ICL 2900 Series—Models 2946 to 2988

MANAGEMENT SUMMARY

The five machines now comprising the ICL 2900 series, namely the 2946, 2955, 2958, 2966 and 2988 represent a much more simplified approach to medium to large central machine marketing than the earlier 2900 range which grew unwieldly and increasingly expensive to support because of incompatibilities and more than one large scale operating system. Moreover the 2958, 2966 and 2988 are based on the considerable success of the 2966, which produced £130 million worth of sales in one year. The 2946 and 2955, essentially the same machine, are not compatible at processor level with the higher numbered machines and really represent a sub-series. All five machines use the same virtual machine operating system called VME 2900 to which all the previous versions of 2900 series operating systems are converging.

This latest 2900 series also incorporates the latest technology, using in part 64K-bit chips, which has the added advantage of making the systems physically smaller than their predecessors. The 2900 series is competitive with IBM's System 38, 4300 and 303X families and comparable ranges from other manufacturers.

The split into effectively two subseries, comprising (a) the 2946 and 2955 and (b) the 2958, 2966 and 2988 is occasioned firstly and less importantly by technology and secondly by the upper limit of main memory capacity. In the 2946 and 2955, 16K-bit chips are used and the maximum main memory capacity is 8 megabytes. These two machines are compatible at processor level. In contrast, the 2958, the 2966 and the 2988 all use 64K-bit chips and, in effect, have an upper limit of 32 megabytes on main memory (the nominal maximum capacity of the 2958 is 8 megabytes but it can be field upgraded to a 2966). The 2958, 2966 and 2988 are compatible at ➢

The latest version of the 2900 series effectively comprises two sub-series, the 2946 and 2955, basically the same machine, and the 2958, 2966 and 2988, where the 2958 and 2988 are closely related to the 2966. Software and hardware have been considerably simplified from earlier 2900 series systems. The 2900 range caters for medium to large organisations which require powerful centralised computing power with considerable distributed processing and networking potential

MODELS: 2946, 2955, 2958, 2966, 2988. (in most cases, ICL will refer to these machines with an oblique added—e.g., 2955/32. These additional numbers are mainly for internal use. In all these cases the basic system is unaltered)

COMPETITION: virtually ranging across the board with top-end minis competing at the lower levels together with models like IBM System 34 and a wide variety of mainframes competing with 2958 upwards

PRICE: from about £130,000 to over £1 million

BASIC SPECIFICATIONS

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

MODELS: ICL 2946, 2955, 2958, 2966 and 2988. Obliques are used (e.g. 2955/32) with numbers to denote particular configurations. ➢

One of the larger models, the ICL 2966 falls between the 2958 and the 2988. 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.

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CHARACTERISTICS

	2946	2955	2958	2966	2988
SYSTEM CHARACTERISTICS					
Date of introduction	Mar. 1980	Oct. 1980	Nov. 1981	Oct. 1980	Nov. 1981
Date of first delivery	Mar. 1980	May 1981	Mar. 1982	May 1981	Apr. 1982
Virtual storage capability	Standard	Standard	Standard	Standard	Standard
Number of central processors	1	1 or 2	1 or 2	1 or 2	1 or 2
Principal operating systems	VME 2900 CME/2/3 DME/2	VME 2900 CME/2/3 TME	VME 2900 CME/2/3	VME 2900 VME/B CME/2/3/G3 CME/S4 DME/G3/S4	VME 2900
MAIN STORAGE					
Storage type	MOS-16K	MOS-16K	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	2M	4M	2M	4M	8M
Maximum capacity—bytes (single)	8M	8M	8M	32M	32M
Dual systems	no	yes	yes	yes	yes
Increment size—bytes	½M	½M	2M	2M	8M
BUFFER STORAGE (SLAVE STORES)					
Cycle time—nanoseconds	128	128	80	80	80
Bytes fetched per cycle	4	4	4	4	4
Data slave capacity—bytes	1K	1K	16K	16K	32K
PROCESSING UNIT					
Machine cycle time—nanoseconds	150	125	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	1 or 2	1 or 2	1 or 2	1 or 2
Device Control Units (DCU)	1 or 2	2 to 6	2 to 6	2 to 6	4 to 6
SCU to main store	10.7MB/s	10.7MB/s	16MB/s	16MB/s	16MB/s
Maximum total transfer rate	3.6MB/s	10.8MB/s	19.6MB/s	19.6MB/s	19.6MB/s
Power ratio	1	1.18	2.27	3.64	6.27

processor level, but incompatible at this level with the lower numbered machines. These and other characteristics of the machines can be seen in the table.

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

Although the trend is rapidly towards there being just one operating system for this series, namely VME 2900, all but the 2988 also support Direct Machine Environment

DATA FORMATS

BASIC UNIT: 8-bit byte. Each byte can represent one alphanumeric character, 2 BCD digits or 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.

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(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 the ICL Network Processor System (NPS). Furthermore all models except the 2946 can be used in a dual configuration.

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 his 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 disc drives and on flexibility in control. Apart from disc drives, ICL offers magnetic tape drives and printers, but only a small number of terminal types and card and paper tape devices. More detail on these is given below.

In order to control peripherals, ICL now provides just two control units, in contrast to the rather confusing variations offered previously. These two control units are termed DCU 1 and DCU 2—the DCU letters meaning "Device Control Unit". The DCU1 is a general purpose controller available on all models. The DCU 2 has been developed to handle a very large number of discs and magnetic tapes. It is provided for use only on the 2958, 2966 and 2988—that is the 2966-based machines. Peripheral devices are connected via couplers to interface modules on both the DCU1 and DCU2.

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

There is also a considerable range of magnetic tape drives. Transfer rates range from 30 kilobytes per second

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.

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 megabyte blocks.

STORAGE TYPE: MOS (metal oxide semi-conductor)

CYCLE TIME: see Characteristics Table. High speed slave stores make the 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 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 ystem 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, 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 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.

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

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.

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 autumn 1981, ICL announced that the main operating system for the 2900 series would be Virtual Machine Environment (VME) 2900. 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 2946, 2955, 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 2900, the main operating system now for the 2900 consists of a base and a series of options which enhance throughput and control. VME 2900 is designed to handle mixed batch, teleprocessing and interactive inputs. Since VME 2900 is file oriented, ICL state that it can be used to take a central part in networks, supporting large numbers of terminals.

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

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 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 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 favoured 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 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.

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.

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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.

USER REACTION

A total of 50 users with 64 installed ICL 2900 Series systems replied to our 1981 survey of British computer users. Six of the users had 2946s, 12 had 2950s, 10 had 2956s, 12 had 2960s, and the other 10 users had a variety of other 2900 models.

Here's how they rated their systems:

	2946	2950	2956	2960	Others
Ease of operation	2.33	3.00	3.10	2.92	3.00
Reliability of mainframe	3.17	2.92	3.20	3.33	2.20
Reliability of peripherals	2.50	2.92	3.20	2.73	2.60
Maintenance service					
Responsiveness	2.50	2.67	3.10	2.83	3.10
Effectiveness	2.33	2.67	2.90	2.75	2.60
Technical support					
Trouble-shooting	1.83	2.42	2.30	2.17	2.50
Education	2.33	2.58	2.60	2.50	2.70
Documentation	1.83	2.25	2.60	2.08	2.60
Manufacturer's software					
Operating system	1.80	2.67	2.70	2.58	2.70
Compilers & assemblers	2.17	2.91	3.00	2.73	3.10
Application programs	1.80	2.75	2.50	1.75	2.56
Ease of programming	2.17	2.64	2.90	2.82	3.00
Ease of conversion	2.00	2.27	2.89	2.00	2.00
Overall satisfaction	2.00	2.75	2.90	2.50	2.67

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

The lower ratings given the 2946 may be attributable, at least in part, to the fact that this is one of the newer systems and the users had had them for an average of only 12.3 months. In other words, these users may still have been having teething pains. A total of 50 percent said that the 2946 hadn't done what they had expected it to and 66.7 percent said they wouldn't recommend it to another user. Both responses are out of line with the user reaction to other models, again suggesting teething pains.

By contrast, 91.2 percent of the 2950 users said the system had done what they expected and 75 percent said they

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.

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.

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), ICLs' name for the central processor, one Store Control Unit (SCU), one operating station, a number of Device Control Units (DCUs)—one for the 2946, 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 and 2966; 8M bytes for the 2988. Memory can be extended to 8M bytes on the 2946, 2955 and 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 to maxima of two on the 2946, three on the 2955 and four on the 2958, 2966 and 2988 (see Characteristics Table).

With the exception of the 2946, 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 maxima of four on the 2955 and six on other systems. Maximum storage size also increases, to 16 megabytes on the 2955 and 2958 and 64 megabytes on the 2966 and 2988.

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.

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would recommend it to another user; the other 25 percent saying that they hadn't made up their minds yet.

Here's a summary of the responses to two key questions:

	2946	2950	2956	2960	Others
Did the system do what you expected it to? (%)					
Yes	33.33	91.67	80.00	50.00	80.00
No	50.00	8.33	10.00	25.00	10.00
Haven't decided	16.67	0.00	10.00	25.00	10.00
Would you recommend this system to another user? (5)					
Yes	33.33	75.00	70.00	33.33	70.00
No	66.67	0.00	10.00	41.67	30.00
Haven't decided	0.00	25.00	20.00	25.00	0.00

ICL has faced some sticky marketing problems with the 2900 Series, many of them of the same type faced by IBM when it introduced the System/360. In native mode, the 2900s are incompatible with the old ICL 1900 range, forcing users to either run in emulation or convert their existing software. There have also been problems with the new operating systems that have caused user dissatisfaction.

The survey results reflect this historical situation in the rather sharp division between happy and unhappy users. In considering the acquisition of one of these systems, it is worth noting that, in most categories, 50 percent or more of the survey respondents rated their systems above average. ICL has continually enhanced the range, and the 2900 Series offers many capabilities well worth consideration.□

The aids are in the form of microcoded operating system packages, with the microcode resident in the OCPs. The 2946, 2955, 2958 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

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) disc 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 2958, 2966 and 2988, the DCU2 has a very high throughput rate (4 megabytes/second) and can support up to 32 disc 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 DISC STORE (EDS) 200: the EDS 200 stores 200 megabytes per disc 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-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 hald 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.

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 133KB/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

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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.

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

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. Adaptors 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 for the 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: ICLS 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) 2900. 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 2900 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 2900: the VME 2900 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 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 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,

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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 2900 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 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 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.

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 it 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 (Avanced 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.

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- **QUERYMASTER: is a simple query language which enables non-DP staff to make enquiries of IDMS and Cobol files.**
- **PDS (Personal Data System): enables non-DP staff to maintain their own data files. PDS includes simple manipulation and enquiry 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.**
- **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 3xFDS 160 fixed discs of 160MB each: 1xEDS 80 Exchangeable disc of 80MB: PR620 600lpm printer	136,576	not possible	1037
basic systems software licence £798/month			
ICL 2955/32 VME SYSTEM			
Processor, 4MB main memory, 2xDCUs, Operating Station, Peripheral Couplers and Synchronous Multiline Comms. Couplers for 15 lines 4XFDS 160 disc drives of 160MB each 2xEDS 80 exchangeable disc drives of 80MB each 3xFDS 640 disc drives of 640MB each 3xGTS 470 magnetic tape drives 470 KB/sec 2xPB 1130 900lpm printers	355,138	not possible	2522
basic systems software licence £935/month			
ICL 2958 VME ENTRY LEVEL SYSTEM			
Processor, 4MB main memory, Store Control Unit, 2xDCUs type 1, operating station, peripheral couplers with a Synchronous Multiline Comms. Coupler for 7 lines 2xFDS 160 160MB fixed disc drives 2xEDS80 80MB exchangeable disc drives 2xFDS640 640MB fixed disc drives 2xGTS 310 magnetic tape drives PB 1130 900 1pm printer	362,299	11265*	1674
basic systems software licence £1361/month			

*These figures are for 5-yr. monthly hire; after 3 years ICL "will discuss different equipment hire at equal or higher hire prices"

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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 2xFDS 160 160MB fixed disc drives 2xEDS80 80MB exchangeable disc drives 4xFDS640 640MB fixed disc drives 2xGTS 470 470KB/sec magnetic tape drives PB 1130 900 1pm printer	581,118	17341*	2173
	basic systems software licence £1361/month		
ICL 2966 VME LARGE SYSTEM			
Processor, 8MB main memory, Store Control unit, DCU Type 1, DCU Type 2, operating station, peripheral couplers 4xFDS 160 160MB fixed disc drives 2xEDS 80 80MB Exchangeable disc drives 9xFDS 640 640MB fixed disc drives 8xGTS 780 789KB/sec. magnetic tape drives on two controllers 2xPB 1130 900 1pm printers NPS Network Processor for 32 lines	955,824	28,008*	3670
Systems software including VME 2900, Cobol compiling and interactive testing system, TPMS, IDMS and DDS	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 2xFDS 160 160MB fixed disc drives 2xEDS 80 exchangeable disc drives 6xFDS 640 640MB fixed disc drives 2xGTS 780 780 KB/sec magnetic tape drives 2xPB 1130 900 1pm printers	873,529	26,680*	2771
	basic systems software licence £1696/month		

*These figures are for 5-yr. monthly hire; after 3 years ICL "will discuss different equipment hire at equal or higher hire prices"