IBM NEWS

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Virtual Storage Announcement Special Edition

New Systems, Programming, Componentry

IBM Announces Virtual Storage 370s

Fellow IBMers:

Today's announcements may ultimately be judged to be among the most significant in the history of our industry.

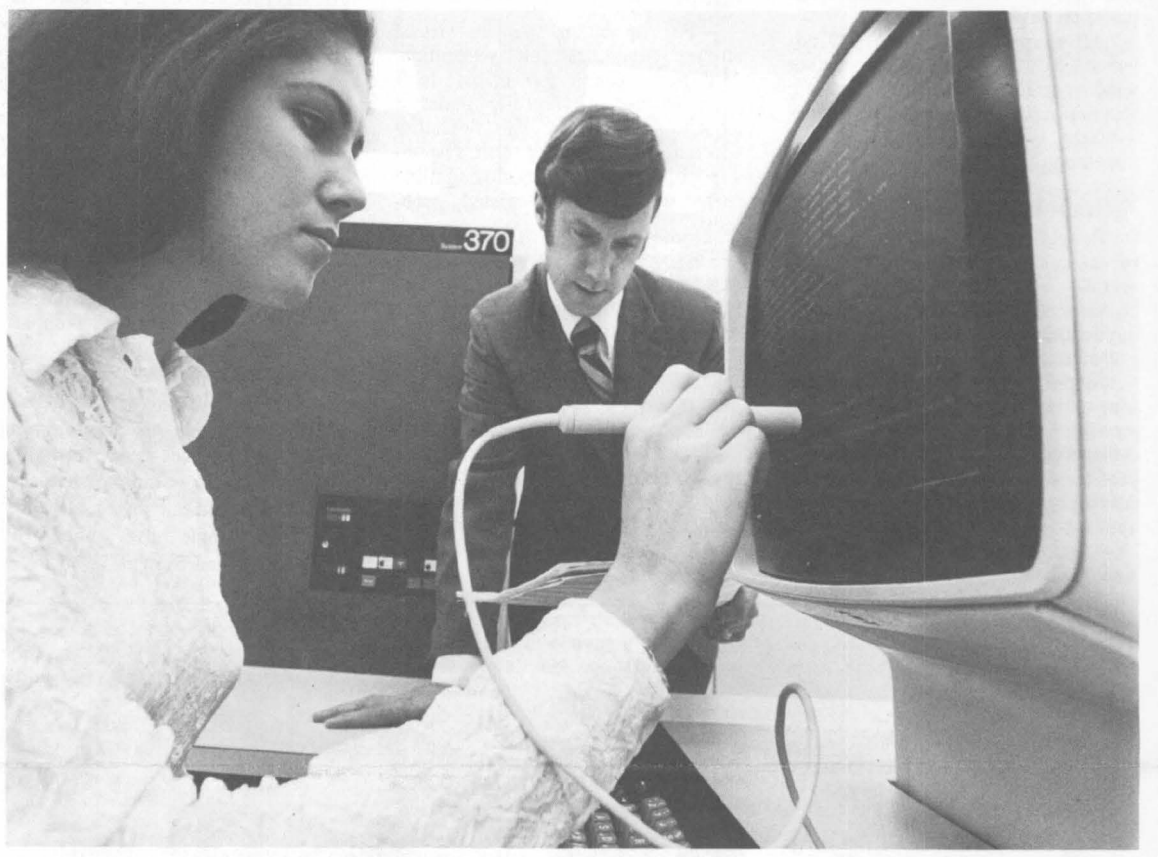
For virtual storage is the potential gateway to major new application areas, particularly those with advanced data base and data communications needs. It makes possible increased programmer productivity through simplified programming requirements. It is truly an idea whose time has arrived.

The concept of virtual storage is not new to IBM *or to our industry. Formerly, its use had been largely restricted to a limited number of sophisticated customers. Now the potential of this powerful tool is available to System/370 users. The formidable task before us is to ensure that all* IBM *customers are provided with the information and insights they must have to reap full benefit from this important computing concept.*

Not to be overlooked in this exciting announcement is the achievement of a computer main memory with the highest level of density we have ever offered: 1,024 bits on a single chip one-eighth of an inch square. We already have manufactured more than one billion bits of this outstanding new FET *componentry. And to ensure quality performance, recorded thousands of hours of systems test data with it.*

Thousands of dedicated, talented IBMers *again have met demanding requirements for creativity, technical excellence and coordination—within an exacting time frame, in a development and manufacturing effort spanning two continents. This is a magnificent achievement for* IBM, *of which every one of us can be justifiably proud.*

T. V. Learson



The newly designed console for System/370 Model 158. The switches, buttons and lights are largely gone, replaced by a cathode ray tube display which allows the operator to execute console functions with a light pen.

Redirection of System/370 Technology Paves Way for New Application Development

A major redirection of IBM System/370 technology, designed to make it easier and more economical for computer users to develop new applications, was announced by IBM today.

The company introduced System/370 virtual storage, an advanced technique that can speed and simplify the development of many computer applications, including remote computing networks and on-line inquiry systems—the key applications of the Seventies. In addition, virtual storage enables a System/370 to process more jobs concurrently, adding new flexibility for user operations.

Virtual storage offers these advantages by enabling people to use a System/370 as if it had up to 16 million characters of main storage—a maximum many times larger than its actual capacity.

To provide virtual storage to System/370, IBM also announced new system control programming, and two new computers — System/370 Models 158 and 168—that introduce the most compact storage circuits ever used in IBM computers. The company also announced that virtual storage is available now for the previously introduced Models 135, 145, 155 and 165.

The vast majority of existing applications programmed for System/370 and System/360 will require little or no programming to take advantage of System/370 virtual storage. In addition, compatibility between all System/370 virtual storage models makes it easier to move up to the larger and more powerful models as processing requirements grow.

"Virtual storage is an evolutionary advance for System/370 that will have a revolutionary effect on computer users for years to come," said Ralph A. Pfeiffer, Jr., IBM vice president and Data Processing Division president.

"Increasingly, computer users are demanding faster and more cost-effective ways of developing data base systems that can communicate up-to-the-minute information rapidly throughout their organizations. To help meet these demands, virtual storage adds a new dimension to System/370's proven performance by giving users expanded freedom to develop advanced applications."

Great Flexibility

With virtual storage, new large-scale applications—such as an on-line order entry program—can be tested immediately, without stopping regu-

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Virtual Storage—What It Does Makes It 'Real'

Based on the dictionary definition of "virtual" it could probably be posed with equal validity that "virtual storage" does or does not exist. That's for philosophers to argue.

The fact is that it works, and in the new and enhanced models of System/370 announced today it will allow IBM's customers to turn loose their most talented, imaginative (and sometimes frustrated) people to develop computer applications that might not have been practically or economically accomplished in the past.

The limitation in conventional multiprogramming is that programs being executed generally must be designed to be in main storage in their entirety, even though large sections of each program are idle for lengthy periods of time, tying up vital main storage space.

vir·tu·al \'vərch-(ə-)wəl, 'vər-chəl\ *adj* [ME, possessed of certain physical virtues, fr. ML *virtualis*, fr. L *virtus* strength, virtue] : being in essence or effect but not in fact —— **vir·tu·al·i·ty** \,vərch-ə-'wal-ət-ē\ *n* —— **vir·tu·al·ly** \'vərch-(ə-)wə-lē, 'vərch-(ə-)lē\ *adv*

What It Is—Simply

Virtual storage links as much as 16 million bytes, or characters, of direct access storage to a computer's main storage through a combination of circuitry and programming. This fully automated resource allows programmers, computer operators and other users to work with their computer as if it had up to 16 million bytes of main storage—even though the computer's real main storage may be only a fraction of that capacity.

The hardware (circuitry) portion of virtual storage is called the dynamic address translation facility (DAT). The programming consists of four system control programs: 1. Disk Operating System/Virtual Storage (DOS/VS); 2. Operating System/Virtual Storage-1 (OS/VS-1); 3. Operating System/Virtual Storage-2 (OS/VS-2); and 4. Virtual Machine Facility/370 (VM/370).

How It Works—Briefly

When programs are placed into virtual storage, they are automatically divided into small sections called *pages*. For ease of addressing, these pages are assigned to larger groups called *segments*. Initially, a page must occupy real storage—the computer's main storage—but as real storage space becomes needed elsewhere, the page is transferred to external page storage on the direct access device. When required again by an operating data processing job, one or more pages are automatically copied back into real storage. The ongoing transfer of pages between

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'Emphasis on People'—Pfeiffer

"With System/370 advanced function," says Ralph A. Pfeiffer, Jr., IBM vice president and DPD president, "we have fulfilled a promise to the customer that began with the price/performance benefits and technical foundation of System/370.

"Now we have the architectural and functional enhancements that can help increase people productivity and thus compress his long-range application development plan.

"All elements of System/370 advanced function, with new operating systems and new technology, add up to a new data processing environment —where virtual storage is key and the emphasis is on people."

Everyone Benefits

"People" benefits occur in all areas of the customer data processing operation — applications development, operations, systems programming, application maintenance.

For example:

—Applications designers may no longer be hemmed in by physical storage sizes. They can cut program design time, take new systems approaches, and devote themselves to developing larger, more advanced applications.

—Applications programmers can spend less time managing storage for their programs and focus on application definition.

—Maintenance programmers no longer need to do major rewrites to update existing applications or to add new functions.

—Systems programmers can tailor the system to installation needs with fewer constraints because many control program functions reside in virtual storage.

—For operations people, virtual storage simplifies job scheduling. Multiprogrammed job mixes don't have to be so carefully matched against real storage. This flexibility can help operations be more responsive to end users by reducing time spent solving system-related problems.

The benefits of advanced function in application design, programming, testing and operations increase the overall value of the data processing center.

Data processing managers will find that they have a wider choice of applications, and find greater flexibility in managing new application development. They now will be able to consider applications that once were unsuitable for implementation because of large fixed storage requirements.

In organizations where on-line applications are a critical keystone of the entire business, multiple on-line applications can co-exist more easily with the same amount of real storage. And many IBM program products that required a larger system may now be used to cut application development costs even further.

In application development, the greater productivity of applications designers and programmers can lead to shorter implementation cycles. This should cut the cost of developing new applications and bring in earlier returns on investments.

"Virtual storage systems," says William W. Eggleston, DPD vice president, marketing, "are the next logical step in system evolution.

"We feel that virtual systems have benefits that can be realized right now . . . and we are letting our customers achieve these benefits with compatibility in mind. This offers the customer many advantages.

"He can move into virtual storage without sacrificing his programming investment, without major retraining of his staff, without major conversion efforts, and without losing the experience his people have gained with System/360 and System/370."

Looking over page proofs of this special edition of IBM News with John Reed, large systems marketing, are Fred Hill, large systems marketing (seated), and, from left, Warren Stuart, intermediate systems marketing; George Ebbert, programming systems marketing; Tom Crowley, large systems marketing; Pete O'Hara, HQ Field Systems Center; and Ray Peck, programming systems marketing. They were some of the members of the special DPD task force set up to implement the announcement.

History of VS Extends Back To System/360

Although IBM was one of the early advocates in the computer industry of virtual storage, its major contribution is in refining the concept for effective use in the marketplace.

In 1964, after the announcement of System/360, leading edge customers—most of them with time-sharing application requirements that exceeded the standard data processing offerings then available—became interested in virtual storage.

To address this request in depth, IBM put Watts Humphrey, then director of time-sharing, CHQ, Armonk, and now SDD Endicott lab director, in charge of a special group.

It resulted in recommendations for a system with Dynamic Address Translation (DAT), the hardware package that makes virtual storage possible.

IBM responded with System/360 Model 67.

The software for the Model 67 was TSS, rich in function but not directly compatible with OS.

(Humphrey, incidentally, coordinated the DPD, SDD and DP Product Group System/370 advanced function announcement efforts.)

Cambridge Involvement

At approximately the same time that DAT came out on the Model 67, the Cambridge Scientific Center under Norm Rasmussen was taking virtual storage a giant step further—it was developing the virtual machine concept on a System/360 Model 40, modified with a special version of DAT hardware. This effort, which was intended to give each 360 user his own computing environment, had three components: the Model 40, a software control program called VMCP/40, and an interactive user monitor dubbed CMS (Cambridge Monitor System).

Cambridge worked on virtual machine concepts throughout 1965 and 1966 and in January, 1967, put the modified Model 40 into internal use supporting a dozen virtual machines.

Bob Burchi, Curt Bury, Mike Siegman and Bob King, DPD HQ. They helped bring virtual storage to the marketplace.

Parallel to this development, part of the Cambridge group that worked on CP/40 began to work on a software solution for the Model 67 user. In the fall of 1967, it completed CP/67, a product-oriented system.

In January of 1968, Cambridge described CP/67 and CMS to SHARE and in July of that year it became available to Model 67 users. This system was the forerunner of VM/370, a DPD product, announced today.

Common Deficiency

CP/67, although it was a Type III program and had batch performance limitations, was compatible with OS and had virtual machine capabilities. But both TSS and CP/67 had a common deficiency—no follow-on hardware which, of course, meant no growth path for IBM customers.

DPD representatives Gale Aguilar, Curt Bury and Bob King expressed to SDD the need for high performance hardware with dynamic address translation and, along with Detroit Automotive SEs Mike Siegman and Bob Burchi, emphasized that the virtual storage concept represented the wave of the future for fast and economical customer application growth. They showed how the virtual storage concept could be applied to address a wide range of problems in all industries. All are now at DPD HQ.

Siegman and Burchi were then working with their customer on an automobile design application. The application had millions of bytes of application programs and data—all of which had to be handled in a short period of time.

The SEs proposed a forerunner of the virtual storage-based OS/VS systems.

This was a subset of the TSS function incorporated within the customer's OS-based operating system. It placed the operating system in control of paging and it provided the potential for performance equal to or better than the original operating system.

Between August 1967 and April 1970, it was demonstrated to officials in DPD, SDD, DP Product Group, World Trade and Corporate Headquarters that it was possible to take the major benefits of virtual storage and apply them with compatibility and high performance to an OS base.

The proposals presented and documented included improved programmer productivity and the importance of on-line growth and compatibility that can be achieved with virtual storage and OS. These concepts became part of proposals that developed into the basis of IBM's plans for its System/370 product line.

VS Key to Development Of New DP Applications

"DPD industry marketing," says Joe M. Henson, DPD vice president, market operations, "views System/370 advanced function as a key step supporting on-line application development efforts in all areas—commercial industries, basic industries and the public sector."

"The virtual storage concept," says W. Lee Noel, director of commercial industry operations, "will provide the reliability customers need with greater economy in the commercial industries.

"The key to reliability for our many on-line customers has always been duplexing (having immediate access to identical, back-to-back computers). However, duplexing can be expensive because it means that both the primary computer and its backup usually had to have identical storage sizes.

"Now, with virtual storage, the customer can get by with one computer of large memory and a backup computer with less.

"The dollars he saves through 'virtual storage duplexing' will enable him to invest more in his primary concern—developing and implementing new applications for future profit."

Smaller Users Benefit

Noel pointed out that although many commercial industry customers were high end of the line users, the smaller user also benefits with virtual storage.

"Virtual storage enables the small user to do the kind of computing previously limited to the large system user.

"It gives him the function he previously could obtain only in an expensive large storage machine. This opens the door to applications that had been almost exclusive to the large user."

Edward R. Frick, director of basic industry operations, also cited the economics of virtual storage in justifying leading-edge applications.

"Concepts like Manufacturing's COPICS, which involve the need for many on-line applications, become more economically feasible with virtual storage," says Frick, "not only by reducing the amount of real memory needed, but also by lowering the application entry cost. The latter point is particularly important in sophisticated applications where precise, tangible benefits can be difficult to determine prior to actual installation of the application.

"The new function will also make the computer more accessible to the engineer in many of our manufacturing and process accounts. He will be able to run large computational programs and simulations presently impossible at the customer site due to the need for large memory.

Centralized Programming

"In addition, virtual storage will permit a number of our customers to move ahead with centralized programming—another cost saver."

Centralized programming — in which programming is done by one location and sent to remote locations—was usually constrained by the need for systems of similar memory size. The new offerings lessen this constraint.

"In short," Frick adds, "virtual storage increases the capability of the computer as a productivity engine by allowing many of our customers to install their backlog of applications at a faster, less expensive pace."

Victor R. Macdonald, vice president, public sector industry operations, feels that the hardware and programming extensions to System/370 provide public sector industry operations with a valuable new marketing dimension.

"With virtual storage," he says, "our customers can increase the productivity of existing systems and also keep the flexibility they need to handle their constantly changing data processing requirements.

"These important advances will also help in the design, programming and operation of new IBM systems for public sector customers and prospects."

Sales Team Trained, Supported for All-Out Effort

To IBM's marketing reps today's announcement is the signal to hit the customer trail to sell System/370 advanced function. Armed with marketing guides to help them customize the benefits of virtual storage for their customers, they have completed DPD's most intensive pre-announcement education program.

"There is good reason," says William W. Eggleston, DPD vice president, marketing, "for the marketing team to feel solid about System/370 advanced function.

"The marketing team is out there with plenty of benefits for the customer, a background of intensive in-house education, some fine sales tools in its kit, and expert backup throughout the division."

Gale R. Aguilar, director of systems marketing, who managed the overall marketing support effort, enumerated the plusses of the extensive pre-announcement preparation for both salesman and customer.

For the salesman:

—**Education.** The 25 hours of education salesmen and systems engineers received represents the most intensive pre-announcement undertaking in DPD history.

—**Planning.** Marketing reps on selected key accounts in all industries attended intensive planning sessions prior to announcement. Proposals were generated and customer seminars planned.

—**Case Histories.** Developed by industry marketing, these become part of the marketing rep's sales kit. They enable him to demonstrate the value of advanced function through customer operations characteristic of specific industries.

—**Marketing Guide.** Called Value of Virtual Storage, this question and answer format leads the salesman and customer down a logical path that will help them determine the value of advanced function in dollars and cents terms.

—**Hot lines.** Application hot lines are now being manned by experts in many industries to answer customer and marketing rep application questions.

For the customer:

—**Formal Offerings.** Formal course offerings are now available so the customer can get up to speed quickly on the new operating systems and technology.

—**Demonstrations.** Demonstrations of these operating systems and technology began on announcement day and will continue at systems centers across the country.

—**Implementation.** All System/370 advanced function components are ready for implementation now or in the near future.

"System/370 advanced function," DPD President Ralph A. Pfeiffer said, "continues the IBM-customer marketing/technical relationship in its highly positive vein.

"I'm confident that the marketing force will apply its knowledge and expertise to the customer's problems, develop imaginative solutions, and then effectively communicate those solutions and their tangible value in customer terms."

Communications Support

DPD communications people produced more than 100 items in the System/370 advanced function announcement package.

"This was one of the most extensive communications support efforts in DPD history," said Bert Reisman, director of communications.

"We were able to reach our objectives because we worked closely with marketing — coordinating our individual efforts and ideas to come up with the most meaningful package for our customers and marketing force."

The communications objectives included:

—Creating an awareness of advanced function concept and benefits, its implementation ease, and IBM's total commitment to advanced function, and

—Reinforcing IBM's strong belief that application growth is a key to the success of data processing.

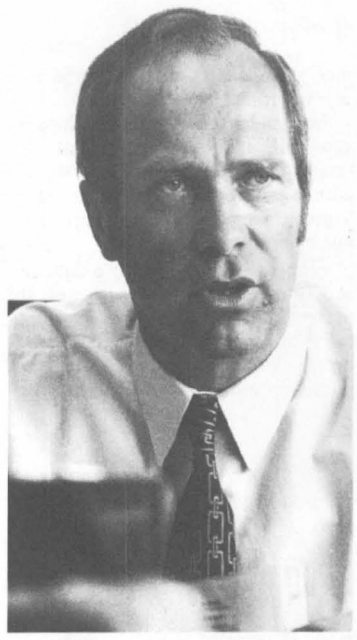
The communications effort began as far back as one-and-one-half years ago when technical publications began researching the myriad of technical data to turn it into systems guides and facts folders for customers and prospects.

The effort continued as the many communications' areas prepared:

- Films, slides, audio-visual presentations and videotapes;
- Brochures, industry-oriented promotional material and proposal inserts;
- Ads which will spread the word in both the business and trade press;
- Blue letters and industry newsletters;
- Internal publications to put together the stories behind the headlines;
- Press kits and press conferences;
- Articles for exclusive business press placement;
- Special issues of Data Processor and Computing Report.

Announcement day materials came together physically in Mechanicsburg, which worked with communications services for packaging and mailing.

In addition, all material available for the field's continuing marketing efforts has been catalogued and mailed to each branch office.



International Product Test Effort Involves 15 Labs

As long as two years ago Product Test was working on some of the things announced today, and in recent months, hundreds of PT people were involved in testing the new products. Here, key members of the Endicott team complete final phases of verifying both the Model 145 and the OS/VS-1. They are, l to r, Howie Lewis, Ron Kerbs, Ron Klish, seated, Warren Schwomeyer, Bob Bevins and Curt Brewton. Product testing was done at 15 locations including Poughkeepsie, Model 158 and OS/VS-2; Kingston, Model 168; Port Chester, VM/370; Uithoorn and Boeblingen, DOS/VS, and Hursley, Model 135.

Additional Technical Details

(For readers who like the details of speeds, sizes and capacities here are some technical specifications.)

The MOSFET (metal oxide semiconductor field effect transistor) storage circuits help reduce space requirements and make the Models 158 and 168 faster in operation than the Models 155 and 165, which use magnetic core storage. A typical Model 168 executes instructions at a rate from 10 to 30 percent faster than a similarly programmed and configured Model 165. The Model 158 can execute instructions at a rate from 20 to 40 percent faster than a Model 155 with comparable programming and configuration.

Storage Capacities

The Model 158 is available with four main storage sizes—one-half million, 1-million, 1.5-million or 2-million bytes. Its buffer storage capacity is 8,192 bytes.

The Model 168 is available in million byte increments to 4-million bytes, a maximum main storage capacity one million bytes higher than for the Model 165. Buffer storage is available in sizes of either 8,000 or 16,000 bytes.

The Model 158 also contains reloadable control storage that holds the microprogramming required for basic system control and for such features as emulation of earlier IBM systems and extended precision floating point. New microcode can be read into reloadable control storage from a small disk cartridge enabling additional features and engineering changes to microcode to be installed quickly and with minimum disruption of system operation.

New, optional features available with the Models 135, 145, 158 and 168 permit economical integrated control of the high-performance IBM 3330 series disk storage.

With these features, up to 32 disk drives, with a total on-line data capacity of 3.2 billion bytes, can be directly connected to Models 158 and 168. Up to 16 drives can be directly attached to Models 135 and 145. Economical, high-capacity disk storage is important for the many advanced computing applications that require large quantities of rapidly available on-line data.

Like earlier System/370s, Models 158 and 168 can use block multiplexing, a technique that permits simultaneous operation of multiple high-speed input and output devices, such as the 3330 disk storage and 3705 communications controller. This capability contributes to high system throughput, the amount of work a system can process in a given period.

CRT Displays Aid Efficiency

Both new systems include cathode ray tube console displays designed to assist the operator through visual tracking of system status. Additionally, the Model 158 features an electronic "light pen" that an operator uses to rapidly call forth operational data for display on the tube.

Also offered is integrated emulation. This option makes it possible for the Model 158 to execute System/370 programs concurrently with programs written for the IBM 1400 series and IBM 7010/70/74. The Model 168 can execute 7070/80/90 programs concurrently with System/370 programs. In addition, the Model 158 offers an OS/DOS emulator that enables DOS programs to operate concurrently with OS jobs.

Precise Process Required to Man

For the past several months, CD Burlington has been producing MOSFET memory components in high volume for use in Models 158 and 168.

The Burlington FET line features these significant advancements in semiconductor manufacturing:

- New and improved tooling.
- Ultra-clean work stations.
- Plant-wide usage of data processing systems to monitor and control process steps, track product yields and collect data for quality assurance and production control analysis.

Advanced Tooling

Bill MacGeorge, manager of FET semiconductor manufacturing at Burlington, says, "Our experience in producing bipolar memory components taught us a lot about layout and design of process equipment, environmental cleanliness, chemical control, product handling—it was an evolutionary type of progress stemming from the pioneering SLT days at East Fishkill.

"One facility we designed uniquely for FET production is the new in-line diffusion area. It is the first of its kind. In one end, we load the wafers to be processed. They undergo 73 separate operations, and then we unload them at the other end of the line. These wafers have never left an ultra-clean environment."

Ultra-Clean Production Line

The FET production line incorporates a series of ultra-clean work stations which permit wafer processing and handling with minimum exposure to contamination by airborne or waterborne particles.

Burlington's clean production environment exceeds the stringent U.S. government specifications on cleanliness developed for the aerospace industry.

"Our concern for cleanliness cannot be overly stressed," says MacGeorge, "because it is so intimately related to the overall yield and reliability of our components. We're trying to prevent contamination by particles that are so small that you need an electron microscope to see them."

Computer-Aided Manufacturing

Process Line Central (PLC)—an integrated network of two IBM System/360 Model 50s, fifteen 1800s, four 1130s and 76 typewriter and graphic display computer terminals —ties together more than five dozen

The competition between "Bill" Pfeffer, photo left, and Bill MacGeorge, center, photo right, is serious but friendly. "Bill" Pfeffer heads FET production at Sindelfingen. His rival, reviewing yield data with managers Jim Weston and Csilla Buturla, heads FET manufacturing at Burlington.

Control, Ultra-Clean Areas ufacture Memory Components

manufacturing processes.

IBM 1800 Data Acquisition and Control System computers are used to monitor and control the critical diffusion, photoresist, evaporation, inline test and sputtering operations.

In setting up PLC, Burlington implemented an IBM program product called Information Management System (IMS) to handle information processing needs for operating its bipolar and FET production lines.

Use of the computerized system accelerated the learning curve associated with introduction of a new product to the line, and real-time information feedback helped to improve FET yields dramatically within a very short time after full-scale production started.

Friendly Competition

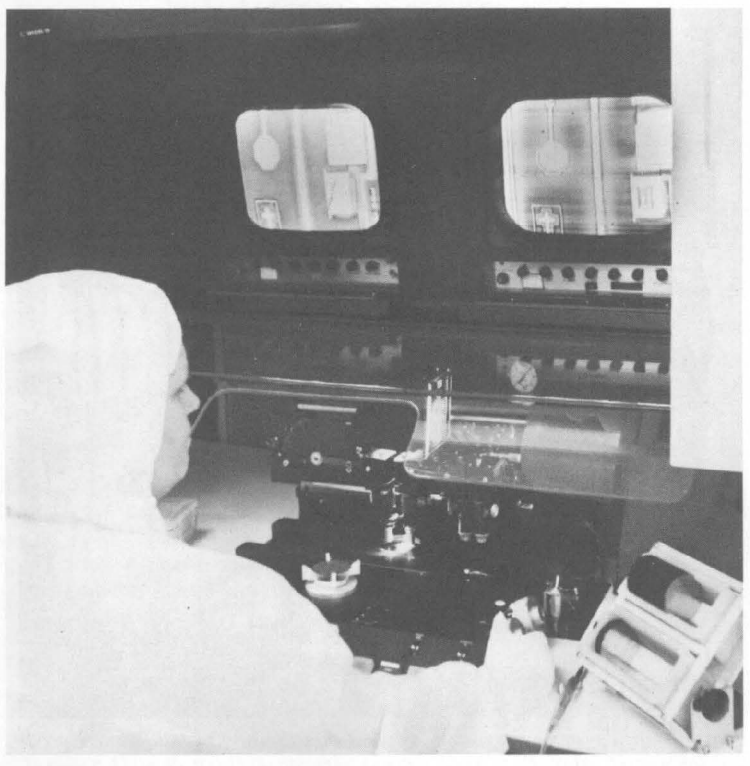
CD Burlington works closely with the Sindelfingen plant, which is producing FET memory components for Models 158 and 168 marketed outside the U.S.

About Burlington's close working relationship with the World Trade plant, MacGeorge says, "Their approach is quite similar to ours. We exchange information and compare data constantly. Each plant keeps the other informed about weekly yields or any trouble spots."

As might be expected, the two plants tend to compete with each other in meeting their product cost and yield objectives.

Wilhelm "Bill" Pfeffer, manager of memory manufacturing at Sindelfingen, cites the positive aspects of competing with Burlington: "It's a healthy competition, and it keeps us sharp. If you have no competition at all, you might say, 'I'm doing great.' But if I see somebody else moving up that learning curve, then I'd better get going because I know I can do better."

MacGeorge says, "Bill Pfeffer and I like to needle each other in a friendly way, and that's good. His people have an awful lot to offer. They do some things better than we do. And we do some things better. So having the appropriate cross-talk and exchange of information is mutually beneficial, and Bill and I both see it that way."



Even the microscope becomes impractical during certain steps in the manufacture of today's ultra-small, ultra-precise transistors. Here, at Burlington, Mrs. Leona Murray uses a television system that magnifies up to 750 times to align wafers during photolithographic process.

Multi-National Components Effort Extends Semiconductor Technology

"Today's announcement of new equipment and programming support for our product line is the direct result of a large multi-national development activity," said Dr. John W. Gibson, IBM vice president and Components Division president.

"For several years now, CD has funded development missions at Essonnes, France, and at Boeblingen, Germany. Today, now that the security wraps have been removed, we can finally acknowledge the efforts and successes of these European teams along with those of their American counterparts at Burlington, East Fishkill, Endicott and Manassas.

"The big technical news, of course, is the use of MOSFET technology in the main memories of Models 158 and 168. But equally important is the mix of new advanced bipolar monolithic circuit technologies in these computers. The fact that these technologies are in high-volume production is a real achievement for the Components Division," Gibson said.

MOSFET Memory Building Blocks

For main memory usage in Models 158 and 168, four 1024-bit MOSFET (metal oxide semiconductor field effect transistor) chips are mounted two each on double-stacked one-half-inch ceramic substrates to provide 4096 bits of storage on each memory array module. (Eight bits make up one byte. Each byte can represent one character or letter or two numbers.)

The FET memory chips, developed by engineers at East Fishkill, Burlington and Boeblingen, are produced at Burlington and Sindelfingen, Germany. Pluggable memory array modules—fabricated by joining the memory chips to substrates and then sealing them in protective aluminum covers—are produced at Burlington and Sindelfingen.

Memory array modules are then sent to Poughkeepsie and Hanover, Germany, for higher level packaging assembly. There, modules are soldered to multi-layer pluggable cards.

Each memory card contains FET array and bipolar support circuit modules. The support modules, developed at Boeblingen and manufactured at Burlington and Sindelfingen, assure compatibility between the FET main memory circuit and associated bi-polar buffer and control storage units.

Customer Benefits

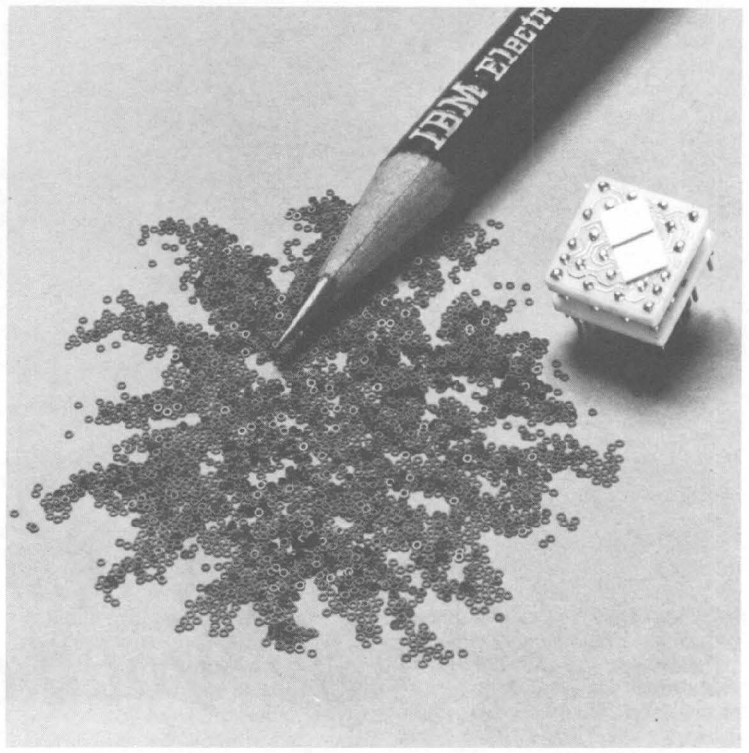
The ultimate beneficiary of IBM's successful international effort to develop and produce FET memory technology is the IBM customer.

Bob Crosby, program system Model 168 manager, SDD Poughkeepsie, cites these contributions of FET storage to Models 158 and 168: "The most readily apparent benefit to a customer is the dramatic reduction in space required for main storage. Compared to a Model 165 with three megabytes of core storage, a Model 168 with an internal capacity of up to four megabytes of FET storage yields a floor space reduction of 55 percent.

"FETs give us increased performance over the old core technology," Crosby says. "The new FET storage transfers data up to four times faster than the 165 core memory."

Early Manufacturing in Lab

During 1971, Paul Castrucci managed a development/manufacturing group in the East Fishkill laboratory



This one-half-inch-square MOSFET memory array module stores 4096 bits of information, equivalent to the number of magnetic cores shown in foreground.

whose efforts accelerated the transition of FET memory components from development to full-scale production.

"We went far beyond the usual pilot line concept," says Castrucci. "Instead we put in place an early manufacturing center of about 300 people and organized a streamlined components production line. Our group took the basic technology that came from the Research Division at Yorktown Heights and worked closely with Bob Elfant's FET product program team. We refined the design, process, tooling and testing routines and wound up with a fully qualified, documented line that produced millions of bits of FET memory. The successful efforts of the East Fishkill group helped Burlington and Sindelfingen set up their production lines and get off to a running start."

Denser MST Logic Modules

Monolithic Systems Technology (MST) logic circuit modules, similar to those used in other IBM System/370 computers, are employed widely throughout Models 158 and 168. Typical modules contain about six logic circuits which operate in the four to eight nanosecond range.

Two developments—one in France, the other in the U.S.—resulted in circuit density improvements.

Etienne Paris, component development manager at Essonnes, describes the contribution of the French group: "We accepted the cost-reduction mission of trying to put more circuits on a single module. Our approach was to interconnect two or three standard MST chips on the module. By designing the module layouts more efficiently, we were able to increase the average number of circuits to eighteen."

Jim Corrigan, MST product program manager, East Fishkill, says, "Our engineers designed a brand new chip, one that can contain up to 25 circuits. Eighteen circuits is about average, though. And we can put two of these chips in a module."

Both versions of the denser MST modules are used for specialized circuit functions in the Model 168 and in the Model 158 console and central processing unit.

Boeblingen Lab Contributions

"In addition to their work in FET memory development, our engineers also developed the high density buffer and did the early development of the MST-A 1024-bit read-only storage component," says Fritz Haist, manager of the Boeblingen component development laboratory. "Both technologies are being used for high-speed applications in the 158 and 168."

In the 158, MST-A performs code conversion and certain high-speed logic functions. In the 168, it provides 20 percent more storage capacity in about one-third the space formerly required by a capacitor read-only storage unit.

The high density buffer (HDB) components are used for store protect arrays in the 158 and 168. A system security feature, the HDB modules contain a series of coded parameters, or "keys," to lock out unauthorized users and prevent access to information contained in main memory.

MST-A and HDB components are manufactured on the MST line at East Fishkill.

Analog Circuitry in Power Supplies

Analog circuit components, developed at Manassas and fabricated at East Fishkill and Essonnes, appear in IBM's new line of power supplies.

Called transistor switching regulators (TSRs), these improved power units are used to supply power to the FET storage and logic function in the 158 and 168.

Each TSR uses analog circuit modules to perform pulse width modulation, operational amplifier and prime power protect functions.

"The Manassas technology helped us to keep the TSRs as compact as possible," says John Cielo, an engineering manager in the SDD Kingston power products area. "The earliest TSR analog circuit designs specified 79 discrete components to be mounted on a printed circuit card. We saved considerable space and reduced our costs by squeezing all those components into three one-half-inch modules."

Major Advances...

(Continued from page 1)

larly scheduled processing or waiting for time on the computer. Virtual storage allows teleprocessing applications to be designed so that main storage can be allocated more efficiently in meeting terminal users' demands for computing time. Rush jobs, such as a management report, can be run without interrupting other processing.

The new flexibility provided by virtual storage also can simplify the design and programming of complex computer applications. In a conventional system, a programmer often must spend time structuring his program to "telescope" it into a limited portion of storage allocated to his job. With virtual storage, he can write his program with little concern about the size limitations of main storage. He can thus concentrate on the application itself, leaving the management of main storage to be handled automatically.

New IBM Storage Technology

System/370 Models 158 and 168 are the first IBM computers to have main storage circuits using monolithic MOSFET technology.

This circuit technology contributes to improved data processing performance over similarly programmed and configured Models 155 and 165 —which use core storage—while permitting the new models to remain within the same price range.

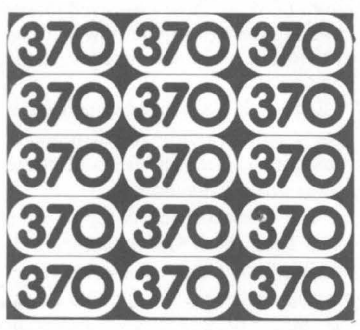
Both new models, as well as the smaller-scale Models 135 and 145, will be able to operate with the company's most advanced disk storage devices—the 3330 series—through use of optional integrated control features. These features add to System/370's economy for applications requiring a large data base.

The Model 158 executes instructions at a rate 20 to 40 percent faster than a Model 155 that is similarly programmed and configured. Its main storage capacity ranges from 512,000 to two million characters of data. The console features a TV-like display with an electronic "light pen" the operator can use to communicate with the system.

The larger-scale Model 168 executes instructions at a rate 10 to 30 percent faster than a comparable Model 165. Its main storage size ranges from one million to four million characters of data, one-third larger than the maximum capacity of the Model 165.

The Model 158 will be manufactured at IBM Poughkeepsie, where it was developed, and at WT plants in Montpellier, France, and Fujisawa, Japan. The Model 168, also developed at Poughkeepsie, will be manufactured at IBM Kingston, and Havant, England.

New Symbol Designed



The System/370 advanced function design symbol, above, appears on material related to the announcement. Its oval designs suggest paging, a basic element of virtual storage.

The design was created by DPD Art Director Jack Reich.

Typifying the widespread development effort behind today's announcement, (left to right) Takeshi Satoh, IBM Japan; Thomas Moss, SMD; Emmanuel Ifeduba, SDD, and Kenneth Meyers, SDD, work together checking out the machine and programming functions of the new Model 158 at Poughkeepsie.

'Accomplishment to be Proud of'—Evans

Behind today's announcement is a package of leading edge innovation representing contributions from virtually every Systems Development Division laboratory. Each new system stands as a tangible accomplishment of the long development effort to offer virtual storage capability.

Aggressive Performance

Bob O. Evans, IBM vice president and president of SDD notes: "Schedules were set and met aggressively. The programming and engineering development teams can be proud of their accomplishments in this extension to System/370."

And from Peter Fagg, SDD director of systems development: "My thanks and congratulations go to the many people throughout IBM who worked so hard to make this very significant announcement, which we believe will offer our customers an important step forward in data processing."

Ted E. Climis, SDD director of programming, calls the achievement of virtual storage "impressive." With all the added programming components and functions, one element remains unchanged, Climis points out: "Just as we were successful in making 370 a growth system from 360, now once again we have provided the basis for improved operating systems with that necessary ingredient—compatibility."

System responsibilities for the Model 135 and 145 were focused in SDD Endicott under System Manager John Keffer. Models 158 and 168 were the prime responsibility of Burt Goldberg at SDD Poughkeepsie.

Improvements—Seen and Unseen

One highly visible improvement among the products announced today, according to Arthur A. Peterson, program systems manager for the Model 158, is the 158's display console. The console includes a cathode ray tube (CRT) as a visual communications link between the operator and the system. Familiar switches, buttons and lights have been largely replaced by character names displayed on the console screen. The operator can execute all console functions by touching a light pen against a control character on the display.

Another advancement, this one invisible to users of the Model 158 and 168, boosts system efficiency from a power and space point of view. It's a new breed of power supply called the Transistor Switching Regulator, or TSR, that packs twice the power efficiency of conventional supplies into half the size and one-fifth the weight. Still other advantages: 50/60-Hertz interchangeability, cost savings, improved serviceability and more protection from brownouts and other power line disturbances.

Work on the TSR family of power supplies, which converts AC line power directly into DC without traditional magnetic and filter components, began more than three years ago in SDD's Kingston laboratory. One member of the family, developed at San Jose, represents the high performance end of the line, with tightly regulated voltages and the highest current capacities yet developed for any IBM product.

Other "unseen" San Jose developments announced today make the high performance 3330 disk storage unit more economically feasible for most System/370 models.

Cooperative Effort

Robert E. Crosby, program system Model 168 manager, credits the experience of development groups and the cooperative efforts of Product Test, Systems Manufacturing Division and Field Engineering Division with much of the success of the development effort.

"At the beginning of our efforts, SDD was committed to other projects. The immediate experience of the design team was ably supplemented by the varied experience of SMD, FE and Product Test engineers," explains Crosby. "Their different experiences helped us optimize design features so as to facilitate test, manufacture, installation and maintenance stages in the system's migration from designer to customer. In addition, we are finding their design experience is simplifying the complex task of moving a system through test and manufacture. I'm confident ease of installation and maintenance will also be traceable to this design experience."

Summing up development effort, Mr. Evans said, "This achievement underlines the realization that complex challenges can be met when diverse groups are given the opportunity to pool their resources, move toward a common objective and create a better product for the customer."

From Uithoorn to San Jose

New Operating Systems Were Multi-Lab Effort

An SDD programming effort that spanned two continents produced three of the System Control Programs announced today.

Responsibility for planning, coordinating and integrating the components into efficient and reliable systems rested with three laboratories. But all SDD Programming Centers contributed to the effort, producing their share of code for the new operating systems.

Uithoorn

James H. Frame, DOS programming systems manager, Uithoorn, The Netherlands, recalls that DOS responsibility came to Uithoorn in 1970.

"We had the unique task of picking up full maintenance responsibility for DOS and almost at the same time development responsibility for DOS/VS. New procedures were established so that at given checkpoints an evaluation could be made of how each SDD location's contribution was fitting into the overall system," notes Frame.

The relocate component in the DOS/VS control program was developed by the Boeblingen, Germany, laboratory in close cooperation with Uithoorn.

Endicott

SDD Endicott was the focal point for OS/VS1. T. Richard Hunter, programming systems manager, has a retrospective view of OS/VS1 development that reflects some of the challenge that was constant over the two-year-plus development cycle.

"The main thrust of our development effort was to extend the solid base of OS/MFT to support all of the capabilities of virtual storage while maintaining compatibility wth OS/MFT. We wanted to make OS/VS1 a true growth system so that OS/MFT can be executed under OS/VS1 without change."

Poughkeepsie

Martin A. Belsky, OS/VS2 system manager, Poughkeepsie, had a similar vantage point during OS/VS2 development.

"Upward compatibility was a must," says Belsky, "but of equal importance were high reliability, perfo-mance and function. We never lost sight of these objectives as our requirements changed through the development process. The concern for quality in each SDD programming center was evident in the code and components we received."

Key Components

Among the many components that make up an operating system, a new one is listed as the result of extensive efforts at the SDD San Jose Programming Center. Virtual Storage Accessing Method (VSAM) is the first major revision in direct access programming over the past six years. It is designed specifically to operate in a virtual storage environment.

In addition to VSAM, the San Jose center delivered more than 250,000 lines of code to each new operating system, involving 20 components. To help accomplish this, the San Jose team developed a form of design automation using a common source library of program modules.

Kingston

Using the wealth of experience gained in TSS, the Kingston Programming Center developed the Virtual Storage Supervisor (VSS), another key segment of the virtual storage operating system. As its name implies, VSS serves as a resource manager, establishing priorities once a program is entered into a system.

Another Endicott contribution is Job Entry Subsystem (JES), a system control program facility designed to get jobs into and out of the system as quickly as possible.

A lot of skilled systems programming went into the new virtual storage products announced today. Here Mike Capani, clerical specialist at SDD Endicott, adds another volume to a library that contains assembled listings of the more than 1.5 million lines of code making up the OS/VS1 operating system developed at Endicott with support from other SDD programming centers in the U.S. and Europe.

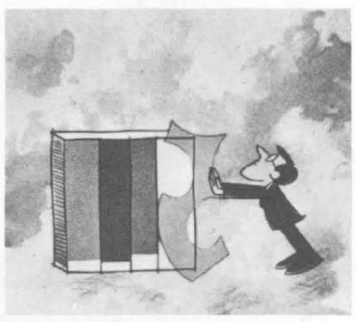
Virtual Storage . . .

(Continued from page 1)

real storage and external page storage is termed *demand paging.*

Demand paging can take place because all instructions and data are referenced by their virtual storage addresses—regardless of whether, at a given time, they occupy real storage or not.

When an instruction or a data record is referenced by a program, the System/370's DAT facility automatically breaks the virtual storage address into segment number, page number within segment, and the posi-

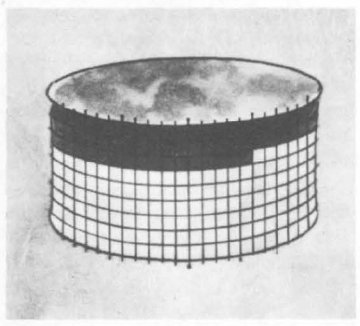


Until now, programmers expended much creativity tailoring and fitting programs to the rigid restrictions of the computer's main memory . . .

tion of the instruction or record with regard to the beginning of the page.

Segment tables and page tables maintained by the system control programming indicate whether the needed page is already in real storage. If this is the case, execution of the program continues. If the page does not exist in real storage, then paging takes place under supervision of the system control programming.

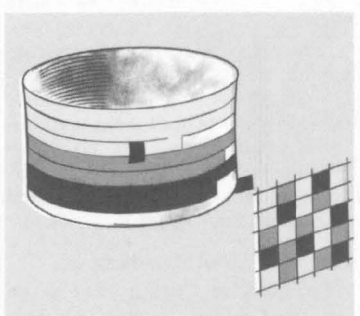
To speed program execution, the dynamic address translation facility contains a *translation lookaside buffer,* which holds the addresses of previously referenced pages located in real storage. If the real storage loca-



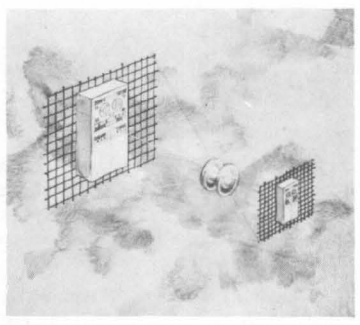
With virtual storage, the computer stores the program—however big or complex—on direct access disks, and divides it into pages . . .

tion of a referenced page is found in this manner, a search of segment and page tables is not required.

Essentially then, virtual storage is a means of managing a computer's main storage dynamically so that a program—or more than one in a multiprogramming environment—



. . . which can be called to main memory, used, and returned instantly and in any required sequence—all under computer management.

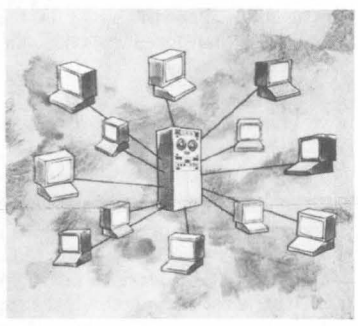


Like a lens that projects an enlarged image, VS projects a main storage capacity greater than the computer's real storage.

can be run on a computer even though total program size exceeds main storage capacity.

The new flexibility provided by virtual storage can help a computer user's staff to make more productive use of their time both in carrying out existing data processing applications and in developing new ones.

Special, high-priority jobs, for example, can be run immediately, without disrupting operations. In some instances this would add a few minutes to the total running time of the regular programs, but in a typical application the additional time



The effect is greater productivity for the computer and the programmer who is now free to innovate and explore new data processing ideas.

should make little impact upon the departments served by the programs.

Besides providing increased flexibility in day-to-day operations, virtual storage may enable the user to develop and implement large-scale applications earlier and more smoothly.

A programmer writing an application program can spend less time coping with main storage size limitations; he no longer has to create special techniques to "telescope" the program into a limited amount of main storage. Allowed to concentrate on the application itself, he can produce new programs more quickly and —equally as important—can alter and expand programs more easily because of the straightforward manner in which they can be written.

Film Credits

The illustrations for this explanation of virtual storage are taken from a 10 minute animated color film produced by the Data Processing Division with assistance from the Systems Development Division.

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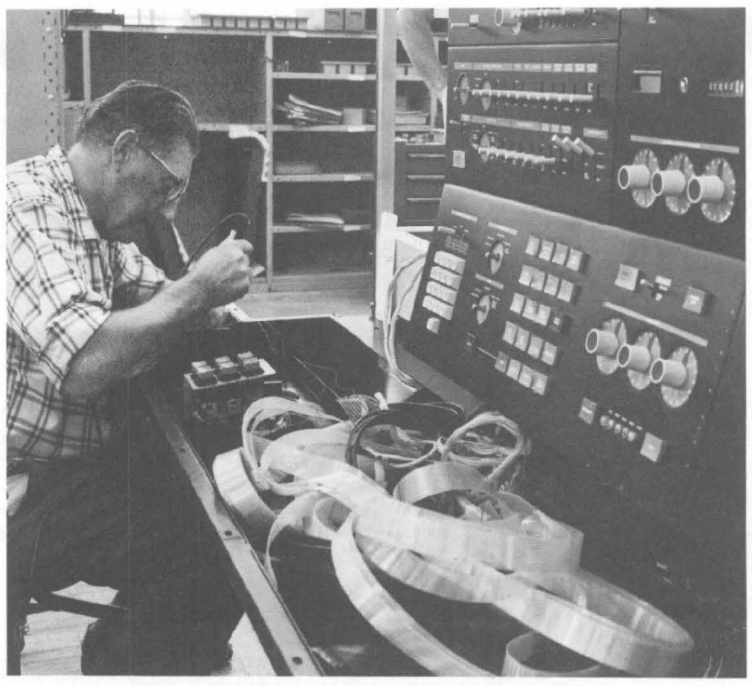

At the Kingston plant, final assembler Carl Sweet makes a solder connection during the wiring of the Model 168 console.

Poughkeepsie and Kingston Responsible for New Systems

"The new products," said Ray F. Boedecker, Systems Manufacturing Division president, "represent a significant step forward in our manufacturing and marketing operations, and provide new opportunity and challenge for our plants."

Although every SMD plant will eventually supply units and sub-assemblies for the computers announced today, final systems responsibility and the bulk of the workload fall on the plants in Poughkeepsie and Kingston. Both of these veteran locations are ready for full-scale production.

Poughkeepsie, which has been involved in IBM manufacturing "firsts" since the mid-40's, will build and test the central processing units for the Model 158, and will have responsibility for the memories in that system.

Poughkeepsie Plant General Manager Louis Voerman welcomed the additional responsibility, stating, "most of our production effort, in fact, will now be in support of the new systems.

"The memories," Mr. Voerman continued, "move us into an entirely new technology in the manufacture of the FET monolithic memory cards. We have the same responsibility for bipolar monolithic memories and we also will manufacture the transistor switching regulator power supplies used in the new systems."

Close Cooperation

In tooling-up for production, Poughkeepsie manufacturing engineering and manufacturing people worked closely with design and development people—both in CD and SDD. Significant new manufacturing processes were established to support the fabrication, assembly and test of these new products.

Curtis K. Smoyer, Poughkeepsie new products manager, was quick to recognize "the vital role played by people in the production control, procurement, information systems, quality, industrial engineering, new products and financial functions. Without our unusually early involvement and unique degree of manufacturing interplay, we would not be able to meet our scheduled shipment dates."

Production of the Model 168 becomes a responsibility of IBM Kingston. Frank Delaney, general manager, describes production as "bulging at the sides." Thus far this year, the Kingston location has shipped its first Model 135 the 3270 Information Display Terminal System and the 7414 Interactive Console.

Mr. Delaney further commented that, "This is a healthy sign. We are fortunate to have people who can handle the job."

Kingston Produces 168

Kingston will build and test the Model 168 including the assembly and test of its bipolar ROS (read only storage), and the MOSFET main memory.

People from Kingston manufacturing and manufacturing engineering areas joined the Poughkeepsie development team over a year ago.

According to Frank Weller, assistant for new products in Kingston, "Products using today's technologies dictate the need for virtually all organizations to achieve a high degree of involvement early in the product cycle. It goes without saying that the Model 168 would not have been possible without the high level support received from the many departments within the Kingston plant."

Field Engineering Accepts Challenge Of New Systems

The introduction of advanced programming concepts—virtual storage and virtual machine—give System/370 vastly broader levels of functional uses not previously available to IBM customers. As these systems become even more productive, customer demands for greater assurances of reliability, availability and serviceability will increase. "Field Engineering," said O. M. Scott, IBM vice president and president of FE, "is ready for the challenge."

To help meet those demands, the varied skills and experiences of people in FE Field Support locations and development groups in SDD, SMD and DPD were applied. Their efforts produced the advanced programming aids needed to support and maintain the expanded capabilities of virtual storage and virtual machines.

Maintenance Tool Developed

Debugging of Operating System/Virtual Storage is made easier for the program systems representative through a new maintenance tool called Dynamic Support System. DSS contains a comprehensive set of commands and functions for debugging almost any part of the system control program or any program operating in a control environment.

DSS uses the program event recording facility of the central processing unit to interrupt normal program operations and to gather, check or modify program data at specified points in the program being run. Once activated, DSS allows the program systems rep to make alterations to data in virtual or real storage and in the system's general purpose registers. It also provides a method of recording data for problem analysis and repair of indicated failures.

Problem determination in the OS/VS environment is aided by a console capability that permits the program systems rep or customer operators to request a complete or selected partial printout of data in virtual or real storage.

FE Field Support people also were involved in the development of four significant system control programs announced today. They are: Operating System/Virtual Storage 1 (OS/VS 1); OS/VS 2; Disk Operating System/Virtual Storage (DOS/VS); and Virtual Machine Facility/370 (VM/370).

Field Support people who played a key role in FE's involvement with the development of Operating System/Virtual Storage 1 and OS/VS 2 are: seated, Jean Tilton, administration analyst, and Chuck Zeig, course development specialist; standing, Service Planning Representatives Chuck Hofmann, Hank Buterbaugh and Clarence Sappington.