ICL 2900 Series, Models 2960—2980

MANAGEMENT SUMMARY

Designed to provide a competitive alternative to the comparable systems offered by other mainframe manufacturers as well as a growth path for users of ICL 1900 and ICL System 4 systems, the medium to large scale models of the ICL 2900 New Range currently include the 2960, 2970, 2976, and 2980. All offer virtual machine and virtual storage facilities and come in modular, open-ended configurations.

ICL has paid special attention to the need for hardware and software reliability in systems running mixes of batch, time-sharing, and transaction-processing jobs. Equal priority has been given to making the 2900 systems flexible so that configurations can be altered to meet changing requirements.

Spanning the same power range as IBM's System/370 Models 148 through 168, the four larger models of the 2900 Series offer a wide variety of configurations as a result of their building-block design.

BACKGROUND

The 1968 merger of International Computers and Tabulators Ltd. (ICT) and English Electric Computers Ltd. left the new company, International Computers Ltd. (ICL), with two incompatible product lines, the ICT 1900 Series and the English Electric System 4 family. Taking advantage of the opportunity to make a fresh start, ICL decided to design a new series of computers based on what users needed rather than on what was technologically possible. The resulting 2900 Series thus incorporates what ICL con- ➢

The medium to large scale range of systems in ICL's new 2900 Series currently includes the 2960, 2970, 2976, and 2980. Each of the four models offers a virtual machine environment, distributed intelligence, and an open-ended design intended to prevent future obsolescence.

CHARACTERISTICS

MANUFACTURER: International Computers Ltd., ICL House, Putney, London, SW15 1SW, England. Telephone: (01) 788-7272. ICL markets its systems in 80 countries.

MODELS: 2960, 2970, 2976, and 2980.

DATA FORMATS

BASIC UNIT: 8-bit byte. Each byte can represent 1 alphanumeric character, 2 BCD digits, or 8 binary bits. Four consecutive bytes form a 32-bit word.

FIXED-POINT OPERANDS: Can range from 1 to 16 bytes (1 to 31 digits plus sign) in decimal mode; 1 word (32 bits) or 1 doubleword (64 bits) in binary mode.

FLOATING-POINT OPERANDS: 1 word, consisting of a 24-bit fraction (6 hex digits) and 7-bit hexidecimal exponent, in short format; 2 words, consisting of a 56-bit fraction (14 hex digits) and 7-bit hexidecimal exponent, in long form; or 4 words, consisting of a 112-bit fraction (28 hex digits) and 7-bit hexidecimal exponent in extended format.

INSTRUCTIONS: 2 or 4 bytes in length. Most instructions are available in both forms. There also are three instruction formats. Primary format instructions are either compu- ➢

This ICL 2970, one of four medium to large scale 2900 Series systems currently available, includes a dual-screen Master Operating Station and, at right, a reconfiguration console. Remote monitors, such as the one behind the consoles, enable operators to receive system messages and alarms while they are away from the master console.

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TABLE I: CHARACTERISTICS OF THE ICL 2900 SERIES

	2960	2970	2976	2980
SYSTEM CHARACTERISTICS				
Date of introduction	March 1976	Oct. 1974	July 1976	Oct. 1974
Date of first delivery	Feb. 1976	Dec. 1974	3rd Q. 1977	April 1975
Virtual storage capability	Standard	Standard	Standard	Standard
Number of central processors	1 or 2	1 or 2	1 or 2	1 or 2
Principal operating systems	VME/K VME/B	VME/B	VME/B	VME/B
MAIN STORAGE				
Storage type	MOS	MOS	MOS	MOS
Read cycle time, nanoseconds	850	620	620	520
Write cycle time, nanoseconds	950	700	700	565
Partial write cycle time, nanoseconds	1470	1140	1140	875
Bytes fetched per cycle	8	8	8 (write), 16 (read)	16
Storage interleaving	None	None	Optional	Yes
Minimum capacity, bytes per system	524,288	1,048,576	1,048,576	1,048,576
Maximum capacity, bytes per system	3,145,728	6,291,456	6,291,456	8,388,608
Increment size, bytes	262,144	262,144	262,144	524,288
BUFFER STORAGE (SLAVE STORES)				
Cycle time, nanoseconds	125	100	100	100
Bytes fetched per cycle	4	4	4	4
PROCESSING UNIT				
Machine cycle time, nanoseconds	125	100	100	100
Processing unit features:				
Floating point	Standard	Standard	Standard	Standard
Extended precision floating point	Standard	Standard	Standard	Standard
Decimal arithmetic	Standard	Standard	Standard	Standard
Fast multiple/divide unit	No	No	Optional	Optional
Real-time clock	Standard	Standard	Standard	Standard
Microprogramming	Standard	Standard	No	No
Pipeline steps	2	4	6	6
Pipeline capacity, instructions	2	7	9	9
Compatibility features:				
ICL 1900 Series emulation by microcode	Optional	Optional	No	No
ICL System 4 emulation by microcode	Optional	Optional	No	No
ICL 1900 Series emulation by attached processor	No	No	Optional	Optional
ICL System 4 emulation by attached processor	No	No	Optional	Optional
CHANNELS				
Store Multiple Access Controls (SMAC's)	1 or 2	1 or 2	1, 2, or 3	1, 2, 3 or 4
Store Access Controls (SAC's)	1 or 2	1 or 2	1 or 2	1 or 2
SAC/Main Storage maximum transfer rate, bytes/second	9,000,000 4 or 8	16,000,000 4 or 8	16,000,000 4 or 8	16,000,000 4 to 16
Trunk Links per SAC				
Trunk Link maximum transfer rate, bytes/second	2,500,000 18,000,000	4,000,000 32,000,000	4,000,000 32,000,000	4,000,000 32,000,000
Maximum total transfer rate, bytes/second				

siders the best available technology but does not push the state of the art. At the same time, ICL has designed the 2900's so that new technology can be added as it becomes available—and reliable—without forcing users to rewrite their software.

Introduction of the larger 2900's began in 1974 with the announcement of the large scale 2980 and the medium large 2970. The medium scale 2960 was introduced 18 months later, in March 1976, followed by the large scale

tational or miscellaneous. Secondary format instructions are store-to-store instructions. Tertiary format instructions are conditional jump instructions.

INTERNAL CODE: EBCDIC (Extended Binary-Coded Decimal Interchange Code).

MAIN STORAGE

STORAGE TYPE: MOS (metal oxide semiconductor).

CYCLE TIME: See table. Note: High speed slave stores (cache memories) make the effective speed of main memory

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2976 in July 1976. ICL is expected to announce additional medium scale models in the future, with the 2950 expected next.

ARCHITECTURE

The 2900's are designed so that most operations are carried out in parallel or at least overlapped. The memory controller, the input/output channel controller, and the peripheral controllers are physically separate from the central processor called the Order Code Processor (OCP) and interrupt it only to report completion of tasks or error conditions. Except in the 2690, address translations and memory fetches are also handled independently.

All four models use pipelining techniques to overlap instruction execution, slave stores (cache memories) to increase fetching rates, and multiple stacks of virtual registers for storing addresses, parameters, and data. The 2976 and 2980 also have a write buffer to smooth the flow of data back to memory.

The 2960 and 2970 are microprogrammed processors. The 2976 and 2980 are hard-wired processors. All currently use the same set of 113 instructions that includes instructions for handling decimal arithmetic, arrays, and strings.

The 2960 has Schottky TTL circuits, the others have a mixture of ECL and Schottky TTL circuits. These circuits plus what ICL calls "matched interconnection" provide high speed with lower power consumption and less heat.

Reliability at the hardware level is maintained by error detection and correction circuits. All 2900 modules and peripherals also can have dual connections to other modules so that any failing module can be switched out. Thus if neither the hardware nor the operating system can correct an error, the operator may be able to keep the system running by reconfiguring it.

COMPATIBILITY

The 2900's are incompatible at the object code level with both the 1900's and the System 4 computers, but ICL provides a choice of four solutions to this problem. A 2960 can be loaded with 1900 or System 4 microcode to create a Direct Machine Environment (DME) in which it functions as a 1900 or System 4. Another approach is to add extra microcode to a 2960 or 2970 so that it can run mixes of 1900 or System 4 programs with 2900 programs. A third option is to attach a special processor to a 2976 or 2980 as a peripheral, enabling it to share the 2900's memory and peripherals. The final option is to convert the 1900 or System 4 programs to run on the 2900 with the help of a series of conversion aids.

All four solutions require that disc files be converted to 2900 format, but 1900 tape files can be retained because several of the 2900 tape subsystems have the ability to read and write tapes in 1900 format. System 4 tapes are compatible with the 2900's.

considerably higher than the figures would seem to indicate. On the 2970, 2976 and 2980, transfers between main memory and the slave stores are made in parallel with central processing unit operations.

CHECKING: All data paths between the central processor and main storage are parity checked by byte. When data is stored, an error-correcting code is substituted for the parity bits. (An 8-bit modified Hamming code is appended to each 8-byte doubleword of data.) When the data is retrieved, single-bit errors are detected and corrected automatically, and most multiple-bit errors are detected.

STORAGE PROTECTION: Each segment of virtual storage is protected by three codes: a 1-bit Execution Permission key, an 8-bit Read access key, and an 8-bit Write access key. Only code associated with an Execution Permission bit can be executed. When a store access is made, the contents of the Access Control Register (ACR) are compared with either the read or write key of the segment. Sixteen levels of privilege are used, values of 0 to 9 by the system software and values 10 to 15 by the applications programs. Access is granted when the contents of the ACR are equal to, or less than, the key assigned to the segment.

RESERVED STORAGE: Each virtual machine is assigned a set of consecutive storage locations for use as a last-in, first-out stack of general purpose 32-bit registers. The hardware-coupled stack varies in size dynamically as the needs of the virtual machine change.

CENTRAL PROCESSORS

GENERAL: The 2960, 2970, 2976, and 2980 members of the New Range are a compatible series of medium to large scale computers. In terms of performance, the 2970 is 2 times as powerful as the 2960, the 2976 is 3.5 times as powerful as the 2960, and the 2980 is 5.5 times as powerful as the 2960. All are pipeline processors, varying in number of pipeline steps and number of slave stores. The 2960 and 2970 are microprogrammed, the 2976 and 2980 are hard-wired.

MICROPROGRAM STORAGE: The 2960 has 32,768 words of microprogram storage expandable in increments of 16,384 words to a maximum of 65,536 words. Microcode for the 2900 instruction set is contained in the first 32,768 words. Expansions, at this time, are used only to store microcode for emulating 1900 Series and System 4 processors. The 2970 has two microprogram stores of 8K 45-bit words and 8K 36-bit words, respectively. Areas of these stores are used to hold both the 2900 microprograms and extra microcode for emulating a 1900 or System 4.

REGISTERS: An effectively unlimited number of 32-bit general purpose registers are available to users in the stack assigned to each virtual machine.

ADDRESSING: Only the stack and certain hardware registers can be addressed directly. All virtual addresses must be translated. A 64-bit Descriptor Register (DR) is used to expedite the handling of arrays and strings and the passing of control between tasks. There are seven types of descriptors, each comprised of 32 bits of control information and a 32-bit address.

The virtual address of an item identifies its location by segment, by page within the segment, and by its displacement from the beginning of the page. When the address translation hardware is asked for the real address of the item, it first makes a parallel search of the Current Segment and Page Registers which hold information on items currently in either the slave store or in main memory. If the address is not in these registers, the translation hardware then searches the Segment and Page Tables to find the item's location on disc.

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PERIPHERALS AND COMMUNICATIONS

ICL offers a full complement of peripherals and communications equipment for the 2900 Series with emphasis on a limited selection of high performance units of each type. The array of peripheral devices available includes fixed-head disc drives, moving-head disc drives, magnetic tape drives, line printers, card readers, card punches, paper tape readers, paper tape punches, and digital plotters. For communications, ICL offers a variety of video display terminals, printers, and cluster controllers.

All peripherals and communications lines interface with the system via one of four types of peripheral controllers. The General Peripheral Controller (GPC) controls all system serial devices; the microprogrammed Disc File Controller (DFC) supports up to 16 high-speed moving-head disc drives; the microprogrammed Sectored File Controller (SFC) controls up to four high-speed fixed-head discs which support the virtual storage capability; and the microprogrammed Communications Link Controller (CLC) provides the normal method for controlling communications systems. The CLC can be replaced by a programmable processor, the Communications Network Processor (CNP), that can function as a front-end processor.

Each peripheral can be attached to two controllers through a switched interface to provide backup operation in case one controller fails.

To support virtual memory operations, ICL offers 5.76 and 6 megabyte fixed-head disc drives. For mass storage, ICL offers two exchangeable-disc drives with capacities of 100 and 200 megabytes. These moving-head disc units provide rotational position sensing to ensure high throughput rates.

The 2900 Series provides three magnetic tape systems ranging in speed from 120 to 320 kilobytes per second. All are based on 9-track, phase-encoded recording using half-inch magnetic tape and are connected via their local controls to the GPC. An NRZI option is offered on two of the units. The drives feature automatic tape threading, in-flight correction of all single-track errors, and an optional compress/expand recording mode for data exchange with 1900 systems.

Card equipment includes two card readers and one card punch. The readers operate at 1200 and 2000 cards per minute and, under program control, optionally transfer data in card image mode. The punch operates at 100 cards per minute.

Paper tape equipment includes a 1500-characters-per-second reader and a 110-characters-per-second punch; both operate under program control and handle 5-, 7-, or 8-level tape.

The 2900 Series train printer, the LP1500, operates at speeds ranging from 858 to 1500 lines per minute depending on the character set used.

INSTRUCTION REPERTOIRE: The order code includes 113 instructions for fixed point, floating point, and decimal arithmetic, for handling character strings, for performing logical operations, and for manipulating information contained in the stack and in the stack registers. There are 43 arithmetic instructions, 14 store-to-store instructions, 3 conditional jump instructions, and 51 miscellaneous instructions.

CONFIGURATION RULES: All 2960 through 2980 systems require a minimum of 1 order code processor (central processing unit), 1 Store Access Control (SAC), and depending on model, either 1 or 2 Store Multiple Access Controls (SMAC's). Minimum memory requirements are shown in Table I. Dual processor systems are available, but at this time they must be configured as two separate systems. ICL plans to provide support in the future for both tightly coupled and loosely coupled configurations. In the meantime, the dual processor system enables the user to reconfigure his system from a control panel to handle changing workloads and to provide backup for failing units.

COMPATIBILITY: 2900's running in native mode are incompatible with 1900 and System 4 software. To enable users to continue using their software, ICL provides, as an option, 1900 and System 4 emulators. For 2960 and 2970 systems, the emulator consists of extra microcode to handle 1900 and System 4 instructions. Systems equipped with the emulator can process both native mode and emulation mode programs at the same time. Another emulation technique, called Direct Machine Environment (DME) and available only for the 2960, combines microcode and software to enable 1900 or System 4 programs to run under 1900 or System 4 operating systems on a 2960. DME does not support the standard 2900 environment or 2900 programs and is intended to be run alternately with VME/B or VME/K.

For 2976 and 2980 systems, the emulator consists of a separate central processor attached to the system as a peripheral. The attached processor, a modified version of a 1900 or System 4 processor, has no memory or peripherals of its own and accesses the 2900's memory and peripherals via a Store Access Control.

All three emulation methods require that disc files be converted to 2900 format. Tape files, however, can be kept in 1900 format if desired because several of the tape drives have the ability to read/write in both 1900 and 2900 format. System 4 tapes are compatible with 2900 tapes.

INPUT/OUTPUT CONTROL

STORE ACCESS CONTROLS (SAC's): Acting as a multiplexer channel, each SAC is connected directly to memory via one of the Store Multiple Access Controls (SMAC's) and to peripheral controllers via 4 to 16 Trunk Links. Simultaneous, high speed transfers between memory and multiple peripherals are possible because the memory-to-SAC channel is 32 bits wide and Trunk Links are 16 bits wide. (See table for transfer rates.) In "fail-safe" configurations, one SAC is connected to two SMAC's and each controller is connected to two SAC's.

PERIPHERAL CONTROLLERS: I/O operations are handled by four types of peripheral controllers which function independently of the CPU. Commands are stored in memory and fetched by the controllers. The four types of controllers are the Sectored File Controller for fixed-head discs, the Disc File Controller for moving-head discs, the General Peripheral Controller for magnetic tape drives, printers, plotters, punched card and punched tape equipment, and system consoles, and the Communications Link Controller for local and remote terminals.

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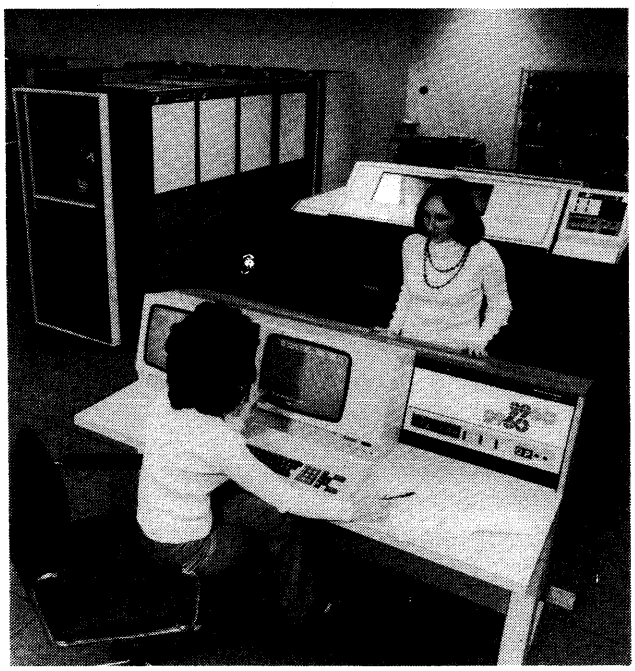

This ICL 2960 system includes a dual-screen master console, an LP-1500 line printer, and, in the four-bay cabinet, a central processor with 524,288 bytes of memory. The left console screen displays system status; the right screen displays the most recent operator commands and the system's responses. An engineer's control processor, built into the end of the central processor cabinet, includes a keyboard, a display, and a cassette reader.

The digital plotter, employing eight vector plotting techniques, plots in 0.05 millimeter increments and operates at 1800 increments per second. It provides a range of facilities including three-pen selection and a manual plotting capability.

Communications equipment for the 2900 Series ranges from teletypewriters to stand-alone systems, including the 7500 Modular Terminal Processors and 2903 computer systems used as remote job entry stations. The 7500's are intelligent, software controlled terminal systems that can be configured with a variety of peripheral equipment to perform interactive or batch tasks in local or remote environments. Visual display terminals feature a 2000 character display and a 96-character set.

SOFTWARE

ICL has developed two operating systems for the 2900 Series. Virtual Machine Environment B (VME/B) is a general purpose system for large 2960's and all 2970's, 2976's, and 2980's. VME/K is a transaction-oriented system designed to squeeze the most work out of a medium scale 2960 in an interactive environment.

From the outside, the systems seem alike, although they currently use different job control languages. Both provide multiprogrammed batch, multi-access computing, and transaction processing facilities. Both create a virtual machine for each job, isolating it from other jobs. Both provide virtual storage facilities that keep code and data

MASS STORAGE

SECTORED FILE CONTROLLER (SFC): Designed to support up to four fixed-head storage devices for virtual storage operations, the SFC is a microprogrammed unit that provides rotational position sensing, command retry, cyclic redundancy checks, and dual recording of sector addresses. When an error is detected, the controller, at the request of the software, will repeat transfer requests several times. Optionally, the controller check-reads a sector one revolution after writing it. A cyclic redundancy check character is added to each data block during writing. The address of each sector is written twice on the track, once in bit complement form, and the two versions are compared during reading with the seek address. The controller has internal registers that can be accessed by the software in the CPU for diagnostic and maintenance purpose. The controller has a peak transfer rate of 3 megabytes/second. Data is transferred in blocks of 1024 bytes, each block representing one virtual page.

FHD-5 FIXED HEAD DISC STORE: The FHD-5 stores up to 5.76 megabytes in 1K sectors. Each of the disc's 512 tracks is divided into 11 sectors of 1024 bytes each. The data transfer rate is 1.31 megabytes per second. Average latency is 5 milliseconds. Rotational speed is 6000 rpm. Up to four FHD-5 drives can be connected to an SFC. Optionally, a drive can be switched between two SFC's for increased reliability.

FHD-6 FIXED HEAD DISC STORE: Each FHD-6 stores up to 6 megabytes in 1K byte sectors. Average latency is 5.2 milliseconds, and the nominal transfer rate is 2.8 megabytes/second. Data are recorded on 4 tracks in parallel in 24 sectors. The disc's 1024 tracks are divided in 256 recording bands of 4 tracks each. Rotational speed is 5760 rpm. Each of up to four drives is connected to a Sectored file Controller by a file interface, an interface module, and an adapter module. Optionally, a drive can be connected to two controllers. The FHD-6 can not be used on the 2960.

DISC FILE CONTROLLER (DFC): Designed to support up to 16 moving-head disc drives, the microprogrammed DFC provides off-line seeking, rotational position sensing, queueing of concurrent accesses, automatic command retry, error correction, error logging, and maintenance and diagnostic facilities. The controller writes a 56-bit cyclic check field at the end of each block of data. During reading, single errors of up to 11 bits can be corrected at the command of software in the CPU. When errors can not be corrected by this method, the DFC makes up to 44 attempts to read a field by a recovery sequence that includes offsetting the heads and advancing and retarding the timing. In the event of file interface errors, track interface errors, seek faults, disc store errors, or main memory service errors, the DFC repeats the failing command several times. For each drive, the DFC logs the number of bytes read, number of head movements made, and number of logic or media errors corrected by retry. Under the control of test programs stored in main memory, the DFC can step through its microprogram and dump the contents of its registers in main memory. The DFC has a peak transfer rate of 1.5 megabytes/second. Each DFC can support two different types of disc drives at one time when equipped with an optional expansion adapter module. Each adapter module accepts up to 8 interface modules of one kind.

EDS-100D EXCHANGEABLE DISC STORE: The EDS-100D stores up to 100 megabytes of data on disc packs with 12 discs and 19 recording surfaces. Average access time, including rotational delay, is 33.3 milliseconds. The peak transfer rate is 806 kilobytes/second. Recording is done on 404 tracks plus 7 reserve tracks. Data are recorded in variable-length sectors. Each sector contains a count block followed by a data block.

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separate, divide jobs into segments of 1024-byte pages, and load pages into any available space. Both make use of a 16-level access-control system that protects each layer of software from lower layers.

But they provide these facilities in different ways.

VME/B, within the limits set by the system manager, is designed to run a varying mix of jobs concurrently without operator intervention. This comprehensiveness has led to two problems common to early releases of major operating systems: high memory requirements and high overhead. But with System Version 21, released in June 1977, ICL says it has solved all the major problems and considers VME/B now to be competitive with any other currently available operating system.

VME/K consists of an Executive and a series of separate subsystems called Function Processors (FP's). Each FP consists of the hardware and software resources unique to one type of computing, such as transaction processing. Because an FP isn't activated until it's needed, VME/K allows the operator to keep operating system overhead to a minimum. Multiple FP's of the same type can be activated by the operator, allowing a 2960 system to be devoted entirely to transaction processing, multi-access, or batch.

The virtual machine concept used by both operating systems reduces overhead and prevents each job from corrupting other jobs or the system software. When a job is loaded, the operating system determines which files, services, and facilities the job needs. The operating system checks its catalog to be sure the job hasn't made any unauthorized requests and then defines a system that exactly meets the job's needs. At runtime, any attempt by the job to use facilities not included in its virtual machine will trigger an interrupt and halt processing of the job until appropriate action is taken.

Although a job can share system and application software with other jobs, it links itself to this code in such a way that all parameters, addresses, and variable data are stored in the job's own stack of registers, making this information inaccessible to other jobs.

ICL currently offers four languages for the 2900's—COBOL, FORTRAN, ALGOL, and BASIC. All except BASIC use re-entrant compilers that allow mixed-language programming. No assembler is available.

COBOL users can develop data base management systems on the 2900's by implementing an ICL version of Cullinane's IDMS package. For users of other languages and for COBOL users not yet interested in creating a data base management system, ICL offers a Data Management Utilities System (DMUS) that includes utilities for file handling.

Packaged application software currently falls into two categories—statistical and manufacturing. More will be

EDS-200 EXCHANGEABLE DISC STORE: The EDS-200 is a double-density version of the EDS-100D. It stores 200 megabytes per disc pack. Each surface has 808 tracks plus 14 reserve tracks. An EDS-100D can be upgraded to a EDS-200.

INPUT/OUTPUT UNITS

GENERAL PERIPHERAL CONTROLLER (GPC): Designed to support up to 15 serial devices, the GPC initiates transfers at CPU command. It fetches control information from main memory and converts virtual addresses to real addresses. Concurrent transfers can take place on all interfaces up to the transfer limit of the controller. The GPC makes parity checks at the trunk interface to the Store Access Control, at the peripheral interfaces, on internal data paths, and on translated addresses. The GPC is connected to each peripheral via an Application Module and an interface. Transfers are made on a fixed-priority basis. The Application Module in the lowest physical position has the highest priority. The GPC's peak transfer rate is 1 megabyte/second.

OPERATING STATIONS (CONSOLES): Each 2900 system has a master operating station (OPER M) consisting of a keyboard display, a 2000-character monitor display, and a reconfiguration console. Each display contains a buffer that allows information to be repeated on up to four free-standing displays (FSD's). Optional additional buffers enable each console display to drive eight FSD's. The reconfiguration console, which optionally includes switches for reconfiguring redundant systems, can support remote alarm units and remote reconfiguration switches. The optional subsidiary operating station (OPER S) includes a keyboard display and a monitor display and also can drive up to 16 FSD's. OPER M is connected to the system via the General Peripheral Controller, and the bootstrap panels and reconfiguration switches are connected to the units controlled. In fail-safe systems, the operating consoles are redundant. The system can be operated from either OPER M or OPER S, and OPER M has two links to the system.

MT-120T MAGNETIC TAPE SYSTEM: The MT-120T subsystem consists of a controller and one tape drive. Up to seven more drives can be added. These 9-track drives can record in either ECMA 36 standard 1600 bit/inch phase-encoded mode or, as an extra cost option, in ECMA 12 standard 800 bit/inch NRZI mode. The drives run at 75 inches/second and transfer date at 120 kilobytes/second (1600 bpi) or 60 kilobytes/second (800 bpi). In Compress-Expand mode, in which 6-bit characters are used for compatibility with ICL 1900 Series systems, the transfer rates are 160 kilobytes/second (1600 bpi) and 80 kilobytes/second (800 bpi). The rewind speed is 240 inches per second. A standard 0.6 inch interblock gap size is used. The combined start and stop interblock gap time is 14 milliseconds. Reading or writing of phase-encoded tapes can be overlapped with skipping operations on other drives. The drives provide automatic loading when tape cartridges are used and automatic threading for tape reels. The drives provide vertical redundancy checks and error correction. The MT-120T controller's command repertoire consists of: initialize, write, read forward, read reverse, skip forward to tape mark, skip reverse to tape mark, skip forward one block, skip reverse one block, write tape mark, auto load, auto dump, and rewind.

MT-200T MAGNETIC TAPE SYSTEM: The MT-200T has the same specifications as the MT-120T, except that it records at 125 inches/second. This increases the transfer rates to 200 kilobytes/second (1600 bpi), 100 kilobytes/second (800 bpi), 270 kilobytes/second (1600 bpi compressed), and 135 kilobytes/second (800 bpi compressed). The rewind speed is 400 inches per second. A standard 0.6 inch interblock gap size is used. The combined start and stop interblock gap time is 10.1 milliseconds.

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From the outside, the systems seem alike, although they currently use different job control languages. Both provide multiprogrammed batch, multi-access computing, and transaction processing facilities. Both create a virtual machine for each job, isolating it from other jobs. Both provide virtual storage facilities that keep code and data separate, divide jobs into segments of 1024-byte pages, and load pages into any available space. Both make use of a 16-level access-control system that protects each layer of software from lower layers.

But they provide these facilities in different ways.

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MASS STORAGE

SECTORED FILE CONTROLLER (SFC): Designed to support up to four fixed-head storage devices for virtual storage operations, the SFC is a microprogrammed unit that provides rotational position sensing, command retry, cyclic redundancy checks, and dual recording of sector addresses. When an error is detected, the controller, at the request of the software, will repeat transfer requests several times. Optionally, the controller check-reads a sector one revolution after writing it. A cyclic redundancy check character is added to each data block during writing. The address of each sector is written twice on the track, once in bit complement form, and the two versions are compared during reading with the seek address. The controller has internal registers that can be accessed by the software in the CPU for diagnostic and maintenance purpose. The controller has a peak transfer rate of 3 megabytes/second. Data is transferred in blocks of 1024 bytes, each block representing one virtual page.

FHD-5 FIXED HEAD DISC STORE: The FHD-5 stores up to 5.76 megabytes in 1K sectors. Each of the disc's 512 tracks is divided into 11 sectors of 1024 bytes each. The data transfer rate is 1.31 megabytes per second. Average latency is 5 milliseconds. Rotational speed is 6000 rpm. Up to four FHD-5 drives can be connected to an SFC. Optionally, a drive can be switched between two SFC's for increased reliability.

FHD-6 FIXED HEAD DISC STORE: Each FHD-6 stores up to 6 megabytes in 1K byte sectors. Average latency is 5.2 milliseconds, and the nominal transfer rate is 2.8 megabytes/second. Data are recorded on 4 tracks in parallel in 24 sectors. The disc's 1024 tracks are divided in 256 recording bands of 4 tracks each. Rotational speed is 5760 rpm. Each of up to four drives is connected to a Sectored file Controller by a file interface, an interface module, and an adapter module. Optionally, a drive can be connected to two controllers. The FHD-6 can not be used on the 2960.

DISC FILE CONTROLLER (DFC): Designed to support up to 16 moving-head disc drives, the microprogrammed DFC provides off-line seeking, rotational position sensing, queueing of concurrent accesses, automatic command retry, error correction, error logging, and maintenance and diagnostic facilities. The controller writes a 56-bit cyclic check field at the end of each block of data. During reading, single errors of up to 11 bits can be corrected at the command of software in the CPU. When errors can not be corrected by this method, the DFC makes up to 44 attempts to read a field by a recovery sequence that includes offsetting the heads and advancing and retarding the timing. In the event of file interface errors, track interface errors, seek faults, disc store errors, or main memory service errors, the DFC repeats the failing command several times. For each drive, the DFC logs the number of bytes read, number of head movements made, and number of logic or media errors corrected by retry. Under the control of test programs stored in main memory, the DFC can step through its microprogram and dump the contents of its registers in main memory. The DFC has a peak transfer rate of 1.5 megabytes/second. Each DFC can support two different types of disc drives at one time when equipped with an optional expansion adapter module. Each adapter module accepts up to 8 interface modules of one kind.

EDS-100D EXCHANGEABLE DISC STORE: The EDS-100D stores up to 100 megabytes of data on disc packs with 12 discs and 19 recording surfaces. Average access time, including rotational delay, is 33.3 milliseconds. The peak transfer rate is 806 kilobytes/second. Recording is done on 404 tracks plus 7 reserve tracks. Data are recorded in variable-length sectors. Each sector contains a count block followed by a data block.

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corrupting other jobs or the system software. When a job is loaded, the operating system determines which files, services, and facilities the job needs. The operating system checks its catalog to be sure the job hasn't made any unauthorized requests and then defines a system that exactly meets the job's needs. At runtime, any attempt by the job to use facilities not included in its virtual machine will trigger an interrupt and halt processing of the job until appropriate action is taken.

Although a job can share system and application software with other jobs, it links itself to this code in such a way that all parameters, addresses, and variable data are stored in the job's own stack of registers, making this information inaccessible to other jobs.

ICL currently offers four languages for the 2900's—COBOL, FORTRAN, ALGOL, and BASIC. All except BASIC use re-entrant compilers that allow mixed-language programming. No assembler is available.

COBOL users can develop data base management systems on the 2900's by implementing an ICL version of Cullinane's IDMS package. For users of other languages and for COBOL users not yet interested in creating a data base management system, ICL offers a Data Management Utilities System (DMUS) that includes utilities for file handling.

Packaged application software currently falls into two categories—statistical and manufacturing. More will be available in the future as ICL modifies packages in the 1900 and System 4 libraries and writes new ones.

USER REACTION

Datapro contacted eight users of the ICL 2900 Series computers during November and December 1977. The users were randomly selected from a variety of sources. This sampling produced five users who had sufficient experience to assess their satisfaction with the systems.

The five usable responses represented six systems including one 2980 and five 2970's; one site had dual 2970's. Our sampling included two university computer centers, a county government, a utility company, and a computer service bureau. Four of the systems had been purchased and the other was rented from ICL. The installed user experience ranged from less than 2 months to more than 22 months and averaged 9.6 months.

A variety of applications was reported. All five users were using their systems for program development and all but one were involved in some manner of data communications. Each also indicated performing either business data processing or scientific and engineering applications, or both.

All five installations were running under the VME/B operating system and used either FORTRAN or COBOL as the primary programming language; two users reported using additional languages as well. Each of the 2970 sites

EDS-200 EXCHANGEABLE DISC STORE: The EDS-200 is a double-density version of the EDS-100D. It stores 200 megabytes per disc pack. Each surface has 808 tracks plus 14 reserve tracks. An EDS-100D can be upgraded to a EDS-200.

INPUT/OUTPUT UNITS

GENERAL PERIPHERAL CONTROLLER (GPC): Designed to support up to 15 serial devices, the GPC initiates transfers at CPU command. It fetches control information from main memory and converts virtual addresses to real addresses. Concurrent transfers can take place on all interfaces up to the transfer limit of the controller. The GPC makes parity checks at the trunk interface to the Store Access Control, at the peripheral interfaces, on internal data paths, and on translated addresses. The GPC is connected to each peripheral via an Application Module and an interface. Transfers are made on a fixed-priority basis. The Application Module in the lowest physical position has the highest priority. The GPC's peak transfer rate is 1 megabyte/second.

OPERATING STATIONS (CONSOLES): Each 2900 system has a master operating station (OPER M) consisting of a keyboard display, a 2000-character monitor display, and a reconfiguration console. Each display contains a buffer that allows information to be repeated on up to four free-standing displays (FSD's). Optional additional buffers enable each console display to drive eight FSD's. The reconfiguration console, which optionally includes switches for reconfiguring redundant systems, can support remote alarm units and remote reconfiguration switches. The optional subsidiary operating station (OPER S) includes a keyboard display and a monitor display and also can drive up to 16 FSD's. OPER M is connected to the system via the General Peripheral Controller, and the bootstrap panels and reconfiguration switches are connected to the units controlled. In fail-safe systems, the operating consoles are redundant. The system can be operated from either OPER M or OPER S, and OPER M has two links to the system.

MT-120T MAGNETIC TAPE SYSTEM: The MT-120T subsystem consists of a controller and one tape drive. Up to seven more drives can be added. These 9-track drives can record in either ECMA 36 standard 1600 bit/inch phase-encoded mode or, as an extra cost option, in ECMA 12 standard 800 bit/inch NRZI mode. The drives run at 75 inches/second and transfer date at 120 kilobytes/second (1600 bpi) or 60 kilobytes/second (800 bpi). In Compress-Expand mode, in which 6-bit characters are used for compatibility with ICL 1900 Series systems, the transfer rates are 160 kilobytes/second (1600 bpi) and 80 kilobytes/second (800 bpi). The rewind speed is 240 inches per second. A standard 0.6 inch interblock gap size is used. The combined start and stop interblock gap time is 14 milliseconds. Reading or writing of phase-encoded tapes can be overlapped with skipping operations on other drives. The drives provide automatic loading when tape cartridges are used and automatic threading for tape reels. The drives provide vertical redundancy checks and error correction. The MT-120T controller's command repertoire consists of: initialize, write, read forward, read reverse, skip forward to tape mark, skip reverse to tape mark, skip forward one block, skip reverse one block, write tape mark, auto load, auto dump, and rewind.

MT-200T MAGNETIC TAPE SYSTEM: The MT-200T has the same specifications as the MT-120T, except that it records at 125 inches/second. This increases the transfer rates to 200 kilobytes/second (1600 bpi), 100 kilobytes/second (800 bpi), 270 kilobytes/second (1600 bpi compressed), and 135 kilobytes/second (800 bpi compressed). The rewind speed is 400 inches per second. A standard 0.6 inch interblock gap size is used. The combined start and stop interblock gap time is 10.1 milliseconds.

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had memory sizes of 2 million bytes; the 2980 site had a 2.5 million byte memory. On-line disk storage averaged 2100 million bytes.

Of the five users, four were using both remote batch and interactive terminals on-site. The number of on-line interactive terminals ranged between 6 and 80. The number of on-line remote batch terminals ranged between one and eight.

The responses of the five users are tabulated below. The number of responses to certain questions is lower than five in cases where the user did not provide a response.

	Excellent	Good	Fair	Poor	WA*
Ease of operation	0	4	1	0	2.8
Reliability of mainframe	1	4	0	0	3.2
Reliability of peripherals	0	5	0	0	3.0
Maintenance service:					
Responsiveness	3	2	0	0	3.6
Effectiveness	1	3	1	0	3.0
Technical support	2	1	2	0	3.0
Manufacturer's software:					
Operating system	1	3	1	0	3.0
Compilers and assemblers	2	3	0	0	3.4
Applications programs	0	1	2	0	2.3
Ease of programming	0	3	1	0	2.8
Ease of conversion	0	1	2	0	2.3
Overall satisfaction	0	4	0	0	3.0

*Weighted Average on a scale of 4.0 for Excellent.

These weighted averages clearly indicate a general level of satisfaction with the 2900 Series. The relative newness of the series and the small population we were able to sample make it difficult to draw specific conclusions.

Perhaps the most common feeling among these users can be summed up by one user's comment that the "2900 is a new range and some problems are still encountered on this account." He went on to say, "however, experience to date is most encouraging."

Most of the respondents cited the hardware and software architecture as the series' principal strength. On the negative side, several comments were made about the relative instability of the operating system. That category, however, received a healthy 3.0 rating. The ratings seem to indicate a greater dissatisfaction with the applications software.

The overall satisfaction was unanimously judged as "Good" by those responding to this category. It is evident that although the ICL New Range is feeling some growing pains, its users are quite satisfied with the range and have confidence in the system's potential and ICL's ability to rectify any deficiencies.

Users, especially those with international operations, should consider the 2900's before upgrading their installations. In addition to the impressive capabilities of the systems themselves, the 2900's offer the additional bonus of ICL service facilities in some areas of the world where other mainframe manufacturers offer little or no support.□

MT-320T MAGNETIC TAPE SYSTEM: The MT-320T is similar to the MT-120T and MT-200T, except that it does not offer 800 bpi recording. The MT-320T operates at 200 inches/second and transfers data at 320 kilobytes/second in standard mode and 427 kilobytes/second in compress-expand mode. Rewind speed is 500 inches per second. The combined start and stop interblock gap time is 6.3 milliseconds.

LP-1500 LINE PRINTER: A train printer, the LP-1500 is available with either 132 or 160 print positions. It operates at 1500 lines/minute with a 48-character train, 1200 lines/minute with a 64-character train, and 858 lines/minute with a 96-character upper/lower case train. OCR-B is the standard font. A train cartridge has 96 slugs, each with four characters on it. Cartridges are interchangeable by an operator. Up to four character-set codes are stored in read-only memory, and the correct code is automatically loaded into a buffer when a cartridge is mounted. Spacing is 6 or 8 lines/inch, and printing is at 10 characters/inch. Format control is under software direction. Forms can range from 3.25 to 20 inches wide and 6 to 18 inches long. The hopper and stacker hold up to 10 inches of paper.

CR-1200 CARD READER: A freestanding unit with integral control that reads 80-column cards serially starting at column one, the CR-1200 employs a photo cell sensing technique and operates at a maximum speed of 1200 cards per minute. The input hopper and output stacker hold up to 3000 cards each.

CR-2000 CARD READER: Identical to the CR-1200 described above but operates at a maximum speed of 2000 card per minute.

CP-100 CARD PUNCH: The CP-100 punches 80-column cards at speeds of up to 100 cards per minute. A buffer holds the data for one card. The punch has an 800-card input hopper and 650-card output stacker.

PTR-1500 PAPER TAPE READER: The PTR-1500 reads 5-, 7-, or 8-level punched paper tape at 1500 characters per second. Standard tape widths accepted include 1 inch, ⅞ inch, and 11/16 inch. ISO 7-bit coded characters are translated into EBCDIC. Alternatively, hexidecimal mode or image mode (with software translation) can be selected by the program.

PTP-110 PAPER TAPE PUNCH: The PTP-110 punches 5-, 7-, or 8-level tape at 110 characters per second. ISO coded 7-bit character are normally punched; alternatively, image or hexidecimal modes can be selected by the program. Powered dispenser and spooler mechanisms each handle up to 1000 feet of tape.

DP-1 DIGITAL PLOTTER: The DP-1 system includes a freestanding digital plotter and a freestanding control unit. The plotter mechanism is a Calcomp 936 Drum Plotter which offers three-pen selection and manual plotting capabilities. Plotting is controlled by programs employing 8-vector plotting techniques. The plotter operates at a maximum rate of 2500 increments per second with the pen up and 1800 increments per second with the pen down. The plotting speed is 125 mm/sec. with the pen up and 90 mm/sec. with the pen down.

COMMUNICATIONS CONTROL

COMMUNICATIONS LINK CONTROLLER (CLC): Each CLC consists of a microprogrammed controller and one to eight Network Interface Modules (NIM's). Each NIM supports up to 16 half-duplex lines, so each CLC can support up to 128 lines. A CLC can be enhanced to serve as a front-end processor by adding memory and a new microprogram. A basic CLC has a 32K byte memory, enough to support

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up to four NIM's. Memory can be increased in increments of 16K. Each CLC can handle a mixture of telephone and telegraph lines working at different speeds ranging from 50 up to 9600 bits/second. The maximum number of lines a CLC can handle may be less than the maximum 128, depending on line speeds, message lengths, and polling rates. The CLC provides auto answering. Each CLC is connected to the 2900 system via a trunk line and to the modems via a Multi-stream Data Transmission Interface, a NIM, and a 4-line interface board. Line control can be either asynchronous or synchronous.

When a CLC is upgraded to a Communications Network Processor (CNP), it can support its own peripherals, including fixed and moving head disc drives, tape drives, and line printers, and can handle message buffering and message switching. CNP's also can be used as remote concentrators.

7181/2 REMOTE VIDEO TERMINAL: The 7181/2 is a keyboard terminal with a 2000-character display and a 96-character set. Features include cursor control, protected fields, optional badge reader, and an optional 30 character/second printer. The 7181/2 can operate at line speeds from 600 to 4800 bits/second.

7181/4 REMOTE VIDEO TERMINAL: The 7181/4 is similar to the 7181/2 described above, but is used in a purely local environment.

7502 MODULAR TERMINAL SYSTEMS: The 7502 is an intelligent software-controlled communications system. Data is transmitted bit serially at speeds up to 9600 bps. Four configurations are available with the following characteristics:

- 7502/10 Interactive Terminal System, 12K to 16K byte processor, up to 8 video terminals, and up to 4 hard copy printers.
- 7502/15 Interactive/Stand-Alone Terminal System, 16K to 40K byte processor, up to 6 video terminals, and 4 hard copy printers; options include 0.5-megabyte floppy disc system, 300-lpm printer, and personal identification device readers.
- 7502/20 Remote Printing Terminal System, 16K to 40K byte processor, one video terminal, and a 300-lpm printer; options include a 0.5-megabyte floppy disc system, up to 4 hard copy printers, and additional video terminals.
- 7502/25 Remote Batch Terminal System, 16K to 28K byte processor, one video terminal, a 300-lpm printer, a 300-cpm card reader, and a personal identification reader; options include a 0.5-megabyte floppy disc system.

Programs can be downline loaded into 7502 systems by the 2900 system, a feature not available on the 7503 Modular Terminal System. Systems employing a floppy disc system can load programs from the diskette. Users of both ICL and IBM mainframe systems can have their 7502 terminals emulate IBM 3270 terminals by using the 7502 Model 70 system.

7503 MODULAR TERMINAL SYSTEM: The 7503 is an intelligent software controlled communications system which can be configured as a remote bulk data input/output station or as a local or remote interactive system. Software control emanates from Terminal Control Programs (TCP's) stored on magnetic tape cassettes. The terminal store size can range from 16K to 56K bytes as required by the TCP used. Data is transmitted bit serially at speeds up to 9600 bps, each data character is represented by 7 data bits and 1 parity bit. Each system can support up to eight peripheral devices including magnetic tape cassettes, video terminals, line printers, card readers, and paper tape readers.

2903 REMOTE JOB ENTRY TERMINAL: A small-scale 2903 computer system can be used as a remote job entry terminal to larger 2900 systems.

TTW1 AND TTW2 TELETYPEWRITERS: Intended for light-duty operation, these stand-mounted keyboard/printers operate at a maximum speed of 10 characters per second. KSR (TTW1) and ASR (TTW2) versions are available with friction or sprocket platen feed and a paper tape reader and punch. The standard speed for keying, printing, and tape reading and punching is 110 bits per second, but 75 bits per second is also available as an alternative. Transmission mode is asynchronous using the ISO 7-bit code plus even parity. Manual calling and answering must be used on switched network connections.

SOFTWARE

Two operating systems are currently offered for the larger 2900's. Both support mixes of batch, multi-access (time-sharing), and transaction processing. Both are virtual storage, virtual machine operating systems designed to take advantage of the 2900's stack architecture. The two operating systems are quite different in design, however, and use different job control languages.

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VME/B: The "B" operating system requires a system with a minimum of 1 megabyte of real memory. VME/B is divided into four groups of subsystems: the Kernel, the Director, Job and Data Management, and Out-of-Process Subsystem.

The Kernel runs at access-control levels 0, 1, and 2, and therefore is protected from all other software running on the system. Kernel responsibilities include the following:

—Creation and deletion of virtual machines.
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—Mapping of virtual machines on to real resources.
—Peripheral and communication controllers.
—Provision of timing facilities to processes.
—Emulation of non-2900 Series processors.
—Errors central to the basic hardware or software.

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—Control of the use of central processor time by jobs to optimize use of system resources.
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—Output spooling.

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Mass storage devices for the 2900 Series include the 100-megabyte EDS-100D exchangeable disc stores, foreground, that also are available in a 200-megabyte version. The drives have an average access time of 33.3 milliseconds and a peak transfer rate of 806 kilobytes per second.

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COMPETITIVE POSITION

ICL, the fifth largest computer company in the world and the largest non-U.S. computer manufacturer, sells and services its products in more than 80 countries. Last year, ICL strengthened its organization by acquiring the international operations of the Singer Business Machines Division.

Application software for the 2900 Series is separately priced and is developed by Dataskil, the largest software house in the U.K. and a wholly owned ICL subsidiary.

ICL receives 100 percent of its revenue from the computer field and its future, unlike that of some of the major companies that have dropped out of the industry, depends entirely on its commitment to computers.

ICL calls the 2900 Series "Your Future System" and sees it as a family that can continue to evolve well beyond the mid 1980's.

Users, especially those with international operations, should consider the 2900's before upgrading their installations. In addition to the impressive capabilities of the systems themselves, the 2900's offer the additional bonus of ICL service facilities in some areas of the world where other mainframe manufacturers offer little or no support.□

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—Output spooling.

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—Management of errors discovered at Director level.
—Control of block structuring.
—Library and context naming facilities.

The Job and Data Management subsystems run at access-control levels 6, 7, and 8 and handle the following activities:

—Introduction of work to the system.
—Scheduling of work submitted.
—Execution and control of this work.
—Record-level data management.
—Output spooling.
—Backup and retrieval of files.
—Accounting and budgeting.

The Out-of-Process Subsystems run at access-control levels 9 through 15 and include responders and schedulers for handling communications with the operator and for handling multi-access (time-sharing) and transaction processing jobs; an output spooler; and a file back-up manager. Although these subsystems run at the same access-control levels as applications software, each of these subsystems runs in its own virtual machine and therefore is protected from other virtual machines.

A single, high level, block structured System Control Language is used by system managers, data administrators, programmers, operators, and field engineers to communicate with the operating system. Each person is assigned a subset of SCL according to his needs and is automatically prevented from using unauthorized commands. A Dedicated Command Processor (DCP) provides fast execution of user-defined SCL macros, thus reducing the number of commands needed at runtime to direct the system.

The System Catalog contains information on users, volumes, files, events, and hardware units. Entries are interrelated. The operating system uses the catalog to find things (such as the physical location of a named file) and to bar unauthorized access to files and facilities.

A virtual machine is created by the operating system for each job at runtime. The operating system uses the information provided by the user in System Control Language to assign hardware and software facilities to the job. In creating the virtual machine, the operating system checks the System Catalog to make sure that no unauthorized facilities are assigned. Once a virtual machine has been created, the job can not use any additional facilities. Thus the job is isolated from other jobs and is, effectively, running alone on a custom-designed system. To conserve real and virtual memory, virtual machines can share code, but intermediate results or data resulting from this sharing are stored within each virtual machine and not in a common area. To optimize the use of peripherals, physical units are assigned to a job only during periods when they are actually needed, not for the duration of the job.

VME/K: This operating system has been designed to make the most efficient use of the resources of a medium scale system. VME/K is comprised of an Executive and one or more of the following Function Processors: (FP's):

—Batch Function Processor
—MAC (multi-access computing) Function Processor
—Transaction Processing Function Processor
—1900 Series Emulation Function Processor
—Operator Command Function Processor
—Bulk Data Switching (BDS) Function Processor
—Engineers Function Processor
—Statistics Function Processor

Executive controls the hardware, the flow of data through the system, and the scheduling of processes. The Function Processors, which are activated only when needed, provide specific services. BDS, for example, provides output spooling, and the Engineers FP provides diagnostic services.

The FP concept allows the system to be heavily weighted toward, for example, transaction processing for part of the day and later reweighted toward time-sharing for the rest of the day. The key to such resource allocation is the ability to activate more than one FP of the same kind. For example, several Transaction Processing FP's can be activated to weight the system toward this application.

An FP is "activated" rather than "called" because each FP is defined in terms of both the hardware and software it requires. Each job running under an FP runs in its own virtual machine.

An FP is always guaranteed its allotted share of real memory but can use more if more is available.

The Executive schedules work in units called exchanges and groups of exchanges called conversations. Each exchange consists of the input of a request for action, processing to deal with the request, and the transmission of a response. A conversation consists of all the exchanges comprising a job.

To reduce the overhead inherent in swapping out an active job, VME/K is designed to log interrupts and handle certain housekeeping chores without swapping out the currently active job. In the interrupt environment, the central processor is diverted for an average of 50 instructions to log interrupts. In the handler environment, the central processor is diverted for an average of 200 instructions. Processing of the current job then is resumed unless a higher priority job has been found on the scheduling queue. Although these interruptions require that the contents of some registers be stored on the job's stack, they do not require changes in the contents of the slave stores or of real memory.

VME/K's Job Control Language (JCL) is used for introducing jobs to the system. Operators use a separate Operator Command Language to interface with the system. JCL statements can be compiled in advance and loaded in object form to reduce the overhead inherent in using a run-time interpreter.

VME/K maintains an Executive Catalog for recording the physical location of files and a Filestore Catalog for recording the ownership of files. When a job is loaded, the Filestore Catalog is checked to be sure the job will seek to access only authorized files. A run-time, the Executive Catalog is used to find the physical location of the files without further reference to the Filestore Catalog.

Under VME/K, the Executive and the Function Processors run at access-control levels 1 through 9 and the application software runs at access-control levels 10 through 15.

COBOL: Effective with System Version 21 of VME/B, ICL will offer the same COBOL compiler under both operating systems, so the following information on the VME/K compiler applies to all 2900 Series systems. The compiler follows the guidelines used in developing American National Standard (ANS) COBOL-74 and offer capabilities equal to the highest level of all ANS modules except Report Writer and Communications, which are not implemented. Instead, the REPORT utility of the ICL Data Management Utility System can be used for preparing reports, and the ACCEPT and DISPLAY verbs can be used to provide transaction processing facilities. ICL has added a number of extensions to the standard, including floating-point arithmetic, and has removed a number of restrictions.

FORTRAN: Effective with System Version 21 of VME/B, ICL will offer the VME/K FORTRAN compiler for all 2900 Series systems. This compiler is based on American National

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Standard (ANS) FORTRAN-1966 and includes, among its enhancements, facilities for handling direct-access files. ICL also offers an optimizing FORTRAN compiler (OFC) that produces more efficient code but requires longer compilation times.

ALGOL: The ALGOL 60 compiler is based on International Standards Organization (ISO) Recommendation R1538. Enhancements extend the facilities for using indexed files and provide limited facilities for direct-access files. Dump and trace facilities are scheduled to be added next year.

BASIC: The BASIC interpreter follows the informal standards set by Dartmouth BASIC and by the National Computing Centre and incorporates a number of capabilities not included in earlier ICL versions of the language.

IDMS: ICL has adopted the Integrated Database Management System (IDMS) from Cullinane Corp. as the standard database management system for the 2900 Series. IDMS is described in detail in Report 70E-272-02.

DATA MANAGEMENT UTILITY SYSTEM (DMUS): This package of file handling programs includes its own high level language, the File Manipulation Language (FML), which is used to specify procedures. Other programs include:

—DATA VALIDATE for validating and loading records into files.
—FILE UPDATE for processing a transaction file against an input master file.
—RECORD COPY.
—EXTRACT for copying selected records and making changes in field values.
—SORT.
—MERGE.
—RECORD LIST for printing all or part of a file.
—REPORT for generating reports.
—COMPARE for comparing the records in two files and listing matched, unmatched, and omitted records.

APPLICATIONS PROGRAMS: ICL offers a variety of applications programs for business, engineering, and scientific functions. Following are brief descriptions of currently available packages.

- Statistics—provides facilities for the management of statistical data structures and the statistical analysis of data. The package is organized to operate in conjunction with a high-level language resembling ALGOL and PL/1 so that statistical and data management statements can be freely mixed with high-level control language statements.

- Matrix Handler and Application Control Language (ACL)—provides an integrated set of procedures for manipulating matrices and for performing matrix operations and calculations. IBM's MATLAN offers similar facilities but does not employ the "English-like" syntax provided by this package.

- Numerical Algorithms Group Library—is a collection of about 300 free-standing numerical algorithms for scientific computing. The routines, which consist of subroutines or functions, are callable from users' programs.

- Linear Programming—employs the common 2900 Series Application Control Language (ACL) and solves the normal mathematical problem of optimization of a linear objective function while satisfying linear constraints in many variables. It is designed to solve problems in product planning and scheduling, blending/alloying mixing, transportation, and investment.

- MGRW (Matrix Generator/Report Writer)—designed for use with the Linear Programming system (described above) to simplify the generation of input data and the analysis of results.

- ACSL (Advanced Control and Simulation Language)—is used to perform simulated experiments to determine the effect of altering the configuration of facilities in a system.

- PERT—is a management system for the planning and control of projects.

- IDH (Interactive Data Handler)—provides a means of formatting the video terminal screens and of validating data input in an on-line mode. Functions included are creation and storage of screen formats, data validation parameters, and data base/file extract display parameters; capture, buffering, and output of large volumes of source data to user files; and display upon request of extracts from user-specified files.

- Prosper—is a specialized high-level language designed to allow a user to create and amend planning models including cash flow forecasting, financial analysis, and risk analysis and simulation models.

- Structural Analysis—enables the structural engineer to perform analyses of skeletal structures for member and restraint reaction, forces and moments, together with joint, linear, and rotational displacements.

- GENESYS—consists of a machine-independent language similar to FORTRAN and a series of applications subsystems which are applicable to civil engineering.

- BOMP—provides the means to create, maintain, and retrieve data from files holding product structure information.

- Material Control—is designed to help provide a solution to the problem of calculating the total production plan necessary to meet a given finished product program in terms of the requirements for parts and for other resources such as machines and operators.

- Factory Scheduling—is a network scheduling system designed to schedule the workload of a factory for a period of a few weeks within a finite resource capacity. System output includes the operations scheduled, a table of resource availability and scheduled usage, and the operations scheduled for each resource.

- Credits—is a system that captures orders from retail outlets from devices such as point of sale terminals, shelf-edge recorders, or written documents which are then allocated and issued from a depot.

PRICING

The ICL 2900 Series systems are marketed on an unbundled basis. All software is subject to a license fee, normally charged on a monthly basis but sometimes on a capital basis either instead of or in combination with monthly charges. Hardware is available for purchase or lease. Maintenance charges are not included.

SUPPORT: Technical support is provided at no extra cost for normal installations, but additional services are billed to the user.

EDUCATION: Courses, on a fee basis, are available in systems appreciation, programming, and operations. Courses also are available for all levels of management.■

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EQUIPMENT PRICES*

CONFIGURATION			Purchase Price £	Monthly Rental** £	Monthly Maint. £
ICL 2960 SMALL SYSTEM					
50153	Order Code Processor				
50353	Store Multiple Access Control				
50451	0.5 Megabyte Store (4 128K Byte Blocks)				
50253	Store Access Control				
50626	Disc File Controller				
53131	EDS-200 Exchangeable Disc Drives (4), 200MB/Drive				
50603	General Peripheral Controller				
51003	OPER-M1 Master Operating Station				
52322	MT-120 Magnetic Tape Drives (4), 120 Kilobytes per Second				
51331	LP-1500 Line Printers (2), 1500 lpm				
		TOTAL PRICE*	547,000	13,000	2,000
ICL 2960 LARGE SYSTEM					
50153	Order Code Processor				
50353	Store Multiple Access Control (2)				
50461	1 Megabyte Store (4 256K Byte Blocks)				
50253	Store Access Control				
50651	Sectored File Controller				
53321	FHD-5 Fixed-Head Disc Drives (2), 5.76MB/Drive				
50626	Disc File Controller				
53131	EDS-200 Exchangeable Disc Drives (6), 200MB/Drive				
50603	General Peripheral Controller				
51003	OPER-M1 Master Operating Station				
52322	MT-120 Magnetic Tape Drives (8), 120 Kilobytes per Second				
51331	LP-1500 Line Printer, 1500 lpm				
51105	CR-1200 Card Reader, 1200 cpm				
		TOTAL PRICE*	773,000	20,600	2,700
ICL 2970 SMALL SYSTEM					
50163	Order Code Processor				
50363	Store Multiple Access Control (3)				
50461	1.5 Megabyte Store (6 256K Byte Blocks)				
50263	Store Access Control				
50651	Sectored File Controller				
53321	FHD-5 Fixed-Head Disc Drive, 5.76MB				
50626	Disc File Controller				
53131	EDS-200 Exchangeable Disc Drives (6), 200MB/Drive				
50603	General Peripheral Controller				
51003	OPER-M1 Master Operating Station				
52141	MT-320 Magnetic Tape Drives (8), 320 Kilobytes per Second				
51331	LP-1500 Line Printer, 1500 lpm				
		TOTAL PRICE*	1,200,000	31,000	3,300
ICL 2970 LARGE SYSTEM					
50163	Order Code Processor				
50363	Store Multiple Access Control (3)				
50461	3 Megabyte Store (12 256K Byte Blocks)				
50263	Store Access Control				
50651	Sectored File Controller				
53321	FHD-6 Fixed-Head Disc Drives (4), 6MB/Drive				
50626	Disc File Controller (2)				
53131	EDS-200 Exchangeable Disc Drives (20), 200MB/Drive				
50603	General Peripheral Controller				
51003	OPER-M1 Master Operating Station				
52141	MT-320 Magnetic Tape Drives (6), 320 Kilobytes per Second				
51331	LP-1500 Line Printers (4), 1500 lpm				
		TOTAL PRICE*	2,020,000	53,000	6,700

** These prices do not include communications subsystems and separately priced software.*
***Prices do not include maintenance.*

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EQUIPMENT PRICES*

CONFIGURATION			Purchase Price £	Monthly Rental ** £	Monthly Maint. £
ICL 2976 SMALL SYSTEM					
50166	Order Code Processor				
50363	Store Multiple Access Control (2)				
50461	1.5 Megabyte Store (6 256K Byte Blocks)				
50263	Store Access Control				
50651	Sectored File Controller				
53321	FHD-5 Fixed-Head Disc Drive, 5.76MB				
50626	Disc File Controller				
53131	EDS-200 Exchangeable Disc Drives (8), 200MB/Drive				
50603	General Peripheral Controller				
51003	OPER-M1 Master Operating Station				
52141	MT-320 Magnetic Tape Drives (8), 320 Kilobytes per Second				
		TOTAL PRICE*	1,700,000	43,700	4,700
ICL 2976 LARGE SYSTEM					
50166	Order Code Processor				
50363	Store Multiple Access Control (3)				
50461	4 Megabyte Store (16 256K Byte Blocks)				
50263	Store Access Control				
50651	Sectored File Controller				
53321	FHD-5 Fixed-Head Disc Drives, 5.76MB				
50626	Disc File Controller (2)				
53131	EDS-200 Exchangeable Disc Drives (32), 200MB/Drive				
50603	General Peripheral Controller				
51003	OPER-M1 Master Operating Station				
52141	MT-320 Magnetic Tape Drives (6), 320 Kilobytes per Second				
51331	LP-1500 Line Printers (4), 1500 lpm				
		TOTAL PRICE*	2,700,000	69,000	8,000
ICL 2980 SMALL SYSTEM					
50173	Order Code Processor				
50373	Store Multiple Access Control (2)				
50471	2 Megabyte Store (8 256K Byte Blocks)				
50273	Store Access Control				
50651	Sectored File Controller				
53331	FHD-6 Fixed-Head Disc Drive, 6MB				
50626	Disc File Controller				
53131	EDS-200 Exchangeable Disc Drives (6), 200MB/Drive				
50603	General Peripheral Controller				
51003	OPER-M1 Master Operating Station				
52141	MT-320 Magnetic Tape Drives (8), 320 Kilobytes per Second				
51331	LP-1500 Line Printers (2), 1500 lpm				
		TOTAL PRICE*	2,500,000	61,000	6,000
ICL 2980 LARGE SYSTEM					
50173	Order Code Processor				
50373	Store Multiple Access Control (4)				
50471	6 Megabyte Store (24 256K Byte Blocks)				
50273	Store Access Control (2)				
50651	Sectored File Controller				
53331	FHD-6 Fixed-Head Disc Drives (4), 6MB/Drive				
50626	Disc File Controller				
53131	EDS-200 Exchangeable Disc Drives (60), 200MB/Drive				
50603	General Peripheral Controller				
51003	OPER-M1 Master Operating Station				
52141	MT-320 Magnetic Tape Drives (6), 320 Kilobytes per Second				
51331	LP-1500 Line Printers (6), 1500 lpm				
		TOTAL PRICE*	4,700,000	120,000	14,500

** These prices do not include communications subsystems and separately priced software.*
***Prices do not include maintenance.*