Control Data Cyber 70 Series

CDC's new Cyber 70 computers, though quite similar to the earlier 6000 Series and 7600 systems, offer hardware and software improvements, new peripheral equipment, and mainframe price reductions that should keep CDC in the vanguard among large-scale computer builders.

MANAGEMENT SUMMARY

The Cyber 70 Series consists of four computer systems which are updated and improved versions of Control Data's earlier large-scale systems, the 6000 Series and 7600. The four systems span a broad range of performance capabilities, from medium-scale to ultra-large-scale, and are well suited for a variety of applications: business or scientific, batch or on-line, local or remote.

Introduced in March 1971, the Cyber 70 systems are scheduled for initial customer deliveries early in 1972. Monthly rentals will range from approximately $20,000 to well over $200,000 per month, with purchase prices ranging from about $900,000 to over $10,000,000.

The four Cyber 70 computers are closely related to their predecessors. In fact, Model 76 is nearly identical with the superfast CDC 7600, while Models 72, 73, and 74 are improved versions of the earlier CDC 6200, 6400, and 6600, respectively.

The Cyber 70 computers bring no new breakthroughs in hardware or software technology. Instead, they preserve all the distinctive architectural features that made the CDC 6000 systems the most respected large-scale computers of the sixties. These time-tested characteristics, ▷

CHARACTERISTICS

MANUFACTURER: Control Data Corporation, 8100 34th Avenue South, Minneapolis, Minnesota 55420.

MODELS: Cyber 70 Series, Models 72, 73, 74, and 76.

DATA FORMATS

BASIC UNIT: 60-bit word in main storage and Central Processors; 12-bit word in Peripheral Processors and I/O channels.

FIXED-POINT OPERANDS: 60 or 18 bits in Central Processors; 6, 12, or 18 bits in Peripheral Processors.

FLOATING-POINT OPERANDS: One 60-bit word, consisting of 48-bit-plus-sign fraction and 11-bit exponent. (Unrounded floating-point operations generate double-precision results, and the upper and lower halves, each consisting of a 48-bit fraction and 11-bit exponent, can be separately recovered.)

INSTRUCTIONS: Central Processor instructions are 15 or 30 bits in length; each 60-bit word holds 2 to 4 instructions. Most 15-bit instructions consist of a 6-bit operation code and three 3-bit register designators. Most 30-bit instructions consist of a 6-bit operation code, two 3-bit register designators, and an 18-bit operand address.

Peripheral Processor instructions are 12 or 24 bits (1 or 2 words) in length. The 12-bit format consists of a 6-bit operation code and a 6-bit operand address or literal operand. The 24-bit format consists of a 6-bit operation code and an 18-bit operand address or literal operand.

INTERNAL CODE: 6-bit BCD is standard "display code."

MAIN STORAGE

STORAGE TYPE: Magnetic core.

CAPACITY: In Models 72, 73, and 74: 32,768, 49,152, 65,536, 98,304, or 131,072 60-bit words in 4096-word banks. (Dual-processor systems require at least 65K.) In Model 76 (SCM): 32,768 or 65,536 60-bit words in 2048-word banks.

CYCLE TIME: In Models 72, 73, and 74: 1.0 microsecond per word. In Model 76: 275 nanoseconds per word.

MAXIMUM DATA RATE: In Models 72, 73, and 74: 10 million words/second (achieved through bank interleaving, in systems with at least 65K words). In Model 76: 36 million words/second. ▶

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along with numerous evolutionary improvements in both the hardware and software, should be good enough to keep the Cyber 70 systems fully competitive with the System/370 and the other current large-scale computers.

BACKGROUND

A full understanding of the Cyber 70 computers requires some knowledge of their predecessors, the CDC 6000 Series and 7600. The initial member of the family, the powerful 6600, went into successful operation early in 1965. The slower and considerably less expensive 6400 was initially delivered in May 1966. The 6500, a dual-processor version of the 6400, followed in December 1967. Control Data delivered the first 6700, a dual-processor configuration of the 6600, in July 1970. The 6200, a slower, lower-priced version of the 6400, rounded out the 6000 Series lineup in November 1970. Approximately 200 of the 6000 Series computers are currently in use around the world.

All of the 6000 Series computers are built around the concept of one or two powerful Central Processors and a fast central memory serviced by multiple independent Peripheral Processors and I/O channels. The Peripheral Processors handle all input/output and system control functions, enabling the Central Processors to concentrate exclusively on computational tasks. Moreover, the 6600 Central Processor has ten independent functional units for concurrent execution of various types of instructions, as well as an 8-word instruction stack that minimizes instruction access times. (The smaller 6000 Series Central Processors lack these features.)

In addition to their multi-processor architecture, the 6000 Series computers also feature multiple levels of memory. Each Central Processor includes 24 operating registers that hold operands, addresses, and address increments; these registers, supported by an efficient repertoire of short instructions (15 and 30 bits), greatly reduce the number of core storage references required to execute most programs. The central memory, accessible to both the Central Processor and Peripheral Processors, contains from 32K to 131K 60-bit words of 1-microsecond core storage in 4K banks. Each Peripheral Processor also has an integral 1-microsecond core storage unit containing 4K 12-bit words. An optional Extended Core Storage unit provides from 125K to 201K 60-bit words of storage whose contents can be transferred to or from central memory at rates up to 10 million words per second. Finally, the 6000 Series offers both on-line and off-line storage on a wide choice of disk and tape drives.

During 1969 Control Data successfully installed the first two CDC 7600 systems, the most powerful computers currently in operation. The 7600 retains the basic architectural features of the 6600 and provides approximately four times the computational power. It includes both a ▷

CHECKING: Five parity bits with each word are checked whenever storage is referenced in Model 76; no parity checking in Models 72, 73, and 74.

STORAGE PROTECTION: Any attempt to reference an address outside the established main storage boundaries for the currently active program results in an interrupt.

EXTENDED CORE STORAGE

STORAGE TYPE: Magnetic core.

CAPACITY: In Models 72, 73, and 74: 0, 125,952, 251,904, 503,808, 1,007,616, or 2,015,232 60-bit words in 125,952-word banks. In Model 76 (LCM): 256,000 or 512,000 60-bit words in 64,000-word banks.

CYCLE TIME: In Models 72, 73, or 74: 3.2 microseconds per 480-bit (8-word) record. In Model 76: 1.76 microseconds per 480-bit (8-word) record.

MAXIMUM DATA RATE: In Models 72, 73, and 74: 10 million words/second (achieved through bank interleaving, in systems with at least 503K words). In Model 76: 36 million words/second (in 512K systems).

CHECKING: Parity bit with each 60-bit word is checked whenever storage is referenced.

STORAGE PROTECTION: Any attempt to reference an address outside the established ECS boundaries for the currently active program results in an interrupt.

PERIPHERAL PROCESSOR STORAGE

STORAGE TYPE: Magnetic core.

CAPACITY: 4096 twelve-bit words in each Peripheral Processor (divided into two independent 2048-word banks in Model 76 systems).

CYCLE TIME: 1.0 microsecond per 12-bit word in Models 72, 73, and 74; 275 nanoseconds per 12-bit word in Model 76.

CENTRAL PROCESSORS

CONFIGURATION RULES: A Model 72, 73, or 74 system can have one or two Central Processors; a Model 76 system is limited to one. In dual-CP Model 74 systems, the second CP is a unified, Model 73-type processor.

FUNCTIONAL UNITS: Each Model 72 and 73 Central Processor has a single, "unified" arithmetic unit that executes all instructions. The Model 74 CP has 10 independent functional units that can operate concurrently, including two Increment units, two Multiply units and one of each of the following: Add, Long Add, Shift, Divide, Boolean, and Branch. The Model 76 CP has 9 independent functional units: Increment, Floating Multiply, Floating Divide, Floating Add, Long Add, Shift, Boolean, Normalize, and Population Count (which counts the number of 1 bits in a word).

REGISTERS: Every Cyber 70 Central Processor has a total of 24 operating registers: eight 60-bit operand (X) registers, eight 18-bit address (A) registers, and eight 18-bit index (B) registers. The X registers hold operands and results. Five of these registers (X1 to X5) hold operands read from main storage and two (X6 and X7) hold results to be sent to ▶

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CHARACTERISTICS OF THE LARGE-SCALE CONTROL DATA COMPUTERS

	Model 72	Model 73	Model 74	Model 76	CDC 6200	CDC 6400	CDC 6500	CDC 6600	CDC 6700	CDC 7600
MAIN STORAGE										
Word size, data bits	60	60	60	60	60	60	60	60	60	60
Cycle time, microseconds	1.0	1.0	1.0	0.275	1.0	1.0	1.0	1.0	1.0	0.275
Minimum capacity, words	32,768	32,768	32,768	32,768	32,768	32,768	65,536	32,768	65,536	32,768
Maximum capacity, words	131,072	131,072	131,072	65,536	65,536	131,072	131,072	131,072	131,072	65,536
EXTENDED CORE STORAGE										
Word size, data bits	60	60	60	60	60	60	60	60	60	60
Cycle time, microseconds	3.2	3.2	3.2	1.76	3.2	3.2	3.2	3.2	3.2	1.76
Words fetched per cycle	8	8	8	8	8	8	8	8	8	8
Minimum capacity, words	125,952	125,952	125,952	256,000	125,952	125,952	125,952	125,952	125,952	256,000
Maximum capacity, words	2,015,232	2,015,232	2,015,232	512,000	2,015,232	2,015,232	2,015,232	2,015,232	2,015,232	512,000
CENTRAL PROCESSORS										
No. of processors	1 or 2	1 or 2	1 or 2	1	1	1	2	1	2	1
Functional units/processor	1	1	10*	9	1	1	1	10	10*	9
Instruction stack	No	No	8 words	12 words	No	No	No	8 words	8 words	12 words
Typical speed, instructions/sec:										
Single processor	900,000	1,200,000	3,000,000	15,000,000	900,000	1,200,000	–	3,000,000	–	15,000,000
Dual-processor system	1,500,000	2,000,000	3,700,000	–	–	–	2,000,000	–	3,700,000	–
PERIPHERAL PROCESSORS										
No. of processors	10 to 20	10 to 20	10 to 20	6 to 13	7 to 10	7 to 20	10 or 20	10 or 20	10 or 20	6 to 13
Word size, data bits	12	12	12	12	12	12	12	12	12	12
Cycle time, microseconds	1.0	1.0	1.0	0.275	1.0	1.0	1.0	1.0	1.0	0.275
Storage capacity, words/PPU	4,096	4,096	4,096	4,096	4,096	4,096	4,096	4,096	4,096	4,096
NO. OF I/O CHANNELS	12 to 24	12 to 24	12 to 24	7 to 15	9 to 12	9 to 22	12 or 22	12 or 22	12 or 22	7 to 15

*Second CP in Model 74 and 6700 systems is a "unified" processor of the type used in Model 73 and 6400 systems.

"small core memory" (SCM) with 32K or 65K 60-bit words of 275-nanosecond storage and a "large core memory" (LCM) with a capacity of 256K or 512K 60-bit words and a maximum data rate of 36 million words per second. A significant configuration difference is that each of the 6 to 13 Peripheral Processors is permanently connected to a specific I/O channel in the 7600 system, whereas the 6000 Series Peripheral Processors can utilize any available I/O channel.

CYBER 70 IMPROVEMENTS

As the accompanying table clearly indicates, the overall characteristics of the Cyber 70 Models 72, 73, 74, and 76 are strikingly similar to those of the earlier CDC 6200, 6400, 6600, and 7600, respectively. But the new models offer some worthwhile new features that significantly improve their power and flexibility.

New facilities of the Model 72, 73, and 74 processors include:

- An Interlock Register, containing 64 or (optionally) 128 bits, whose individual bits can be set or tested by the Peripheral Processors to facilitate I/O channel reservations, system interlocks, and inter-processor communications.

- Four Compare/Move instructions (in Models 72 and 73 only), which permit high-speed move and comparison operations on strings of 6-bit characters and should greatly improve performance in business data processing applications.

main storage. Data is automatically transmitted between main storage and an X register whenever an address is placed into the corresponding A register. The AO and XO registers have no connection with main storage and can be used to hold intermediate results. Seven B registers (B1 through B7) serve as index registers, while the eighth (BO) provides a constant zero value.

INDIRECT ADDRESSING: Not used in the Central Processors.

INSTRUCTION STACKS: The Model 74 Central Processor has a stack of eight 60-bit registers which hold from 16 to 32 instructions, minimizing the number of memory references required to access repetitive sequences of instructions. Model 76 has a 12-word instruction stack. Models 72 and 73 have a single 60-bit instruction buffer register.

INSTRUCTION REPERTOIRE: Consists of about 75 basic instructions divided into the following functional categories: 18 Branch and Control, 8 Boolean, 9 Shift, 6 Floating Add/Subtract, 2 Long Add (integer sum and difference), 4 Multiply, 3 Divide, 24 Increment, and 1 Pass (no operation). In addition, Models 72 and 73 have 4 additional Compare/Move instructions to handle operations on variable-length strings of 6-bit characters, and Model 76 has 9 additional Control and I/O instructions.

Arithmetic facilities include floating-point addition, subtraction, multiplication, division, and normalization; 60-bit fixed-point addition, subtraction, and multiplication (with division handled as a special case of floating-point division); and 18-bit fixed-point addition and subtraction (for address arithmetic).

INSTRUCTION TIMES: Execution times, in microseconds, for representative instructions are listed below. Note that the concurrent operation of the multiple functional units in Models 74 and 76 leads to higher overall performance than

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- An Integer Multiply instruction, which permits convenient multiplication of short integers and is particularly advantageous in FORTRAN subscript computations.

- New Monitor Exchange Jump instructions, which provide more flexibility in system control functions.

- A Central Memory Access Priority (CMAP) feature, which gives a designated Peripheral Processor priority over the others in accessing main storage and helps to ensure the optimum utilization of Extended Core Storage.

- Improved instruction stack operations (in Model 74 only), which result in faster execution of some instruction sequences.

In addition, Models 72, 73, and 74 place a substantially stronger emphasis upon the effective utilization of Extended Core Storage (ECS) than did their Series 6000 predecessors. The optional ECS subsystem consists of from one to sixteen 125,952-word storage banks, a controller, and one or more Distributive Data Paths (DDP's). Each DDP connects to an I/O channel and provides a new data path between ECS and the rest of the system. It permits direct access to ECS by a Peripheral Processor, thereby reducing the data traffic through the main storage unit. In a multi-computer installation, separate Cyber 70 systems can share a single ECS unit, accessing it through both main storage and I/O channels (via DDP's).

The Cyber 70 computers use the same discrete-component circuit technology as their predecessors, in contrast to the integrated circuits found in most of the competitive systems. Control Data defends its position by stressing that the speed, cost, and reliability of the circuits, rather than the packaging technique, are the factors that count—a point that few prospective users are likely to dispute.

Like its competitors, Control Data is placing increasing emphasis upon system reliability, recoverability, and maintainability. Although the Cyber 70 computers lack the advanced hardware diagnostic facilities of the IBM System/370, they include a variety of hardware/software safeguards to detect and attempt recovery from transient failures. The Cyber 70 software also provides dynamic error logging and periodic execution of on-line diagnostic programs. Moreover, most of the system components can be duplexed to provide for "fail-soft" operation.

PERIPHERAL EQUIPMENT

The Cyber 70 computers utilize most of the existing Series 6000 and 7600 peripheral devices. Control Data manufactures one of the industry's broadest lines of peripheral equipment and enjoys a thriving business as a ▷

might be inferred from the times listed here. (Also see the typical speeds, in instructions per second, in the table on the preceding page.)

	Model 72, CDC 6200	Model 73. CDC 6400, CDC 6500	Model 74, CDC 6600, CDC 6700	Model 76, CDC 7600
Fixed-point add/subtract	0.90	0.60	0.30	0.055
Floating add/subtract	1.40	1.10	0.40	0.110
Floating multiply	6.00	5.70	1.00	0.138
Floating divide	6.00	5.70	2.90	0.550
Logical sum/difference	0.80	0.50	0.30	0.055
Load register	0.90	0.60	0.30	0.055
Test and branch	0.80 to 1.60	0.50 to 1.30	0.80 to 1.50	0.055 to 0.303

INTERRUPTS: Three types of error conditions and one external condition cause Central Processor interrupts: address out of range (i.e., storage protection violation), operand out of range (i.e., exponent overflow), indefinite result, and execution of an Exchange Jump instruction by a Peripheral Processor or Central Processor.

PERIPHERAL PROCESSORS

CONFIGURATION RULES: A Model 72, 73, or 74 system can include 10, 14, 17, or 20 identical Peripheral Processors. A Model 76 system can include from 6 to 13 Peripheral Processors.

INDEX REGISTERS: Any of the first 64 locations in core memory can be used as an index register.

INDIRECT ADDRESSING: One level of indirect addressing is possible for load, store, and arithmetic instructions; indexing and indirect addressing can be combined.

INSTRUCTION REPERTOIRE: Consists of about 65 instructions oriented toward system control, I/O control, and logic functions. Arithmetic capabilities are limited to fixed-point addition and subtraction.

INSTRUCTION TIMES: Range from 1 to 4 microseconds and average 2 microseconds per instruction in Model 72, 73, and 74 systems; range from 0.14 to 1.10 microseconds in Model 76 systems.

INTERRUPTS: The status of I/O channels, peripheral equipment, and other processors is indicated by hardware flags that can be examined by the Peripheral Processors. Execution of an Exchange Jump instruction in a Peripheral Processor causes interruption of the current Central Processor program and initiation of another program whose parameters are defined in an associated "exchange package".

INPUT/OUTPUT CONTROL

I/O CHANNELS: A Model 72, 73, or 74 system can include 12, 18, 21, or 24 I/O channels, all of which can be used by any of the Peripheral Processors.

A Model 76 mainframe can have 7, 11, or 15 I/O channels. One Peripheral Processor can be connected to each of these channels (up to a maximum of 13), and peripheral and communications control stations can in turn be connected to the 8 I/O channels on each Peripheral Processor. ▶

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supplier of this equipment to other mainframe builders. Among the units available to Cyber 70 users are high-performance disk files, 7-track or 9-track magnetic tape units with transfer rates of up to 240,000 characters per second, a 1200-1pm train printer, and a variety of communications controllers and remote terminals.

New peripheral equipment announced along with the Cyber 70 computers includes:

- The 844-2 Mass Storage Subsystem, an IBM 3330-style disk system that stores up to 118 million characters on each removable 11-disk pack.

- The 733-10 High-Speed Batch Station, a programmable batch terminal that can include up to four 1200-1pm printers, two 1200-cpm card readers, and a 250-cpm punch.

- Three economical remote terminals: the 711 CRT Display Terminal, the 30-cps 712 Keyboard/Printer Terminal, and the Teletype-compatible 713 Conversational Display Terminal.

- The 791-1 Communications Subsystem, a programmable communications multiplexer capable of controlling up to 48 full-duplex lines.

- The 7611-10 Service Station, which provides both data communications and unit record I/O facilities for Model 76 systems.

SOFTWARE

The Cyber 70 computers will use improved versions of the CDC 6000 Series and 7600 software. The early 6000 Series software fell far short of effectively harnessing the exceptional hardware capabilities of these computers, but most of the early limitations have been overcome as a result of over five years of user experience and continuing CDC development work.

SCOPE, which has been the principal 6000 Series operating system for several years, will be available to Model 72, 73, and 74 users in a new version designed to take full advantage of the new Cyber 70 hardware facilities. SCOPE handles intermixed local batch, remote batch, and interactive jobs in a multiprogramming mode and gives its users a wide choice of programming languages, including COBOL, FORTRAN, ALGOL, BASIC, JOVIAL, and the COMPASS assembly language.

Model 72, 73, and 74 installations can alternatively use the newer KRONOS Time-Sharing System. KRONOS emphasizes interactive processing from remote terminals but can also handle intermixed local and remote batch jobs. KRONOS supports interactive BASIC and FORTRAN as well as batch-mode FORTRAN, COBOL, ALGOL, and COMPASS.

CONFIGURATION RULES: Each I/O channel may be connected to one or more external devices, but only one device at a time can utilize the channel.

SIMULTANEOUS OPERATIONS: One input or output operation on each I/O channel can be overlapped with computing in the Central Processor and Peripheral Processors. Every I/O operation is executed under the direct control of a Peripheral Processor.

MAXIMUM DATA RATES: Each Model 72, 73, or 74 I/O channel can transfer up to 1 million 12-bit words (or 2 million 6-bit characters) per second. Each Model 76 Peripheral Processor can handle up to 4 million 12-bit words (or 8 million characters) of I/O data per second.

MASS STORAGE

841 MULTIPLE DISK DRIVE: Provides large-capacity random-access storage in interchangeable 11-disk packs which are physically compatible with the IBM 2316 Disk Pack (though the recording format differs from that of the IBM 2314 Direct Access Storage Facility). Available in six models: 841-3 (three on-line drives plus one spare) through 841-8 (eight on-line drives plus one spare). Each drive stores up to 35.84 million 6-bit characters and has a comb-type access mechanism that can read or write up to 179,200 characters in each of its 200 positions. Each track holds up to 8960 characters in 640-character sectors. Average head movement time is 75 milliseconds, and data transfer rate is 420,000 char/sec. An 841 subsystem can be connected to two Model 72, 73, or 74 I/O channels via a 3553-1 Mass Storage Controller and a 6681 Data Channel Converter. A second 3553-1 controller provides read/write simultaneity.

844-2 MASS STORAGE SUBSYSTEM: Provides fairly rapid access to extremely large quantities of data stored in interchangeable 11-disk packs. An 844-2 subsystem consists of one or two 7054 or 7654 Controllers and from two to eight 844-2 Disk Storage Units. The 7054 Controller is used with Models 72, 73, and 74, and the 7654 Controller with Model 76. The use of two controllers permits simultaneous read and/or write operations. Each CDC Type 872 Disk Pack holds up to 708 million bits or 118 million 6-bit characters, so an 8-drive subsystem can store up to 944 million characters on-line. Each of the 19 recording surfaces on the 11-disk pack contains 404 data tracks, and each track is divided into either twenty-four 644-character sectors (with the 7054 Controller) or three 5160-character sectors (with the 7654 Controller). Head movement time ranges from 10 to 55 milliseconds and averages 30 for random accesses. Average rotational delay is 8.3 milliseconds, and data transfer rate is 1.13 million characters per second. The 844-2 is regarded as the principal mass storage device for the Cyber 70 computers.

6638 DISK SYSTEM: Provides fairly large-capacity random-access storage on non-interchangeable disks. Contains 72 disks (128 data recording surfaces), which are equally divided between two side-by-side vertical spindles. There are two independent comb-type access mechanisms, each serving 36 disks. Six read/write heads serve each recording surface. A total of 12 heads are activated at any one time, permitting 12-bit parallel transfers of data. Data capacity depends upon record size; e.g., 131 million 6-bit characters with 640-character records or 167 million characters with 4084-character records. (Also available is a half-capacity model, the 6638-2.) Head movement time ranges from 25 to 110 milliseconds, average rotational delay is 26 milliseconds, and data transfer rate is 1.68 million characters/second. The 6638 Disk System includes one control unit with two I/O channel connections; an

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▷ The design differences between Model 76 and the smaller Cyber 70 computers, particularly in the control of I/O operations, necessitate a separate set of software facilities for Model 76. SCOPE 2, the Model 76 operating system, handles intermixed batch and interactive jobs and supports input and output via multiple magnetic tape stations, unit record stations, communications stations, or smaller Cyber 70 or Series 6000 computers. At present, however, Model 76 users have only a limited assortment of language processors (COBOL, FORTRAN, and COMPASS) and application programs to choose from.

COMPATIBILITY

Within the Cyber 70 Series, Control Data promises that jobs will be directly transferable between comparable Model 72, 73, and 74 configurations with no changes to control cards or source decks. When a user upgrades from a Model 72, 73, or 74 system (using SCOPE 3.4 or later) to a Model 76 (using SCOPE 2 or later), only "minor changes" will be required.

Since the Cyber 70 hardware and software has evolved directly from the earlier CDC 6000 Series and 7600 systems, users can count on a high degree of program and data compatibility between the older and newer CDC systems.

Compatibility with the IBM System/360/370 and other competitive systems, however, is quite limited. The Cyber 70 computers use a 6-bit BCD character code and 60-bit word length, in contrast to the 8-bit EBCDIC or ASCII character code and 32-bit, 36-bit, or 48-bit words used in many competitive lines. Moreover, Control Data's disk recording formats preclude data interchange with competitive equipment via disk packs. On the other hand, CDC's 9-track magnetic tape drives and 8-bit data handling routines (under SCOPE 3.4.1) will facilitate the interchange of EBCDIC or ASCII-coded data on magnetic tape, and CDC's ANS-compatible COBOL and FORTRAN compilers should make it possible to transfer programs written in these languages without undue difficulty.

DISTRIBUTED PROCESSING

Control Data has long stressed the advantages of distributed processing—the assignment of each processing function to the hardware element capable of performing it in the most cost-effective manner.

In the Cyber 70 systems, the Central Processor and main storage are reserved for productive computation. Lower-level functions, such as I/O and system control, are distributed among the multiple Peripheral Processors. Users communicate with the Peripheral Processors via both local and remote I/O stations equipped with various types of peripheral devices. ▷

optional second control unit permits simultaneous read/write operations. Used in many CDC 6000 Series systems, the 6638 will be superseded by the 844-2 Mass Storage System in most Cyber 70 systems.

7638 DISK SYSTEM: Provides large-capacity random-access storage on non-interchangeable disks for Model 76 systems only. Contains 72 disks (128 data recording surfaces), which are equally divided between two side-by-side vertical spindles. There are two independent comb-type access mechanisms, each serving 36 disks. One read/write head serves each recording surface. Sixteen heads are activated at any one time, permitting 16-bit parallel transfers of data to and from the disks. Each track stores 40 sectors of 5160 six-bit characters each. Maximum data capacity of the system is 800 million characters. Head movement time ranges from 20 to 145 milliseconds and averages 85. Average rotational delay is 17.8 milliseconds, and peak data transfer rate is 7 million characters/second. The 7638 system includes two independent read/write control units and connects to two Model 76 Peripheral Processors.

INPUT/OUTPUT UNITS

650 SERIES MAGNETIC TAPE TRANSPORTS: These units read and record data on 1/2-inch tape in 7- or 9-track IBM-compatible formats, in either even-parity BCD mode or odd-parity binary mode. They can read in both the forward and reverse directions. Up to 8 tape transports can be connected to either a single- or dual-channel controller. A 3518 (1-channel) or 3528 (2-channel) Controller and a 6681 Data Channel Converter are used in Model 72, 73, and 74 systems. A 7618 (1-channel) or 7628 (2-channel) Controller is used in Model 76 systems.

Eight different transports are available, with the following recording modes, tape speeds, recording densities, and data transfer rates:

Model 657-1: 7 tracks; 37.5 ips; 200/556/800 bpi; 7,500/20,800/30,000 char/sec.

Model 657-2: 7 tracks; 75 ips; 200/556/800 bpi; 15,000/41,700/60,000 char/sec.

Model 657-3: 7 tracks; 112.5 ips; 200/556/800 bpi; 22,500/62,500/90,000 char/sec.

Model 657-4: 7 tracks; 150 ips; 200/556/800 bpi; 30,000/83,300/120,000 char/sec.

Model 659-1: 9 tracks; 37.5 ips; 800/1600 bpi; 30,000/60,000 bytes/sec.

Model 659-2: 9 tracks; 75 ips; 800/1600 bpi; 60,000/120,000 bytes/sec.

Model 659-3: 9 tracks; 112.5 ips; 800/1600 bpi; 90,000/180,000 bytes/sec.

Model 659-4: 9 tracks; 150 ips; 800/1600 bpi; 120,000/240,000 bytes/sec.

405 CARD READER: Reads standard 80-column cards photoelectrically at up to 1200 cpm; can also read 51-column cards at up to 1600 cpm. Reads both Hollerith-coded and binary cards. Has a 4000-card input hopper, a 4000-card primary stacker, and a 140-card secondary stacker. The 3447 or 3649 Controller connects a ▶

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▷ Control Data's new CYBERLINK service adds an important new dimension to the possibilities for distributed processing. CYBERLINK enables a Cyber 70 user to direct peak-period overloads or extra-large jobs to CDC's CYBERNET computer network, which currently includes large-scale computers in Boston, Houston, Los Angeles, Minneapolis, New York, Palo Alto, and Washington. The communications link can be either a voice-grade or wide-band (40,800 bps) line.

Control Data claims that the CYBERLINK service will enable a Cyber 70 user to buy only as much equipment as he needs to handle *average* loads rather than *peak* loads, with a remote CYBERNET computer handling the occasional overloads. The concept is an intriguing one, and it will be interesting to see whether CDC can effectively solve the associated problems of file availability, data security, job accounting, and availability of CYBERNET resources when and where the user needs them.

PRICING AND SUPPORT

The Model 72, 73, and 74 mainframes and Extended Core Storage units are priced substantially below their 6000 Series counterparts—as much as 40 percent lower in the case of ECS purchase prices. Prices of most peripheral devices and the Model 76 mainframe, however, are unchanged. Overall, the revamped pricing structure puts the Cyber 70 systems in line with the System/370 and other new large-scale computer families, all of which offer substantially more computing power and internal storage per dollar than their predecessors.

Additional savings are possible through Control Data's new long-term leases. Financed by CDC's Commercial Credit Company subsidiary, these flexible lease plans offer unusually attractive discounts (over 30 percent in some cases) to users who are willing to commit themselves for longer terms than the basic one-year lease period.

Since January 1970, Control Data's pricing has been unbundled to a greater degree than any other major computer builder. Separate charges are imposed for technical support, educational courses, equipment maintenance, and all software released after January 1, 1970. The systems software for a typical Cyber 70 installation will add about $2,000 to the monthly rental bill, in addition to a one-time installation charge of $4,500.

Clearly, the Cyber 70 computers are neither simple nor inexpensive machines. Yet their distinctive characteristics and impressive capabilities demand serious consideration in virtually every large-scale computer procurement. □

Control Data's new 844-2 Disk Storage Units store up to 118 million characters per spindle, transfer data at 1.13 million characters per second, and have an average head movement time of 30 milliseconds.

▶ single card reader to one or two Model 72, 73, or 74 I/O channels via a 6681 Data Channel Converter. Each controller contains a full-card buffer.

415 CARD PUNCH: Punches standard 80-column cards, in either Hollerith or binary format, at up to 250 cpm. Has a 1200-card input hopper and a 1500-card output stacker. The 3446 or 3644 Controller connects a single card punch to one or two Model 72, 73, or 74 I/O channels via a 6681 Data Channel Converter. Each controller contains a full-card buffer.

512-1 LINE PRINTER: Uses a 48- or 64-character horizontal "train" of engraved type slugs. Rated printing speed is 1200 lpm with the 48-character trains. Has 136 print positions. Four different interchangeable train cartridges are available: the 48-character IBM AN and HN arrangements, the 64-character CDC 501 Line Printer set, and a 64-character ASCII subset. Other character sets are available on special order. Maximum skipping speed is 70 inches/second. The 3555-1 Controller includes a full-line buffer and connects one printer to a single Model 72, 73, or 74 I/O channel via a 6681 Data Channel Converter.

7611-1 LOCAL OPERATOR'S STATION: Provides local unit record and/or magnetic tape I/O facilities for a Model 76 system. Includes processing facilities, 8 million characters of disk buffer storage, a display console, power and cooling apparatus, and an interface for connection to a Model 76 Peripheral Processor. Controls a maximum of one 407-1 Card Reader (1200 cpm), one 417-1 Card Punch (250 cpm), two 517-1 Train Printers (1200 lpm), and two ▶

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617-1 Magnetic Tape Transports (7-track, 30/83.3/120KC). Most combinations of up to four of these devices can operate simultaneously.

243-1 GRAPHICS SUBSYSTEM: Consists of an interactive display console and control unit with a 12-by-12-inch CRT display, symbol generator, vector generator, alphanumeric keyboard, function keyboard, light pen, and core buffer consisting of 4096 twelve-bit words with a 1.2-microsecond cycle time. Connects to a Model 72, 73, or 74 I/O channel via a 6681 Data Channel Converter.

6681 DATA CHANNEL CONVERTER: Permits CDC 3000 Series peripheral equipment to be connected to a Model 72, 73, or 74 I/O channel. Each 6681 allows connection of a maximum of eight 3000 Series controllers (or four under the standard software) to a single channel.

6683/7683 SATELLITE COUPLERS: Permit direct connection between two 12-bit Cyber 70 I/O channels. The 6683 is used with Models 72, 73, and 74, and the 7683 is used with Model 76. The Satellite Couplers are always used in pairs, one at each end of the data link. Data is transmitted at a rate approaching 1 million 12-bit words/second.

COMMUNICATIONS EQUIPMENT

6671 DATA SET CONTROLLER: Controls up to 16 modems in any combination of the following types: AT&T 103 (at 110 bits/second), AT&T 201 (at 2000 or 2400 bits/second), or equivalent models. Connects to one Cyber 72, 73, or 74 I/O channel. Operates in half- or full-duplex mode, depending upon the type of modem in use. Includes a 64-word core memory (28 bits per word) to buffer both data and control information.

6673 DATA SET CONTROLLER: Interfaces a Model 72, 73, or 74 I/O channel to one or two leased broad-band communications lines. Controls synchronous transmission at 40,800 bits/second in half-duplex mode. An AT&T 301B modem is required on each line.

6674 DATA SET CONTROLLER: Interfaces a Model 72, 73, or 74 I/O channel to a maximum of four leased broad-band communications lines. Controls synchronous transmission at 40,800 bits/second in half-duplex mode. An AT&T 301B modem is required on each line.

7077-1 COMMUNICATIONS STATION: Connects up to three 791-1 Communications Subsystems (described below) to a Model 72, 73, or 74 Peripheral Processor, providing the capability for controlling up to 144 communications lines. Includes 8192 sixteen-bit words of 1.1-microsecond core memory, which is used for I/O buffering and can be expanded to a maximum of 32K words in 8K increments. Requires one shared I/O channel and one dedicated Peripheral Processor.

7611-10 SERVICE STATION: Provides communications and unit record I/O facilities for Model 76 systems. The basic 7611-10 includes: a Service Station Processor, 8192 eight-bit bytes of 200-nanosecond memory, 32,768 bytes of 1.1-microsecond memory, 8 million bytes of "microdrum" storage on 2 drums, 3 I/O channels (one of which is reserved for the drums), and a console display and keyboard. A Service Station Expansion option adds 32,768 more bytes of 1.1-microsecond memory, 8 million more bytes of drum storage, and 3 more I/O channels. Each I/O channel can accommodate either a 733-10 High-Speed Batch Station, which provides local card I/O and printing

facilities, or a 791-1 Communications Subsystem, which controls up to 48 communications lines.

791-1 COMMUNICATIONS SUBSYSTEM: A programmable communications multiplexer capable of controlling up to 48 full-duplex lines at speeds ranging from 75 to 50,000 bits/second. Interfaces with a Model 72, 73, or 74 system through a 7077-1 Communications Station or with a Model 76 system through a 7611-10 Service Station. Contains 4096 sixteen-bit words of 200-nanosecond core memory (expandable to 8192 words), a cyclic encoder unit, and control logic. The basic 791-1 accommodates up to 16 full-duplex lines. Up to four 8-line expansion modules can be added to boost the capacity to 48 lines. Each line requires a 792 Communications Adapter of the appropriate model. The total number of lines that can be serviced by a 791-1 Subsystem depends upon the types and speeds of the lines; e.g., up to 48 full-duplex lines at 2400 bits/second or up to 4 full-duplex lines at 50,000 bits/second.

733-10 HIGH-SPEED BATCH STATION: A programmable batch terminal, announced along with the Cyber 70 systems. Can be used either as a remote terminal, connected to any Cyber 70 computer via a communications link and a 791-1 Communications Subsystem, or as a local unit record I/O station, connected to a Model 76 computer via a 7611-10 Service Station. The basic 733-10 consists of: 4096 sixteen-bit words of 200-nanosecond memory, a "microdrum" for system storage, a 1200-cpm card reader, and a 1200-lpm line printer. Optional equipment that can be added includes a second card reader, up to three additional printers, one 250-cpm card punch, one 733-130 Data Set Adapter, and a keyboard/display unit (used in remote terminal configurations only). The addition of a card punch and/or a second card reader or printer requires the use of an additional 4K words of memory. The 733-10 can drive any four of its I/O devices simultaneously at their full rated speeds. The 733-130 Data Set Adapter, required for remote terminal use, permits data transmission over a broad-band communications link at 50,000 bits/second via an AT&T 302 or 303 modem.

711 CRT DISPLAY TERMINAL: Displays eight 80-character lines in an 8-by-10-inch viewing area on a 15-inch CRT screen. Has a standard typewriter keyboard plus a 10-key numeric keygroup. Includes an integral control unit with a 640-character MOS semiconductor memory. Connects to a Model 72, 73, or 74 system through a 6671 Data Set Controller. Data is transmitted in half-duplex, synchronous mode at up to 4800 bits/second. Optional features include Expanded Memory, which adds another 640 characters of MOS buffer memory; CRT Protect, which adds several data protection features; and CRT Data Control, which adds insert/delete, partial page, and other useful editing functions.

712 KEYBOARD/PRINTER TERMINAL: Consists of a serial impact printer rated at 30 characters/second, standard typewriter keyboard plus 10-key numeric keygroup, integral controller, MOS buffer memory, and communications interface. Connects to a Model 72, 73, or 74 computer system through a 6671 Data Set Controller. Data is transmitted in half-duplex, synchronous mode at up to 4800 bits/second. Both character and control codes are fully ANSI-compatible.

713 CONVERSATIONAL DISPLAY TERMINAL: Serves as a direct replacement for Teletype remote terminals on either leased or dialed telephone lines. Displays eight 80-character lines in an 8-by-10 inch viewing area on a 15-inch CRT screen. Has a standard Teletypewriter

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keyboard plus additional controls and a 10-key numeric keygroup. Includes an integral control unit with a 640-character MOS semiconductor memory, expandable to 1280 characters. Connects to a Model 72, 73, or 74 system through a voice-band line and either a 6671 Data Set Controller or a 791-1 Communications Subsystem. Data is transmitted asynchronously at 75, 110, 150, or 200 bits/second.

SOFTWARE FOR MODELS 72, 73, & 74

SCOPE OPERATING SYSTEM: SCOPE is the principal operating system for Control Data's large-scale computers. Two versions, SCOPE 3.3 and SCOPE 3.2, are currently in use on the CDC 6000 Series computers, and two improved versions, SCOPE 3.4 and SCOPE 3.4.1, were announced along with the Cyber 70 computers. SCOPE 3.4 is scheduled for delivery in the third quarter of 1971 and SCOPE 3.4.1 in the second quarter of 1972. The discussion that follows is devoted to the facilities of SCOPE 3.4 and 3.4.1.

SCOPE schedules and controls all operations of a Cyber 70 system and is oriented toward efficient utilization of the hardware capabilities for multiprocessing and multiprogramming. SCOPE can handle intermixed local batch, remote batch, and interactive jobs. A job consists of one or more programs preceded by control cards specifying the job name, priority, time limits, and other pertinent information. Jobs from all sources are arranged in five queues according to their priorities. The operator can adjust the system scheduling parameters to expedite the processing of the current job mix.

Various components of the SCOPE software reside in main core storage, Extended Core Storage, Peripheral Processor (PPU) storage, and the system disk unit. One PPU contains the SCOPE Monitor routine and permanently controls the system's overall operations. A second PPU is permanently assigned to control the console keyboard and displays. All of the remaining PPU's are available to perform I/O and system tasks as required.

Extended Core Storage (ECS) can be used for five different functions under SCOPE 3.4 and 3.4.1: (1) as a residence device for system library programs; (2) as a buffering device between mass storage and main core storage for large blocks of sequential I/O data; (3) as the primary swap device for jobs swapped into and out of main storage by the System Scheduler; (4) as a residence device for selected small files; and (5) as a fast random-access storage unit under user-program control (e.g., for processing large matrices).

Approximately 7K words of main core storage are reserved to hold SCOPE system tables, inter-processor communication areas, and frequently used subroutines. The remainder of main storage is allocated to user jobs and can hold up to 15 independent programs at a time. A "control point area" for each active job contains information such as the job name, length, starting address, cumulative time used, I/O equipment assigned to the job, control statements, and a 16-word "exchange package" that preserves the contents of all Central Processor registers required to start or resume the program.

Jobs assigned to control points and awaiting execution are stacked by priority. When the job currently using the Central Processor is interrupted (e.g., to await completion of a PPU function), the next job in the stack is moved to the top and initiated or resumed. Control points are conserved by swapping out a whole job, if possible,

whenever its time quantum is exhausted or a higher-priority job is waiting. This frees the control point for another job and effectively removes the 15-program limit on concurrently active jobs. Jobs that use ECS or non-allocatable equipment are rolled out rather than swapped; this releases the job's main storage area but not its control point.

SCOPE has a flexible library organization that provides for multiple system and/or user libraries. Each library and its associated directory is logically independent of the others.

SCOPE and its unified logical I/O package, called Record Manager, provide facilities for sequential, indexed sequential, and direct-access files. Sequential files can use any of four blocking methods and eight record types. (A separate data management system, MARS VI, provides inverted file handling techniques.) Query/Update is a simplified language that facilitates interrogation and updating, in either batch or interactive mode, of files created by Record Manager. A set of file utility routines called FORM (File Organizer and Record Manager) can copy files, modify blocking and record formats, select and reformat specific records, convert IBM 360/370 files to CDC formats, and perform various data transcription functions.

A Time-Critical Module option, consisting of a group of special PPU and Central Processor routines, equips SCOPE to control on-line real-time applications in which a fast response is essential.

INTERCOM is a set of communications control routines that provide users at remote terminals with both interactive and batch-mode access to a Cyber 70 computer system. The INTERCOM routines establish a suitable interface between the remote users and the SCOPE operating system. A Text Editor permits interactive creation and editing of programs and data files. Terminal users can also enter programs into the SCOPE batch queue and receive the resulting output. The Interactive Graphics System (IGS), an integral part of the current INTERCOM version, permits interactive problem-solving by users at graphics consoles such as the CDC 274. INTERCOM supports the 6671, 6673, 6674, and 7077-1/791-1 communications controllers and a variety of remote terminals, including Teletype Models 33 and 35 and the CDC 200, 711, 712, 713, 733-10, and 1700. Additional capabilities for input/output from remote batch terminals are provided by the IMPORT routines, which support the CDC 1700 Computer or 8231 Remote Terminal.

Programming languages available to Model 72, 73, and 74 SCOPE users include ALGOL, BASIC, COBOL, COMPASS, FORTRAN, and JOVIAL.

KRONOS TIME-SHARING SYSTEM: KRONOS 2, delivered early in 1971 for the CDC 6000 Series computers, is also available for use on Cyber 70 Models 72, 73, and 74. KRONOS concurrently handles four types of job processing: interactive terminal processing, local batch processing, remote batch processing, and deferred batch processing (of jobs entered via an interactive terminal). The system is designed to service up to 512 active time-sharing terminals, or up to 16 remote batch terminals plus a number of time-sharing terminals.

Like SCOPE, KRONOS uses the Peripheral Processors to handle system and I/O functions and the Central Processor to execute user programs. Main core storage holds the user programs and certain KRONOS routines and tables. Extended Core Storage (ECS), when available, is used as a ▶

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high-speed swapping device and as a storage medium for user data files.

Jobs enter the KRONOS system from the central site and from remote time-sharing and batch terminals. A program's initial priority depends upon its origin, with time-sharing jobs normally entering at the highest priority. While jobs are waiting in the input queue, their priorities are periodically increased. The highest-priority jobs are scheduled into main storage.

A CPU priority scheme allocates Central Processor time to each job in main storage. Processing continues until: (1) the job is completed, (2) the job is forced out of memory by a higher-priority job, (3) the job exceeds its allotted time slice, or (4) a terminal I/O operation is requested. When a job exceeds its allotted time slice, it is rolled out of main storage, reassigned a lower priority, and placed in a "roll-in queue" to await the availability of another time slice.

Programming languages available to KRONOS users include Interactive BASIC, Interactive FORTRAN, FORTRAN Extended, COBOL, ALGOL, and COMPASS. A KRONOS Control Language (KCL) provides overall system control, and a Text Editor enables terminal users to edit and manipulate files.

COBOL: Two COBOL compilers are currently receiving full CDC support for Models 72, 73, and 74.

COBOL 3 operates under KRONOS 2 or SCOPE 3.3 and provides most of the facilities of the full American National Standard COBOL language. Features include the SORT verb, Report Writer, Mass Storage, Table Handling, and Segmentation facilities, plus an optional cross-reference listing.

COBOL 4 runs under SCOPE 3.4. It provides all the language facilities of COBOL 3 plus: (1) additional features to provide full ANS COBOL compatibility; (2) ability to use the new Compare/Move and Integer Multiply instructions for increased object-program speed; (3) increased flexibility in file definition; (4) a Record Manager interface for more efficient processing of sequential, indexed sequential, and direct-access files; and (5) smaller core requirements at both compilation and object time.

FORTRAN: Five FORTRAN compilers are currently receiving full CDC support for Models 72, 73, and 74.

FORTRAN (RUN) 2.3 operates under KRONOS 2 or SCOPE 3.3 and provides the facilities of FORTRAN II and IV plus a number of useful CDC extensions such as ENTRY, ENCODE, DECODE, BUFFER IN, and BUFFER OUT statements. FORTRAN (RUN) 3 operates under SCOPE 3.4 and provides all the facilities of Version 2.3 plus increased compilation speed, higher execution throughput, use of the new Integer Multiply instruction, and use of the Record Manager software for object-time I/O.

FORTRAN Extended 3 runs under KRONOS 2 or SCOPE 3.3 and provides ANS language compatibility while maintaining a high degree of compatibility with earlier CDC FORTRAN compilers; other features include random access to files on mass storage devices, extensive debugging capabilities, and options that provide a choice of rapid compilation or optimized object programs. FORTRAN Extended 4 runs under SCOPE 3.4 and provides all the above facilities plus increased compilation speed, use of the new Integer Multiply instruction, use of the Record Manager software for object-time I/O, and a common library with FORTRAN (RUN) 3.

Interactive FORTRAN (TSRUN) 1 operates under KRONOS 2. It provides essentially the same language facilities as FORTRAN (RUN) 2.3 plus interactive compilation, unformatted I/O, and mass storage I/O.

ALGOL: Compilers for the ALGOL-60 language, with I/O procedures as defined in both the IFIP and ACM sets, are available for operation under both SCOPE and KRONOS. The SCOPE 3.4 version, ALGOL 3, features interactive execution under INTERCOM, direct access to Extended Core Storage, linkages to subroutines coded in other languages, debugging and error recovery aids, and improved code optimization.

BASIC: The BASIC 2 compiler operates under either SCOPE or KRONOS in either batch or interactive mode. The language is largely compatible with Dartmouth BASIC for the GE-200 Series computers; extensions include three-dimensional arrays, multiple assignment statements, file I/O, and improved diagnostics.

COMPASS: The standard symbolic assembly language for the Cyber 70 computers, COMPASS replaces the earlier ASCENT and ASPER languages and can be used to prepare programs for either the Central Processor or Peripheral Processors. The language includes flexible macro facilities, pseudo-operations, and address-field expressions. The COMPASS 2 assembler runs under KRONOS 2, supports all Cyber 70 and CDC 6000 Series instructions except Compare/Move, and permits assembly on any of these computers of programs intended for execution on any other. The COMPASS 3 assembler runs under SCOPE 3.4; in addition to the COMPASS 2 facilities, it supports the Compare/Move instructions, permits assembly-time use of the Record Manager software for I/O, and provides extensions for object-program formatting.

UTILITY ROUTINES: Sort/merge programs are available for operation under both SCOPE and KRONOS. Both versions use a tournament sort, employing the replacement selection technique, for internal sorting. Merging is performed either by the balanced or polyphase merge technique for tape sorts or by the oscillating sort/merge technique for disk sorts. Options permit tag sorting and insertion of the user's own code.

The CDC operating systems include utility routines to handle diagnostic, loading, data transcription, data communications, and library maintenance functions.

APPLICATIONS PROGRAMS: A modest assortment of CDC programs for specific applications is available for Models 72, 73, and 74. Among the principal ones are:

    APT (numerical control)
    MARS VI (inverted-file data management system)
    OPHELIE (linear programming)
    PERT/Time
    SIMSCRIPT (simulation language)
    SIMULA (simulation language)

SOFTWARE FOR MODEL 76

SCOPE 2 OPERATING SYSTEM: Scheduled for delivery in the third quarter of 1971, SCOPE 2 will supersede SCOPE 1 as the principal operating system for Model 76 and for the nearly identical CDC 7600 system. SCOPE 2 schedules and controls all system operations and is oriented toward efficient utilization of the hardware capabilities for multiprocessing and multiprogramming. It handles intermixed local batch, remote batch, and interactive jobs.

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Various components of the SCOPE 2 software reside in small core memory (SCM), large core memory (LCM), and system disk files. Only 5120 words of SCM are required to hold resident routines, I/O buffers, and tables. The remaining resident portions of the system library are held in LCS. A variable number of user jobs can be multiprogrammed within the remaining areas of SCM and LCM. Jobs are initiated on the basis of priorities and executed in a time-slicing mode.

SCOPE 2 consists of four major parts: System Interchange, System Executive, Job Supervisor, and Interrupt Handlers. The System Interchange serves as a clearing house for servicing requests and transferring control between other functional components of the system. The System Executive handles task-oriented functions: scheduling, resource allocation, I/O queue processing, and interfacing to the real-time monitor. The Job Supervisor performs job-oriented functions: handling of user requests, job initiation and termination, and management of files, records, and buffers; the Supervisor is attached to each job and swapped between storage hierarchies with the job. The Interrupt Handlers empty the SCM input and output buffers into and from larger buffers in LCM and permit data to be "streamed" between the various levels of storage.

SCOPE 2 supports input/output via distributed magnetic tape, unit record, communications, and computer stations. The computer stations can be CDC 6000 Series or other Cyber 70 computers using the SCOPE 3.4 operating system.

Programming languages available under SCOPE 2 are currently limited to COMPASS, FORTRAN, FORTRAN Extended, and COBOL. Other software facilities promised for the Model 76 include a sort/merge, data management facilities, system utilities, a real-time monitor, remote job entry, conversational time-sharing, and linear programming.

COBOL: The COBOL 1 compiler runs under SCOPE 2, contains most of the full American National Standard COBOL language, and adds language extensions that permit effective use of the Model 76's multiple levels of storage. The CODASYL subprogram facility is included, and object-code optimization is an optional feature.

FORTRAN: Two FORTRAN compilers are available for operation under SCOPE 2. FORTRAN 2 is an extended version of FORTRAN IV and 6000 Series FORTRAN 2.3; additional statements give the user control over the use of SCM and LCM. FORTRAN 2 Extended provides ANS language compatibility with earlier CDC FORTRAN compilers; other features include random access to files on mass storage devices, extensive debugging capabilities, and options that provide rapid compilation or optimized object programs.

COMPASS: This symbolic assembler, capable of assembling programs for either the Central Processor or Peripheral Processors, is an extension of the 6000 Series COMPASS assemblers. It accommodates the instructions which are unique to Model 76 and provides additional macros and pseudo-operations.

PRICING

EQUIPMENT: The following system configurations illustrate a few examples of the wide range of possibilities within the Cyber 70 line. All necessary control units and adapters are included in the indicated prices. The quoted rental prices are for 1-year leases and include equipment maintenance.

MODEL 72 SYSTEM: Consists of 72-12 Central Computer with 32K words of main core storage, 125K words of Extended Core Storage, 4-drive 844-2 Disk Storage Subsystem (472 million characters), eight 659-2 Magnetic Tape Transports (120KC) and dual-channel controller, 1200-cpm card reader, 250-cpm card punch, and 1200-lpm printer. Monthly rental and purchase prices are approximately $37,700 and $1,385,000, respectively.

MODEL 73 SYSTEM: Same as Model 72 system above, with 73-12 Central Computer (32K) replacing the 72-12. Monthly rental and purchase prices are approximately $40,600 and $1,505,000, respectively.

MODEL 74 SYSTEM: Consists of 74-14 Central Computer with 65K words of main core storage, 503K words of Extended Core Storage, two 8-drive 844-2 Disk Storage Subsystems (1888 million characters), twelve 659-4 Magnetic Tape Transports (240KC) and two dual-channel controllers, two 1200-cpm card readers, two 250-cpm card punches, and two 1200-lpm line printers. Monthly rental and purchase prices are approximately $118,600 and $4,450,000, respectively.

DUAL-PROCESSOR MODEL 74 SYSTEM: Same as Model 74 system above, with dual-processor 74-24 Central Computer replacing the single-processor 74-14. Monthly rental and purchase prices are approximately $128,800 and $4,850,000, respectively.

MODEL 76 SYSTEM: Consists of 76-18 Central Computer with 65K words of Small Core Memory, 512K words of Large Core Memory, 8 PPU's, and 9 I/O channels; two 7638 Disk Systems (1600 million characters); and four 7611-1 Local Operator's Stations, each equipped with a 1200-cpm card reader, 250-cpm card punch, 1200-lpm printer, and two 120KC magnetic tape transports. Monthly rental and purchase prices are approximately $229,700 and $8,738,800, respectively.

SOFTWARE: All Control Data software released after January 1, 1970, is separately licensed and priced to domestic commercial customers. Software released prior to that date is generally offered at no additional charge. Each separately priced product is licensed for a minimum of one year, and the license agreement can be terminated upon 90 days' notice thereafter. Each software license includes one machine-readable copy of the software itself and one copy of the associated documentation. The price list that follows shows the initial fees and monthly royalties for specific Cyber 70 software products.

SUPPORT: The services of Control Data analysts are available to Cyber 70 users at a price of $35 per hour or $1,220 per week, with a minimum charge of 3 hours per day for each analyst. Analyst services include systems analysis and design, application design and development, conversion and implementation planning, installation evaluation and improvement, major system modifications, installation of special utilities, etc. Installation and maintenance of the standard Cyber 70 software products is included in the software license fees.

EDUCATION: All customer education and training courses (other than sales-oriented seminars and presentations) are provided by the Control Data Education Institutes and are

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separately priced. Most user-oriented Cyber 70 courses range from 2 to 5 days in length and cost from $105 to $300 per student.

CONTRACT TERMS: The standard Cyber 70 Series rental contract permits unlimited use of the equipment; there are no extra-use charges. Control Data maintenance service is separately priced.

LONG-TERM LEASES: The new Commercial Credit/Control Data Computer Leasing Program offers flexible leases for 3- to 7-year periods. The basic lease plan covers a 3-year term, allows unlimited use, includes liberal substitution and add-on privileges, and is cancellable after 24 months upon 90 days' notice. The base 3-year lease price for a 65K Model 73 mainframe, for example, is $25,590, or 8.9 percent lower than the standard 1-year monthly rental. Additional discounts from the base 3-year lease price are offered for longer lease terms (up to 7 years), for extensions of the non-cancellable period, for waiver of substitution privileges, and for payment of each year's rental in advance. Thus, the monthly charge for a 65K Model 73 mainframe could be reduced to as little as $18,916 per month under a 7-year, non-cancellable lease without substitution privileges—a 33 percent reduction from the standard 1-year monthly rental price of $28,100. ■

The Cyber 70 System Console features dual CRT displays and a typewriter-style data entry keyboard.

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EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (1-year lease)*
PROCESSORS AND CORE STORAGE				
Model 72	Central Computer (includes 10 PPU's, 12 I/O channels, system console, 2 Data Channel Converters, power and cooling equipment, and main core storage as indicated)			
72-12	1 CPU & 32,768 words	530,000	2,772	13,400
72-13	1 CPU & 49,152 words	750,000	3,411	19,350
72-14	1 CPU & 65,536 words	1,025,000	4,051	25,250
72-16	1 CPU & 98,304 words	1,315,000	5,442	32,750
72-18	1 CPU & 131,072 words	1,570,000	6,832	38,900
72-24	2 CPU's & 65,536 words	1,245,000	5,131	31,250
72-26	2 CPU's & 98,304 words	1,535,000	6,521	38,750
72-28	2 CPU's & 131,072 words	1,790,000	7,912	44,900
Model 73	Central Computer (includes 10 PPU's, 12 I/O channels, system console, 2 Data Channel Converters, power and cooling equipment, and main core storage as indicated)			
73-12	1CPU & 32,768 words	650,000	2,789	16,250
73-13	1 CPU & 49,152 words	870,000	3,428	22,200
73-14	1 CPU & 65,536 words	1,145,000	4,068	28,100
73-16	1 CPU & 98,304 words	1,435,000	5,459	35,600
73-18	1 CPU & 131,072 words	1,690,000	6,849	41,750
73-24	2 CPU's & 65,536 words	1,445,000	5,148	36,200
73-26	2 CPU's & 98,304 words	1,735,000	6,538	43,700
73-28	2 CPU's & 131,072 words	1,990,000	7,929	49,850
Model 74	Central Computer (includes 10 PPU's, 12 I/O channels, system console, 2 Data Channel Converters, power and cooling equipment, and main core storage as indicated)			
74-12	1 CPU & 32,768 words	1,710,000	6,417	42,750
74-13	1 CPU & 49,152 words	1,930,000	6,795	48,700
74-14	1 CPU & 65,536 words	2,205,000	7,173	54,600
74-16	1 CPU & 98,304 words	2,495,000	7,611	62,100
74-18	1 CPU & 131,072 words	2,750,000	8,048	68,250
74-24	2 CPU's & 65,536 words	2,605,000	7,800	64,200
74-26	2 CPU's & 98,304 words	2,895,000	8,238	71,700
74-28	2 CPU's & 131,072 words	3,150,000	8,675	77,850
	Model 72 & 73 PPU Upgrades:			
10268-1	Adds 4 PPU's (for total of 14) and 6 I/O channels (for total of 18)	135,000	240	3,400
10268-2	Adds 3 PPU's (for total of 17) and 3 I/O channels (for total of 21)	46,000	180	1,150
10268-3	Adds 3 PPU's (for total of 20) and 3 I/O channels (for total of 24)	46,000	180	1,150
	Model 74 PPU Upgrades:			
10269-1	Adds 4 PPU's and 6 I/O channels	135,000	240	3,400
10269-2	Adds 3 PPU's and 3 I/O channels	46,000	180	1,150
10269-3	Adds 3 PPU's and 3 I/O channels	46,000	180	1,150
10267	Interlock Register Expansion (for Model 72, 73, or 74; doubles register size to 128 bits)	8,000	0	200
	Extended Core Storage for Models 72, 73, & 74:			
7030-1	125,952 60-bit words	196,200	1,288	5,800
7030-2	251,904 60-bit words	319,400	1,703	9,560
7030-4	503,808 60-bit words	567,700	2,432	17,150
7030-8	1,007,616 60-bit words	1,085,300	3,512	32,960
7030-16	2,015,232 60-bit words	2,050,000		65,400
	ECS Register Options (each adds a 480-bit buffer register and I/O channel connection to the ECS Distributive Data Path):			
10266-1	Second ECS Register	16,700	75	430
10266-2	Third ECS Register	16,700	75	430
10266-3	Fourth ECS Register	16,700	75	430
Model 76	Central Computer (includes 6 PPU's, 7 I/O channels, maintenance control unit with card reader and display, power and cooling equipment, and both "small" and "large" core memory as indicated):			
76-12	32,768 words of SCM and 256,000 words of LCM	4,100,000	12,720	82,000
76-14	65,536 words of SCM and 256,000 words of LCM	4,740,000	14,120	96,600
76-16	32,768 words of SCM and 512,000 words of LCM	5,380,000	15,600	109,000
76-18	65,536 words of SCM and 512,000 words of LCM	6,020,000	17,000	123,600
7602-1	Model 76 PPU (includes 4096 words of core storage)	50,000	100	1,100
7606-1	Model 76 Data Channel Unit (consists of four additional CPU I/O channels)	58,000	115	1,200
MASS STORAGE				
841	Multiple Disk Drives:			
	841-3; 3 on-line drives	92,220	303	1,865
	841-4; 4 on-line drives	118,720	357	2,425
	841-5; 5 on-line drives	143,100	411	2,935
	841-6; 6 on-line drives	165,360	465	3,395
	841-7; 7 on-line drives	203,520	573	4,150
	841-8; 8 on-line drives	203,520	573	4,150
3553-1	Mass Storage Controller (for 841)	36,040	141	700
844-2	Disk Storage Unit; 118 million characters	28,000	100	550
7054-1	Mass Storage Controller (for 844-2)	90,000	290	1,710
7654-1	Mass Storage Controller (for 844-2)	90,000	290	1,710

*Rental prices do not include equipment maintenance.

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Control Data Cyber 70 Series

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (1-year lease)*
MASS STORAGE (cont)				
6638	Disk System; 167 million characters	344,500	816	8,995
6638-2	Disk System; 84 million characters	233,200	708	4,415
10037	Additional Read/Write Control for 6638	28,090	65	690
7638	Disk System; 800 million characters	400,000	1,100	10,895
INPUT/OUTPUT UNITS				
657-1	Magnetic Tape Transport; 7.5/20.8/30 KC	17,890	76	320
657-2	Magnetic Tape Transport; 15/41.7/60 KC	29,150	125	430
657-3	Magnetic Tape Transport; 22.5/62.5/90 KC	36,970	146	670
657-4	Magnetic Tape Transport; 30/83.4/120 KC	46,640	157	810
659-1	Magnetic Tape Transport; 30/60 KC	18,550	87	325
659-2	Magnetic Tape Transport; 60/120 KC	26,235	119	460
659-3	Magnetic Tape Transport; 90/180 KC	38,160	157	685
659-4	Magnetic Tape Transport; 120/140 KC	43,885	168	810
3518-1	Magnetic Tape Controller; 1x8; for 657 drives only	32,860	152	560
3518-2	Magnetic Tape Controller; 1x8; for 657 and/or 659 drives at 200, 556, or 800 bpi only	39,355	179	690
3518-3	Magnetic Tape Controller; 1x8; for 657 and/or 659 drives at 200, 556, or 800, or 1600 bpi	46,640	195	855
3528-1	Magnetic Tape Controller; 2x8; for 657 drives only	53,000	303	1,065
3528-2	Magnetic Tape Controller; 2x8; for 657 and/or 659 drives at 200, 556, or 800 bpi only	61,480	308	1,160
3528-3	Magnetic Tape Controller; 2x8; for 657 and/or 659 drives at 200, 556, 800, or 1600 bpi	69,960	314	1,260
7618	Magnetic Tape Controller; 1x8; for 657 and/or 659 drives at 200, 556, 800, or 1600 bpi	46,640	195	855
7628	Magnetic Tape Controller; 1x8; for 657 and/or 659 drives at 200, 556, 800, or 1600 bpi	69,960	314	1,260
405	Card Reader; 1200 cpm	24,910	71	370
3447	Card Reader Controller; single channel	12,720	60	190
3649	Card Reader Controller; dual channel	18,020	44	315
415	Card Punch; 250 cpm	20,140	65	260
3446	Card Punch Controller; single channel	24,380	71	430
3644	Card Punch Controller; dual channel	36,040	103	640
512-1	Line Printer; 1200 lpm	47,700	243	780
595	Train Cartridge (for 512-1)	3,180	0	105
3555-1	Line Printer Controller; for 512-1	28,620	49	605
7611-1	Local Operator's Station	236,500	910	4,675
407-1	Card Reader; 1200 cpm	24,910	83	360
417-1	Card Punch; 250 cpm	20,140	76	250
517-1	Line Printer; 1200 lpm	47,700	292	735
617-1	Magnetic Tape Transport; 30/83.3/120 KC	46,640	243	805
243-1	Graphics Subsystem	68,900	373	1,515
6681	Data Channel Converter	14,840	44	300
6683	Satellite Coupler (for Model 72, 73, or 74)	10,600	27	172
7683	Satellite Coupler (for Model 76)	15,000	36	300
COMMUNICATIONS EQUIPMENT				
6671	Data Set Controller (for 16 voice-grade lines)	44,520	157	1,100
6673	Data Set Controller (for 2 broad-band lines)	37,100	130	815
6674	Data Set Controller (for 4 broad-band lines)	55,120	195	1,165
7077-1	Communications Station (for up to 144 lines)	42,500	120	1,100
7611-10	Service Station	150,000	510	4,000
10263-1	Service Station Expansion Feature	25,000	90	500
791-1	Communications Subsystem Control (for up to 16 lines; each requires a 792 Adapter)	38,000	100	950
791-2	Communications Subsystem Module (for 16th through 24th lines)	22,500	60	560
791-3	Communications Subsystem Module (for 25th through 32nd lines)	4,000	10	100
791-4	Communications Subsystem Module (for 33rd through 40th lines)	4,000	20	100
791-5	Communications Subsystem Module (for 41st through 48th lines)	4,000	20	100
792-1	Communications Adapter (compatible with AT&T 103 modems at 75 to 1800 bps)	350	2	8
792-2	Communications Adapter (compatible with AT&T 201 and 203 modems; operates at 2400, 4800, or 9600 bps)	400	2	10
792-3	Communications Adapter (compatible with AT&T 300 modems; operates at 19,200, 20,800, or 50,000 bps)	480	3	12
792-10	Communications Adapter (allows automatic dialing into the DDD telephone network via an AT&T 801 Auto Dialer)	550	4	14
733-10	High-Speed Batch Station	96,800	650	2,330
733-101	Terminal Card Punch (250 cpm; for 733-10)	20,000	100	390
733-110	Terminal Train Printer (1200 lpm; for 733-10)	42,000	260	895

*Rental prices do not include equipment maintenance.

Control Data Cyber 70 Series

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (1-year lease)*
COMMUNICATIONS EQUIPMENT (cont)				
733-120	Terminal Card Reader (1200 cpm; for 733-10)	18,000	90	390
733-130	Data Set Adapter (for 733-10)	600	0	15
733-140	4096-word Memory Increment (for 733-10)	16,200	32	390
733-150	Keyboard and Display (for 733-10)	3,200	20	70
711-10	CRT Display Terminal	3,500	20	90
711-100	Expanded Memory (for 711-10)	320	0	10
711-101	CRT Protect Feature (for 711-10)	140	0	5
711-102	CRT Data Control Feature (for 711-10)	160	0	6
712-10	Keyboard/Printer Terminal	4,950	40	150
713-10	Conversational Display Terminal	1,995	15	60
711-100	Expanded Memory (for 713-10)	320	0	10

*Rental prices do not include equipment maintenance.

SOFTWARE PRICES

		Initial Fee	Monthly Royalty
SCOPE 3.4 SOFTWARE (MODELS 72, 73, & 74)			
F303-01	SCOPE 3.4 Package, including COMPASS 3 AND FORM 1	4,500	900
F303-03	FORTRAN 3	0	250
F303-04	FORTRAN Extended 4	0	250
F303-05	COBOL 4 (SORT verb requires F303-06)	0	250
F303-06	Sort/Merge 4	0	250
F303-07	Time-Critical Module 3	0	150
F303-08	Query/Update 1	0	100
F303-09	Intercom 4	0	200
F303-10	PERT/Time 1	0	0
F303-11	SIMSCRIPT 2	0	0
F303-14	APT 2	0	0
F303-15	BASIC 2	0	0
F303-16	ALGOL-60 2	500	250
F303-17	SIMULA 1	0	200
F303-19	JOVIAL 1	1,000	250
F303-21	FORTRAN 2	0	0
KRONOS 2 SOFTWARE (MODELS 72, 73, & 74)			
F402-01	KRONOS 2 Package, including COMPASS 2, FORTRAN 2, Interactive FORTRAN, and Interactive BASIC	4,500	1,200
F402-02	FORTRAN Extended 3	0	200
F402-03	COBOL 3 (SORT verb requires F402-04)	0	200
F402-04	Sort/Merge 3	0	200
F402-05	ALGOL-60 1	500	200
F402-06	Export/Import 200 1	0	0
F402-07	SIMSCRIPT 2	0	0
F402-08	APT 2	0	0
F402-09	SIMULA 1	0	200
F402-10	PERT/Time 1	0	0
SCOPE 2 SOFTWARE (MODEL 76)			
G102-01	SCOPE 2 Package, including COMPASS 2	4,500	2,000
G102-02	FORTRAN 2	0	200
G102-03	FORTRAN Extended 2	0	200
G102-04	COBOL 1 (SORT verb requires G102-05)	0	200
G102-05	Sort/Merge 1	0	200