ICL 2900 Series

MANAGEMENT SUMMARY

The 2900 series is becoming a single compatible series based around its most successful model, the 2966. Of the two subseries which formed the 2900 range in the summer of 1982, the 2946 is the only model no longer actively marketed, leaving the 2955 as the sole survivor of the lower end machines (the lower subseries) which have processors incompatible with 2966-based systems.

The two major changes to the 2966-based systems are, the emergence of the 2957, which can be regarded as a smaller version of the 2958, and the addition of CAFS (Contents Addressable File Store) in its ISP (Information Search Processor) version as an official part of the 2900 series. In its CAFS–800 configuration, this system operated only on dedicated files using ICL's old range of disk and the 1900 operating system. It was expensive and sold in very small numbers. The latest CAFS–ISP operates with standard formats, uses ICL's latest disks and will function with the VME operating system. CAFS–ISP will be reported on separately.

The complete 2900 series now comprises: the 2955, 2957, 2958, 2966 and 2988. All the 2966-based machines, that is the 2957, 2958, 2966 and 2988 will be made available in what the ICL terms "super-dual" configurations, as well as in the more usual dual configurations. A super-dual system provides a higher level of automatic error recovery than a dual and provides dual access to ICL's latest disks, the MDSS range. This super-dual configuring is one step along the ICL path towards continuous operability, remote maintenance and unattended operation.

Picture shows the ICL 2966 mainframe computer which can be configured with single or dual processors having up to 32M bytes of store.

The latest version of the 2900 series consists of two subseries: one comprises the 2955 alone, and the other consists of the 2957, 2958, 2966 and 2988. The CAFS (Contents Addressable File Store) system, in its ISP form, is now a part of the 2900 series. Software and hardware have been significantly simplified compared with earlier 2900s, but still service the same sector, namely medium to large organizations requiring powerful centralized computing power with considerable distributed processing and networking potential.

MODELS: ICL 2955, 2957, 2958, 2966, 2988. In many cases ICL will refer to these machines with an oblique added, e.g., 2955/32. These additional numbers are mainly for internal use and the basic system remains unaltered.
COMPETITION: The 2900 series competes with IBM's System 24, System 36, System 38, 4300, and 303X families and comparable ranges offered by other manufacturers.
PRICE: From approximately £150,000 to over £1,000,000.

CHARACTERISTICS

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

MODELS: ICL 2955, 2957, 2958, 2966 and 2988. Obliques are used (e.g. 2955/32) with numbers to denote particular configurations.

DATA FORMATS

BASIC UNIT: 8-bit byte. Each byte can represent one alphanumeric character, 2 BCD digits of 8 binary bits. The word of 32-bits is formed from four consecutive bytes.

FIXED POINT OPERANDS: 1-16 bytes (1-31 digits plus sign) in decimal mode: one word (32 bits) or one double word (64-bits) in binary mode.

FLOATING POINT OPERANDS: a word consisting of a 24-bit (6 hex digit) fractional part plus a 7-bit hexadecimal exponent in long form or, in extended form, 4 words with 112-bit fractional part (28 hex digits) plus 7-bit hexadecimal exponent.

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

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Table 1. CHARACTERISTICS

	2955	2957	2958	2966	2988
SYSTEM CHARACTERISTICS					
Date of introduction	Oct. 1980	Nov. 1982	Nov. 1981	Oct. 1980	Nov. 1981
Date of first delivery	May 1981	—	Mar. 1982	May 1981	Apr. 1982
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 CME/2/3 TME	VME CME/2/3	VME CME/2/3	VME VME/B CME/2/3/G3 CME/S4 DME/G3/S4	VME
MAIN STORAGE					
Storage type	MOS-16K	MOS-16K, 64K	MOS-16K, 64K	MOS-16K, 64K	MOS-16K, 64K
Read cycle—nanoseconds	750	750	750	750	750
Write cycle—nanoseconds	600	600	600	600	600
Partial write—nanoseconds	1200	1200	1200	1200	1200
Bytes fetched per cycle	8	8	32	8	64
Storage interleaving	no	no	yes	no	yes
Minimum capacity—bytes	4M	4M	2M	4M	8M
Maximum capacity—bytes (single)	8M	8M	8M	32M	32M
Dual Systems	yes	yes	yes	yes	yes
Increment size—bytes	½M	2M	2M	2M	8M
BUFFER STORAGE (SLAVE STORES)					
Cycle time—nanoseconds	128	80	80	80	80
Bytes fetched per cycle	4	4	4	4	4
Data slave capacity—bytes	1K	16K	16K	16K	32K
PROCESSING UNIT					
Machine cycle time—nanoseconds	125	80	80	80	80
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	Standard
Real-time clock	Standard	Standard	Standard	Standard	Standard
Microprogrammed	yes	yes	yes	yes	yes
Pipeline steps	2	2	2	2	2
Pipeline capacity instructions	2	2	2	2	2
Compatibility features					
ICL 1900 series emulation by microcode	yes	yes	yes	yes	no
ICL 2903, 2904 emulation by microcode	yes	yes	yes	yes	no
ICL System 4 emulation	no	no	no	yes	no
CHANNELS					
Store Control Units (SCU)	1 or 2	1 or 2	1 or 2	1 or 2	1 or 2
Device Control Units (DCU)	2 to 6	2 to 6	2 to 6	2 to 6	4 to 6
SCU to main store	10.7MB/s	16MB/s	16MB/s	16MB/s	16MB/s
Maximum total transfer rate	10.8MB/s	19.6MB/s	19.6MB/s	19.6MB/s	19.6MB/s
Power ratio	1.18	—	2.27	3.64	6.27

The current 2900 series uses, in part, the latest technology in the form of 64K-bit chips. These have the added advantage of making these systems physically smaller than their predecessors. The 2900 series is competitive with IBM's System 34, System 36, System 38, 4300 and 303X families and comparable ranges from other manufacturers.

The split into effectively two subseries comprising (a) the 2955 and (b) the 2957, 2958, 2966 and 2988, is occasioned firstly and less importantly by technology, and secondly by the upper limits of main memory capacities.

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

MAIN STORAGE

Main storage on the 2900 series consists of at least one Store Module. Each such module contains up to 4 megabytes of 16K-chip memory in either half-megabyte or 2-megabyte blocks or, alternatively, of 64K-chip memory in 2 or 4 or 8 megabyte blocks.

STORAGE TYPE: MOS (metal oxide semi-conductor)

In the 2955, 16K-bit chips are used and the maximum main memory is 8 megabytes. In contrast, the 2957, 2958, 2966 and 2988 all use 64K-bit chips and, in effect, have an upper main memory limit of 32 megabytes because of field upgrading capabilities. The 2957 has a nominal maximum main memory size of 8 megabytes, but it can be field upgraded to a 2958: the nominal maximum capacity of the 2958 is 16 megabytes, but it can be field upgraded to a 2966. The 2957, 2958, 2966 and 2988 are compatible at processor level, but incompatible at this level with the 2955. These and other characteristics of the machines can be seen in Table 1.

All five models support virtual memory, virtual machine processing and use microcoded instructions. To optimize processing speed, pipelining techniques are applied—also throughout the range.

Althought the trend is rapidly towards there being just one operating system for this series, namely VME, all but the 2988 also support Direct Machine Environment (DME), an emulation mode which enables software from the earlier ICL 1900 and System 4 computers to run on the 2900s. Both VME (Virtual Machine Environment) and DME can be run concurrently using Concurrent Machine Environment (CME).

All models support traditional batch, remote batch, time sharing and transaction processing. 2900 series models may also be used in a network with ICL Network Porcessor System (NPS).

To ensure enhanced reliability, all 2900 systems can be installed in redundant configurations which allow any faulty modules to be bypassed. The operator reconfigures the system from an operating station on all but the 2988, where the requisite reconfiguration takes place automatically. It is expected that this ability will allow the 2988 to run continuously for 7500 hours (equivalent to around 3½ years) of single shift working.

PERIPHERALS AND COMMUNICATIONS

ICL's range of peripherals and communications for the 2900 series reflects the improved technology and greater capacity of the models within it. There is now a very large variety of peripherals with the accent on medium to large capacity disk drives and on flexibility in control. Apart from disk drives, ICL offers magnetic tape drives and printers, but only a small number of terminal types and card and paper tape devices.

In order to control peripherals, ICL now provides just two control units, in contrast to the rather confusing variations offered perviously. These two control units are termed DCU 1 and DCU 2—the DCU letters meaning "Device Control Unit." The DCU 1 is a general purpose controller available on all models. The DCU 2 has been developed to handle a very large number of disks and magnetic tapes and may have one or two CAFS-ISP modules associated with it. It is provided for use only on the 2957, 2958, 2966 and

CYCLE TIME: see Characteristics Table. High speed slave stores make effective speed of main memory much higher than the figures indicate.

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 Acess 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 2957, 2955, 2958, 2966, and 2988 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 circuts 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.

All models are microprogrammed machines, thus permitting emulation of earlier ICL ranges.

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.

These microprogrammed processors are two-stage pipeline processors consisting of an instruction scheduler to fetch and decode instructions and 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.

Micocoded processors have the advantage that it is possible to optimize frequently used code and, in fact, on these

2988—that is the 2966-based machines. Peripheral devices are connected via couplers to interface modules on both the DCU 1 and DCU 2.

Both the DCU's and the network processor can be connected to ICL's Information Processing Architecture (IPA) for communication and networking purposes.

There is a very wide range of disk drives available from ICL. These have come increasingly under the label Modular Disk Storage System (MDSS), which includes both fixed and exchangeable disks. The older terminology, FDS, for fixed disks and EDS for exchangeable disks is still in use however. Disk capacities range from 160 megabytes to 651 megabytes on fixed disks and from 79 to 200 megabytes on exchangeable disk pack drives.

A most significant recent addition to the range of mass storage options is the CAFS system (Contents Addressable File Store) which will run under VME in a version which bears little relationship to the old CAFS 800. The new CAFS is called CAFS ISP (Information Search Processor).

CAFS, in general, is designed to retrieve file information directly, instead of going through a conventional string of related indices and, more importantly for the 2900 user, is designed to effect this as a self-contained task, independently of the central processor. Its targeted market area includes personnel inquiries, telephone directory inquiries, analysis of reports of operating incidents or any field where there is likely to be a heavy load of queries. An associated aid, ICL's Querymaster—the CAFS query language, has been rewritten to take full advantage of the CAFS hardware in provision of high-speed general inquiry tool.

There is also a considerable range of magnetic tape drives. Transfer rates range from 30 kilobytes per second to 780 kilobytes per second. All tapes are 9-track with many of them offering compressed recording capability together with features such as autoloading with tape cartridges.

ICL now also offers a much wider range of printers than that originally made available for the 2900 series. For example, besides the original 1500 line per minute printer, ICL now offers three band printers in addition. Speeds on these are from 200 lines per minute with a 96-character set to 1130 lines per minute with a 48-character set.

ICL also markets a laser printer whose printing mechanism produces page printing rather than working on a line-by-line basis. The speed is equivalent to 21,000 lines per minute with 12 lines to the inch.

Two card readers are offered—one at 300 cards per minute and the other at 1000 cards per minute. Both use photoelectric means of reading the cards input.

A single model of card punch is available. The maximum speed is 60 cards per minute. The buffer capacity is one card.

microprogrammed ICL systems, there is separate microcoding 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 favored by ICL.

The objective of pipelining and slave stores is to speed up the execution time of instructions. This is achieved 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 components 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.

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.

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

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

SOFTWARE

In the autumn of 1981, ICL announced that the main operating system for the 2900 series would be Virtual Machine Environment (VME). It would incorporate the best of the then currently used VME/B, VME/B–E and the earlier VME/K operating systems.

The other ancillary operating systems on the 2900 series will continue to be used for as long as necessary. These are:—Direct Machine Environment (DME), which is an emulation mode available on the 2955, 2957, 2958 and 2966; Concurrent Machine Environment (CME) which permits these four machines to run both VME and DME at the same time. Emulation is of interest only to 2900 users converting from earlier ICL systems (System 4 and the 1900 series).

VME, the main operating system now for the 2900 consists of a base and a series of options which enhance throughput and control. VME is designed to handle mixed batch, teleprocessing and interactive inputs. Since VME is file oriented, ICL states that it can be used to take a central part in networks, supporting large numbers of terminals.

The virtual machine concept usd 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, 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.

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

ADVANTAGES AND RESTRICTIONS

There has always been a user migration path from ICL's older models to their 2900 series, but the cost of that route has been enormous. For an example, ICL has spent a significant amount of time and money to develop a uniform operating system for the series. There is now one operating system, called "VME," which until mid-1983 had the appellation, "VME 2900." Well over £100 million is reputed to have been spent on its development. As with

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 serches the Segment and Page Tables to find the item's location on disk.

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 minimum configuration for any computer in the current 2900 series consists of one Order Code Processor (OCP), ILCs' name for the central processor, one Store Control Unit (SCU), one operating station, a number of Device Control Units (DCUs)—one for the 2957, two for each of the 2955, 2958 and 2966, and 2988—plus main memory. The minimum main memory for each machine is as follows: 2M bytes for the 2946 and 2958; 4M bytes for the 2955, 2957, 2958 and 2966; 8M bytes for the 2988. Memory can be extended to 8M bytes on the 2955 and 2957, 16M bytes on the 2958 and 32M bytes in the cases of the 2966 and 2988, with all systems in single processor configurations. More DCUs may also be added up to a maximum of three on the 2955 and four on the 2957, 2958, 2966 and 2988 (see Characteristics Table).

Each 2900 series system may have a second processor and a second SCU. These produce a performance increase of about 1.6 to 1.8 times that of the corresponding single processor configuration. More DCUs may also be connected on the dual systems—with a total of four on the 2955 and six on other systems. Maximum storage size also increases, to 16 megabytes on the 2955 and 2957, 32M bytes on the 2958 and 64 megabytes on the 2966 and 2988.

"Super-dual" configurations for the 2966-based members are the same as dual systems except that the OCPs and DCUs are not cross-connected.

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 eariler systems on the 2900 series machines.

The aids are in the form of microcoded operating system packages, with the microcode resident in the OCPs. The 2955, 2957, 2958 and 2966 can run both ordinary 2900 series programs and emulation programs simultaneously by using Concurrent Machine Environment (CME). This allows two operating system to be run together—Direct Machine Environment (DME) for the old machines and Virtual Machines Environment (VME) for the 2900 series. CME is available in various forms to cater for differing combinations of old and new machine software.

other major operating systems, it has run through release after release and has undergone some name changes along the way.

Also the fact that all the 2900 series, except one, the 2955, is based on ICL's best-selling 2966 model, has much simplified the architecture and most other facets of the series.

Mainly because of these two factors and its time in service, the 2900 series is a good value for the money, and is fully proven and reliable. Its shortcomings are mainly due to its age and therefore, by the latest standards, outdated technology. All ICL's 2900 series have one central processor and no other, so that compared with multiprocessor machines which have input/output processors, communications processors and the like, they are at a disadvantage. This deficiency may show itself by rather rapid degradation in a heavily terminal/workstation/communications environment. But none of this should detract from the fact that ICL's 2900 series is, overall, as good as its competition and often better.

USER REACTION

A total of 73 users with 98 installations responded to our 1982 survey of British users. Seven of the users had 2946s, 13 had 2950 and 2955 models, 25 used 2956 and 2960s, 10 had 2966s installed, and 11 had models 2970 through 2988. As indicated, many responses were given by users of machines no longer actively marketed, but they do still provide useful information on the 2900 line.

Here's how they rated their machines:

	2946	2950 & 2955	2956 & 2960	2966	2970 & 2988
Ease of operation	2.71	3.17	2.92	3.18	3.00
Reliability of Mainframe	3.29	2.92	3.00	3.06	2.36
Reliability of Peripherals	2.29	2.62	2.84	2.65	2.64
Maintenance Service:					
Responsiveness	2.71	2.46	2.88	2.82	3.10
Effectiveness	2.00	2.46	2.60	2.65	2.80
Technical support:					
Trouble-shooting	1.57	2.15	1.96	2.47	2.60
Education	2.57	2.54	2.28	2.59	2.40
Documentation	2.14	2.38	2.32	2.53	2.45
Manufacturer's software:					
Operating system	2.43	2.92	3.20	3.06	3.20
Compilers & Assemblers	3.00	3.00	3.00	3.12	3.00
Applications Programs	2.29	2.50	2.54	2.73	2.57
Ease of programming	2.43	2.77	2.76	3.00	2.90
Ease of conversion	3.20	3.00	2.48	2.87	2.90
Overall satisfaction	2.43	2.77	2.72	2.82	2.73

*Weighted averages on a scale of 4 for Excellent, 3 for Good, 2 for Fair, and 1 for Poor. □

INPUT/OUTPUT CONTROL

DEVICE CONTROL UNIT 1 (DCU 1): this is a microprocessor-controlled general purpose controller which is available on all five members of the series. It can be configured to a user's specific peripheral and communications needs. Connection of devices to the DCU 1 is effected through specialized couplers which support: up to 16 fixed (FDS) or exchangeable (EDS) disk drives and/or up to 7 serial devices such as magnetic tape drives and printers, together with up to 15 communications lines via two Synchronous Multi-Line Communications Couplers (SMLCCs).

DEVICE CONTROL UNIT 2 (DCU2): available only on the 2957, 2958, 2966 and 2988, the DCU2 has a very high throughput rate (4 megabytes/second) and can support up to 32 disk drives—giving for example well over 20 gigabytes of FDS 640. Connections are also provided for line printers, card readers and magnetic tape units.

MASS STORAGE

EXCHANGEABLE DISK STORE (EDS) 200: The EDS 200 stores 200 megabytes per disk pack. Each surface has 808 tracks plus 14 reserve tracks. The EDS 200 is obsolescent and is being phased out of production.

FDS–640 FIXED-DISK STORE: The FDS—640 stores up to 651 megabytes of data on 12 fixed disks 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-DISK STORE: FDS 160 drives are supplied in pairs. Each FDS 160 stores up to 160 megabytes of data on four fixed disks 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-disk drive as the other half of the pair.

EDS–80 EXCHANGEABLE DISK DRIVE: EDS–80 units are supplied in pairs. Each EDS–80 stores up to 79 megabytes of data on a disk 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.

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), 200KB/s (1600 bpi), 100KB/s (800 bpi), 266KB/s (1600 bpi compressed), 133KB/s (800 bpi compressed) or 1040KB/s (6250 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 (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.

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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), 626 KB/s (6250 bpi compressed), 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), 413 KB/s (6250 bpi compressed), 106 KB/s (1600 bpi compressed), and 52 KB/s (800 bpi compressed). The combined stop/start times are 10.0 (GCR) and 16.0 ms (PE).

GTS-2 780 MAGNETIC TAPE SYSTEM: The GTS-2 780 comprises a controller and one tape drive. Up to 3 more drives can be added. Each drive is 9-track and recording may be either in ANSI X.354-1976 standard group coded recording mode or in ISO 3788 standard 800 bpi NRZI mode. Drive speed is 125 ins./sec. and transfer rates are 780 KB/sec. (6250 bpi), 200 KB/sec. (1600 bpi), 100 KB/sec. (800 bpi), 1040 KB/sec. (6250 bpi compressed), 266 KB/sec. (1600 bpi compressed) or 133 KB/sec. (800 bpi compressed).

The rewind time for a standard 2400 ft. reel is less than one minute. A standard 3 ins. gap is used for GCR and 0.6 ins. for PE recording. The combined start/stop times are 4.4ms (GCR) and 7.0ms (PE). Reading or writing in any mode can be overlapped by skipping operations on other devices. Drives are automatically threaded with and without autoload cartridges. The GTS-2 780 controller can: 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-2 470 MAGNETIC TAPE SYSTEM: The GTS-2 470 has the same specification as the GTS-2 780, except that the tape speed is 75 ins./sec., 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), 626 KB/s (6250 bpi compressed), 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-2 310 MAGNETIC TAPE SYSTEM: The GTS-2 310 has the same specification as the GTS-2 780, except that the tape speed is 50 ins./sec., decreasing the transfer rate and increasing the start/stop times. The transfer rates are 310 KB/s (6250 bpi), 80 KB/s.(1600 bpi), 40 KB/s (800 bpi), 413 KB/s (6250 bpi compressed), 106 (1600 bpi compressed), or 52 KB/s (800 bpi compressed). The combined start/stop times are 10.0 ms (GCR) and 16.0 ms (PE).

MT-120T MAGNETIC TAPE STREAM: 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 data 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.

MTS-60 MAGNETIC TAPE SYSTEM: The MTS-60 comprises from one to eight tape drives and is connected to a coupler within a DCU1 on 2900 series machines, with the coupler providing the control logic. Recording is either in ISO 3788 standard 1600-bpi phase encoded mode or in ISO 1863 standard 800-bpi NRZI mode. The drive speed is 37.5 ins./sec. 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 ins/sec. A standard 0.6 ins. 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 MTS-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 on e 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-1550 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.

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 two input hoppers with a total capacity of 1000 cards and two 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 disk 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

SYNCHRONOUS MULTI-LINE COMMUNICATIONS COUPLER (SMLCC): the SMLCC is designed for small to medium extent communication requirements. A maximum of two SMLCCs can be fitted to the DCU1 and these can have up to 15 lines attached with a maximum line speed of 9600 bits per second. ICLs' XBM protocol is supported. Adapters are becoming increasingly available for other protocols, including currently, X25 and asynchronous working.

NETWORK PROCESSOR SYSTEM (NPS): this comprises a front-end processor and appropriate software. It was launched in November 1981 to cater to medium to large networks. Local links can be made to up to 4 mainframes. The basic number of lines is 24 and this can be extended to 256. Protocols supported are, currently, ICL's XBM, asynchronous and X25. Local Area Networks (LANs) are one of the areas planned for the NPS.

INFORMATION PROCESSING ARCHITECTURE (IPA): corresponding to IBM's SNA, IPA offers a wide range of facilities for distributed computing and for networking most of the ICL product range. These facilities include the ability to transfer jobs, program code and bulk output from one system to another, distribution of TP applications between a number of cooperating systems and access to a remote service through a user's local system. IPA will be the reference point for future ICL communications and networking products in both hardware and software areas.

SOFTWARE

GENERAL: ICL's earlier set of operating systems for the 2900 series will gradually be phased out and be replaced by a single operating system called Virtual Machine Environment (VME). The operating systems which are now reaching the end of their useful life are: DME (Direct Machine Environment), which permits emulation of obsolete ICL products, such as the 1900: VME/B on which the new VME is based and which offers more facilities than any other VME product; VME/K, designed for the small system user; CME (Concurrent Machine Environment) which allows obsolete machine programs and 2900 series programs to run concurrently and TME (Transaction Machine Environment).

VME: the VME 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.

—Process interrups, 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.

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—Provision of timing facilitis to processes.

—Emulation of non-2900 Series processors.

—Error 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 Catalog 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.

—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/her 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.

The VME operating system is designed for use on all the 2900 Series.

— 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, comprehensive on-line program development and testing aids, and other packages including compilers and financial modelling systems, a database handler (IDMS—Integrated Database Management System), a Transaction Processing Management System (TPMS) and a Data Dictionary System (DDS).

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 orginator, 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 originator.

- 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 and immediate reaction to changing work loads.

CME: Concurrent Machine Environment is specifically intended for the ICL 1900 or System 4 user. CME allows the concurrent running of both DME and VME systems on the 2900 series.

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COBOL: This 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: This compiler is based on American National Standard (ANS) Fortran, 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 68 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. Pascal and APL compilers are also available.

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. VME 2900 also supports an extended version called IDMS-X.

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. IBMs 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.

- REPORT MASTER: is used to extract data from databases and elsewhere and to produce reports.

- QUERYMASTER: is a simple query language which enables non-DP staff to make inquiries of IDMS and Cobol files.

- PDS (Personal Data System): enables non-DP staff to maintain their own data files. PDS includes simple manipulation and inquiry facilities.

- 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.

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- **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. ■

EQUIPMENT PRICES

	PURCHASE PRICE £	MONTHLY RENTAL £	MONTHLY MAINT. £
ICL 2946 VME ENTRY LEVEL			
Processor, 2MB main memory, Device Control Unit (DCU), Operating station, Peripheral couplers with Synchronous Multiline Comms. Coupler for 7 lines 3 x FDS 160 fixed disks of 160MB each: 1 x EDS 80 Exchangeable disk of 80MB: PR620 600lpm printer	136,576	not possible	1,037
basic systems software license £798/month			
ICL 2955/32 VME SYSTEM			
Processor, 4MB main memory, 2 x DCUs, Operating Station, Peripheral Couplers and Synchronous Multiline Comms. Couplers for 15 lines 4 x FDS 160 disk drives of 160MB each 2 x EDS 80 exchangeable disk drives of 80MB each 3 x FDS 640 disk drives of 640MB each 3 x GTS 470 magnetic tape drives 470KB/sec 2 x PB 1130 900lpm printers	355,138	not possible	2,522
basic systems software license £730/month			
ICL 2957/31 VME SYSTEM			
Processor, 4MB main memory, 2 x DCUs type 1, 1XSMLCC (Synchronous Multiline Communications Coupler) for 7 lines, 2XMDSS fixed/exchangeable disk drives with 80MB on exchangeable disk and 160MB on fixed disk, one MT60 magnetic tape, one LP360lpm line printer	190,000 (approx)	—	—
ICL 2958 VME ENTRY LEVEL SYSTEM			
Processor, 4MB main memory, Store Control Unit, 2 x DCUs type 1, operating station, peripheral couplers with a Synchronous Multiline Comms. Coupler for 7 lines 2 x FDS 160 160MB fixed disk drives 2 x EDS 80 80MB exchangeable disk drives 2 x FDS 640 640MB fixed disk drives 2 x GTS 310 magnetic tape drives PB 1130 900lpm printer	362,299	11,265	1,674
basic systems software license £1361/month			

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EQUIPMENT PRICES

	PURCHASE PRICE £	MONTHLY RENTAL £	MONTHLY MAINT. £
ICL 2966 VME ENTRY LEVEL SYSTEM			
Processor, 4MB main memory, Store Control Unit, DCU type 1, operating station, peripheral couplers and Synchronous Multiline Comms. Coupler for 15 lines 2 x FDS 160 160MB fixed disk drives 2 x EDS 80 80MB exchangeable disk drives 4 x FDS 640 640MB fixed disk drives 2 x GTS 470 470KB/sec magnetic tape drives PB 1130 900lpm printer	581,118	17,341	2,173
basic systems software license £1361/month			
ICL 2966 VME LARGE SYSTEM			
Processor, 8MB main memory, Store Control Unit, DCU type 1, DCU Type 2, operating station, peripheral couplers 4 x FDS 160 160MB fixed disk drives 2 x EDS 80 80MB Exchangeable disk drives 9 x FDS 640 640MB fixed disk drives 8 x GTS 780 789KB/sec. magnetic tape drives on two controllers 2 x PB 1130 900lpm printers NPS Network Processor for 32 lines Systems software including VME 2900, Cobol compiling and interactive testing system, TPMS, IDMS and DDS	955,824	28,008	3,670
basic systems software license £3513/month			
ICL 2988 VME ENTRY LEVEL SYSTEM			
Two processors (duplex), 8MB main memory, Store Control Unit, DCU type 1, DCU type 2, operating station, peripheral couplers and Synchronous Multiline Comms. Couplers for 15 lines 2 x FDS 160 160MB fixed disk drives 2 x EDS 80 exchangeable disk drives 6 x FDS 640 640MB fixed disk drives 2 x GTS 780 780KB/sec magnetic tape drives 2 x PB 1130 900lpm printers	873,529	26,680	2,771
basic systems software license £1696/month			