ICL 1900 Series

MANAGEMENT SUMMARY

The ICL 1900 Series is by far the most widely used line of computer equipment produced by any manufacturer based outside of the United States. Worldwide installations total more than 3000 systems ranging in size from the 1901A to the 1906S, a span roughly comparable to the IBM 360/30 through the 370/158.

Only the four newest 1900 processors — the 1901T, the 1902T, the 1903T, and the 1904S — are currently in new production, but ICL has pledged to support the entire 1900 Series until at least the early 1980's. ICL has done a good job of prolonging the effective marketing life of the series by constantly upgrading the hardware and software. The 1900's provide a growth path both for current 1900 users who are not yet ready to move up to the medium or large scale models of the 2900 Series and for users of ICL's small-scale 2903's and 2904's.

The 1900's also offer an interesting alternative for non-ICL users who plan to move eventually to the ICL 2900's but need more capacity immediately. By following ICL's Forward Compatibility Standards for programs written in high level languages, 1900 users can assure themselves of a smoooth transition to the 2900's. In addition, 1900 object programs can be run on the 2900's in either of two emulation modes. And many 1900 peripherals can be carried over to 2900 systems. But the product's greatest asset today is the availability of an extensive amount of reliable and time-proven system and applications software.

The market for 1900's is active. ICL's sales of new and rebuilt 1900 equipment currently are running at a rate of £70 million a year.

Current 1900 system prices range from about £3000 per month for a 1901T to about £25,000 per month for a 1904S.

With four current processor models, the British-built ICL 1900 Series effectively handles a broad range of workloads and applications. Introduced in 1964, the series has been steadily expanded and improved; it now includes such advanced facilities as virtual storage and front-end communications processors.

CHARACTERISTICS

Manufacturer: International Computers Ltd., ICL House, Putney, London SW15 1SW, England. Telephone 01-788-7272. ICL also maintains offices worldwide in 80 countries.

MODELS: 1901T, 1902T, 1903T, and 1904S.

DATA FORMATS

BASIC UNIT: 24-bit word. Each word location in main storage consists of 24 data bits and 1 parity bit, and can hold four 6-bit BCD characters, one single-precision binary operand, one half of a double-precision binary operand, or one instruction.

FIXED-POINT OPERANDS: One or two 24-bit words, with sign in leftmost bit position.

FLOATING-POINT OPERANDS: One word, consisting of 8-bits-plus-sign exponent and 37-bits-plus-sign fraction, in normal precision; two words, consisting of 8-bits-plus-sign exponent and 74-bits-plus-sign fraction, in extended precision.

INSTRUCTIONS: One word. Arithmetic and logical instructions include one 12-bit operand address field and one 3-bit field that specifies one of the eight general registers.

INTERNAL CODE: 6-bit BCD.

MAIN STORAGE

STORAGE TYPE: Semiconductor.

This photo shows part of a typical installation of the medium-scale 1904S system. From left to right are a high-speed card reader, line printer, 196K-word central processor (housed in the cabinets at the rear), card reader, and paper tape equipment.

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BACKGROUND

International Computers Limited, the United Kingdom's principal computer company, was formed through a 1968 merger of International Computers and Tabulators Limited (ICT) and English Electric Computers Limited. Previously, ICT had absorbed the computer interests of EMI, Ferranti, and General Electric (Great Britain), while English Electric had absorbed the computer activities of Elliot Automation, Leo Computers, and Marconi. Thus, ICL today represents a consolidation of most of the United Kingdom's computer development and production resources. To this base, ICL last year added the international operations of the Singer Business Machines Division.

The company has approximately 31,000 employees and markets its products in more than 80 countries around the world. Its activities range from basic research through development and manufacturing to the provision of comprehensive post-sales support and service.

The 1900 Series was introduced by ICT in September 1964, just five months after IBM announced the System/360. The 1900 Series originally included the 1902, 1903, 1904, 1905, 1906, 1907, and 1909 central processors. The small-scale 1901 processor joined the family a year later. In 1967, ICT added eight more processors: the 1904E, 1904F, 1905E, 1905F, 1906E, 1906F, 1907E, and 1907F. All of these models use discrete-component circuitry and core memories, and all are now out of production.

The large-scale 1906A was introduced in October 1967. The smaller 1901A, 1902A, 1903A, and 1904A followed in January 1968. All of these "A" models utilize integrated circuits and faster, more compact core memories, and they provide an average of 2.5 times more processing power than their predecessors.

In April 1971, ICL substantially enhanced the 1900 Series by unveiling the 1902S, 1903S, 1904S, and 1906S processors plus several new peripheral and software products. The new "S" processors offer significant increases in computing and/or input/output speeds over the corresponding "A" models. A curious feature of the "S" series is ICL's use of three different main storage technologies: magnetic core in the 1902S and 1903S, MOS semiconductor in the 1904S, and plated wire in the 1906S. Only the 1904S is still in production.

In September 1973, ICL introduced the 1903T, a system about 30% faster than the 1903S. It has a semiconductor memory, a buffered interface that assembles bit streams into words before transferring the data to memory, and, optionally, a paging unit for virtual memory operations.

In December 1973, ICL added the 1901T and 1902T. Both have semiconductor memory, an integrated disc controller, and an integrated adapter for local and remote CRT terminals. The 1901T is about 70% faster than the 1902A, and the 1902T is about 70% faster than the 1902S. For users with only occasional need for on-line inquiry capabilities, ICL provides roll-in/roll-out software that

CAPACITY: See table.

CYCLE TIME: See table.

CHECKING: Parity bit with each word is generated during writing and checked during reading.

STORAGE PROTECTION: Provided through datum (base) and limit registers or through the optional paging mode in Models 1903T and 1904S.

CENTRAL PROCESSORS

REGISTERS: The first eight words of each user program in main storage serve as 24-bit general registers (i.e., accumulators) for that program and its subprograms. The first three registers in each program can also be used as index registers. In Models 1903T and 1904S, eight fast hardware registers are provided to serve as the general registers for the currently active program; since only one set of hardware registers is provided, its contents must be shifted into the first eight main storage locations of the interrupted program whenever an interrupt occurs.

INSTRUCTION REPERTOIRE: The complete 1900 Series instruction set contains approximately 120 instructions and provides facilities for fixed-point binary arithmetic, floating-point binary arithmetic, loading, storing, comparing, branching, shifting, logical operations, decimal-to-binary and binary-to-decimal radix conversions, input/output, and supervisory control. Floating-point arithmetic hardware, however, is an extra-cost option for all models.

The arithmetic and logical operations are implemented by microprograms in read-only storage, but the input/output and control instructions are implemented as "Extra-codes" (i.e., standard subroutines within the Executive that are executed whenever the instructions are encountered). Floating-point arithmetic instructions can also be implemented as Extracodes in processors that lack the floating-point hardware features.

INSTRUCTION TIMES: See table.

PAGING: Models 1903T and 1904S can be equipped with the optional Paging Unit, after which they can be operated either in the paging mode or in the normal datum/limit mode. In the paging mode, each program has 3 million words of virtual storage available to it, in 1024-word blocks. (An additional 1 million words are logically addressable, but this area is reserved for system software use.) Both the computer's main memory and the disc or drum backing store (which contains up to 3 million words per program) are divided into pages of 1024 words. The paging hardware and software "map" the blocks of virtual storage into the pages of main memory and the backing store.

Translation between the virtual addresses contained in instructions and real main memory addresses is performed by a hardware-implemented table-lookup process that accesses tables in main memory which are created and maintained by the operating system. The translation is speeded by a group of 8 Current Page Registers which hold the most recently referenced virtual storage block addresses and their main memory equivalents. Whenever a program references a block that is not currently residing in main memory, an interrupt occurs and the required block is fetched from the backing store. A "learning program" in the operating system keeps track of the frequency of block usage and attempts to keep in core memory the blocks which are most likely to be required.

CONSOLE: All central processors are equipped with a console typewriter (a Teletype Model 33 ASR) that is used primarily for communication between the system operator and the Executive.

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CHARACTERISTICS OF THE 1900 SERIES PROCESSOR MODELS

	1901T	1902T	1903T	1904S
GENERAL CHARACTERISTICS				
Date of introduction	December 1973	December 1973	September 1972	April 1971
Monthly mainframe rental (approximate range)	£1230 to £2800	£3300 to £5500	£5000 to £9000	£8500 to £14,000
MAIN STORAGE				
Storage type	Semiconductor	Semiconductor	Semiconductor	Semiconductor
Word size, data bits	24	24	24	24
Cycle time, microseconds	4	2	0.8	0.3
Words fetched per cycle	1	1	1	1
Storage interleaving	None	None	None	None
Available capacities, words	16,384	32,768	65,536	98,304
	32,768	49,152	98,304	131,072
	49,152	65,536	131,072	196,608
	65,536	81,920	196,608	262,144
		98,304		
		114,688		
		131,072		
CENTRAL PROCESSOR				
Add time, microseconds (24-bit binary fields)	12	6	4	2
Multiple/divide hardware	Standard	Standard	Standard	Standard
Floating-point hardware	Optional	Optional	Optional	Optional
Real-Time Clock	Optional	Optional	Standard	Standard
Program Timer	Optional	Optional	Standard	Standard
Paging Unit	No	No	Optional	Optional
Multiprogramming facilities	Optional	Optional	Standard	Standard
CHANNELS				
No. of integrated I/O adapters	2	2	None	None
No. of standard I/O channels	5 to 7	5 to 11	6 to 18	6 to 18
No. of fast I/O channels	0 to 6	4 to 12	4 to 12	4 to 18
No. of high-speed I/O channels	0 or 1	0 or 1	0 or 1	0 to 2
Maximum total I/O data rate, characters/second	630,000	830,000	2,500,000	5,000,000

enables a terminal to temporarily interrupt batch processing.

The four current models offer 1900 Series users both an improvement in price/performance and the beginning of a transition to the communications-oriented 2900 Series.

ICL markets the 1900 Series throughout most of the world, including Eastern Europe and Russia, but not in the U.S. Even so, the 1900 Series is of interest to many U.S.-based companies because its broad scope, intrafamily compatibility, and widespread availability make it a strong contender for use in their overseas computing installations.

ARCHITECTURE

Unlike most computer systems unveiled during the past decade, the ICL 1900 Series is distinctively different from IBM computers of both the past and present. In designing the 1900 Series, ICL apparently placed maximum emphasis upon architectural simplicity and intrafamily compatibility — and has achieved these objectives in truly impressive fashion. But the resulting equipment and software, though generally straightforward and effective, is likely to prove disturbingly unfamiliar to users of IBM or IBM-like computers.

In defiance of the trend toward 8-bit byte-oriented systems, the 1900 Series processors use a fixed 24-bit word

INPUT/OUTPUT CONTROL

I/O CHANNELS: Four basic types of channels are available in the various 1900 Series processor models, in the quantities shown in the table. The channel types can be described as follows:

- **Standard (or "hesitation") channels — Used primarily for character-by-character I/O operations on devices whose data transfer rates do not exceed 50,000 characters/second. In Models 1902T through 1904S, these channels can also operate in "burst" mode to handle magnetic tape and disc units with transfer rates up to 250,000 characters/second. The standard channels share the internal logic of the central processor.**
- **Fast channels — Used primarily for magnetic tape and mass storage devices with data transfer rates in the range of 50,000 to 450,000 characters/second. These channels are controlled by independent logic; the 1903T and 1904S use a Peripheral Autonomous Control (PAC) with a 4-character buffer for each channel.**
- **High-speed channels — Used for high-performance mass storage devices with data transfer rates up to 1.5 million characters/second. Controlled by the PAC in Models 1903T and 1904S.**
- **Integrated adapters — Standard on the Models 1901T and 1902T, they permit direct connection of up to 8 EDS 60 disc drives, 3 local CRT terminals, and 1 modem for remote CRT terminals.**

CONFIGURATION RULES: In general, each 1900 Series I/O channel accommodates a single peripheral device or subsystem, subject to the speed limitations mentioned above.

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length and a 6-bit internal character code. Moreover, all arithmetic is done in fixed-word-length binary mode; no hardware instructions for decimal arithmetic are available. (ICL supplies standard subroutines for performing decimal arithmetic on variable-length fields, but these are compartively slow.) Thus, the architecture of the central processors seems to be oriented toward scientific rather than business applications — but their effective radix conversion facilities and fast binary arithmetic largely compensate for the lack of decimal arithmetic and make them effective performers in business applications as well.

Multiprogramming is a featured capability of all 1900 Series central processors. Effective storage protection is provided for 4 to 48 independent main programs, depending upon the processor model, and the hardware multiprogramming facilities are well supported by the standard ICL software.

Other facilities that help to boost the performance of the 1900 Series processors include independent, concurrently-operating floating-point arithmetic units (optional), independent channel controllers for high-speed I/O operations (in Models 1903T and 1904S), eight hardware-implemented general registers (in Model 1904S), and paging facilities (optional for Models 1903T and 1904S).

ICL, through its optional Paging Unit, was offering the advantages of virtual storage to large-scale computer users long before IBM added the capability to the System/370 in August 1972. ICL's paging scheme is generally similar to the one employed by IBM. Up to 3 million words of virtual storage are available to each program, in 1024-word blocks. Paging is an automatic function of the hardware and the associated GEORGE 4 operating system, and no changes to existing programs are required when an installation converts to the paging mode of operation.

PERIPHERALS AND COMMUNICATIONS

Users of the ICL 1900 Series can choose from a broad range of disc drives, magnetic tape units, printers, card readers and punches, paper tape readers and punches, and communications equipment, as well as a Universal Document Reader that optically reads marks and/or printed characters from paper documents. ICL's line of Exchangeable Disc Store (EDS) units include models whose specifications are generally similar to those of the IBM 2311 and 2314, plus a "double-density" version of the 2314-style drive. Magnetic tape units are offered in 9-track, 1600-bpi models; all use industry-compatible tape formats and are packaged in clusters consisting of two to six tape drives plus control unit.

ICL can provide 100 and 200 million character capacity disc devices upon request for users with large storage requirements. Also, a train printer that operates at up to 1500 lines per minute is available. Users requiring a variety of high performance peripherals should probably consider moving directly to the 2960 system.

No dual-channel peripheral controllers are available, but manual switches enable two or three peripheral devices to share a channel or two central processors to share a peripheral device or subsystem.

SIMULTANEOUS OPERATIONS: Concurrently with computing, a Series 1900 processor can handle one I/O data transfer operation on each installed channel, subject to the maximum total I/O data rate specified in the table.

MASS STORAGE

2814 EXCHANGEABLE DISC STORE (EDS 30): Provides large-capacity random-access storage for Models 1901T through 1904S on 11-disc packs which are physically interchangeable (but not format-compatible) with the IBM 2316 Disk Pack. Each 2814 transport unit accommodates one on-line pack holding up to 30.7 million 6-bit characters. A 2814 EDS 30 subsystem consists of either a 2812/2 control unit and from one to nine 2814 transports or an F1497 integrated control unit and from one to eight 2814 transports, providing a total storage capacity of up to 276.3 or 245.6 million characters, respectively. Each transport has a comb-type access mechanism that can read or write up to 151,552 characters (20 tracks) at each of its 203 positions. Each track is divided into 15 sectors of 512 characters each. Average head movement time is 60 milliseconds, average rotational delay is 12.5 milliseconds, and data transfer rate is 416,000 characters/second. The 2812/2 control unit is an internally programmed controller that handles the queuing, initiation, control, and checking of all data transfer operations, buffers all data transfers between the EDS transports and main memory, performs automatic error checks during reading and writing, permits multiple simultaneous seek operations, and facilitates maintenance of the subsystem.

2815 EXCHANGEABLE DISK STORE (EDS 60): Provides large-capacity random-access storage for Models 1901T through 1904S on 11-disc packs which are physically interchangeable (but not format-compatible) with the IBM 2316 Disk Pack. The EDS 60 is a "double-density" version of the EDS 30 described above, with improved access times. Each 2815 transport accommodates one on-line pack holding up to 61.5 million characters. An EDS 60 subsystem consists of a 2812/3 control unit and from three to nine on-line 2815 transports, providing a total storage capacity of up to 553.5 million characters. There are 406 tracks on each of the 20 recording surfaces. Each track is divided into 15 sectors of 512 characters each. Average head movement time is 35 milliseconds, average rotational delay is 12.5 milliseconds, and data transfer rate is 416,000 characters/second. The 2812/3 control unit performs the same programmed functions as the 2812/2 described above.

2816 EXCHANGEABLE DISC STORE (EDS 60): The 2816 is a dual-access version of the 2815 described above. It has two device interfaces to permit the connection of two control units and additional facilities for the protection of either interface when in use. Its recording characteristics are identical to those of the 2815.

2851 DRUM STORAGE SYSTEM: Serves as a high-speed backing store for the automatic operating systems in Model 1904S. As such, it cannot be directly addressed by user programs. A 2851 subsystem consists of a 2851/1 control unit and from one to eight 2851/2 or 2851/4 drum storage units. Both drum units have a storage capacity of 2,097,152 characters and an average rotational delay (half-revolution time) of 6.3 milliseconds, and both record data in 128-word sectors. The 2851/2 records 4 bits in parallel, with 32 sectors in each band of 4 tracks; while the 2851/4 records in bit-serial mode, with 8 sectors in each track. Data transfer rates are 1,400,000 characters/second for the 2851/2 and 350,000 characters/second for the 2851/4.

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For data communications, ICL offers a variety of central-site control equipment plus remote batch terminals, teletypewriters, and CRT display units. Two front-end communications processors are available to lighten the load that would otherwise be imposed upon the central processors by multi-line communications networks. Although the 1900 Series communications facilities are entirely adequate for most applications, the ICL 2900 Series computers are generally more effective in complex real-time environments because of their superior interrupt-handling facilities and more advanced architecture.

SOFTWARE

The 1900 Series software, like the hardware, is designed to satisfy a broad range of applications requirements and workload volumes. Users can choose the facilities that best meet their needs from a wide variety of operating systems, compilers, and applications programs.

A software Executive, required in every 1900 Series installation, complements the hardware by handling functions such as program loading, input/output control, and operator communications. In addition, most installations use an operating system, and ICL offers a choice of five different versions of GEORGE (GEneral ORGanizational Environment). GEORGE 1 and 1S are straightforward, single-job-stream operating systems, and GEORGE 2 adds input and output spooling facilities. GEORGE 3, usable on larger systems with disc storage, is a comparatively powerful system that offers multiple job streams, an integrated File Store data management system, remote job entry, and interactive programming facilities. GEORGE 4, designed for 1903T and 1904S systems operating in the paging mode, offers essentially the same user facilities as the non-paged GEORGE 3 system.

For business applications, 1900 Series users generally choose to write their own programs in COBOL, PLAN (the 1900 Series symbolic assembly language), or RPG II. Scientific programmers can choose to work in FORTRAN, ALGOL, BASIC, or any of several less popular languages. The COBOL, FORTRAN, and ALGOL compilers and the PLAN assembler are all available in numerous versions designed for different hardware configurations. In addition, ICL offers conversational-mode compilers for FORTRAN and BASIC, as well as high-speed compile-and-run processors for FORTRAN and ALGOL.

More than 60 ICL-developed applications packages are now available to 1900 Series users. These programs span a broad range of applications, with particular emphasis upon data management, production control, operations research, statistics, civil engineering, electrical engineering, and numerical control.

COMPATIBILITY

Intrafamily compatibility was a principal design goal of the 1900 Series, and ICL has achieved this goal to a

INPUT/OUTPUT UNITS

9-TRACK MAGNETIC TAPE SYSTEMS: These systems read and write data on standard ½-inch tape in 9-track, industry-compatible formats. Six types are available, with the following characteristics:

Type 2508: 37.5 ips; 1600 bpi, phase encoded; 80,000 char/sec. (This unit is no longer available new.)

Type 2509: 75 ips; 1600 bpi, phase encoded, 160,000 char/sec.

Type 2510: 37.5 ips; 1600 bpi, phase encoded, optional NRZI facility; 80,000 char/sec.

Type 2511: identical to Type 2510 but does not include magnetic tape control.

Types 2508 and 2509 are ofered in clusters of two, three, or four drives plus controller. Up to five single transport Type 2511 units can be connected to a Type 2510 unit for a maximum of one control unit and six transports for any one system.

Each 24-bit word is recorded in 3 consecutive rows (or frames) of tape, with 8 data bits and 1 parity bit in each row. (Note that the data transfer rates are expressed in 6-bit characters rather than rows.) Data can be read in either the forward or reverse direction.

The Type 2508 and 2509 Magnetic Tape Systems provide automatic loading (which permits 10-inch reels contained in special cartridges to be loaded in about 10 seconds) and vacuum-operated capstans. All models feature in-flight correction of single-bit errors.

2101 CARD READER: Reads standard 80-column cards serially, on demand, at up to 1200 cpm in Type 2101/0 and 2000 cpm in Type 2101/2. Both versions include integrated control units. The 3000-card feed hopper and single 3000-card stacker can be loaded and unloaded while the reader is operating. Card data in the ICL 1004, 1300, 1500, 1900, or proposed ISO character code is translated into the 1900 Series internal code. The optional Card Image feature transfers the full card pattern into main memory.

2102 CARD READER: Reads standard 80-column cards serially at up to 300 cpm. Accepts the same codes as the 2101, above. The 1000-card feed hopper and single 1000-card stacker can be loaded and unloaded while the reader is operating.

2104 CARD READER: Reads standard 80-column cards serially at up to 600 cpm. Accepts the same codes as the 2101, above. The 1000-card feed hopper and single 1000-card stacker can be loaded and unloaded while the reader is operating.

2151 CARD PUNCH: Punches standard 80-column cards in row-by-row fashion at 300 cpm. Has an integrated control unit and a full 80-character buffer. Translates data from the 6-bit internal code into the ICL 1900 card code. Performs a hole-count check upon punching accuracy. Has a 1000-card input hopper and two 850-card stackers.

1916/2 PAPER TAPE READER: Reads 5, 6, 7, or 8-track tape at 1000 char/sec. Automatically translates the 8-track ICL 1900 paper tape code (based on the ISO 7-bit code) into the 6-bit internal code. Handles other codes through program translation and/or through the optional Tape Image feature, which transfers an exact bit image of all 8 tracks to main memory.

1925 PAPER TAPE PUNCH: Punches 5, 6, 7, or 8-track tape at up to 110 char/sec. Automatically translates the 6-bit

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degree well beyond that of many competitive computer families. Minor differences in the input/output and control logic of the various processor models, as well as differences in their hardware instruction repertoires, are resolved by the software Executives. Thus, with only minor exceptions, users can count on full upward compatibility of programs, data, and job description commands throughout the 1900 Series. Moreover, it is practical, within reasonable limits, for a smaller 1900 Series system to serve as a backup machine for a larger one — an important consideration in underdeveloped countries where computers are relatively few and far between.

Because of ICL's independent approach to its design, the 1900 Series offers no program compatibility, at the machine or assembly-language level, with any competitive computer system. ICL's implementations of the COBOL, FORTRAN, ALGOL, and BASIC languages, however, are in accordance with the established standards for these languages.

Moreover, 1900 programs written in high level languages to ICL's "Foward Compatibility Standards" can be easily converted to run on the 2900 Series in native mode.

Data compatibility with the IBM System/370 and other current computer systems is also quite limited. The ICL systems use standard 80-column cards and industry-compatible 9-track magnetic tape formats, but the ICL disc packs use fixed-sector-length formats which are incompatible with those of other systems. Moreover, the 1900 Series uses 6-bit BCD characters and 24-bit words, whereas the current IBM systems use 8-bit EBCDIC characters and 32-bit words. ICL does, however, provide methods for converting 1900 Series files to 2900 Series format.

COMPETITIVE POSITION

In price/performance, ease of use, and overall effectiveness, the 1900 Series compares favorably with comparable offerings of IBM and other manufacturers.□

internal code into the 8-track ICL 1900 paper tape code (based on the ISO 7-track code). Handles other codes through program translation and/or through the optional Tape Image feature.

2601 & 2602 PAPER TAPE READER PUNCHES: Read 5, 6, 7, or 8-track tape at up to 250 or 1000 char/sec., respectively, and punch it at up to 110 char/sec. The reader and punch share a single I/O channel and can operate simultaneously by interleaving their data transfers to and from main memory. Code-handling facilities are the same as those of the 1916/2 and 1925, above.

2408 PRINTER: Prints up to 300 lpm using the full set of 64 characters. Has a conventional drum-type printing mechanism, 132 print positions, a full-line print buffer, and an integrated control unit. Spacing is 10 characters/inch horizontally and 6 or 8 lines/inch vertically. Skipping speed is a maximum of 30 inches/second. Uses the ECMA 11 OCR-B Size 1 type font. Format control is handled by an 8-track tape loop. Accepts forms from 4 to 18 inches wide and up to 18 inches long. A dynamic stacker is optional.

2409 PRINTER: Prints up to 600 lpm. All other specifications are the same as those for the 2408.

2430 PRINTER: Prints up to 850 lpm with a 96-character set, up to 1200 lpm with a 64-character set, and up to 1500 lpm with a 48-character set. Has a train printing mechanism that uses interchangeable print cartridges which can be used to provide a variety of type faces and alphabets; e.g. Arabic or Cyrillic. Up to 8 read-only memories are provided for driving up to 8 different character sets. Available with either 132 or 160 print positions, the printer includes an integrated control unit, a full-line print buffer, and a dynamic stacker. Spacing and type font are the same as those of the 2408, above. Skipping speed is a maximum of 75 inches/second. Accepts forms from 3.25 to 20 inches wide and up to 18 inches long.

1934 DIGITAL INCREMENTAL PLOTTERS: Produce X-Y plots on 120-foot rolls of paper, using a drum-type plotting mechanism. Six models (1934/1 through 1934/6) are available, offering a choice of step sizes (0.004, 0.005, or 0.01 inch), plotting speeds (200 or 300 steps/second), and plotting widths (11 inches on 12-inch paper or 29.5 inches on 31-inch paper).

UNIVERSAL DOCUMENT READER: Optically reads marks and/or characters from paper documents. Consists of a single feed hopper, a mark reading head and/or a character reading head, and 3, 6, 9, or 12 stackers (plus a reject tray and a "no destination" stacker). Handles documents in two size ranges: "small" documents from 4.75 to 8 inches in length by 3 to 6 inches in width, and "large" documents from 8 to 13 inches in length by 4 to 8.5 inches in width. Small and large documents are read at the rate of 300 and 150 documents/minute, respectively. The optical mark reading head can identify marks made by a pencil, imprinter, typewriter, or line printer; a matrix of up to 60 rows of 23 marking positions, plus a mandatory clock track, can be handled on a large document. The optical character reading head reads one line of characters printed in the ECMA "B" Size 1 type font at either 8 or 10 characters/inch; reading speed is 550 characters/second. When both heads are installed, marks and characters can be read simultaneously from the same documents.

COMMUNICATIONS EQUIPMENT

7900 SERIES COMMUNICATIONS SYSTEMS: A range of modules which can be combined to form multi-line communications control systems of either the character-buffering or message-buffering type. These modules include: (1) line termination units, which convert signals from the communications lines into the appropriate form; (2) line scanners, which assemble the bits received over the lines into characters; and (3) communications processors (used only in message-buffering systems), which utilize stored programs supplied by ICL to control the communications functions, store complete messages, deal with errors, and accumulate line performance statistics for maintenance purposes. The 7900 Series systems can be used with Models 1901T through 1904S.

In character-buffering systems, individual characters are transferred between the line scanner and the central processor, which is responsible for all line control and message buffering functions; because of the heavy load imposed upon the central processor, this type of system is suitable for only a limited number of lines. In message-buffering systems, complete messages (or blocks of messages) are transferred between the central processor and the communications processor. All control procedures are carried out by the dedicated control programs in the communications processor, thereby greatly reducing the communications load upon the central processor.

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This ICL 1901T configuration includes the processor, foreground, with teletypewriter console and, left to right, a card reader, two disc drives, and a line printer.

ICL's principal communications processor is the 7903, which includes 16K, 24K or 32K 16-bit words of 1.1-microsecond core storage and an integrated paper tape reader. The 7903 accommodates up to four 7903/9 Scanner Selectors, and up to three line scanners can be connected to each Scanner Selector. The 7903 can therefore support up to 128 lines. The 7903 includes an interprocessor module that permits it to be connected to a 1900 Series central processor via a standard interface.

ICL also offers the 7905, which can serve as either a local front-end processor or as a remote concentrator. A basic configuration includes 16K words of 750-nanosecond core memory, a real-time clock, an executive console, and a communications controller. Memory can be expanded to 48K and a variety of peripherals added. Maximum throughput is 150,000 characters/second. The 7905 accommodates up to 16 7905 line scanners with a maximum of 255 channels ranging in speed from 50 to 48,000 bps. A 7905 can be connected to a 1900 via a 7987/1 Local Processor Link.

The 7900 Series includes four basic types of line scanners:

- A "universal" scanner with CCITT interfaces for up to 16 communications lines, for both synchronous and asynchronous devices operating at 50, 75, 100, 150, 200, 300, 600, 1200, 2400, 3600, or 4800 bits/second.
- A "universal" scanner with CCITT interface for up to 16 communications lines, for both synchronous and asynchronous devices operating at 110 bits/second, and at up to 4800 bits/second when used with self-clocking modems.
- A telegraph-only scanner for up to 63 teletypewriter terminals communicating asynchronously at 50, 75, 100, 150, or 500 bits/second.
- A telegraph-only scanner for up to 63 teletypewriter terminals communicating asynchronously at 100 bits/second; designed for large in-house teletypewriter systems and for the UK Post Office Datel 100 Service.

TERMIPRINTER: A modified GE TermiNet 300 teletypewriter, capable of transmitting and printing data at switch-selectable speedsof 10, 20, or 30 characters/second. Prints by means of a molded polyurethane belt containing two complete sets of print characters on the tips of flexible fingers; the belt rotates continuously between a bank of print hammers and an inked ribbon. The basic KSR models includes a standard typewriter keyboard and offers a choice of either 75 or 118 print positions and either friction or sprocket feed. For ASR operation, a paper tape reader and punch (or reader only) can be added. Receive-only (RO) models are also available, with 118 print positions and either friction or sprocket feed. ISO coding is used, and there are 96 printable characters, including both upper and lower case alphabetics.

7181 VISUAL DISPLAY UNIT: Provides local or remote displays of alphanumeric data. Consists of a CRT display, buffer store, character generator, and typewriter-style keyboard. An optional keyboard extension, consisting of a block of numeric keys, can be used to enter either numeric data or special function codes. The CRT screen displays up to 2000 characters in 25 lines of 80 characters each, in a viewing area 10.4 inches wide by 6.9 inches high. The character set consists of 92 symbols, including both upper and lower case alphabetics. Editing operations include character insert and delete, line insert and delete, erase, tabulate, and computer-controlled message formatting. For hard copies of displayed data, a teletypewriter (receive-only or automatic send/receive) or Termiprinter (receive-only) can be connected to the display unit.

For local use, the 7181/4 Visual Display Unit is connected to a 1900 Series computer via a 7180/1 Control Unit. The 7180/1 has 16 channels, and each channel can be connected either directly to a display unit, or indirectly via a 7180/7 Expansion Unit. Each 7180/7 can accommodate 15 display units, enabling a single 7180/1 to control up to 240 display units. Each display is linked to the control unit be a cable up to 5000 feet in length (or 10,000 feet when an Expansion Unit is interposed). Data is transferred at up to 1 million bits/second.

For remote use, the 7181/2 Visual Display Unit is connected to a 1900 Series computer via a suitable communications link. Data can be transmitted to or from the 7181/2 at up to 4800 bits/second. Up to 24 display units can share a single modem and leased line through the use of a Line-Sharing Adapter. Each adapter has 8 channels, and one or two 8-channel expansion modules can be added to accommodate 16 or 24 terminals.

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7502 MODULAR TERMINAL PROCESSOR: Supports up to 8 CRT terminals and 4 hard copy printers, or any combination of dual floppy disc (diskette), card reader (300 cpm) and line printer (300 lpm) with a reduced number of CRT terminals and hard copy printers. The 7502 has from 12K to 40K bytes of memory and a CRT console and communicates at a rate of 600, 1200, 2400, or 4800 bps. ICL offers a range of terminal executives which are "tele-loaded" from the 1900 processor and support remote data input and bulk printing, remote job entry, interactive file inquiry and update, and mixed-mode working. The dual floppy disc provides a stand-alone capability for data input, validation, and local file printout. A Terminal Processing Language (TPL) provides limited user programming facilities. Up to 3 7502 processors can be cascaded from a single point on one line.

7503 MODULAR TERMINAL PROCESSOR: Supports up to 16 CRT terminals and 8 hard copy printers or any combination of card reader (300 cpm), paper tape reader (500/750 char/sec), and line printer (150/300/500 lpm) with a reduced number of CRT terminals and hard copy printers. The processor includes either a CRT or typewriter console, either single or twin magnetic cassette drive, and from 16K to 64K bytes of memory. In addition to communication rates of up to 4800 bps, the 7503 can communicate at 9600 bps when connected to a 7905 Communications Control System. A range of terminal executives to support interactive, remote job entry, and mixed-mode operations are available and are loaded from cassette.

SOFTWARE

ICL distinguishes between Executives, which must be used in every 1900 Series installation, and operating systems, whose use is optional in all models.

EXECUTIVE: This basic software system complements the 1900 Series hardware by performing the following principal functions:

1. Interpretation and execution of the operator's commands to the system, which are entered via the console typewriter or prepunched cards or paper tape.
2. Provision to the operator of information about the system's status and any irregular conditions.
3. Control of all data transfers to and from peripheral devices, including error checking and recovery.
4. Implementation of "Extracodes" (i.e., standard subroutines that are executed whenever certain machine instructions are encountered in a program). Extracodes are used for input/output and control operations, as well as for certain arithmetic instructions in the smaller 1900 Series processors.
5. Loading, initiation, and termination of programs.
6. Allocation of peripheral devices to specific programs.
7. Control of multiprogramming (i.e., allocation of the central processor's time among two or more operational programs and prevention of interference between the programs).

One or more versions of the Executive are available for each of the 1900 Series central processors. The smaller versions lack facilities for multiprogramming. Main memory requirements for the Executive naturally vary with the complexity of the system and its configuration.

AUTOMATIC OPERATOR: This basic operating system complements the Executive on the Model 1901T. It enables a series of programs to be successively loaded and executed with a minimum of operator intervention; there are no facilities for multiprogramming or for the use of program libraries on magnetic tape or disc. The minimum configuration for use of the Automatic Operator is an 8K central processor, one card or paper tape reader, and one output device. Certain control statements used by the Automatic Operator are not compatible with those used by the GEORGE operating systems.

GEORGE 1: This single-stream operating system can be used by installations with at least 16K words of main memory, either magnetic tape or disc storage, a card or paper tape reader, and a line printer. GEORGE 1 is an overlaid system that can reside on either magnetic tape or disc. Using job description commands on punched cards or paper tape, GEORGE 1 can successively load and execute a series of programs contained in a magnetic tape or disc library. It can also produce memory dumps, edit source programs and data files on magnetic tape, and perform other useful utility functions. Complete or partial job descriptions that are used repeatedly can be defined, named, and filed as "macros" to save operating time. GEORGE 1 has no multiprogramming facilities, but multiprogramming processors with sufficient main memory and peripheral equipment can use two or more copies of GEORGE 1 to run multiple job streams in parallel.

GEORGE 1S: This subset of the GEORGE 1 operating system can be used by installations with as little as 8K words of main memory, one disc drive (EDS or TEDS), a card or paper tape reader, and a line printer. GEORGE 1S is issued as an integral part of the overlaid single-programming Executive for Model 1901T and requires no additional main memory while a job is being run. It performs essentially the same functions as GEORGE 1, above. Job descriptions written for GEORGE 1S can be submitted without change to the GEORGE 1 and 2 operating systems.

GEORGE 2: This extension of the GEORGE 1 operating system adds capabilities for "spooling" of input and output data in Models 1902T and above. An input stream of job descriptions, programs, and/or data can be transcribed from punched cards or paper tape to magnetic tape or disc, and output data can be transcribed from magnetic tape or disc to a printer. Although user programs are still executed in single-stream fashion, the disc-to-disc or tape-to-tape mode of operation made possible by the input/output spooling generally yields improved throughput. GEORGE 2 requires at least 24K words of main memory and occupies three program slots in the central processor.

GEORGE 3: This comparatively powerful multi-stream operating system can be used on Model 1903T and 1904S processors with at least 64K words of memory. Also required are 500,000 words of direct-access (disc or drum) backing storage, 4 magnetic tape drives, card or paper tape reader, line printer, console typewriter, program timer, and real-time clock. GEORGE 3 complements the multiprogramming Executive by providing the following principal facilities:

1. Job schedulers which enable the system to process a number of jobs simultaneously in both on-line and background modes. The high-level scheduler analyzes the overall job mix and determines the proportion of computer time to be allocated to each job. The low-level scheduler then allocates a time slot to each job and controls the switching from job to job.
2. A comprehensive job description language, which can be submitted to the processor via punched cards, paper tape, or a console typewriter. Complete or partial job descriptions can be defined as "macros" and filed on disc.
3. Spooling of input and output data on disc files or magnetic tape (called "off-lining" in ICL parlance).

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4. A File Store data management system, which organizes the user's data files into a tree-structured hierarchy. Users need to concern themselves only with the contents of their files; GEORGE 3 will store them on discs or magnetic tapes, maintain multi-level directories, retrieve specified records for processing, safeguard the files against unauthorized access, and periodically dump them onto magnetic tape so they can be reconstituted at any time.

5. Multiple on-line programming (MOP) facilities, which permit multiple remote teletypewriters to be used as on-line interactive terminals. Each teletypewriter user has all the relevant facilities of the system at his disposal; he can use the standard command language, access the central File Store, and enter, edit, compile, and execute programs. The resulting output can be transmitted back to the teletypewriter and/or printed by the central computer.

6. Remote job entry and control facilities, which permit jobs to be entered from remote locations via ICL 7503 Communications Terminals or 2903 computers. These jobs are run in the same way as other background work, and their output can either be returned to the originating terminal or written on central-site peripheral devices.

7. Accounting and budgeting facilities, which aid in analyzing and controlling the system's utilization. Monitoring information, including details of each job's progress, is accumulated in a central file. ICL provides a basic log analysis program, and the user can add others to suit his particular needs. Budgets can be allocated to individual users to control their use of the system's resources, and can be checked each time a job is initiated.

GEORGE 4: This extension of GEORGE 3 is the standard operating system for Model 1903T and 1904S processors operating in the paging mode. It offers essentially the same user facilities as GEORGE 3, but all are adapted to operate in a paging environment. The principal changes are in the scheduling and space-allocation routines, and an added "page-turning" routine controls the swapping of pages between main memory and the required 2851 Drum Storage System. GEORGE 4 automatically divides all object programs into 1024-word blocks and "maps" them into pages of main memory and the backing drum. Programs and job descriptions written for execution under GEORGE 3 can be run without change under GEORGE 4.

1900 DRIVER: This is a set of standard routines designed to handle the functions which are common to on-line data communications systems and to control the progress of each message though the system. The 1900 Driver accepts incoming messages, initiates processing by the appropriate user-written application routines (or "beads"), monitors transfers to and from disc or tape files, and passes outgoing messages to the communications network. A set of program testing aids permits individual beads or groups of beads to be tested independently of the communications equipment. The 1900 Driver can be used on 1900 Series processors that have at least 16K words of main memory and use an overlaid multiprogramming Executive.

COMMUNICATIONS MANAGER: This software is designed to operate with an overlaid multi-programming executive to control the messages between communications devices and user-written application programs in medium-sized systems (48K to 96K words) so as to permit the simultaneous use of such systems for transaction processing, remote job and data entry, and multi-access computing with a system such as MINIMOP.

MINIMOP: The "multiple on-line programming" systems controls the simultaneous operation of up to nine remote teletypewriters used as on-line interactive terminals. Background batch jobs can be run concurrently with the interactive programs under the control of GEORGE 2, the Communications Manager, or the Executive.

COBOL: ICL offers a range of compilers for the standard COBOL language, including a Compact COBOL system that implements a restricted subset of the language and runs on the smaller 1900 Series processors. Main memory requirements for compilation are 5888 words for Compact COBOL and at least 10,240 words for COBOL. Also required are a card or paper tape reader, line printer, and either 4 magnetic tape drives or 1 disc unit. Features of the larger COBOL compilers include mass storage statements, sorting, COBOL Library facilities, batch compilation, and the ability to compile COBOL programs as separate segments which can later be consolidated into larger object programs or incorporated into programs written in other languages. Typical compilation speeds range from about 50 lines/minute for an 8K magnetic tape system with both source and object programs on slow I/O devices to about 1000 lines/minute for a 32K system with all files on disc. ICL also offers Decision Table Preprocessors that enable users to express complex problems in a straightforward tabular form, which is automatically translated into a COBOL source program and then compiled.

FORTRAN: ICL offers a wide range of compilers for three distinct levels of the FORTRAN language. ANS Basic FORTRAN compilers are available for systems with as little as 4K words of main memory and either card, paper tape, magnetic tape, or disc I/O. Full ANS FORTRAN compilers are available for 16K systems with the same four I/O media. The more powerful 1900 Extended FORTRAN language requires at least a 32K disc system for compilation; larger systems can use special compilers designed to minimize either the object-program execution time (Optimizing FORTRAN) or the compilation and testing time (FLAIR). FORCON is a conversational version of FORTRAN designed for on-line use via remote teletypewriters; it runs under the control of GEORGE 3 or 4.

BASIC: ICL's implementation of the BASIC language is a conversational system designed for use in an on-line programming environment under the GEORGE 3 operating system. The BASIC system features an interactive source-language analyzer and editor, program-file maintenance facilities, an "instant calculation" facility, and extensive diagnostic aids. The language is compatible with most other implementations of BASIC.

ALGOL: ICL offers numerous compilers for two distinct levels of the ALGOL language. Basic ALGOL compilers are available for systems with as little as 4K words of main memory and either card, paper tape, magnetic tape, or disc I/O. The more powerful ALGOL 60 language requires at least a 16K system with disc, magnetic tape, or paper tape I/O. BABS (Basic ALGOL Batch System) is a fast, in-core compiler designed to process batches of small programs in educational or research environments.

RPG2: ICL offers a compiler for RPG2 but provided no information about it.

PLAN: This is the basic symbolic assembly language for all models of the 1900 Series. It enables the programmer to exert firm control over all the hardware facilities, yet it is comparatively easy to use because of the underlying architectural simplicity of the 1900 Series architecture. Several versions of the PLAN assembler are available, for 4K card or paper tape systems, 8K magnetic tape or disc systems, and 32K magnetic tape or disc systems. The larger versions include comprehensive macro-instruction facilities.

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UTILITY ROUTINES: ICL offers an appropriate complement of sort/merge, data transcription, diagnostic, and other utility routines for the 1900 Series. PATSY (Program Automatic Testing System) is designed to simplify batch compilation and testing of programs written in PLAN, or COBOL.

IDMS: ICL offers a version of Cullinane's Integrated Database Management System (IDMS) for the 1900 Series systems. For a complete description of this package, see Report 70E-272-02.

APPLICATION PROGRAMS: ICL currently offers more than 60 application packages spanning a wide range of business, engineering, and scientific functions. Of particular significance is NIMMS (1900 Integrated Modular Management System), a comprehensive data management system oriented toward industrial requirements planning, shop scheduling, stock control, and factory cost control. NIMMS can be used on a 32K disc system. As an off-shoot of NIMMS, ICL offers a generalized Data Base Management System (DBMS). Other noteworthy programs for the 1900 Series, together with their minimum main memory requirements, include:

Data Management Software — 16K
FIND-2 (information retrieval and reporting) — 8K
SCAN (inventory analysis and control) — 8K
PERT — 8K
PEWTER (simplified PERT) — 8K
PROMPT (production control system) — 16K
PROP (financial planning system) — 8K
PROSPER (financial model-building) — 16K
COMPAY 1D (payroll) — 8K
SHREAD (share registration) — 16K
Linear Programming — 8K
Vehicle Scheduling — 16K
CSL, Mark 2 (simulation language) — 16K
SIMON (simulation language) — 16K
Scientific Subroutines — 8K
Statistical Analysis — 8K
Survey Analysis — 8K
Cut and Fill — 16K
Traverse Computation — 8K
Continuous Beam Analysis — 16K
Pipe Stressing — 16K
AC Load Flow — 16K
AC Network Reduction — 16K
Transient Stability — 16K
DC Network Analysis — 16K
Furness Traffic Prediction —8K
Fluid Distribution Network Analysis — 16K
X2F Numerical Control System — 8K
MILMAP (numerical control) — 16K
Profiledata (numerical control) — 16K
Analysis of Plane Frames and Grids — 16K
Analysis of Space Frames — 16K
NELAPT (numerical control) — 40K
PLUTO (chain files) — 16K
MARC. (library cataloging) — 16K
SLAM (Simulation Language for Analogue Modeling)—32K
BOMP
On-Line Order Entry — 16K

PRICING

ICL declined to provide any official price data on the 1900 Series equipment. Note, however, that approximate mainframe prices are listed in the table on page 70C-533-01c. ICL is currently marketing the 1900 Series on a "bundled" basis. There is no additional charge for most ICL software except to commercial service bureaus. ■