ICL 2900 Series, Models 2946 to 2982

MANAGEMENT SUMMARY

Fulfilling the promise made when it introduced the ICL 2900 New Range in 1974, ICL has continually updated and improved the series while maintaining compatibility with the earliest models. The result is a technologically up-to-date series of systems based on more than five years of actual experience. Because of the modular design of the systems, evolution can continue indefinitely.

The currently marketed models—the 2946, 2955, 2966, 2977, and 2982—illustrate this evolution. All have been announced since 1979 and are competitive with the IBM 4300 and 303X families.

All five models support virtual memory and virtual machine processing techniques and use instruction pipelining to increase their processing speed.

In addition to the native Virtual Machine Environment (VME), the three smaller, microcoded models can support Direct Machine Environment (DME), an emulation mode that enables software from the earlier ICL 1900 and System 4 computers to run on the 2900s. Concurrent Machine Environment (CME) enables the 2955 and 2966 to run both VME and DME concurrently.

All models support traditional batch, remote batch, and time sharing. Special software enables the three smaller models to carry out transaction processing.

For enhanced reliability, all 2900 systems can be installed in redundant configurations that allow system modules to be bypassed if a fault develops. Using a special console, the operator can reconfigure the system from his operations station.

The medium to large scale range of systems in ICL's 2900 series currently consists of the 2946, 2955, 2966, 2977, and 2982. Each offers a virtual machine environment, distributed intelligence, and an open-ended design intended to prevent future obsolescence. Prices of typical configurations range from £197,000 to £2,060,000.

CHARACTERISTICS

MANUFACTURER: International Computers Ltd., ICL House, Putney, London SW15. Telephone (01) 788-7272. Telex 22971. ICL markets its systems in 80 countries.

MODELS: The 2946, 2955, 2966, 2977, and 2982 are currently marketed actively. Processors of models no longer sold to new customers can be supplied to upgrade existing installations. These models as the 2905, 2950/10, 2950/20, 2956, 2960, 2960/10, 2970, 2972, and 2976.

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 hexadecimal exponent, in short format; 2 words, consisting of a 56-bit fraction (14 hex digits) and 7-bit hexadecimal exponent, in long form; or 4 words, consisting of a 112-bit fraction (28 hex digits) and 7-bit hexadecimal exponent in extended format.

INSTRUCTIONS: 2 or 4 bytes in length. Most instructions are available in both forms. There also are three instruction

One of the most recently announced models, the ICL 2966 falls in the middle of the range between the 2946 and the 2982. The system shown is equipped to run in the Concurrent Machine Environments mode and has both a 2966 console, foreground, and a George 3 console, background, for controlling 1900 series emulation.

ICL 2900 Series, Models 2946 to 2982

CHARACTERISTICS OF THE ICL 2900 SERIES

	2946	2955	2966	2977	2982
SYSTEM CHARACTERISTICS					
Date of introduction	Mar. 1980	Oct. 1980	Oct. 1980	Feb. 1981	May 1979
Date of first delivery	Mar. 1980	May 1981	May 1981	June 1981	Oct. 1979
Virtual storage capability	Standard	Standard	Standard	Standard	Standard
Number of central processors	1 or 2	1 or 2	1 or 2	1 or 2	1 or 2
Principal operating systems	VME/K CME/2 DME/2	VME/K VME/B-E CME/2 TME	VME/K VME/B VME/B-E CMF/2/3/B3 DME/G3/S4	VME/B VME/B-E	VME/B VME/B-E
MAIN STORAGE					
Storage type	MOS—16K	MOS—16K	MOS—16K	MOS—16K	MOS—16K
Read cycle, nanoseconds	700	700	700	580	580
Write cycle, nanoseconds	750	750	750	530	530
Partial write cycle time, nanoseconds	1400	1400	1400	1000	1000
Bytes fetched per cycle	8	8	8	8	16
Storage interleaving	None	None	None	No	Yes
Minimum capacity, bytes/system	1M	2M	4M	6M	2M
Maximum capacity, bytes/system	8M	8M	8M	16M	16M
Increment size, bytes	½M	½M	2M	1M	2M
BUFFER STORAGE (SLAVE STORES)					
Cycle time, nanoseconds	125	125	80	100	100
Bytes fetched per cycle	4	4	4	4	4
Data slave capacity, bytes	1K	1K	16K	1K	1K
Cache store, bytes	—	—	—	16K	16K
PROCESSING UNIT					
Machine cycle time, nanoseconds	150	125	80	113	113
Processing unit features:					
Floating point	Standard	Standard	Standard	Standard	Standard
Extended precision floating point	Standard	Standard	Standard	Standard	Standard
Decimal arithmetic	Standard	Standard	Standard	Standard	Standard
Fast multiply/divide unit	No	No	No	Optional	Optional
Real-time clock	Standard	Standard	Standard	Standard	Standard
Microprogramming	yes	yes	Yes	No	No
Pipeline steps	2	2	2	6	6
Pipeline capacity instructions	2	2	2	9	9
Compatibility features:					
ICL 1900 Series emulation by microcode	Yes	Yes	Yes	No	No
ICL 2903, 2904 emulation by microcode	Yes	Yes	Yes	No	No
ICL System 4 emulation	No	No	Yes	No	No
CHANNELS					
Store Multiple Access Controls (SMAC)	—	—	—	2, 3, or 4	2 or 4
Store Access Controls (SAC)	—	—	—	1 or 2	1 or 2
Store Control Units (SCU)	1 or 2	1 or 2	1 or 2	—	—
Device Control Units (DCU)	1 or 2	1, 2, or 3	2 to 6	1	1
SAC or SCU to mainstore	10.7MB/s	10.7MB/s	10.7MB/s	16MB/s	16MB/s
Maximum total transfer rate	7.2MB/s	7.2MB/s	7.2MB/s	16MB/s	16MB/s
Power ratio	1	1.45	4.0	6.5	7.3

In VME mode, the microcoded 2946, 2955, and 2966 use the same set of 113 instructions as the hard-wired 2977 and 2982, ensuring compatibility.

PERIPHERALS AND COMMUNICATIONS

ICL's range of peripherals and communications for the 2946, 2955, 2966, 2977, and 2982 is a much wider set than that originally offered, with the accent on medium to large capacity units and flexibility in control. There is a considerable choice available in fixed and exchangeable disc drives, magnetic tape drives, and printers, but not many choices in terminals and card and paper tape devices.

formats. Primary format instructions are either computational 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

Main storage of the 2946, 2955, and 2966 consists of a minimum of one Store Module. Each module contains up to 4 megabytes of 16K-chip memory in either half-megabyte or 2-megabyte blocks, dependent on the system. Block cycle time is about 725 nanoseconds per 8 bytes with the instantaneous peak transfer rate per module at 3.6, 5.4, 7.2 megabytes per

ICL uses four types of controllers for general peripheral devices and a fifth for communications. The four types of controllers of the general kind are: the Sectored File Controller (SFC) for fixed-head discs; the Disc File Controller (DFC) for moving head discs; the General Peripheral Controller (GPC) for magnetic tape drives, printers, card and paper tape equipment, and system consoles; and the Device Control Unit (DCU) for moving head discs and the types of peripherals also connectable to a GPC. The Communications Link Controller (CLC) is used for local and remote terminals.

ICL offers a very wide range of disc drives—now coming increasingly under the Modular Disc Storage System (MDSS) label which includes both fixed and exchangeable discs. The older terminology, FDS for fixed discs and EDS for exchangeable discs, is, however, still in use. Capacity ranges from about 6 megabytes to 651 megabytes on fixed discs and from 79 to 200 megabytes on exchangeable disc pack devices.

ICL now offers no less than eight magnetic tape drive systems, some dating back to the old ICL 1900 range of peripherals. Transfer rates range from 20 kilobytes per second to 780 kilobytes per second. All tapes are 9-track, with many of them offering compressed recording capability together with such features as autoloading when tape cartridges are used.

ICL now also offers a much larger set of printer options than those originally made available with the 2900 series. Besides the 1500 line per minute printer offered originally, ICL now provides three band printers. Speeds are from 200 lines per minute with a 96-character set on the slowest band printer to 1130 lines per minute on the fastest when using a 48-character set.

In addition, ICL also has a laser printing system which prints on a page by page basis rather than by line. The speed is equivalent to 21,000 lines per minute with 12 lines to the inch.

Two card readers are available. These function at 300 and 1000 cards per minute, respectively. Both have photoelectric means of reading cards.

One buffered card punch is offered. This has a maximum speed of 60 cards per minute. The buffer holds data for one card.

Paper tape equipment comprises a reader and a punch. The reader has a speed of 1500 characters per second while the separate punch works at 110 characters per second. Both handle 5, 7 or 8 level tapes.

SOFTWARE

ICL provides three different operating environments for the 2900 series. Virtual Machine Environment (VME), the native mode, is available on all models. Direct Machine Environment (DME) is an emulation mode available on

second for the 2946, 2955, and 2966, respectively. The main store highways are 8 bytes wide. Microprogram storage is available.

Main memory on the 2977 and 2982 comprises a minimum of two Common Storage Modules (CSMs). Each CSM contains a Store Multiple Access Control Unit (SMAC) and up to 4 megabytes of 16K-chip MOS memory in 1 megabyte blocks. Block cycle time is 500 nanoseconds per 16 bytes, and the instantaneous peak transfer rate per module is 16 megabytes per second. The main store highways are 8 bytes wide.

STORAGE TYPE: MOS (metal oxide semiconductor).

CYCLE TIME: See Characteristics table. High speed slave stores make the effective speed of main memory much higher than the figures indicate. On the 2977 and 2982, transfers between main memory and the slave stores are made in parallel with CPU 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

The 2946, 2955, 2966, 2977, and 2982 encompass a wide range of power and processing facilities. They are all pipeline processors permitting the overlapping of up to 6 instructions. In addition, slave stores are used. Processing speed is also enhanced by the use of 17-layer printed circuit boards which provide matched interconnections and minimize pulse distortion. High-speed, low-power LSI circuits also contribute to the same end.

Optimization of these 2900 models is further supplemented by the use of modular units, each devoted to a specialist function—such as instruction processing or store access control. These and other units can work concurrently, thus benefitting throughput.

There is a very significant bonus from this modular approach: systems can be more closely matched to user requirements and reconfiguration is also easier. Each modular unit can be isolated for repair or maintenance without interrupting operation of the system as a whole.

The 2946, 2955, and 2966 are microprogrammed machines, thus permitting emulation of earlier ICL ranges. In contrast, the 2977 and 2982 are essentially hardwired, although parts of their pipeline are microprogrammed.

the 2946, 2955, and 2966. Concurrent Machine Environment (CME), called a "harness" by ICL, enables the 2955 and 2966 to support both VME and emulation concurrently. Emulation is of interest only to users converting from the earlier ICL product lines, the 1900 series and the System 4 series.

VME has three versions—VME/K for the 2946, 2955, and 2966, VME/B for the 2966, 2977, and 2982, and VME/B-E, which allows users to gradually build up to full VME/B capability from a much lower base. It will work on all systems from 2946 upwards.

VME/K has as its objective a high throughput. It is intended for the medium-size on-line application where systems' experience is limited, but where there is a definite need for automatic scheduling due to a high workload. VME/K, from release KSV 16 onwards, is upwards compatible with VME/B in its file structure, its compilers, and its object program interfaces. And 20 of its 30 JCL statements are also compatible with VME/B's more powerful SCL. VME/K, ICL states, will frequently be installed as part of a distributed system within an extensive network.

ICL recently announced that VME/K would be phased out and replaced by VME/2900, a new operating system based on VME/B-E.

VME/B is a large operating system designed for mixed batch, interactive, and teleprocessing workloads on the 2900 series from the 2966 upwards. It is marketed for the user who needs a high degree of automatic scheduling combined with built-in data protection and security. The system is file-oriented and can play a central role in star networks, supporting a large number of MAC, TP, and RJE terminals.

The latest of the VME series of operating systems is the entry level VME/B-E which was announced in November 1980. VME/B-E is a stripped down version of VME/B to which options and facilities may be added to bring the system to full VME/B capability.

The virtual machine concept used by all the VME operating systems is designed to reduce overhead. It also 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, anv 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.

The hardwired processors contain a multi-stage pipeline which generates addresses, performs arithmetic operations, and converts virtual addresses to real addresses. On the 2977 and 2982, up to nine instructions can be held and up to six overlapped in the pipeline. Pipelining is also applied on the microprogrammed processors but techniques are different from those used on the hardwired machines.

The three microprogrammed processors actively marketed are the 2946, 2955, and 2966. They use an "integrated storage system," in which the main memory comprises one or more modules without access control circuits, resulting in their just being blocks of memory.

Microprogrammed processors are two-stage pipeline processors consisting of an instruction scheduler to fetch and decode instructions and a microcode processor to handle operands and arithmetic instructions.

Instruction scheduling time (the time taken to fetch instructions and data) is minimized by the application of block fetch techniques.

Microcoded processors have the advantage that it is possible to optimize frequently used code and, in fact, on these microprogrammed ICL systems, there is separate micro-coding for each operating system—such as DME (Direct Machine Environment) and VME (Virtual Machine Environment).

ICL calls the central processing units Order Code Processors to emphasize that they are not concerned with I/O but solely with program instructions, arithmetic, logic, data manipulation, and interrupt control.

SLAVE STORES: To explain slave stores, it is necessary to examine the pipelining processes favoured by ICL. These vary from one model to another. For example, the processes used on the 2946, 2955, and 2966 differ from those on the now superseded 2972 and 2976, which in turn are not the same as the technology applied on the 2977 and the current top of the range, the 2982.

The objective of pipelining and slave stores is to speed up the execution time of instructions. This is achieved on the 2946, 2955, and 2966 by dividing the Order Code Processor (OCP) into three main units—the Instruction Scheduler, the Microcode Processor, and the Store Accessing Unit.

The idea behind this division is to enable as much overlap as possible to take place between these three units. If overlapping within a unit can also take place, so much the better.

Dealing with these three units in turn: the Instruction Scheduler forms the first part of the pipeline. Its job is mainly to fetch instructions from storage and decode them—i.e., break them down into their component parts, such as operand, registers used and address.

Operands are passed to the second unit, the Microcode Processor, which breaks the operands down further and executes them in part. It also performs arithmetic and other operations. Overlap between the first two units frequently occurs, so that when an instruction is being decoded by the Instruction Scheduler, the second unit, the Microcode Processor, is completing the processing of the previous instruction.

The third unit, the Store Accessing Unit, provides the interface between the OCP and the main store. To optimize the accesses to store, the Store Accessing Unit has two fast-access slave stores—the Data Slave and the Current Page Registers.

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USERS' RATINGS IN TERMS OF WEIGHTED AVERAGES

	Ease of Operation	Reliability of Mainframe	Reliability of Peripherals	Responsiveness	Effectiveness	Trouble-Shooting	Education	Documentation	Operating Systems	Compilers and Assemblers	Applications Programs	Ease of Programming	Ease of Conversion	Overall Satisfaction
Model 2950	3.1	3.1	2.8	3.1	2.7	2.3	2.4	2.1	2.8	2.8	2.6	2.8	3.1	2.9
Model 2956	3.2	2.4	2.8	2.8	2.6	2.2	2.6	3.0	2.8	2.8	2.4	2.6	3.2	2.6
Model 2960	3.2	2.9	2.8	3.2	2.6	2.8	2.9	2.8	3.2	3.0	2.4	2.9	2.9	3.1
Model 2970 & 2980	2.8	1.5	2.5	3.5	2.3	2.0	2.8	2.5	2.5	3.5	—	3.3	2.5	2.3
ICL 2900's All Models	3.1	2.8	2.8	3.1	2.6	2.5	2.7	2.5	2.9	2.9	2.5	2.9	3.0	2.9

Basis for computing Weighted Averages is 4 for each user rating of Excellent, 3 for Good, 2 for Fair, and 1 for Poor.

In addition to the system software, ICL provides a broad range of language compilers and applications programs.

USER REACTION

In April 1980, Datapro surveyed 39 ICL 2900 Series users who collectively owned, rented, or leased 46 separate computer systems.

The system population was distributed as follows:

Model	No. of Systems
2950	9
2950/10	9
2956	2
2956/10	3
2960	16
2960/10	3
2970	1
2972	1
2980	2

About 19 percent of the Model 2950 users had purchased their systems, 44 percent had rented the equipment, and 38 percent had leased their systems.

Of the ICL 2956 users, 20 percent had bought their systems; the remaining 80 percent had selected the rental option.

Approximately 29 percent of the ICL 2960 users had purchased their equipment, 14 percent were renting, and a 57 percent majority were leasing.

ICL 2970, 2972, and 2980 users showed a decided preference for purchasing their systems, with only 1 of the 4 respondents leasing the equipment.

The principal applications the users had installed were:

Accounting	87%
Payroll/Personnel	67
Transaction Processing	44
Manufacturing	33
Engineering/Scientific	23

The Data Slave consists of 64 cells, arranged in pairs. Each cell pair can hold up to 32 bytes of data and 32 bytes of addressing information—the object being to 'slave' any two 16-byte areas in virtual storage fulfilling certain conditions. Since virtual memory is large and the slave memory small, a statistical process is applied with an algorithm so that new information is always placed in the cell with the least-recently used coded address. The coded address itself is worked out using a so-called "hashing" algorithm, whereby virtual storage is partially mapped on to the slave storage by using selected bits of the virtual storage address. To prevent errors, information left in a cell, after slaving some other part of virtual storage, is marked invalid.

The Current Page Register Slave also comprises 64 cells with each cell containing 32 bytes of data. Each cell can contain a virtual address and the corresponding real address in main store. The associative addresses are formed in a similar way to that used in the Data Slave and by applying a comparable optimizing "hashing" algorithm. To avoid accessing difficulties, this Current Page Register Slave storage is updated whenever its cells do not hold the virtual-to-real address translation required for the current main storage access.

The ICL 2966 uses a similar process, but the remaining members of the upper 2900 series, the 2972 and 2976 (now both superseded) and the 2977 and 2982, use other pipelining processes which, for example, reduce the time to fetch data to 110 nanoseconds. A process is used on these machines whereby up to 6 instructions can be in various stages of execution.

REGISTERS: An effectively unlimited number of 32-bit general purpose registers is 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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Very few of the respondents planned to replace their systems in 1980. Two users indicated that they were planning to migrate to another manufacturer's equipment.

Of the users planning to acquire or implement additional software in 1980, 14 said they intended to acquire additional software from ICL, and 12 said they planned to acquire proprietary software from other suppliers.

The major area of planned expansion was data communications. Thirty users planned to expand their data communications facilities, and 12 users anticipated increasing their distributed processing facilities.

The users were asked if they would recommend their present system to another user in their same situation. About 77 percent said they would recommend their present system, and about 17 percent said they would not.

From a list of the possible advantages to the system, the users were asked to check off any or all significant ones. Below, in the order of relative importance to the users, are the top five.

1) Programs/data compatible, as vendor promised.
2) System easy to expand/reconfigure.
3) Terminals/peripherals compatible, as vendor promised.
4) Users happy with response time.
5) Delivery and/or installation of equipment was ahead of schedule.

The users were also requested to check a list of problems they might have encountered with the system. The majority of users did not indicate that they had any problems. However, 28 percent of the users said that the vendor did not deliver the software on schedule, and 19 percent complained that the vendor did not provide all promised software or support.

The survey results seem to indicate a relatively high degree of user satisfaction, particularly in the areas of conversion ease, ease of programming, response time, and ease of operation.□

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: The 2946 and 2955 have a minimum configuration of 1 Order Code Processor (OCP), 1 Store Control Unit (SCU), 1 Device Control Unit (DCU), main memory, and one operating station. Minimum main memory on the 2946 is one megabyte and on the 2955, 2 megabytes. Basic configurations can be expanded by one more OCP, an extra SCU, additional main memory up to 8 megabytes maximum, and a free-standing operator's display. I/O capability on the 2946 can be supplemented by an extra DCU and on the 2955 by two extra DCUs. Four DCUs can be used on a dual 2955.

The 2966 minimum configuration comprises 1 OCP, 1 SCU, 2 DCUs, a 4-megabyte main store, and one operating station. The DCU incorporates a coupler for synchronous multi-line communications. The 2966 basic configuration can be increased by an extra OCP, an extra SCU, up to 4 further DCUs, and up to 4 megabytes of additional main memory. Further operating stations and free-standing displays may also be added. An ICL Distributed Array Processor (DAP) can be linked via an SCU.

The 2977 basic configuration consists of 1 OCP, 2 Store Multiple Access Controls (SMACs), 1 Store Access Control (SAC), 2 Common Storage Models (CSMs), each having 1-megabyte of memory, a further 4 megabytes of memory, 1 DCU, 1 operating station, 1 reconfiguration console, 1 free standing display, and 1 General Peripheral Controller (GPC).

The basic 2982 consists of 1 OCP, 2 SMACs, 1 SAC, 2 CSMs with 1 megabyte each, 1 operating station, 1 reconfiguration console, and 1 GPC. The 2982 has interleaved CSMs.

The 2977 and 2982 can each be enhanced by the addition of up to 2 SMACs, a second OCP and/or second SAC. Further GPCs, DCUs, operating stations, and free-standing displays may also be connected. A systems configuration unit replaces the reconfiguration console when a second OCP is added.

In addition to the above, the 2977 can have two more CSMs and another 10 megabytes of main memory. The 2982 can have another 2 CSMs plus another 14 megabytes of main store.

If dual OCPs are used, they require 2 SACs, one per OCP. The OCPs, SACs, and CSMs are all interconnected, with system reconfiguration controlled by a system reconfiguration unit. A peripheral switching console may also be used to control peripheral switching between GPCs and/or DCUs and also GPC or DCU switching between SACs.

All ICL DAP can be connected to any of the above single and dual OCP systems.

COMPATIBILITY: Software for the 2900 series is not compatible with that for earlier ICL machines. However, ICL has a number of conversion aids which make it possible to run software for these earlier systems on the 2900 series machines.

The aids are in the form of microcoded operating system packages, with the microcode resident in the OCPs. Systems equipped with microcode (the 2946, 2955 and 2966) can run both ordinary 2900 series programs and emulation programs simultaneously by using Concurrent Machine Environment (CME). This allows two operating systems to be run together—Direct Machine Environment (DME) for the old machines and Virtual Machine Environment (VME) for the 2900 series. CME is available in various forms to cater for differing combinations of old and new machine software.

INPUT/OUTPUT CONTROL

STORAGE 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 Lines 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 five types of peripheral controllers which function

independently of the CPU (Order Code Processor in ICL terminology). Commands are stored in memory and fetched by the controllers.

Controllers include the Sectored File Controller (SFC) for fixed-head discs; the Disc File Controller (DFC) for moving-head discs; the General Peripheral Controller (GPC) for magnetic tape drives, printers, punched card and paper tape equipment, and systems consoles; the Device Control Unit (DCU) for moving-head discs and/or those peripherals connectable through a GPC; and the Communications Link Controller (CLC) for local and remote terminals.

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 address. 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 diagnostics 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 in 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.

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 off-setting 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.

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.

DEVICE CONTROL UNIT (DCU): Designed to support up to 16 fixed-disc drives (FDS) or up to 8 exchangeable-disc drives (EDS), and/or serial devices such as magnetic tape, line printers, etc. the DCU for the 2946, 2955, and 2966 systems can control discs and up to 7 serial devices together with up to 256 communications lines via one or two synchronous multi-line communications couplers (SMLCCs). The DCU for the 2977 and 2982 can control either discs and up to 6 serial devices, or if no discs are connected, up to 9 serial devices.

FDS-640 FIXED-DISC STORE: The FDS-640 stores up to 651 megabytes of data on 12 fixed discs with 20 recording surfaces. Average access time is 33.3 milliseconds with peak transfer rate at 1.21 megabytes/second. Recording is on 830 tracks plus 12 reserve tracks. Additional space is provided on each track to enable a single defect of up to 72 bytes in length to be skipped. Data can be recorded in variable length sectors. Each sector contains a count block followed by a data block.

FDS-160 FIXED-DISC STORE: FDS 160 drives are supplied in pairs. Each FDS 160 stores up to 160 megabytes of data on four fixed discs with 5 recording surfaces. Average access time is 38.3 milliseconds. Peak transfer rate is 1.21 megabytes per second. Recording is on 816 tracks plus 6 reserve tracks. Additional space is provided on each track to allow a single defect of up to 72 bytes in length to be skipped. Data can be recorded in variable length sectors. Each sector contains a count block followed by a data block. FDS-160 can also be supplied with an EDS-80 exchangeable-disc drive as the other half of the pair.

EDS-80 EXCHANGEABLE DISC DRIVE: EDS-80 units are supplied in pairs. Each EDS-80 stores up to 79 megabytes of data on a disc pack with 5 recording surfaces. Average access time is 38.3 milliseconds. Peak transfer rate is 1.21 megabytes per second. Recording is on 808 tracks plus 14 reserve tracks. Data can be recorded in variable length sectors. Each sector contains a count block followed by a data block. EDS-80 can also be supplied with an FDS-160 as one of the pair.

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

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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.

GTS-780 MAGNETIC TAPE SYSTEM: The GTS-780 consists of a controller and 2 tape drives. Up to 2 more drives can be added. The drives are 9-track and can record in either ANSI X3.54-1976 standard Group Coded Recording mode or in ISO 3788 standard 800 bits/inch NRZI mode. Drive speed is 125 inches/second with a transfer rate of 780 kilobytes/second (6250 bpi), 200 KB/s (1600 bpi), 100KB/s (800 bpi), 266 KB/s (1600 bpi compressed) or 133 KB/s (800 bpi compressed).

The rewind time for a standard 2400-foot reel is less than one minute. A standard 3-inch gap is used for GCR and 0.6-inch for PE recording. The combined start/stop times are 4.4 ms (GCR) and 7.0 ms (PE). Reading or writing in any mode can be overlapped with skipping operations on other devices. The drives provide automatic threading from 2400-foot reels, with or without autoload cartridges. The GTS-780 controller's command repertoire comprises: 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.

GTS-470 MAGNETIC TAPE DRIVE: The GTS-470 has the same specification as the GTS-780, except that the tape speed is 75 inches/second, decreasing the transfer rate and increasing the start/stop times. The transfer rates are 470 KB/s (6250 bpi), 120 KB/s (1600 bpi), 60 KB/s (800 bpi), 160 KB/s (1600 bpi compressed), or 80 KB/s (800 bpi compressed). The combined start/stop times are 7.0 ms (GCR) and 11.0 ms (PE).

GTS-310 MAGNETIC TAPE SYSTEM: The GTS-310 has the same specification as the GTS-780, but with a tape speed of 50 inches/second. The transfer rates are 310 KB/s (6250 bpi), 80 KB/s (1600 bpi), 40 KB/s (800 bpi), 106 KB/s (1600 bpi compressed), and 52 KB/s (800 bpi compressed). The combined stop/start times are 10.0 ms (GCR) and 16.0 ms (PE).

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 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 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.

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/second. The combined start and stop interblock gap time is 6.3 milliseconds.

MT-60 MAGNETIC TAPE SYSTEM: The MT-60 consists of from one to eight tape drives and is connected to a coupler within a DCU on the 2946, 2955, or 2966. This coupler provides the control logic for the MT-60 system. Drives are 9-track with recording in either ISO 3788 standard 1600-bpi phase-encoded mode or ISO 1863 standard 800-bpi NRZI mode. The drive speed is 37.5 inches/second, with transfer rates of 60 KB/s (1600 bpi), 30 KB/s (800 bpi), 80 KB/s (1600 bpi compressed), or 40 KB/s (800 bpi compressed). Rewind speed is 150 inches/second. A standard 0.6-inch gap is used. Combined start/stop time is 29.0 ms. Reading or writing in any mode can be overlapped by skipping operations on other devices. The drives provide automatic threading when cartridges are used. The MT-60 controller's command repertoire is the same as that for the GTS-780.

MT-30 MAGNETIC TAPE SYSTEM: The MT-30 consists of from one to eight tape drives. It uses the same coupler as the MT-60. The MT-30 drives are 7-track and recording is in standard ISO 1861 800-bpi NRZI mode. The drive speed is 37.5 inches/second and transfer rate is 30 KB/s (800 bpi), 20.8 KB/s (800 bpi compressed). Rewind speed is 150 inches/second. The combined start/stop times are 33.0 ms. Reading or writing can be overlapped with skipping operations on other devices. Automatic threading is possible when cartridges are used. The MT-30's command repertoire is the same as that of a GTS-780 except that there is no read reverse.

LP-1500 LINE PRINTER: A train printer, the LP-1550, 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.

LP-1130 LINE PRINTER: The LP-1130 is a band printer. it is linked to a DCU coupler which provides its control logic. Speed is 1130 lines per minute with a 48-character set, 900 lpm with a 64-character set and 660 lpm with a 96-character set. there are 132 print positions. A band has 384 characters on it, and bands are interchangeable. Printer control electronics automatically sense the size of the print set, 48, 64, or 96 characters. Printing is at 10 characters/inch and spacing at 6 or 8 lines to the inch. Format control is under software direction. Forms may be from 6.0 to 16.75 inches wide and from 8.0 to 14.0 inches long. The hopper holds up to ten inches of paper, and a free-fall stacker is provided.

LP-720 LINE PRINTER: Identical to the LP-1130, the LP-720 operates at 720 lines per minute with a 48-character set, 600 lpm with a 64-character set, and 440 lpm with a 96-character set.

LP-360 LINE PRINTER: The same as the LP-1130, the LP-360 operates at 360 lpm with a 48-character set, 300 lpm with a 64-character set, and 200 lpm with a 96-character set.

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CR-1000 CARD READER: The CR-1000 is a free-standing unit with integral control which reads 80-column cards. A photo-cell sensing mechanism is used. Speed is 1000 cards per minute. The input hopper and output stacker each hold up to 1000 cards.

CR-300 CARD READER: Identical to the CR-1000, but operating at a speed of 300 cpm.

CP-60 CARD PUNCH: Punches 80-column cards at speeds up to 60 cpm. A buffer holds the data for one card. The punch has 2 input hoppers with a total capacity of 1000 cards and 2 output stackers with a total capacity of 800 cards.

LPS-14 LASER PRINTING SYSTEM: An off-line printing system which prints at a speed of 146 12-inch pages per minute (maximum effective printing speed 21,000 lines per minute with 12 lines per inch). The system consists of an operating unit (control console, video display with keyboard, flexible disc drive, and one or two magnetic tape units) and the laser printing unit. Included is the ICL 2900 software required to generate the relevant formats on the 9-track phase-encoded magnetic tapes for subsequent printing on the laser printer.

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, hexadecimal mode or image mode (with software translation) can be selected by the program.

PTP-1100 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 hexadecimal modes can be selected by the program. Powered dispenser and spooler mechanisms each handle up to 1000 feet of tape.

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 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 Multistream 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, andf line printers, and can handle message buffering and message switching. CNP's also can be used as remote concentrators.

TTW1 AND TTW2 TELETYPEWRITERS: Intended for light-duty operation, these stand-mounted keyboard/printers operate at a maximum speed of 10 character 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

GENERAL: ICL offers a variety of operating systems for the 2900 range, partly as a result of the incompatibility existing betwen 2900 series and earlier computers. DME (Direct Machine Environment) is essentially an emulating operating system (for example, in one of its versions, DME iwll permit the 2900 user to run 1900 series programs). For the 2946, 2955, 2966, 2977, and 2982, the most important operating systems are VME/B and VME/K—although CME (Concurrent Machine Environment) and TME (Transaction Machine Environment) can be used with the VME systems.

VME/B is designed for the large system user (2966 upwards) and has a large range of facilities. An entry-level version, VME/B-E, is available for smaller models.

VME/K is intended for the smaller system user—up to and including the 2966.

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 Managment, 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.
—Process interrupts, including system calls and returns, extracode, and program error interrupts.
—Communication between virtual machines and between protection levels within a virtual machine via the event system.
—Mapping of virtual machines on to real sources.
—Peripheral and communication controllers.
—Provision of timing facilities to processes.
—Emulation of non-2900 Series processors.
—Errors central to the basic hardware or software.

The Director runs at access-control levels 3, 4, and 5 and provides the following services:

—Control of the use of central processor time by jobs to optimize use of system resources.
—Loading facilities and facilities for creating work space for jobs.
—Scheduling of the allocation of peripherals, volumes, and files to jobs.
—Maintenance of privacy on files, tapes, volumes, etc.
—Physical file management for peripherals and communications equipment.
—High level event management.
—Access to System Catelog information on users, files, events, hardware units, volumes, etc., and control of relationships between items in the catalog.
—Operator communications facilities and management of operator stations.
—Facilities for creating and deleting journals and input/output on journals.
—Output spooling.
—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.

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—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 Systems 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 itermediate 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 is designed for use on ICL's 2946, 2955, and 2966. VME/K is modular, with one of its objectives being ease of installation and use. It has two principle types of components:

—The base operating system, whose function is to control the hardware resources of the computer and to make them available to the user in as an efficient and reliable way as possible.
—An infrastructure of utilities, such as a screen editor, and other packages including compilers and financial modelling systems, a database handler (IDMS—Integrated Database Management System), and a transaction processing monitor.

Both the above components and their elements are used to carry out three different types of processing:

- Batch processing, which can be effected in one of two ways: local batch processing in which jobs are submitted through an input device directly to the main computer and processed independently of the work originator, and remote job entry (RJE) in which programs and/or data are entered from a terminal.
- Transaction processing (TP) in which transactions (e.g., an airline booking) are entered remotely, processed immediately, and a response sent back to the operator.
- Multi-Access Computing (MAC) in which jobs are controlled interactively from a terminal.

These three types of work are handled by the same mechanisms, with clear benefits in economy of code.

Communication with VME/K is carried out by the VME/K Command Language (KCL), which is a "high-level free-format language." Each command issued to VME/K has a command name which identifies the function of the command and, usually, a set of parameters which provide information essential to successful execution of the command. KCL commands can be given through any input device, including a console, card reader, or interactive terminal. The format of KCL commands is independent of the input device. Sets of KCL commands may be stored as macros or compiled as procedures, providing a simple means of controlling large work units which follow a predictable sequence.

ICL claims that because the different types of work—batch, MAC and TP—which occur in most installations have characteristic patterns in their use of system resources, VME/K will enable systems management to achieve quickly:

—Control of resource usage for different classes of job.
—Optimized throughput due to effective use of resources.
—Prevention of excessive resource usage by individual users.
—Ability to simplify input of jobs by users.

CME: Concurrent Machine Environment is specifically intended for the ICL 1900 user. CME allows the concurrent running of both DME and VME systems on the 2900 series.

TME: Transaction Machine Environment is designed for the smaller system user (2955 and below) who has relatively few programming and operating system resources. TME is work-station oriented and is intended to give the smaller system user both network and database capability.

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 offers 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 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.

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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 consists 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 analusis, 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 2946 SYSTEM				
Order Code Processor with DME Facility, 1MB of memory, console, DCU, and disc controller				
EDS-80/FDS-160 (2) disc drives 60KB/s tape drive 300 cpm card reader 720 lpm printer				
	TOTAL PRICE**	197,000	6,000	1,035
ICL 2955 SYSTEM				
Order Code Processor with VME Facility, 2MB of memory, console, DCU, and disc controller				
EDS-80/FDS-160 (2) disc drives FDS-640 disc drive 120KB/s (2) tape drives 1130 lpm printer				
	TOTAL PRICE**	325,000	9,150	1,560
ICL 2966 SYSTEM				
Order Code Processor with VME Facility, 4MB of memory, console, 2 DCU's, and 2 disc controllers				
FDS-640 (6) disc drives 470KB/s (4) tape drives 1130 lpm printer				
	TOTAL PRICE**	642,000	18,000	2,400
ICL 2977 SYSTEM				
Order Code Processor, 6MB of memory, 2 SMACs, 1 SAC, 1 GPC, console, 2 DCUs, and 2 disc controllers				
Dual EDS-80 disc drives Dual FDS-160 (3) disc drives FDS-640 (6) disc drives 470KB/s (4) tape drives 1130 lpm printer 300 cpm card reader				
	TOTAL PRICE**	1,244,000	36,000	6,400
ICL 2982 SYSTEM				
Order Code Processor with 8MB of memory, 2 SMACs, 1 SAC, console, 1 GPC, and 4 DCUs				
Dual FDS-160 (4) disc drives FDS-640 (6) disc drives EDS-80 (2) disc drives 320KB/s (3) tape drives 1130 lpm printer 300 cpm card reader				
	TOTAL PRICE**	2,060,000	54,600	7,490

**Prices do not include maintenance.*
***Prices do not include communications subsystems or separately priced software.*

ICL 2900 Series, Models 2960-2980

New Product Announcement

On November 13, 1980, ICL announced several enhancements to the 2900 Series, including two new models—the 2955 and 2966—and Concurrent Machine Environments (CME), a microcode "harness" which enables some 2900 systems to run 1900 Series and 2900 Series programs in parallel. ICL also announced VME/B-E, an entry level version of its VME/B operating system.

New 2955 Processor

The ICL 2955 processor is a medium size microcoded machine with a comprehensive set of facilities aimed at attracting first-time users as well as users of less-powerful ICL systems.

Offering improved price/performance, the 2955 provides approximately 20 percent more power than the ICL 2950/20 for about the same price and is 50 percent more powerful than the 2946 (now the smallest machine in the 2900 Series). The new machine is also competitive with the IBM 4331 Model 2, the Honeywell DPS-8/44 and the Sperry Univac 1100/61-C1, ICL states.

Like other models in the 2900 Series, the 2955 is modular in concept, each module performing its particular function autonomously and in parallel with other modules to maximize processing speed and throughput. Modules include an Order Code Processor (OCP) for high-speed execution of logic, arithmetic, and data manipulation functions; a 16K-chip based Main Store Module (MSM) of between two and four megabytes; a Device Control Unit (DCU) which handles peripherals and communications equipment; and a Store Control Unit (SCU) which multiplexes OCP and DCU accesses to the common store.

A minimum system comprising OCP/MSM/DCU/SCU plus an operating station and what the company describes as "a full range of peripherals," costs approximately £340,000. This can be enhanced on-site by increasing MSM capacity up to four megabytes, adding an extra OCP, an extra SCU and two more DCU's.

Operating systems software is extra and includes the K version of VME (Virtual Machine Environment), a communications and database oriented system which provides each terminal user with unrestricted use of computing resources tailored to the user's needs, and does so without the machine switching to a supervisory mode. VME/K enables the 2955 to provide virtual-machine support to around 300 terminals, depending on the application, and is designed for dedicated large-scale workloads requiring automatic work-scheduling. Its high level language resources include compilers for ALGOL, BASIC, COBOL, FORTRAN, Pascal and RPG II.

Also supported is a new upgrading aid for users of ICL 1900 and lower-powered 2900 systems, called CME/2 (Concurrent Machine Environments). CME/2 enables users of these systems to run their existing DME (Direct Machine Environments) software on the 2955 while they are developing VME/K software. Parallel operation of DME and VME/K includes cross-regime access of files.

In common with other ICL computers and terminals, the 2955 will progressively support the company's Information Processing Architecture (IPA) procedures for creating networking and distributed processing systems based on the ISO seven-layer Open Systems Interconnection model.

At present, the new machine utilizes Full XBM, ICL's combined batch and interactive operation protocol, for private networks; and employs protocol adapters for communications with other manufacturers' hardware. Similar techniques are used for X25 operation via public packet-switched networks.

ICL plans to increase the 2955's distributed data processing capabilities by developing a 2955 version of TME (Transaction Processing Environment), the operating system used on the ME29, ICL's workstation-oriented computer system. This will enable the 2955 to act as a hub for networks of ME29's. TME for the 2955 is scheduled for early 1982.

Quantity deliveries of the ICL 2955 are scheduled to commence in June, 1981.

New 2966 Processor

The 2966 processor is a compact ECL-based machine which provides an upgrade path for users of 2950, 2956 and some 2960 systems, as well as for 1900 and System 4 machines.

2900 users and users of Direct Machine Environment (DME) systems from transferring to the VME/B environment.

Available for use on 2955 and 2966 as well as 2972, 2976 and 2982 machines, VME/B-E provides a set of entry-level facilities for concurrent mixed workload operation, and a range of options for more-advanced requirements. Options can be added at any time so that system complexity can be increased at a rate in line with user needs and ability.

Rapid implementation is achieved through a procedure called Warmstart which enables system disks containing essential software files to be created before the system is issued, the objective being to establish an environment suitable for the early needs of the user.

Full exploitation of the 2900 virtual machine architecture enables a changing mixed workload to be matched against the system resources available. Efficient processing is achieved by hardware-assisted implementation of user protection, virtual store and data management mechanisms.

An extensive set of high level languages is available with a wide range of data management products. Networks can be implemented by means of ICL's Information Processing Architecture (IPA) facilities which permit both batch and interactive data transfer between terminals and different mainframes.

Ease of use features include interactive screen prompting mechanisms which guide the user and reduce the number of decisions to be made. They also reduce the time spent at multi-access (MAC) terminals. Access to the system is via a single Systems Control Language (SCL). The combination of these two factors results in easier training and enhanced productivity of staff at all levels, ICL states.

Options available are:

1. A Batch Recovery Option providing checkpoint and restart facilities that allow program recovery/restart from the most recent checkpoint.

2. A System Programming Option for detailed tailoring of the VME/B-E system to specific requirements, including the provision of installation-defined journals and the use of timer-initiated tasks.

3. A Work-Scheduling Option extending VME/B-E facilities to permit use of installation-defined work profiles and provide greater control over mainstore scheduling and order code processor allocation. This also enables the creation of non-standard algorithms.

4. An Accounting Option for measuring resources used by each job, and logging data for later analysis. It provides the ability to define cost tables and establish charging rates for each resource used.

5. A Filestore Management Option for extending file management capabilities.

The cost of a VME-B system for a 2966 installation is £1,100 a month, and options range between £48 and £317 a month.□