6.)

With more than 13,000 miles of communications lines by the end of fiscal 1969, CDC was offering its data services at more than 40 data centers throughout the world, a more than 550 percent increase over its 1964 holdings. (Id.)

e. CDC's Acquisitions (1963-1969). The story of CDC's expansion in the 1960s cannot be fully understood without considering CDC's acquisitions during that period. Between 1963 and 1969, CDC acquired some 43 companies, at a total cost of over $897,000,000. (Norris, Tr. 5788-89; PX 355, pp. 3-9; DX 296.) All of those companies--with the exception of Cedar Engineering, Kerotest and Commercial Credit Corporation (which is discussed in some detail below)--were supplying an EDP product or service at the time of acquisition. (Norris, Tr. 5794-95.)

CDC's numerous acquisitions, most of which were paid for by CDC stock (Norris, Tr. 5789), enabled it to broaden its product and service offerings quite rapidly without the substantial development time that internal expansion would have required.* As Norris stated in a draft of a 1973 speech:

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* That is not to say that CDC did not expand internally as well, particularly through increased vertical integration. For example, CDC decided in 1966 to have its research division manufacture integrated circuits for use in the prototype of the 3500 computer rather than buy circuits from Texas Instruments. (DX 432.) Also in 1966, CDC reduced costs by bringing the manufacture of card module assemblies, memory cores, memory planes, memory stack assemblies and logic chassis assemblies in-house. (DX 13839, p. 9.)

> "Our high P/E ratio stock, or Chinese money, as we often termed it, was used to acquire companies with complementary technology, products, services and markets. In other words, we were not trying to broaden our base as in a conglomerate, but rather to buy new computer products and services and markets to spread development costs and gain economies of scale as rapidly as possible." (DX 284, p. 7.)

Norris agreed that this was "an alternative to investing money in research and development" and was "very successful for Control Data for that purpose". (Tr. 5804-07.)

Speaking about the acquisitions in general, Norris testified:

> "[W]e wanted to have our own peripheral equipment to put on our computer systems so that we would have full control over the cost and quality. We wanted to broaden out our product line both with respect to hardware as well as software.
>
> "In some instances we bought data services businesses, which gave us additional revenue and profit. And we were able to take those services in turn and have them sold by a larger marketing organization." (Tr. 6092-93.)

Thus, in the fiscal year ending June 30, 1964, "Control Data made significant additions to its technical capabilities and product lines, and broadened its market areas" by way of a number of acquisitions. It acquired companies with capabilities in the areas of: digital computers for use in power, chemical, petroleum and oil industries; card punch and reader systems and other peripheral devices; optical character recognition equipment; data collection systems; data processing services; printers; and analog to digital conversion equipment. (DX 13838, p. 5.)

In the fiscal year ended June 30, 1965, CDC acquired companies with capabilities in electronic display devices and programming consulting services, as well as a business data processing center and two companies whose products, involving radar, for example, incorporated the use of digital computers. (PX 355, pp. 5-6.)

In the year ended June 30, 1966, CDC acquired the commercial computer operation of General Precision Inc.'s Librascope Group. "Included in the purchase were General Precision's commercial computer rental and service contracts, and inventory of commercial computers" as well as its "highly experienced commercial computer sales and service organization." Other acquisitions were of an electronic systems engineering company, a Hong Kong firm doing assembly of electronic components, particularly ferrite cores, and an Italian firm operating data centers in Italy. (DX 13839, p. 3.)

In 1967, CDC acquired, among others, C-E-I-R, (DX 296, p. 2) because, as Norris testified:

> "[C-E-I-R] had the American Research Bureau, which was using a computer in surveying the listener response in the television and radio industries; there was Automation Institute--these are schools to teach computer programming and computer operation; there was a data services business . . . . And it was primarily those three areas that were particularly interesting to Control Data." (Tr. 5796-97.)

CDC Vice President Lacey testified that the acquisition of C-E-I-R "was an additional entry for Control Data into the data services and consulting services business, beginning steps of our broadening of our business line". (Tr. 6632-33.)

CDC's single most important acquisition--Commercial Credit--occurred in 1968. (PX 355, p. 8.) In August 1968 CDC acquired Commercial Credit, "a diversified financial institution . . . with nationwide and Canadian operations in financing, lending, leasing, factoring, and insuring" (DX 13342, p. 16) for 4,825,720 shares of CDC stock, with a total market value of $745,573,740 (PX 355, p. 8)--by far the most expensive acquisition made in the 1960s by Control Data. (Id., pp. 3-9.) The principal reason CDC acquired Commercial Credit was to gain a financial services subsidiary in order to enable CDC better "to finance computer leasing." (Norris, Tr. 5643; see Lacey, Tr. 6586-88.)

Initially, CDC marketed its computer systems on a purchase-only basis. However, by 1961 or 1962, CDC had realized that many EDP customers demanded leases and, accordingly, it began to offer its system for lease as well as purchase. (Norris, Tr. 5641-42.) Hence, CDC over time has offered one-year, three-year, five-year and longer leases. (Norris, Tr. 5644.) CDC first offered three-year leases in 1966 and non-cancellable five-year leases in 1967, both at a discount from its short term lease price. (DX 295.)

CDC's changeover to leasing as well as purchase required that CDC "raise additional sources of capital . . . [i]n order to finance the leases [because] when you lease a computer you get paid on a monthly basis, but you have to incur the total cost of the computer at the time it is delivered." (Norris, Tr. 5642-43.) Thus, in 1966, CDC entered into an arrangement with Leasco whereby Leasco would purchase CDC systems and then lease them to customers on a long-term basis. (DX 13839, p. 2.) However, CDC cancelled that agreement the following year "in light of current and prospective financing plans of the Company". (DX 13840, p. 12.) According to Norris, it was not until CDC acquired Commercial Credit Corporation in 1968 that CDC ultimately "solved the problem of financing leases". (Tr. 5643-44.)

f. Conclusion. When the 1960s began, CDC was a virtual new entrant in the EDP industry, having been incorporated only three years earlier. (DX 271, p. 7.) It perceived itself as being principally, if not solely, a supplier of large scientific computers. (Norris, Tr. 5624.) By the end of the 1960s, CDC was firmly established as a major, diversified competitor in the EDP marketplace. It had achieved great success with its 6000 Series computers. It had added considerably to the business data processing capabilities of its computer offerings, to the point that by 1969 approximately 40 percent of its business came from "pure business data processing". (Schmidt, Tr. 27477-78.) It had greatly expanded its peripheral equipment offerings and begun a successful business as an OEM supplier of peripherals. And it had increased the number of its Data Centers from six to 40. (DX 13838, p. 8; DX 13843, p. 6.) The 1960s were indisputably a period of great success for Control Data Corporation.

47. SDS. Scientific Data Systems ("SDS") was formed in 1961 with an initial capitalization of approximately $1 million, raised from a San Francisco venture capital company and the firm's original founders. (Palevsky, Tr. 3128, 3193.)* SDS was the idea of Max Palevsky who furnished approximately $60,000 to $80,000 of its initial capitalization: "I put up half the money in cash and half as a note." (Palevsky, Tr. 3127, 3193.) For his investment, Palevsky received "something in excess of 15%" of SDS's equity. (Palevsky, Tr. 3193-94.)

Palevsky had begun his business career as a research analyst for the Bendix Corporation in 1952, in "the division of Bendix that was starting to explore computers". His responsibility was "[p]rimarily logic design, computer design . . . . It was a time when everybody did everything". Upon leaving Bendix in 1956, Palevsky organized the Packard Bell Computer Corporation, a subsidiary of Packard Bell, which "buil[t] specialized digital computers, special purpose digital computers, and eventually a small general purpose

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* The witnesses testifying about SDS/XDS (SDS was called XDS--Xerox Data Systems--when it became a division of Xerox) were Max Palevsky (described above), Harvey Cohen and F. R. Currie. Only Palevsky was with SDS in the early years. Cohen arrived about 1964 and held a number of positions, including in 1967-68 the Director of Marketing Operations. (Cohen, Tr. 14427-28.) Currie also came in 1964 and held various marketing positions, becoming Vice-President of Sales in 1968-69. (Currie, Tr. 14909-13.) At Xerox Data Systems, Cohen became Vice President of Advanced Systems, Business Development Group (Cohen, Tr. 14427-28, 14521) and Currie became Vice President of the Data Processing Division reporting to Cohen. (Currie, Tr. 14917, 14922-23.) Currie later moved to the Corporate Marketing staff. (Currie, Tr. 14923-24.)

computer and digital systems".* (Palevsky, Tr. 3121.) In 1961, Palevsky left Packard Bell because

> "that company had come on hard times. The ideas I had about how to proceed in the computer industry required much stronger backing from the parent company which they could not provide. . . . I also felt that the computer industry is a very unique kind of industry, and it was very difficult working under a management that really knew nothing about the industry itself, so that it made sense to be independent, and, of course, there were opportunities to make a great deal of money". (Palevsky, Tr. 3127-28.)

SDS initially conducted all its activities in a 5,000 square foot facility with approximately 17 people of whom 12 were professionals. (Palevsky, Tr. 3196, 3198; DX 45, p. 4.) Its first product was the SDS 910 computer system, delivered in mid-1962, less than a year after its organization. (PX 5774, p. 13.) That first product was designed to take advantage of an opportunity perceived by SDS for high performance hardware offered with little support to sophisticated customers for use in real time applications. The market opportunity in fact existed and the 910 and subsequent products were very successful. SDS built on the success of its initial specialization. Throughout the 1960s, it successfully expanded its product line both by offering its computers to a wider set of customers for a wider range of applications and by producing more and more of its own peripherals and software, which it had previously acquired from other vendors.

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* Palevsky defined a general purpose digital computer as "an electronic device with a stored program, which may be changed, and depending upon the program, can operate a large variety of tasks". (Tr. 3132-33.)

SDS grew at an extraordinary rate while also achieving substantial profitability--in fact, SDS "produced continually increasing profits virtually from inception". (PX 5774, p. 6.) Its average annual compound growth rate from 1962 to 1968 was 115%. Even after the first two years, it continued to grow at a rate of approximately 50% per year. (DX 46, summarizing data contained in DX 44 and DX 45.) Its revenues, which by 1964 had reached $20.5 million, rose to $100.7 million by 1968, the last full year before it merged with Xerox. SDS was merged with Xerox in 1969, in exchange for Xerox stock valued at approximately $980 million. Of this amount, Palevsky received approximately $100 million worth of stock. He had also received several million dollars from previous sales of SDS stock. (Palevsky, Tr. 3195-96.)

a. The SDS Entry Strategy. SDS implemented a consciously determined strategy to capitalize on what it saw as a market opportunity. Palevsky testified that at its formation in 1961, SDS had "two markets" in mind for its products, "one market being what I would characterize as the real time computer market, and the other, the small to medium scientific computer market". (Palevsky, Tr. 3133.)* SDS began to market computers of high performance hardware offered for real time applications to customers that did not need a

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* Palevsky described "scientific data processing" as processing where "a relatively small amount of data is entered into a computer, a large number of arithmetic operations are performed on data and a relatively small amount of data is produced in some printed form". "Business data processing", he said, "has the opposite meaning". (Palevsky, Tr. 3136.)

lot of software and support services from the manufacturer.* (Palevsky, Tr. 3137; PX 2103 (Tr. 23290).)

As Palevsky testified:

> "It was part of the market that essentially no one had attended to. At that time the other companies were really concentrating primarily on computers as devices into which one fed documents that contained data, cards, tapes, etc., and out of which one got printed answers.
>
> "Our computers were intended for a market which fed real time data, that is, data that came from centers in a steam generating plant or a missile launching site or some astronomical instrument and produced signals that, say, worked the valves on a steam generating plant or indicated to other pieces of equipment within the launch site the status of various functions within a space vehicle so that it didn't work as a computer works in an air-conditioned computing center, but rather as part of the whole complex of operational equipment". (Tr. 3135.)**

This strategy was highly successful. Palevsky testified that SDS, "at the beginning", was able to sell its products with "a very large gross profit":

> "We were able to do that at the beginning because we provided hardware, that range of hardware and other services that was

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* SDS did not initially attempt to market its product to "business data processing customers" because SDS "didn't have the kind of people who understood the business market and the need of the business market and we had not developed the software, the applications engineering, the general support that the customer needed". (Palevsky, Tr. 3137.)

** In its 1966 Annual Report, SDS described its formation as follows:

> "In 1961, when SDS was founded, highly experienced technical personnel skilled in the design, production and marketing of small scientific and systems computers were uniquely available in southern California. During that same period, the scientific and engineering segment of the computer market required small, real-time computers which could monitor and control experiments or testing programs and rapidly process the results. Recognizing the requirements of this market, the initial objectives of SDS management were to attract competent technical personnel and effectively apply their experience to meet this demand." (DX 982, p. 4.)

relatively unique and consequently the customer was willing to pay a relatively large sum for it." (Palevsky, Tr. 3155.)

DEC was the only other firm Palevsky remembered producing products similar to those of SDS in the early 1960s. (Palevsky, Tr. 3136.)

The recognition by users of the potential benefits of the early SDS products--obvious from SDS's growing revenues--was expressed by NASA's Ames Research Center, which described its procurement of an SDS 920 computer system in 1963 as follows:

"The integration of digital computers into physical systems dedicated to specific areas of research has only recently become economical and feasible through the reduction of equipment costs and component size. One of the first such systems in use at Ames was installed in 1963. This computer (SDS-920) was purchased by the Guidance and Control Systems Branch and applied to research on on-board computer and display requirements for spacecraft and aircraft." (DX 5316, p. 9.)

Subsequently, and rapidly, SDS expanded its product line and its marketing approach. SDS attributed its "early and sustained profitability" to its ability to meet the needs of its users:

"Because of the rapid growth of the computer industry, the age of a company has not been a principal factor in its professional or financial maturity. Far more critical in a company's potential is its ability to understand and act upon the changing requirements of the marketplace. It is to this posture that SDS conforms." (DX 44, p. 5.)

b. <u>The SDS 910.</u> SDS's first computer was the SDS 910, which Palevsky described at trial as a "special purpose general purpose computer"--by which he meant "a computer that had all the characteristics of what was generally known as a general purpose computer, with the added capability of operating . . . within a systems environment, that is, it was a computer that was easy to integrate with diverse types of special purpose equipment". (Palevsky, Tr. 3132, 3134.) The "main frame" sold for $80,000 to $90,000; "[t]hen, depending on the peripherals, it got more expensive". Palevsky described the peripherals as being, "at the beginning, rather primitive equipment": paper tape punches, paper tape readers and card equipment. Also, at the beginning, the SDS 910 was marketed with "very primitive software, really just an operating system". (Palevsky, Tr. 3134.)

c. The Expansion of the SDS 900 Series. In 1963, SDS had expanded its line by announcing the SDS 920, 930 and 9300. (DX 44, p. 7.) Those systems were compatible with the 910 and were designed with a "building block" design philosophy. (*Id.*) The 92 and 925 were introduced in 1964.* (*Id.*, p. 3.) In its 1964 Annual Report, SDS told its stockholders that with the introduction of the "small, high-speed SDS 92 and the medium scale SDS 925, the company now offers a family of six compatible, general purpose computers--the SDS 92, 910, 920, 925, 930 and 9300--providing the flexibility required for both industrial and scientific systems". (*Id.*, p. 7.)

SDS did not actually "manufacture" its 900 series computers; rather it assembled them. That is, SDS purchased the various parts (they were "readily available to anyone who wished to purchase them") and put those parts together in a system of its design at its facility (Palevsky, Tr. 3198-204), a practice SDS pursued for several years. SDS purchased:

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* "The 925 was a modification of the 930 to . . . provide a faster lower-priced machine. It was software compatible, and was really just a modification of another product." (Palevsky, Tr. 3214.)

-- Certain basic components for its central processing units and memory (i.e., transistors, resistors and capacitors) from the "[s]tandard avenues of supply--[f]rom the manufacturers of those components". (Palevsky, Tr. 3198-200.)

-- Core memories "at the beginning from Fabri-Tek", which was "one of a number of companies that supplied core memories"; SDS acquired the memories in the form of core stacks, then assembled them in boxes. (Palevsky, Tr. 3199.) SDS subsequently acquired core memories from Ampex, Magnetic Memories "and probably one or two others"; when "we got to a certain size we generally had three sources of supply so that we were always assured that one of them would be there". (Palevsky, Tr. 3200-01.)

-- Tape drives and tape control units from Ampex, Computer Products, and Potter Instruments; eventually, SDS made its own tape drives and controllers. (Palevsky, Tr. 3201-02.)

-- Printers and a few printer control units from NCR and Data Products and, in the case of "some specialized ones", from "small companies"; at the time of its acquisition by Xerox in 1969, SDS was buying printer mechanisms from NCR. (Palevsky, Tr. 3202; see Plaintiff's Admissions, Set I, 9 ¶¶ 191.0-.2.)

-- Disk drives and disk drive controllers from Control Data (and "perhaps some of them from California Computer Products"). (Palevsky, Tr. 3203.)

-- Card punches from Univac; card readers were initially acquired from a third party, but SDS subsequently built them itself. (Palevsky, Tr. 3203.)

-- A few cathode ray tube terminals from Control Data; however, SDS built most of these itself. (Palevsky, Tr. 3203.)

-- "[S]tandard [Teletype] keyboard devices from Western Electric". (Palevsky, Tr. 3204.)

SDS both wrote software for its computer systems and used outside software services. Software services were provided by Programmatics and another firm, and "a number of smaller firms for very specialized things". SDS also had "a number of users groups and a number of our users' programs became standard programs that were then widely distributed" by SDS. Additional software was obtained from a European company (a predecessor of CII), which was licensed by SDS "to build our computers in France". (Palevsky, Tr. 3205-06.) SDS itself furnished maintenance service. (Palevsky, Tr. 3134-35.)

The SDS 920 had certain instructions that were not included in the earlier 910 and "a slightly more sophisticated input-output system". It was marketed to essentially the same customers as the 910. (Palevsky, Tr. 3162.)

The SDS 930 was "larger and faster and, again, somewhat more complex structurally". It was partially marketed to the same group of customers as the 910 and the 920, but was also marketed "to a greater extent to the general scientific community". (Palevsky, Tr. 3162.) For example, an SDS 930 was used for data reduction and analysis at the Mississippi Test operations center associated with the NASA Slidell Computer Complex (DX 5836, Reeves, pp. 55-56) and, at the Kennedy Space Center, an SDS 930 performed off-line simulation of launch vehicle events for training, supplied input data to Mission Control in Houston and handled a "fuel loading" system. (DX 5652, pp. 116, 123, 164.) Palevsky testified that when it was first introduced, the SDS 930 competed with the IBM 1620 "[a]nd then when the 360 was introduced, the 360/30s, 40s and 44s". (Palevsky, Tr. 3185.) Other competitors with the 930 were Computer Control Company (later bought by Honeywell) and DEC. (Palevsky, Tr. 3165.)

Palevsky described the SDS 9300 as "conceived much more as a data processing system, as a computer that would sit in a central computing facility and essentially provide printed answers, as opposed to being interconnected on a real time basis with other sources of data". It was marketed "to the scientific community", but performed a still broader mix of applications. One customer was DuPont, which had previously integrated SDS computers "into systems for controlling chemical processes". It acquired this new computer not only for a "specific process they wanted to control but rather for a general computing purpose, so that the customer may have been the same, but the part of the company would be different". (Palevsky, Tr. 3163.) Similarly, Digicon, Inc., used a 9300 to process seismic data collected from oil fields and also to process its accounting records. (DX 4085, Poe, pp. 18-19, 21.)

Palevsky testified that with the 9300, SDS "had now entered the more traditional and more highly developed market for computers and no longer had the edge of the innovations" it had made in "real time computers" on which to rely.* This engendered "[a]ll the difficulties that go with a highly competitive sales situation--marketing situation". (Palevsky, Tr. 3164.) Palevsky testified that SDS's "main competitors" in marketing the 9300 were IBM and Control Data (and later, Digital Equipment). (Palevsky, Tr. 3165.)

SDS had supported a "growing program of research and development" and committed "substantial capital to advanced product planning". One of the results was its announcement in 1964 of what it claimed was "the first computer to use monolithic integrated circuits, the SDS 92". As a result of the use of integrated circuits, SDS's manufacturing costs were "decreased while the reliability of SDS computers is improved at least three times over present models". (DX 44, p. 5.) Withington, writing in 1964, concluded that:

> "The most significant development in components has been the approximately 50% reduction in the manufacturing cost of high-speed circuits over the past three years. This quite rapid development has enabled new small companies (e.g., Scientific Data Systems, Digital Equipment Corporation) to enter the computer market with low-priced computers of high performance. . . . This reduction in manufacturing cost has been at least partly responsible for the recent price reductions on older computers and the lower prices of new ones. The user has benefited, and the market has been enhanced." (PX 4829, p. 31.)

By the end of 1964, SDS told its stockholders that its computer systems were "presently being used by industrial, scientific and

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* "As the technology in the computer industry evolved, there were no longer those pockets, there were no longer those market areas that had relatively little competition." (Palevsky, Tr. 3155-56.)

government organizations in many diverse applications ranging from space exploration to construction, medical research to food processing". (DX 44, p. 3.) The number of SDS employees had increased from 438 in 1963 to 1,357 at the end of 1964. (Id.) The year 1964 was also a year of expansion abroad. According to SDS's Annual Report for that year, "[f]rom nuclear experimentation in Geneva to automotive manufacturing in Tokyo, SDS computer systems are finding an accelerating and receptive market throughout the world. . . . In the first significant year of SDS activity abroad, computers were ordered or installed in more than 15 countries." (Id., p. 17.)

Expansion, plus SDS's program of research and development, required capital. Requirements for capital also increased because, according to Palevsky, SDS was leasing more of the 9300s than it had prior computers. (Palevsky, Tr. 3164.) In 1964, "due to [its] rapid growth", SDS made its first public offering of common stock, offering 382,375 shares and raising almost $5,000,000. (DX 44, pp. 3, 21.)

SDS engaged in a continued pursuit of growth and expansion through continued product improvements. In SDS's 1965 Annual Report, following the announcement of IBM's System/360, SDS stated:

> "The character of the computer market changed substantially last year as the result of advances in both the understanding of the technology and in the manner in which computers should be employed. . . . [T]hese changes point to the increasing use of total management information systems for business, scientific, aerospace and industrial control applications.
>
> "As is always the case in the computer field, the new market demands increased performance economically, in terms of more computations per dollar, and an expanded array of supporting services such as programming, field services and training." (DX 981, p. 4.)

In 1965, SDS brought out the 940, designed for simultaneous access by multiple users at remote locations. SDS took the 930, increased its memory capacity, and integrated rapid access data storage units and communications equipment. A 930 system costing $250,000 was thereby transformed into a 940 system costing $1 million. (DX 981, p. 3; DX 982, p. 12.) SDS called the 940 a "timesharing computer". It was used, among others, by several commercial time-sharing service bureaus (DX 45, p. 7) as well as by a data center established by SDS itself to sell time to remote users in the Los Angeles area. (DX 983, p. 3.) Similarly, White, Weld & Co. used its 940 to implement a financial information system that permitted its individual subscribers to request portfolio information on a variety of companies. (DX 982, p. 12.)

By the time of the introduction of the 940, SDS had announced the development of its own magnetic tape units and rapid access disk files as well as a line of digital logic modules. (DX 981, p. 3.)

Also, in mid-1965, SDS "announced a new business programming package for all its computers to supplement the extensive library of programs presently available to scientific users". The package, known as MANAGE, was "expressly designed to facilitate corporate decision making by management personnel outside of the data processing department". (DX 981, p. 4.) Similarly, SDS adopted some of the marketing practices of others in the industry. In 1965-66, it offered the Federal government a 14% discount towards equipment purchase "[f]or qualified Government schools and training institutions when primary application of the data processing system is for educational and training purposes". (DX 47, p. 16.) It also offered the government the provision of "programming aids, including programs[,] routines, sub-routines, translation compilers and related items without extra charge". (Id., p. 3.) By 1966 SDS was marketing its computers on a variety of lease terms as well as selling them. (Palevsky, Tr. 3207.)

SDS continued to grow dramatically during 1965. It doubled its number of installations in one year. New business received during the fourth quarter of 1965 was greater than any previous quarter in the company's history. To finance this continued expansion, SDS sold 47,500 shares of $100 par cumulative preferred stock to a group of insurance companies, raising $4,750,000 in the second quarter of 1965. And in February 1966, it sold $10 million in convertible subordinated debentures to a group of institutional investors. (DX 981, p. 3.)

d. The Sigma Series. By 1965 SDS had begun the development of its Sigma series of computers--its third-generation line. In fact, in that year (following IBM's announcement of System/360), the Sigma family "occupied the attention of virtually every department in the company". (DX 981, p. 9.) It was announced in 1966, with the first of the series, the Sigma 7, announced in March of that year and the second, the Sigma 2, in August. The remainder of the family was announced starting in 1967. (Palevsky, Tr. 3226.) By 1971, the Sigma family included the 2, 3, 5, 6, 7, 8 and 9. (PX 5774, p. 13; DX 13400, p. 22; DX 13401, p. 19.) According to SDS, the Sigma family delivered "more computations per dollar than any other commercially available machine". SDS touted its versatility: "The impact of Sigma, however, lies in its broad application for business, industry and science as well as its ability to perform an almost unlimited number of different applications at virtually the same time." (DX 981, p. 6.)*

The Sigma Series was a response to the IBM 360 line. A Sigma 7 press release, dated March 15, 1966, stated that Sigma "represents the first family of computers with an entirely new design since the IBM 360 announcement" and that "Sigma 7 features a total capability for both business and scientific data processing". (DX 52, p. 1.) SDS attempted to set its prices 10 to 15 percent lower than IBM's prices on the products that IBM had announced two years earlier. (Palevsky, Tr. 3150.)** An effort was made to price each of the separate boxes at prices below IBM's, but a comparison could not be made on the basis of the performance of the systems as a whole because "then you get into the problem of what is a typical set of operations and it becomes very complex to do". (Palevsky, Tr. 3269-71.) Apparently, SDS felt that a dollar price advantage was necessary to overcome the obvious customer acceptance of System/360. (See Palevsky, Tr. 3149-50, 3176, 3270-72.)

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* For example, SDS contended that a Sigma "can simultaneously run an inventory control program together with a real-time process control application. At the same time, 200 users at remote consoles throughout the country could be time sharing the central processor". (DX 981, p. 6.)

** Currie testified that "generally" although "not always", SDS tried to have somewhat lower prices than IBM for equivalent performance on the order of 10 to 15%, and tried to have "an advantage over a company like Univac". (Tr. 15175-76.)

Palevsky testified that the Sigma computers compared to the 9300 "were more complex structurally. They were much faster, and some of the computers in that line were compatible so that we had on a very small scale something like the 360, that is, we had a number of computers of various sizes that were program compatible." (Palevsky, Tr. 3165-66.) As with the 360, SDS "designed standard interface units". It also "developed special programs which simplify the design, engineering, and final assembly of various building blocks or components into total systems." (DX 982, p. 12.)

For the Sigma series, SDS acquired Potter tapes, Control Data disk drives, NCR printers, Teletype console typewriters and Uptime card equipment. (Currie, Tr. 15507.) However, because peripheral equipment was viewed as a "critical element" in third-generation computer systems, SDS had sharply increased its planning for internal development and production of peripherals. In 1966, SDS began delivering its own magnetic tape units and had completed development of Rapid Access Data files, which it called "two important peripheral products for data storage that were completely designed and produced by the company". These products were expected "to enhance the capabilities of SDS computer systems". (DX 982, p. 10.) SDS stated its reasons for undertaking peripheral equipment development programs internally rather than acquiring independent manufacturers or continuing to purchase from suppliers as follows:

> "First, SDS can realize a significant improvement in profit margins on equipment which the company produces internally.

> "Second, peripherals designed to complement the capabilities of Sigma computers provide an additional competitive advantage for SDS systems.
>
> "Third, high reliability must be designed into the equipment and quality control assured during production, thus minimizing the cost for servicing faulty peripherals.
>
> "Fourth, and most important, the technology is advancing too rapidly to permit SDS to rely primarily on suppliers. The new series of Rapid Access Data files is an example. Developed with a considerable investment, SDS RADs are among the most advanced secondary storage devices in the industry. The availability of the various RAD models provides SDS with a significant advantage in marketing Sigma computer systems." (DX 982, p. 10; see also Palevsky, Tr. 3277-78.)

SDS provided "advanced software, including operating systems for real time, batch, and time-sharing operations, FORTRAN IV and COBOL compilers, assemblers" and various applications software, including a library with "[m]ore than 1000 utility and mathematical programs" for the Sigma family. (DX 49, pp. 2, 8.) SDS obtained between 20% and 50% of this software--specifically assembly languages, compilers, a Data Management System package, a linear programming package and a communications package--from software houses such as Digitek, Programmatics, Bonner & Moore, Informatics, Computer Usage Corporation, Computer Sciences Corporation, Dataware, CII, and Scientific Resources. (Currie, Tr. 15388-89.)

At first, according to Palevsky, the Sigma series was offered "to essentially the same market as before". Gradually SDS "started to market it for applications that were mixed scientific and general data processing" (Palevsky, Tr. 3166), and began to expand into applications for general business and industry, including marketing to business data processing customers. (Cohen, Tr. 14684-86.) By this time, "changes in the technology" had begun to "blur" the distinctions between business and scientific data processing. (Palevsky, Tr. 3137.) More and more customers started using a single computer for both types of computation"; if one were to ask "say in '65 how many installations used a single computer for both purposes and say by '68 how had that grown . . . I would guess that that had grown tenfold". (Palevsky, Tr. 3254-55.) Both because of that change and a perception that the area SDS was focusing on was becoming too confining, SDS was "forced" to enter the "market" for business data processing customers. (Palevsky, Tr. 3137.)

At the time of the Sigma 7 announcement, SDS issued a press release stating:

> "Until now, explained SDS president Max Palevsky, computers were generally built either for business data processing or for solving problems of a scientific nature or for real time control systems. 'But because of its advanced internal architecture,' Mr. Palevsky stated, 'Sigma 7 is the only medium priced computer that can deliver outstanding performance in any of these applications.'" (DX 53, p. 1.)

Similarly, the Sigma 5 was "designed for operating real-time programs simultaneously with general purpose scientific and business problems". (DX 982, p. 8.)*

SDS was advertising its Sigma 7 computer system as "unfair to IBM . . . Sigma 7 does everything a 360/50 does. At a fraction of the cost. Sigma 7 is a little cheaper than the 360/50 and a good deal

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* In its 1966 and 1967 Annual Reports, SDS stated that although its Sigma series would perform business data processing applications, that did not mean that it was abandoning the customers on whom it had heretofore built its business. (DX 982, p. 4; DX 983, p. 4.)

faster. The combination gives Sigma a 25 to 65 percent edge in cost/performance." (DX 54.) Cohen testified that the Sigma 7 "did indeed" perform business data processing applications. (Cohen, Tr. 14631.) For example, the Harrison Radiator Division of General Motors used Sigma equipment for its data processing requirements, which were "principally" inventory control, which, according to Cohen, would be a business data processing application. (Tr. 14610-11.) Cohen also testified that, looking only at the CPU, input/output processors and main memory, the Sigma 7 could in fact do everything that the IBM 360/50 could do. (Cohen, Tr. 14622-24.)*

According to an XDS sales guide (DX 50, p. 102/001-29), a report based upon what was happening in the field, the 360/50, 360/40, 44, 65 and the 1800 were "competitors" of the Sigma 5 as late as 1972. (Palevsky, Tr. 3232-33; see also Tr. 3185, 3228-29.) According to Cohen, IBM's 360/44, 50, 65, 67 and 75, as well as the 1130 and 1800, were the IBM systems SDS "most commonly competed with". (Cohen, Tr. 14555-56; PX 433.)**

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* However, when the array of peripherals and software available on the IBM 360/50 was taken into account, Cohen was of the opinion that the Sigma 7 could not do all of what the 360/50 could. (Cohen, Tr. 14624.) Palevsky testified that the Sigma 7 was comparable to the 360/50 in terms of the hardware capability, but not in terms of the total system. (Tr. 3243-45.)

** In the early 1970s, the "prime competition" for the Sigma 5 was the IBM 370 Models 135, 145 and 155; the DECsystem 10; the SEL (Systems Engineering Laboratories) 86/88 and the Univac 418-III. (Palevsky, Tr. 3231-32; DX 50, p. 102/001-29.) For the Sigma 6 and 9, the "prime competitors" were the IBM 370 Models 135, 145, 155; the DECsystem 10 and the PDP 10, Models 1040, 1050, 1055 (dual processor); and the Univac 1106. (Palevsky, Tr. 3247; DX 51, p. 103/001-13.) For the

Competition for the Sigma series included products from many suppliers in addition to IBM. Cohen listed 21 companies (plus leasing companies) as competitors to SDS/XDS "in the computer systems market" during the period 1966 to 1972: IBM, Honeywell, Univac, GE, CDC, Burroughs, DEC, SEL, Modular Computer Corporation, Fischer & Porter, Varian, Hewlett-Packard, Data General, Radiation, Inc., Harris, Collins, Comten, Interdata, Electronic Associates ("on occasion"), EMR, RCA ("occasionally") and said there were "very likely" others. (Cohen, Tr. 14600-09.)

Palevsky mentioned as competitors to SDS: IBM, CDC, DEC, CCC (Computer Control, later acquired by Honeywell), Univac ("occasionally"), Burroughs ("rarely") and Honeywell (rarely, until the latter's acquisition of CCC), and General Electric ("in certain applications"). (Palevsky, Tr. 3166.) Engineering Associates, CCI, NCR, ICL, EMR and COM were also competitors. (Palevsky, Tr. 3233; DX 50, p. 102/001-30.)

Cohen listed the "effective competitors" (he defined these as companies which won 20% to 25% of the competitions in which they were engaged) (Cohen, Tr. 14723-24) of SDS in specific application areas:

In time sharing, he listed IBM, Honeywell (after the acquisition of General Electric's computer business), Univac, GE and

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Sigma 8, the "prime competition" was the IBM 370 Models 145 and 155, the SEL 86/88, DECsystem 10, the Univac 1106/1108, and the CDC 6200/6400. (Palevsky, Tr. 3238; DX 50, p. 102/001-30.)

DEC.

In real time, he listed IBM, Honeywell, Univac, CDC, DEC, SEL;

In seismic, IBM and Univac;

In scientific batch, IBM, Univac, GE and later Honeywell (after its acquisition of GE's computer business), CDC and DEC;

In communications, GE, Univac, IBM and Comten; and

In multi-use/multimode, IBM, Honeywell (after the GE acquisition), Univac, CDC and DEC. (Cohen, Tr. 14729-30.)

IBM competed with SDS as an "effective competitor" in every application area, and the systems which competed with those of SDS spanned the IBM product line: the 1130, 1620, 1800, 360/44, 360/50, 360/65, 360/67, 370/145, 370/155 and 370/158. (Cohen, Tr. 14555-60; PX 433.)

Indeed, Wright--IBM Director of Time-Sharing Marketing in the period from 1964 to 1965 and Director of Marketing for Government, Education and Medical Region from 1965 to 1969--testified that SDS was among IBM's "principal competitors". (Tr. 12993.) IBM was well aware of SDS during the mid- and late-1960s. On December 22, 1964, Learson reported to T. J. Watson, Jr., about the serious competition SDS posed to IBM's 360/40 and 360/50. (PX 1288, p. 2.) That concern intensified over the next several years. (See the discussion of the Model 44, pp. 412-13.) SDS also appeared as one of the nine "major computer manufacturers" reported on in internal IBM reports on the financial results of certain of its competitors. (See, e.g., PX 3451.)

e. The Merger. The Sigma family brought still more growth for SDS. During 1966, which was described by SDS as "a crucial transitional year", SDS offered two issues of convertible subordinated debentures totaling $22,500,000 and retired short-term bank loans. (DX 982, p. 3.) From the fourth quarter of 1966 to the fourth quarter of 1967, the year which SDS saw as a "critical" period "during which the character of . . . future expansion" was "largely determined", SDS doubled its production of EDP equipment. It stated that in 1967, it "successfully completed its first product line transition, began a major facilities expansion, and initiated new product development and cost control programs to sustain orderly growth". (DX 983, p. 3.)

By 1969, SDS had achieved that orderly growth and had reached what would be, for SDS as an independent entity, the pinnacle of its success. It told its stockholders that its international sales in 1968 had increased by more than threefold over 1967 and that "[t]he sale of SDS products outside the United States is expected to continue to increase significantly through the company's increasing involvement in the various international markets". (DX 45, p. 12.) SDS stated that it "ranks among the world's ten largest computer manufacturers" with assets of $113 million and more than 4,000 employees (id., p. 4), and described itself as "one of the world's largest suppliers of commercial time-sharing systems". (Id., p. 6.)

In 1969, SDS was acquired by the Xerox Corporation, a company that had achieved "a position of eminence as a worldwide enterprise" through the remarkable acceptance of the xerographic copier. (PX 5774, p. 6.) Xerox's revenues for the year 1968 (excluding Rank Xerox, Ltd., its British affiliate that marketed its products abroad) were $896 million and its net income was $116 million (including the income from Rank Xerox). (DX 13857, p. 3.) SDS was acquired for approximately $980 million worth of Xerox stock.* (Palevsky, Tr. 3195.)

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* The Xerox acquisition of SDS and the subsequent activities of XDS are discussed below. (See pp. 1125-44.)

48. Digital Equipment Corporation. Digital Equipment Corporation ("DEC") was founded in 1957 by Kenneth Olsen and Harlan Anderson (Hindle, Tr. 7318.),* both having previously been associated with M.I.T.'s Lincoln Labs where they worked on Whirlwind and SAGE. (DX 13833, p. 5.) DEC set up production on one floor of a converted woolen mill in Maynard, Massachusetts, with three employees. (DX 13858,p. 1.) Its initial capitalization was $70,000, all of which was invested by the American Research and Development Corporation--a Boston-based venture capital firm. (Hindle, Tr. 7476.) Its first products were laboratory logic modules--"printed circuit boards containing components which are used to do logical functions in an electronic sense: add, etc." --that were then used to test and build other manufacturers' computers. (Hindle, Tr. 7318-19; DX 13858, p. 1.)

The story of DEC is one of extraordinary growth and enormous success in the computer business. From its beginning and throughout the 1960s, DEC achieved extremely

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* Winston R. Hindle, Jr. was the only witness from DEC. Mr. Hindle joined DEC in 1962. From 1967 through his testimony in 1975, Mr. Hindle was Vice President and Group Manager of the company with responsibility for numerous products within the DEC product line. His responsibility encompassed the development, marketing, sales support, planning and financial areas. Mr. Hindle had served on the executive committee of DEC, as well as the Finance and Administration and Marketing Committees. (Hindle, Tr. 7313-18, 7337.) As of 1979, Mr. Hindle was Vice President, Corporate Operations. (DX 12323, p. 47.)

rapid growth by taking advantage of new technology and its own research and development to manufacture an ever-expanding product line. DEC's total assets grew from $5.7 million in mid-1964 to $114.8 million in mid-1970.* (DX 511, p. 14; DX 13845, p. 10.) DEC's profits after taxes went from $889,000 in 1964 to $14.4 million in 1970 (DX 511, p. 1; DX 13845, p. 10.) Its worldwide EDP revenue grew from $4.3 million in 1961 to $12.6 million in 1964, to $142.6 million in 1970, rising at an annual compound growth rate of 44% per year. (DX 526.) By virtue of the $70,000 investment in 1957, American Research and Development had acquired 78% of DEC's common stock. (DX 13833, pp. 5-6, 21.) In 1968, it sold 215,000 shares of DEC stock for a gain of more than $26 million (DX 13834, p. 9), and in 1972, it distributed the remainder of its DEC stock, valued at $382 million, to its shareholders. (DX 514, p. 6; DX 13835, p. 4.)

DEC acquired more and more space in its woolen mill, and its original three employees were joined by many others. It began expanding overseas in 1964. It formed its first sales subsidiaries in the United Kingdom and Australia in that year. In 1965, offices in Canada and Germany were added. (DX 13845, p. 3; DX 13846, p. 3.) Sales

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* Financial information for DEC first became publicly available in 1964.

offices in France, Japan and Sweden followed in 1966. (DX 13847, p. 19.)* By 1966, DEC occupied 338,000 square feet in its original location in Maynard, Massachusetts and employed 1100 people (DX 13847, p. 3), had 24 sales offices in six countries, and had about 800 computer installations. (DX 517, p. 1.) By 1970 it had manufacturing plants in England, Puerto Rico and Canada, as well as several in Massachusetts, employed 5,800 people (DX 511, p. 3.), and had computer installations in eleven countries. (DX 517, p. 2.).

The financing of this expansion required capital. In 1963, $300,000 was borrowed from American Research and Development Corp. However, by the end of its 1964 fiscal year, DEC had accumulated over $3 million in retained earnings. (DX 13845, pp. 10-11.) Retained earnings rose to $4.3 million in 1965, $15 million in 1968, $24 million in 1969 and $38.8 million in 1970. (DX 511, p. 15; DX 13846, p. 12; DX 13979, p. 7.) DEC made its first public stock offering in August 1966, raising $4,800,000. (PX 5026, p. 15;** DX 13847, p. 3.) From 1968 to 1970 it had three additional public offerings, raising a total of $63.5 million. (PX 4562, p. 17; DX 511, p. 17; DX 512, p. 11; DX 13979, p. 8.) A review of DEC's Annual

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* In 1961, all revenue was domestic. In 1964, 91% of revenues were generated domestically. By 1970, the domestic percentage had dropped to 72%. (DX 526.)

** A more legible copy of PX 5026 has been marked as DX 13848.

Reports reveals that this outstanding record enabled DEC to meet its financing needs with no reliance on long-term bank loans. As Hindle testified, "Digital's expansion has not ever been limited by the ability to raise capital." (Tr. 7476.)

It is interesting to note in this connection that DEC generally chose not to tie up its capital in financing leases for its customers, feeling that it had "better ways to invest" its money. When its customers wanted to lease, DEC would put the customer in touch with leasing agents who would "use their capital and not Digital's capital". These "leasing agents" were organizations "willing to finance a customer's computer over a period of time". When DEC did offer leases directly to its customers, it generally sold them to financial institutions immediately thereafter. (Hindle, Tr. 7369-70.)

DEC's success was due in part to its commitment to product development. Hindle testified that "Digital has through the years spent between 8 and 11 percent of revenues annually on research and product development. . . . We have felt that product development was a vital part of our success. The rapid advances of technology in the computer field have meant that we must keep abreast of these advances and incorporate them and understand them in our product lines as rapidly as we could." (Hindle, Tr. 7383-84.) That commitment paid off and, as Withington testified, DEC "always maintained a position of technological leadership or at least currency with any significant competitor and always provided an adequate breadth of product line, maintenance and support". (Withington, Tr. 56016.)

DEC's computer systems began with small, high performance hardware offered with relatively little support to sophisticated customers capable of providing themselves the software and services for the application of those products to their needs. Palevsky of SDS described the early DEC computers as being similar to the small and medium-scale 900 series computers marketed by SDS principally for real-time and scientific applications, also in the early 1960s. (Palevsky, Tr. 3133-36.) Over time, DEC's products grew in capacity and capability and DEC expanded its customer support, its marketing and its software and service offerings. That process has continued and DEC now offers one of the broadest product lines in the industry and markets it to the whole spectrum of EDP customers. (See below, pp. 717-31, 989-92.)

DEC's first computer, the PDP 1, was delivered in 1960, and it was followed by the PDP 4 and 5 in 1962 and 1963, respectively. From 1964 through 1970, DEC also introduced the PDP 6 (1964), PDP 7 (1964), PDP 8 (1964), PDP 8S (1966), LINC 8 (1966), PDP 9 (1966), PDP 10 (1967), PDP 8I (1968), PDP 8L (1968), PDP 12 (1969), PDP 14 (1969), PDP 15 (1969) and PDP 11 (1970). All of these DEC computers were classified by Hindle as "general purpose computers", except the PDP 14.* (Hindle, Tr. 7321-24, 7327, 7388; PX 377-A.) As we

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* The PDP 14 was not a general purpose computer "because it has a program which is preset prior to its delivery, and then it only operates on that same program when used by the customer". (Hindle, Tr. 7327.)

shall see, each of DEC's successive product announcements expanded the breadth and capabilities of its product line, contributing to DEC's phenomenal success.

a. PDP 1, 4, 5 and 7. DEC's first computer was the PDP 1, delivered in 1960 (and withdrawn in 1963 or 1964). (Hindle, Tr. 7318-19, 7321; DX 507, p. 10.) The PDP 1 was "an outgrowth of the technology that was incorporated into the line of logic modules, although there was a completely separate design from the logic modules in our product line prior to that". (Hindle, Tr. 7319.)

The original purchase price of a PDP 1 was in the neighborhood of $125,000 to $243,000. (DX 13858, p. 2; Plaintiff's Admissions, Set II, ¶¶ 240.2, 371.3(d).) It was designated "PDP" (Programmed Data Processor), a nomenclature that DEC used throughout the 1960s for its products, because "EDP people could not believe that in 1960 computers that could do the job could be built for less than $1 million". (DX 13858, p. 2.)

At Stanford University, Professor John McCarthy used a PDP 1 to conduct some of the earliest research on time-sharing in the early 1960s. (Feigenbaum, Tr. 29531-32, 29535-36; DX 13858, p. 3.)* A PDP 1 was also used, in conjunction with an IBM AN/FSQ-32

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* The PDP 1 "operated primarily independently", but was "link[ed] through a disk" to an IBM 7090. "[O]ccasionally there would be a lash-up which would exercise LISP on the 7090, which is a system developed . . . [at Stanford] that would communicate through the disk to the PDP-1." (Feigenbaum, Tr. 29532-33.)

computer, as "the major input/output vehicle for the various remote devices" in a "general-purpose time-sharing system" at the System Development Corporation (SDC) in June 1963.* (DX 7622, p. 3.) That time-sharing system was produced "under the sponsorship of ARPA[**] and . . . utilized ideas developed at both Massachusetts Institute of Technology and Bolt, Beranek, and Newman, as well as some original techniques". The various remote devices used as part of this system included "Teletypes . . . and other computers" that could be run "from within SDC, and from the outside". PDP 1's, as well as the CDC 160A and the IBM 1410, were also expected to be used at remote stations as part of this system. (Id.) In 1962, the Atomic Energy Commission's Lawrence Livermore Laboratory selected a PDP 1 over a 1401 proposed by IBM to perform what it described as "scientific and engineering" applications. (DX 2992, pp. 18, 1113.)

DEC introduced the PDP 4 computer system in 1962, and the PDP 5 in 1963. (Hindle, Tr. 7321.) The PDP 5 was offered with keyboard-printer, paper tape reader and punch and a software package

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* "Time-sharing, in this case, means the simultaneous access to a computer by a large number of independent (and/or related) users and programs." (DX 7622, p. 3, emphasis in original.)

** ARPA is the government's Advanced Research Projects Agency, which was established in 1958 and whose "primary mission . . . is to support research and development of advanced projects which have potential value to the Department of Defense". (Plaintiff's Admissions, Set I, ¶¶ 1.0, 2.0.)

including FORTRAN. (DX 13928 .) "Although the term 'minicomputer' wasn't used during the time of the PDP-5," DEC would have considered the PDP 5 a "minicomputer". (Hindle, Tr. 7325.)* According to the 1964 DEC Annual Report, the PDP 5 was used in "numerous applications in physics, biomedicine, industrial process control, and systems applications". (DX 13845, p. 8.)

In the early sixties, DEC's research and development effort produced the "flip chip" modules (DX 13845, p. 3) which, like IBM's SLT, combined printed circuits with discrete components (id., p. 2) and which made possible the introduction in 1964 of the smaller, faster and cheaper PDP 7 and 8 to replace the PDP 4 and 5.** An IBM Win and Loss Report for August 1964 reported competition between the DEC PDP 4 and the IBM 1401 and between the PDP 7 and the 360/30. (PX 3630, p. 6.) The Atomic Energy Commission selected a PDP 7, installed in January 1967, over a 360/30, as well as systems bid by CDC, SDS, Univac and Honeywell. (DX 2992, p. 49.)

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* Hindle testified that the term "minicomputer" (which "[p]eople in the industry started to use . . . in the middle 1960's") "is not a precise term", but rather has "a broad range of definition[s]" as used in the industry. Hindle's "own view" of a minicomputer is a system "priced at less than $50,000". (Tr. 7325.) By this he meant that "the smallest available configuration could be configured for less than $50,000". (Tr. 7453.)

** Withington commented in 1964 that the rapid reduction in manufacturing costs of high-speed circuits enabled DEC, among others, "to enter the computer market with low-priced computers of high performance". (PX 4829, p. 31.)

b. PDP 6. The PDP 6 was first delivered by DEC in 1964. (Hindle, Tr. 7321.)* DEC's Annual Report for 1964 described the PDP 6 as "an expandable system which can start as a very basic configuration and grow through the addition of processor, memory and input-output options into a major computation facility equivalent to the largest commercial systems currently offered". (DX 13845, p. 6.) At the time, the PDP 6 was the largest of DEC's computer systems, ranging in price from $350,000 to $750,000. DEC described it as "equivalent to the very large computers used by scientific laboratories". The PDP 6 was used in "large data processing assignments", including Brookhaven National Laboratory, the Rutgers University Physics Department, the Universities of Aachen and Bonn, Germany, the University of Western Australia, Lawrence Radiation Laboratory, United Aircraft Corporation, Applied Logic Corporation, Yale, MIT's Laboratory for Nuclear Science, the University of Rochester, Stanford University and the University of California at Berkeley. (DX 13845, p. 3; DX 13846, p. 8; DX 13847, p. 7.)

Also, the PDP 6 was "designed for time-shared use" and DEC bid a multiprocessor version of it to MIT's Project MAC, one of the earliest and most important experiments in the use of time sharing. DEC was "in among the finishers" for this award, who included: CDC, bidding a 6600; IBM, bidding a 360/50; GE, the

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* The PDP 6 was withdrawn in 1967, when it was succeeded by the PDP 10 which "incorporates all the features of the earlier machine". (Hindle, Tr. 7321; PX 5026 (DX 13848, p.3).)

winner of the contract with a modified 635; and RCA, with a 3301. A $1 million PDP 6 was chosen by Project MAC as a peripheral processor for the time-sharing system. (PX 2961, pp. 1, 3; DX 13845, p. 3.) An IBM Win and Loss Report for August 1964 reported additional competition between the PDP 6 and the IBM 360/50. (PX 3630, p. 6.)*

At the Lawrence Berkeley Laboratory of the Atomic Energy Commission, a PDP 6 was bid against an IBM 360/70 and a CDC 6600, among others. A CDC 6600 was installed in January 1966. (DX 2992, p. 11.)

At Lawrence Livermore Laboratory, two PDP 6's were acquired in 1965-66 and used as control computers in the OCTOPUS network. Because Lawrence Livermore required a faster memory than DEC could supply, it solicited bids for add-on memory, receiving bids from five companies in addition to DEC, and awarding contracts to Lockheed and Ampex. (DX 4572.) That acquisition was an indication of things to come: there was later, primarily in the 1970s, substantial development of DEC plug-compatible equipment, in part reflecting the great popularity of DEC computer systems. (See, e.g., Hindle, Tr. 7422-23, 7444-45.)

c. <u>PDP 8.</u> The PDP 6 procurements were prestigious, but DEC's financial growth was more affected by the PDP 8 series of

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* The United Aircraft Research Laboratories offered computation services with equipment consisting of an IBM 360/50 system, a Univac 1108 system and a "DEC PDP-6 Time-sharing system" including "a paper tape reader, and both drum and magnetic tape auxiliary storage" and accessible "through most standard terminal units". (DX 7506, p. 44.)

computer systems--one of DEC's most successful. The PDP 8 was first introduced in 1964 as a replacement for the PDP 5. Due to the use of integrated circuits, the PDP 8 was four times faster than the PDP 5 at two-thirds the price. (Hindle, Tr. 7321; DX 13845, p. 3; DX 13846, p. 3.) Using the price/performance improvements made possible by the "FLIP-CHIP circuit modules and automated production techniques", the PDP 8 opened new market opportunities for DEC (such as typesetting) and expanded its base of scientific-oriented users. (DX 13846, p. 3; DX 13847, p. 8.) The PDP 8 was offered with "disk storage units, terminals, tape units, line printers, cathode-ray tube display units". (Hindle, Tr. 7334.)

Perlis testified that the PDP 8 "generalized very nicely to other machines and it itself gave birth to a whole line of offspring" (Perlis, Tr. 1877); the "parent" itself "received a remarkably immediate acceptance". (DX 13847, p. 8.) As a result of the greater than expected demand, DEC expanded its manufacturing facilities in 1965. By mid-1966, over 400 PDP 8's had been installed. (DX 13846, p. 3; DX 13847, p. 8.)

The various other members of the PDP 8 family in existence at the time of Hindle's testimony in November 1975 were introduced from 1966 (the PDP 8S) through 1974 or 1975 (the PDP 8A) with the later members of the family still in delivery. (Hindle, Tr. 7322.) After the original introduction of the PDP 8, each new member of the PDP 8 family was introduced at a lower price because of "changes in manufacturing technology, semiconductor prices, and peripheral prices as purchased from our vendors". (Hindle, Tr. 7347-48.)* The systems of the PDP 8 family were software-compatible (Hindle, Tr. 7421) with DEC providing three "general purpose operating systems" for them. (Hindle, Tr. 7346-47.) It was "generally true", although "not . . . one hundred percent true", that the same peripherals could be used on all systems in the family. (Hindle, Tr. 7421-22.)

First deliveries of the PDP 8 went to such organizations as Stanford Research Institute, Harvard Medical School, Massachusetts Institute of Technology and the University of Wisconsin. The PDP 8 was also offered to the newspaper and book publishing fields for automatic typesetting (DX 13846, p. 6) and to laboratory, industrial and educational users. (Hindle, Tr. 7331.)

In addition, approximately 30 to 50% of the PDP 8 family was sold OEM,** some as processors alone, some as processors plus memory, and some as total systems. (Hindle, Tr. 7330.) When sold OEM as a processor only, the purchaser would acquire "from another manufacturer the appropriate devices necessary to perform input or output functions", with either the customer or DEC providing "inter-

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* Hindle testified that in pricing its products, DEC takes several factors into account: (i) the computer systems DEC believes will be competitive with the one being priced, (ii) conditions in the segments of the market into which the product is expected to be sold, (iii) manufacturing and support costs, (iv) expected profit. (Tr. 7337-38.)

** OEMs are systems vendors or manufacturers which incorporated the PDP 8 processors into their systems or products. (Hindle, Tr. 7330-31.) DEC generally charged OEM buyers and end-user buyers the same prices. (Hindle, Tr. 7348.)

facing services" for the input and output devices. (Hindle, Tr. 7330-31.) Since 1964, these OEM purchasers have marketed PDP 8 systems for business data processing. (Hindle, Tr. 7332.)

Business data processing applications that are performed on PDP 8 computer systems include "invoicing, accounts payable, inventory control, order processing" and others. (Hindle, Tr. 7389.) In addition, PDP 8's have been used for "real time data collection from instruments", "to assist in the teaching process", in "industrial control applications", including "the automation of industrial process controls, the collection, analysis and reporting of quality control data, test data, material handling data", in "commercial typesetting applications" such as "copy editing, in hyphenization and justification" and "setting classified advertisements", in "data communications applications" such as "message switching, data multiplexing, data concentration" or "front end processing". Different users use the PDP 8 to perform different applications and in some cases the same user might use the same PDP 8 computer system to do, for example, both business data processing and industrial control applications. (Hindle, Tr. 7389-91.)

DEC itself, prior to 1972, had largely been "unsuccessful" in marketing the PDP 8 directly for business data processing applications because it had not worked "on the packaging to make the product suitable and attractive to the business data processing customers". (Hindle, Tr. 7489-90.) Then, in 1972, DEC introduced the Datasystem 300, an adaptation of the PDP 8 specifically designed for business data processing. The "primary difference" between the PDP 8 and the DEC Datasystem 300 was that the latter was packaged in a different type of console and used a business-oriented language called DIBOL. The Datasystem 300 was offered with the same peripherals as the PDP 8. (Hindle, Tr. 7333-34.)

During the period prior to 1975, the PDP 8 competed with IBM's 360 and 370 computer systems when used as part of larger DEC computer systems like the PDP 10 and singly against the IBM System/3, System/32 and 1130. (Hindle, Tr. 7341, 7442; PX 377-A.)* IBM's John Akers recalled losing to a PDP in 1966, when he bid a 360/20 for a typesetting application at Worcester Telegram. (Akers, Tr. 96713.) The PDP 8 also had the ability to perform terminal or input/output applications as part of a computer system with an IBM CPU or some other manufacturer's CPU. (Hindle, Tr. 7394.) DEC considered the products of IBM when setting the price for the Datasystem 300. (Hindle, Tr. 7338-39, see Tr. 7341.)

By any standards, the PDP 8 was a successful and significant product. At the time of Hindle's testimony in late 1975, between 30,000 and 40,000 PDP 8's had been sold (Hindle, Tr. 7329), and the

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* Hindle testified that in drawing up PX 377-A (which was offered in evidence "for an illustrative purpose" and "to assist Mr. Hindle in testifying about each of the products listed thereon" (Tr. 7320-21)) and in testifying to competition generally, he meant "one for one competition", i.e., a situation in which both DEC and DEC's competitor will bid for a product with the same price and the same performance to do the same job or where DEC "would bid two or three of our products to compete with one of the products from the other company". (Tr. 7414-17.)

PDP 8 was being marketed "to a wider variety of customers", including "communications customers" and "business data processing customers". (Hindle, Tr. 7331-32.)

d. PDP 10. In 1967, DEC introduced the PDP 10.* The PDP 10 was the first of a family of computer systems later marketed as the "DEC System 10". (Hindle, Tr. 7324.) Hindle testified that the PDP 10 could do "all of the different kinds of applications that are performed by the PDP 8" as well as additional applications characterized by DEC as "non-business computation applications", such as the manipulation and analysis of "scientific, engineering, or numerical data". (Tr. 7391-92.) The PDP 10 was "introduced to serve . . . laboratory users, industrial users, education users, a class of users we call the data service industry. . . . This is a class of computer users who purchase--or lease or rent--computer equipment and then offer various kinds of services to clients." (Hindle, Tr. 7359.) When introduced, it could have been purchased "for prices in the vicinity of $450,000, all the way up to configurations which would be a million and a half dollars". (Hindle, Tr. 7359.) It was not actively marketed on an OEM basis, but generally was sold directly to end users. (Hindle, Tr. 7358.)

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* Using his definition of "minicomputer" (a computer system in which "the smallest available configuration could be configured for less than $50,000" (Tr. 7453)), Hindle classified all DEC computer systems introduced during the 1960s as "minicomputers" except for the PDP 10, which was too large and too expensive to meet that definition. (Tr. 7325-27, 7358-59.)

In 1969, DEC described the PDP 10 as follows:

> "serving business, industry, and science in a multitude of installations throughout the world. They keep track of bubble chamber events in physics laboratories, analyze blood chromosomes, work in banks, teach in high schools and universities, and perform a myriad of other tasks. New applications are constantly appearing and current applications steadily grow. Customers find new approaches, add new equipment, develop more software. Systems designed solely for real-time tasks often expand to include program development or business data processing. The applications described here demonstrate the PDP-10's inherent flexibility." (DX 519-B, p. 7.)

The PDP 10 competed on a "one for one basis" with the IBM 360, 370 and System/3 computer systems. (Hindle, Tr. 7442; PX 377-A.)* In establishing the price of the PDP 10, DEC looked at the IBM 360 series, specifically the Models 30, 40 and 50, as well as systems offered by Honeywell, General Electric and Scientific Data Systems. (Hindle, Tr. 7361-62.)

The DECsystem 10 was announced in 1971 as a family of systems "spanning virtually the entire large-scale range" and was based upon the PDP 10 processors.** (DX 512, p. 1; DX 522, p. 3.) (The DECsystem 10 is discussed in the section of this narrative deal-

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* This competition is demonstrated by the procurements of government agencies. For example, at the Atomic Energy Commission, a PDP 10 was proposed in competition with an IBM 360/44 and a SEL 810A. The SEL 810A was selected and installed in December 1968. Earlier that year, the Commission selected a Sigma 7 bid against an IBM 360/50 and a PDP 10. On another occasion, a PDP 10 was successfully bid against a 360/50 at the Commission and installed in late 1969. The Department of Health, Education and Welfare chose a PDP 10 over a proposed 360/40 in 1969. (DX 2992, pp. 73, 86, 118, 858.)

** The DECsystem 10 peripherals embodied some improvements compared to the peripherals offered with the PDP 10. In particular, there was a better quality printer and a disk drive with a removable disk pack. (Hindle, Tr. 7362-63.)

ing with the 1970s.) Both the PDP 10 and the DECsystem 10 were highly successful. By 1974, over 400 such systems had been installed. (Hindle, Tr. 7380; DX 525, p. 10.)

e. PDP 15. The PDP 15, introduced in 1969 (Hindle, Tr. 7323), was originally "marketed to laboratory users, industrial users, education users", but with the addition of another programming language ("MUMPS")--a "business-oriented language"--it was also marketed for business data processing applications starting in the early seventies. (Hindle, Tr. 7377.) "Representative applications" performed by the PDP 15 were "nonbusiness computation applications, business data processing applications, real time data collection and instructional computing applications as well as industrial control applications". (Hindle, Tr. 7441; PX 377-A.) Hindle testified that the PDP 15 competed "on a one for one basis" with the IBM 1130, 1800, System/7, 360 and 370 computer systems. (Tr. 7441; PX 377-A.) By late 1975, between 800 and 1,200 PDP 15s had been installed. (Hindle, Tr. 7380.)

f. PDP 11. As with the PDP 8, the PDP 11, introduced in 1970, was the designation for a family of computer systems. (Hindle, Tr. 7323.) At the time of introduction DEC expected to market it "to the entire group of users . . . described for the PDP 8, which would include laboratory users, education users, industrial users, engineering users, [and] communications users". As with the PDP 8, between 30 and 50 percent of the PDP 11s were sold to OEM purchasers who wrote applications programs and offered the PDP 11 for business data processing applications.* (Hindle, Tr. 7349-51.) But, DEC preferred to market the PDP 11 as a system rather than just the processor. (Hindle, Tr. 7349.) In 1972, the DEC Datasystem 500 series was introduced for marketing to business data processing customers. DEC took the PDP 11, added software capabilities, including BASIC, and put it in a "separate type of package" that looked different to the user. "But other than that, there were no significant differences." (Hindle, Tr. 7351-52, 7355-57.)

Hindle testified that the PDP 11/15 and 11/20, smaller members of the PDP 11 family, competed on a one-for-one basis with the IBM 1130, System 3 and System 7 computers, and also with the 360 and 370 in configurations which included the PDP 10. (Tr. 7441, PX 377-A.) Larger members of the PDP 11 family, like the 11/45 and 11/70, competed on a one-for-one basis with IBM 360 and 370, as well as System 3, System 7 and 1130.** (Tr. 7414-15; PX 377-A.) Like the PDP 8, the smaller PDP 11 computer systems might "be used to perform terminal or input/output applications" as part of computer systems whose main

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* Hindle described the OEM marketing as follows:

> "An OEM customer of ours . . . would then hire and train and use programmers, who would write applications programs for the PDP 11 system for that particular problem application that he had identified as a marketing segment, and then would proceed to sell the combined PDP 11 system with the application programs that he had designed to the end user." (Tr. 7351.)

** The PDP 11/45 and PDP 11/70 were announced in 1971 and 1975, respectively. DEC does not consider the PDP 11/70 to be a "minicomputer". (Hindle, Tr. 7323, 7325-27.) Even some PDP 11/45s have been configured into systems with prices as high as $250,000. (Hindle, Tr. 7456.)

CPU was manufactured by IBM or by manufacturers other than IBM or DEC. (Hindle, Tr. 7394.)

In pricing the products in the DEC DataSystem 500 series, DEC looked at the prices of the IBM System 3, System 7, System 32, 360 and 370 systems. (Hindle, Tr. 7354.)

The PDP 11 family has been a highly successful and significant product line, but its story, like that of the DECsystem 10, unfolds in the 1970s.

g. Peripherals and Software. The rapid proliferation of DEC's product line during the 1960s extended to peripheral and software offerings as well. Although as late as 1969 Memorex was marketing disk file products to DEC on an OEM basis (Spitters, Tr. 42067-68) with 1969 sales of approximately $5,000,000 (Spitters, Tr. 42072), by 1970 DEC had "introduced many new peripherals including those of our own internal design and manufacture, such as disks, paper tape, DECtape, display systems, and real time interface equipment". (DX 517, p. 2.) DEC's 1970 Annual Report proclaimed that "[i]n order to expand the capabilities of its computers, DEC provides a wide range of peripheral equipment", including large magnetic tape systems, storage drums, teletypes, high speed paper tape readers, card readers and punches, line printers, incremental plotters, digital-to-analog converters and various controllers. (DX 511, p. 10.)

DEC had also worked on software, introducing new software features "[w]ith each mainframe that is a new version of a previous machine". (DX 517, p. 2.) It had provided "DIBOL", a "business oriented language" for the PDP 8, and added COBOL to the PDP 10. (DX 517, pp. 3, 5.)

In 1967 it developed application packages called "Computerpacks" which from 1967 to 1969 were marketed together with the DEC hardware at no separate charge. (Hindle, Tr. 7426.) The "Computerpack" was actually a complete turnkey system for users desiring systems that required a minimum of programming and computer experience. DEC merely added an application package to a PDP 8 and marketed the result as a "Computerpack". For example, the "Quickpoint-8" was offered for numerical control tape preparation; the "Communic-8" was offered for data communication applications; the "Time-Shared-8" was offered for general purpose time-sharing applications; and the "LAB-8" was offered for nuclear magnetic resonance spectroscopy applications. (DX 6868, pp. 7-10; DX 10776, pp. 8-13.)

h. Competition. DEC's approach to the market was different than that of IBM. DEC in the 1960s offered fast, inexpensive hardware with less versatile and generalized software and service than that offered by IBM. As shown in PX 377-A, DEC marketed most of its machines announced in the 1960s to "experienced" and "moderately experienced" users. Perlis described the PDP systems as they were perceived in the university environment: "[I]t was generally felt that . . . PDP systems . . . for delivering the same amount of work, were cheaper than the IBM systems." He estimated that the PDP 10 was about 20% cheaper than a 360/50 because of the "attendant staff of operators, people to handle the variety of software that is used . . .

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and so forth" associated with the IBM 360 Model 50 while PDP 10's were operated "without any staff whatsoever in attendance on the machine during its period of operation, which runs 24 hours a day, seven days a week".* (Tr. 1976-77.) In this respect, the bundle of services associated with the IBM 360 line provided an opportunity for DEC to obtain a price advantage with users who did not want or need those services. Thus, as is illustrated by the discussion below, DEC offered hardware and software more tailored than the generalized System/360 to enable users to perform one or a few applications in a decentralized way rather than on a central IBM computer.

Competition from DEC was felt within IBM in the 1960s. Wright, who was a Director of Marketing in IBM's Data Processing Division in the 1960s, included DEC on his list of "principal competitors" during the 1964 to 1969 time period. (Wright, Tr. 12993.) Similarly, when Rooney was employed by IBM in the mid-1960s as a Branch Manager in New York, DEC was competing in the "marketplace" for the "manufacture and marketing of systems for commercial or scientific usage". (Rooney, Tr. 11733.) Akers recalled meeting DEC in three different situations in which he was personally involved in the 1960s with 360 equipment competing with computer systems from DEC. (Akers, Tr. 96713-14.) He studied DEC both as a salesman in Vermont and a

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* Of course, with IBM "the user receives an enormous amount of service, an enormous amount of software, very good maintenance and for many users that is well worth the 20 per cent difference". (Perlis, Tr. 1978.)

marketing manager in Boston (Tr. 96679) and, when in the New York Media branch office, found that IBM had "a good deal of competition from the Digital Equipment Corporation". (Tr. 96680.)

The competition between DEC and IBM was not only on a "one-for-one" basis. As Hindle explained, "[i]t would be possible that in a given computer application a customer could choose one powerful machine to do the job or could choose several less powerful machines and decentralize the job. In that type of situation we would have one machine competing with several machines from a different manufacturer." Such competition would arise, for example, because "[c]onsidering the total system cost of both software and hardware, a distributed network of smaller computers can often be a cost-effective alternative to the single, centralized computer". Alternatively, as Hindle said, "[i]t is possible to have several smaller computer systems which are not interconnected electronically" competing with a single larger computer system. (Tr. 7415-17.)

Similarly, the IBM Commercial Analysis Department described this competition in the Quarterly Product Line Assessment for the first quarter of 1970: "Mini-computers affect IBM's business potential by implementing one application out of several possible applications in a prospect's business." And, according to the report, the application selected for the minicomputer was frequently the application having the greatest economic justification. The off-loading of that application could eliminate the opportunity for IBM to supply the customer with a "larger and more comprehensive computer installation".

(PX 2567, p. 186.) The report also commented on the success of minicomputers:

> "Mini-computers have established a substantial base and continue to widen their base each year. Digital Equipment Corporation is now ranked #3 in total CPU's representing about 5,600 units (8%) out of the 70,000 total domestic CPU's reported for year end 1969 by Diebold." (Id.)

Other companies also met DEC as competition in the 1960s. Palevsky testified that DEC competed with SDS's Sigma Series. (Tr. 3228-29.) Honeywell management believed that Honeywell systems competed with systems from DEC as well as those from General Electric and Hewlett-Packard.* (Binger, Tr. 4593-94.)

DEC entered the seventies a large and profitable company with a successful and popular product line. Its 1970 fiscal year revenues were $135.4 million with income before taxes of $25.5 million. (DX 511, p. 1.) It had some 500 computers installed in the Federal government, or almost 10% of the total number, making it the third ranked supplier in terms of numbers of computers (behind IBM and Univac). (DX 924, p. 6.) But, despite the impressiveness of those indicators of success, they were but small fractions of the DEC that was to emerge in the next decade.

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* Spangle included DEC as well as Sperry Rand, NCR, Burroughs and CDC in a list of Honeywell's competitors. (Spangle, Tr. 4933-34.)

49. AT&T. Despite the continuing restrictions of its 1956 Consent Decree, AT&T expanded its offerings of computer-related products and services during the 1964-1969 period. Its U.S. EDP revenues, as a result, grew from $125.6 million in 1964 to $477.75 million by 1969. (DX 8224, p. 133.)

As it did in the 1950s, AT&T competed in the computer industry in at least two ways during the 1960s. The first involved Western Electric's manufacture and marketing to the Bell System operating companies of stored program controlled electronic switching systems and automatic intercept systems. Because of the Bell System's enormous size and the fact that the Bell operating companies are free to and do in fact buy EDP products and services from non-Bell affiliated companies, this is a very important source of business to computer vendors who vie with Western Electric for the business of the Bell System. (See DX 5945, Dunnaville, pp. 6-8 and discussion below.) During the 1960s equipment developed and manufactured by AT&T competed for the business of the Bell System with the equipment of other EDP vendors, including IBM. (Id.)*

The second form of competition is AT&T's offering of EDP products and services to non-Bell customers. While this business

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* Despite their corporate relationships, the various subsidiaries of AT&T--including Western Electric Company and the Bell Telephone operating companies--deal with each other "on an arms' length basis". Each company "is structured as a separate corporate entity", and is "regulated closely and carefully" by the various regulatory agencies (both state and federal) which administer the telephone system. (DX 5945, Dunnaville, pp. 4-5.)

is also a large one, AT&T is restricted in the extent to which it can compete in this area by the 1956 Consent Decree. (See United States v. Western Electric Co., [1956] Trade Reg. Rep. (CCH) ¶ 68,246 (D.N.J. 1956).)*

Competition for Bell System EDP Business. By mid-1963 at least--while System/360 was in the planning stages--IBM executives understood that IBM was facing direct and substantial competition from AT&T and that its new computer systems would more and more be competing with AT&T's. As IBM Senior Vice President T. V. Learson wrote to IBM Chairman T. J. Watson, Jr. and President A. L. Williams in August 1963, less than a year before the announcement of System/360:

> "1. IBM, as well as most of our well-known competitors, are competing directly with AT&T in both the terminal [**] and the message switching equipment area today.
>
> "2. The next generation of machines will handle indistinguishably data and voice.

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* The 1956 Consent Decree does not, however, limit AT&T in any way in its sale of EDP products and services to the United States Government. Thus, in the SAFEGUARD anti-missile program, the Army chose AT&T-developed hardware and software rather than commercially available computers and software. (DX 5057, pp. 3-7; see also DX 5061.)

For the period 1964-1969, AT&T's revenues from the sale of EDP products and services to the United States Government were as follows:

1964--$37,856,000
1965--$40,216,000
1966--$51,737,000
1967--$50,964,000
1968--$51,949,000
1969--$65,746,000. (DX 5945, Dunnaville, pp. 12-13.)

** Of course, in 1963, as in the rest of the 1960s and the 1970s, AT&T's terminal business was not limited to the Bell operating companies. (See discussion below.)

"3. The product serving the market area above will also include our new processors [System/360].

"4. The present central plant of AT&T will be replaced by this same equipment.

"5. We plan to expand our sales effort into the plants of the independent telephone companies, both here and abroad.

"6. Since the equipment we will supply to our customers will be identical to what AT&T will require for their plant, they may well represent a possible new market." (DX 12408.)

Mr. Learson's observations were borne out in 1965, when AT&T's first electronic switching system, developed by Bell Labs and manufactured by Western Electric, went into service. (DX 14210, p. 7.) Western Electric has described that system--the No. 1 ESS--as follows:

"The No. 1 ESS is an automatic common-control type switching system directed by a stored program. . . . System intelligence, control, and actions are determined by a program stored in a semipermanent memory and the temporary memory. Variations and changes are accomplished primarily by changing the stored program rather than by changing apparatus and wired logic.

". . . .

"Central Control is capable of performing, one at a time, many types of logic on instructions from Program Store. Each instruction is a binary word. . . ." (DX 6880, pp. 1-2.)

Similarly, AT&T in 1964 described the No. 1 ESS in the following terms:

"The central processor controls the operation of the No. 1 electronic switching system by executing sequences of program instructions. . . ."

". . . .

"[A stored program system, as used in ESS,] consists of memories for storing both instructions and data, and a logic unit which monitors and controls peripheral equipment by performing a set of operations dictated by a sequence of program instructions. . . .

". . . .

". . . Therefore the central control can be described as an input-output processor superimposed on a general-purpose data processor." (DX 6886, pp. 1, 3.)*

That sounds like the description of a computer and indeed it is.** (DX 12419, pp. 6-7; see also DX 6883, p. 1; DX 10447, p. 4-5; DX 13832, pp. 14-15.)

In the first part of the 1960s IBM was actively marketing its computer systems for telephone applications, including switching. Beginning in 1963, for example, Southwestern Bell and IBM began to

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* The No. 1 ESS consisted of even more than memories and logic, of course. The Bell System engaged in procurements for tape and disk drives for the No. 1 ESS and was reported within IBM to have chosen Ampex and Burroughs, respectively. (DX 12412.)

** With the advent of stored program controlled electronic switching, it became clear that the technologies of electronic data processing and communications were beginning to converge. As AT&T stated in its 1964 Annual Report:

"The pace of change in communications technology strongly emphasizes the fallacy of trying to manage progress by walling it in. Our field is communications and we mean to stick to that, but to fragmentize the field artificially and set up arbitrary fences would be harmful rather than helpful to the public interest. Electronic switching, described in this report, is only one of the big steps into a wide, wide future; there are many other important developments as well.

". . . .

"A point of special interest is the expanding role of electronic data processing in research and development as well as in operations. Bell scientists and mathematicians have created new computer languages, so that more problems can be solved and answers obtained in the most useful form. . . . And in the day-to-day conduct of our business, electronic data processing is now employed in many, many ways." (DX 13831, pp. 14, 16.)

study the design of a computer-controlled automatic intercept system.* (DX 12411, p. 4.)** The computer system, installed in 1965, contained two IBM 1447 processors, four IBM 1311 disk drives, an IBM 1442 card reader, two IBM 7770 audio response units, and an IBM 2910 automatic intercept switch, as well as some non-standard hardware. (Id., pp. 5-7.) Western Electric later developed and marketed such equipment itself. (DX 6881.) Western's automatic intercept system had a control complex which it described as "a data processing system operating through the use of stored programs to process intercepted calls. The control complex monitors and directs the peripheral equipment." (DX 6881, p. 2.) Further, other vendors, besides IBM and AT&T, offered such systems as well. In the late 1960s, for example, IBM and Honeywell competed for an intercept application at the New York Telephone Company. (DX 12422.)

IBM similarly has bid its computer systems for other network switching applications. In a 1964 memorandum, IBM Vice President J. C. McPherson brought to the attention of IBM President A. L. Williams the Bell System's impending switchover to electronic computers for its central office exchanges, describing the switchover as "an extraordinary

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* An automatic intercept system provides assistance to telephone callers when they have dialed a number not presently in service such as a changed or disconnected number. (See DX 6881, p. 1; DX 12411, p. 4.)

** We are aware that DX 12411 was not received in evidence, but we believe it is reliable and rely on it because it appears to be written by an IBM employee with detailed knowledge of the IBM System installed in St. Louis at Southwestern Bell.

opportunity for our company [IBM] to expand its business by a serious effort to participate in this vast electronic construction and programming effort". (DX 5612; see also DX 12410.) IBM did in fact propose the use of a System/360 instead of No. 1 ESS to AT&T. (That event is described in the Department of Justice's First Statement of Contentions and Proof in United States v. AT&T, DX 9016A, pp. 448-50.)* As IBM Vice President John F. Akers testified, one of the "major ways" IBM has competed with AT&T

> "is in the electronic switching systems that the American Telephone & Telegraph Company employs to switch messages and to switch lines and to do customer billing and accounting information.
>
> "IBM over the years has competed with those systems. We have bid System 360 products, we have bid Series 1 products, we have bid System 7 products, and perhaps others." (Tr. 97036-37.)**

Moreover, in 1965 IBM engaged in contract negotiations with Canadian Bell "for over ten 360 systems for use in network switching". (DX 12413, p. 13.) IBM's sales strategy, according to IBM employee, G. W. Woerner, Jr., was "to convince the Bell System that the telephone companies should solve their problems with general purpose computers procured directly from IBM". (DX 12420.)⁄

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* We are aware that DX 9016A was not received in evidence but rely on the assertion of the Department of Justice because it is supported by other independent evidence. (See DX 5612; DX 12410; DX 12416; DX 12420; Akers, Tr. 97036-37.)

** Mr. Akers also identified AT&T as one of the companies with which IBM has "competed for business on a one-for-one basis" since 1964. (Tr. 96704-05.)

⁄ Similarly, in 1966, IBM entered into negotiations with General Telephone & Electronics and Automatic Electric "on the feasibility of IBM building the computer processor portion of a message switching system". (DX 12421, p. 2; see also DX 12418.)

IBM also considered supplying parts for the ESS, by offering core memories to the Bell System to replace the ferrite sheet memories produced by Western Electric (DX 12416, pp. 1-2), as well as offering other "IBM standard products". (Id., p. 3.)

In September 1965, Geoffrey Gordon of IBM, a member of the Special Systems and Equipment Department formed under IBM Vice President J. C. McPherson to market IBM equipment to the telephone companies for communications applications (see DX 12418), wrote a memorandum comparing the data processing capabilities of No. 1 ESS and System/360. He concluded that "[t]he two systems architectures are similar and most ESS1 instructions have equivalents in System 360." (DX 12414, p. 2; emphasis in original.) Although No. 1 ESS had "a few highly specialized instructions and features . . . that make ESS1 much more efficient" in performing its "network scanning operation", "[o]utside this area System 360 is judged to be as effective as ESS1 although its performance could be improved by adding some features. . . ." (Id.)

In August 1965, a task force was convened within IBM to study IBM's policy with respect to communications. (DX 12419, p. A.) In November 1965, that Task Force issued a report which concluded, in part:

> "Technologically there will be no distinction between an electronic switching center and a computing center. Both will be able to perform the same functions. . . .
>
> ". . . .
>
> "Communications should be recognized as part of our business . . . . In our judgment by 1970 fifty per cent of our business will involve communications-oriented products." (DX 12415, pp. 1-2.)

The Communications Task Force issued another report in March 1966 which stated:

> "<u>The professional level of the [common] carriers' research and engineering</u> is fully competitive with IBM's.
>
> " . . . .
>
> "Some believe that the business interests of IBM and AT&T will inevitably lead to a direct conflict. Others believe that we can have peaceful coexistence on business courses that never converge. Yet there is no question that the resources and entrenched communications position of AT&T make it potentially a formidable competitor indeed.
>
> " . . . .
>
> " . . . Although AT&T is a major customer for IBM data processing systems, its manufacturing subsidiary, Western Electric, has the ability to gear up to volume computer production." (DX 12419, pp. 7-9, emphasis in original.)*

The Communications Policy Task Force's 1966 Report also stated that:

> "ESS is a form of computer, a stored program transistorized digital system. . . .
>
> " . . . .
>
> "AT&T sees ESS as a means of providing its customers with a number of new services (all of which have data processing characteristics). These include a 'memory service' that permits adding a third party to a conversation, shortened dialing of frequently called numbers, and automatic transfer of incoming calls to another telephone. For its business customers, AT&T will use ESS for services that have such data processing features as message retrieval and automatic insertion of date, time, and message number.

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* The Task Force further stated that, as of the date of its Report (March 1966), "[a]ll IBM products have the technical characteristics necessary for a communications system. System/360--in both its equipment and programming support--is specifically designed with an advanced capability in data communications." (<u>Id.</u>, p. 2.)

"... Should AT&T decide to offer a shared data processing service, it could be offered as an adjunct to ESS, and take advantage of that broad-based structure. AT&T is thus in a position to shift to a more aggressive role whenever it chooses." (DX 12419, pp. 6-7.)

Indeed, by 1966, No. 1 ESS did provide an Automatic Message Accounting application in addition to its basic switching function. (DX 6884.)*

Thus, by 1968, then AT&T Chairman H. I. Romnes could state, as he did in a speech he gave to the Spring Joint Computer Conference of the American Federation of Information Processing Societies, that:

"[O]ne way and another we have been involved with computers a long time. And the thought I would like to convey is that we think we have gained an experience and an understanding that can be very helpful.

"I believe we understand the potentials of computers and the importance of communications in achieving them. I likewise believe we can contribute a great deal toward the realization of great aims.

"It is sometimes said, as you know, that the nationwide dial system is like a giant computer. Is this merely--or mainly--a figure of speech?

"No, not at all. It is a fact. . . .

" . . . .

"Today, as direct dialing has extended over the whole nation, our data processing equipment has become much more

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* In 1966, AT&T reported to its shareholders that

"[i]n all sorts of ways we are using the new computer-communications technology to improve service and hold down costs. Electronic switching systems (which are themselves computers of a special kind) are a massive example of this effort but there are many others as well." (DX 13832, pp. 14-15.)

For example, AT&T used the same technology developed for its electronic switching systems to provide a variety of other functions such as automatic message accounting (DX 6884) and traffic service position applications. (DX 6883.)

complex. . . .

"Now, with the development of transistor technology, we have started to use electronic processors to handle calls, rather than those that employ electromagnetic relays and switches. These processors of ours, like yours, have a vastly increased memory capacity and operate at electronic speed. . . .

"These new systems of ours, I might add, are big and complex. Their executive programs range from 70,000 to 200,000 or more words, and thus are in the range of the largest time-sharing general-purpose computer operations." (DX 10447, pp. 3-5.)*

Mr. Romnes and AT&T were not alone in perceiving the confluence of EDP and communications by the late 1960s.** In 1971, the

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* For example, in 1970, AT&T engineers described the Stored Program Control No. 1A processor--a follow-on to the No. 1 ESS processor--as "a general purpose stored program electronic processing system". (DX 6883, p. 1.)

Western Electric Company's revenues from the sale of its stored program central data processors and related equipment and software (such as No. 1 ESS and AIS) to the Bell System operating companies for the years 1964-1969 were as follows:

1964 -- $20,419,000
1965 -- $37,013,000
1966 -- $62,458,000
1967 -- $61,789,000
1968 -- $108,546,000
1969 -- $227,285,000. (DX 5945, Dunnaville, pp. 7-9.)

** Indeed, the Department of Justice itself commented in its 1968 submission to the FCC in Computer Inquiry I:

"Data processing and communications, which were formerly quite separate, are becoming increasingly interdependent as a result of the rapid growth of computer technology and efficiency.

" . . . .

"Although the functions of remote access data processing and of message switching are quite distinct, each system employs the same type computer facilities.

"Consequently, either system can readily be designed to perform the function of the other and in fact many computer systems are used to perform both functions." (Plaintiff's Admissions, Set II, ¶¶ 312.2, 312.13-.14.)

Federal Communications Commission issued its final decision and order in an inquiry it had initiated in 1966 into the regulatory and policy problems presented by the interdependence of computers and communications services and facilities. In that final decision, the FCC found:

> "There is virtually unanimous agreement by all who have commented in response to our Inquiry, as well as by all those who have contributed to the rapidly expanding professional literature in the field, that the data processing industry has become a major force in the American economy. . . . There is similar agreement that there is a close and intimate relationship between data processing and communications services and that this interdependence will continue to increase. . . . We stated in our Notice of Inquiry, and no respondent has challenged the finding, that common carriers 'as part of the natural evolution of the developing communications art' were rapidly becoming equipped to enter into the data processing field, if not by design, by the fact that computers utilized for the provision of conventional communication services could be programmed additionally to perform data processing services." (In the Matter of Regulatory and Policy Problems Presented by the Interdependence of Computer and Communication Services and Facilities, 28 F.C.C. 2d 268-69 (1971) ("Computer Inquiry I").)

<u>Other AT&T Competition</u>

In addition to competition with outside EDP vendors for sales within the Bell System, AT&T also competed in the 1960s in other areas. For example, AT&T continued to offer its modems for sale generally. (See DX 6890; DX 6893.) AT&T offered its Data Set* 202-B in 1963, stating that it "[t]ransmits and receives business machine codes over regular telephone lines. . . . Provides direct two-way communications between many types of business machines . . . [and] makes possible direct computer-to-computer operation". (DX

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* "Data Set" is the AT&T trade name for modems.

6893, p. 2.)

AT&T's 200, 300, 400 and 800 series modems, as well as the AT&T 10A Data Line Concentrator, have been manufactured and marketed for use as part of a communications processor. (DX 2891, pp. 2-4.) As such, they competed with IBM's modems marketed for the same purpose and indeed--as AT&T's brochures put it--by "reduc[ing] the need for separate data processing equipment at other locations" (DX 6893, p. 3) and "mak[ing] possible centralized data processing operations" (id.), provided customers with an alternative to other forms of data processing equipment. (See Knaplund, Tr. 90897-98.)*

Perhaps the most familiar example of AT&T's presence, however, is provided by its terminal products, most of which are manufactured and sold by Western Electric's subsidiary, Teletype Corporation. As the parties stipulated in 1975:

> "American Telephone and Telegraph Company manufactures and markets in the United States electronic digital computer terminals which perform input and output functions for electronic digital computers. Some or all of American Telephone and Telegraph's electronic digital computer terminals are used by end users as a part of 'general purpose electronic digital computer systems'." (DX 4906, pp. 6-7; see also, DX 2930, pp. 2-4.)

That statement is every bit as true when applied to the 1960s.

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* AT&T's revenues from the sales of data sets for the period 1964-1969 were as follows:

1964 -- $5,893,000
1965 -- $13,699,000
1966 -- $21,470,000
1967 -- $25,297,000
1968 -- $37,791,000
1969 -- $48,825,000 (DX 5945, Dunnaville, pp. 9-10.)

IBM, for example, has long been aware that its terminal products faced substantial competition from AT&T's terminal offerings. As noted earlier, Mr. Learson's 1963 memorandum to Messrs. Watson and Williams highlighted the fact that "IBM, as well as most of our well-known competitors, are competing directly with AT&T in both the terminal and the message switching equipment area today." (DX 12408.) In 1966, IBM's Communications Policy Task Force reported that "AT&T is already on the market with some impressive terminal products. These include the high-speed Inktronic printer (200 characters-per-second in the $100/month class) . . . . The Bell System has a huge installed base in terminals . . . ." (DX 12419, pp. 5-6.)

In October 1967, an IBM Quarterly Product Line Assessment prepared by the Commercial Analysis Department of IBM's Data Processing Division identified Teletype Corporation's teletypewriters as "[t]he major competition to our 2740 and 1050 terminals". (PX 2125, p. 121.) In May 1968, another Quarterly Product Line Assessment considering an IBM product program "intended to bridge the existing gap between IBM's low-speed (1050) and high-speed (2780) general-purpose terminal capabilities", observed that "[t]his terminal market is presently held largely by paper tape transmission systems such as AT&T DataSpeed . . . terminals." (PX 2238, pp. 149-50.) That report called AT&T's Teletype Corporation "IBM's Major [sic] competitor in the terminal area". (<u>Id.</u>, p. 201.)

In June 1968 an IBM task force report on data communications concluded that "AT&T will increase offerings of competitive products, e.g., terminals." (DX 9083, p. 24.) IBM Vice President Paul W. Knaplund, under whose supervision the report was prepared, testified that that report meant "that AT&T was then offering and would continue to offer on an increasing basis terminals, such as the teletype [sic] terminals in particular, modems . . . attachable to or incorporated in those terminals, and communication services incorporating terminals as well as a part of their tariffed offerings through the operating companies, so that AT&T at that time was offering terminals as a product and was also offering through its operating companies terminals in combination with modems and communications", something which continued and increased in later years in competition with IBM and with others. (Knaplund, Tr. 90897-98.)*

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* Teletype Corporation's EDP revenues (rounded to the nearest thousand) for the period 1964-1969 were as follows:

1964 -- $61,422,000
1965 -- $83,554,000
1966 -- $87,188,000
1967 -- $67,290,000
1968 -- $76,101,000
1969 -- $110,722,000 (DX 5945, Dunnaville, as amended by Letter, Dunnaville to Deutsch, February 27, 1975, included as part of DX 5945.)

50. <u>The Emergence of IBM Plug-Compatible Manufacturer (PCM) Competition.</u> As we have discussed previously, "the introduction of System 360, featuring compatibility across a complete line and constituting a major commitment by the IBM Corporation", presented IBM's competitors with a business opportunity of "developing IBM compatible equipment".* (PX 3908A, p. 5.) By marketing plug-compatible devices to end users of System/360, competitors of IBM could take advantage of the same benefits accruing to IBM from the modularity and standardized interface features of System/360 (Case, Tr. 73473-75), and especially from the product line's compatibility.** (PX 3908A, p. 5; see also

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* A plug-compatible peripheral is functionally equivalent to the unit which it replaces and allows the systems software and the CPU hardware to operate in the same manner as if the systems manufacturer's unit were attached. (Enfield, Tr. 20765, 21016; Gardner, Tr. 36881-84; Andreini, Tr. 46973; G. Brown, Tr. 51017-18; Withington, Tr. 58839.)

** It is important to bear in mind, however, that there were costs imposed by this systems architecture, costs which were recognized by the developers of the System/360. (See, e.g., DX 1657.) A basic concern was in fact the cost imposed by the modularity of the peripherals controllers, which prompted questioning of the decision to package the I/O control electronics in a separate box. J. W. Haanstra, GPD President and Chairman of the SPREAD Committee, wrote the following on February 26, 1963, to C. J. Bashe, Manager of GPD Technical Development:

> "If we really examine the 1401, we find that one of the big steps forward was the use of the main frame to accomplish I/O control functions. I am seriously concerned about NPL [System 360] if we do not have some outlook for this kind of economy. I know all the esthetic beauty of clean interfaces etc., yet true integration of I/O control function in the CPU is a real cost saver and extremely important. Further, it is crucial for machines toward the bottom of the line or else they only become inept imitators of the larger machines." (DX 1656.)

PX 2262.) Because the same peripheral equipment could be used with any model of the System/360 family (Navas, Tr. 41394-95; Hughes, Tr. 71939-40), the number of models of a given type of peripheral device could be minimized, resulting in at least three benefits to IBM--and to a manufacturer of IBM plug-compatible products:

(1) the reduction of development expenses, especially those associated with developing the various models;

(2) the reduction of unit manufacturing costs as a consequence of higher production volume for each type of unit; and

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Mr. Bashe responded one week later, reporting his discussion with Dr. Brooks, who was then IBM Processor Manager of the System/360:

> "I had lunch with Dr. Brooks and opened the question of whether it was in fact considered important to maintain identity between logical interfaces and the mechanical boundaries of machines -- even at increased cost. I was pleased and rather surprised to find that Dr. Brooks felt it would be foolish indeed to pay an inordinate price in even one machine for maintaining that identity. He volunteered the statement that if a considerable part of the market for a device such as a printer depended upon having a special version of that printer which was, for example, designed for native attachment to one or two of the smaller machines, then it probably should be done in that manner -- but preserving at any cost the logical identity in programming from machine to machine." (DX 1657.)

One month later, Dr. Brooks wrote:

> "I am very unhappy that our present packaging philosophy is leading us to stand-alone boxes for input/output control units. It seems to me we should be able to arrange to get the control units in the same physical frames using common power with either the CPU's or the devices in almost every case, and that, as necessary, we should allow spare space in CPU's for the accommodation of more or less expected amounts of input/output control units." (DX 1658.)

These same concerns would lead to packaging decisions in the 1970s in favor of I/O controller integration. (See below, pp. 1051-52.)

(3) the reduction of administrative overhead by virtue of simplifying the management of the lease base. (Navas, Tr. 41395-96; Hughes, Tr. 71939-40.)

In addition, competitors could copy IBM's design and, in particular, use its systems software, thus having lower development costs than IBM.

IBM management recognized this competitive risk as early as 1961. (Knaplund, Tr. 90497-98; DX 1404A, p. 40, (App. A to JX 38).) A System/360 Compatibility Committee was formed for the purpose of examining "possible competitive developments compatible to System/360" and recommending possible responses to that competition. (PX 3908A, pp. 4, 21-24.) After completing its study,* the Committee concluded that competitive systems manufacturers would investigate the possibility of developing processors compatible to System/360 and that I/O manufacturers, both independent and divisions of systems manufacturers, could achieve a position to market plug-compatible peripheral devices at prices approximately 20% below IBM's. (PX 3908A, p. 4; see Knaplund, Tr. 90497-98.) The Committee also foresaw "concerted activity from competitors in marketing I/O devices on System/360 in the Federal Government". (PX 3908A, p. 4.)

But even IBM's Compatibility Committee very much under-

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* The Compatibility Committee formed two groups: ". . . a Processor group to evaluate the possibility of competitive systems compatible to System/360, and an I/O group to consider the likelihood of compatible competitive equipment either in conjunction with other systems or directly attachable to System 360." (PX 3908A, p. 5.)

estimated the surge in PCM business that would take place.* The extraordinary success of System/360 attracted a number of companies into the business of replacing IBM System/360 peripherals with comparable "plug compatible" equipment, especially those original equipment manufacturers (OEMs) which were manufacturing peripherals for other systems manufacturers. (PX 4847, p. 1.) These plug-compatible devices were transparent to the IBM operating system and hence involved minimal effort to attach.** (Wright, Tr. 13236-38; Enfield, Tr. 20765-68; Ashbridge, Tr. 34900-02; see also Welke, Tr. 19191-92.) Ironically, the very success of the System/360 had spawned even more competition for IBM. (See DX 2583; DX 2585; DX 2587; DX 2589.)

a. <u>From OEM to PCM.</u> The IBM plug-compatible peripherals business was an outgrowth of the earlier OEM (Original Equipment Manufacturer) business. (See below, pp. 759-61.)

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* The Committee report further concluded that only a competitive replacement for the Model 30 was likely and that while I/O manufacturers would attempt to sell tape drives and terminals to System/360 end users, IBM disk, card and printer equipment "should not be greatly affected on System/360". (PX 3908A, p. 4.) At that time the Committee did not foresee the full success of the System/360 since there were two full years of uncertainty after the announcement of the system about whether the entire line would in fact be successful. (Withington, Tr. 58597.) System/360 proved, of course, to be an extraordinary success with users, beyond "wildest expectations". (Evans, Tr. 101122-23; see also Cary, Tr. 101360.)

** PCM devices included tape or disk drives that attached to the IBM control unit. (Gardner, Tr. 36880; PX 4472, p. 7; DX 12446; see G. Brown, Tr. 51064-65; see p. 770 below.) Marketing of control units and peripheral subsystems began in about 1970. (Compare DX 4249, p. 5 with DX 1576, p. 6; compare DX 13851, p. 9 and DX 13900, pp. 5-6 with PX 5593, pp. 7-8.)

In the 1950s and 1960s companies offering computer systems, such as Burroughs, DEC, GE, Honeywell, RCA, SDS and Sperry Rand, often did not manufacture their own components and peripherals but instead purchased that equipment from companies producing computer components and peripherals on an OEM basis. (Palevsky, Tr. 3198-205; Binger, Tr. 4549-50; Macdonald, Tr. 6898-99; Beard, Tr. 8999-9000, 9935-36, 10197-99; McCollister, Tr. 9598-607; Spitters, Tr. 42067-68; Withington, Tr. 56243-44, 58365-66; DX 1482B, p. 80.) Burroughs, for example, purchased printers and tape drives from Potter. (Macdonald, Tr. 6898; Peterman, Tr. 99944; DX 13899, p. 8.) CDC, GE, NCR and Sperry Rand all bought tape drives from Ampex. (Ashbridge, Tr. 34793-96, 34850-53.) GE purchased disk drives from Bryant, Telex, and CDC. (Ashbridge, Tr. 34792-94; G. Brown, Tr. 51017, 51057, 51542; DX 14475, p. 9.) SDS was able to enter the systems business in the early 1960s by assembling components and peripheral equipment manufactured by OEMs. SDS obtained core memory from Fabri-Tek, Ampex, and Magnetic Memories; printers from Data Products and NCR; tape drives and tape control units from Computer Products and Ampex; disk drives and disk control units from CDC and CalComp; card readers and card punch equipment from Univac; cathode ray tube terminals from CDC; and keyboard devices from Western Electric. (Palevsky, Tr. 3198-204.) RCA acquired equipment from OEMs in order to improve the functional capability of its systems; RCA computer systems incorporated IBM card I/O equipment, Anelex printers, and Bryant disks. (McCollister, Tr. 9598-606; Beard, Tr. 9935-36, 10197-99.)*

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* A 1968 study of peripheral manufacturers presented to the IBM Management Committee reported the following OEM relationships:

Systems Companies	OEM Equipment	OEM Suppliers
Burroughs	Printers	Potter
CDC	Fixed Head Disk	Vermont Research Corp.
	Printers	Anelex
GE/BULL	Fixed Head Disk	Burroughs; Digital Data, Inc.
	Movable Head Disk	CDC; Data Products Corp.
	Printers	Anelex; Olivetti
	Paper Tape I/O	Omni-Data
Honeywell	Fixed Head Disk	Vermont Research Corp.; Burroughs
	Movable Head Disk	CDC; Bryant
	Terminals	Bunker Ramo
NCR	Tapes	CDC
	Terminals	Sanders
RCA	Fixed Head Disk	Vermont Research Corp.; Bryant
	Movable Head Disk	IBM; Bryant; CDC
	Printers	Anelex
	Card I/O	Data Products Corp.
SDS	Fixed Head Disk	Digital Data Inc.
	Movable Head Disk	Data Products Corp.
	Printers	NCR
	Card I/O	Data Products Corp.; Univac
Univac	Fixed Head Disk	Vermont Research Corp.; Bryant
	Movable Head Disk	Data Disc; Memorex
	Tapes	Potter; Oki

(PX 2267B, p. 27.)

IBM employees regularly studied the peripherals of its systems competitors, whether manufactured by them or acquired from OEMs. Thus, in November 1964 they studied the competition provided by OEMs in appraising its technological position in the marketplace. (PX 6671, pp. 1, 3, 13, 15, 18, 22.) And again in December 1964 an IBM Peripheral Task Force analyzing the peripherals on IBM's systems reported its conclusion that IBM would lose approximately 500 system sales by the end of 1965 if IBM did not improve delivery schedules and lower minimum prices of peripherals. (PX 1271, pp. 1, 3.) Moreover, with System/360 IBM's disk files gave the company a competitive advantage in selling systems. (See above, pp. 393-95.)

The OEMs benefited from the emergence of computer leasing companies, which were organized to purchase CPUs, memories, and peripherals for lease to end users at lease rates below those rates of the major computer system suppliers. With the vast expansion of leasing companies in the late 1960s, manufacturers making the transition from OEM sales to the production of IBM plug-compatible equipment found it convenient to enter into OEM-like agreements with leasing companies. This enabled them to have their products marketed to end users without themselves having to provide a marketing force. Leasing companies, on the other hand, profited by being able to take advantage of the peripheral manufacturers' lower prices. (Enfield, Tr. 20827-29; Spitters, Tr. 42071; Friedman, Tr. 50458-60; PX 4834, p. 43; PX 4847, p. 2; see also the discussion of leasing companies at pp. 797-802 below.)

Companies entered the OEM field from the electrical, electronics or communications businesses, such as Ampex, Collins Radio, and Potter Instruments, and new companies were formed by EDP industry employees who sought to take advantage of the opportunity. (Guzy, Tr. 33168-69; Navas, Tr. 41240-42; Aweida, Tr. 49071-73; PX 4847, p. 1; DX 4741: Yang, Tr. (Telex) 6116; see also pp. 762-80 below.) These OEMs sold their products to attach to the computers of several different companies. (Guzy, Tr. 33584; Ashbridge, Tr. 34792-95, 34850-54; G. Brown, Tr. 51056-65, 51427-31, 51433-35; DX 1302; DX 1482, p. 1; DX 4122; DX 12544.)

The OEM business had, however, its "vagaries and unpredictabilities" because OEMs depended upon the business decisions of the systems manufacturers. (Spitters, Tr. 54352-58; DX 1270, p. 5.) As the 1960s progressed, systems manufacturers shifted their productive resources as peripherals became an area of increasing profitability and consequence to systems performance. These systems manufacturers turned to in-house development and production of peripherals in response to the growing business opportunity in that area. (Palevsky, Tr. 3277-78; Binger, Tr. 4550-51; PX 4201, pp. 3-5.) In 1960 peripherals had represented only about twenty cents of every hardware dollar spent on a computer system. (PX 4201, p. 3; DX 1553A, p. 13.) But by the late 1960s, peripherals had grown to constitute more than half of the systems price, and the expectation was that peripherals would continue to increase as a portion of the computer users' budget.* (Binger, Tr. 4596-98; Spangle, Tr. 5338-39; Norris, Tr. 6018-19; McCollister,

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* According to an internal IBM report, "[f]rom 1960 until [February 1970] the ratio of hardware dollars spent for peripherals increased from 19¢ to 60¢ of each dollar". (PX 2530, p. 3.)

Tr. 9587-91; see also PX 2267B, p. 9.) By July 1970, Burroughs, GE, NCR, RCA and Sperry Rand, which had previously purchased tape products on an OEM basis, were producing their own tape products; CDC, GE and Honeywell, which had previously purchased OEM disks, were producing their own disk products. (PX 3135B, pp. 1, 8-9.) Subsequently, newer companies like DEC and SDS also began to produce some of their own peripheral devices. (See the discussions of DEC and SDS at pp. 702, 705-06, 731.)

At about this time, CDC became an active OEM supplier. In the period 1968 to 1975, CDC marketed card equipment, disks and drums, memories, printer equipment, tape equipment, and terminal equipment to as many as 150 companies on an OEM basis. (Norris, Tr. 6021-30; G. Brown, Tr. 51002; DX 297; see also DX 4228, p. 3.) Notably, CDC was active in the late 1960s marketing on an OEM basis its non-IBM plug-compatible disk drives. (G. Brown, Tr. 51056-87.) CDC's first OEM shipments of disk drives occurred in 1966; CDC shipped its 9492 drives first to Honeywell and then to GE and ICL. (G. Brown, Tr. 51032-34.) In 1967 CDC started shipping its 2311-type non-IBM compatible drives, the 9433 and 9434, to such OEM customers as Honeywell, GE, Siemens, and RCA. (G. Brown, Tr. 51056-59.) CDC also offered on an OEM basis a 2314-type non-IBM compatible disk drive with a hydraulic actuator, the 9480. It was announced in 1968 and delivered, starting in 1969, to such customers as XDS, ICL, Saab, and CII. (G. Brown, Tr. 51078-79, 51087.) CDC announced and delivered in 1970 voice coil actuator versions of its 2314-type non-IBM plug-compatible disk drives, the 9736 and 9742. Principal customers were Siemens, ICL, CII, XDS, and Telex. (G. Brown, Tr. 51080-81.) CDC developed these voice coil versions because it was in heavy competition with CalComp for OEM contracts with Burroughs. (G. Brown, Tr. 51082.) CDC also announced in 1969 a 2314-type non-IBM plug-compatible disk drive, designated the 841, for use in its own systems for delivery in 1970. (G. Brown, Tr. 51068.)

As the systems manufacturers built their own peripherals capability, a number of OEMs began in 1967 and 1968 selling plug-compatible peripheral equipment directly to end users of IBM System/360 equipment. (Guzy, Tr. 32400-04, 33168-69; Ashbridge, Tr. 34852-54; DX 2851; DX 6740; see histories of individual companies, pp. 762-780 below.) Successful PCM installation did require overcoming customer reluctance to have a multi-vendor computer system. But that reluctance started disappearing in the late 1960s. (DX 7568, pp. 45-51; see below, pp. 759-62, 784-88.) As Stephen J. Butters, security analyst for Putnam Management Company, wrote in 1970:

> "Perhaps the single most important factor that has created opportunity for independent peripheral manufacturers is the evolving maturity of computer users. A constantly increasing number are reducing their dependence on mainframe suppliers and recognizing the cost savings and performance advantages of using independents." (PX 4201, p. 4; see also Brueck, Tr. 22251.)

A significant event marking the acceptance of multi-vendor installations occurred in June 1969, when the Comptroller General of the United States formally reported to Congress the results of a study conducted by the General Accounting Office (GAO) on the acquisition of components and peripheral equipment for Federal government computer installations. The report found that a number of private organizations had installed plug-compatible equipment and achieved substantial savings; it recommended that Federal agencies take immediate action to require replacement of leased computer components and peripherals with cheaper plug-compatible units. (DX 7568, pp. 3-4.)*

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* The Comptroller General's report stated in part:

"<u>FINDINGS AND CONCLUSIONS</u>

> "Recently, numerous independent manufacturers of peripheral equipment . . . have made a concentrated effort to compete with the systems manufacturers. . . .
>
> ". . . .
>
> "GAO identified selected computer components that are directly interchangeable (plug-to-plug compatible) with certain other systems manufacturers' components and are available at substantial savings.
>
> "GAO found that a number of private organizations had installed available equipment of plug-to-plug compatibility and had achieved substantial savings. Yet it found only a few instances where Federal agencies had availed themselves of this economical means of acquiring computer components. . . .
>
> "On the basis of observations at commercial organizations visited during the study, GAO believes that the acquisition of plug-to-plug compatible components for ADP systems, either in operation or on order, provides an opportunity for Federal agencies to achieve significant savings in costs, an objective which is in line with the President's program of cost reduction in the Federal Government. . . .

"<u>RECOMMENDATIONS OR SUGGESTIONS</u>

> "GAO recommends that the head of each Federal agency take immediate action to implement steps requiring replacement of leased components that can be replaced with more economical plug-to-plug compatible units. . . ." (DX 7568, pp. 3-4.)

The report also recommended acquisition of non-plug-compatible components:

> "<u>Potential savings available by using components that are not plug-to-plug compatible</u>
>
> ". . . .

The Veterans Administration acted upon this GAO study, examining plug-compatible replacements for its IBM 2311 disk drives, and recommending leasing Marshall, Linnell, and MAI 2311-type compatible drives. (DX 7582.) The result of the examination by the Veterans Administration and then other Federal agencies was the institution of government-wide peripheral equipment replacement programs, involving the procurement of not only disks but also tapes, memory, communications equipment, terminals, printers, and drums at cost savings to the Government. (DX 6257, Gold, pp. 111-15, 128-31; DX 9071, Crone, pp. 114, 118-19, 123-25.)

The PCMs thus could be and were in fact successful. (Withington, Tr. 56033-34; see histories of individual companies below.) By 1970 PCMs were shipping tape drives, disk drives, terminals, communications controllers and add-on memory. Some companies offered more than one type of plug-compatible peripheral, beginning with one product and then branching out. (PX 4847, pp. 1-2; see the stories of individual companies below.)

The business of these PCMs did not stop with IBM, however; the PCMs also marketed their IBM plug-compatible peripherals, with minor modification, on an OEM basis to non-IBM systems manufacturers. (Guzy, Tr. 33168-74; Navas, Tr. 41235-41; Spitters, Tr. 42066-69;

"<u>Recommendation</u>

"In view of the significant savings that may be realized when acquiring non-plug-to-plug components that are included in an ADP system, we recommend that the heads of all using departments and agencies investigate the feasibility of acquiring components from alternate sources of supply and interfacing the independent manufacturers' components into manufacturers' computer systems." (DX 7568, pp. 33-34.)

G. Brown, Tr. 51057-59; DX 1302; DX 1482, p. 1; DX 4113: Terry, Tr. (Telex) 3310-12.) For example, ISS sold its 2314-type IBM plug-compatible disk drive not only to Telex for marketing to users of IBM computers but also to Hewlett-Packard. (DX 4113: Terry, Tr. (Telex) 3310-12.) Memorex marketed its 630 (2311-type) and 660 (2314-type) disk drives not only directly to users for attachment to IBM computers but also to a number of different systems manufacturers, including RCA, Burroughs, Univac, Honeywell, DEC, Datacraft, SEL, Hewlett-Packard, NCR, Siemens, Phillips, and ICL. (Guzy, Tr. 33168-74; DX 1302; DX 1482.) Ampex sold its tape drives and add-on memory which were used for attachment to IBM systems to 75 or 100 different manufacturers. (DX 4004, Flanigan, pp. 62-65.) And CalComp marketed its Century Data disk drives to BASF, Burroughs, Univac, Nixdorf, and some 25 other OEM customers. (Navas, Tr. 41235-37; DX 1886, p. 7; PX 5584, p. 16.)

b. <u>PCM Entrants.</u> We now consider the history of some of the early plug-compatible manufacturers during the 1960s.

(i) <u>Telex.</u> From its organization in the 1930s until 1959, Telex was a family-owned business devoted to making hearing aids and a limited line of acoustic products. (DX 10658, p. 9.) In 1959 Telex experienced a "significant change in the ownership of the Company", and the new owners began "to implement a comprehensive growth program". (DX 14474, p. 2.) In the next few years Telex became, through "internal growth and acquisition", "a broadly-based electronics manufacturer" of "instruments, controls, components and special products for the electronics industry" and "phonographs and radio-phonographs for the retail market". (DX 10657, p. 15; DX 10658, pp. 8-9.)

In 1962 Telex acquired Midwestern Instruments, a supplier of telemetric and specialized electromechanical devices for the space program and instruments and magnetic tape devices for industry. (DX 10658, pp. 2-3.) Telex called the acquisition "one of the most important moves in its history". (DX 10658, p. 2.) Following the acquisition, Telex sold magnetic tape drives "to small, special purpose computer-type companies, making equipment for special, narrow purposes". (Jatras, Tr. 35209.)

In the mid-1960s, the large number of IBM tape drives in service attracted Telex's interest in the IBM plug-compatible tape business. In January 1966 Stephen J. Jatras, Telex's President, wrote to Roger M. Wheeler, Telex's Chairman and Chief Executive Officer:

> "The fact that there are 53,000 IBM Digital Tape Transports in the field has represented a tempting target for ourselves and others who build equipment of this kind. The greatest problem in penetrating this market has been that of convincing potential customers that they would be supplied with service equal to that they are accustomed to from IBM. In addition to convincing the customer of this, there was also the problem of actually carrying out such a [service effort].
>
> "We have recently found a method for satisfying the service requirements for this kind of equipment. Several of the large leasing companies such as Data Processing Associates (formerly Doheny Leasing Company) and Management Associates, Inc. have recently sprung up and made a major penetration into the IBM replacement market. Both of these companies have established service branches primarily staffed with ex-IBM personnel." (DX 1721.)

Jatras also estimated that the engineering costs for the design of "a modification list for the standard M4000 Digital Tape Transport [which Telex was then marketing] so that [Telex could] offer an IBM compatible machine" was "approximately $42,000". (DX 1721.)

Telex did in fact enter the business of manufacturing IBM plug-compatible tape drives after receiving a contract from DuPont. Jatras described this turn of events in his testimony:

> "[O]ne of the men who worked for Midwestern Instruments had earlier made a proposal that we undertake the idea of trying to convert or redesign one of our digital tape drives, such that it would interface with an IBM CPU, and we studied that for a while and appropriated some money to do some preliminary work and to actually begin the development program of the interface electronics.
>
> "We . . . had, up until that time, been a manufacturer for OEM markets primarily, and the prices that prevailed in the IBM plug-to-plug market . . . looked quite attractive to us, and we saw a good profit opportunity.
>
> "Subsequently, the DuPont Company, on some independent means, decided they wanted to replace their IBM 729s, and by that time we were probably halfway done with our engineering program, and when we responded to the request for a quotation, apparently we were the only ones that could, in a convincing way, meet their delivery requirements, and we won that order.
>
> "After we won that order and put some equipment in the field with them and put another installation in, we became convinced that we understood how to make the machines work in that environment, and we then eventually reached the decision to go into the market in the broader sense." (Jatras, Tr. 35209-10; see also Ashbridge, Tr. 34799.)

Telex began deliveries of its 729-type drives in 1967. (DX 4249, p. 5; DX 10654, p. 6.)

Telex tape drive sales increased rapidly. (DX 13856, p. 3.) Tasting success in its computer-related business, Telex expanded its product line to include disks and printers as well as tapes. (DX 4242, p. 2; DX 4250, p. 6.) On April 21, 1969, Telex entered into an agreement with Information Storage Systems, Inc. (ISS) to market and service ISS-built 2311-type and 2314-type disk drives. (DX 13856, p. 3.) In early 1970, Telex reached an agreement with CDC for the marketing of "a complete printer subsystem, utilizing a train type mechanism manufactured by CDC" and a controller manufactured by Telex. (DX 4250, pp. 4, 7.)

Telex's rapidly expanding EDP business was reflected in its domestic EDP revenues, which increased from $870,000 in 1966 to $23,006,000 in 1969 and almost tripled to $65,628,000 in 1970. (DX 8224, p. 554.)

(ii) Ampex. In 1955 Ampex produced its first tape drive for use with a computer. (DX 13884, p. 22.) After that time, Ampex manufactured magnetic tape drives for sale on an OEM basis. (PX 4847, p. 1.) Its biggest customer was General Electric, but the list of customers also included NCR, CDC, Burroughs, Collins, Sperry Rand, and several European manufacturers. (Ashbridge, Tr. 34794; PX 3237A, p. 7; DX 13883, p. 9.)

In 1960 Ampex stated its "plans to continue development and introduction of memory devices tailored to the advanced requirements of manufacturers of computers and other data-processing equipment". (DX 13880, p. 5; see also DX 13881, pp. 1-2.) In the next few years, Ampex offered several new tape systems as well as core memory. (DX 4004, Flanigan, pp. 65-66; DX 13882, p. 8.) In 1962 Ampex sold "three major models" of tape drives on an OEM basis to such companies as CDC, NCR and GE. (Ashbridge, Tr. 34794.) In the 1964 to 1974 period, Ampex sold its tape drives to 75 or 100 different manufacturers of computer systems, including not only IBM but also Burroughs, General Automation, RCA, Honeywell, DEC, GE, Hewlett-Packard, NCR, Sperry, and Varian Data Machines. (DX 4004, Flanigan, pp. 62-63.) The tape drives sold to all of these companies were substantially the same product. (Id., p. 63.)

Ampex was one of the first companies to enter the IBM plug-compatible replacement business. (PX 4847, p. 1.) Like Telex, Ampex entered the business after being asked to bid on replacing DuPont's IBM 729 tape drives. Although Telex received the contract, the event brought a change in Ampex's marketing emphasis. (Ashbridge, Tr. 34797-99.) Ampex, in 1968, began marketing a replacement for IBM tape drives directly to end users. (Ashbridge, Tr. 34799-800; DX 13836, p. 9.) The drive, the TM-16, was a plug-compatible drive for replacement of IBM's 729 and 2401 tape drives. (PX 3237A, pp. 7-8; DX 4756, p. 36; DX 13836, p. 9.)

Ampex reported on this move to its shareholders in its 1968 Annual Report:

> "Typically, Ampex has supplied tape transports to major computer manufacturers or developers of specialized data systems. With the TM-16, the company is seeking an entirely new customer group, the users of data processing equipment. It is completely interchangeable with IBM tape transports systems and may be used instead of IBM transports with virtually any IBM computer now in service. Available for purchase or lease, the TM-16 may enable the end user to save as much as 50 per cent in transport costs." (DX 13836, p. 9.)

Ampex was the first company to offer add-on memory to end users of IBM systems.* In its 1969 Annual Report, Ampex stated:

> "While most Ampex core products are sold to manufacturers, the first end-user installations of Ampex core memories were made during the year at major data processing centers. Two Ampex Model RM extended core memories, each capable of storing nearly 10 million bits, were installed for use with two IBM 360/50 computers at the Kaiser Foundation Research Institute in Oakland, California." (DX 13884, p. 22.)

According to M. K. Haynes, IBM's Director of Storage Technology:

> "The Ampex LCS was originally designed and built for IBM attachment to the Model 91. After we had terminated the contract, Ampex continued the development to make it into a product which they had marketed and installed. The present Ampex situation is that they have installed three LCS units, all on 360 Model 50's." (PX 3656A, p. 3.)

Like other PCMs, Ampex prospered in the late 1960s. Ampex's net sales and operating revenues increased from $170 million in 1966 to $298 million in 1969 and $314 million in 1970. (DX 2978, pp. 16-17.) Ampex's domestic EDP revenues increased from $13.8 million in 1960 to $30.6 million in 1969 and $35.7 million in 1970. (DX 8224, p. 526.)

(iii) Memorex. Memorex was incorporated in February 1961 by four former employees of Ampex, each of whom invested $3,125 for a total investment of $12,500. (Spitters, Tr. 42040-53.) Additional capital of $1,250,000 was raised from "a group of some two dozen insti-

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* Subsequently, Ampex also sold core memory that was used with computer systems made by GE, Litton, RCA, DEC, Univac, and CDC as well as IBM. (DX 4004, Flanigan, pp. 65-66.) In the five or 10 years prior to 1974 Ampex sold its core memory products to as many as 100 different companies for incorporation in their computer systems. (Id., p. 65.) The core memory module sold by Ampex to all of these purchasers was "for all practical purposes identical". (Id., pp. 66-68.) The only difference in terms of cost was the interface, but that was "relatively nominal compared to the cost of the core memory". (Id., p. 67.)

tutions and individuals", including the Allstate Insurance Company and the Bank of America. (Spitters, Tr. 42052-53.) The company was formed to go into the business of manufacturing magnetic recording tape for computer and commercial broadcasting applications. (Guzy, Tr. 32330-31; Spitters, Tr. 42040-43.) D. James Guzy, Memorex's Executive Vice President and Chief Operating Officer when he left the company in 1973 (Guzy, Tr. 32316), testified that he invested in the company because "a proposal to manufacture magnetic tape was a particularly attractive one at that time, because there was only one principal supplier worldwide of that kind of product . . . [t]he 3M Company". (Tr. 32330.)

In the summer of 1962 Memorex began operations (DX 1264, p. 8), marketing computer tape to IBM systems users (Spitters, Tr. 42066), as well as instrumentation tapes. (DX 1264, pp. 8-10.) In the next few years, Memorex established itself as one of the three principal manufacturers of precision magnetic tape. (PX 4336, p. 5.) From 1964 to 1967 Memorex marketed its computer tape to Burroughs, Honeywell, CDC, Univac, NCR, DEC, and ICT. (Guzy, Tr. 32356-57.)

In 1967, "[b]uilding on its expertise in precision magnetic coatings" (PX 4336, p. 5), Memorex began developing disk packs for IBM and other systems manufacturers' disk drives. (Guzy, Tr. 32373, 32377-78; DX 1265, p. 17.) Laurence Spitters, Memorex's President, Chairman, and Chief Executive Officer, testified about the attraction for Memorex to enter into the disk pack business:

"Beginning in 1964, the market for disk packs developed with the shipment into the computer marketplace of 2311 type removable disks, and subsequently, I believe in 1967, with the shipment of 2314 type equipments, which called for a higher quality disk pack, a higher valued disk pack, these products were used by a large number of the several thousand customers to whom Memorex was daily calling upon selling its computer tape.

"These products involved, to some extent, some of the magnetic coating formulation, technologies that Memorex had for some years employed in its tape business.

"So, consequently, with this congruence of marketplace and its opportunities and technologies to some extent, it seemed most advisable for the company to enter the disk pack business." (Tr. 42090; see also DX 1265, p. 17.)

Memorex began marketing its first disk packs in September 1967. (DX 1266, p. 4.) Memorex, through its entrepreneurial subsidiary,* Disk

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* In the years 1967 to 1969, Memorex used a device called an "entrepreneurial subsidiary" to enter the disk pack, the disk drive, and the output microfilm printer businesses. (DX 1267, p. 7; DX 1268, p. 7.) In an entrepreneurial subsidiary, Memorex retained a majority ownership interest and provided financial support, marketing assistance, management expertise, and manufacturing capabilities. The remaining minority ownership was retained by "technically skilled individuals" who developed under contract a certain product and who had an incentive in capital gain. If the enterprise were successful, Memorex had the right to acquire the minority ownership interest in exchange for shares of Memorex common stock according to a predetermined ratio based upon the degree of success. (DX 1267, p. 5; DX 1268, p. 7; DX 1547, pp. 9-11; see also Spitters, Tr. 42094-102.)

As we describe later, the use of "entrepreneurial subsidiaries", as well as other accounting techniques employed, while enriching Memorex's founders and original shareholders, eventually led to substantial criticism of Memorex in the financial community. The use of the entrepreneurial subsidiaries was part of the speculative financial strategy of Memorex under Laurence Spitters, who made speeches about the strategy to members of the financial community. That strategy most notably included the use of debt leverage to minimize the issuance of equity so as to attempt to achieve capital gains for Memorex shareholders, especially for original shareholders such as Spitters himself. (Spitters, Tr. 54187-206; DX 1547; DX 1548.) The use of high leverage, which received criticism from "conservative investors and from bankers" (Spitters, Tr. 54207-08), would in fact later cause Memorex to have difficulties in paying the debt service (Spitters, Tr. 43106) and in obtaining capital.

Pack Corporation, sold disk packs both on an OEM basis and to users of IBM, CDC, and Honeywell computer systems. (Guzy, Tr. 32373.)

A natural direction of growth was from disk packs to disk drives. (DX 1268, p. 17; DX 1482B, p. 1.) In 1966, another entrepreneurial subsidiary of Memorex, Peripherals Systems Corporation, was formed to develop a key-to-disk entry recording system. (Guzy, Tr. 32364-66.) Although that device was not developed, the Peripherals Systems Corporation did successfully develop Memorex's first disk file, the Model 620. (Guzy, Tr. 32368-69.)

The Memorex 630 was an IBM plug-compatible 2311-type disk drive (DX 1267, p. 17) that attached to the IBM 2841 control unit. (Gardner, Tr. 36880.) It was sold "primarily" on an OEM basis and to leasing companies, especially MAI, which marketed it to IBM System/360 users; initial deliveries were made to MAI in 1968. (Guzy, Tr. 32370; DX 1267, p. 17.) At that time Memorex had "no marketing and no service organization", and Memorex required MAI's support (Spitters, Tr. 42071; DX 1482, p. 1), just as Potter IBM plug-compatible tape drives had been first offered to end users and serviced by MAI. (J. Jones, Tr. 79037-38.)

Memorex also marketed the 630 to Digital Equipment Corporation, which attached the file to its own computer systems. The 630 files marketed to MAI had a different interface from those marketed to DEC. (Guzy, Tr. 32383-84.) Memorex 630 drives with different interfaces were also marketed to other systems manufacturers. (Guzy, Tr. 33168-73, 33587-603; DX 1302.)

In 1969, Memorex adopted a plan to organize the company into two parts, (i) the magnetic media business, and (ii) the equipment group, which would consist largely of the two subsidiaries, Peripherals Systems Corporation, and Image Products Corporation. (Guzy, Tr. 32380-82.) In May of 1969, the equipment group had only the 630 disk file on the market but was developing a computer output microfilm system. It planned, however, to expand its disk file product line. (Guzy, Tr. 32382-83.)

Guzy testified that Memorex's strategy for its equipment group was to begin by expanding its disk file line, selling to OEMs. This would "produce some cash to finance the forward development of the corporation". The second part of the program was to take these same products into the end user marketplace directly. The objective was to develop an end user sales and service organization. The combination of the volume of product being manufactured for OEMs and the additional volume sold to end users "would give us overall lower costs" and this, in turn, would allow the third phase of the program, the development of Memorex's own systems. (Guzy, Tr. 32385-86.) Such lower costs through higher volume, of course, relied on the fact that Memorex had a single product line or at least common facilities for production of OEM and plug-compatible products. (Navas, Tr. 41395-96.)

OEM sales were to come first because they were easiest. Spitters testified that:

> "To market to MAI required a skeletal sales organization, principally consisting of Mr. Guzy and one or two assistants. There was no service capability required, and of course, Memorex

> had none. And it was principally relating to the absence of an end user marketing force and service force that we undertook selling to a very small group of OEM customers; and, secondly, OEM customers were cash customers, and that was important to the cash requirements of the company." (Tr. 42071; see also DX 1267, p. 6.)

The first two phases of this strategy depended on producing IBM-like disk drives and Memorex hired a large number of disk drive engineers who had worked at IBM, writing to its customers to inform them of this fact. (Guzy, Tr. 32862-64, 32899-908, 33255-58; DX 1296, p. 2.) Between 1968 and 1971 Memorex hired approximately 600 former IBM employees and attempted to recruit nearly 600 other IBM employees. Among those hired was a cadre of engineers with experience in disk drive design. (Guzy, Tr. 32863-64, 32899-907, 33257-58; JX 34; DX 1418, p. 30.)

Memorex followed its 630 disk file with its 660 disk drive, which was "styled and intended to be an IBM 2314 type disk drive". (Guzy, Tr. 32776.) The 660 was announced in 1968 (DX 1267, p. 17), with volume production beginning in the second quarter of 1969. (DX 1268, p. 17.) Memorex initially marketed the 660 to a number of OEM customers. (Guzy, Tr. 33168-73, 33590-602; DX 1302.) For example, Memorex shipped about 1,200 660 disk drives to RCA, with the drive attaching through an RCA controller. (Guzy, Tr. 33177-79; DX 1302, p. 1.) It obtained an agreement from Univac for similar shipments, attaching through the Univac controller, but Univac terminated the agreement because of the poor performance of the disk drives. (Guzy, Tr. 33179-82; DX 1302, p. 1.)

Memorex subsequently marketed the 661 control unit for the

660 disk drive. The 661 was plug-compatible with IBM's System/360 and could replace the IBM 2314 control unit at 15% below IBM's price. (DX 1268, pp. 17, 19; DX 4756A, p. R-84; DX 4756, pp. 16-17; see also Case, Tr. 74117-18.) The control unit was announced December 17, 1969 (DX 1298), one day after Memorex had signed an agreement with a group of former IBM employees to develop such a product for Memorex. (Guzy, Tr. 33255-74; JX 34; DX 1297; DX 1298; DX 1299.)

Phase two of Memorex's strategy--marketing directly to end users--began shortly after the equipment group was formed in May of 1969, somewhat earlier than Memorex had anticipated. Guzy testified that the advance in timing occurred because, due to "recessionary influences", OEM customers were not taking the number of units which had been forecasted and, also, Memorex found it easier to hire people, "particularly salesmen and service men who were experienced in the computer industry. So it was able to come together faster." (Guzy, Tr. 32513-15.) In its 1970 Annual Report, Memorex stated that:

> "Concurrent with growth was the Company's transition from a reliance upon OEM customers (original equipment manufacturers) to an equipment products business based upon marketing to computer users. In 1969 and early 1970, an insignificant volume of products had been marketed to users. In the second half of 1970, approximately 90% of production was shipped to computer users." (DX 1269, p. 7.)

During 1969 and 1970, Memorex's disk sales grew substantially. Memorex stated in its 1969 Annual Report that its sales of disk drive products had been $15 million in 1969, the first full year of production. However, "[t]hroughout most of the year, sales were production limited and production was restricted by facilities.

Manufacturing space tripled during the year, but it was not until October that the major expansion occurred which accommodated a sharp increase in production". (DX 1268, p. 17.) Memorex's employees increased from 1,916 at year end 1968, to 3,409 at year end 1969, to 6,101 at year end 1970. (DX 1269, pp. 28-29.) By October 1969, Memorex had commenced phase three, the development of its computer system. (Guzy, Tr. 32423.)

The 1960s were years of great growth for Memorex. Spitters stated in 1968 that the company's sales volume had grown from zero to more than $60 million in seven years. (DX 1547, p. 12.) Its domestic EDP revenues increased from $390,000 in 1962 to $41,500,000 in 1970. (DX 8224, p. 547.)

Spitters explained that this expansion was financed by utilizing both the public securities market and bank credit. Starting with $1,250,000 of external capital, Memorex increased that capital in 1962 by $608,000. In late 1962, early 1963, sale and leaseback arrangements brought Memorex more than $650,000. Memorex also borrowed from the Bank of America; by 1966, the amount borrowed was $6 million. Memorex had a public offering of $12 million in 1966, and with those proceeds it repaid Memorex's bank debt. But by 1969 Memorex had again borrowed approximately $40 to $50 million from the Bank of America. (Spitters, Tr. 42101-07.)

Speaking in March 1969, Spitters stated that:

> "Our original investors who provided the 1961 and 1962 funding have enjoyed a capital appreciation of their investment of more than 80 times.
>
> "And our original public stockholders, who purchased

Memorex shares of the first public offering in March 1965, have received a 10-times appreciation of their investment." (DX 1548, p. 13.)

(iv) ISS. Information Storage Systems was formed by 12 IBM employees who had resigned in December 1967 from the IBM San Jose facility, which had responsibility for disk drive development and manufacture. (DX 4741: Yang, Tr. (Telex) 6116.) These 12 people, who were sometimes called the "Dirty Dozen", had worked in key disk development positions at IBM, and some of them even had been part of the Merlin (3330) program. (Whitcomb, Tr. 34566; DX 4756B, p. 96; DX 4739: Wilmer, Tr. (Telex) 4266.)

In April 1969, ISS granted Telex the "marketing rights to end user customers for disc pack drives manufactured by [ISS] . . . ." (DX 4756A, p. 36; see also PX 4732A, p. 12.) Before ISS had shipped any product on its own, Telex also assumed responsibility for servicing the ISS drives. This initially meant that Telex had rights to the 701, a plug-compatible replacement for the 2311. (DX 4250, p. 7; DX 4756A, p. 36.) Other disk products were added to the ISS line later in 1969. In September, ISS announced its 714 disk, which was a plug-compatible replacement for the IBM 2314. In November, ISS announced the 728 Control Unit, allowing the "728/714 system [to be] plug-for-plug compatible with the 2314 on an IBM selector channel". (DX 4756A, pp. 50, 71-72.) Telex also marketed these products to end users. (DX 4242, p. 8; DX 4250, p. 7; DX 4741: Yang, Tr. (Telex) 6117-20.)

ISS began its first product shipments in August 1969, and its sales for that year were $648,000. By 1970, ISS revenues were $24,247,000. (PX 4732A, pp. 11, 14.)

(v) <u>CalComp/Century Data Systems.</u> California Computer Products (CalComp) was incorporated in September 1958, and the company's primary business for the next decade was computer plotter systems, associated electronic equipment, and related software. By 1966 CalComp claimed it was a major supplier of digital plotting equipment and that of the digital plotter systems in operation, more than half had been supplied by CalComp. (DX 10736, pp. 3, 6.) By 1972 CalComp laid claim to being the pioneer in as well as the world's leading supplier of digital plotter hardware and software. (PX 4445, p. 7; PX 5583, p. 8; see also PX 5581, p. 10; DX 13885, p. 1; DX 13844, pp. 3, 6-13.) IBM marketed a CalComp-manufactured plotter as the IBM 1627. (Northrop, Tr. 82500.)

Century Data Systems was formed in 1968 by several former SDS engineers to enter the plug-compatible disk drive field. (PX 3655, p. 9; PX 4298, p. 1.) In October 1968, CalComp made an initial investment in Century Data Systems, becoming the major investor. (PX 5582, p. 7.) This investment was increased "from 49% to 66%" in March 1970 (PX 5581, p. 32; PX 5582, pp. 5, 7), and then to 94% in October 1971. (PX 5583, pp. 5, 26.)

Century Data shipped its first plug-compatible disk drive (a 2311-type) in June 1969. (PX 5324, p. 46.) Century Data later became the "first company to produce and ship a 2314 equivalent". (DX 4756A, p. 8; DX 10735, p. 10.) CalComp purchased these disk drives from Century Data for resale to end users. (PX 5581, p. 10; DX 10735, p. 8.) Century Data also marketed the disk drives to leasing companies such as Randolph and to other computer companies such as Nixdorf (through BASF) and later Burroughs and Univac on an OEM basis. (PX 3146A, p. 1; PX 5581, p. 10; PX 5582, p. 7; DX 1886, p. 7; DX 12194; see also Guzy, Tr. 33201-02.)

CalComp's gross revenues increased from $16.8 million in 1968 to $20.4 million in 1969 (DX 10735, pp. 26-27) and in 1970 Century Data Systems' revenues for the fiscal year ending June 1970 were $4 million. (PX 4201, p. 13.) CalComp's U.S. EDP revenues rose from $11.2 million in 1967 and $13.3 million in 1968 to $22.6 million in 1970. (DX 8224, p. 531.)

(vi) Sanders Associates, Inc. Sanders was founded in 1951 (DX 13903, p. 4), and for the first 15 years pursued a corporate policy of being a progressive defense-oriented electronics firm. (DX 13903, pp. 4-7; DX 13904, pp. 5-7; DX 14220A, pp. 4-6, 10-11; DX 13906, pp. 11-12.) Sanders grew from a fledgling outfit with $495,000 in revenues in 1952 to a growing company with $59,764,000 of revenues in 1965 and with many important contracts, especially for electronic weapons and aerospace systems. (DX 13905, pp. 10-11; DX 13906, pp. 6-12, 27; see also DX 13908, p. 11; DX 13910, pp. 18-23.)

One key contract was for the development of the Saturn V monitoring and launch checkout system, which required use of the most up-to-date command and control display terminal techniques available. The Saturn V system included techniques for video mapping, random plot vectoring, and Photo Pen editing. NASA contracted for seven of these systems. (DX 13906, p. 18.) By 1966, four became operational. (DX 13907, p. 18.)

From this base Sanders concentrated resources into information processing technology and entered the non-Government display terminal business in the mid-1960s. (DX 6024, March, p. 4; DX 13906, pp. 14, 18.) In its 1965 Annual Report, Sanders announced its entry into the commercial display business:

> "The new Sanders 700 Communicator series of display systems will interface with any modern high speed data processing system to give instantaneous multiple station access to computer stored information. They permit operators to call up and edit data for all kinds of business operations--inventory, sales production, credit, costing, traffic--and immediately up-date the computer file.
>
> "Efficient and versatile display devices multiply the usefulness and value of computer handled information by several orders of magnitude. While competition exists along a wide front of manufacturers, the intense need for capitalizing to the fullest possible extent on computer capabilities makes this a logical choice for Sanders' heavy experience in display technology. The market is, as a matter of certainty, on the verge of an expansion that matches the pace of the computer industry itself.
>
> "The Series 700 uses microcircuitry techniques exclusively, techniques that are a special forte of Sanders data handling engineers. By use of microcircuitry, the Series 700 offers basic advantages in generating, transmitting, and editing of business data. Since creative technology of a character that can leap frog existing techniques provides a vital margin of market superiority, the information display field appears to be a logical commercial growth opportunity for the company." (DX 13906, p. 18, emphasis in original.)

In 1966 Sanders formed a Data Systems Division to coordinate low cost display manufacturing and marketing activities. The first product the Division began delivering was the 720 communicator display system in September 1966. The 720 had both data display capacity and editing features, including the capability to update computer stored information while the 720 was off-line from the computer. (DX 13907, p. 19; see also DX 10169.)

The following year, 1967, saw Sanders broaden its product line and offer interface equipment for use with the IBM System/360. (DX 13908, p. 13.) Sanders offered new Models 960 and 620 display terminals and a Clini-Call data management system for hospitals. The 960 could present alphanumeric messages and graphic data that a Photo Pen sensor system was capable of editing, permitting a "dialogue" between the display and computer to solve data problems. (Id.) The 620 was announced by Sanders as a stand alone display system (DX 10170), intended for economical, remote single station operation needed in such cases as branch offices and distant warehouse locations. (DX 13908, pp. 12-13.) The Clini-Call system was designed so that hospitals could keep up-to-the-minute information on each patient from admission to discharge. (DX 13908, p. 13; see also DX 13909, pp. 22-23.)

Sanders met with such success in marketing these EDP products that in 1968 Sanders announced company objectives "to expand [data management and display systems] sales to 30-50% of [its] total business within the next three to five years" and "to become one of the leaders in the field". (DX 13909, pp. 3, 22.) Sanders based these objectives on the belief that the business for data management and display systems and computer peripheral equipment was "the fastest growing segment of the American economy". (DX 13909, p. 22.) Sanders strove to achieve these objectives in 1968 with the announcement of still more products, including an airline reservation terminal system for Braniff International, the SANDAC 200 communications processor, the Model 731 communications buffer, the ADDS 900 display system, and the SD-500 data storage and retrieval system for micro-filmed data. (DX 13909, pp. 23-25.) The 731 was fully compatible with System/360 software and could link up either with the multiplexor or selector channels of the 360, thus enabling Sanders to replace IBM computer equipment. (DX 10169, p. 10; DX 10174; DX 13909, p. 25.)

By 1969 Sanders was firmly entrenched in the EDP business "[w]ith its broad range of data communications systems and products". (DX 13910, p. 26.) Sanders had customers for its communications products in more than 150 businesses. (DX 13910, pp. 26-31.) EDP revenues grew from $724,000 in 1966 to $23,124,000 in 1969 and $36,424,000 in 1970. (DX 8224, p. 158.)

c. <u>PCM Price Competition and Success.</u> As one would (and IBM did) expect, where largely imitative products are introduced some time after the originals, PCMs were able to and did offer their products at lower prices than IBM. As Mr. Whitcomb* explained, IBM

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*Richard A. Whitcomb was employed by IBM for sixteen years, until September 1971 when he left to join the Itel Corporation. Before leaving IBM Whitcomb's last position, which he held for three years, was that of Product Marketing Manager, Input/Output Systems, in the Data Processing Division Headquarters. The Data Processing Division is the domestic sales arm of IBM. As a product manager, Whitcomb had the responsibility in the peripherals field for the market acceptance of those products. (Whitcomb, Tr. 34183-86; JX 5, p. 166.) Whitcomb explained:

would go in and do whatever was necessary to make the installation and after the installation had been made, the PCM would come along and offer his device at a lower price and replace the IBM device. (Tr. 34454-55.) H. G. Figueroa, Vice President of Marketing Development in IBM's Data Processing Division wrote in July 1970:

> "We lose due to price and secondarily as a result of lack of function . . . .
>
> "[T]he OEM discount averaged 27% below IBM's cost in loss situations." (PX 2615A, p. 1, emphasis in original; see also Whitcomb, Tr. 34458-61.)

The PCM price advantage was at least 10 to 15%. (Whitcomb, Tr. 34459-60; Navas, Tr. 39678-81; PX 4472, pp. 15-16; see also Haughton, Tr. 95169-70.)* In many cases, however, the price discounts over IBM equipment were even more substantial. For example, in November 1968, Frank Cary wrote to T. J. Watson, Jr. about the Telex and Potter price advantage in tape drives:

> "Midwestern Instruments (a division of Telex) and MAI (Management Assistance, Inc.), the sales organization for Potter

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> "You're responsible for the welfare of the product, and that means that you have to have certain information about what the competition is doing, what the development program is within IBM." (Whitcomb, Tr. 34185.)

The "prime responsibility" Whitcomb had was to measure the revenues derived from IBM peripherals products. (Whitcomb, Tr. 34185-86.)

* CDC and STC also priced below IBM when they entered the PCM business. CDC "generally" priced its IBM plug-compatible peripherals 10-15% below IBM with respect to end user customers. (Lacey, Tr. 6574.) STC priced its IBM plug-compatible products 10-20% below comparable IBM products. (Aweida, Tr. 49274-87.)

Instrument tape drives, are actively marketing direct replacement of IBM's 2400 Series drives. The OEM's predominate thrust has been replacing leased drives on purchased CPU's and their current purchase prices range from 25% to 50% less than IBM's 2400 Series" (PX 2343.)

There were similar reports in and outside IBM:

(1) IBM DP Group employees reported to the Management Committee in July 1968 that "OEM's price their products . . . at approximately 50-60% of our price for the tape drives coupled with quantity discounts" (PX 3086);

(2) ~~in January 1969, Peripherals Weekly reported that the~~ Telex 729 type tape drive cost "more than 50 per cent less than a comparable IBM 729" (DX 4756A, p. 3);

(3) IBM San Jose Market Research employees reported in February 1969 that "[t]he IBM price [of 2311's] is discounted as much as 40% by competition" (PX 2392, p. 2);

(4) in May 1969, J. Haddad wrote to Cary that Ampex had "begun offering plug-compatible main memory to 360 customers at about one-third of the IBM price" (PX 2441A, p. 1; see also Andreini, Tr. 47542-45);

(5) in June 1970, Telex planned to price their printer up to 25% "below IBM" (DX 1682, p. 11);

(6) in September 1970, Computer Daily reported the price of a newly announced 2314 plug-compatible by CDC as 27 per cent below the IBM price (see JX 38, pp. 938-39; DX 4756B, p. 102; and

(7) Elliot Gold of the ADP Procurement Division of the General Services Administration wrote in October 1970 that "[d]ur-

ing the last year, a large number of items have come into the marketplace which replace certain IBM and Univac [plug-to-plug] components at savings ranging up to 41 per cent on rental and 60 per cent on purchase" (DX 4555).

In addition to lower list prices, PCMs did not charge for additional use of equipment beyond 176 hours per month as IBM did. Free overtime usage was most attractive to the high-usage customers, customers who were running their systems on a two- or three-shift basis. (Whitcomb, Tr. 34460-62; PX 3847A, p. 19.)

PCMs also offered other financial incentives that further reduced their prices. These discounting practices included

-- long term leases with lower monthly charges;

-- free trial periods from 30 days or more;

-- special discounts off list price;

-- volume discounts;

-- free transportation from the plant to the customer's site; and

-- "rent forgiving practices".

These practices in some cases increased PCM discounts by as much as two or three times that indicated by their list prices. (Whitcomb, Tr. 34460-62; Ashbridge, Tr. 34911; Spitters, Tr. 54432-33; Withington, Tr. 56630-32; Powers, Tr. 95386-87; PX 4201, p. 6; DX 1743; DX 4243.)

PCMs were able to offer lower prices because they would install their products in existing IBM installations and thereby avoid the substantial costs that IBM had incurred and continued to bear in systems development and marketing, in product research and development, and in software support. (Spitters, Tr. 55286-87; Haughton, Tr. 95169-70; Cary, Tr. 101336-48; PX 2308, p. 220; DX 1542, p. 4; DX 1673; DX 1848; DX 1926, p. 10; DX 4226, p. 20.)

As a result of its lower prices, there was rapid growth in the shipment of PCM equipment in the late 1960s. (Whitcomb, Tr. 34454-55; Withington, Tr. 56427-31; PX 4875, p. 1.) By 1968, there was "a sudden and very rapid growth" in the quantity of equipment shipped by plug-compatible peripheral manufacturers who were "displacing, or replacing the installed IBM equipment". This phenomenon started in the tape drive area and spread to the disk drive area. The "growth" of these companies, "in terms of the number of pieces of IBM equipment which were being displaced was very rapid". (Whitcomb, Tr. 34454-55; see also DX 6257, Gold, pp. 143-45.) By the end of 1969, IBM was receiving plug-compatible competition in add-on memory (Andreini, Tr. 46986), as well as in disks, tapes, printers, and terminals. (McCollister, Tr. 9327; Cooley, Tr. 31841-42.)*

The success of the PCMs in displacing IBM equipment was a significant concern within IBM in the late 1960s. In May 1968, W. J. Hollenkamp informed V. R. Witt, SDD's Director of Storage Products at the San Jose Laboratory (JX 5, p. 171), about the shift of OEMs into marketing IBM plug-compatible tape drives directly to IBM end

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* The IBM Management Committee Minutes of March 11, 1970, and the Management Committee Report of March 24, 1970, to the IBM Management Review Committee both note the substantial growth of PCM competition in disk, tape, and memory. (PX 2552B, p. 3; PX 2558B, p. 2.)

users. Mr. Hollenkamp noted that the PCMs were underpricing IBM, sometimes by as much as 55%, and that with the involvement of leasing companies in the data processing industry the trend was likely to continue. (PX 3237A, p. 6.)

At a July 15, 1968, meeting of the IBM Management Committee, a presentation on plug-compatible peripherals was made by the Data Processing Group (DPG) staff at the request of IBM's President, T. V. Learson. (PX 2267B, pp. 1, 4.) The presentation reported on the substantial compatible competition in the areas of disk drives, tape drives and control units, printers, and card I/O and reported an anticipated growth in PCM shipments. The presentation attempted to analyze the reasons for the tremendous success of PCM competition. Among the reasons given were (a) the "explosive growth" in tapes and disks, (b) the availability of technology, (c) the mobility of people, (d) the availability of service and sales support with the advent of leasing and service companies, (e) the availability of capital to new companies seeking to exploit a more mature technology, and (f) the questioning of the one-vendor concept, especially by the Government. (PX 2267B, p. 13.) The Management Committee agreed with the DPG staff that IBM "should maintain [its] position in the I/O area through technical superiority". (PX 2267B, p. 2.)

The August 1968 Quarterly Product Line Assessment (QPLA), prepared by the Commercial Analysis Department of the Data Processing Division, also reflected the increasing competition that IBM was facing in the peripherals area:

"IBM has produced superior I/O equipment. Now it is freely copied, or improved upon, and presented to our customers as 'plug-for-plug' compatible. And it is! We have reached a point where every piece of I/O gear must be able to hold its own, in terms of price/performance, in a highly competitive market." (PX 2308, p. 220; see PX 2306, p. 2.)

At the October 17, 1968, Management Committee meeting a more optimistic note was struck with respect to tapes. While PCMs were considered to be established in the business, it was believed that IBM's new tape products would be an effective competitive response:

"increased investment in tape drive engineering in 1967 and 1968 had produced products which are technically superior to competitive offerings". (PX 3096A, p. 3.)

In November 1968, Frank Cary, then IBM Vice President and General Manager of the Data Processing Group, also emphasized the need to compete with "superior technology and function, and not price alone". He reported to Thomas J. Watson, Jr., IBM's Chairman, that Midwestern Instruments and MAI were "actively marketing direct replacement of IBM's 2400 series drives" and that "the strategy of new technology announcements [was] the most effective way" to respond to the PCM competition in tapes. (PX 2343.)

Nevertheless, PCM competition in tapes grew stronger. In May 1969, R. A. Whitcomb, the DPD Product Marketing Manager for Input/Output Products (JX 5, p. 166) (before leaving for Itel), informed Rodgers that IBM had already lost over 1 million points (monthly rental value) to competitive tape drives; that 2.5 million further points were "doubtful"; that competition was "installing all they can produce";* and

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* During this period PCMs were expanding their facilities in an effort to keep up with the demand for their products. (DX 1268, p. 4; DX 4249, p. 2; DX 4250, p. 6; DX 13900,pp. 3, 8; DX 13884, p. 22.)

that IBM's estimate of its losses through 1971 was going to be exceeded by 50%. Whitcomb's recommendations included reducing delivery times and cutting prices on IBM's most advanced tape drives.* (PX 2430A, pp. 2, 4.) And at the July 8, 1969, Management Committee meeting, PCM competition in tape drives was reported to be growing at 13% per month. (PX 3201A, p. 1.)

Also in July 1969 DPD President, F. G. Rodgers, in response to a request from IBM President Learson, told Learson that the "plug-to-plug tape and disk market [was] growing at a rate in excess of 70%". Rodgers also reported that the PCM activity would continue for at least four reasons: (1) systems manufacturer activity in the IBM plug-compatible peripherals business had increased; (2) leasing companies had committed approximately $170 million to PCM peripheral manufacturers for the purchase of disk and tape drives that the leasing companies would market; (3) the Federal Government was encouraging multiple vendor systems; and (4) contract terms and conditions would become more varied with pricing tailored for quantities, cluster installations, and long term leases. Rodgers added that IBM's strategy in response to this PCM activity was to cut prices and enhance performance on existing drives. (PX 3117.)

IBM employees recognized the substantial threat PCMs presented to IBM's systems business. A presentation made to the IBM Management

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* At a May 1969 General Managers meeting, J. M. Hewitt also recommended price cutting as a response to the Ampex LCS add-on memory competition. (PX 3654, pp. 5-6.)

Committee in July 1968 had forecast that in a period of six years, 1967 to 1973, when computed in millions of points, disks would more than triple, and tapes, printers and card I/O would more than double. Also in that same presentation it was forecast that peripheral equipment shipped by independents would increase in the period 1968 to 1974 from $200 million to $800 million. (PX 2267B, pp. 9-10.) The competitive evaluation done for the Merlin disk file in January 1970 included an analysis of disks offered both by systems manufacturers and by PCMs and took into account the PCM-leasing company marketing arrangements. (DX 7858.) A February 1970 talk on competition in the tape area by W. J. Hollenkamp (a talk which he was later to describe as "optimistic" and "mild in describing the threat that we face from competition") concluded that "the problem we face in IBM today" is that "it takes all the running you can do to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that." (PX 2530, pp. 1, 21-22.) Whitcomb, who at the time was DPD Product Marketing Manager for Input/Output Systems (JX 5, p. 166), concluded that if IBM had taken no price or product action, there would have been "[a]n increase in an accelerating rate of the plug compatible manufacturers versus the IBM inventory" and it would have been only a brief period of time before the PCMs would have replaced a very large portion, if not most or all of the tapes and disks attached to IBM central processing units. (Tr. 34456-57.)

The PCM competitive threat accelerated in 1970 with the issuance on February 2, 1970 of the Bureau of the Budget's Bulletin

No. 70-9. The Bureau directed federal agencies "to review and make certain determinations on whether leased peripheral equipment components in computer systems supplied by the system manufacturer should be replaced with less costly equipment available from independent peripheral manufacturers or other sources". (PX 3829, p. 2; see also PX 3960.) To facilitate this review, the General Services Administration was to send a listing to each agency of all installed leased components scheduled to be retained. Each agency was required, upon receipt of the listing, to review it and determine if "substitution action should be taken", and if action should not be taken, the agency was to indicate the reason and return the annotated listing to the GSA "no later than April 15, 1970." (DX 5212, pp. 2-4; see also PX 3829.)

V. R. MacDonald, DPD Vice President and Manager of the GEM Region, wrote to Messrs. Beitzel, Papes and F. G. Rodgers when he learned of the BOB Bulletin and gave his analysis of the IBM exposure--an estimated 8.27 million points of tape drives and disk drives which were subject to replacement by PCMs. (PX 3829, pp. 4-5; PX 3960.)

The Bulletin also prompted H. E. Cooley, Vice President of Development of IBM's Systems Development Division, to write to B. O. Evans, SDD President:

> "I consider this, along with other Government action . . . to be extremely serious.
>
> "I am seriously considering appointing myself as a one man task force to try to come up with some new ideas on the problem." (PX 3829, p. 1.)

Evans conveyed this message to Beitzel:

"This is such a serious question it deserves our best attention. Perhaps it makes sense to have Hank Cooley, Vic Witt, Vic Macdonald, and Howard Figueroa assemble as a task force to consider all of the ramifications of this action and insure that IBM's plans are the most responsive". (DX 1260.)

Evans testified about the appointment of the Cooley Task Force:

> "[E]arly in 1970, the peripheral marketplace was in a lot of trouble. System manufacturers, the plug compatibles, the leasing companies, were hitting us hard. We didn't know it at the time, but the beginning of the economic adjustment was on us and our lack of success in the marketplace was startling.
>
> "Mr. Cooley came to see me in February or March of 1970 and, at that time, he suggested that the problem was getting so serious and the pressure was going to be on us for solutions even more than they had, and Cooley suggested that he go over and work full-time alone on the problem of what more we might do.
>
> "I felt the problem was indeed serious and thought it was of such consequence that perhaps we ought to have a broader group than that, and it ended that we brought in, under Mr. Cooley's stewardship, a number of top professionals from the business. We brought in the Director of the Boulder Laboratory, the man most responsible for magnetic tape development; we brought in the Director of the San Jose Laboratory, the man most responsible for disk file development; we brought in an executive from the Data Processing Division in the United States from an area that was being hit hardest at that time by the competition; we brought in a representative from World Trade; and this group went to work then for some time looking at whether we could accelerate our technologies that were emerging, or if there was anything that we could do with technologies at hand to find a better way." (DX 4740, Evans, pp. 4005-06; see also PX 3829; DX 1260.)*

The next month, in March 1970, the IBM Management Committee

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* Cooley's and Evans' concerns were well-founded. A substantial amount of IBM's peripheral equipment was replaced in Government agencies. By February 1970, the Defense Department alone had identified 480 IBM tape units and 99 IBM disk drives to be replaced. (PX 3127A, p. 10.) H. S. Trimmer, Jr. of GSA advised Congressman Jack Brooks, Chairman of the Subcommittee on Government Activities, that "of approximately 3300 such components in the Government inventory as of June 30, 1970, over 1800 have been replaced." (DX 4323, p. 1.)

designated peripherals as a key corporate strategic issue.* (PX 2546A.) "Because the competitive statistics indicated there was greater competition than there had previously been" (Hume, Tr. 33034), the Management Committee was interested in establishing "a long range, well-defined and understood peripheral strategy" and included specific products in the scope of the intended review: "magnetic tape drives, direct access storage products, impact printers, card readers and punches, associated control units, and main and large capacity memory products". (PX 2546A.) The scope of the review was expanded a few days later "to include multiplexors (local and remote) and competitive compatible displays" because the purpose of examining peripherals as a key corporate strategic issue was "to examine [IBM's] policies and [IBM's] strategies

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* Mr. Cary explained the significance of defining a Key Corporate Strategic Issue (KCSI):

> "it's their [the Management Committee's] way of telling the operating unit that that's an issue . . . . they want to review more frequently than at operating plan review time." (Tr. 101388.)

In 1969, when the KCSI process was being established, many diverse subjects were designated as KCSI, including:

> "NS, the 3.7, remote computing, FSD special processor, MC/ST, Copier, and SBC futures. Those placed on a pending list were ACS, DPG leasing, FSD systems management, Carnation, DP Goals issues, WTC Goals issues, the OPD composer, OPD and SRA development, and IRD measurement." (PX 2420A, p. 1.)

Other examples of matters that were designated "Key Corporate Strategic Issues" were "The Copier II", the announcement of the whole new line of products in 1970 (NS), and recruiting. (Cary, Tr. 101389-90.)

The procedure of designating issues as "Key Corporate Strategic Issues" was stopped in June of 1971 because these issues "became so numerous that they . . . really weren't very meaningful any longer . . . ." (Cary, Tr. 101390.)

vis a vis competition and not individual products" and it was felt "that by confining it to local systems I/O gear we may be ignoring some key policy and strategic issues dealing with the communications problem". (PX 2550A, p. 1.) Ralph Pfeiffer, the IBM Director of Marketing, was assigned the lead Corporate Staff responsibility for the review (PX 2546A), in which role he was to supply a statement of "Corporate concerns" to Mr. Cooley's Task Force. (PX 2548A.)

At the March 11, 1970, Management Committee meeting, the key corporate strategic issue of peripherals was discussed. (PX 2552B, pp. 2-3.) The Management Committee concluded that the business opportunity for PCMs remained attractive and gave this assessment of their competitive position:

> "Continuing financial backing is likely. Larger volumes and broader product lines should aid OEM's in reducing manufacturing costs as well as reducing marketing expense and enhancing maintenance coverage. Users will use cost savings as a prime reason for procurement. The entrepreneurial opportunity will continue to be attractive to quality personnel. Therefore, accelerated competitive penetration is possible. . . ." (PX 2552B, p. 3.)

The Management Committee requested that the work being coordinated by Mr. Cooley proceed "as rapidly as possible" since by May of that year it would be necessary to price the not yet announced System/370. (PX 2552B, pp. 3-4.) And in its report to the Management Review Committee, the Management Committee stated that the peripherals area was IBM's "number one challenge". (PX 2558B, p. 2.)

The initial finding of the Cooley Task Force was that "there was nothing terribly significant that could be done through existing technologies". (DX 4740: Evans, Tr. (Telex) 4007.) Cooley, along with Evans, conveyed this finding to Mr. G. B. Beitzel, Vice President of IBM's DP Group, with the recommendation that IBM was "going to have to find price/performance through some policy pricing." (DX 4740: Evans, Tr. (Telex) 4007.) Beitzel did not believe that was "a proper recommendation from his development forces", and according to Evans, "threw us out . . . and sent us back to the drawing board, so to speak, to see if we could find anything more". (DX 4740: Evans, Tr. (Telex) 4007-08.) As a consequence, Cooley came back in the late summer of 1970 with several recommendations. His conclusion then was that the best way to compete was through technological excellence. (PX 3135B, pp. 1, 47, 49, 59-62; see also Whitcomb, Tr. 34488.) Mr. Evans testified about Mr. Cooley's recommendations:

> "[W]e would have to intensify the assignment of resources, have to assign more resources to the development of disk and tapes and their successor equipment." (DX 4740: Evans. Tr. (Telex) 4008; see also PX 3925, p. 8; PX 3991, p. 3.)

As the Management Committee recognized in March 1970, pricing of System/370 and System/370 peripherals required taking into account PCM competition. (See DX 7858; Fassig, Tr. 31997-98; Whitcomb, Tr. 34288-89; see also Withington, Tr. 56412, 56520-21.) Competitive analysis within IBM had warned that this competition should be taken into account in planning for the System/370. In the November 1968 QPLA, the Commercial Analysis Department urged consideration of "non-system competition" from "non-IBM I/O devices" in assessing the marketability of System/370 intermediate systems. (PX 2360, p. 112.)

Throughout 1970 PCM competition rapidly "accelerat[ed] in volume and scope", posing "a serious threat to IBM's potential for growth". (PX 3854A, p. 1.) The April 1970 QPLA reported that IBM faced serious competition in both tapes and disks: "IBM's most serious problem" was "the replacement of installed 2400 Series units by compatible drives". (PX 2567, pp. 212-13.) The August QPLA called PCM replacement of IBM 2311 disk drives a "major competitive problem" and proceeded to sound a warning about several types of competitors marketing disk products like IBM's 2311 and 2314 disks which were challenging the superiority of IBM's disk products:

> "Memorex builds 2310, 2311 and 2314-type files, marketing direct to end users. Their marketing agreement with MAI for the 2311-type file is still in effect.
>
> "G.E. is providing Greyhound with 1000 disk drives for 2311 replacement.
>
> "Potter offers 2311 and 2314-type files and storage control units to end users. ISS markets their 2311 and 2314-type files in conjunction with Telex. Friden manufactures and markets a 2311-type file in conjunction with Talcott.
>
> "Marshall Laboratories markets a drive interchangeable with the 2311, but with two R/W heads per arm. They also announced a 2314-type file.
>
> "Century Data Systems builds 2311 and 2314-type files, and markets them through Cal-Comp. Century Data has licensed BASF to manufacture and market these units in Europe, and they are particularly active in West Germany.
>
> "In addition to the above, CDC, ICL, and Fujitsu are manufacturing 2311-like drives for their own use, and also are selling them OEM to other computer manufacturers.
>
> "Hitachi manufactures and markets 2311 and 2314-type files for their own use, and are selling them OEM to other computer manufacturers. They do not presently have a U.S. outlet but are actively seeking one.
>
> "Univac announced their 2314-type device (Univac 8414 Disc Subsystem) for use on the Univac 9000 and 1100 Series computers. Honeywell has delivered the H274 (2314-type device) for attachment to the H200 and larger Honeywell systems. NCR announced a 2314-type device (NCR 657 Disk Drive) for the Century 200 system.

". . . .

"A recent trend in the competitive market reveals potential exposure in the disk drive area for IBM 1130 and 1800 systems. Intercomp, BCD Computing Corporation, IOMEC, Caelus, Memorex, and Community Computing Corporation have announced files in competition with the IBM 2310, 2311, and 1810 disk drives on the 1130 and 1800 systems. . . ." (PX 2627, p. 179, emphasis in the original.)

IBM was having trouble keeping track with the success of the PCMs, and forecasting their future success even though the forecasts were done "on a very consistent basis all during this time period". (Whitcomb, Tr. 34362.) Forecasts of installed PCM 2314 spindles were done on April 10, October 3, and October 31, 1970. The April 10 forecast saw 5,800 spindles of PCM 2314s installed by 1972. The October 3 forecast revised this figure to 8,700, and the October 31 forecast raised that figure again to 15,000. The April 10 forecast predicted that 12,500 spindles of PCM 2314 spindles would be installed by 1974, but the October 31 forecast revised this figure to 17,300. Moreover, DP Group forecasted that if the PCMs introduced a double density 2314, the number of PCM 2314 spindles would by 1974 increase to 21,400--60 percent of all 2314 type disk drives installed on IBM systems. (PX 3965.)

In short, despite the spectacular success of System/360, IBM was facing increasing intense competition as a result of the growth of PCM competition, the efforts of systems manufacturers in peripherals, and the continuing importance of OEM relationships. The dynamic, competitive nature of the EDP industry was demonstrated by these developments. Productive resources were channeled into the increasingly profitable field of peripherals, both by systems manufacturers and by independents, resulting in more alternatives for users in configuring EDP systems. IBM clearly faced the choice of responding to this vigorous competition or of losing more and more business.

51. Leasing Companies. To understand some of the reasons underlying the explosive growth of leasing companies in the late 1960s and to put their history in perspective, we first examine some aspects of their operations.

a. An Overview of Leasing Company Operations. Computer leasing companies acquire equipment from various sources. They purchase new computer equipment from manufacturers (like IBM), thereby qualifying for Investment Tax Credit when and to the extent it is available. They also purchase through users who have leased equipment already installed, using the purchase option credits accumulated by the users.* (Friedman, Tr. 50558-59; Spain, Tr. 88735.) In some instances, they obtain EDP equipment through used equipment brokers or through acquisition of companies that own such equipment.

Having purchased the equipment, leasing companies become new sources of supply for the same equipment, offering the user additional terms and conditions and financial alternatives to those available directly from the manufacturer. Although leasing companies are customers of IBM when purchasing from it, they are competitors when they lease the equipment to users. They generally must offer their equipment

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* On October 1, 1965, IBM announced a purchase discount plan applicable to System/360. Under this plan, rental credits accrued during the first 12 months of rent could be taken as a credit against purchase. The percentage of rental credit that could be taken varied from machine to machine, but, in effect, the discount available on purchase at the end of the first year of rental was approximately 12%. At the same time, IBM discontinued the practice of requiring a 1% (of purchase price) payment which had previously been required from users to preserve their option to acquire installed equipment. Therefore, "entrance under the plan [was] automatic". (DX 14136, pp. 1-3.)

at lease prices below those of the manufacturer or on different terms and conditions; otherwise, there would be little reason for customers to lease from them.

Leasing companies also compete across product generation cycles by reducing prices on older IBM equipment (e.g., System/360) thereby making it price/performance competitive with newer equipment (e.g., System/370 or 43XX). (JX 3, ¶ 23.) This competition is heightened by the fact that some leasing companies not only reduce prices on older equipment, but also enhance its performance through the addition of peripherals or software from vendors other than IBM. This competition from leasing-company-owned equipment constrains the pricing of IBM's products and affects their terms and conditions. (See, e.g., Withington, Tr. 57023-29, 58630-31; see pp. 826-30, 1026-30 below.)

Moreover, there has been another important competitive effect of leasing companies. During the 1960s (and thereafter) they have acted as systems integrators, combining hardware and software from more than one manufacturer into systems. (JX 3, ¶¶ 13-14.) In so doing, they have encouraged the wider acceptance of mixed systems. In addition, they have provided a source for the sale of the products of the plug compatible suppliers and have, in effect, augmented the marketing forces of those suppliers, facilitating their entry and initial growth. (JX 3, ¶¶ 15-16.)

The opportunity for profitable leasing company operation arises primarily from differences in suppliers' expectations about future prices. The rate at which prices for existing equipment will decline in the future is uncertain. If the pace of technological change or the introduction of competitive equipment is relatively slow, then the prices for computer equipment will decline more slowly. If, on the other hand, technological change or competitive product introductions are relatively rapid, the price levels of such equipment will decline more quickly; the rate of price decline is dependent in large part on how many vendors are marketing the equipment or alternatives to the equipment and on what the prices are on the alternatives.

Because of this uncertainty, a leasing company may perceive an opportunity to make a profit based upon its differing expectation about the future value of the computer equipment it is seeking to acquire. If a leasing company believes that the equipment can be leased at relatively high prices for a longer period than the current market prices for lease and purchase indicate, then it can act upon that belief and acquire the equipment at current purchase prices hoping to make a profit by keeping the equipment on lease sufficiently long to more than recoup (in present value terms) the purchase price plus its associated costs. Of course, if the leasing company miscalculates, then it will suffer losses. (JX 3, ¶¶ 9-10.)

There are many factors that affect the profitability (or the projected profitability) of leasing companies:

> "The financial results achieved by, and reported by, leasing companies depend on a host of factors including, but not limited to, the cost of EDP equipment purchased, the timing of purchase of EDP equipment, the rental charged and the terms and conditions

of lease agreements, the availability of capital, the interest rates paid on funds borrowed to purchase EDP equipment, marketing and remarketing costs, maintenance and reconditioning costs, the amount of EDP equipment that comes off rent, the length of time required to re-lease EDP equipment, the availability and utility of the investment tax credit, the accuracy of the forecast of the period for which and the rate at which EDP equipment will produce revenue, the rate of price-performance improvement offered by manufacturers and other leasing companies, the accounting principles utilized to record income and expense, the success or failure of ancillary activities and the skill of management." (JX 3, ¶ 18.)

Some of these items deserve further comment.

(i) <u>The Investment Tax Credit.</u> A purchaser acquiring computer equipment has, over the years, often been entitled to an Investment Tax Credit* (ITC) for some percentage of the investment in new equipment.** Generally, leasing companies could take full advantage of this since they universally depreciated their equipment beyond the eight years necessary to qualify for the full investment tax credit during the periods it was available in the 1960s.⁄ They could pass through the ITC to customers in one form or another or make use of it

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* The Investment Tax Credit was a key factor in the operations of leasing companies. (DX 10640, p. 5; see also Friedman, Tr. 50752-53; Spain, Tr. 89619-21.)

** The availability of the ITC has changed over time and is controlled by the federal tax laws. The ITC became applicable on January 1, 1962 (Revenue Act of 1962, P.L. 87-834), was, with some exceptions, suspended from October 10, 1966 to March 9, 1967 (P.L. 89-800; P.L. 90-26), and was terminated, with some exceptions, from April 19, 1969 to August 15, 1972. (Tax Reform Act of 1969, P.L. 91-172 § 703(a); Revenue Act of 1971, P.L. 92-178 § 101.)

⁄ EDP manufacturers, when leasing their equipment, usually do not qualify for the full benefit of the Investment Tax Credit because they depreciate their equipment more rapidly than the leasing companies, as discussed below.

themselves. (Friedman, Tr. 50752-55; DX 14190, p. 2.) Where the credits were retained, the practical effect of the ITC was to reduce the cost of the leasing company's investment in new equipment through current tax benefits. When a leasing company decided not to retain the ITC and passed it onto the lessee as a price reduction, it offered many customers, in effect, a reduction in the after-tax lease rate the customer would pay.

However, the availability of the ITC was controlled by law and changed significantly over time. In addition, the realization of the ITC by leasing companies themselves depended upon the existence of sufficient taxable income to utilize the entire credit as an offset against tax liability.

(ii) Marketing Costs. The costs and efforts associated with the marketing and remarketing of EDP equipment are also key factors in a leasing company's eventual profitability. (DX 10640, p. 3; DX 14326, p. 5.) A manufacturer offering a computer system to a user must configure it to suit the user's application needs and must convince the user that his proposal is better than that of his competitors. Such proposals can be quite elaborate.* A leasing company, when it offers the identical equipment (i.e., offers to buy a configuration from the manufacturer and then lease it to the user), generally incurs no such costs. It often can simply wait until after the customer has chosen his configuration and the marketing effort has been

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* See, for example, the various proposals made to the Union Carbide Corporation for its major computer procurement. (DX 3703; DX 3705; DX 3710.)

accomplished, and then offer the customer the equipment he had already selected at a lower price. (Spain, Tr. 88735, 88752-53.) This practice enabled leasing companies to operate with small marketing staffs during the 1960s. For example, SSI (which became Itel), signed lease contracts, for equipment with an original cost of more than $100 million, in 1968, with a marketing staff of perhaps one person at the beginning of the year and between five and eight at the end. (Friedman, Tr. 50382; DX 2223, p. 3.) This marketing approach (similar to that used initially by PCMs) helped to keep leasing company costs down.

When the leasing company has to re-lease equipment to new customers, however, it may not be able to do so by simply walking in and offering a configuration that the user has already selected. (Spain, Tr. 88752-53.) Even if it has in its inventory equipment identical to that sought by the prospect or being proposed by the competition, it has to bear the reconditioning, transportation and installation costs. Moreover, a leasing company must bear the risk that when the equipment comes up for re-lease, it will have "odd" configurations or pieces of equipment left over after the new lessees have chosen the configurations they require. Furthermore, when leasing companies market older equipment in competition with new equipment (e.g., System/360 versus System/370 or 43XX) the leasing company has to convince the customer that his proposal is superior to proposals for newer equipment. Such a proposal will undoubtedly take some effort and expense. The leasing company can no longer "piggyback" entirely on the manufacturer's efforts.

(iii) <u>Capital Availability and Cost.</u> Among the most important factors in the growth and profitability of leasing companies are the availability and the cost of capital. All leasing operations depend on their ability to raise capital to purchase equipment. (See, e.g., DX 10208, p. 150; DX 10495, p. 5; DX 14190, p. 1.) An increase in capital costs, in general, or interest rates, in particular, significantly affects the profitability of leasing operations. (See, e.g., JX 3, ¶ 18; DX 10208, p. 150.)

Capital can be raised by leasing companies as debt or as equity. The ability to raise capital either way depends in large part on a leasing company's profitability or, rather, on how its profitability appears to prospective investors or lenders. (Spain, Tr. 88730; JX 3, ¶¶ 20, 21.) The basic assumption underlying leasing companies' profitability, and indeed their ability to do business in the first place, is the belief that purchased equipment will continue to be leased at relatively high prices for a longer time than expected by the manufacturer. (See Spain, Tr. 88734.) That assumption was also crucial to the leasing companies' apparent profitability, because the leasing companies purchasing 360 equipment in the middle and late 1960s depreciated that equipment at a considerably slower rate than did IBM (or than other manufacturers generally*). (Davidson, Tr.

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* For example, CDC depreciated its equipment over 4 years (DX 14197, p. 11); Honeywell over 6 years; DX 122, p. 14); and GE over 5 years (DX 122, p. 14; see also Davidson, Tr. 98761-63).

98761-68.) Some leasing companies used straight line depreciation over a minimum of eight years (a sufficient period to take full advantage of the ITC) but more typically 10 years* and assumed a 10% residual value thereafter. (Spain, Tr. 88733-34; Davidson, Tr. 98761-63; JX 3, ¶ 19; PX 4834, p. 43.) Such relatively slow depreciation tended to make reported profits appear high in the early years as did the leasing company practices of "flowing through" ITC to the early years and deferral of certain expenses (e.g., marketing, interest, start-up costs) beyond the initial lease term. (Buffett, Tr. 100377-80; Davidson, Tr. 98761-68; PX 4437, pp. 1-2.) It was "child's play to show very substantial profits" using the accounting methods of the leasing companies. (Briloff, Tr. 80724-25.)

"The profits <u>inter alia</u> reported in accordance with the accounting policies they adopted made risk leasing companies attractive to the capital markets where they raised billions of dollars in the period 1966-1969". (JX 3, ¶ 20.) They were thus able to raise money relatively easily and to buy more equipment. (JX 3, ¶ 21.) Additional purchases, accounted for in the same manner, cumulated the effect, and made leasing company profits appear to grow even more, making leasing companies even more attractive to investors. However, when the accounting practices and the reality of the depreciation

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* E.g., Dearborn Computer Corp. (DX 6966, p. 22); DPF&G (DX 10495, p. 16); Itel Corp. (DX 2231, p. 28); Randolph Computer Corp. (DX 14476-A, p. F-10; see also PX 4436, p. 2).

assumptions were called into question, the bubble burst and the situation changed from one of easy credit to one of tight credit almost overnight. (See pp. 810-18, 1030-35 below.)

b. The History of Leasing Companies in the 1960s. The 1960s witnessed the emergence and (in the latter part of the decade) the explosive growth of leasing companies in the computer industry--companies which purchased computer equipment and then leased it to end users. There were a number of reasons for that growth, a principal one being the success and nature of IBM's System/360.

Leasing companies did not begin with System/360, however. After 1956, the date of the Consent Decree which required IBM to sell as well as lease (JX 4, ¶ 29), opportunity existed for companies to purchase IBM equipment and then lease and sell it to users in competition with IBM. Indeed, it was the potential for such additional competition to IBM that was apparently one of the Antitrust Division's goals in requiring IBM to accept the Consent Decree provision. Leasing companies, such as MAI, soon began to offer leases on IBM equipment in competition with IBM, dealing initially in unit record equipment and later in computers. (DX 14084, pp. 4-6; DX 13850, p. 5.) However, Greyhound claimed to be the first firm to execute a third-party lease for a computer system, having leased an IBM 7090 to "a major aerospace company" in 1961. (DX 10347, p. 1.) In 1966 Greyhound created the Greyhound Computer Corporation to take over its computer leasing operations. (DX 14195, p. 9.)

By 1965, a number of what were to become the largest computer leasing companies were already in existence. MAI and Bankers Leasing were founded in 1955 (DX 4043, Coonan, pp. 6-7; DX 14084, p. 9); Leasco was founded in 1961 (DX 10208, p. 4); Levin-Townsend was in operation by 1963 (DX 14446, p. 3); and Randolph was founded in 1965. (DX 14089, p. 2.)

Nevertheless, EDP leasing started slowly relative to its post-1965 expansion. Thomas Spain, who was in charge of IBM's relations with leasing companies in the late 1960s, estimated that from 1961 through 1965, annual leasing company purchases of IBM EDP equipment (principally second generation equipment) were between $10 million and $24 million. (Tr. 88729.) By comparison:

> "In the first nine months of 1966 . . . leasing company purchases of IBM EDP equipment had climbed to over $75 million, and over $60 million of these purchases were of the newer IBM 360 equipment. As of October 1, 1966, leasing companies owned over 33% of all purchased 360 central processing units." (Spain, Tr. 88729; see also PX 4260, pp. 3, 23, 24.)

Purchases in the first nine months of 1966, then, were three times greater than in any previous full year of leasing company purchases. Randolph alone had purchased over $24 million of System/360 equipment --as much as all leasing companies had invested in any prior year. (See Spain, Tr. 88729; PX 4260, pp. 12, 21-23.)

As discussed in more detail below, leasing company growth continued to be very rapid throughout the rest of the decade. In 1969, IBM estimated that cumulative leasing company purchases of IBM equipment totaled $2.5 billion, up from $200 million in 1965. (PX

4504, pp. 3, 7.) Annual revenues of leasing companies showed similar growth. Boothe's domestic EDP revenues went from $440,000 in 1967 to $44.3 million in 1969 (DX 8224, p. 530); Diebold's went from $258,000 in 1967 to $30.8 million in 1969 (DX 8224, p. 73); Greyhound's went from $1 million in 1962 to $50 million in 1969 (DX 8224, p. 539); Itel's went from $1.4 million in 1967 to $38.7 million in 1969 (DX 8224, p. 543); Leasco's went from $8.5 million in 1967 to $37.7 million in 1969 (DX 8224, p. 150); Levin-Townsend's went from $371,000 in 1964 to $34 million in 1969 (DX 8224, p. 157); MAI's went from $17 million in 1965 to $63 million in 1969 (DX 8224, p. 152); and Randolph's went from $1.5 million in 1965 to $41.7 million in 1969 (DX 8224, p. 162).*

The number of leasing companies also grew dramatically. For example: by 1969, IBM listed 231 leasing companies in a report analyzing the activity of leasing companies and over 250 were listed as competitors in IBM's 1970 Branch Office Manual as compared with the 92 listed in a 1966 report on leasing company activity. (PX 2414, pp. 62-78; PX 4315A, pp. 129-34; DX 9416B.**)

(i) Leasing Company Growth. There were a number of factors which combined to produce the explosive growth of leasing companies in

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* Some of these revenues include EDP revenues of acquired EDP leasing companies.

** We realize that DX 9416B is not in evidence. We use it nonetheless because we believe that it is reliable since it merely reflects those companies listed in IBM's Branch Office Manual, which were designated "leasing companies".

the middle to late 1960s.

Important among these factors was the nature of System/360 itself. Leasing company success is dependent on, among other things, their ability either to remarket their equipment easily (DX 10640, p. 3; DX 14326, p. 5.), or to keep it on rent for a long time. The widespread customer acceptance of System/360 indicated that there would be a large set of potential customers for remarketing by leasing companies. (PX 4834, p. 43; see also Spain, Tr. 88729-30.) Further, leasing companies perceived that the compatibility of the 360 processors and peripherals, the standardization of 360 peripherals, the modularity and flexible configurability and the all-application nature of 360 greatly enhanced the remarketability of a 360 inventory. (Friedman, Tr. 50376-79.) Finally, IBM had made a huge investment in programming systems for System/360 consonant with its efforts to produce an architecture which would be longlasting. (Friedman, Tr. 50376-79; Case, Tr. 73239-40, 73345-57; DX 3635A; DX 14201, p. 1.) Hence, leasing companies expected that 360 equipment was likely to remain usable for a very long time (Friedman, Tr. 50376-79), even by customers using later IBM equipment.* (Friedman, Tr. 50376-79.) Hence, while leasing companies dealt in equipment of other manufacturers as well (Spain, Tr. 88749; JX 3, ¶ 13; PX 4436, p. 2), they bought very large amounts of IBM 360 equipment.

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* As it turned out, this view was to a limited extent correct; however, the usefulness of some 360 equipment did not mean that all 360 equipment owned by leasing companies would continue on rent or that the leasing companies could expect to derive the same rental revenue from that equipment which did remain on rent in year ten or even in year four or five as in year one--competition was too fierce and the pace of technological change too rapid.

Another factor contributing to the growth of leasing companies dealing in IBM equipment was that leasing companies in the 1960s were able to offer longer term leases than IBM offered. During the 1960s IBM only offered its products on a month-to-month basis or for purchase.* This created a "gap" which leasing companies sought to use to their advantage (Friedman, Tr. 50372-73.)--an opportunity to offer IBM equipment on leases of several years duration with reduced monthly charges. (PX 4832, p. 10; DX 2223, p. 16; DX 14188, p. 8; DX 14075, p. 9; DX 10208, p. 4; DX 14189, p. 17.)

During the 1960s other systems suppliers began to offer leases of one or more years with reduced rates for the longer terms. (Norris, Tr. 5991; Hangen, Tr. 6371-72; PX 4832, p. 10; DX 278; Spangle, Tr. 4953; Brown, Tr. 52613-14; Withington, Tr. 56624.) Some of the longer term lease offerings apparently arose in part because of leasing company competition. McCollister testified that RCA's "accrued equity contract" (a contract for an installment purchase over six years convertible to a lease at the option of the customer) owed its "impetus for the conception and development of the use of this contract to some considerable measure because of the presence of leasing companies in the marketplace". (Tr. 9802-05.) Univac and CDC also felt similar leasing company

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* Indeed, until January 25, 1966, the 1956 Consent Decree prohibited IBM:

> "from entering into any lease with users of its EDP equipment for a period longer than one year, unless such lease was terminable after one year by the lessee upon not more than three months' notice to IBM." (JX 4, ¶ 41.)

pressure. (Brown, Tr. 52609-10; DX 75; DX 76, p. 2.) IBM itself began offering longer term leases in 1971 with the Fixed Term Plan and continued to do so with various subsequent lease plans. (JX 4, ¶ 42.)

Other factors facilitated the growth of leasing companies. The Investment Tax Credit, which, during this period, provided for a credit against taxes of up to 7% of the purchase price of new equipment, was in full effect for all but a five-month period from the IBM 360 announcement until 1969. (See pp. 800-01 above.) Additionally, in 1966 the General Services Administration enhanced the opportunity for leasing company deals with the Federal Government by permitting the purchase and leaseback of EDP equipment on commercial prices, terms and conditions. (PX 4315A, p. 18; see also DX 14486.) The door was opened even further when, on July 1, 1966, IBM modified its procedures "to allow the United States Government to assign to leasing companies the right to purchase at IBM's standard commercial terms, prices and conditions most EDP equipment already installed at facilities of and leased by the United States Government." (JX 3, ¶ 28(a).)

Leasing company purchases of 360 equipment were high through the first ten months of 1966. In October, 1966, however, the Investment Tax Credit was suspended and the money market was tight. (P.L. 89-800; DX 14191, pp. 21, 22, 24; DX 14085, p. 6.) As a result, leasing company purchases declined despite IBM's announcement of the "3X3" price change on September 29, 1966, by which purchase prices were lowered and lease prices raised by 3%. (PX 4322, p. 11; see pp. 806-07 above.)

In March 1967, the Investment Tax Credit was reinstated, the "credit crunch" began to ease and leasing company acquisitions picked up. (P.L. 90-26; PX 3056, p. 3.) The pace of leasing company purchases continued to rise rapidly and in 1968 the heaviest concentration of 360 purchases occurred. (DX 9416A;* see PX 2414, p. 5.) Leasing company stock prices also soared (see Briloff, Tr. 80725-26) and many new firms entered the business in 1967 and 1968. (PX 4495, p. 5; PX 4499, p. 4.)**

These were the "go-go years" of the stock market (Briloff, Tr. 80696-706; see Welke, Tr. 17401-03; Buffett, Tr. 100360, 100358-63) and "computer" was a magic word. A company could raise a million dollars merely by having "Computer", "Software", or "Data Processing" in its name. (Welke, Tr. 17401-02; see Buffett, Tr. 100359-63.) It was "a time when it appeared that the financial community, those who were supposedly sophisticated . . . had lost their reason". (Briloff, Tr. 80705.) It was "a mania" where virtually all EDP companies could

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* We realize that DX 9416A is not in evidence. We use it because we believe it to be reliable. It was prepared, as Mr. Akers testified, simply by aggregating the revenues for 360 CPUs and memory taken from IBM's accounting records and ledgers for those companies which were identified by IBM, in the regular course of business, as leasing companies. (Akers, Tr. 97069-70.) Mr. Akers further testified that he believed the exhibit to be reasonably accurate. (Tr. 97070.)

** Some of the largest leasing companies started during this period. Boothe Computer Leasing Co. wrote its first lease in November 1967. By the end of 1968 Boothe owned over $140 million of EDP equipment. (See pp. 821-22 below.) Itel wrote its first lease in March 1968 and by the end of the year owned over $100 million in equipment. (See p. 824 below.) Other leasing companies purchased significant amounts of EDP equipment as well. For example, Diebold purchased $166 million from 1968 through 1969, and Leasco purchased over $200 million between 1967 and 1969. (Spain, Tr. 88749; DX 10208, p. 118.)

sell stock and convertible and subordinated debentures* (Welke, Tr. 17403-04) and leasing companies were part of the mania. They were glamour companies (Briloff, Tr. 80720-28; Buffett, Tr. 100359-62),** which meant "there [was] a presumptive contagion . . . from one company in a particular industry to others." (Briloff, Tr. 80705.)

Leasing companies through a combination of depreciating their equipment relatively slowly and taking other liberties with their accounting (see pp. 803-04 above) were showing impressive book profits. (Spain, Tr. 88730-34; Davidson, Tr. 98763; JX 3, ¶ 20.) This relationship was noted by, among others, the Morgan Guaranty Trust Company and Professor Briloff. (PX 2181A, p. R1; DX 2263.) Their stocks soared soared and traded at astronomical price-to-earnings ratios. (Briloff, Tr.

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* Convertible debentures were, according to the Morgan Guaranty Trust Company, used by almost all computer leasing companies for establishing net worth positions that would allow them to acquire five to ten times as much computer equipment as was on their books in early 1967. (PX 2181A, p. R1.) They were attractive to speculators because they were not subject to the 70% margin requirements imposed upon stock until late 1967. (See DX 14124.) They were widely used by leasing companies and through accounting for them on a non-diluted rather than diluted basis (not charging equity for some value of the conversion option), they had the effect of inflating their profits. The effect was not insubstantial. An internal IBM leasing company report shows:

> "A) MAI for the year ended 9-30-66 reported earnings per share of $.62, which would have dropped to $.58.
>
> "B) For the year ended 5-31-67, DPF&G would have dropped to $1.17 from $1.35 per share.
>
> "C) GC Computer for the fiscal year ended 12-31-66 would have shown a decline of $.21 per share from $.85 to $.64." (PX 3056, p. 13.)

** Other glamour companies of the time included various EDP companies including PCM's, conglomerates, franchisors and land franchisors. (Briloff, Tr. 80720-28; Buffett, Tr. 100359-62.)

80725-26; PX 4322, p. 9.) Their revenues increased dramatically as well.* It was quite easy for leasing companies to raise capital during that period (JX 3, ¶ 21); indeed, they raised billions.

Leasing companies did not limit their capital raising efforts to the issuance of securities. They were able to secure sizable lines of credit from banks as well. For example, Leasco had a credit line of $51.5 million in 1967 (up from $5 million in 1966) (DX 10208, p. 28); Greyhound Computer Corp. had a credit line of nearly $100 million in 1968 (DX 14076, p. 24); Randolph had a credit line of $81 million in 1968 (DX 14090, p. 4); Boothe Computer Corp. had a $93.5 million credit line in 1968. (DX 14326, p. 5.)

Some leasing companies also used IBM as a major source of credit by paying for equipment purchased on IBM's installment payment plan. In fact, they availed themselves of $313.5 million in installment credit from IBM between 1968 and 1970 alone. (JX 3, ¶ 25.) A report prepared by IBM employees on leasing companies stated that "in a current prospectus, one company has indicated IBM installment credit as its primary debt source. Others use it essentially in the same manner but without formal announcement." (PX 2414, p. 20.)

During the course of the late 1960s IBM took a number of steps to accommodate the demands of installment credit customers, including leasing companies. (JX 3, ¶ 28(c)-(e).) The debt to equity ratio of 5:1 which IBM then utilized as one of its installment credit

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* See pp. 806-07 above.

guidelines was believed by IBM credit officers to be liberal, indeed, even more liberal than debt to equity ratios "commonly used" by lending institutions, and was meant to enable IBM to "[a]ccommodate leasing companies". (See JX 3, ¶ 28(d); DX 1552, pp. 5-6.) And the guidelines remained in use despite IBM's belief that "the value of [leasing] companies' inventories was substantially overstated and their creditworthiness accordingly impaired". (JX 3, ¶ 28(d).)

The ease with which leasing companies were able to raise capital can be seen in both the size and the pace of their equipment purchases. Boothe, for instance, wrote its first lease in November, 1967. Less than one year later when it stopped purchasing 360 equipment, it had an inventory of over $140 million. (See pp. 821-22 below.) Itel showed similar growth. Itel wrote its first lease in March 1968 and by the end of the year had leases on equipment valued at over $130 million of which it owned $104 million*. (See p. 824 below.) Both these companies moved from inception to being regarded within IBM as among the ten largest in less than one year. (PX 2414, p. 56.)

(ii) <u>The Emergence of New Challenges.</u> By 1969, however, things began to change again for leasing companies. The Investment Tax Credit was withdrawn,** interest rates rose sharply, the stock

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* Other companies showed a similar ability to finance significant purchases of EDP equipment. (See p. 811 above.)

** The Investment Tax Credit was unavailable for property acquired from April 19, 1969 (unless it had been contracted for prior to that date) (Tax Reform Act of 1969, P.L. 91-172, § 703(a)) through August 15, 1971, except for property ordered and acquired after March 31, 1971. (Revenue Act of 1971; P.L. 92-178, § 101.)

market fell and the financial press soured on the leasing companies. Regarded as glamour companies just several months earlier (pp. above) leasing companies, as observed by Professor Briloff (DX 2263) and the Morgan Guaranty Trust Company (PX 4371, p. 6), began to lose their glitter.*

Starting in 1969 and continuing through 1970, the economic conditions were such that, as a practical matter, capital was not readily available. As noted in the 1969 Diebold Annual Report: "Record high interest rates during 1969 together with the scarcity of credit brought the computer leasing business in the U.S. to a virtual standstill." (DX 14190, p. 1.) Leasco's experience is also a case in point: "[d]espite the company's strong record, Leasco stopped writing new leasing business. . . . That decision was predicated on one especially salient fact: the continued high cost of money which would erode future profit margins." (DX 10208, p. 150, see also p. 143.) DPF&G also cut back its purchases due "principally to prevailing tight money conditions". (DX 10495, p. 5.)

General economic conditions were dismal, but they seemed especially so for leasing companies due to a changing--much more skeptical--perception of them on the part of the financial community. Articles began to appear in the financial press criticizing leasing company accounting practices. (See, e.g., PX 4371, pp. 4, 7; DX 2263.) In a December 2, 1968, Barron's article entitled "All a Fandangle",

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* Problems encountered by some leasing companies are treated more fully in the discussion of the 1970s. (See pp. 1030-35 below.)

Professor Abraham Briloff voiced his concern that leasing companies' practices and procedures had "one primary objective--to create an air of excitement regarding performance, to give an unreal appearance of accomplishments and to offer the promise of even greater attainments tomorrow". (DX 2263, p. 1.) Briloff severely criticized the leasing companies' depreciation practices, their use of the "flow through" method of allocating Investment Tax Credit, and their deferral of costs beyond the initial lease term. He called for a "halt to the game" because of the "bedazzlement and the delusion spreading to ensnare the multitudes". (Id., p. 10.)

The changing perception of the leasing companies was reflected in the prices of leasing company stocks which declined "very markedly and substantially". (Briloff, Tr. 81081-82) Their access to credit was also affected. A Morgan Guaranty Report of early 1969 states:

> "Since THE WALL STREET JOURNAL article on October 31, 1968, there has been some hesitation on the part of major banks to add to [computer leasing companies] existing lines of credit." (PX 4371, p. 4.)

By 1970 the stock market had collapsed (Lee, Tr. 41732-33; see also DX 3021) and a recession was in full swing, compounding the fiscal problems peculiar to the leasing companies.

Leasing companies were beginning to encounter other difficulties as well. As initial leases expired, equipment came off lease. Many leasing companies were for the first time faced with the task of remarketing their equipment. As we have indicated, this was a much more substantial undertaking than the initial placement of the equipment where by-and-large the leasing companies relied upon the manufacturers to configure and sell the systems. (Spain, Tr. 88752-53.) Hence, marketing staffs had to be enlarged. The number of leasing companies had also grown substantially, which intensified the competition for favorable prospects (Spain, Tr. 88754), a phenomenon also observed by the Morgan Guaranty Trust Company. (PX 2181A, p. R14; PX 3105, pp. 5-6.) Leasing companies also began to experience competition of a new sort--plug compatible manufacturers were now marketing their own peripheral products in competition with leasing company-owned peripherals. (Spain, Tr. 88754; DX 1494, as discussed Navas, Tr. 40120-21, 41265-66; see also DX 14327, p. 2.) As a result of this heightened competition and the changing demands of users and prospects, features and peripheral products which were included in systems coming off rent did not always match the demands of the new users to whom the leasing companies were marketing. (See DX 14211, p. 6.) Perhaps most important of all, by 1969 System/360 equipment was five years old and in the interim other manufacturers had introduced products with improved price/performance and the announcement of a new line of IBM equipment (System/370) was on the horizon. (See, e.g., DX 14340, p.4; DX 14485, p. 37.)

The result of all this was a decline in lease rates together with an increase in marketing costs, all coinciding with the higher cost of money. (Spain, Tr. 88754; DX 14190, p. 1; DX 14340, p. 6.)

As one would expect, leasing company acquisitions of IBM equipment in 1969 were substantially lower than in 1968, and the decline of 360 purchase activity continued in 1970. (DX 9416A.)

(iii) Diversification. By the end of the decade, many leasing companies had diversified their operations. They developed various marketing relationships with plug-compatible manufacturers, thereby becoming "conduits for better price-performance EDP equipment produced by a variety of EDP manufacturers". (JX 3, ¶ 14.) They "assembled and upgraded their leased computer systems with EDP products that improve the price-performance characteristics of those systems". (JX 3, ¶ 14.) For example, MAI was marketing Memorex disk drives and Potter tape drives, and DPF&G was marketing Ampex tape drives. (Spitters, Tr. 42067-68; PX 4834, p. 43; PX 4436, pp. 6, 9.) Greyhound was marketing its GCC 3311 disk storage unit made to its specifications by General Electric (DX 4756A, p. 39),* and DPF, by the end of 1970, was marketing IBM compatible tape drives under its own name. (DX 10495, pp. 2-3.)

The relationships were beneficial to both the leasing companies and the plug compatible manufacturers. By integrating the lower cost plug compatible peripherals into systems they owned, the leasing companies were able to increase the price/performance and, hence, the competitiveness of their systems. In addition, "[l]easing companies substantially reduce[d] the financial resources required" by

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* Greyhound later sued General Electric as a result of reliability problems Greyhound's customers were experiencing with the General Electric disk drives. (see DX 14331, p. 41.)

the plug compatible manufacturers from whom they purchased (JX 3, ¶ 15), by providing ready cash to the manufacturers (JX 3, ¶ 16) and reducing the marketing costs of those manufacturers. As noted above, however, the plug compatible manufacturers also competed with leasing companies offering their lower-priced peripheral products in competition with the peripheral products in the leasing companies' inventories. (See p. 817 above.)

c. <u>Some Individual Companies.</u> Leasing companies had many similarities in many of the ways discussed above, but each company had its particular history and characteristics. A few of the important leasing companies of the 1960s will be discussed in more detail.

(i) <u>Greyhound.</u> The Greyhound Corporation acquired the Boothe Leasing Corporation* as a subsidiary in 1962. (DX 14193, p. 5.) It claimed to be the first third party computer lessor by virtue of a lease written in 1961. (DX 10347, p. 1.) Its U.S. EDP revenues were $1 million in 1962, and had increased to $13.4 million by 1965. (DX 8224, p. 539.)

In that year Greyhound changed the name of its subsidiary from "Boothe Leasing" to "Greyhound Leasing and Financial Corp." ("GL&FC") (DX 14194, p. 7) and in the following year, Greyhound Computer Corporation ("Greyhound") was organized as a subsidiary of GL&FC and shares and convertible debentures were sold to the public.

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* This is not to be confused with Boothe Computer Corporation which was formed by the same Mr. Boothe after leaving Greyhound in 1967.

(DX 14195, p. 9.)

Greyhound reported that, by the end of 1966, it had an EDP portfolio at cost (not including accumulated depreciation) consisting of $47.3 million of second generation IBM equipment, $20.2 million of IBM 360 equipment and $5.6 million of other equipment.* (DX 14195, p. 10.) It reported that its 360 portfolio increased to $75.6 million by the end of 1967 (DX 14075, p. 24), $154.8 million by the end of 1968 (DX 14076, p. 24), and $188.2 million at the end of 1969 (see DX 14341, p. 41.) Greyhound "had completed by mid-year [of 1969] most of its purchases of computer equipment". (DX 14341, p. 18.)

During the period 1965-69 Greyhound's EDP revenues also rose steadily. Its U.S. EDP revenues went from $13.4 million in 1965 to $17.3 million in 1966 to $49.9 million in 1969. (DX 8224, p. 539.)

Not all of those revenues came simply from purchasing and leasing IBM equipment. Like many other leasing companies, Greyhound also marketed equipment of peripheral manufacturers, and Greyhound purchased and marketed the 3311 disk drive made for it by General Electric. (DX 4756A, p. 39; see p. 818 above.) In addition, Greyhound offered data services. By 1967 it had begun to diversify

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* Greyhound was depreciating its second generation IBM equipment on a straight line basis over eight years or to 12/31/73, whichever was shorter. It was depreciating its 360 equipment over ten years and the other computer equipment over 3 to 8 years. (DX 14074, p. 21.)

into computer service centers and project management, forming a "data services division" to operate service bureaus and provide consulting services to customers in computer planning, installation and operation. (DX 14075, p. 6.) In 1969, it offered time-sharing services through Greyhound Timesharing Corporation, formed in September 1968. (DX 14076, pp. 9-10.)

Computer leasing, however, was Greyhound Computer's major area of operations in the 1960s. It stated in 1967 that its leases ranged in general from leases which are terminable on 30 days notice to leases with initial terms of up to eight years. It reported that most of the early leases of the company, by dollar volume, were for initial terms of one to three years. (DX 14195, p. 9.) However, in 1968, Greyhound reported that in the previous year it had "modified our rate structure to encourage longer term leases. The result: 'Many leases written in the last half of 1967 encompassed terms of two to five years.'" (DX 14075, p. 9.)

(ii) Boothe Computer Corporation. Boothe Computer Corporation ("Boothe") was founded in 1967 (DX 14188, p. 2) by two former officers of Greyhound Computer Corporation. (DX 14195, p. 2.) Boothe wrote its first 360 lease in November of that year. Approximately eight months later, internal IBM estimates ranked Boothe as the seventh largest computer leasing company in the United States. (PX 3082, p. 34.) In the last two months of 1967 Boothe purchased nearly $12.8 million in EDP equipment. (DX 14188, p. 2.) Boothe was "the leading 1968 purchaser [of 360 equipment] with acquisitions amounting to $131 million". (PX 2414, p. 5.) Boothe announced in October 1968 that its "planned acquisition program" was virtually complete (DX 14326, p. 2) and by year end Boothe's EDP portfolio exceeded $144 million. (DX 14326, p. 2.)

Boothe's 1968 acquisitions were financed in part through the sale of common stock. In May of 1968, Boothe's initial public offering of 150,000 shares of common stock reached the market at $18 per share and closed near $50 by the end of the first day. (See DX 14101.)*

Boothe added to its already substantial 360 portfolio in 1970 through the acquisition of the $50 million System/360 portfolio of GAC Computer Leasing Corporation in November 1970 on what it called "very favorable terms". By so doing Boothe increased its "ownership in the United States and Canada of IBM 360 equipment to $220 million". (DX 14189, p. 5.)**

Boothe revenues increased nearly as dramatically as its acquisitions. From 1967 to 1969 Boothe's U.S. EDP revenues went from $440 <u>thousand</u> to $44 <u>million</u>. (DX 8224, p. 530.)

Boothe reported that it wrote leases of one to five years,/

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* Boothe had made a private offering of 1,150,000 shares of common stock at $12 per share in November 1967. (DX 14101.)

** In the 1960s, Boothe depreciated its 360 equipment on a ten-year straight line basis. (DX 14340, p. 14.)

/ Boothe wrote a six year lease with the Southern Railway. (Jones, Tr. 79039-40.)

generally providing "for early termination after 12 months upon payment of a termination fee". (DX 14095, p. 13.)

Boothe operated abroad as well as in the United States. It had subsidiaries in Canada, Switzerland, and the United Kingdom with the Swiss company conducting business in both Germany and Italy. (DX 14326, p. 3.)

Boothe decided fairly early to use the cash flow generated by its computer leasing business to invest in "other phases" of the EDP industry. As it put it, it wanted to become "multicomputer-lateral". (DX 14340, p. 4.) To accomplish this end, it had formed its Brokerage Division in 1968, "to engage in the purchase and sale of computer systems and components from existing non-manufacturer users". (DX 14326, p. 2.) This was an obvious adjunct for a leasing company engaged in the marketing and remarketing of computer systems to users. In 1969 the company also formed Boothe Resources International which "specializes in the computer services and software field". Boothe Resources operated a computer resource center in Los Angeles, "whose purpose is to bring the full benefit of data processing to businesses, industries, and municipalities" and serve as "the showroom for the peripheral equipment manufactured by Viatron Computer Systems Corporation," for which Boothe Resources International was the dealer in the western United States. (DX 14340, pp. 6-7.)

In 1969 Boothe formed yet another subsidiary to engage in the marketing of EDP equipment, Dataware Marketing, Inc., which "engaged in marketing peripheral equipment internationally, and in the domestic brokerage of second-user computers and computer equipment". It began immediately to distribute the products of Courier Terminal Systems, Inc., "a manufacturer of CRT data entry and retrieval terminals and quality line printers". (Id., p. 7.)

Boothe's involvement in peripherals was not limited to marketing the Courier terminals. Through another subsidiary, the Boothe Computer Investment Corporation, Boothe "placed equity investments in companies manufacturing peripheral gear or engaged in computer-related services. At year end, 1969, equity interest in 11 such companies had been acquired." (DX 14340, p. 7.) One of those companies was Courier Terminal Systems.*

(iii) Itel. Itel was incorporated in December 1967, as SSI Computer Corp. It wrote its first computer lease in March 1968, and by the end of that year, had lease contracts covering computer equipment at original cost of $130 million of which it owned approximately $104 million. (DX 2223, p. 3.) Gary Friedman, who was Executive Vice President of the corporation in 1968, testified that all of this equipment was marketed by a sales force which went from perhaps one person at the beginning of the year to somewhere between five and eight at the end of it. (Friedman, Tr. 50382.) An IBM report on leasing companies listed Itel (SSI Computer) as having the ninth

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* In 1976 Boothe owned 99.4% of Courier's outstanding voting stock (DX 14096, p. 6) and in 1978 Boothe sold Courier Terminals to the International Telephone & Telegraph Corporation, for $50 million in cash and notes at a gain after taxes of nearly $20 million. (DX 14071, p. 5.)

largest IBM computer portfolio at the end of its first full year of operation. (PX 2414, p. 56.) By the end of 1969, Itel owned approximately $195.5 million of computer equipment. (DX 2226, p. 16.)

Its U.S. EDP revenues rose sharply as well, going from $9.6 million in 1968 to $38.7 million in 1969, and to $46.9 million in 1970. (DX 8224, p. 543.)

Itel offered leases "normally written for initial terms of 24 to 60 months" to fill the "gap" between purchase and the short term lease offered by IBM. (Friedman, Tr. 50373; DX 2223, p. 16.) It "typically" either purchased equipment already on order or purchased installed equipment using the customer's purchase option credits. (Friedman, Tr. 50558-59.) It leased to companies in a "wide range of industries" including "utilities, transportation, general manufacturing, aerospace, textiles, petroleum, chemicals, publishing, banking, insurance, auto manufacturing, finance, food processing and medical services". (DX 2223, p. 9.)

Itel also diversified its activities and it stated in its very first annual report that it was "actively seeking acquisition of complementary services and product lines. The objective of this program is to build a diversified company concentrating on data processing activities . . . ." (DX 2223, p. 9.) This was an aim which it described a year later as its "continuing objective". (DX 2226, p. 7.) In 1969 it acquired the Statistics For Management Data Processing Corporation, a specialized service bureau. (Id. pp. 8-9.) And, in the same year it "entered the peripheral equipment field through the formation of an affiliate, Diablo Systems, Inc.", which would "concentrate initially on the manufacture of mass memory devices and then intends to produce other related peripheral equipment". (DX 2226, p. 10.)* In April of the following year, it acquired Intercontinental Systems, Inc., a manufacturer of word processors, data terminals and off-line systems. (DX 2229, p. 18.) In 1970 it reported that its "European activity centers on container leasing, the word processing and data communications terminal field and sales of computer peripheral equipment". (Id., p. 9.) Its most important acquisition, however, was not to come until early 1971 with the acquisition of Information Storage Systems. (DX 14260.)**

d. The Effects of Leasing Companies on IBM. The dramatic growth of computer leasing companies in the 1960s had two kinds of effects on IBM. First, IBM's Annual revenues increased immediately as purchases by leasing companies and others spurted in the late 1960s--a phenomenon which IBM had difficulty in projecting accurately. (Spain, Tr. 88737-38.) Second, IBM faced accelerating competition from leasing companies culminating in the impact of the large amounts of 360 equipment in leasing companies' portfolios on IBM's pricing of System/370.

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* Diablo Systems, Inc. was sold to Xerox in 1972 (DX 2231, p. 29) at a profit of "[e]ighteen to twenty million" (Friedman, Tr. 50400.)

** Information Storage Systems was sold to Sperry Rand in July 1973 for at least $23 million. (DX 14280; DX 2232, p. 35.) However, pursuant to a complicated financial arrangement based upon receivables and future revenues, Itel eventually received approximately $60 million. (Friedman, Tr. 50438-39.)

Certain IBM employees recognized the competitive impact of leasing companies early. An analysis of leasing companies prepared within IBM in September 1966, for example, recognized the "increasing potential" for competition from leasing companies, stating:

> "[w]ith capable marketing personnel, substantial inventories, and attractive rental rates, leasing companies represent an increasing potential for replacing IBM installed rental equipment. We are aware of current proposals which would result in the replacement of IBM rental units. (PX 4315A, p. R-4; see also p. R-16.)

The report also recognized potential effects on future generations of IBM equipment.

> "Even though newly announced machines reputedly 'obsolete' older equipment, there is always a price at which the 'obsoleted' equipment has a better price-performance . . . than newer equipment. It appears that leasing companies will be in a position to offer this price-performance advantage for some years to come." (PX 4315A, p. R-16.)

This is possible because:

> "[w]hen leasing companies have recovered a significant portion of their investment, they will be in a position to manipulate the price/performance ratio of their equipment. This could create an important additional consideration relative to the price level of potential new IBM product announcements." (PX 4315A, p. R-5.)

The recognition of leasing companies as competitors* dic-

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* Other manufacturers also recognized leasing companies as competitors. Gordon Brown of CDC testified that lease plans offered by CDC were designed to compete with leasing company offerings of IBM and other competitive equipment. (Brown, Tr. 52609-52610; see also James, Tr. 35048.) McDonald of Univac testified that although leasing companies were customers when they purchased Univac equipment, Univac salesmen reported that leasing companies became competitors thereafter. (McDonald, Tr. 3995-3996; see also DX 75; DX 76; DX 78, p. 1.) RCA's "accrued equity contract" (a contract for an installment purchase over six years convertible to a lease at the option of the customers) was "to some considerable measure [brought about] because of the presence of leasing companies in the marketplace". (McCollister, Tr. 9802-05.)

tated their treatment as such, and IBM salesmen were so directed.*

This early recognition of competition from leasing companies was reinforced in later periods. By February 1968 an internal report on leasing company activities stated: "[c]ollectively leasing companies are potentially IBM's biggest domestic competitor. . . ." (PX 3455A, p. R-37.) In 1970, it was also noted that "System/360 inventories used as competition to IBM during 1969 dramatically increased.** In March 1969 internal IBM estimates projected that leasing companies' ownership of the total installed base of IBM equipment would increase to 17.7% by year end 1969 (up from 5% on December 31, 1965)--some 43.3% of all purchased IBM equipment. (PX 2414, pp. 53, 55.)/

Such competition clearly constrained IBM's pricing of System/370.// For example, a February 20, 1969, Quarterly Product Line Assessment (QPLA) prepared by the Commercial Analysis Department of IBM's Data Processing Division stated: "When NS0 and NS1 [to become

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* IBM salesmen were required to report leasing company and other competitive activity, although these reports tended to undercount significantly that competition. (See Akers, Tr. 96868-69, 97112-13; PX 2512A, p. 17.)

** On March 11, 1971, Rodgers expressed the Data Processing Division's concern to Watson, Learson and Cary about the high level of replacement activity brought about, <u>inter alia</u>, by competition from leasing companies. (DX 8059.)

/ It was also estimated that leasing companies owned 16.1% of total installed base of IBM equipment on December 31, 1968--41.5% of all purchased IBM equipment. (PX 2414, p. 55.)

// Withington also concluded at the time he testified that leasing company competition constrained IBM's pricing of 370. (Withington, Tr. 57023-29; 58630-31.)

System 370/135, 145] are announced, IBM will be faced with competition from three sources: (1) other computer vendors, (2) owners of IBM computer systems, and (3) computer-oriented service companies." (PX 2388, p. 117.) And, the report continued, "[c]ompetition from owners of IBM computer systems will come primarily from leasing companies and from System/360 purchase customers who sell their used systems. Both of these sources could make lower-priced System/360s available to compete with NS0 and NS1 with competitive price/performance." (Id.)

In March 1969 Gil Jones, IBM Senior Vice President wrote in a report of the Management Committee (MC) to the IBM Management Review Committee (MRC), that "[o]ur old 360 purchase inventory will remain a major competitive product. There is an added unknown in the possible merger of OEM's, software houses and leasing companies." This report also opined that System/360 equipment offered at a price discount of only approximately 30% would be an effective competitive product against System/370 at the prices then planned for the new system. Particular exposures identified were the projected 370 purchase prices and maintenance charges. Simply stated, IBM management was of the opinion that leasing companies' offerings of System/360 equipment would, with the 370 lease, purchase and maintenance prices then planned, cut deeply into the customer acceptance of System/370, particularly the purchases. (DX 14201, pp. 1-2; see also DX 14479, p. 1.) In fact, thereafter the purchase prices on System/370 were reduced. (See PX 4505.) Renewed efforts were also made to reduce the projected maintenance expenses and charges which led to an extension of the warranty period. (See pp. 920-22 below.) In addition, on

May 10, 1972, as warranty periods providing for free maintenance services were beginning to expire on the first purchased System/370 units, IBM announced a substantial reduction in its minimum monthly maintenance charges.* (DX 13521.)

The competitive effects of leasing company 360 offerings on IBM's pricing of 370 continued beyond the initial 370 announcement date. In January 1971, Learson and Cary, then President and Senior Vice President, respectively, considered a proposal for a general price increase by the Data Processing Group. They each visited four to five sales offices. Learson wrote:

> "What we found there was . . . strong activity by the leasing companies in reinstalling available equipment at reduced rentals for very short terms--12 to 18 months. In truth, what is happening to the 360 line is that prices are being reduced instead of being increased. In some cases, they are selling their leased inventories at 50% off original price, with payments deferred 24 to 36 months. Coupled with this atmosphere is our own action in reducing prices on files and tapes and the OEM's reacting with a further price cut." (DX 8063.)

Thus as we have seen, the impact of leasing companies on IBM, minimal at the start of the decade, increased rapidly in the mid-to late-1960s. And as the decade came to an end, leasing companies substantially impacted IBM's pricing and plans for the new 370 line. That constraint was to continue in the 1970s. (See pp. 1026-30 below.)

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* For example, the 370/155I minimum monthly maintenance charge was reduced from $2,160 to $1,730 per month. (DX 13521, p. 2.)

52. Service Bureaus. A service bureau "offers to perform certain specific data processing applications on its own equipment for a fee". (Plaintiff's Admissions, Set II, ¶ 977.0.) It "purchases or rents a computer from a computer manufacturer or systems manufacturer and then proceeds to perform problems for a customer, or to let a customer perform problems on the apparatus for himself, depending on what type of service bureau it is. The service bureau may provide additional functions. They may assist the customer with his software problems, they may assist him with printed copies of the material and other things as part of their service". (Eckert, Tr. 917; see also Weil, Tr. 7159; O'Neill, Tr. 76020.)

a. Entry and Growth. Service bureaus were a natural development in the computer industry. They began before 1960, but grew rapidly, often explosively, in number thereafter. It was easy to start a service bureau; all that was needed was a computer system and the ability to run it.* For example, Digicon, Inc. had six founders in 1965, each of whom put up about $330. (DX 4085, Poe, p. 11.) By 1970, Digicon had $1.5 million in U.S. EDP revenues. (DX 8224, p. 356; see also DX 4076, DiPietro, p. 10 (DP&W, Inc.--began on $75,000); DX 5930, Davenport, p. 12 (Davenport Data Processors--began on $5,500).)

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* As the FCC stated in its Tentative Decision in Computer Inquiry I (Dkt. No. 16979): "For a relatively small capital investment, a service firm can be formed, computer equipment can be leased, and programmers can be hired." (Plaintiff's Admissions, Set II, ¶ 306.10.)

Many of these companies grew fantastically in just a short time. Optimum Systems, Inc., for example, had $300,000 in U.S. EDP revenues in 1967, its first half-year of operation, and $10.5 million in 1970. (DX 6015, Roach, pp. 12-13; DX 8224, p. 504; see also DX 3975, Moranz, pp. 5-6; DX 8224, p. 313 (TCC, Inc.--started in 1968, $6.7 million in U.S. EDP revenues in 1970); DX 5816, Vallario, p. 9; DX 8224, p. 621 (Bergen-Brunswig Corp.--entered the EDP business in 1964, $2.5 million in U.S. EDP revenues in 1970); DX 5933, Biegel, p. 3; DX 8224, p. 50 (Bradford Computer and Systems--started in 1968, $9.8 million in U.S. EDP revenues in 1970); DX 5988, Leslie, p. 3; DX 8224, p. 95 (Insco Systems--started in 1968, $15.4 million in U.S. EDP revenues in 1970); DX 6190, Stapp, p. 10; DX 8224, p. 521 (Middle South Services--started in 1963, $5.1 million in U.S. EDP revenues in 1970); DX 8122, Larribeau, p. 10; DX 8224, p. 577 (Information Systems Design--started in 1966, $1.6 million in U.S. EDP revenues in 1970); DX 8224, p. 557; DX 13916, p. 6 (Tymshare--started in 1966, $10.2 million in U.S. EDP revenues in 1970).) The Association of Data Processing Service Organizations, Inc. (ADAPSO) reported that the average service center firm's revenues increased 50 percent in the year 1965-66 alone. (Plaintiff's Admissions, Set II, ¶ 325.11.)

Some service bureaus primarily offered computer time; others offered programming and other services ancillary to the use of computer time, such as systems and software design, application packages (often proprietary to the service bureau) and other specialized services. (See, e.g., DX 7425, pp. 4, 12; DX 10324, pp. 52, 57, 86; DX 10667, pp. 3, 10.) Some service bureaus developed their own computer languages or other software tools which were available to their users. Others offered their own configurations of hardware with enhanced capabilities. (See, e.g., DX 6914, p. 4; DX 10324, pp. 55, 119; DX 13917, pp. 2, 7, 8.)

Entrants sprang from a number of sources. New firms started from scratch and offered computer services as their principal business. (E.g., Bradford Computer and Systems and Digicon, Inc., above, pp. 831-32; ADP and Tymshare, below, pp. 848-50.) Firms already in the EDP business saw an opportunity for profit and opened service bureaus. Those ventures began as an attempt to gain customers for their other computer products and services. (See, e.g., Lacey, Tr. 6611, 6687; DX 340A, pp. 3, 10; DX 367, pp. 21-22; DX 13912, p. 20.)

Thus, for example, Greyhound Computer Corporation, which began as a leasing company in 1962 (DX 14193, p. 5), announced the opening of two service bureaus in 1968 using General Electric and IBM equipment. (DX 10346.) Itel, which entered the EDP business as a leasing company in 1967 (Friedman, Tr. 50355, 50361), acquired a service bureau business in 1969. According to Itel, the acquisition gave it "a solid entry into . . . one of the fastest growing areas of the data processing industry". (DX 2226, p. 8.)

Systems manufacturers also had service bureau businesses, many of which are described in the sections on individual manufacturers in the 1960s elsewhere in this testimony. By the end of the decade, CDC, NCR, IBM, Honeywell and General Electric had extensive service bureau operations. (Lacey, Tr. 6634-35; PX 328, p. 21; PX 4832, p. 21; DX 123, pp. 28, 33; DX 284, pp. 1, 4; DX 340A, pp. 3, 10; DX 367, p. 21; DX 13843, p. 6.)

Finally, businesses which owned their own computer systems but were not utilizing them fully for their own needs naturally found it attractive to offer unused time to other users for a fee. (See, e.g., Plaintiff's Admissions, Set II, ¶¶ 321.8, 341.5, 345.2.) Banks and aerospace companies, in particular, began to sell computer services. (See, e.g., DX 5819, Hammaker, p. 4 (Connecticut Bank and Trust Co.); DX 6150, Pettit, p. 4 (Grumman Corp.); DX 6151, Lynch, p. 4 (Harris Trust and Savings Bank).) As time went on, brokers arose which made it a business to find computer time for users and often then went into the service bureau business directly. The Bergen-Brunswig Corp., a drug company, began in the EDP business because it "had idle capacity on an IBM 1401 computer, and at first we started offering it to some of our customers who we sensed needed help in accounts receivables. It mushroomed after that and six months later we had to add a second computer to render those services". (DX 5816, Vallario, p. 10.) By 1970, Bergen-Brunswig had U.S. EDP revenues of $2.5 million. (DX 8224, p. 621; see also DX 5637, Allen, pp. 24-25 (Fulton National Bank in Atlanta makes available its excess computer time for a fee); DX 6180, Hager, pp. 4-6 (Marine Midland Bank subsidiaries sell data processing services to bank customers); DX 13943, (Westinghouse offers services by using its corporate computer center); DX 13924, (Computer Usage Company brokers idle computer time).)

As is discussed more fully below at pp. 843, 876-77, the Federal Government also saw the benefits to be derived from selling excess computer time and, through the General Services Administration, set up a program which, by 1966, facilitated the use by one government agency of the EDP services of another government agency. (Plaintiff's Admissions, Set II, ¶¶ 368.0-.2; see, e.g., ¶¶ 369.11, 369.15, 369.21.) GSA also operated Federal Data Processing Centers, service bureau enterprises which offered processing, systems design, programming and applications software to various government agencies for a fee. (Id., ¶¶ 364.0-.2, 364.4.) A final method available to government agencies to supply their EDP needs was GSA's full-service remote computing network. The network was provided by Computer Sciences Corp.'s INFONET Division under a government contract, and was developed "to provide Federal agencies with an economical and broadly based supply of certain types of computer services". (Id., ¶¶ 367.2-.4.)

b. Time Sharing and the "Computer Utility". The development of service bureaus was given a substantial impetus in the 1960s by the growth of time sharing, the apparently simultaneous use of a computer by many users. (JX 1, p. 115.) Instead of physically transporting data between the customers' premises and the service bureau, time-sharing services allowed terminals to be placed at the users' installations to access on line a central computer. (See Norris, Tr. 5828-29.)

The development of time sharing was responsible for the entry of many new service bureaus and encouraged the expansion of batch processing service bureaus already in existence. Currie of Xerox testified that "[w]hen the time sharing technique was developed . . . many entrepreneurs saw an opportunity to start a business and offer this service to users, and so many commercial time sharing service bureaus were established in the late sixties, and [SDS] provided computers to many of these companies". (Tr. 15346.)

General Electric, in particular, emphasized time-sharing services, although it started off in the service bureau business offering batch services. (Weil, Tr. 7133-34.) In 1966 GE had "the most widespread and successful of the scientific, time-shared service bureaus". (PX 4832, p. 21.)* The GE time-sharing service was originally based on the GE 235 and "was primarily aimed at solution of small engineering or technical problems". (Weil, Tr. 7134-35.) As the number of languages available for the 235 increased, the applications grew into "somewhat larger scientific and into the commercial sphere". (Weil, Tr. 7135-36.) But the success of the GE time-sharing service bureaus rested on the 635. The 635 was bigger and was "aimed at solving bigger problems". As more languages became available "there were more and more" business applications for the

* Reginald H. Jones testified that GE had lavished "very solid dedication" on its time-sharing service bureaus, and had made "very major investments" in the business, had done "very good work" in software and had "good technological offerings". Consequently, in 1970 GE's Ventures Task Force concluded that the time-sharing service was "an opportunity that we should pursue", even though GE had earlier gone through "difficult financial straits" with the business and had had "substantial writeoffs". (Tr. 8799-800.)

635. (Weil, Tr. 7137-38.)

Other time-sharing service bureaus started off performing scientific and engineering applications but progressively shifted their emphasis to commercial applications. For example, the president of Tymshare, Inc., was reported as saying that there had been a shift in the usage of time-sharing services towards business applications in the 1960s; whereas in the late sixties 75 percent of Tymshare's income came from engineering/scientific applications, by mid-1971 more than half the firm's income came from commercial applications. (DX 2765; see also DX 13917, p. 1.)

The president of Time Share Corp. wrote in a 1968 article:

> "Today the typical [time-sharing] user is no longer buying just raw computer power alone. He is beginning to buy both applications and computing power. And the applications are increasingly being found in the business area. Time-sharing is being recognized as a powerful aid to business decisions. The once-remote computer has been replaced by the familiar teletypewriter . . . at the manager's point of contact." (PX 2404-A, p. 25; see also Currie, Tr. 15346-47.)

As the concept of time sharing developed in the middle and late sixties, observers were impressed by its apparent efficiency and economy. There was growing talk of an "equipment utility" which would "directly connect terminals on the users' premises with networks of computers and data transmission links", eliminating the need for each user entity to possess its own computer.* (PX 4832, p. 27;

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* For example, Withington wrote in 1967: "It is apparent that service bureaus are evolving into a revolutionary new form, an 'equipment utility' . . . . [T]en or fifteen years from now, of the money the customer spends for computing equipment (excluding expenditures for software or services), perhaps 40% may be spent on the use of facilities of the equipment utility, rather than for computers of his own". (PX 4832, p. 27.)

see also DX 5324, pp. 1-5.) According to GE's Weil:

> "[T]he hope was here that what we could do was to permit shared remote access to a large and, hence, capable and efficient, central computer and make possible the carrying out of applications remotely by this time shared computer as opposed to having each of the users having to have his own smaller, less capable, less flexible and potentially less efficient system". (Tr. 7203-04.)*

Western Union was advertising in 1966 a complex "designed to provide information, communications and processing services in much the same way as other utilities supply gas and electricity". (DX 13942, p. 26; see also DX 6872; Plaintiff's Admissions, Set II, ¶¶ 304.21-.23.) One of the best-known prototypes for the "utility" concept was the ARPA network.**

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* Weil said that in retrospect the technology changed and the "computer utility" never materialized:

> "Right now it is possible to have a small capable remote computer available at low cost so that the use of time sharing systems for small engineering calculations which we envisioned, small to moderate engineering calculations which we envisioned, would be carried out on time sharing systems, are today in fact carried out by very small, usually desk-top calculation systems which are these days quite capable".

Thus, in general, "there is much less reason today for having a large central computing element". (Tr. 7257-58.)

** ARPA (Advanced Research Projects Agency) is a Federal agency whose primary mission is "to support research and development of advanced projects which have potential value to the Department of Defense." (Plaintiff's Admissions, Set I, ¶¶ 1.1, 1.2, 2.0.) "ARPA is probably the largest sponsor of computer science research within the United States Government." (<u>Id.</u>, ¶ 5.2.)

In 1968 ARPA conceived the idea of ARPANET, a network of interconnected computers intended to permit the sharing of computer resources by many users. (Plaintiff's Admissions, Set I, ¶¶ 39.0, 41.0, 45.0, 48.0.) The network has large and small computers, minicomputers and timesharing terminals. (DX 7528, Mahoney, pp. 82-83.) "Through ARPANET individual users can access processing capability and storage capacity located in different parts of the country." (Id., ¶ 46.0.) According to Edward J. Mahoney, former Deputy Director of the General Accounting Office, the ARPA network was an "outstanding example" of the "public utility" concept of computer use.* (DX 7528, Mahoney, pp. 81-83.) Dr. Perlis of Yale (who was an early user of time sharing at Carnegie Tech in the 1960s) testified that

> "[I]n effect, what the ARPA network showed was that we were about at the beginning of what we might call the Network Age of computing where computers will be tied together in a network like the telephone network, using satellites, etc." (Tr. 1869.)

The opportunity to enter the service bureau business through these numerous avenues produced a phenomenal number of entrants. Withington estimated that there were approximately 1,400 service bureaus in the United States by 1966 (PX 4832, p. 26); ADAPSO estimated that there were 700 such firms with total revenues over $500 million. (Plaintiff's Admissions, Set II, ¶¶ 325.0, 325.9, 325.10.) As Withington wrote in 1967:

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* Mahoney felt that the term "public utility" was "carrying it out a little too far". What was really meant was "many people sharing . . . information . . . and using terminals to do calculations in a sort of giant computer network" and that is what came about with ARPANET. (DX 7528, Mahoney, pp. 81-83.)

"New, small companies have unlimited opportunity (and equal risk) in the service area. Large companies not now in the business will try to enter, seeking the new opportunities, and some will undoubtedly succeed. Overall, the growth potential of the industry appears as great as ever, though the industry is moving in new directions, and the pace of evolution and competition shows no signs of slackening." (PX 4832, p. 32.)

As seen above, many who entered also grew at remarkable rates during the 1960s. In doing so they became significant competition to the manufacturers of computer hardware.

c. <u>Competition.</u> In providing computer time, programming and other computing services, service bureaus compete with manufacturers in providing users with alternatives to the acquisition, use or expansion of their own hardware and software. (Currie, Tr. 15349; Withington, Tr. 56986-89, 56993, 57001-02; DX 4076, DiPietro, pp. 6-7; DX 5652, Bruns, pp. 156-57; DX 5821, Brownell, p. 16; DX 5937, Alkema, p. 9; DX 5816, Vallario, p. 16; DX 6026, Gehring, pp. 12-14; DX 6088, Zweifel, pp. 19-20; DX 6128, St. Amant, pp. 11-12; DX 6243, Mortensen, p. 6; DX 8122, Larribeau, pp. 11-12; DX 8175, Finelli, pp. 17-19; see also DX 84, pp. 2-3.) Thus, "[s]ome computer users may obtain their own equipment, may have their data processing done by establishments such as service bureaus, data centers, time-sharing companies, or may purchase time from another user." (Plaintiff's Admissions, Set II, ¶ 957.0.) McDonnell Douglas Automation, among others, advertised to this effect, urging users to "expand your computing capacity without leasing or buying computers" and saying of the IBM 7094 that "you <u>could</u> buy one, you <u>could</u> lease one but it's cheaper and simpler to hire ours by the hour". (DX 10324, pp.

59-60, emphasis in original; see also DX 6872, p. 1 (Keydata--"all the benefits of a large computer with none of the problems"); DX 11202 (ADP--"[Y]ou don't have to buy a computer to get [answers]. You can buy computing, instead"); DX 11759 (Martin Marietta Data Systems--On-site remote job entry computing service "as a replacement for an existing facility . . . e.g. manufacturer replaces 370/135").)

The small user, contemplating the acquisition of his first computer system, could forego or delay that acquisition by having his work done at a service bureau. (Currie, Tr. 15605-06.) Large users, as well, with heavily loaded equipment could off-load some of their work and thereby postpone or forego the acquisition of additional EDP equipment. (Norris, Tr. 5819; Currie, Tr. 15350-51; J. Jones, Tr. 79982-84; DX 4085, Poe, pp. 19-20; DX 6088, Zweifel, pp. 16-17.) Users also turned to service bureaus in place of their own equipment to acquire flexibility, to fill in gaps in their own data processing equipment without acquiring new hardware, to take advantage of the additional services offered and to automate new applications (often at lower cost due to less overhead than the alternative of installing hardware). (See Norris, Tr. 6078-79; PX 4832, pp. 11, 32; DX 5821, Brownell, pp. 16-17; DX 6026, Gehring, pp. 14-15; DX 7532, Parten, pp. 188-91.) Thus, the service bureau's customers included both those with their own data processing installations and those without. (DX 4085, Poe, p. 19; DX 6026, Gehring, pp. 12-14; DX 6088, Zweifel, p. 18.) As Applied Logic, a service bureau, described it:

> "In large companies, many have their own computers but also utilize Applied Logic services because of the unique, flexible, large scale facility which permits greater depth in programming. In fact, of all Applied Logic's clients, 40% are corporations in the top 500.

"In small companies, not in a position to buy their own computers, Applied Logic time sharing is practical because the user is charged only for actual computer time used. There is no minimum charge, capital expenditure, or maintenance cost involved." (DX 7393, pp. 110, 117; see also DX 6080, Dale, pp. 10-11.)

That these alternatives exist is confirmed by customers' experience. For example, Chemical Bank at one point decided to off-load from its main IBM computer system its personnel recordkeeping. According to James Welch, Senior Vice President of the Information Services Group for Chemical Bank (DX 3656, Tr. 74673-74), the two alternatives considered were a service bureau in New Jersey, which also offered a package program for the application, and a computer system from Hewlett-Packard. (Tr. 75278-79.) Welch recommended the selection of Hewlett-Packard. (Id.) Southern Railway used six to eight service bureaus instead of its own computer system to do time sharing. Its decision was based on "plain old economics and management judgement" that it was cheaper and a better use of Southern's personnel resources to use the service bureaus.* (J. Jones, Tr. 79440-42, 79982-84.)

Other examples of such choices include:

(a) Datamatic, Inc., which in 1967 submitted a proposal to the Southwest Louisiana Electric Membership Corporation "to automate and process their accounting and engineering functions", and won over a proposal submitted by IBM involving IBM hardware. (DX 6128, St. Amant, pp. 4, 11.)

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* Although these decisions occurred in the 1970s, as shown above, these alternatives were fully available in the 1960s.

(b) DP&W provided Medical Associates of Chelmesford, Massachusetts, services "which eliminated the complete installation of IBM equipment" previously on lease from IBM. (DX 4076, DiPietro, pp. 3, 6-7.)

(c) The Aerojet Company of Sacramento had two 360/65's installed. When its four operating divisions were organized into three separate independent companies, two of those companies came to Information Systems Design (ISD), a service bureau, to do their processing and one of the Model 65s was returned to IBM. When the remaining company's business declined a year or so later, it returned the other 65 to IBM and gave its business to ISD. (DX 8122, Larribeau, pp. 5, 12-13.)

(d) The Federal Government saved millions of dollars by having its agencies offer their excess computer time or services to other agencies (see above, p. 835) as an alternative to acquiring new EDP equipment or services. It estimated savings of $26 million in 1966 and $86 million by 1970. Examples of such savings include the SEC's provision of computer time to the Naval Ship Systems Command; the Environmental Science Services Administration's provision of computer time to 23 different government activities; and GSA EDP personnel's provisions of systems analysis and program development aid for HUD. (Plaintiff's Admissions, Set II, ¶¶ 368.2, 369.4, 369.9, 369.14; see also ¶¶ 369.6, 369.7, 369.10.)

The competition provided by service bureaus was well understood within IBM, as well as by other hardware manufacturers. As early as 1964, Cary, at the time President of the Data Processing Division (Tr. 101325), received a report entitled "Remote Scientific Computing" which noted that time-sharing service bureaus could be profitably implemented by non-manufacturers because technical skill need only be devoted to one location. The report projected "an immediate, rapid development of interest in the service bureau form of business". (PX 2964-A, pp. R29-R30.) IBM employees continued to track this growth and reported on the increasing service bureau competition. The Quarterly Product Line Assessment (QPLA) of November 1968, written by members of the Commercial Analysis Department, examining competition for the 360/25 and 360/30, stated that:

> "Computer-oriented service company competition is getting stronger every day as new service bureaus and time-sharing companies spring up and existing ones expand. Both of these sources compete by reducing prospective customers' computer needs." (PX 2360, p. 139.)

The May 1969 QPLA reiterated that such companies "offer services which may substitute for additional computer function and/or capacity" (PX 2437, p. 108), and noted that

> "Timesharing services are being sold by almost every type of business including computer manufacturers, service bureaus, financial institutions and new entrepreneurs. When all the vendors of services are grouped regardless of their industry classifications, the explosive growth of this segment of the data processing market becomes apparent." (Id., p. 294.)

These same IBM employees analyzed service bureau competition in assessing the competitiveness of IBM's planned 370 line (PX 2388,

p. 117), and Cary testified that service bureau competition constrains IBM's prices. (Tr. 101642.)

Similarly, Currie of Xerox testified that Xerox Computer Services salesmen, in accounts with small computer systems, had "been successful on a number of occasions in replacing the computer hardware". In other instances, XCS competed with "the hardware vendors, the small computer system vendors in providing a solution to a customer" currently using another service bureau for accounting or doing its accounting work on accounting machines. (Tr. 15603-06.) In Currie's judgment, the services of XCS were offered as competitive alternatives to the use of a centralized data processing system:

> "XCS services are in my opinion an effective competitor for all general purpose computer systems".* (Tr. 15611-12, see also Tr. 15477-90.)

Norris of CDC testified that a user has the alternative of installing minicomputers or a larger computer system or using CDC's data services in solving his data processing problems. (Tr. 5997; see also Tr. 5698.) Reginald Jones, Chairman and Chief Executive Officer of General Electric, testified that GE has "always understood that the service business, in effect, competes with the manufacturer, because you attempt to sell the customer service rather than have him go out and buy his own machine. We say 'We'll put a terminal in your place and you can use our system'". (Tr. 8848; see also Macdonald, Tr. 6900 (service bureaus competed with Burroughs "rather extensively" because

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*XCS services were only offered after 1970, but the analysis applies equally to the 1960s.

they are "an alternative for the user having his own individual system of a small-scale or medium-scale, which he could use for the same purpose"); Rooney, Tr. 12039-40, 12482.)

By the end of the 1960s service bureaus had become a major force. The FCC, in its 1970 Tentative Decision in Computer Inquiry I (Docket No. 16979), estimated that there were more than 800 service bureaus with total annual sales exceeding $900 million. The Commission estimated that more than 5,000 companies had sold excess computer time and capacity. (Plaintiff's Admissions, Set II, ¶¶ 306.7-.9; see PX 4835, pp. 36-38 (over $1 billion in revenues in 1970).) The history of a few service bureaus active during the period follows.

McDonnell Automation (McAuto). Among the early entrants into the service bureau business was the McDonnell Corporation. McDonnell was a major aircraft manufacturer with 1959 sales of $436 million. (DX 11074, p. 2.) It established the McDonnell Automation Center in 1960 to provide "complete electronic data processing services both for scientific work as well as in administrative fields such as inventory control, marketing analyses, production control and accounting". (Id., p. 14.) The company had 300 EDP employees and was about to acquire an IBM 7080 and 7090. (Id.) The center advertised that its equipment "encompass[ed] virtually every size and type available . . . . This variety of machines enables the Center to process any size or type of program at the lowest possible hourly rates, because a customer is not bound to a single machine" (DX 10324, p. 155) and stated that it was the first commercial user to install an IBM 360/30, the first to install a CDC 6400 and the first to install an RCA Spectra 70/55. (Id., pp. 82, 234.)

The McDonnell Automation Center also offered systems design, consulting and programming services. In the late 1960s it offered ICES, a series of computer languages for civil engineers. (Id., pp. 52, 55, 57, 86.) Other services included a demand deposit system for banks using the Center's MICR equipment and a "Basic Seismic Package" for geological applications. (Id., pp. 58, 70.) McDonnell Automation combined digital and analog computers at its Center and described this "hybrid" system as combining "the unique benefits of each [component] system". (Id., p. 119.) McDonnell also offered a linear programming package, MPS/360, to operate on its 360/50-75 coupled system, as well as on other 360s. (Id.)

McDonnell had added centers at many locations as the sixties progressed. It coined the word "Datadrome" to describe what it called "facilities for the application of data technology and computing solutions to the problems of business, science, industry and government", and stated:

> "From the oil fields and the auto showrooms, from the drafting tables and the construction foreman's notebook, from 100 stories over Chicago to the shifting silt of the Missouri River, from a fourth grade spelling class to a fourth orbit space rendevous, the dynamic problems of the world are being brought to the Datadromes of the McDonnell Automation Company for solution." (Id., pp. 233-34.)

By 1970 its inventory of computer equipment was valued at over $125 million, its staff had grown to 3,000 and its clients included the Federal Reserve Board, General Motors Corp., the Atlantic

Richfield Company, the Social Security Administration and Illinois Bell Telephone Company. Revenues for 1970 exceeded $47 million. (DX 11075, p. 12.) A new company, designated "McAuto", had been formed by combining McDonnell Automation with McDonnell Douglas' "West Coast computer operations". The consolidation "strengthen[ed] McAuto's position in competing for commercial and government data processing business". (Id.)

Automatic Data Processing (ADP). ADP was already in the service bureau business at the start of the decade. It had begun in the late 1940s by performing payroll services for customers using manually operated bookkeeping and accounting machines and later converting to IBM punched card equipment. It installed its first computer, an IBM 1401, in November 1961, "to offer a substantially broader range of services for its many clients". (DX 13875, p. 3.) By 1964 ADP had placed orders for System/360 and called itself "the largest independent payroll processor in the nation, preparing payrolls for approximately 500 firms with 80,000 employees whose annual wages total almost a half-billion dollars". (DX 13876, pp. 3-4.) ADP had decided that "major growth was in order". It assembled a marketing force, which undertook a "missionary and educational program" to sell ADP's services to the business community. This was supported by advertising and direct mail promotions. The result, according to ADP, was "unlike anything the data processing services industry had seen". Revenues increased twenty-twofold and earnings fifty-eightfold in six years. (DX 14212, pp. 6-7.) Along the way ADP acquired a number of other companies, developed capabilities in "back office" processing applications for brokerage houses, accounts receivable processing, time-sharing and portfolio applications, and expanded its geographic coverage. (DX 10320, p. 18; DX 13877, pp. 5, 12; DX 13878, pp. 4, 5, 8; DX 14212, p. 9; DX 13879, p. 3.) By 1970 ADP was processing the payrolls of 7,000 firms totalling $5 billion in wages. (DX 13879, p. 3.) ADP's U.S. EDP revenues rose from $187,000 in 1957 to about $2 million in 1963, $4.7 million in 1964, $20 million in 1968 and $37 million in 1970. (DX 8224, p. 135.)

Tymshare. Tymshare, Inc. began offering time-sharing services in 1966 (DX 13916, p. 6), and in the following year generated $1 million in U.S. EDP revenues. (DX 8224, p. 557.) One of the first time-sharing concerns not associated with a hardware manufacturer, Tymshare developed its own applications packages, programming systems and certain hardware, such as channels and interfaces. (DX 13917, pp. 1, 7.) In 1970 it acquired Dial-Data, another service bureau, to broaden and increase its customer base and to expand its technical research and development capability. (DX 13917, p. 1.) Prior to 1970 Tymshare "relied quite heavily on engineering and scientific computation". Beginning in 1969, Tymshare "began to develop applications packages and programming systems designed to open the use of our services to a much broader group of customers, primarily in the business, commercial, and financial activities." Tymshare's "market profile" by 1970 had "shifted to one that is approximately balanced between engineering and business use". (DX 13917, p. 1.); see also DX 2765.)

By the end of the decade Tymshare had accomplished its "most significant" achievement, its TYMNET communications network. 19 cities were connected through 25,000 miles of telephone lines over which traffic was directed by a "combination of specialized hardware and software" developed by Tymshare. There were more than 20 terminals compatible with this service, including one designed to Tymshare's specifications. Compatible plotters were also available. (DX 13917, pp. 3, 8.) 1970 domestic EDP revenues had risen to more than $10 million. (DX 8224, p. 557.)

53. Software Companies. In the late 1950s and early 1960s, a few independent software firms were founded which "for the most part . . . started doing Government contract work. To some extent, then, in addition, they also began undertaking work for some of the computer manufacturers as well". (Welke,* Tr. 17383; see also Tr. 17072; DX 1049, pp. 5-6.) Such firms included Computer Sciences Corporation, Planning Research Corporation, Computer Usage Corporation, Informatics, Applied Data Research and System Development Corporation. (Welke, Tr. 17014, 17071-72, 17382; see below.) Welke testified that by approximately 1965 there were 40 to 50 independent suppliers of software programming. (Tr. 17384.) The leaders in this field in the 1965 or 1966 period were "[p]eople like, again, Computer Sciences, Applied Data Research, Comress, PRC, System Development Corporation". Such companies "were still at that point working with government, in large part, they were still . . . doing work for the computer manufacturers themselves, and increasingly they were getting involved in the commercial marketplace, the private sector". (Welke, Tr. 17082-83; DX 1049, pp. 5-6.) Several factors stimulated the growth of

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* Lawrence Welke founded International Computer Programs, Inc. (ICP) in 1966. When he testified Welke was President of ICP (Welke, Tr. 17003, 17005.) Among the services supplied by ICP is the publication of catalogs of available software packages. (Welke, Tr. 17003-04.) Welke started to survey software suppliers for the ICP listings in 1966. (Tr. 17040-41.) Welke testified that ICP was in daily contact with software product vendors in the late sixties and that since 1968 ICP has been engaged in research activities as a normal part of its business to determine the number and business practices of companies in the software product business. (Tr. 17051-53.)

independent software companies during this period: the work software vendors were doing for computer manufacturers,* advances in software technology, the proliferation of computers and the shortage of qualified people. (Welke, Tr. 17383-84; DX 1049; see also Withington, Tr. 56790.) The latter two factors led users to seek to "supplement their staff". (Goetz,** Tr. 17497.) Welke testified that additional factors contributed to the growth in such firms during this time period:

> "I think it was a general recognition on the part of the people that were going into the business that there was more money to be made programming with an independent software firm than there was if you were in a user shop or working for a computer manufacturer.
>
> "A lot of firms were formed by people leaving the computer manufacturer's employment, and that wasn't just IBM, everybody was experiencing that loss. IBM had the most to lose because they had the most people to lose. But I guess word spread rather easily and quickly that it was possible to get a government contract and go into business with a very low entry fee for going into business as a contract programming firm." (Tr. 17083.)

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* Welke estimated that between 30 and 50 percent of the systems software developed for third-generation computers was done by independent software suppliers. (Tr. 17388-91.) Firms developing systems software for computer systems manufacturers during this period included Applied Data Research, Informatics, Computer Applications, Computer Usage, Computer Sciences and CEIR. (Goetz, Tr. 17489-90.) Examples of systems manufacturers contracting for systems software in this way include Univac (Welke, Tr. 17074) and Honeywell. (Spangle, Tr. 5092-94.) Burroughs used software houses "rather extensively" (Macdonald, Tr. 6901-02), and SDS obtained a "significant part" of its software from software houses, between 20 and 50%. (Currie, Tr. 15385-89.)

** Martin Goetz was, at the time of his testimony, Senior Vice President and Director of the Software Products Division of Applied Data Research. (Goetz, Tr. 17420.)

In the period after 1964, the entry and growth of independent software companies were stimulated by the development and introduction of System/360 because of the "increased complexity of the hardware technology as well as the software technology." (Welke, Tr. 17385-87, 17078-81, see Tr. 19195.) Users ordering System/360 needed help in planning for and converting to the new hardware and software. "And this, in turn, caused a demand that was reflected back onto the software firms." (Welke, Tr. 17078-81; DX 1049, p. 5.) Also, during the period of the introduction of System/360 "people expanded the use of computers and put more and more applications on" which required more programming. (Id.)

Users wishing to solve problems and take advantage of the complexities and of the technology and not wishing to hire systems programmers at high salaries found that "with the increased complexity of solving the problem, if you are going to do your own program, your costs for the programming will increase . . . the comparative cost of buying the product becomes more attractive as the cost of the in-house programming, the cost of the in-house solution goes up." (Welke, Tr. 19195-97.) In terms familiar to economists from the days of Adam Smith,* as the market grew it became efficient to have increasing division of labor and to hire specialists rather than each user meeting his own needs in-house.

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* A. Smith, An Inquiry into the Nature and Causes of the Wealth of Nations, (1776), Ch. 3.

The development of such specialists was aided by the fact that entry into the business did not require large size or much capital investment. (DX 1049, p. 3.) To enter contract programming

> "what is needed is some technical knowledge. If you learn to be a technician in a user's office or with a computer manufacturer, once you are so educated, you in effect have earned the right to set up a contract programming firm.
>
> "The cost of doing it being minimal, you can work out of your house or apartment; at the very most, you might have some initial office expenses should you choose to rent space, but there is no investment necessary as far as equipment; there is no expenditure for capital assets. All you need is a coding pad and a sharp pencil." (Welke, Tr. 17404-05, see also Tr. 17083.)

A number of independent software companies formed in the late 1950s or early 1960s had enjoyed rapid growth by the late 1960s. For example, Computer Sciences Corporation, established in 1959, had U.S. EDP revenues of $67.2 million in 1969. (DX 7425, p. 5; DX 8224, p. 532; see pp. 861-64 below.) Informatics, Inc., formed in 1962, had U.S. EDP revenues in 1969 of $19.8 million (DX 8224, p. 542; DX 8796, p. 7; see pp. 864-65 below.) Applied Data Research, formed in 1959, had corporate revenues in 1969 of $6.2 million. (Goetz, Tr. 17441, 18580.)

In the late 1960s, the growth in suppliers of software "exploded". (Welke, Tr. 17392.) Goetz, then Vice President of Applied Data Research, wrote in late 1969 or early 1970 that starting with "about 20 major programming firms . . . and perhaps several hundred smaller organizations" in 1965, "the number of and size of individual concerns within the independent programming software field have doubled each year." (Goetz, Tr. 18773-74; DX 1096, p. 2.)

Welke estimated there were about 2,800 vendors of software in 1968 at the end of the period he described as "the flowering of the independent software industry".* (Welke, Tr. 17392-96.)

Withington testified that "the number of firms in the software business increased at a faster rate in [the late 1960s] than during any other period." (Tr. 56791.) Welke estimated that by 1969 contract programming accounted for revenues of $600 million, while software products accounted for another $20-25 million. (Tr. 17167-68, 17180-81.)

Despite this growth, revenues of independent software vendors represented only a minor fraction of the aggregate expenditures for programming made by users. Welke estimated that user expenditures for programming went from around $200 million in 1960 to $3-4 billion in 1965, to $8 billion in 1970 and $12 billion in 1975. (Tr. 17318-20.) He estimated that at the time of his testimony in 1976, "easily 80 percent" of the "total moneys spent by computer users" for programming "is in-house programming effort". (Tr.

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* Welke's publication, ICP Quarterly, listed about 75 companies offering 140 to 150 software products in 1967, about 140 companies offering 375 to 400 software products in 1968 and, by mid-1969, approximately 370 companies offering nearly 1,000 software products. (Welke, Tr. 17398-99.) This does not include the firms offering only contract programming services as opposed to software products. (Welke, Tr. 17042-43.) A software product is able to satisfy a particular need of a number of different users; contract programming service is the provision of software and systems assistance tailored to a single user's needs. (Welke, Tr. 17070-71, 17085-86, 17384-85; Goetz, Tr. 17461-62.)

19206-07; see Withington, Tr. 56772.)

Software houses, seeking to market software to users, were also competing against the software offered by systems manufacturers (DX 1049, p. 8), which since the 1950s has accounted for less than 10% of the aggregate industry programming expenditures.* (Welke, Tr. 17156-58; 17321-24.) Withington agreed that "over the course of the history of the industry, users and independent software houses have written more than 90 percent of the applications programs in use for general purpose computer systems." (Tr. 56772.)

There was another source of programs available--programs interchanged among users. Once a program has been developed, the cost of distributing it to additional users is essentially zero, requiring merely the duplication of decks of cards or reels of tape and the dissemination of a manual. As computers developed, therefore, it became relatively inexpensive for users to engage in a practice that was greatly to their advantage, namely, helping each other learn how to use the equipment more efficiently and avoiding needless duplication of programming effort. Manufacturers often recognized the benefits of such exchanges. (Perlis, Tr. 1996-97; McCollister, Tr. 11063-65; Case, Tr. 73151-53; see Palevsky, Tr. 3206; Spangle, Tr. 4907-09.) Dr. Perlis of Yale testified concerning SHARE, an IBM users organization:

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* Welke also testified that from 1955 to the time of his testimony in 1976 computer systems manufacturers employed less than 10 percent of all computer technicians, programmers and systems analysts. (Tr. 17326.)

"It was an extraordinarily--again I use the word 'extra-ordinarily', because it really was a very worthwhile from the standpoint of those people who were in the--very worthwhile organization, that was able to convey a large amount of information to its members. One learns more about what was going on in the computer field by going to SHARE meetings than almost anywhere else in the fifties and sixties, and maybe today, to this day, for all I know, but certainly during those days the SHARE meeting was a scene where a large amount of information about the practical use of the IBM 704, 709 and 7090, was passed back and forth and it represented to the acquirers of those machines a real, positive benefit--increase in value of those machines." (Tr. 1921-22.)

Such user groups assisted the independent software house in keeping costs down

"primarily by putting much of the R&D effort for that product, the research and development for modifications and enhancements for that product back to the users of that product. So in effect, the people who are using the product on an everyday basis are the ones that are supplying input to the software seller on how he can keep his product as usable and as up to date as possible. If he did not have that user group doing that for him, he'd have to expend some effort and some monies doing it himself with his own staff." (Welke, Tr. 17248.)

Software companies grew and prospered during the 60s, and the free exchange of software contributed to the growth of software. Writing in 1966 "to state the opposition of the Department of Justice to the issuance of patents on computer programming methods", Donald F. Turner, then Assistant Attorney General in charge of the Antitrust Division, described the situation eloquently:

"The computer industry is one of the most dynamic in the American economy, in terms of absolute as well as relative growth, and further rapid expansion is anticipated. . . . Current investment in programming, or the 'software' portion of the computer industry, is approximately equal to the equipment or 'hardware' portion, and should surpass it in the very near future. Growth in the software portion of the computer industry has been facilitated by a remarkably free and easy exchange of ideas, concepts, and programs. One of the notable features of the programming industry, indeed, has been the widespread establishment, sponsorship, and universal acceptance of joint user groups to facilitate the exchange of programs and algorithms. As a result, for the past twenty years, almost all basic ideas in computer programming have been available openly to all computer users.

"One of the major policy arguments advanced for extension of patent protection to computer programs is a supposed need to encourage individuals and companies to invest in programming development. But it is difficult to conceive how the field of programming could have grown faster, or that its past growth has been hampered in any meaningful fashion by a lack of investment funds. If anything, the current free interchange of programs has lead [sic] to an extraordinarily efficient use of scarce programming talent and has kept needless duplication of existing programs and techniques to a minimum. Furthermore, many small software companies have achieved financial and technical success by producing more efficient versions of widely used manufacturer-developed programs. These more efficient versions of operating programs benefit other software producers, computer manufacturers, computer users, and the general public. In the light of past experience, any step which could upset the vital interchange of programming material should be approached with the utmost caution." (DX 9110, pp. 1-2.)

During the 1960s the software companies competed with IBM and other hardware manufacturers in two ways. First, programming supplied by software companies competed against the software provided by hardware manufacturers. (DX 1049, p. 8.) For example, Autoflow which was supplied by Applied Data Research, QUICKDRAW which was marketed by NCA, and other independently supplied software competed with IBM's Flow Chart Software. (Goetz, Tr. 17506-07, 18662-66; Welke, Tr. 19217-19; DX 1064.) Informatics sold Mark IV in competition with IBM's Generalized Retrieval System. (Welke, Tr. 19218.) In fact, Welke estimated that between 75 and 85 percent of the systems software products listed in the ICP Quarterly in 1969 were systems software usable on IBM computers and said that "in most cases" IBM had a competitive offering. (Tr. 19216-17.)

Software houses were successful in competing against manufacturer-supplied systems software because of the wide number of users who might experience cost savings from a more efficient piece of systems software. Welke testified that during the late 1960s, the most successful independently supplied software products, "the big winners, the market leaders, as it were", were all competing against IBM systems programming which was not separately priced. (Tr. 19217.) Examples were ADR's Autoflow and Informatics' MARK IV. (Welke, Tr. 17156-58.) One of the reasons such products were successful is that there are "additional cost factors that come into play other than merely the price of the package. There conceivably can be hardware savings or processing cost reductions as a consequence of the systems software product being used. (See Jones, Tr. 79417-19.) So that even though the product has a price, that price or that cost is offset by other cost reductions made possible because of the product." (Welke, Tr. 19354, see also Tr. 19267-70, 19349-50; PX 4833, p. 28; DX 3950, pp. 17-18.)

Second, the software provided by independent software companies competed directly with the sale of computer hardware by reducing the amount of computer equipment required by a user. Welke testified that certain operating system enhancements and other independently supplied software "reduce[s] the requirement for machine hardware". (Tr. 19267.) Enfield* testified that "there's obviously

* At the time of his testimony in 1976, Enfield was president of The Computer Software Company. (Enfield, Tr. 19841.)

two solutions or two methods to solve any particular problem of performance. The first . . . would be the installation of an additional or faster, larger computer system. The second is . . . a software solution . . . ." At the Bank of Virginia, Enfield wrote a spooling system as an alternative to an additional System/360 Model 30 or migration to a Model 40. (Tr. 19910-11.) Moreover, according to Enfield, his company's EDOS software (marketed as a product in 1972) could improve the performance of an IBM system by 20 to 33 percent permitting the installed system to do 20 to 33 percent more work "for the same amount of money". (Tr. 20134-36.) Louis Benton, owner and General Manager of Staff, a programming firm, testified that his firm believed that in some cases it could effectively compete by reducing a customer's hardware needs through more efficient design, systems engineering and more sophisticated software. "There are always software hardware trade-offs in a system where some software, or more effective software can be used in place of hardware." (DX 3970, pp. 6, 8-9.) David Oppenheim, Chief Executive Officer and Director of Abacus Programming, testified that his software firm encountered a "situation at Hughes where it seemed that we would need some extra core memory and we were able to improve the compiler and the program so the additional memory would not be necessary". (DX 4028, pp. 8-10, 14-15; see DX 6123, Smith, pp. 8-10; DX 6244, Clay, pp. 17-18.) The GRASP system marketed by Software Design Inc. (SDI) is a spooling package that, according to SDI, can increase system availability by 15 to 30 percent with "typical users" gaining "at least 20 percent more throughput" and can "often eliminate hardware". (DX 6711; DX 6713.) Wayne K. Smith, President and chief executive officer of Data Processing Consultants, Inc., a service bureau, testified that the use of add-on memory plus GRASP "improved our hours, available hours, by approximately 20 percent" and gave his firm capacity which would otherwise have been attained by the upgrading of its 360/30 to a 360/40 or the acquisition of an additional Model 30. (DX 6123, Smith, pp. 2, 8-10.) Rupert J. Lissner, President of LCS Data Processing, Inc., testified: "There are a lot of examples of [users having chosen software as an alternative to hardware] . . . I think the most impressive one[s] . . . have names like 'Sprint' and "Grasp', and the result there in our case, and I am sure in everyone else's case, is to save a great deal of hardware expense by installing a piece of software . . . ." (DX 6169, pp. 11-12; see also DX 6145, p. 13.)

We now consider the history of some of those firms that were active and successful software firms in the 1960s.

Computer Sciences Corporation (CSC). Computer Sciences Corporation, which Welke identified as one of the leaders in contract programming around 1965-66 (Tr. 17082), began in that business in 1959. In 1973, the company described its early history as follows:

> "The initial technical capability on which Computer Sciences Corporation was founded in April 1959 was Systems Software. CSC has designed, developed and implemented more programming systems than any independent company in this field. CSC's first contracts were with computer manufacturers and required the development of systems programming packages for their machines. The first project

was the production of a FACT compiler for Honeywell, closely followed by the LARC scientific compiler for Univac, and then a major effort for Univac in which CSC developed the complete operating system, the executive system, and all of the processors and compilers for the 1107. The latter project represented a significant state-of-the-art advance at that time, an advance which immediately brought industry-wide recognition of CSC as a major force in the software industry. Major design and development projects for IBM and other manufacturers followed soon after. Since that time, programs have been developed for over 50 machines, and customers have included virtually all major computer manufacturers, large companies in other industries, and Federal,* state, and local governmental agencies. Compilers designed and developed at CSC are rated among the fastest in the industry and are noted for their object code efficiency. Many CSC-developed computer languages, compilers, and software systems are standards for the Armed Forces.

"Through its history, CSC systems programming activities have expanded from simply completing a specified project to functioning as a system architect for a computer manufacturer or other user. In this role, CSC helps to determine the operational characteristics required of the software to realize and even amplify the rated maximum effectiveness of the computer equipments." (DX 7425, p. 5.)**

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* For example Computer Sciences worked on major programming systems for NASA's Goddard Space Flight Center in the 1960s. (DX 7533, pp. 11-12.)

** CSC's President, William Hoover, similarly described the company's founding:

"CSC was formed in 1959 in recognition of the rapidly growing requirement for systems software as a basic adjunct to the computer hardware. The users of computers were making increased demands on the computer manufacturers to provide FORTRAN compilers, operating systems, COBOL compilers and related systems programs.

"The very substantial shortage of personnel skilled in this field and the lack of capability of most manufacturers to develop these complex software systems provided a very favorable business environment for the establishment and initial growth of Computer Sciences. . . . CSC has since

CSC also developed software products. (Perlis, Tr. 1850-51.) In 1964 CSC began development of the Computax system, an income tax preparation program designed for the accounting profession. (DX 7426, pp. 13-14.) CSC then developed a ticket service program and a series of package programs for users of the IBM System/360 performing "such standard functions as payroll, general ledger, accounts receivable, personnel management, commercial loan and systems activities." (DX 7426, pp. 14-15.) As of 1970, CSC had "a product line of 12 packages in the field, all satisfactorily installed and operational with multiple clients, and all verifying the ability to design standard applications which can serve many different users". (DX 7426, p. 15.) CSC also developed its own communications network (INFONET) providing time-sharing information services with the Univac 1108 as a nucleus, utilizing its own proprietary time-sharing operating system. (DX 5194, pp. 2-5; DX 7426, p. 15.)*

CSC grew rapidly during the 1960s. Its U.S. EDP revenues were $5.7 million in 1964, $17.8 million in 1965, $67.2 million in 1969 and $82 million in 1970. (DX 8224, p. 532; see also DX 7426, p. 21.) Indeed, Welke agreed that during the middle to late 1960s

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developed more systems software than all other independent companies combined, and more than most computer hardware companies. . . . The company is currently working on systems software projects for most of the major computer manufacturers, including IBM, Univac, CDC and XDS." (DX 7426, pp. 8-9.)

* As mentioned in the Service Bureaus section, INFONET was developed by CSC for the U.S. government to provice services to federal agencies. (Plaintiff's Admissions, Set II, ¶¶ 367.2-.4.)

Computer Sciences was one of the developing examples of very successful businesses in the software area which served as a model for potential new entrants. (Tr. 17405-06.)

Informatics, Inc. Informatics was formed in 1962 and initially provided programming services to the federal government. (Welke, Tr. 17071-72; DX 5985, Thomas, p. 7.) Between 1962 and 1969 Informatics expanded its product offerings to include programming services to computer manufacturers and non-government end-users, proprietary program products and data center computer services. By 1969 Informatics had U.S. EDP revenue of $19.8 million. (DX 8224, p. 542; DX 13891, pp. 4-5, 11.)

In 1967 Informatics described its "principal business" as "the sale of custom products and services--analysis and programming services for particular computer applications." (DX 13982, p. 5.) Informatics performed programming work for NASA, the armed services, the National Library of Medicine, the Office of Education and U.S. intelligence agencies. In 1967 Informatics stated that "[f]or the U.S. State Department, we completed the implementation of a modern communications based inquiry system." (Id.) In addition, in 1967 Informatics characterized itself as "a leading supplier of software and consulting services to the computing industry itself, through contracts with IBM, Univac, GE, Control Data, Scientific Data Systems, NCR and Honeywell." (Id., p. 11.)

Informatics' major proprietary software product in the 1960s was Mark IV, which was announced in late 1966 or early 1967 and first delivered in 1967. Mark IV was "a general purpose data base management system" initially developed to operate on IBM 360 computers. (Withington, Tr. 57662-63; DX 7116, p. 3; DX 13982, p. 6; DX 14082, p. 2.) When Mark IV was initially marketed it competed with IBM's unpriced "generalized retrieval system". (Welke, Tr. 17156-58, 19218.) Welke identified Mark IV as among the most successful independently supplied program products in the 1960s. (Tr. 19217.)

By September 1968 there were over 60 installations of Mark IV. (DX 10611.) In 1969, only 13 months after that product was first marketed, Informatics reported that there were 171 installations of Mark IV which made a "significant contribution to [Informatics'] revenues and income". (DX 13891, p. 4.) By 1973 Informatics had implemented Mark IV for IBM 370 and Univac Series 70 equipment. In 1973 Informatics stated that "[l]arge and small users throughout the world are using Mark IV in a complete spectrum of applications. 600 Mark IV installations . . . at the present time make Mark IV one of the most successful software products ever developed." (DX 7116, p. 2.) Welke estimated that at the time of his testimony in 1976, Mark IV had approximately 1000 installations and had generated over $30 million of revenue for Informatics. (Tr. 17163.)

Informatics built on the strength of Mark IV to expand into the data center business. In 1969 Informatics began its first data center operations in Los Angeles and San Francisco as "the first steps in a planned nationwide data center operation using the Mark IV system and eventually offering on-line and timesharing Mark IV service for business applications." (DX 13891, p. 5.)

54. The Role of the Federal Government. Particularly in the 1950s and early 1960s, the Federal government played an important role in promoting the advance of computer technology.* The government viewed the development and application of ever more advanced computers as critical to the nation's security and accordingly, encouraged and financed leading edge work throughout the industry. The pioneering work of the National Security Agency in the 1940s and 1950s continued through the 1960s. That story is well documented at paragraphs 18-25, 29-55, 60-98, 267-455 of the classified NSA Stipulation. (DX 3420A.) Those paragraphs show NSA to be at all times at the leading edge of computing and exerting a great deal of influence on the computer industry.

Many military-related applications required capability

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* Some non-governmental users also played an important role in advancing the state-of-the-art in computing during the 1950s and 1960s. For example, in the late 1950s and early 1960s, American Airlines, working jointly with IBM, developed the first real-time passenger name reservation system, called SABRE ("Semi-Automatic Business Research Environment"). (Welke, Tr. 17313-14; O'Neill, Tr. 76005-08, 76231; see also above, pp. 138-39.)

Non-governmental users were also important in the development of interactive computing or time sharing. For example, SABRE had some of the characteristics of time sharing (Wright, Tr. 13329), and General Motors, beginning in 1957, worked toward developing an interactive time-sharing system to help design automobile bodies, in a joint development effort with IBM. (Hart, Tr. 80228.) The main thrust for time sharing, however, came from the universities. Dartmouth, working together with General Electric, developed one time-sharing system in the early 1960s (Weil, Tr. 7106-07), and MIT's Project MAC with its major procurement in 1965, pushed both IBM and GE (the winner of the procurement) into the development of major new time-sharing systems with Dynamic Address Translation. (See above, pp. 418-36, 505-12.)

for performing in "real-time", and it was in military applications that such capability was first achieved, SAGE being one of the earliest and best examples. (Weil, Tr. 7044; Crago, Tr. 85975; see above, pp. 68-79 .) Further, in the late 1950s and early 1960s, the government supported work to build the most advanced and most powerful computers then possible (including NORC, LARC and STRETCH), for, among other things, weapons systems development and testing and the design of nuclear weapons. (See above, pp. 126-30.) Defense needs also spurred later efforts to build smaller, but more powerful computers for use in aircraft, satellites, missiles and other small spaces. (DX 13455, p. 3; DX 5421, Davis, p. 214.)

The establishment of NASA and the manned space flight program in 1958, followed by President Kennedy's 1961 commitment to the goal of landing a person on the moon before the end of the decade, provided still further impetus for what Christopher Kraft, Director of Flight Operations at NASA, described as IBM's "pioneering" efforts in real-time computing (DX 7578, p. 2), and for developing both large-scale, advanced computers, and powerful, small computers. It is amazing to think that in 1961 "the computing capability did not exist" even to make the decision as to whether to abort an orbital flight, let alone make a lunar landing possible. (DX 7530, Kraft, pp. 48-49A.)

The needs and the assistance of the Federal government provided opportunities for companies starting out in the EDP field. (See pp. 13-21, 68-79, 181, 191-92, 203, 213, 217, 219, 221-23, 229-30, 238-242, 246 above.) William Norris, the founder of CDC, speaking in 1961, stated:

> "The huge government expenditure for research and development is the equalizer between large and small companies. Approximately 70% of all basic research done in the United States is financed by the government. This means that most of the new additions to scientific knowledge are just as available to the little company as to the large company." (DX 331, p. 9.)

Similarly, Ray Eppert, then President of Burroughs, spoke in 1959 about the importance of military development contracts:

> "There is another important factor in our research program--namely, the powerful stimulus provided by military development contracts. . . .
>
> "This team effort in researching for new breakthroughs in technology has had the effect of developing scientific and engineering know-how in a fraction of the time such new developments would otherwise have consumed. No one private company could afford the basic research required for many of the new techniques if it had to depend entirely on its results in the marketplace to repay its efforts. But the knowledge gained by organizations involved in research for new military techniques is helping to strengthen total competency on commercial products.
>
> "Burroughs has shared in these government-underwritten programs. . . .
>
> ". . . .
>
> "This cross fertilization between our military and commercial development activities has important implications for the future." (DX 10283, pp. 6-7.)

Computer developments originally undertaken for military purposes were indeed carrying over into other uses. Thus, the General Accounting Office stated in a December 1960 report to Congress that:

> "[T]he growth in the development and use of electronic computer systems has been rapid and is related to research efforts undertaken in connection with military applications." (Plaintiff's Admissions, Set IV, ¶ 204.0.)

This was particularly so with the development of real-time applications. (Weil, Tr. 7044; see also DX 5313, pp. 14-15; DX 5654, Webster, pp. 360-62.)

In addition to its role in supporting and funding special research and development efforts, the Federal government was important simply as a user of computers and a customer of the EDP suppliers. In fact, during the 1960s, the Federal government was the largest user of computer equipment in the world. (DX 4355, pp. 6, 11; DX 7567, p. 9; DX 13455, p. 1; Plaintiff's Admissions, Set II, ¶ 312.8.) It "increased its inventory of computer systems from 531 in June 1960 to 5,277 in June 1970, when it owned ADP equipment which cost $1.9 billion and rented equipment which would cost $1.2 billion to purchase."* (DX 4355, p. 6; see also DX 7566, p. 16; Plaintiff's Admissions, Set IV, ¶ 221.0.) By any measure, government use of computers was large and expanded rapidly throughout the decade. (See, e.g., DX 923, pp. 1, 7, 10-12, 17-23; DX 924, pp. 2-19, 595-97; DX 4589, pp. 5-16, 297.)

By the middle of the decade, the acquisition of computers had become sufficiently important to warrant special attention in the form of legislation--the Brooks Bill. Prior to 1965, the government's EDP equipment was acquired in essentially the same manner as other personal property, with each agency responsible for its own equipment requirements. Such acquisition decisions were made largely on a decentralized basis with a view only to the individual agency's needs.

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* ADP (Automatic Data Processing) is the government's abbreviation for Electronic Data Processing equipment plus unit record equipment. (DX 924, p. 595.)

However, there were three central-type agencies involved in the acquisition of EDP equipment--the Office of Management and Budget (OMB), the General Services Administration, and the Department of Commerce. (DX 4355, pp. 11-13.)

Despite the decentralization of responsibility, it was government policy to acquire equipment at the least possible cost, promoting and taking advantage of competition among manufacturers. The Bureau of the Budget issued a circular "to the heads of executive departments and establishments" in October 1961, stating:

> "Two prime factors will be considered in the selection of equipment: (1) its capability to fulfill the system specifications, and (2) its overall costs, in terms of acquisition, preparation for use, and operation.
>
> ". . . .
>
> ". . . The method of acquiring ADP equipment will be determined after careful consideration of the relative merits of all methods available (i.e., purchase, lease, or lease-with-option-to-purchase). The method chosen will be that which offers the greatest advantage to the Government under the circumstances which pertain to each situation." (DX 5207, pp. 1-3.)

This decentralized decision-making failed to take into account the availability of computer equipment elsewhere in the government or the possibility that the equipment chosen by a particular agency might also be used by another one. As the government expanded its acquisition of EDP equipment, the potential benefits from the coordination of acquisitons decisions increased. In 1965, the Brooks Bill was enacted, amending the Federal Property and Administrative Services Act of 1949 to include general purpose computers and related services* under the GSA's procurement authority.

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* The Bureau of the Budget's ADP Glossary defines "general purpose

(See DX 5703, p. 11 et seq.; Plaintiff's Admissions, Set II, ¶ 354.1.)*

As summarized in a report to Congress by the Comptroller General in 1971, the new law:

> "[g]ave GSA the operational responsibility for coordinating a Government-wide ADP management program. . . . GSA was given exclusive authority to acquire all general-purpose ADP equipment for use by other agencies.
>
> ". . . GSA was to administer an ADP Fund for the acquisition of agencies' equipment requirements. The agencies were to obtain annual appropriations from the Congress to reimburse the ADP Fund.
>
> "The law also provided for the establishment of a management information system of inventory and fiscal data. . . .[**] [for] efforts to achieve optimum utilization of ADP resources and to ensure that the Government evaluates all acquisition alternatives so that equipment is acquired in the most economical manner practicable." (DX 4355, p. 14.)

The legislative history of the Brooks Bill indicated that the program to be implemented should have the results of:

> "-- improving the Government's bargaining position through volume acquisitions;
>
> "-- basing rental-versus-purchase evaluations on the value of equipment to the Government as a whole rather than on its anticipated useful life to the initial user; and
>
> "-- selecting equipment for purchase which, on a Government-wide basis, offers the greatest purchase advantage." (Id., p. 14; see also DX 5377, pp. 1-2.)

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computer" as "a computer designed to solve a large variety of problems; e.g., a stored program computer which may be adapted to any of a very large class of applications." (DX 1783, p. 13.)

* The text of the Brooks Bill is contained in PX 481.

** Thus, the GSA has maintained an inventory of general purpose computers in the Federal government.

Among other things, GSA was to consider the "possibility that additional procurement sources could be cultivated to serve as competitive alternatives to the exclusive procurement of equipment directly from manfacturers [sic]" and the "possibility of procuring equipment and software . . . as separate items". (DX 4355, pp. 15-16.) In addition, the Bureau of the Budget* and GSA encouraged the use of plug-compatible peripherals and the acquisition of EDP equipment from third party leasing companies. (DX 4321, p. 1; DX 5212, p. 1; DX 9071, Crone, p. 101; see pp. 759-61, 782-90, 960-61, 975-76.)

The resulting effort was implemented by the GAO, the OMB, the National Bureau of Standards and the GSA. The OMB put out instructions designed to ensure that the agencies satisfied their EDP needs in the most economical manner. The GAO assured that the implementing instructions issued by OMB and GSA were adhered to. The Bureau of Standards provided technical advice. The operation of these agencies in combination could be analogized to the organization of a commercial establishment with top management, those responsible for daily operations and the technical advisers. (See DX 9071, Crone, pp. 50-52.)

Three of the programs arising from the Brooks Bill deserve additional description. They are the GSA Reutilization Program, the ADP Fund, and the ADP Sharing Program.

<u>The GSA Reutilization Program.</u> The Federal government began taking advantage of its size as a user by actively seeking efficiently to reutilize EDP products which it owned. As with leasing

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* The Bureau of the Budget was renamed the Office of Management and Budget pursuant to Reorganization Plan Z of 1970.

companies and used equipment brokers outside of the government, such efforts lead to older, purchased equipment competing for business with the new offerings of EDP manufacturers.

GSA was responsible for EDP reutilization in the Federal government. (Plaintiff's Admissions, Set II, ¶ 134.6.) And, DSA (the Defense Supply Agency) worked in close cooperation with the GSA with respect to EDP reutilization. (Plaintiff's Admissions, Set II, ¶ 134.7.) Within the DSA the Defense ADPE Reutilization Office (DARO) acts "as a marketing type agency with respect to the disposal of excess computer equipment within the Department of Defense, and through GSA to other Federal agencies and programs. (Id., ¶ 138.0.)

Federal agencies were expected to determine whether their needs could be met either by utilizing excess EDP equipment or by sharing installed equipment before seeking new acquisitions. (DX 9071, Crone, p. 44; Plaintiff's Admissions, Set II, ¶ 357.9.) The reutilization program involved hundreds of millions of dollars. The acquisition cost of government ADP equipment transferred or reutilized during fiscal years 1965-1970 totalled almost $563 million. (Plaintiff's Admissions, Set II, ¶ 371.9.)

The increase in reutilization of EDP equipment by the government was boosted, in part, by the increase in the amount of EDP equipment purchased, rather than leased, by the government, beginning around 1963, when the GAO urged more extensive purchasing of EDP equipment by the government. The percent of government-installed computer equipment that was purchased rose from 17.0 percent in 1962, to 21.3 percent in 1963, to 59.8 percent in 1969. (DX 923, p. 19; see Plaintiff's Admissions, Set IV, ¶ 215.4.) It was also facilitated by the general purpose nature of the equipment, which by definition could be utilized in many different applications.

The GSA reported that the government realized cost reductions through reutilization of government-owned excess EDP equipment between 1966 and 1970, totaling over $330 million. (Plaintiff's Admissions, Set II, ¶ 371.10.) These savings, of course, came about because the reutilized equipment competed successfully with new equipment which the government would otherwise have acquired. (See Plaintiff's Admissions, Set II, ¶¶ 371.0, 371.1, 371.11.)

Excess equipment which could not be reutilized efficiently within the Federal Government was disposed of elsewhere. Surplus government-owned equipment has been donated to approved recipients, such as state and local governments or educational institutions, or sold on the open market. (Plaintiff's Admissions, Set IV, ¶ 228.1.)*

<u>The ADP Fund.</u> In its 1965 Report to Congress (which led to the Brooks Bill), GAO recommended legislation to establish an ADP revolving fund, to be available:

"(a) for procurement of equipment;

"(b) for procurement of ADP contracted services when needed; and

"(c) to facilitate the establishment of service

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* One example was the Minuteman I guidance computer. Between April 1969 and December 1971, the Department of Defense permitted GSA to offer 230 Minuteman I computers for reutilization. All were taken and as of December 1971, there were 113 unfilled requests outstanding. (Plaintiff's Admissions, Set II, ¶ 539.0-539.3.)

centers, equipment pools, and time-sharing arrangements." (Plaintiff's Admissions, Set IV, ¶ 223.0.)

The Brooks Bill authorized the establishment of such a fund, to be managed by the GSA. The fund was "activated" in fiscal 1968 with an initial capitalization of $10 million in appropriations with an additional appropriation of $20 million in January 1971. (DX 5714, p. 3; Plaintiff's Admissions, Set II, ¶ 370.2.)

GSA was authorized in May 1968, to "acquire excess government owned equipment and rent the equipment to agencies through the ADP Fund at rates which would ensure the continued solvency of the fund but which would be lower than the rates charged by suppliers." (Plaintiff's Admissions, Set II, ¶ 370.1.) Thus, "[t]he GSA leasing of EDP equipment financed by the ADP Fund is sometimes an alternative, to the extent of ADP Fund resources, to acquisition of EDP products for Government agencies". (Plaintiff's Admissions, Set II, ¶ 370.4.)

One of the ways in which the ADP Fund increased the alternatives open to government agencies was by allowing them to take advantage of the lower rentals offered in long-term lease plans. The ADP Fund was established without fiscal year limitation, and accordingly, could be used by certain Federal agencies to enter into long-term leases for EDP equipment (instead of either short-term rentals or purchases), where their own budgetary/statutory constraints would prevent them from entering into a lease with a term beyond one year. (See DX 4355, p. 15; Plaintiff's Admissions, Set II, ¶ 370.9.) In addition, the ADP Fund functions like a leasing company for government agencies. (DX 5654, Webster, pp. 129-31; DX 5834, Hiniker, pp. 4-5;

DX 7528, Mahoney, pp. 109-10; see also DX 6257, Gold, pp. 17-18; DX 9071, Crone, pp. 20-21.)

<u>ADP Sharing Program.</u> The reutilization program and the ADP Fund increased the extent to which Federal agencies actively considered old equipment in competition with new computers they might otherwise have acquired. Such competition was further enhanced by the possible use of excess computer <u>time</u> in lieu of hardware acquisition. Indeed, whereas through the reutilization program, the GSA acted as an internal government computer broker/dealer and the ADP Fund as an internal government leasing company, the sharing of computer time created internal government service bureaus. As with service bureaus outside the government, this took two forms: the use of excess time on computers otherwise utilized by users, and the creation of data processing centers with computers dedicated to the provisions of time and services to a variety of users. (DX 5188, p. 2; Plaintiff's Admissions, Set II, ¶ 364.1.) Such service bureaus provided users with further alternatives to hardware and software procurement. (See, e.g., Plaintiff's Admissions, Set II, ¶ 357.8.)

In 1964, even before the Brooks Bill, the Bureau of the Budget stated the following policies regarding "the sharing of electronic computer time and related services" among government agencies:

> "(a) The practice of offering available electronic computer time and related services for use within and among agencies of the Federal Government is to be followed as a means of increasing the utilization of equipment.
>
> "(b) The use of sharing is to be considered by departments and establishments and their field offices

as a principal means to perform essential computer work for which electronic computer resources are not at hand in the organization.

"(c) Agencies are encouraged and are expected to utilize the referral services provided by Computer Sharing Exchanges or equivalent services as may be established to identify sources of assistance available for sharing purposes." (DX 5461, pp. 1-2; Plaintiff's Admissions, Set II, ¶ 357.9.)

As with the other EDP-using activities of the government, such activities were systematized under GSA following the Brooks Bill.

The program was a success:

"From fiscal year 1966 through fiscal year 1970, cost avoidance by GSA resulted in the probable avoidance of expenditure of the following amounts of money by sharing products of Government agencies as an alternative to acquiring new EDP equipment or services": $250.8 million. (Plaintiff's Admissions, Set II, ¶ 368.2, see ¶¶ 369.0-.18 for specific examples; see also DX 5654, Webster, pp. 67-69, 106-07.)

Separate service bureau operations were also set up. GSA operated 12 Federal Data Processing Centers (financed through the ADP Fund) which offered the following services to government agencies and contractors: computer processing, systems design and programming, data conversion, and applications software. (Plaintiff's Admissions, Set II, ¶¶ 354.5, 364.3-.4.)*

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* In addition to the larger Federal Data Processing Centers, there are a number of "Joint Use Centers . . . in which more than one agency with a data processing requirement joins together to do their work either by time-sharing or splitting shifts". (Plaintiff's Admissions, Set II, ¶ 366.0.)

55. Planning for New Products.

a. Introduction. Even in 1964, IBM management was determined that the organization would not simply sit back and enjoy the fruits of the success which it was already beginning to achieve with System/360. IBM management realized, given the lessons of the vigorous competition in the early 1960s, that however successful 360 would turn out to be, competition would not stand still. As Thomas J. Watson, Jr., wrote in November 1963:

> "I believe that whenever we make a new machine announcement, we should set up a future date at which point we can reasonably assume that a competitor's article of greater capability will be announced. We should then target our own development program to produce a better machine on or before that date." (PX 1077, p. 2.)

Thus, planning commenced for future generations of equipment even before the System/360 was delivered. On October 9, 1964, A. K. Watson (IBM Senior Vice President) wrote to Gibson and Piore (both IBM Vice Presidents and Group Executives):

> ". . . I think it is extremely important that you put together a group of engineers from each of your divisions who will now be starting to design the next generation machine and do this on a continuing basis, taking advantage of possible improvements in monolithics technology, any new memory technology, printing, etc." (DX 14394.)

It was also recognized within IBM that the future competitiveness and price/performance advances of IBM's computer systems would depend on new peripheral devices as well as processors and memory. IBM's System/360 Compatibility Committee reported in August 1964, that:

"The heretofore heavy emphasis on processor planning as the criterion for improved price/performance should be re-oriented towards I/O developments. The across-the-board improvements in price/performance which will be required in the 1967-68 time period will probably be brought about more by improved I/O capability than by CPU and memory improvements." (PX 3908A, p. 22; see also PX 6671, p. 27.)

In particular, continued improvements in input/output equipment were expected to be needed "to keep System/360 a viable product line. . . ." (PX 3908A, p. 22.) As we have seen, IBM did in fact announce greatly improved disk drives (the 2314) and tape drives (the 2401 Models 4, 5, 6 and the 2415) in the two years following the announcement of System/360. (See pp. 393-95 above.) Peripheral developments were also eventually to contribute significantly to the next generation of computer systems.

The history of System/360, as we have discussed to this point, reveals an on-going pattern in which IBM introduced products, competitors responded with lower prices or improved products, and then IBM responded again with lower prices and/or improved products of its own. This pattern was captured at least in part by the testimony of a number of IBM's competitors who testified, in conclusory terms, that they attempted to price their products, either by cutting prices or introducing product improvements, to obtain a price/performance advantage over IBM's existing computer systems--particularly System/360 systems.* As one would expect, that goal represented only a rough

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* See, e.g., McDonald, Tr. 2883-84; Palevsky, Tr. 3149-50, 3176; Norris, Tr. 5653-54; Hangen, Tr. 6350-51, 10861-62; R. Bloch, Tr. 7598-99, 7601-02; Beard, Tr. 8492-94; Rooney, Tr. 11826; Wright, Tr. 13082-84; Currie, Tr. 15175-76.

"rule of thumb" (see R. Bloch, Tr. 7599-601) and was necessarily imprecise because of the functional differences between the competitive systems and IBM's systems and the variations in performance among computer systems from application to application. (Fernbach, Tr. 497-503; Scherer, Tr. 2482; Palevsky, Tr. 3270-71; McDonald Tr. 4182-83, 4195-96, 4207-12; Norris, Tr. 6038-39; Lacey, Tr. 6570-72, 6800-01; Beard, Tr. 10091-93; Withington, Tr. 56758-60.)

Most of the characterizations of those competitive thrusts focused primarily on obtaining a throughput per dollar (usually labeled "price/performance") advantage. (Palevsky, Tr. 3270-71; McDonald, Tr. 4188-90; Norris, Tr. 6038-39; Lacey, Tr. 6570-72; Beard, Tr. 10084-88, 10097-102; Hangen, Tr. 10837; Rooney, Tr. 12129-30.) Of course, important elements of value to users were not captured by the price/performance equation, and many of these elements were advantages of System/360 that competitors were unable to match.*

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* Such as the disk drives and printers, the breadth of peripherals, software, service and other features. See Perlis, Tr. 1977-78; Norris, Tr. 6040-41; Lacey, Tr. 6708-10; Hindle, Tr. 7448-51; McCollister, Tr. 9370; Beard, Tr. 9048-49, 10088-95, 10276, 10322-23, 10325; Rooney, Tr. 12048-49, 12055-57, 12122, 12135-37, 12190-94, 12550-51; Currie, Tr. 15459; Butters, Tr. 46450; Withington, Tr. 55898, 56218-19, 56240-41, 56250-52, 56591-92, 56764-72, 56800-02, Case, Tr. 72881, 73428; Knaplund, Tr. 90504-05; Evans, Tr. 101132-34, 101137-38, 101141; PX 1099A; PX 1967, p. 1; PX 4829, pp. 17-18. The point here is not to criticize the crude attempts to measure price/performance, as an economic matter, but to recognize that the competitive responses of IBM's competitors (and the resulting IBM responses) and the significance to users of those responses were both more complex and less clear cut than that single measure could indicate.

In any event, because System/360 was so overwhelmingly successful and widely accepted, IBM's competitors often aimed their later announced and delivered products at existing 360 users, attempting to offer them an incentive to remove installed 360s to be replaced with different equipment. (McDonald, Tr. 4205-06; R. Bloch, Tr. 7596-97; Beard, Tr. 10103; Rooney, Tr. 12420-21; Wright, Tr. 13083-84.)

This "leapfrogging" nature of competition was, and is, characteristic of the computer industry. (Hindle, Tr. 7447-48; R. Bloch, Tr. 7761-62; R. Jones, Tr. 8866-67; McCollister, Tr. 9697, 11069-74; Beard, Tr. 10103-05; Hangen, Tr. 10414-15, 10423-24; Butters, Tr. 49449-50; Withington, Tr. 56459-60, PX 353, p. 23; DX 426, pp. 7-8.) As we have seen, IBM was as mindful of the need to outstrip its competitors as they were of the requirement to be better than IBM, and repeatedly, IBM was forced to come out with improved products or lower prices in order to remain competitive. (Knaplund, Tr. 90519-20, 90503; Evans, Tr. 101045-49; PX 1045; PX 1077; PX 1090; PX 1099A; PX 2990, pp. 1-4; PX 4256, p. 2; PX 4565; PX 4830, pp. 20-22; DX 1525; DX 4773, pp. 3, 6; DX 4795; DX 4806; DX 8886, p. 43.) Neither IBM nor its competitors could have been successful for very long had they done otherwise.* That "leapfrogging" competitive interaction presented

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* Hindle, Tr. 7447-49; R. Jones, Tr. 8865; Hangen, Tr. 10431, Currie, Tr. 15751-53; Brooks, Tr. 22704-05; Withington, Tr. 56522-25, 56540, 56556-57, 56560, 56565; J. Jones, Tr. 78990-91, 78995-97; Knaplund, Tr. 90473; Evans, Tr. 101271-72; DX 426, pp. 7-8; DX 1404A, pp. 73-90 (App. A to JX 38); DX 3726; PX 1079; PX 1194A, pp. 1-3; PX 1214; PX 1256 (DX 14504); PX 2964A, pp. 4-6, 26-30.

awesome challenges to the industry participants: they were compelled to strive for a sufficient lead with each product to withstand the competitive responses destined to follow. Thomas J. Watson, Jr., expressed that challenge in mid-1963, as the announcement of System/360 approached:

> "I think it important to note, however, since we seem to have suffered for a few months or even years because our machines predated the effective competitive machines now in the marketplace, that we now make these machines good enough so they will not be just equal to competition, for I am sure that once they are announced, our competitors will immediately try to better them. This is all to the good and I am for competition, but I want our new line to last long enough so we do not go into the red." (DX 4806.)

As Watson predicted, competitors closed the lead that System/360 had given IBM and put IBM to the test again in the latter part of the 1960s. By then those competitors included, in addition to the systems manufacturers, vigorous and rapidly growing groups of PCMs, offering simple box-for-box replacements for IBM equipment, and leasing companies, offering individual boxes and configured systems in competition with IBM. Moreover, service bureaus and software houses had proliferated and grown enormously over the decade, assuming roles of increasing competitive importance in the EDP industry. IBM responded to the competitive challenges with a new line of improved equipment which became System/370.

Design planning for what would become System/370 began in 1965, and the engineering work began "in earnest in 1966". (DX 4740: Evans, (Telex) Tr. 3937.) Case, who was Director of Architecture at IBM during the planning for the new systems, described the objectives for the development of System/370 as follows: IBM was to develop its own integrated logic circuits--MST, i.e., Monolithic Systems Technology (see E. Bloch, Tr. 91501-02)--and integrated memory circuits. It was "to extend the architecture of System/360 in order to make System/370 more valuable to users and, therefore, more attractive to them". System/370 was to be upward compatible from System/360. Dynamic Address Translation, developed in the Model 67, and related systems software were to be added to support virtual memory. Various other improvements, related to program control facilities, reliability and availability, were also to be included. All of these features, of course, contributed toward an overall objective: "It was our objective in designing System/370 to design . . . a new family of central processing units utilizing new circuitry and new technology to achieve new levels of price performance for the user." (Case, Tr. 73609-13, 73732.)

Such new levels of price/performance for central processing units were to be accompanied (as would be required if system performance were not to be limited by input/output performance) by improved price/performance in peripheral equipment.

> "Similarly, we had an objective to make available new technology and new circuitry to achieve new levels of price/performance for the auxiliary storage devices, that is, for the direct access storage devices and for the magnetic tape devices." (Case, Tr. 73732-34.)

In addition to the new disk drives and tape drives, there were to be fixed head file devices (Case, Tr. 73734-35), block multiplexer channels (Case, Tr. 73695-99), new terminals (Case, Tr. 73737-

41), a 3705 communications control unit (Case, Tr. 73741-47), a mass storage system which Case described as an "ancestor" of the 3850 (Case, Tr. 73747-48), and a new high speed printer, the 3211 (DX 1437).

Fifteen months prior to announcement of the first System/370 models, the planning goals were discussed by the Management Committee:

> "Kennard [Vice-President, Development, SDD] summarized the intent of the meeting as being to review basic NS objectives and strategy, terminal-oriented and data base computing systems, NS plans, and marketing plans as they relate to the NS systems. The basic NS objectives are to allow customers and IBM to meet market requirements on an evolutionary basis. Kennard depicted the marketplace of 1970-75 as moving towards communications oriented, on-line usage. He enumerated the basic functions which would have to be improved, increased or added to satisfy this demand. Improvements are required in CPU's and channels, availability, access methods and front-end tie-ins. Increased function is required in memory size, channels, and on-line data files. New functions are required in I/O devices, such as tape, terminals, displays, printers, and conversational compilers with associated control programs." (PX 2399, p. 1.)

The strategy for the new systems, however, was "evolution not revolution". (PX 5621, p. 17.)

In addition, based upon the experience with System/360, IBM planned to stagger the announcements of its next generation of CPUs to avoid the excessive strains and demands which the simultaneous announcement of the entire 360 line had placed on the business. Since the concept of compatible families was now well established, this approach, unlike the situation at the announcement of System/360, would not subject the customer to unnecessary uncertainties. The new processors were to be announced "one or two at a time at approximately six month intervals" starting with the largest two models in the summer of 1969.

(Cary, Tr. 101359-361.)

As we shall see, the design for and development of the new systems were to involve a complex interaction among the development and application of new technologies for memory, logic circuitry, disk drives and tape drives and the achievement of advances in operating systems architecture. Although some of these pieces constitute stories in and of themselves, they each played a crucial role in the ultimate announcements of System/370 and in the achievement of the basic goals for the next generation: the attainment of a substantial price/performance improvement over System/360, the extension of the System/360 architecture, the maintenance of upward compatibility from System/360 and the addition of improved capabilities and function--to respond to competitive developments, to meet the changing demands of users, and to foster continued expansion of the use of EDP products and services.

b. <u>Tape Drive Developments: The 2420 and 3420 (Aspen).</u> In 1965-66, after its announcement of the 2401 and 2415 tape drives, IBM began a longer range program to develop new and superior tape drives to supplant the ones just announced. That development led first to the 2420 and later to the 3420, known in various stages of its development as PRIME, HATS and Aspen. (DX 4740: Evans, Tr. (Telex) 4122-24; Aweida, Tr. 49617-22; DX 2158; Cooley, Tr. 31942; DX 7751, pp. 3-7.)*

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* In the mid-1960s, IBM's "development focus" was on the System/360. IBM "in essence took development monies away from magnetic tapes . . . [and] other technology areas" and concentrated on System/360. "As the development bulge of System/360 began to pass", however, IBM reassigned development resources to "programs of technical excellence . . . that led to . . . the development of what became the 2420 and later the 3420 tape subsystem family". (Evans, Tr. 101294-96.)

The 2420. Development of the 2420 (known in development as the "D30R") was reviewed in late 1966:

> "We started early in 1965 to develop a truly superior tape drive that uses the latest technology to achieve improved reliability and faster thruput while staying compatible with the 2400 line. The technologies chosen provided increased tape speed, faster access time and linear rewind characteristics far superior to any known drive. These characteristics substantially improve the thruput of our Medium and Large scale Systems/360." (DX 7751, p. 3.)

Among the features of that new tape drive technology were automatic threading (id., pp. 3-4), the use of a single capstan to enhance reliability (id., p. 5), the use of SLT technology throughout (id., p. 6) and the use of fewer components leading to greater reliability and serviceability. (Id.) It was anticipated that the D30R drive with these advantages could be manufactured at the same or even less cost than the 240X. (DX 7752, p. 3.) It was also proposed in late 1966, that a new tape drive (later called the "D30X") utilizing the D30R mechanism be introduced to supersede the existing 240X drives for "small and medium system users", in order to give them the same advantages. (DX 7752, p. 1.)

The need for such improved tape drives was even more apparent by the time they were announced. In December 1967, the Management Committee reported to the Management Review Committee that, although the DP Group analysis of "peripheral equipment exposures and related action programs" indicated that IBM's peripheral products were superior to competitive alternatives in most areas, tape drives faced at least a potential threat:

"Frank Cary recognizes an immediate exposure, especially in the tape drive area, which stems mainly from an improving marketing and service capability, and the attention the trade is giving to these obviously better performing tape drives. Frank feels this exposure can be contained at the level of about 1,000 drives, since at the announcement of the D30R in January we will re-establish technical superiority and indicate to the market that our entire tape line will be renovated.

". . . .

"In retrospect, it is recognized that our strategy in tapes, which stretched old technology too far, too long, created the threat we are now experiencing. Conversely, because of our technical superiority in the file area, we are able to react and keep ahead. The Group is committed to avoid this problem in the future." (PX 2152A, pp. 1-2.)

On April 15, 1968, C. B. Rogers, Jr. (Vice President, Marketing, Data Processing Division) wrote to F. G. Rodgers (President, Data Processing Division): "The competitive tape unit market is moving fast and we anticipate even greater acceleration in the future", pointing out the agreement by which Potter and MAI would market Potter tape drives. (PX 3958, p. 1.)

The IBM 2420 Model 7 was announced on January 30, 1968, for use with the System/360 Models 50, 65, 75 and 85. It incorporated a single capstan drive, 200 inch per second tape speed, automatic threading, cartridge loading and compatibility with all IBM 1600 bpi phase encoded tapes.* (JX 38, p. 840.)

Meanwhile, plans were being implemented to extend the D30R technology to slower speed tape drives (D30X program) for use with the

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* The single capstan drive was directly coupled to a unique high torque, low inertia motor developed at IBM. The characteristics of the motor helped to make the 2.0 millisecond access time possible. (DX 7751, p. 5; see also DX 12689, p. 9.)

360/30 and up. (DX 7710, pp. 5-6.) Because of its high data rate, the 2420 Model 7 could not be used with systems smaller then the 360/50, but other aspects of its technological advances were desirable for the users of those smaller IBM systems. (See DX 5155, Gruver,* pp. 42-43; see also DX 7838, p. 3.) That program was given a "kick off" meeting on January 5, 1968. (DX 7710, pp. 1, 4.) By February, it was reported that "Boulder is making real progress on the slower speed D30R-like drives". (DX 7669.) Important goals of the program were improvements in reliability and serviceability as well as cost reduction. (Id.; DX 7698.)

In July 1968, the Management Committee received a presentation on peripherals. It was told that "the 2401 Models, one through six, are the most vulnerable to the competitive compatible products in that they are roughly half the price of our products and are of a newer technology". The DPG strategy "to compete in the competitive compatible products area" was, among other things, to "[m]aintain technical superiority". (PX 2267B, p. 1.) The planned schedule of announcement for the new technology IBM tape drives was also reviewed. (Id.) The Management Committee reported to the Management Review Committee:

> "We have announced a tape drive which is technically equal in the high performance area, and have plans to announce technically competitive products in the other capacity ranges in October 1968 and June 1970. At those periods of time we will be equal in technical performance. We will be technically equal, but not equal in price/performance

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* Howard Gruver, at the time of his testimony, was Vice President of Engineering for Peripheral Development at the Telex Corporation. (DX 5155, Gruver, p. 3.)

basis. DPG is actively working on strategies to combat this exposure but in the MC's opinion, we are, at best, in a weak posture in this area today.

"Based on the extended capacity of the competitive manufacturers, we stand to lose a significant amount of highly profitable business unless a plan can be implemented to plug the dike. DPG has been asked to report back to the MC by September with a validated forecast of expected impact of competitors' and their plans to respond to this threat." (PX 3086.)

IBM had caught up and was pushing ahead in its technological development of tape drives. A presentation to the Management Committee in mid-October 1968, stated that "while we were behind in technological development in the tape drive area in 1965 and 1966, the increased investment in tape drive engineering in 1967 and 1968 had produced products which are technically superior to the competitive offerings". (PX 3096A, p. 3; see also PX 3104, p. 2.) In November 1968, Cary (IBM Senior Vice President and General Manager, Data Processing Group) wrote to Watson (IBM Chairman of the Board) concerning tape drives and discussing competition from Telex and MAI who were "actively marketing direct replacement of IBM's 2400 Series drives". He stated:

"Our tape strategy is to compete with superior technology and function, and not price alone. . . .

"We believe the new 2420 single capstan technology . . . will narrow the price differential between us and the other manufacturers, increase customer satisfaction, and regain technical leadership for IBM. . . .

"Our next move is the planned announcement of the second model of our new technology tape drive, the 2420 Model 5, which is scheduled within the next 30 days." (PX 2343.)

The 2420 Model 5 was announced on December 2, 1968. According to the announcement, it was attachable to System/360 models from the Model 30 through the Model 91; offered a format compatible with the 2400 and the 2415 series Models 4, 5 and 6, as well as the 2420 Model 7; but had half the speed of the 2420 Model 7. (JX 38, p. 932.) Although the component parts of the Model 5 differed largely from the parts of the earlier Model 7 (see DX 7710, p. 2), the Model 5 embodied most of the advantages of design that the Model 7 had introduced, including automatic threading and cartridge loading capability. (JX 38, p. 932.) The goal had been to "cost reduce [the Model 7] to make it a more manufacturable machine" and that was accomplished by changes in the organization and packaging of the machine. (See Aweida, Tr. 49091-94; DX 5155, Gruver, pp. 38-40.) The 2420 Model 5 was offered at a substantially lower price than the 2420 Model 7. (See JX 38, pp. 841, 932.)

Outside IBM, the 2420 Model 5 was perceived as an important development. A memorandum written by three engineers of The Telex Corporation stated:

> "The [IBM 2420] Mod 5 is a very well planned, designed, engineered, and production-designed machine, taking advantage of high production type tooling. It has been cost reduced far better than any IBM drive I have seen.
>
> ". . . .
>
> "The IBM 2420 Model 5 is a completely different tape drive from the IBM 2420 Model 7. It is very apparent that the Mod 5 is the drive that they have spent the greatest amount of time and money on. It has been cost-reduced and highly styled." (DX 1769, pp. 1-2.)

<u>The 3420 (Aspen).</u> Around 1967, a new, more ambitious program emerged from the development effort that had produced the 2420 Models 7 and 5. That program, first known within IBM as PRIME and then as HATS

and then, in 1968, as Aspen, resulted in the 3420, announced in November 1970 as part of the System/370 announcements. (See Aweida, Tr. 49617-22; DX 2158; Cooley, Tr. 31942; DX 4740: Evans, Tr. (Telex) 4122-24; JX 38, p. 981.)

In August 1967, a Phase Review of the project, then called HATS (High Availability Tape Subsystem), set forth as objectives the improvement of availability, price/performance, reliability and serviceability with the use of one-half inch compatible tape. Drives were planned for 3200 and 1600 bits per inch, and were to have 360 programming compatibility and incorporate NS (System/370) architecture. They were to have a much higher data rate than any existing IBM drive, including the D30R (2420 Model 7). Announcement was planned for September 1969. (DX 3116, pp. 1, 2, 3, 6, 13, 28.)

A year later, in September 1968, the name of the project had been changed to Aspen. The goals remained generally the same, but announcement was scheduled for June 1971. (DX 3087, pp. 1, 2, 5, 7, 9.)

That 1971 announcement was one piece of a multi-part strategy. The strategy, which included the announcement of the 2420 Model 5 and the first customer shipment of the 2420 Model 7 in 1968, was to go on in 1970 with the announcement of a mass storage device and then to the announcement of the first Aspen drive in 1971. (See PX 2343.)

That time table proved too slow. By October 1969, activity by leasing companies and peripheral manufacturers was expected to increase. It was reported in IBM that while the 2420 was "currently competitive", competition was "expected to equal or exceed the capabilities" thereof with rental or purchase prices lower or comparable to IBM's. (PX 4033, p. 28.)

In order to accelerate the development effort, the Aspen program was divided into two parts, Aspen Intermediate and Aspen Advanced, to be announced in September 1970 and June 1973, respectively. (Id., p. 20.) "The Aspen Intermediate Program is currently targeted to meet the OEM competitive pressures that are increasing in the field today. . . ." With the Aspen program concentrating only on Aspen Advanced, "[i]t has become apparent that this product by itself would not stop erosion of our tape products inventory. . . . To meet the competition then, the Aspen 'Intermediate' Program has been introduced to supplement the Aspen 'advanced' high performance plan". (PX 5360, pp. 1-2.) Aspen Intermediate was planned to have a density of 1600 bits per inch; Aspen Advanced, a density of 6400 bits per inch. Aspen Intermediate was to have tape speeds of 50, 100 or 200 inches per second; Aspen Advanced, tape speeds of 100 or 200 inches per second. As a result, Aspen Intermediate would have a data rate ranging from 80 to 320 kilobytes per second; and Aspen Advanced, from 640 to 1,280 kilobytes per second. Aspen Intermediate was seen as "protecting our tape investment" on 360/40s and 50s and early A48s (subsequently announced as the 370/155), while Aspen Advanced, to which Aspen Intermediate was "a more logical step", was seen as a way of insuring long term system price/performance. (Id., pp. 2-3.) Competition to which the strategy was addressed included both systems companies that had by 1969 announced tape subsystems equal to or better than the 2400 line and were expected to match the 2420 in the near future, as well as leasing companies and peripheral manufacturers. (PX 4033, pp. 28, 33; see also PX 5360.)

There were pressures within IBM to speed up delivery of the Aspen Intermediate and the announcement of Aspen Advanced. (PX 5564; see also PX 5360; DX 14388.) Indeed, Corporate Marketing expressed doubts that the entire strategy would be in time or would be sufficient. In early October 1969, R. A. Pfeiffer (IBM Director of Marketing) wrote to W. D. Winger (Product Manager, Tape Devices, SDD) concerning the Tape Devices Strategic Plan:

> "Corporate Marketing disagrees with the subject strategy for the following reasons:
>
> "1. The strategy does not address critical requirements in the 1/2 inch tape marketplace identified by market requirements statements and increasing competitive penetration of IBM's tape drive base.
>
> ". . . .
>
> "3. The strategy does not positively indicate that IBM will regain and maintain price/performance superiority over competitive manufacturers.
>
> "4. The risks of insufficient advanced technology efforts are identified in your strategy, but resolution is not addressed." (PX 4212, p. 1.)

In particular:

> "The growth of the OEM installed/on-order position, coupled with their projected production capability, requires immediate IBM response to protect and grow our market." (_Id._, p. 2.)

Further, with reference to price/performance comparisons:

> "Inclusion of OEM plug-compatible units shows IBM price/performance deficient in the critical Intermediate and Large Systems areas.

"We do not see positive assurance that IBM will regain price/performance superiority from competitive manufacturers." (Id., p. 3.)

Winger replied on October 30:

"I believe this has been answered by the funding of Aspen Intermediate to permit announcement 9/70."

Aspen Intermediate was to be announced for both System/360 and the new systems. (PX 5563, p. 1.) It was "price competitive with system manufacturers and OEM at their lowest quote prices" but the long range strategy called for "additional functions and improved performance". (Id., p. 2.)

However, these efforts presented

"a problem of adequate resources to bring out a burst of products while at the same time building a technology base for future products and product enhancements. The alternatives are to add resources or to accept the risks or to cut out product programs. I have listed the choices in order of my preference. This is an SDD funding issue." (Id., p. 2.)

Pfeiffer replied in mid-November, saying: "The first customer shipment date and delivery schedules for Aspen Intermediate drives should be improved. . . . The lack of advanced product technology efforts has not been resolved." (PX 5564, p. 1.) In particular, "in light of current OEM strength, first customer shipment [of Aspen Intermediate] should be reduced to 9-12 months after announcement to maximize competitiveness of the new drives". Also, while it was understood that advanced technology efforts were "primarily a funding issue, [w]e are not satisfied that acceptance of the risks involved with insufficient new product technology development is a proper strategy". (Id., p. 2.) That debate had occurred repeatedly over the years between IBM's staff and line organizations: how best to fund the expenditures and absorb the risks involved in the rapid technological development demanded by the competitive race.*

Aspen Intermediate was announced as the 3420 tape drive, Models 3, 5 and 7, on November 5, 1970, with first customer shipment scheduled for October 1971. As announced, the drives were attachable to all 360 models above the Model 20 and to all models of System/370. (JX 38, pp. 981, 983.) The three models had tape speeds of 75, 125 and 200 inches per second and provided format compatibility with all IBM 240X and 2420 tape drives through the ability to accept both NRZI and phase encoded tapes. (JX 38, pp. 981-3, 985.)

Although IBM capitalized on the basic design of the 2420 in its development of Aspen (PX 4033, p. 48), the end result was a significantly improved tape drive and control unit. Some of the differences between the 2420 and its control unit (the 2803) and the 3420 and its control unit (the 3803) were:

(i) The 3420 provided a wider choice of recording formats, densities and tape speeds than the 2420. This gave the user greater flexibility in configuring a tape subsystem to meet his requirements. (JX 38, pp. 840, 932, 982, 985; DX 7619: Winger, Tr. (Telex) 5709-10.)

(ii) The 3420 achieved on the order of 20 percent improvement in access time over previous tape drives. (DX 7619: Winger, Tr.

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* IBM had spent more than $10 million on Aspen by the time it was shipped. (DX 7619: Winger, Tr. (Telex) 5695.)

(Telex) 5714-15.)*

(iii) The 3420 achieved a 25 percent improvement in rewind time over the 2420. (DX 7619: Winger, Tr. (Telex) 5716.)**

(iv) The 3420 simplified maintenance. No adjustments in the basic read/write circuitry were required (DX 4253, p. 6), and a number of manual pneumatic adjustments were eliminated (DX 4253, p. 9). "[A]n outstanding development in Boulder Lab [was] a pneumatic device which automatically adjusts and controls the pneumatics piped to various portions of the drive, making a multitude of individual adjustments, that appeared in the 2420, unnecessary." (Cooley, Tr. 31941.)

(v) The built-in programmable diagnostic capability of the 3803 controller also contributed to Aspen's maintainability. Aspen was able to detect and identify problems in the tape subsystem as they occurred. (PX 3784B, p. 36; PX 3962, p. 8; DX 2137, p. 6; DX 4253, pp. 17-22; DX 5155, Gruver, pp. 62-64, 73, 96-97; DX 7619: Winger, Tr. (Telex) 5706-08, 5713.)

(vi) Use of monolithic circuitry in the 3420 drive and 3803 controller provided for more logic capability on fewer cards and in a smaller space with a resulting improvement of more than 25% in reliability over the 2420 family. As a result of the reduction

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* "Improved access time was achieved by positioning the readhead gap closer to the data, thereby reducing the access time interval in subsequent reads." (DX 2137, p. 1.) DX 2137 is an article by three IBM employees at the IBM Systems Development Division Laboratory in Boulder, Colorado, which discusses what those individuals believed to be the "design innovations" of the IBM 3803/3420 Magnetic Tape Subsystem.

** "Improved rewind time was achieved by more positive control over the tape as it enters the vacuum columns, and the control was obtained with a new configuration of tachometers for high-resolution tape speed information." (DX 2137, p. 1.)

in space requirements, the 3803 controller was only half the size of the 2803, and the switching circuitry (which in the 2420/2803 was contained in a standalone box) could be included under the covers of the 3803.* (JX 38, pp. 981, 985; DX 4253, p. 7; DX 4740: Evans, Tr. (Telex) 4129-31; DX 5155, Gruver, pp. 59-60, 65-67, 89, 94; DX 7619: Winger, Tr. (Telex) 5698.)

(vii) The 3420 offered a new method of attaching the tape drive to the tape control unit--a radial attachment with the control unit at the center and drives attached as the spokes of a wheel are, rather than as a "daisy chain" attachment, with a whole string of drives attached at one end to the control unit. Whereas in the "daisy chain" attachment the failure of one tape drive would mean the failure of the whole string, radial attachment meant that "if a tape unit malfunctions it could be worked on while the rest of the tapes were on line". (DX 4740: Evans, Tr. (Telex) 4130; see also PX 3962, p. 8; DX 2137, p. 5.) In addition, the radial attachment increased users' flexibility in the physical arrangement of the computer installation. (Case, Tr. 73735-36.)

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* ". . . [C]ircuitry changes were made in the 3420 tape drives which had the effect of putting some of the very critical circuits associated with reading and writing on the magnetic tape itself actually in the tape drive rather than in the control unit where they had been before. Putting those circuits actually in the tape drive rather than in the control unit where they had been before improved the reliability of the signals transmitted from the tape drive to the control unit when the magnetic tape was read; and it also allowed for longer cable lengths between the tape drive and the control unit, because the signals were more thoroughly conditioned and were capable of being sent without distortion down longer lengths of cable." (Case, Tr. 73736.)

(viii) Finally, the 3420 included a new digital interface between the tape drive and the controller; the 2803/2402 had used an analog interface. "The significant difference is in the fact that the higher voltage of the digital interface gives better noise rejection characteristics." (DX 2137, pp. 4-5; see also Cooley, Tr. 31940-41; DX 5155, Gruver, pp. 91-92.)

The 3420, with the faster rewind and faster mounting and dismounting of tape reels, provided higher thruput than the 2420. (DX 4740: Evans, Tr. (Telex) 4135-37.) In addition, it had considerably lower manufacturing costs than the 2420 Model 7. (DX 4740: Evans, Tr. (Telex) 4139-43.) The advantages of the 3420 were widely acknowledged. (DX 3119, pp. 1-4; DX 4201, pp. 1-6; DX 4421, pp. 1-2.)

c. Disk Drive Developments: The 3330 (Merlin), 2319 and 3340 (Winchester). With System/360, IBM had placed disk drives in a position of central importance. By the late 1960s, disk drives had proved a major competitive success and IBM again planned its 370 systems around new, high performance disk drives, including the Merlin and the Winchester.

> "[I]t was important for the whole System/370 family that the new disk storage capabilities be made available, because the relative speed and cost of the central processing unit was such that they really demanded improved speed and cost characteristics in the direct access storage devices if the system was to remain reasonably balanced; that is, if it was not to be held back by the lack of available technology and disk storage." (Case, Tr. 73734.)

(i) The 3330 (Merlin). So important was the Merlin file perceived to be to the success of System/370, that the initial announcement of the 370 line was held up for almost a year because the Merlin file (also known as the 2314B) was not ready at the planned announcement time of late 1969. (Cary, Tr. 101360-63; see also Case, Tr. 73732-34; PX 2399, p. 4; PX 2468A, p. 2; PX 2474B, p. 1; PX 2502B, p. 3.)

Despite the work progressing on Merlin, there was concern within IBM about the adequacy of technological development in the disk drive area, which was felt to be critical to IBM's continued technical superiority. On March 5, 1969, Erich Bloch (Director of the Poughkeepsie Laboratory, SDD) wrote to Al Shugart (Product Manager, Direct Access Storage Products, SDD), concerning that development effort:

> "In summary, let me make a general observation about the DASD product area. Our systems are competing across an increasing spectrum of performance and applications against improving competition. At the same time DASD devices are becoming more important to good system balance and performance. In this environment it is important that IBM market a full set of DASD products in order to fit the right combination of cost, capacity and performance to the application. . . . It is important that you understand and recognize this need so that you can plan for a broader and more flexible DASD product line than the very limited one we now have." (DX 13442, pp. 2-3.)

The delay in the announcement of Merlin was seen as serious, not only because it was needed to make 370 systems competitive but also because of the increasing pressure from plug-compatible disk drive competition. For example, in April 1969, T. V. Learson (President), wrote to F. T. Cary (then Senior Vice President), concerning a recent ISS* disk announcement:

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* ISS was a PCM formed in 1967, by 12 former IBM employees who had been working at the IBM San Jose facility--some of them specifically on the 3330 development. (See above, p. 775.)

"You have read of the ISS 701. I am quite alarmed that it has been announced prior to and at superior specifications to our 2314A-3. They have moved to the new electromagnetic actuator which we are postponing until announcement of the Merlin file. Their average access time is one half the speed that we are planning on the 2314A-3 and is 25% faster than the Merlin file.

"I realize that we have more capacity planned, but there is nothing to stop them from adding capacity."* (DX 12115.)

The actuator involved was the voice coil actuator (or high speed electromagnetic actuator (see DX 1437, p. 3)), which was considerably faster than the hydraulic actuator used on the 2314 (see Haughton, Tr. 94857) and the development of which was responsible for some of the 3330 delays. (PX 2474B, p. 1.)

By July of 1969, a number of competitors had announced equipment comparable to IBM's 2314, which was first delivered in 1967. (PX 2474B, p. 1.) By January 1970, an evaluation of the "file facility environment" in connection with Merlin Phase III level forecast assumptions, stated:

"From the announcement of the 2314 in 1965 until late 1968 IBM had significant competitive advantages in this product area, as no competitor could offer a direct access device with the price, capacity, performance, and interchangeability characteristics of the IBM 2314. The situation today, however, has changed radically as most system manufacturers now have announced devices which are virtually identical in specifications to the IBM 2314." (DX 7858, p. 2.)

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* Cary wrote back to Learson, explaining that the electromagnetic actuator that Learson had written about was "not itself applicable to the 2314", that it would take about a year to develop such an actuator for the 2314, and that it was "impractical" to begin such a program so late in the life of the 2314. Moreover, Cary added, the Merlin as then planned would give IBM a "significant edge" in "both technology and product performance" over "all the competition". (DX 12116.)

ISS and Memorex were expected to announce in late 1970 or early 1971, "modular Merlin-Type drives at 10% to 15% below the IBM equivalent price and no extra shift charges"; first customer ship of those devices was expected by late 1972. By 1973, Merlin-type announcements were expected from major systems manufacturers, with first customer ship anticipated late in 1974, by which time it was expected that "plug-compatible devices of the Merlin-Type will be in heavy production". (DX 7858, pp. 4-5.)

Thus, even before the announcement of Merlin, competitive responses were expected:

> "MERLIN competition will be from both plug-compatible and system vendors. The key point here is the timing of this competition. It is our opinion that the significance of the MERLIN release will force the data processing industry to react faster than the assumptions predict. This reaction will probably be in two areas--MERLIN equivalents and 2314 price cutting and/or enhancements. We expect the latter to be the key competitor to MERLIN initially and improved MERLIN equivalents in the 73 timeframe. . . . Experience has shown that the competition is not limited to direct plug-compatible devices.
>
> ". . . We, therefore, see the MERLIN competition in two categories:
>
> "System Vendors--Must offer MERLIN price performance as soon as possible to be competitive.
>
> "OEM Peripherals--Active development of MERLIN equivalents with 2314 price cuts and enhancements in the short term." (DX 4237, pp. 2-3.)

The 3330 disk drive and associated 3830 control unit were announced on June 30, 1970, with the initial processors of the 370 line. It was announced for use with System/370 and with the 360 Models 85 and 195. (DX 1437, p. 1; see also PX 4505.) The 3330 was a very substantial advance in IBM disk drives. It offered disk capacity up to 800 million bytes in a single facility. It had almost double the number of tracks and the density, and over three times the capacity of the 2314. Its data rate was 2-1/2 times that of the 2314; its average access time with the high speed electromagnetic actuator was half that of the 2314. (PX 6414A, p. 6; DX 1437, pp. 1, 3.)

The 3330 was also recognized outside IBM as a significant innovation and advance. Rooney of RCA listed it as a "significant innovation" which "brought to the users significantly improved price/ performance, capability of storing and retrieving data on disks at much faster speeds than we had hitherto". He agreed that, "to the extent that it was better, it made it very difficult for other people who wished to compete with IBM systems to compete with those systems". (Rooney, Tr. 12048-49; see also Wright, Tr. 13131-33; Currie, Tr. 15495-501; Withington, Tr. 56250-51.)

(ii) <u>The 2319 and 3340 (Winchester).</u> While the 3330 was the most important disk drive development planned for the System/370, it was not the only one. (See Case, Tr. 73733-34.) The need for a broader line of disk drives had been stressed by Erich Bloch in March 1969. (DX 13442.) It was evident that Merlin would not provide "the right combination of cost, capacity and performance" (DX 13442, p. 2) for the lower end of the 370 line, that is, for processors from the 370/145 down. (Haughton, Tr. 94913-14; PX 3696A, p. 5.)

After unsuccessful attempts to create a program for such a disk drive, and with 370 processor development far along, those responsible for intermediate and small systems were beginning to think in terms of an alternate, interim solution--the attachment of the existing 2314 drives to the new processors. E. F. Wheeler, Systems Manager for Intermediate Systems, wrote to Shugart, in April 1969, concerning "DASD Support for Intermediate Systems":

> "For the past year we have been unsuccessful in obtaining a firm committed program for Intermediate Systems future systems.
>
> "Attempts by ourselves and Small Commercial Systems to negotiate a file program for the low end of the line have resulted in several iterations starting with Clover, Shamrock and finally Zen.
>
> "The delay to evaluate yet another technical solution coupled with the uncertainty of funding and manpower has left me no choice but to proceed with a 2314A file attachment for the C86.
>
> ". . . .
>
> "Accordingly I am removing references to Clover/ Zen from the base case of the current S68/C86 [370 Models 145 and 135] Forecast Assumptions. If at some future date firm committed schedules can be laid in to support a new file program, we will be happy to negotiate an alternate case to measure its effect on systems acceptances." (DX 1456.)

In 1969, Haughton, an IBM Senior Engineer, was attempting to develop a low-cost, low-end file, by looking at "new technology", rather than the heads and disks developed for Merlin or the 2314. After a number of iterations, "by mid-summer we had come up with a rather revolutionary new approach", which would involve the removability not only of the disk pack itself but of an entire disk "module" in which the heads as well as the pack would be contained. This development was to become Winchester. (Haughton, Tr. 94912-21; PX 3696A, pp. 1, 5, 8; PX 4538, p. 1.)

Mid-1969 was very late, however. The announcement of the first processors of the System/370 line, 370/155 and 165, had already been delayed from mid-1969 to mid-1970, because of the lateness of the Merlin program. It was evident that Winchester would not be ready for the planned announcements of the 145 (S68), 135 (C86) and 125 (T55) processors, announcements expected to begin in the fall of 1970. (DX 4740: Evans, Tr. (Telex) 4010-11; PX 4143; PX 4149.)

As a result, the Data Processing Division wanted to announce attachment of the 2314 to those processors as an interim step. At the end of July 1970, J. J. Keil, Director of Systems Marketing, wrote to M. J. Kelly, New Product Manager for Direct Access Storage Products, SDD, that the plan to attach 2314-type devices to System/370 was "solely due to the lack of a timely new DASD technology for the low-end 370 CPU's". (PX 4143.)

IBM faced a dilemma. On the one hand, it could not do without a relatively low cost disk drive for the low-end processors. As C. T. Carter, Product Marketing Manager for Intermediate Systems, wrote to Keil, in April 1970, the attachment of a 2314-type device was believed to be

> "needed to enhance the NS systems price in the 1970-1973 time frame. It is in this period that we must maximize our competitive posture in the Model 20/25/30 marketplace. The competition in this market will include not only today's NCR 100/200, MH [Minneapolis Honeywell] 115, and UN [Univac] 9200/9300 but new competitive announcements as well as discounted leasing companies 360's." (PX 4138, p. 2.)

On the other hand, plug-compatible manufacturers were already replacing IBM 2314s. To use the 2314 as the disk drive of choice until Winchester was ready meant continued exposure to replacement by PCM competition. Moreover, customers, once having acquired these 2314s from IBM or 2314-type devices from PCMs, might be reluctant to move up to Winchester or Merlin--moves which would be necessary if they were to expand their usage of data processing to take advantage of the full capacity of the 370 line. (See, e.g., PX 5343.)

The 2314s that had been marketed for System/360 were at this time "coming back almost by the trainload" because the competition was displacing those devices. (DX 4740: Evans, Tr. (Telex) 4011.) The attachment of the 2314 at its current prices to the new processors was, of course, out of the question. It would simply invite a flood of replacements by plug-compatible manufacturers already supplying 2314-type disk drives. (See, e.g., PX 4214.) Moreover, it would not fill the need for a low-cost disk device and would raise the 370 systems' prices to unacceptable levels. Therefore, a new, low-priced disk drive of the 2314-type was the chosen solution. The result was the 2319. Even though it was recognized that the low price of the attachment would put "[p]ressure on Winchester Price/Performance Improvements" (DX 9374, p. 6), Group Finance took the position in the financial analysis of the 2319 in September 1970, that IBM should announce it at "the low-price assumption" of the "<u>$1000</u> price in that this price level assures <u>maximum revenue</u> and <u>profit</u> to IBM". (<u>Id.</u>, pp. 5, 7, emphasis in original; see also Powers, Tr. 95336-40.)

The new, low-priced 2319 disk drive was achieved through a combination of factors. IBM employed a re-use program for the 2314 spindles that were being returned to IBM as a result of competitive displacements, incorporating those spindles into the 2319. (Whitcomb, Tr. 34505-07; DX 4740: Evans, Tr. (Telex) 4012, 4023-25; see also Dunlop, Tr. 93812-13.) In addition, the 2319 was announced with "native attachment" to the CPU, meaning that an entire box--the control unit--had been eliminated by the incorporation of its functions into the disk drive and into an integrated file adapter in the CPU. The use of new, more compact MST technology (as opposed to SLT) facilitated the integration of that function in a cost-effective way. (Haughton, Tr. 95021-22; DX 4740: Evans, Tr. (Telex) 4023-25, 4076-77.)

The native attachment represented a long recognized approach to cost reduction: minimization of the number of boxes. (Hurd, Tr. 86622-23; DX 1656; DX 1657; DX 1658; DX 7630, Herzfeld, pp. 21-22.) Analyses conducted within IBM indicated that such attachment was a feasible approach for the 2319 and that it would provide significant cost-saving benefits both to IBM and to users. (PX 4132, p. 1; DX 7619: Winger, Tr. (Telex) 5686-87; see also DX 1662.) Native attachment for System/370 was first announced as the optional Integrated File Adapter (IFA) for attachment of the 2319 to the 370/145 in September 1970 (PX 4527, pp. 1, 3) and the 370/135 in March 1971 (PX 4528, pp. 1, 3). It constituted a product improvement, as well as a cost savings. (See DX 4740: Evans, Tr. (Telex) 4023-25, 4084; DX 4742, Kevill, pp. 523-26.)

Winchester itself was eventually announced as the 3340 Direct Access Storage Facility in March 1973. (PX 4538; Case, Tr. 73734.) It was a highly innovative and successful product and has been widely copied by others. (See the discussion below, pp. 1055-56, 1105, 1300.)

d. New Processor Planning (NS and System/3). Coincident with IBM's planning and development of improved peripherals, particularly tape drives and disk drives, its strategy for the development of a new generation of CPUs and memories was formed and implemented.

(i) Monolithic Logic and Memory. During the development of SLT from 1961 to 1966, IBM laid the groundwork for the eventual use of monolithic semiconductor circuits. The same substrates and tooling used to manufacture SLT were applicable to the assembly of monolithic circuitry. (E. Bloch, Tr. 91500-501.)*

IBM's work on development of monolithic semiconductor memories (of which the two principal types are bipolar and FET memories) began around 1964 "in an attempt to find a memory technology which could overcome the speed, cost and size limitations of magnetic core technology."

> "IBM undertook the development work on monolithic semiconductor memories . . . because of the potential of monolithic semiconductor memories to be faster, cheaper, smaller and more reliable than magnetic core memories. The potential advantages of monolithic semiconductor memories were based on projections that they would be denser, would require fewer external connections, less power and less cooling and would be fabricated using existing semiconductor processes and would avoid duplication by using the same technology and packaging as monolithic semiconductor logic circuitry." (E. Bloch, Tr. 91537-38.)

Thus, it was hoped that in addition to the performance advantages of the new technology, IBM would be able to achieve economies of production and packaging by utilizing a single integrated technology for

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* Since 1963 Erich Bloch has held a variety of executive positions in connection with the development of IBM's processors, memories and memory and logic components. (DX 9116.)

logic and memory across a family. (See E. Bloch, Tr. 91563; PX 4401; PX 6312, p. 3.)*

Logic technology moved to MST:

> "As of 1968 the development of monolithic semiconductor circuitry at IBM had reached the point where major performance and cost improvements could be achieved by using monolithic semiconductor instead of SLT circuits in logic circuitry. IBM first used monolithic semiconductor logic circuitry in the 360/85 and the System/3 Model 10 computers, which were announced in January 1968 and July 1969, respectively. The particular family of circuitry used in the 360/85 and System/3 Model 10 computers was Monolithic System Technology ('MST')." (E. Bloch, Tr. 91501.)

The MST modules, cards and boards used the same packaging techniques as those used with SLT modules, cards and boards, which provided cost-savings advantages. (E. Bloch, Tr. 91502; see DX 3564.) Other advantages were greater density, a higher level of integration and a substantial increase in reliability (by a factor of 10 over SLT). (E. Bloch, Tr. 91502.) Monolithic semiconductor circuitry was used for logic circuitry and buffer storage in the 370/155 and 165, announced in 1970. (PX 4505, pp. 2, 4.)

IBM's first use of monolithic semiconductor memory was in the storage protect memory of the 360/91 and 360/95, the first of which was delivered in October 1967. (E. Bloch, Tr. 91539-40.) The experience gained with design and development of monolithic semiconductor

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* Erich Bloch testified that another goal and potential benefit of the new technology was the integration of memories into the CPUs, with the resulting benefits of improved performance and reliability as well as cost-savings. (Tr. 93324-26, see also Tr. 91548-51.) That goal could not be achieved with the 370/155 and 165 because of IBM's inability to produce sufficient components. (E. Bloch, Tr. 93325-26.)

memories by 1968 "led IBM's memory designers and developers in the Components Division . . . to conclude that it would be feasible in the near future for IBM to utilize only monolithic semiconductor memories". (E. Bloch, Tr. 91541.) That view was accepted at the highest level within IBM. "On January 25, 1968, IBM's Management Review Committee decided to abandon any further magnetic core memory development and it was decided that from that point on, IBM would develop only monolithic memories." (E. Bloch, Tr. 91541; PX 2177A, pp. 3-4; Cary, Tr. 101428-29; DX 8056.) That switch in technologies represented the new application to memories of an existing logic technology. (E. Bloch, Tr. 91874.) Cary testified:

> "We made a decision way back in January of 1968, that core memories . . . were not going to be the memories of the future; that semiconductor memories were going to be the important memories of the future and we stopped development of core memories completely. We took a tremendous risk in doing this, because a lot of people continued to cost reduce and improve core memories. We stopped our development on them and we went full bore into the development of semiconductor memories." (Tr. 101428.)

As in other areas, competition was increasing and certainly was not going to stand still. By July 1969, J. A. Haddad (IBM Vice President) wrote to G. E. Jones (IBM Senior Vice President), to nominate corporate memory strategy as a key corporate strategic issue:

> "The last year has seen a drastic increase in competition in memory, with every indication that we shall soon be facing major inroads to both installed and on-order memory as well as increasing price competition in all phases of the memory market. We must have a strategy to lead the competition (we no longer possess our previous lead position), rather than to be pushed around by it.
>
> ". . . .

". . . Memory is central to our products, processors, and profits. Memory profit is a major factor in processor profitability as well as the key new factor in performance. In large systems we are lagging in speed and price, and in very small systems we are non-competitive in both price and speed. Memory prices affect memory size, which affect programming requirements, I/O and storage requirements, and total systems thruput." (PX 4565.)

As the announcement date for the first 370 processors approached, however, it was apparent that IBM would not be ready to produce monolithic memories in adequate quantity and it was decided to announce the 155 and the 165 with core memory. The smaller 145 (which was announced a few months later) was to have bipolar monolithic memory derived from SLT (see E. Bloch, Tr. 92294); although by that time, FET memory was preferred but could not be readied in time. (E. Bloch, Tr. 92910-12, 91542; Cary, Tr. 101412-13; DX 4740: Evans, Tr. (Telex) 3937-42, 3959-63; PX 3130A, pp. 2-3; PX 4324; PX 4400, pp. 2, 4.)

It was recognized that the memories announced with the 155 and the 165 were "very old technology" and "were going to go very shortly non-competitive in the sense of the availability of semiconductor memories". (Cary, Tr. 101403-04.) Cary testified:

"[W]e knew that they did not have long life and that if we didn't get competitive technology in the marketplace that we wouldn't be competitive either with the plug compatible type of manufacturer or with the other systems manufacturers. Everyone was going this way just as hard as they could go." (Tr. 101429.)

Nevertheless, monolithic circuitry was utilized in the processor logic and the buffer storage for the 370/155 and 165 announced in June 1970. Despite the use of the old, slow core memory, the new processors were two to five times as fast as the earlier 360/50 and 65, because of the use of the new monolithic circuitry. (DX 4505, pp. 2, 4.)

Monolithic logic and memory circuitry, including FET Memory, were to be utilized in subsequent products when available. (PX 3256C; see also E. Bloch, Tr. 91501; Cary, Tr. 101430.) That goal was achieved. (DX 9157A; see also E. Bloch, Tr. 91543-45, 91550-51.)

(ii) System/3. In designing the 360, IBM produced an architecture that was to last for a long time. It was an architecture which, as the SPREAD Report (DX 1404A (App. A to JX 38)) had predicted, was suitable for processors in the range initially announced on April 7, 1964. However, as the report had also indicated, "it was not yet evident" that compatibility could be extended downward to less powerful processors. (JX 38, ¶ 2, pp. 2-3.) As we have seen, IBM's attempt in this direction, the 360/20, resulted in a system only partly compatible with the rest of the line. (JX 38, p. 297; see also Case, Tr. 73370-71.) In 1969, IBM announced a small, low-cost system that departed from System/360 architecture: the System/3. (DX 8073.) This was the first of several such low-end IBM systems.

IBM was able to introduce its low-cost system in July 1969 in part because "[a]s of 1968 the development of monolithic semiconductor circuitry at IBM had reached a point where major performance and cost improvements could be achieved by using monolithic semiconductors instead of SLT circuits and logic circuitry". The System/3 Model 10 was one of the first two IBM computers to use Monolithic System Technology (MST). (E. Bloch, Tr. 91501.)

The System/3 announcement was not merely the announcement of a new processor. It also involved "new families of disk files and printers, a keyboard and console typewriters, and unique programming capabilities".* (PX 2459, p. 7.) The System/3 "was a new, low entry computer system . . . that was aimed at bringing total computer capability to the small user at the thousand dollar a month rental price, approximately, having full capability of I/O function and programming support". (James, Tr. 35037.)** The initial announcement (the Model 10) offered both a card-oriented and a disk-oriented system. (DX 8073.) The card was of particular interest because "[t]he focal point of System/3 is a new 96-column card". This card was "about 1/3 the size" of earlier cards but could contain 30 per cent more information. This meant "less space and storage requirements, easier handling, reduced mechancical [sic] loads, smaller sized machines for processing the cards and, therefore, a lower cost system. Hence, the 96-column card made it possible for System/3 to become the economical, high performance system that it is." (PX 2459, p. 9.)

The system was designed as a "low entry" system. Some forecasts within IBM indicated discontinuance of 40 per cent of the accounts using leased unit record equipment. "Without System/3, it was estimated that 50% of these discontinuances would go to competition (Univac 9200, Honeywell 110, GE 105/115, NCR C-100). System/3 will allow the company to save approximately one-half of these losses". (Id., p. 16.) But, it was not a system intended merely for small users. As IBM's 1969 Annual Report stated:

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* The 5445 disk drive for the System/3 utilized the 2314-type spindles that were also used in the 2319. (Gardner, Tr. 37456.)

** Jack James was President of Telex Computer Products, Inc., at the time of his testimony. (Tr. 35012.)

"Although it was designed primarily for small business, it is also expected to find application in large firms that wish to decentralize their data processing capabilities." (DX 3364, p. 8.)

To manufacture and develop System/3 enhancements and other products not using the System/360 architecture, IBM formed the General Systems Division within the Data Processing Group in early November 1969. (DX 8072.) This "was done in order to have a management focus on the product line that was currently in development and to . . . do a better job in the plans for improving the product line that was transferred to General Systems Division . . . and to do a better job in enhancement in follow-on plans for the products that remained in the Data Processing Product Group". A dedicated marketing and service capability was provided in the General Systems Division five years later. (Akers, Tr. 97401-03.)

Customer reaction to System/3 was "enthusiastic". (DX 3364, p. 8; see Withington, Tr. 58435.) By the end of 1970, its first year of deliveries, more than 1,600 had been installed in the United States. (DX 2609B, p. 185.)

(iii) Virtual Memory. As we have already seen (pp. 431-35 above), IBM developed Dynamic Address Translation (DAT) as a hardware device in the 360/Model 67, combining it with systems software to enhance the system's time-sharing capabilities. That effort had proven difficult and expensive and, despite earlier plans to include those features with the new systems, by 1969 the plans were proceeding, with DAT (or relocate) not to be included in the initial 370 line. (DX 4740: Evans, Tr. (Telex) 4184; PX 6672, p. 2; PX 2500, pp. 1-2.) However, at that time, it had been implemented successfully in the Model 67. (See pp. 435-36 above.) B. O. Evans, on returning as President of the Systems Development Division from the Federal Systems Division in 1969, was "quite surprised" to discover that omission on the night before assuming his new office. He considered it to be "fundamentally wrong" (DX 4740: Evans, Tr. (Telex) 3938, 4184-85; see Evans, Tr. 101299-301)*:

> "I felt so intensely about Dynamic Address Translation and the advantages of virtual memory that within the first hour that I was in my new job I hand-picked several professionals from across the development team to go to work full-time immediately and get me a plan for virtual memory on System/370." (DX 4740: Evans, Tr. (Telex) 3941.)

Evans understood the advantages of virtual memory, which would give the appearance to the user of having a very large memory at his disposal, and facilitating multiprogramming and communications oriented applications. That understanding began at the time of the MIT Project MAC procurement and grew through his work in the Federal Systems Division with various government programs. (DX 4740: Evans, Tr. (Telex) 3942-52; see Evans, Tr. 101300-01.) The reason for concern about the absence of the relocate feature and virtual memory in the plans for the 370 was an awareness of the growing importance of time sharing and communications-oriented processing. The System/360 had, indeed, been built in part on the belief that communications-oriented processing would grow in importance. The initial planning for the new systems

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* Evans' surprise was natural. He had been sent out to the Federal Systems Division as "a little punishment" precisely because the "very demanding IBM management" viewed it as a "fundamental mistake" in System/360 architecture that Dynamic Address Translation had not been included. (DX 4740: Evans, Tr. (Telex) 3950-51.)

recognized the demand for more and more on-line usage and toward multiple users accessing the computer from remote locations.

That need was discussed at a meeting of the Management Committee in March of 1969. (PX 2399, p. 1.)

Several days later, the Management Committee reported to the Management Review Committee that "[t]he communication based data processing market is large and rapidly increasing". About 30 percent of that "market" represented "the true remote terminal time sharing market" including in-house time sharing and service bureaus. IBM's position in this area was felt to be weak with IBM "behind in both hardware and software". (DX 14201, pp. 5-7; see also PX 2399, p. 2.)

The need for virtual memory was being felt by others in IBM. In June 1969, C. B. Rogers, Jr. (Vice President of Marketing and Development, DPD), wrote to C. E. Branscomb (President of SDD), stating the Data Processing Division's view that "progress has been unsatisfactory" toward the production of "a viable NS announcement plan". He stated:

> "Market requirements are not being met with SDD's current announcement and support plan. The CPU's provide improved price/performance for doing today's processing, but do not offer significant new function for continued growth.
>
> ". . . .
>
> "Implementation of the virtual memory concept -- with functional compatibility throughout the NS line, combined with multiprocessing -- can extend NS's price/performance range dramatically. We view virtual memory implementation as necessary and fundamental to meeting market requirements in the early 1970's." (PX 4270, p. 1; see also PX 4272.)

The anticipated solution was a phased introduction of the relocate hardware, with the initial machines designed to utilize it when it was available. But, that plan entailed development costs and difficulties. (See PX 2399, p. 1.) Specifically for time sharing, a proposed answer was "an interim plan" involving increased funding for time sharing under DOS and OS operating systems and a re-emphasis of the TSS time-sharing operating system. The long range plan consisted of two parts, the first, the new NS operating system and a new DOS operating system both "designed to enhance time sharing" and,

> "[t]he second, and equally important part of the strategy, is the relocation hardware necessary to really do this job. This is scheduled for announcement in 1973 with installations in 1974." (PX 2412, p. 3; DX 14201, p. 6; see PX 2399, p. 2.)

That plan was adequate in concept, if attainable; but, it had two timing questions: Could the initial 370 announcements be made in 1970 with provision for relocate and virtual memory? When could relocate be ready? The plan said mid-1973 or 1974 in response to the second question. That was too late according to C. B. Rogers, Jr.:

> "Not having relocation support until 6/73 or 1/74 is totally wrong. It's too far out. The logic that we can't support it until then is unsatisfactory. We think TSS could be modified to accommodate the '67 scheme on NS." (PX 4270, p. 4.)

The market, trending toward remote computing, would not wait on the IBM development effort. The need for relocate was a matter of increasing concern through the fall of 1969. (PX 2487A, p. 2; PX 4033, p. 13; PX 4233.)

By late 1969, it was too late to get relocate into the first System/370 announcements, scheduled for mid-1970. (PX 2502B, p. 3.) Evans considered delaying those announcements or shipments until the design of Dynamic Address Translation was finished and the monolithic memory technology was available, but that delay would have left IBM at an even more substantial competitive disadvantage:

> "But the situation was . . . that System 360 had been out in the field for about six years and competition had become, since 360's announcement, with ever-improving components and systems, and so, competitively speaking, the System 360 was out of gas, and when we looked at the users' requirements, as we saw them in late 1969, that delaying System 370 another two years or more to get dynamic address translation, et cetera, into the machines, didn't seem reasonable.
>
> "So we made a thoughtful decision to proceed with the 155 and the 165 and the so-called vanilla version of the System 370 phasing in dynamic address translation and semiconductor memory technology as quick as we could." (DX 4740: Evans, Tr. (Telex) 3961-62; see also PX 4324; PX 4421, p. 2; PX 3256B, pp. 1-2; Cary, Tr. 101394-95.)

IBM also sought to improve its offerings for remote computing in other ways. In December 1969, it announced new software: the Interactive Terminal Facility (ITF), "a new low-entry timesharing system" which provided "timesharing power for System/360 under OS or DOS" (DX 14335), and the OS/360 Time Sharing Option (TSO) which was "intended to support the terminal-oriented requirements of a wide range of users" under OS/360. (DX 1091, p. 1.)

The 370/155 and 165 were announced in June 1970 on a schedule that had been already delayed because of the unavailability of the Merlin disk drive. (PX 4505.) Relocate and virtual storage were not announced with the initial System/370 announcements in 1970; the first announcement of virtual storage for System/370 was made in August 1972, when IBM announced the 370 Models 158 and 168, containing Dynamic Address Translation. IBM also announced at that time that DAT could be purchased to implement virtual storage on the 370/155 and 165, and was available on the 370/145 (announced in September 1970) and 370/135 (announced in March 1971) without additional charge. (DX 1639; DX 1640.)

By mid-1972, the principal goals of System/370 had been attained. (Case, Tr. 73749-51.)

(iv) NS Prices. We have already seen how competitive developments impacted the planning for almost all parts of the new systems, influencing with respect to most parts, the technology employed, the capabilities sought, and the development and announcement schedules used. All of those things, of course, plus the prices of competitive products and services affected the price that the user was willing to pay for IBM's offering when compared to that of the competition.*

The Commercial Analysis Department of the Data Processing Division, in its Quarterly Product Line Assessment of February 1969, reported that:

> "When NS0 [370/135] and NS1 [370/145] are announced, IBM will be faced with competition from three sources: (1) other computer vendors, (2) owners of IBM computer systems, and (3) computer-oriented service companies.
>
> "It is expected that Burroughs, NCR, and Sperry Rand will be our strongest competition in respect to marketable products when NS is introduced. . . .

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* For example, Currie of Xerox, testified that if IBM had lowered its prices in 1970, then "I expect some other companies would have had to lower their prices to some extent as well . . . [b]ecause I think that computers are selected based upon price/performance . . . and if IBM lowered its price that would give it a more favorable price/performance." (Tr. 15694-95.) Also, if, in the 1970 time frame, IBM were to raise its prices, "IBM would lose orders, would lose lease base". (Tr. 15752-53.)

"Honeywell is expected to announce a new series in 1970. Thus, they could once again be a formidable competitor. . . .

". . . .

"In World Trade, American or American-associated companies should be the prime competitors. However, ICL will continue strong; Philips may have gotten a foothold with their P1000 series; and Siemens may have introduced a new series. In addition competition may come from Japanese companies such as Fujitsu offering their products outside of Japan.

"Competition from owners of IBM computer systems will come primarily from leasing companies and from System/360 purchase customers who sell their used systems. Both of these sources could make lower-priced System/360's available to compete with NS0 and NS1 with competitive price/performance.

"Computer-oriented service company competition will come from time-sharing companies and service bureaus. Both offer services which may substitute for additional computer function and/or capacity." (PX 2388, p. 117.)

The report went on to compare the price/performance (on a monthly lease price basis) of those new systems configurations with the lease prices then expected to the "best of competition",* concluding that "NS0 and NS1 are rated superior to competition . . . ." That conclusion was based upon the assumption of "no significant price changes". (PX 2388, p. 121, see pp. 125-128.) Similar conclusions were expressed with respect

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* John Akers, IBM Vice President and Group Executive, explained that the "QPLAs" represented reports from "the salesmen's critical perspective how our product line compared" with "not all competition" but "the best of competition". (Akers, Tr. 96584, 96587-88.)

Over the planning period, IBM management regularly compared the price/performance (of which "price" is obviously an important element) and capabilities of competitive announcements with the planned characteristics of the new systems. (See, e.g., DX 14199, concerning the RCA Spectra 70/46; DX 13864, concerning the Oki-Univac 9400, announced in Japan; DX 14317, concerning the CDC 7600; DX 14200, concerning the GE 655.)

to the price/performance of the NS2 (370/155) and the 553 (370/165), assuming the availability of the Merlin disk drive. (PX 2388, pp. 48, 68.)

As of March 1969, it appeared that the price/performance of the NS systems (System/370) would represent an improvement on an average of 1.8 times over System/360. With the exception of the dramatic change from the 1401 to the 360/30 "this is not too dissimilar from the historic past". (PX 2399, p. 3; see also DX 14201, p. 2; PX 2502B, p. 2.) However, that meant that System/360s owned by leasing companies and users would "remain a major competitive product". In addition, "[t]here is an added unknown in the possible merger of OEM's, software houses and leasing companies" (DX 14201, p. 2), with the possible marketing of 360 CPUs enhanced in price/performance by plug-compatible peripherals and independent software. (See, e.g., PX 2388, pp. 119-120.) It appeared to IBM management as of March 1969, that with the planned prices for the NS CPUs, "a leasing company can compete on an equal basis with NS by discounting the 360 30%". (DX 14201, p. 4.)

On March 13, 1969, Cary wrote to Branscomb, listing issues concerning NS strategy to be discussed at the next General Managers' meeting. Those issues included "competitiveness of our purchase prices" and "high maintenance costs". (DX 14479.) The principal concern was that high purchase prices and high maintenance charges would cost IBM sales of System/370 CPUs, with many of the losses being to leasing companies and other owners offering discounted System/360 CPUs for sale or lease.

That concern continued through early 1970 (PX 2468A, p. 2; PX 2502B, p. 2; PX 2558B, p. R21; PX 4233), and, as announced in June 1970, the purchase prices on the 370/155 and 165, as well as on the 3360 processor storage, were lowered substantially from the planning assumptions. (See PX 4505, pp. 3, 5-6.)

The substantial differential between 360 and 370 maintenance prices contributed to the competitive exposure as well. The planned maintenance charge for the NS2 (370/155) was $4,930, although cost reduction actions were expected to reduce it to $2,620. (PX 2399, p. 4.) The differential was due in part to the fact that maintenance prices for the 360 were felt to be too low "probably by half" (PX 2399, p. 4), and to the cost of the "increased inventory of maintenance parts, brought about in part by integrated circuitry" for the new machines and to the time necessary for field engineers to gain experience with the new software and hardware. (DX 14201, pp. 2-3.)

As had been forecast, by the time of announcement substantial improvement had been made in reducing costs and thus prices of NS maintenance. (PX 2399, p. 4; PX 3256C, p. 2.) Thus, at the time of announcement, the monthly maintenance charges on the 155 were about $2,200--less than one-half those contemplated by planning assumptions. (PX 2399, p. 4; PX 4505, p. 3.) Moreover, IBM decreased the effective maintenance price of System/370 still further by increasing the warranty time on purchased CPUs, channels and memories to 12 months from the three-month warranties on System/360. (PX 3256C, p. 2; PX 4505, p. 1.)

Later, in 1972, as warranties began to expire on the purchased System/370 units, IBM announced further reductions in maintenance charges on those machines amounting to, for example, about 15% on the 155 processor. This made monthly maintenance charges on the 155 about $1,750. (DX 13521, p. 2.) Adjusted for inflation, the decrease was even greater.

e. Conclusion. Notwithstanding the enormous success of IBM's System/360 as announced in 1964, and IBM's continued technological improvements thereafter, by 1969 IBM confronted serious competitive challenges to its position of technological leadership and price/performance superiority. The state of technological development and implementation for the new products being planned in the face of those challenges caused consternation among IBM top management. Pressures were exerted throughout the organization by the insistence that the new products had to be better and announced and delivered sooner. The organization responded, but IBM was unable to announce on schedule the range of product capabilities that management felt necessary to sustain IBM's superiority. Consequently, IBM entered the 1970s engaged in a struggle to achieve the ambitious goals it had established in response to competition for its next generation of systems.

56. Growth of the EDP Industry. One fact about the EDP industry is so clear and unequivocal that its significance can be easily overlooked. That fact is the extraordinary growth in the use of computers over the first 20 years of the EDP industry's existence--a phenomenon that continued unabated over the next decade.

Descriptions from a wide range of sources attest to the dynamism and unprecedented growth of the industry over this period. For example, Donald F. Turner in 1966, while Assistant Attorney General in the Antitrust Division of the Department of Justice, wrote:

> "The computer industry is one of the most dynamic in the American economy, in terms of absolute as well as relative growth, and further rapid expansion is anticipated." (DX 9110, p. 1.)

The General Accounting Office (GAO) stated in a 1971 report to Congress that "[t]he automatic data processing industry is very young and the industry grew at a tremendous rate from the late 1950s to 1971". (Plaintiff's Admissions, Set IV, ¶ 231.0.) Lacey, Vice President, Corporate Development, CDC, reported to new CDC employees in 1969 that the industry "is unique in industrial history in the rapidity of its growth since its birth little more than twenty years ago". (DX 438, p. 1.) The GE APL Master Plan of 1970 reported that "[t]he computer industry is one of the fastest growing segments of both the U.S. and overseas economies". (PX 353, p. 18.) And Butters, in his "Computer Industry Review" of 1970, wrote that "[t]he computer industry has been considered the fastest growing major industry in the world". (DX 1553A, p. 2.)

The Department of Justice stated in 1968 in a "response" submitted to the Federal Communications Commission's Computer Inquiry I (Docket No. 16979):

> "Although only 20-odd years old, the computer industry appears likely to become one of the world's largest industries within the next 10-15 years.
>
> "The growth of the computer industry has been startling.
>
> "In 1950, only a handful of computers were in use while today it is estimated that 60,000 computers are in use and 25,000 more are on order." (Plaintiff's Admissions, Set II, ¶¶ 312.5-7.)

The growth in the use of computers is evidenced by estimates of the numbers of computers installed and also by estimates of the value of EDP equipment shipped by the manufacturers. For example, the 1972 Census of Manufacturers (prepared by the Bureau of the Census of the Department of Commerce) reported that the value of shipments by all producers of "electronic computing equipment" (Standard Industry Classification Code 3573) grew from $4,048.8 million in 1967 to $6,108.0 million in 1972. (DX 14310, p. 35F-15.) Other Federal government estimates are comparable. The Comptroller General of the United States, in a report to Congress in June 1969, estimated that the computer industry had grown from "a few experimental computers" in the late 1940s, to "400 computers installed in the United States" in 1955, to "approximate[ly]" 6,000 in 1960, to "installations" in excess of 67,000 in 1968. He stated: "The computer hardware market is believed to have reached a value of about $7.2 billion during 1968 and is expected to grow at a 15 to 20 percent annual rate over the next 5 years." (DX 7568, pp. 13-14.)

The magnitude of and the rate of the growth in the use of computers are also reflected in the results of the joint deposition program of suppliers of EDP products and services over the period 1952 through 1972 ("Census II"). (See DX 3811; DX 8224.) Of the 618 companies reporting U.S. EDP revenue in 1972, only 9 had such revenue in 1952, 75 in 1960 and 188 in 1964. The total U.S. EDP revenues reported by those companies grew from $39.5 million in 1952, to $1.3 billion in 1960, to $3.2 billion in 1964, to $12.8 billion in 1972. (Id.) These revenues grew at a compound growth rate of 33.5% over that period. (Id.)

This phenomenal growth indicated by these aggregate statistics consisted of the following parts:

(i) The number of users of computers continually increased;

(ii) The number of uses (applications) of computers continually increased;

(iii) Existing users of computers continually increased the computational power that they utilized; and

(iv) The price/performance of computer products and the ease of their use continually improved.*

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* In October 1964, Withington wrote:

> "We believe that the major factors in the development of the computer market have been:
>
> "Constant increase in the number of computer users.
>
> "Constant development of new computer applications.
>
> "Constant increase in the number of persons engaged in making use of computers.
>
> "Constant improvement of cost-performance that causes users to replace old equipment with new." (PX 4829, p. 8.)

Moreover, the rate of growth in the demand for computers was continually underestimated by most participants in and observers of the industry and, in retrospect, called, as in the quotations above, "startling", "unique", and "tremendous". (DX 5504, p. 8; see also DX 5476, pp. 6-7.)

a. Increase in the Number of Users of Computers. Withington wrote in 1964, after the announcement of System/360, that:

> "The single most important factor in the historic growth of the computer market has been the increasing number of computer users. This increase has been made possible by constant reduction of the minimum cost of computers and greater understanding of how computers might be used." (PX 4829, p. 8.)

But, he went on to project, "new users will become increasingly hard to find in the United States". He reasoned that "there are approximately 25,000 companies with net worth of over one million dollars. In general, it is fair to assume that any company smaller than that is not likely to acquire a computer: in fact, many firms with a net worth of five million dollars do not use a computer." (PX 4829, p. 8.)

By the very next year, however, Withington had changed his mind. He stated:

> "The number of organizations using computers continues to increase rapidly, primarily because computer systems with complete capabilities are becoming available at steadily lower costs. Thus they come within the reach of organizations that could not previously afford such computer systems: for example, the IBM 360/20 and 1440, the Honeywell 120, and the Univac 1004. More than 2,000 such machines were installed during 1965, representing shipments of considerable dollar value to the manufacturers." (PX 4830, p. 8.)

By 1967, it had become apparent to Withington how wrong he had been in 1964:

> "[T]he experience of recent years has shown that, as the costs of small computer systems decline, great numbers of new users enter the market. We expect this trend will continue, and by the end of 1971 there should be many thousands of new computer users who do not now have machines." (PX 4832, p. 8.)
>
> * * *
>
> "The situation is becoming more dynamic rather than less so, and the only safe prediction at this point is that pace of change, and the growth of the industry as a whole, will remain extremely rapid." (PX 4832, p. 6.)

Withington's observations that the number of users continued to expand were repeated in 1968 and 1969. (PX 4833, p. 10; PX 4834, p. 14.)

The continued importance of new users to the growth of the industry and to the expansion of the business of individual suppliers was just as clearly recognized by the EDP companies at the end of the decade. For example, in its "Master Plan" of January 1970, GE stated that:

> "The computer industry has grown and will continue to grow at a rapid rate. The influx of customers new to computing, combined with the expansion of present customers to more powerful systems and more sophisticated applications, provide a growth thrust that is discernible well into the 1970's." (PX 353, p. 18.)

Indeed, in that Master Plan GE predicted that 30% of the users of its new APL system would be "new users" of computer equipment. (Id., p. 54) Similarly, Ray Macdonald of Burroughs testified when asked whether the number of users for data processing equipment had increased or decreased over the ten years from 1964 to 1974:

"Well, I think two phenomena have taken place. I think that we have a very considerable number of new users, and I think we have much more extensive use of data processing equipment by those that were already using it ten years ago.

". . . .

"I would think that [the trend of users switching from electromechanical methods of data handling to computers] will continue because the cost of stored program computers, very small stored program computers, is continually declining and will be offered -- is being offered and will be offered in many of these applications at more cost-effective rates for stored program equipment than for the prior types of equipment, and I think also we are finding new applications. I think they are the two effects. The replacement of older applications that have been identified with older types of equipment, and I think that we are also finding many new applications." (Tr. 6926-30.)

Also, as we have seen (pp. 395-400, 911-13), when IBM announced its 360/20 in 1964 and the System/3 in 1969, an important goal was to attract new users of computers and to compete with other manufacturers' efforts to do so--a goal that was to continue to motivate IBM product announcements in the 1970s.

b. Expansion by Existing Computer Users. Of course, substantial contribution to the growth of the industry came from the almost insatiable demand for additional computing power from existing users of computers. That demand was clearly recognized by the manufacturers. (See, e.g., Macdonald, Tr. 6926-30; PX 353, p. 18.) Hart, from General Motors Research, stated that through 1970, the "demand for computing power supplied by GMR . . . doubled every year and a half since we installed the 701 in 1954". He continued, "We fully expect this growth to continue over the next 20 years". (DX 3753 (Tr. 80198).)

An important example of the trend in computer usage in general was the increasing use of computers by the United States government, the world's largest user of computers. (DX 4355, p. 6; see also DX 7566, pp. 10, 16; Plaintiff's Admissions, Set IV, ¶¶ 206.0, 221.0. That growth obviously reflects the expansion by existing users as well as the introduction of new agencies to the use of computers. According to reports by the Comptroller General and by the General Services Administration, the number of computers installed in the Federal government went from five in 1952, to 531 in 1960, to 1,862 in 1964, to 5,277 in 1970, and kept on growing. (DX 923, pp. 11-17; DX 924, pp. 2, 596-97; DX 7568, pp. 13-14.) Indeed, according to the Department of Justice's 1968 submission to the Federal Communications Commission:

> "There was approximately a four-fold increase in the use of computers by the U.S. Government, the computer industry's largest customer, between 1962 and 1967.
>
> "This four-fold increase in the use of the number of computers understates the actual increase in computer capability.
>
> "One dollar bought about four times as much computational power in 1966 as it did in 1962." (Plaintiff's Admissions, Set II, ¶¶ 312.8-312.10.)

c. <u>Explosion of New Applications of Computers</u>. The initial development of computer applications consisted of applying computers to perform jobs that had been previously performed by other means. Thereafter, computers were increasingly applied to perform jobs that could not previously have been performed without computers.

Thus, for example, Knaplund testified that when Consolidated Vultee, later Convair, the aircraft company, first acquired an IBM 701 in the early 1950s, the work that was undertaken "was in part a transfer of work from unit record equipment, but it was very largely, and I would say within a matter of months predominantly, work of the type that could not have been done in the same form or perhaps at all on unit record equipment". (Tr. 90613, 90620-22.) Hurd testified that computers could "perform problems which punched card equipment simply could not perform". For example, General Motors and North American Aviation "were processing data which involved a totality of applications such as order entry, checking the validity of orders, placing requirements on the factory, scheduling production, controlling inventory, and controlling manufacturing, all in a single, integrated operation and with no human intervention". Oak Ridge Laboratories "was using computers to simulate a diffusion plant, the purpose of which was to enrich uranium". And various "property, casualty and life insurance companies were using computers to maintain and update on a daily or weekly basis files which, in the case of large companies, continued millions and even tens of millions of policies". (Hurd, Tr. 86347-50; see also Hart, Tr. 80221-22.)

Indeed, the General Accounting Office, in a report to Congress in 1960, stated that the "[p]rogress achieved in the development and application of . . . automatic information processing systems have borne out earlier predictions" that computers will cause "a second industrial revolution." (Plaintiff's Admissions, Set IV, ¶ 205.0; see also DX 44, p. 5.)

However, by the early 1960s, although more and more ways in which computers could be applied were being conceived, only the first steps toward realizing such applications had been taken. Withington stated in 1964:

> "In the past decade, most computers were sold to do simple jobs -- payrolls and scientific applications. Most computers today are still doing simple tasks. The exotic computer applications that abound in the literature are the exception, not the rule.
>
> "We believe that the next wave of computer applications is just beginning. If the first generation of computer applications consisted mainly of record keeping and scientific computations, the second generation will consist of automatic decision rules (for inventory control, credit, etc.) and design automation. Third-generation applications will involve real-time systems. . . . No one has begun to define the limits of computer technology." (PX 4829, p. 9.)

Similarly, in its 1960 report to Congress on computers, the General Accounting Office gave a "partial listing" of the applications in which computers were then being used by the government. These included:

> "(a) air traffic control; (b) automatic production recording; (c) business and management control systems; (d) communication systems; (e) engineering and scientific research; (f) information retrieval systems; (g) intelligence activities; (h) linguistics; (i) mathematics; (j) medical research; (k) military surveillance systems; (l) military tactical operations; (m) statistical studies; and (n) weather forecasting." (Plaintiff's Admissions, Set IV, ¶ 207.0.)

The GAO noted:

> "[A]pplications in several of [those] fields . . . were in their infancy, but that some of the techniques which had proved useful in one field were being carried over to other fields." (Id., ¶ 211.3.)

In the 1960s, real-time systems were increasing in importance. SDS, perceiving this trend early, capitalized on it by building on the uses of computers for real-time applications such as process control to achieve an impressive success. (See above, pp. 693-96.)

Others saw real-time applications in terms of interaction between man and computer. In June 1964, Weil, in a presentation to GE's executive office, stated:

> "The single most important trend in the information processing market today is that we are moving away from batch processing, where information is collected for a far-flung organization by fundamentally manual methods and then processed in a batch through a computer system. . . .
>
> "The information processing business of tomorrow . . . will have transaction data entered into the system through communications lines, processed against massive central files on a random-nonscheduled basis and returned via communication lines to the user, frequently all in a matter of seconds. Prototypes of this kind can be found in the airline reservations systems, in military command and control systems and in process computer installations.
>
> ". . . .
>
> "The direct access system . . . will play a large part in the growth of the computer business in the next few years. We predict by 1974 80% of the domestic shipment volume of information processing systems will be serving the direct access market and almost one-half of this will be remote terminals. The classic batch system, which dominates today's market, will continue to exist but will play a diminishing role in the equipment market." (PX 320, pp. 9-10.)

Users were active in developing real-time applications. William Francis, Director, Information Systems Office, of the Department of State, testified that "in my work in the State Department since 1963, . . . almost all of the focus of my activity has been on developing on-line systems in various subject matter fields." (DX 5416, Francis, pp. 7-8.) John Jones testified that when he joined Southern Railway in September 1963, D. W. Brosnan, Southern Railway's President and Chief Executive Officer:

> "was quite dissatisfied with the progress that had been made in learning to use the computer to support rail

operations, and . . . the view he clearly expressed to me was that the company had put a lot of effort into learning how to use the computers in accounting, but where the business of the railroad really was, where the big money was really made and spent, was in operations. And so he gave me a two-fold charge, which was to first of all get on with the job of supporting operations by the development in his words, of a real-time system, and further, to do this in such a way that the end result was . . . a single general information system for the railroad as opposed to what he had right then, which was three segmented systems." (Tr. 78954-56.)

Surveying the industry in 1965, Withington wrote:

"New uses for computers are continually being developed, but the rate of development of important new applications has never been greater than it is now. Because the new applications are particularly heavy consumers of computer capacity, their effect on the total market can be very great. Most of today's important application-development efforts are concentrated on providing direct and immediate service from the computer to the user -- the timesharing concept, in which all users receive simultaneous and immediate service from a central machine."

" . . . .

"The effect of the proliferation of these systems will be to expand both the uses to which computers are put and the demand for computer capacity, and to significantly expand the total market for computers." (PX 4830, pp. 10, 14.)

People were exploring and discovering new ways to use computers. President Johnson, in June 1966, urged the Federal government to do the same. He directed the head of every Federal agency "to explore and apply all possible means" to "use the electronic computer to do a better job" and to "manage computer activity at the lowest possible cost". He went on to state:

"The electronic computer is having a greater impact on what the Government does and how it does it than any other product of modern technology.

"The computer is making it possible to

"-- send men and satellites into space

"-- make significant strides in medical research

"-- add several billions of dollars to our revenue through improved tax administration

"-- administer the huge and complex Social Security and Medicare programs

"-- manage a multi-billion dollar defense logistics system

"-- speed the issuance of G.I. insurance dividends, at much less cost

"-- save lives through better search and rescue operations

"-- harness atomic energy for peaceful uses

"-- design better but less costly highways and structures.

"In short, computers are enabling us to achieve progress and benefits which a decade ago were beyond our grasp.

"The technology is available. Its potential for good has been amply demonstrated, but it remains to be tapped in fuller measure.

"I am determined that we take advantage of this technology by using it imaginatively to accomplish worthwhile purposes.

"I therefore want every agency head to give thorough study to new ways in which the electronic computer might be used. . . ." (DX 5377, pp. 1-2.)

By the date of this memorandum (June 1966) the Federal government was reported to use 2600 computers, employ 71,000 people in computing activity and to spend "over $2 billion annually to acquire and operate this equipment, including special military type computers." (Id., p. 2.)

The Department of Justice reviewed the growth of the industry in its submission to the Federal Communications Commission's computer inquiry in 1968. After commenting on the "startling" growth of the "rapidly evolving, highly competitive data processing industry" (Plaintiff's Admissions, Set II, ¶¶ 312.4-.10), the Justice Department stated:

> "The growth of computational capability has been accompanied by a rapid growth in the diversity of computer applications.
>
> "[One source listed over] 1,200 computer applications in such diverse fields as business, government, manufacturing, education, law, medicine, sports, science, engineering, national defense, social welfare, music, and language." (Id., ¶¶ 312.11-.12.)

The Department of Justice identified quite clearly the increasing importance of communications processing and on-line computing.

> "The number and variety of remote access data processing systems, both real-time and batch processing time, is already very large and rapidly growing." (Plaintiff's Admissions, Set II, ¶ 312.23.)

The Department of Justice gave examples of the uses of remote access computing:

> "The following categorization of existing applications is sufficient to underscore the commercial and practical importance of the entire remote access computer industry:
>
> "(a) Conversational time-sharing systems (always real-time) -- these involve the simultaneous sharing of a central computer among a group of users located at remote terminals and connected to the central computer by communications circuits.
>
> "(b) Inquiry systems (usually real-time) -- in such systems, typified by stock quotation services, a large number of terminals are connected to a single data processing center by means of communication lines; the system enables remote users to query a frequently updated central store of information.
>
> "(c) Remote batch processing systems -- these

systems permit the central processing of tasks that originated at and are transmitted from distant locations.

". . . .

"(f) Information distribution systems -- these systems, capable of operating on either real-time or batch basis, often operate like inquiry and document-production systems without the need for specific, repeated customer inquiry.

"(g) As information relevant to the needs of a particular subscriber is received by a central computer of such a system, the information is automatically and selectively transmitted to the subscriber via communications lines.

"(h) The distribution of railroad freight traffic information to railroad traffic agents, shippers, and consignees is an example of such a system." (Id., ¶ 312.24.)

The variety of new applications and the changes in the types of uses were highly interrelated with the EDP suppliers' development and planning efforts for new products. As we have seen, IBM designed System/360 to facilitate communications-oriented processing (see above, pp. 290-94, 311, 314-20, 324-26, 417) and the perceived growing importance of remote computing and time sharing heavily influenced the 360 Model 67 and then the System/370 planning. (See above, pp. 419-31, 913-18.) Similarly, these were the years of the Project MAC development and GE's emphasis on time-sharing capabilities. (See above, pp. 505-12.) Technological advances and improved capabilities implemented by EDP suppliers facilitated the expansion of computer applications. At the same time, individual suppliers had to tailor their development efforts to satisfy the changing demands of the users.

As stated in GE's APL "Master Plan" in January 1970:

"This unusual growth rate [of the computer industry] stems from high customer acceptance and his exploitation of the computer's ability as well as the industry's ability to constantly improve the price/performance capability and system adaptability. The shift of customer usage from batch to direct access, the greater use of communications, and the ever-expanding set of applications -- all indicate the dynamic, growing nature of the industry and, in fact, provide the basis for the growth which must be in tune with these moves by the customer." (PX 353, p. 18.)

d. Improved Price/Performance and Ease of Use. The increase in the ways in which computers were used were made possible by sharp price/performance improvements, increases in computer capabilities, and, in particular, by increasing ease of use. These changes both increased computer usage by existing users and produced a large influx of new users in the period 1963-1970.

Similarly, Perlis testified that as the "price/performance of the hardware side of the computer" improved, "our appetites as users of the computers" increased. "[C]omputers are so much more capable of doing things than we know how to tell them to do at any stage, that they represent a reservoir for our wishes, as it were, and everything seems to indicate that we are just going to continue to load these computers with more and more software in order to perform the tasks that we have in mind. . . ." (Tr. 1830-31; see also DX 3753 (Tr. 80193).)

Withington wrote in 1965 that "[t]he improved economics thus make it possible to use computers for previously unprofitable work. As users discover this, total usage grows." (PX 4830, p. 9.) Again, in 1967, commenting on improvements in price/performance:

"The most direct effect of this improvement will be further growth within existing markets. Present users of computers will find it economically justified to use computers for applications not justified before." (PX 4832, p. 8.)

In 1968:

"As the costs of complete computer systems decline, thousands of new users appear and marginal applications of existing users become justified." (PX 4833, p. 10.)

The computer was becoming more familiar and, in particular, easier for human beings to use. A good deal of this was due to the improvement in software. Higher level languages had made it possible to program in languages more readily accessible to human beings than the ones and zeros which characterized machine languages. Also, advancing operating systems made it possible to program without the annoyance of having to keep track of memory addresses or do hexadecimal arithmetic.

Donald F. Turner, then Assistant Attorney General for Antitrust, stated in 1966:

"[C]urrent practice and trends in programming . . . remove the programmer further and further from the necessity of considering the details of computer circuitry, or even machine language. Programmers increasingly concentrate on developing algorithms; they spend less and less time with the details of how the algorithm is handled by the hardware of the computer. This appears to be the most efficient use of programming talent." (DX 9110, p. 3.)

This was an important feature, because programming talent was "scarce". (Id., p. 2)* Given such shortage, the improvement of operating systems and other sophisticated programs became more and

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* Similarly, Withington wrote in 1965:

"[T]he productivity of the individual computer programmer is increasing. Until recently, it was necessary to prepare all computer programs in the specific language of the computer and to more important. Not surprisingly, software houses developed which specialized in providing such programs to users. (See above, pp. 851-53; PX 4832, pp. 10-11; PX 4833, pp. 27-28.)

The increase in interactive computing was interrelated with the increasing ease of use of computers. Hart of General Motors wrote in 1971:

> "There are two phenomena which we have noticed with the advent of interactive computing: (1) the threshhold of complexity--of the difficulty associated with using a computer--has been lowered significantly. As a result, the number of new users has increased rapidly during the past five years. Probably more than half of the 2000 or so users of our Honeywell (GE) time-sharing system were previously non-computer users--and would not have become users of a batch system.
>
> "The other phenomenon has to do with human productivity. Whereas the average engineer may be able to get five times as much work done per unit time, the outstanding creative man may get 10-20 times as much done. With a batch system, this man was frustrated by turnaround time--whereas with an interactive system, he can proceed full speed without the computer getting in his way.

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carefully design the programs to circumvent the inadequacies of the machines. Now the computers have fewer limitations for the programmer, and the use of automatic programming languages (particularly COBOL) is increasing. A programmer can probably produce 50% more work per day now than he could five years ago. . . . The requirements for computer programmers are generally satisfied rather quickly because retraining takes only a few months. However, project leaders and systems analysts do not become available so quickly. . . . There is already a shortage of these creative and managerial personnel, particularly for the development of the newer and more advanced applications. . . . However, the scarcity will have less effect on the growth and the use of computers for conventional applications, for these applications are well established and require minimum creativity and few top-level personnel." (PX 4830, pp. 9-10.)

"If it sounds like I am promoting interactive computing, it's because I am. I believe it represents a revolutionary new way of using computers to solve problems, and we are only beginning to understand what it means." (DX 3753 (Tr. 80191).)

Computer price/performance was also improving very rapidly in quantifiable ways. Hart, writing in 1971, wrote that "[t]he changes which occurred in the 14 years between the 701 in 1954 and the 360/65 in 1968 can only be described as revolutionary." The cost per problem had improved by a factor of 100. "For $20,000 you can now purchase a whole minicomputer which could run rings around the 701." This, of course, enabled more efficient use of increasingly expensive scientific personnel. "It is interesting to note, during the past 20 years . . . while computing cost has gone down by a factor of 1,000, costs of engineers and scientists has tripled." These improvements "have largely come about from revolutionary changes in computer hardware technology", however, "[t]here has also been a revolution in software technology which has helped to make more efficient use of computer hardware--this is the operating system (currently typified by IBM's OS/360)." (DX 3753 (Tr. 80187-88).)

Other witnesses also attested to the improvement in price/performance. For example, Frank Heinzmann of Eastern Airlines observed in 1973 that "there has been a fairly dramatic improvement in the price/performance, particularly over the last six or seven years". (DX 5154: Heinzmann, pp. 3387-88.) William Terry of Hewlett-Packard explained in 1973:

"[I]t has been my experience there is a continuous innovation of technology and an almost continuous and very rapid degree of change. . . . I have seen it in our own product line. Our first computer [in 1966], the 2116 was a very large box, heavy, hot, with 8,000 words of memory and sold for something like $28,000. Seven years later [1973] we offer an improved machine, in almost every respect for something like $5,000. That is an illustration from my own company of how rapidly this change has been taking place." (DX 4113: Terry, pp. 3314-15.)

The statistical evidence of the price/performance improvements is dramatic. Some examples for IBM products make the point. The IBM 650 processor, announced in 1953, was able to process 700 instructions per second; the 1401 processor, announced in 1959, was able to process 5,000 instructions per second; the 360/Model 30 processor, announced in 1964, was able to process 30,000 instructions per second, a 40 times increase in speed over about ten years. (DX 4755.) Maximum main memory increased from 10,000 bytes on the 650 to 65,536 bytes on the 360/30, or by 6-1/2 times. (DX 1402, p. 11; DX 911, p. 5.) The rental price of the 360/30 at announcement, however, was about equal to the rental price of the 650 at announcement. (DX 1402, p. 3; DX 911, p. 6.) Welke testified that with respect to the cost of the central processing unit's operation "from one generation to the next on computers, if you speak of the IBM line of equipment, the second generation being a quantum step lower than the first . . . . Taking the first generation as one, the second generation was ten times as fast or 1/10 the cost. The third generation would be ten times that or 1/100 of the first." (Tr. 17304-05.) In addition, progress in memory components has meant that "not only have the components been improved in their efficiency, in their ability to perform reliably, but the space or the sizes that they occupy has also gone down. . . ." The "number of cubic feet taken up by a byte of information, if you will, again normalized to one in 1948, [has gone] down to one thousandth of that in 1968, and hopefully down to a millionth of that in 1988." (PX 289; Perlis, Tr. 1829.)

Similar improvements were achieved in peripheral devices. For example, IBM's 350 magnetic disk drive, announced in 1956, had a data rate in characters per second of 8,800, an access time of 600 milliseconds and a capacity per spindle of 4.4 million characters. (DX 3554D.) The 2314 disk drive, announced in 1965, had a data rate of 312,000 characters per second (over 35 times faster), an access time of 75 milliseconds (80 times faster), and a capacity per spindle of 25.87 million characters (5 times greater). (DX 3554D.) The storage capacity per dollar of rental increased from 7,692 characters to 38,255 characters. (Tr. 94860-61; JX 38, pp. 439-40; PX 6072.) IBM magnetic tape drives from the 729-III, announced in 1957, to the 2420 Model 7, announced in 1968, achieved a three-fold increase in recording density and a six-fold increase in data rate per dollar of rental. (Case, Tr. 72650-55; JX 38, pp. 840-41; PX 4526, p. 3; DX 3553B.)

Dr. Perlis estimated that the price per operation had decreased "a thousand to one" during the period 1948 to 1968 and projected the same decrease for the period 1968 to 1988. (Tr. 1993.)

These improvements in ease of use, price/performance and capabilities, attracted new users, enabled existing users to expand their data processing and contributed to the explosion of the uses of computers. To take advantage of such improvements, existing users upgraded and converted their old equipment. Withington testified that "during the entire eight-year period, 1955 to 1963, something in the range of 30 to 40 percent of users having acquired one computer system changed to a computer system of another manufacturer." (Tr. 57678.) Further, "perhaps 40 to 50 percent of users acquiring an initial system from one manufacturer subsequently converted to a noncompatible computer system of the same manufacturer." (Tr. 57680-81.)

Such changes generally cost users time and money--personnel had to be retrained and programs had to be converted--and customers took those costs into account in making procurement decisions. (See, e.g., J. Jones, Tr. 78771-72; DX 3753 (Tr. 80193.).) Generally, the costs of such conversions are "relatively minor" where the programming has been done in higher level languages such as COBOL. (Macdonald, Tr. 6914; J. Jones, Tr. 79689-90; see also J. Jones, Tr. 78868-69, 78877-78; DX 3753 (Tr. 80192-93.).) In any event, customers made such changes because the conversion costs were less than the resulting benefits. As Hart informed his colleagues at GM:

> "While [a user who disliked having to convert] was groaning, his roommate was cheering because he could now solve his problem faster, cheaper--or at all! And many new users were attracted by new capabilities . . . . The overall benefits (to the computing community) from each change have overshadowed the conversion costs required." (DX 3753, (Tr. 80192.).)

57. <u>Conclusion.</u> As we have just discussed, continuous innovation in computer techniques and technology during the 1960s led to dramatic improvements in the price/performance, function and usability of computer systems. Users could do their computing faster, cheaper and easier, and also do a whole host of new applications that could not previously have been done cost effectively or, perhaps, at all. The new wave of applications that emerged--particularly real time, on-line, interactive types of applications--permitted users to make computers an integral part of their businesses, rather than merely fast accounting machines to do a payroll or perform statistical calculations. The resultant potential for increased business productivity through the use of computers attracted new users and provided existing users with incentives to expand their computing installations and apply their computer systems to ever more sophisticated applications.

The histories of individual companies and types of competitors set out above reveal that EDP suppliers perceived--although always underestimated--the extraordinarily rapid growth in the number of computer users and uses and the insatiable demand for computing power and capacity and attempted to satisfy the demand by offering the types of hardware and software that users wanted. Such attempts led to a stretching of the technology and still further performance and cost breakthroughs. As that cycle repeated itself, hosts of opportunities were created for companies to grab a new or a bigger slice of the action. Existing suppliers were able to and did expand their operations and grow rapidly, and a variety of emerging new suppliers were able to achieve startling success in a relatively short period of time.

As the technology and the applications changed, so too did the ways in which users acquired and changed their computer systems. In the 1950s and early 1960s, customers installing their first systems typically acquired a complete system from a single system supplier. (See O'Neill, Tr. 76243; PX 4829, p. 34; DX 5654, Webster, pp. 251-52.) Because of the limited number of options and limited configuration possibilities of those systems, users who wanted to upgrade or significantly expand their computing capability also, typically, acquired complete, new systems. (See J. Jones, Tr. 78714; Withington, Tr. 56170-71.) During that time period, however, "competitive necessity" was ringing in a new order, and manufacturers were being forced to make their systems more and more modular:

> "As users' demands for . . . breadth of hardware functionality grew, the manufacturers attempting to compete were forced to maintain continuous developments of different modular types of equipment that could be configured together into models offered to the user. . . . This occurred in the late 1950s . . . perhaps 1958 through 1962." (Withington, Tr. 56174.)

Customers were interested, for example, in having the option of moving to a larger central processing unit without reprogramming and without replacing all the other parts of their system:

> "Through this process [of replacing and adding individual boxes without a single conversion,] it would have evolved to a point where the computer system, both in terms of the individual machine model as entirely replaced, and the modes of use as changed, and the systems programs being replaced in a modular fashion along the way as well, has become entirely different. Thus, the beginning and the end point of the process are totally distinct, and yet at no one point in time would there have been a moment at which one could say: At this point the entire system changed from one to another." (Withington, Tr. 58270-71.)

whether or not a system offered that flexibility was one factor users took into account in making procurement decisions. (See J. Jones, Tr. 78980-83 (Southern Railways selection of IBM 7040/44); Plaintiff's Admissions, Set IV, ¶¶ 66.0-.2 (Knolls and Bettis selection of Philco 2000 Models 211/212).)

As we have seen (see pp. 296-304, 332-40 above), IBM responded first and most forcefully to this competitive impetus and reaped the greatest benefits from doing so. But, as IBM and other systems suppliers accommodated users by making their product lines more modular (see, e.g., Withington, Tr. 56174-75, 58229-30), they also created opportunities for new competitors to begin marketing boxes directly against the individual boxes in those new computer systems (see, e.g., DX 2583), which now could be reconfigured at will. Moreover, entry of such box suppliers was facilitated by their ability to tap the software support of the systems suppliers and copy the designs of their products. Thus, as O'Neill of American Airlines testified:

> "[In] the latter part of the Sixties and into the early part of the Seventies, and I will say from about 1966 through about 1973-74, manufacturers, other manufacturers other than IBM, started to develop and sell compatible tape drives, disk drives, printers that would operate with little conversion, although some conversion was involved, with little conversion on the IBM processors.
>
> "That doesn't mean to say that the Honeywells and the Burroughs and the NCRs and the CDCs were not there, because they were also putting in their systems. But what happened was more choices became available.
>
> "Ampex was selling memory, for instance; Calcomp was selling disk drives; Potter was selling tape drives.

"There were a number of alternatives that one could evaluate, which meant that they did not have to buy all their equipment from one manufacturer . . . .

"What that means is that we can get our data processing done at a lower cost." (Tr. 76244-45, 76248.)

O'Neill continued:

"We [American Airlines] tend to buy boxes [rather than systems].

". . . .

"We can put together the pieces and pick and choose the best boxes at the lowest cost from the various manufacturers that are offering those boxes." (Tr. 76249; see also J. Jones, Tr. 79036-39, 79044-49, 79622-24, 79880.)

As these new suppliers entered into competition against IBM and others, users were increasingly willing and able to replace their systems--box by box. (See, e.g., Withington, Tr. 56026-27.) The Federal government and others turned to PCMs for replacement boxes. (See DX 5212, pp. 1-2; DX 7568; DX 5654, Webster, pp. 248-52; DX 6257, Gold, p. 119.)

By 1970 "many acquisitions decisions were already being made in a modular fashion" and customers were increasingly "adding computer products" in lieu of replacing whole systems. (Withington, Tr. 56189-90; Akers, Tr. 96667-70.) V. O. Wright explained:

"During the time even when I was in IBM, in the late 1960's, placing that in the time frame of '68-'69, there was developing at that time a change in the manner of marketing and in the manner of buying data processing equipment.

"Many new manufacturers had come into existence, particularly those that were manufacturing plug compatible equipment that plugged into, was compatible with, IBM systems, and the federal government took the leadership in trying to increase the use of such equipment in the federal government because they viewed it from the standpoint of its saving the Government money by buying a large number of magnetic tape units, a large number of disks at a quantity price, in which they were able to get further discounts and attaching those units to IBM systems.

"So specifically in answer to your question, in the late 1960's there was a new movement underway which did focus much more on boxes than it did on systems, particularly after a system was first installed and the advantages might be realized by reducing the cost of those systems by replacing certain of the boxes in those systems.

"Q Did that continue, sir, during the period of time, that movement toward boxes, that you were at the RCA Corporation, that is, from the beginning of 1970 until the beginning of 1972?

"A Yes, it did. And also while I was in Amdahl and also while I was in Xerox that same movement continued to build, and it enlarged and became a more significant factor in the computer business." (Wright, Tr. 13540-41.)

Nor did the box competitors limit their focus to IBM. According to Wright, who was Chairman of RCA's Peripheral Task Force in 1970, RCA performed a market survey and was both "surprised" at the amount of non-RCA equipment attached to their systems and "quite shocked" at the number of users who expressed an intention to attach non-RCA peripherals to RCA systems in the future (Wright, Tr. 13554-57; DX 862):

"This was clearly a continuation of that trend, . . . where many users who used to be really dependent upon one manufacturer for all of the boxes comprising a system, had learned that it was possible for them to achieve certain benefits by procuring and mixing boxes from different manufacturers in the same system. It was a continuation of that trend." (Wright, Tr. 13557.)

The increasing trend toward modular replacement permeated the area of systems software as well. That trend coupled with users' unslakeable thirst for applications programming, triggered an explosion in the number of software suppliers during the latter half of the 1960s. (See above, pp. 853-55, 838-39.) In the meantime, leasing companies and service bureaus were also burgeoning and providing a host of new alternatives for users and increasing competitive pressure on hardware manufacturers. (See above, pp. 807-14, 826-46.)

For all of 360's spectacular success, IBM could not match the growth of all these competitors. The expansion of EDP companies during the 1960s, both in number and size, was astounding. We have seen already (pp. 923-26, above) that the joint deposition program of various EDP companies (Census II) revealed an exponential growth in the number of companies reporting U.S. EDP revenues over the years 1952 through 1972 and a similar growth in the total U.S. EDP revenues of those companies. (Dubrowski, Tr. 84209-10; DX 8224.) From 1961 through 1970, the number of companies reporting U.S. EDP revenues increased from 98 to 582. (DX 8224.) Moreover, from 1961 through 1970, the U.S. EDP revenues of those companies, as reported in Census II, excluding IBM, grew from $796,386,000 to $6,820,225,000 or an amazing compound growth rate of 27.1% per year. During those same years, IBM's U.S. EDP revenues grew at an impressive but lagging compound growth rate of 17.6% per year. (DX 3811.)

The implications are perfectly clear. Hundreds of new competitors entered the industry. In the aggregate, the U.S. EDP revenues of those companies grew some 55% faster per year than IBM over the entire period. As a result, IBM's share of total U.S. EDP revenues fell: from 1961 to 1970, IBM's share of the reported U.S. EDP revenues dropped dramatically from 51% to 34%. (DX 3811; DX 8224.)

Similar trends were evident in the Federal government. In 1967 the GSA Inventory of general purpose ADP equipment included hardware supplied by 104 different companies. (DX 4579.) By 1972, that number had risen to 340. (DX 4584.) Moreover, between 1960 and 1972, IBM's share of the number of computers installed in the GSA inventory fell from 54.8% to 21.2%. (DX 4593, p. 7.)

For IBM and other EDP companies, the influx of competitors during the 1960s required constant vigilance and a readiness to respond quickly with new and better products. Any other course would have amounted to "going out of business". As GE's APL "Master Plan" stated:

> "One of the key aspects of technology in the computer field is its high rate of obsolescence. Never in the history of technology has the pressure of competition and the lure of highly rewarding markets created such a dynamic evolution." (PX 353, p. 23.)

In short, one of the results of competition in the computer business was that companies in the industry were constantly forced to come out with new and better products in order to keep the customers that they have and in order to get additional customers. (Hindle, Tr. 7448-49; see also R. Bloch, Tr. 7761-62; R. Jones, Tr. 8865-67; McCollister, Tr. 9697; Hangen, Tr. 10423-24; Withington, Tr. 56556-58.)

The competitors in the industry have attested to the increase in competition during the 1960s. McCollister of RCA described the appearance of "more prominent and vigorous competition [more sources of new product introduction] in the last ten or fifteen years [1960-75] than there was at an earlier time . . . ." (McCollister, Tr. 9313.) Terry of Hewlett-Packard described the "explosion of competitors". (DX 4113: Terry, Tr. (Telex) 3316-17.) Hindle of DEC described the industry as "a tough competitive marketplace." (Hindle, Tr. 7448; see also R. Jones, Tr. 8865-67; Hangen, Tr. 10415; Butters, Tr. 46654; Oelman, Tr. 6129-30; PX 1077; DX 1406; DX 4806; DX 193, pp. 2-3.)

The result of this competition for the user has been a veritable bonanza. Users have been rewarded with constantly better products at increasingly lower prices, as the technological advances have been passed on to users through the competitive pressures of the market. (See Withington, Tr. 56580; Hangen, Tr. 10423-24; R. Bloch, Tr. 7761-62; McCollister, Tr. 9697; PX 376, p. 19; DX 7523, Farrar, pp. 56-57; DX 4321; PX 4830, p. 29; DX 9067, Higgins, pp. 104-05; DX 7527, Slaughter, pp. 109-110; DX 7528, Mahoney, pp. 17-18.) Commenting on PCM competition in particular, the International Data Corporation reported in 1972:

> "As the independent peripheral manufactuers strive to fill their potential and the mainframe companies react to hold onto their own business, prices will come down as product performance and variety improve. And that's a bonanza from the user's point of view, since he wins in both cases." (DX 3132, p. 4.)

Competitors have been forced to march to the customers' tune. As Withington testified, "'the user controls this industry in the end'". If a user "is offered unsatisfactory products, he will not buy them, meaning that if a product is not perceived by the user as meeting his basic requirements for data processing, or if its price/performance are [sic] in any way unsatisfactory to him, he will cause the product to fail by refusing to accept it." (Withington, Tr. 58571-72.)

In 1972, Harold S. Trimmer, Jr., Acting Commissioner, Automated Data and Telecommunications Service of the General Services Administration, wrote, and Elliott Gold, Director of the ADP Procurement

Division of the GSA, concurred:

> "'The essential point that we wish to convey is that the current ADP market is dynamic and extremely competitive. The emergence of new sources of supply offers considerable opportunity to produce significant economies in the procurement of ADP equipment.'" (DX 6257: Gold, pp. 96-97.)

For the users of EDP equipment, things have only gotten better.