2900 VME/B Technical overview

ICL

ICL 2900 Series

2980
2970
2960
with
VME/B

Communications Excellence

Your Future System will be required to serve large numbers of people operating at many different locations.

The 2900 Series provides

an efficient, totally protected communications environment through virtual machine processing

simple implementation of transaction processing systems through High Level Languages and the shareability of all code

fast interrupt handling due to the use of a hardware-driven stack

software and hardware designed with an inherent ability to handle communications systems naturally

a wide range of communications equipment

Evolutionary Data Management

Your Future System must provide flexible methods of handling large amounts of business information.

The 2900 Series

ensures effective data handling by incorporating the basic data management functions within the fundamental system architecture

enables the user to implement complex information systems easily through the independence of programs and files

allows the user to grow from simple to complex information systems without the need for reprogramming

Ease of Implementation

Your Future System must combat the problem of rising people-costs.

The 2900 Series

is a High Level Language machine allowing the user to implement and test all his applications in these languages

provides a natural System Control Language making the system easy to use

enables simple systems to be developed with minimal effort by using an integrated Data Management Utilities System

offers modular application software to meet a wide range of user requirements

Workload Versatility

Your Future System will need to offer a wide range of services to satisfy your organisation's total information processing requirements.

The 2900 Series provides

operating software which supports multiple transaction processing, multi-access and batch services, simultaneously

virtual machine processing, ensuring a secure environment for all users and enabling the various services to be handled efficiently

both hardware and software which can be tailored so as to match an organisation's particular needs

Hardware and Software Resilience

Your Future System will be at the heart of your organisation. It must therefore provide a reliable service.

The 2900 Series provides

hardware which has been built using advanced, proven technology

error detection and containment, inherent in the system architecture

structured hardware which can be reconfigured so as to isolate faulty units

a unique engineering approach to software ensuring improved levels of reliability

layered software implementation enabling errors to be contained and system software protected

More Usable Power

Your Future System will need to be powerful, but it must not dissipate this power in managing its own activities.

The 2900 Series provides

hardware and software designed together as part of a single range architecture to support user needs

greater system throughput by dispersing intelligence throughout the hardware structure

operating software that has been built to maximise total work throughput

a reduction in system software administration by means of hardware-assisted procedure calling

Application Continuity

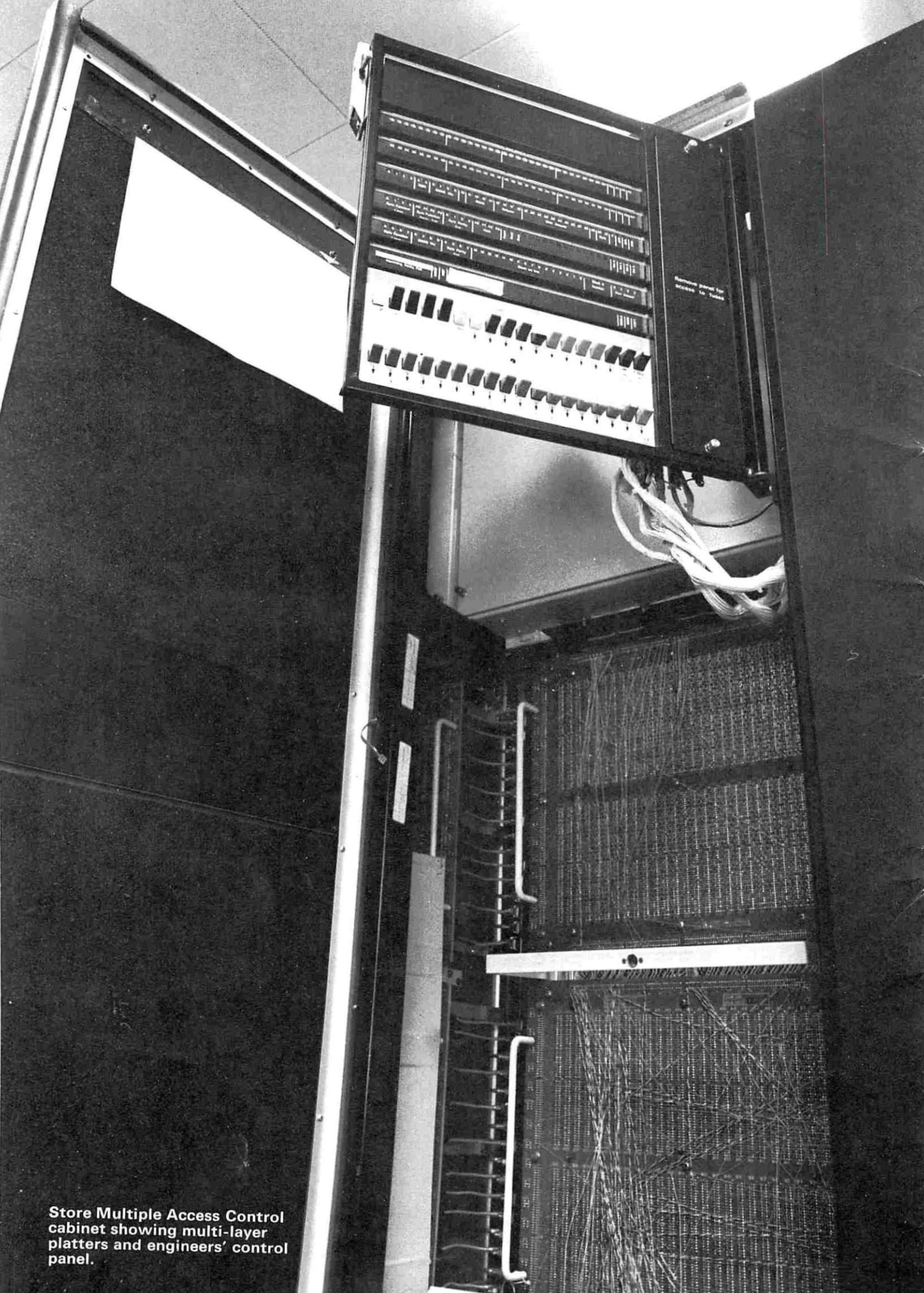
Your Future System must protect the users' investment in current applications while ensuring the continuity needed for those new applications which will be implemented during the coming decade.

The 2900 Series

protects your investment in peripherals and terminals through their range-independence

provides application continuity through a comprehensive set of transition aids

protects your future investment in applications through a totally open-ended design. Changes both to technology and hardware devices can be made without invalidating the user's investment



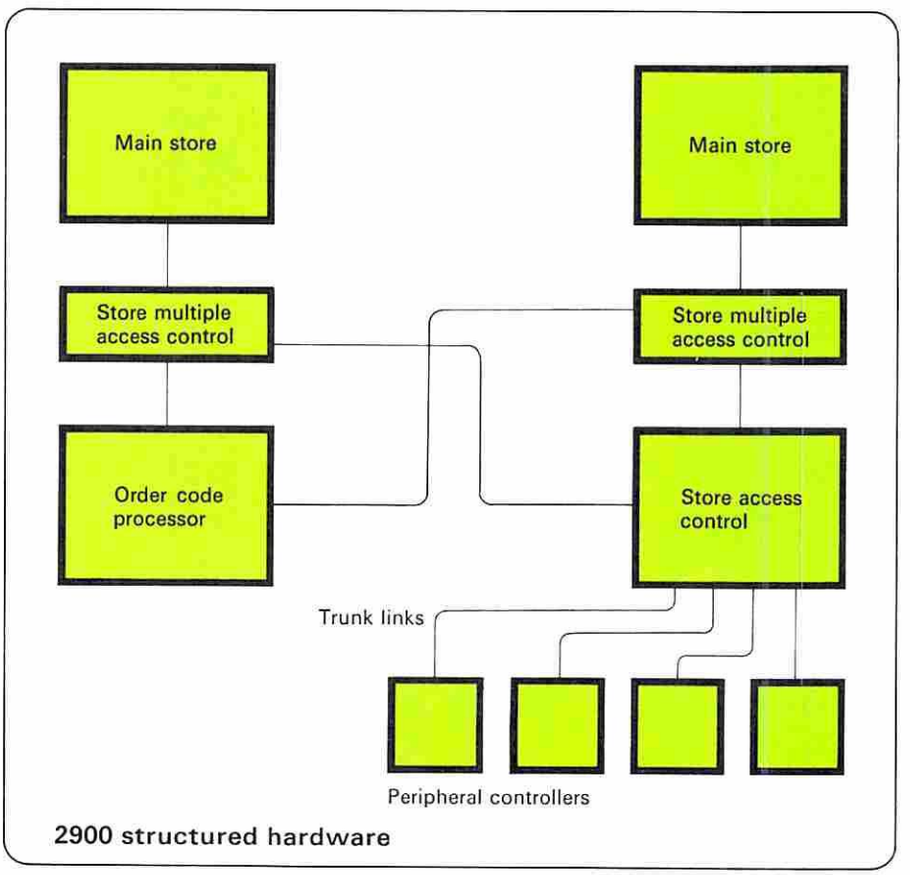
Store Multiple Access Control cabinet showing multi-layer platters and engineers' control panel.

Section 11

Powerful, structured hardware

The 2900 Series hardware offers the user a powerful method of satisfying his future computer needs. In particular it provides:

- **Advanced, proven technology**
- **High-speed processing through the use of slaving and pipelining techniques**
- **Very high data throughput using dispersed intelligence**
- **Natural multi-processor systems**
- **Total resilience capability**
- **Specialist intelligent peripheral controllers**
- **New and expanded set of peripherals**



2900 structured hardware

A structured approach to hardware

The 2900 Series has taken to its logical conclusion the structured approach to hardware design towards which previous ICL systems have progressed.

The system is entirely modular with each module performing a particular specialist function autonomously and therefore in parallel with other modules.

The 2960, 2970 and 2980 processor systems consist of a number of modules including:

Order code processors

These execute program instructions at high speed and are concerned with arithmetic, logical functions and data manipulation.

Store access controls

These are autonomous units satisfying all the main store access requirements of the peripheral controllers. The order code processor is thus freed from this activity.

Main store units

2900 Series main store uses semi-conductor technology providing high-speed access and improved reliability. Main store highways are several bytes wide providing exceptionally fast data throughput.

All main store units are independent and can be accessed simultaneously via Store Multiple Access Controls (SMACs).

This structured approach to hardware design provides the 2900 Series with:

high efficiency, since each module is now performing a specialised function;

very powerful systems, through the natural ability to provide multi-processor systems;

systems that can be tailored more to the specific needs of the user, either in the area of processing power or data throughput;

extensive growth potential in economic stages through the addition of extra modules;

the ability to incorporate new techniques and technologies with complete forward compatibility so as to provide the user with new and improved levels of performance and reliability.

Advanced, proven technology

The 2900 Series uses a development of the proven advanced circuit and matched interconnection technology currently in use on the larger ICL 1900 and System 4 ranges of computers.

The circuit technology used is ICL 1000 and Schottky TTL. This provides the advantages of:

higher circuit speeds

less power consumption

lower heat dissipation.

Thus the 2900 Series can provide the user with more processing power than current range systems within the same physical environment.

The matched interconnection platter technology, in which ICL leads the world, has been further developed on the 2900 Series.

Both the 2970 and 2980 use up to 20-layer platters, and the 2960 uses up to 17, each supporting

macro circuit boards. This technique ensures that the circuits operate at their optimum performance and allows more power to be packed into a smaller space.

The 2900 Series has been designed and built using the advanced computer aided design techniques. developed by ICL. Some of the most significant aspects of the technology have arisen from using this approach.

This highly automated design system ensures that the design is accurately progressed through the implementation phase and, by automatically generating circuit testing procedures, ensures that the final product performs to its specification.

Advanced processing techniques

The 2960, 2970 and 2980 order code processors derive their considerable power from the use of two advanced processing techniques:

Pipelining

Slave Stores.

Pipelining

Pipelining is a development of the technique of instruction overlap, currently in use on the largest 1900 processors, and allows the execution of several instructions simultaneously.

Each computer instruction is broken down into a number of logically separate operations, and the hardware logic of the order code processor is divided into corresponding sections. In this way it is possible, by the use of hardware interlocks, to process several instructions simultaneously, each instruction being at a different stage of execution.

Slave stores

The use of slave stores on the 2900 Series ensures that the pipeline is provided with high-speed access to the instructions and operands that it requires.

These new specialised slave stores, when compared with the traditional general purpose cache memories, considerably improve the access time to operands. This is possible because of the ability to predict the location of the next operands required, due to the concentration of activity provided by the 2900 Series' use of stack processing.

New levels of hardware availability

The 2900 Series has been built to set new standards in reliability through its use of proven, advanced technology. In addition, the hardware incorporates a wide range of features to deal with errors that may occur, either through human mistakes or hardware malfunction. These include:

Internal hardware self-correction

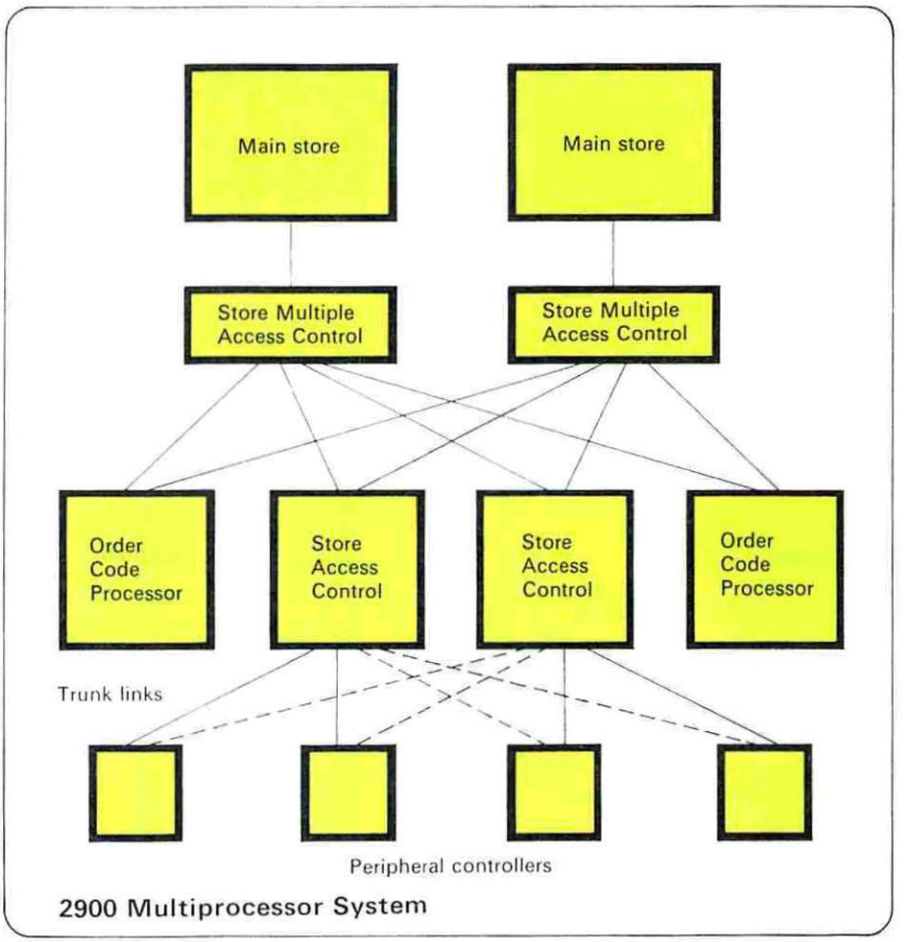
Reconfiguration.

Hardware self-correction

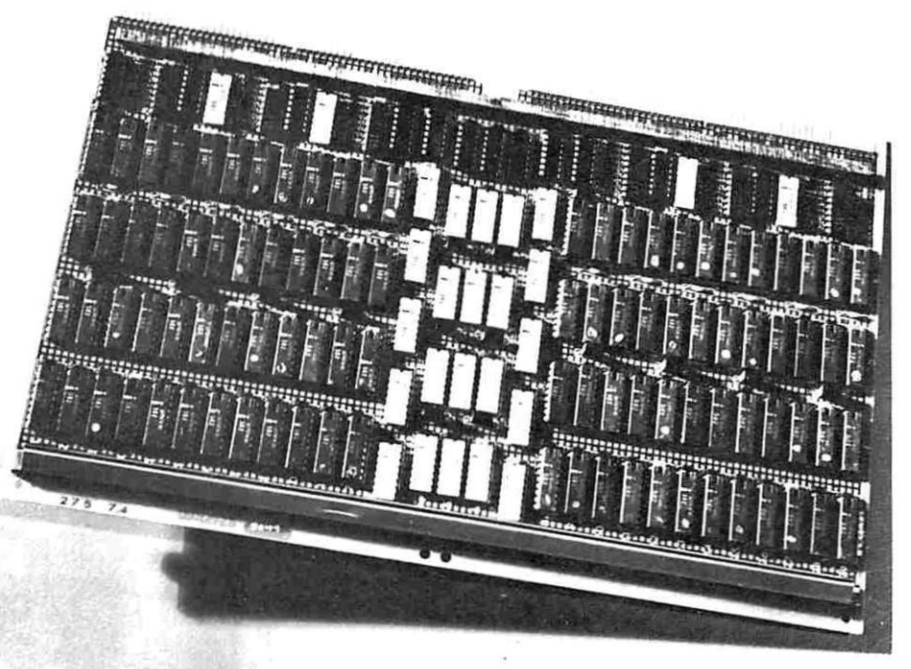
The 2900 Series hardware incorporates extensive features for error detection and correction to minimise the effects of any failure.

In the main store modules, the SMAC performs Hamming-type checks in order to correct single-bit errors and to detect the majority of multiple-bit errors.

The Store Access Control (SAC) carries out comprehensive parity checks not only on all data received from trunk links or the main store but also on all addresses and control information.



2900 Multiprocessor System



The Order Code Processor itself incorporates a high level of internal checking in order to reduce the incidence and effect of errors. A highly advanced prediction method checks out almost all operations within the processor. When an error does occur most instructions are automatically retried.

The 2900 Series also provides information on the current and historical status of all parts of the system, allowing the effective use of preventative maintenance-time by the engineers.

Reconfiguration

The modular structure of the 2900 Series is vital for providing the total resilience capability through reconfiguration.

All system modules can be replicated and thus isolated for maintenance and repair, allowing the rest of the system to continue.

The 2980 system

The 2980 is a high performance system which is suitable for both scientific and commercial applications. It is capable of providing high resilience and excellent data handling for on-line transaction processing and mixed workload systems.

Configuration

The minimum 2980 system comprises:

One order code processor

One store access control

Two store multiple access controls

One million bytes of high-speed semiconductor store.

This basic configuration can be enhanced by providing:

An extra order code processor

An extra store access control

Two additional store multiple access controls

An additional seven million bytes of main store

An attached processor capable of executing 1900 or System 4 programs.

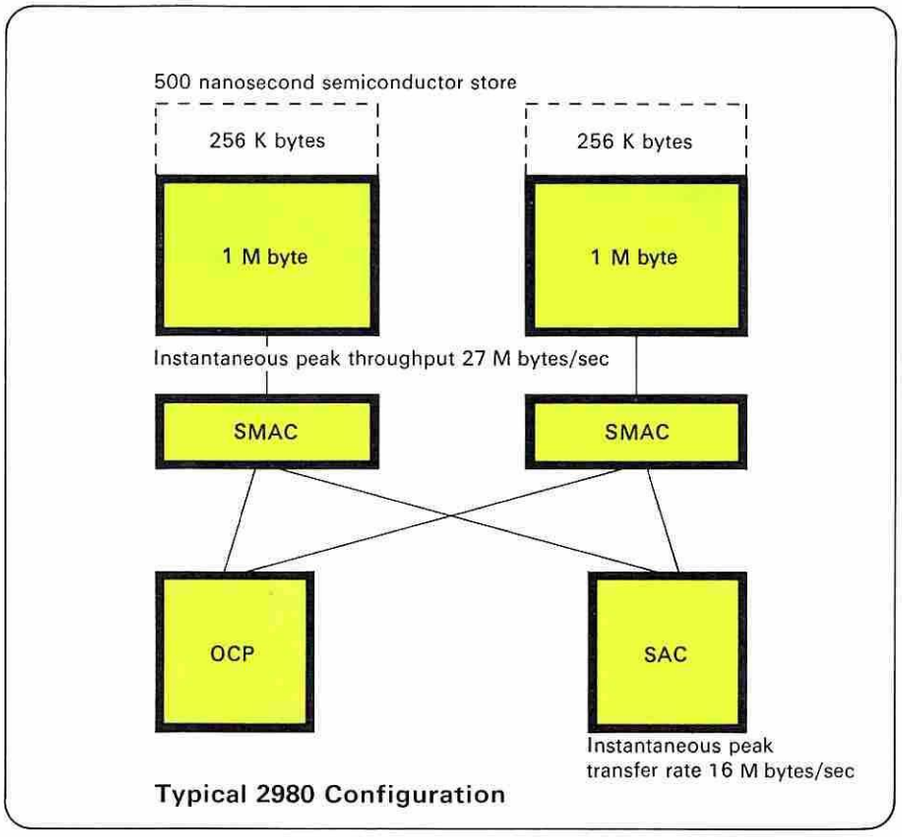
Performance

The 2980 is a very high performance system:

POWU II	0·3 milliseconds

Instantaneous peak throughput rates

SMAC	27 Mbytes/second
SAC	16 Mbytes/second
Trunk Link	4 Mbytes/second



Typical 2980 Configuration

Pipeline

The 2980 employs a multi-stage pipeline which includes not only an arithmetic unit but also independent multiplication and string handling units, reflecting the importance that the 2980 attaches to data handling.

Slave stores

Instructions and operands on the 2980 are accessed by the pipeline from three high-speed slave stores. Each of these stores exists to service a particular stage of the pipeline, one containing instructions, one containing primary operands and one secondary operands.

Instructions and operands are transferred from main store to the respective slave stores in blocks thus providing a very high probability that the information required will already be in the slave stores.

Associated with each slave store is a set of address registers. When an instruction or an operand is required, all registers are read in parallel to discover whether the required item is in main or slave store.

It is the combination of a high hit rate on the slave stores and the associative accessing of such stores which provides the 2980 with its exceptional processing capabilities.

Resilience

The 2980 offers a high level of resilience due to the built-in error recovery procedures described previously, and the total reconfiguration capability of the system.

The 2970 system

The 2970 is a medium-to-large-scale system which is suitable for both scientific and commercial applications. It is capable of providing high resilience and excellent data handling for on-line transaction processing and mixed workload systems.

Configuration

The minimum 2970 system comprises:

One order code processor

One store access control

One store multiple access control

One million bytes of high-speed semiconductor store:

This basic configuration can be enhanced by providing:

An extra order code processor

An extra store access control

Two additional store multiple access controls

An additional five million bytes of main store

An attached processor capable of executing 1900 or System 4 programs.

Performance
The 2970 is designed to provide the following high performance levels

POWU II 1·0 milliseconds

Instantaneous peak throughput rates

SMAC 16 Mbytes/second

SAC 16 Mbytes/second

Trunk Link 4 Mbytes/second.

The Order Code Processor
The 2970 employs a multi-stage pipeline allowing up to three instructions to be executed simultaneously as well as a slave store to reduce access time to operands on the stack.

In addition to executing 2900 instructions a non 2900 order code can be implemented, within the OCP, by means of a micro-program emulation feature. This is an alternative to using the attached processor.

Resilience
The 2970 offers a high level of resilience due to the built-in error recovery procedures described previously and the total recon-figuration capability of the system.

The 2960 System
The 2960 is a medium scale system which is suitable for both scientific and commercial applications. It is capable of providing high resilience and excellent data handling for online transaction processing and mixed workload systems.

Configuration
The minimum 2960 system comprises:

One order code processor

One store access control

One store multiple access control

One million bytes of high speed semiconductor store

The basic configuration can be enhanced by providing

an extra order code processor

an extra store access control

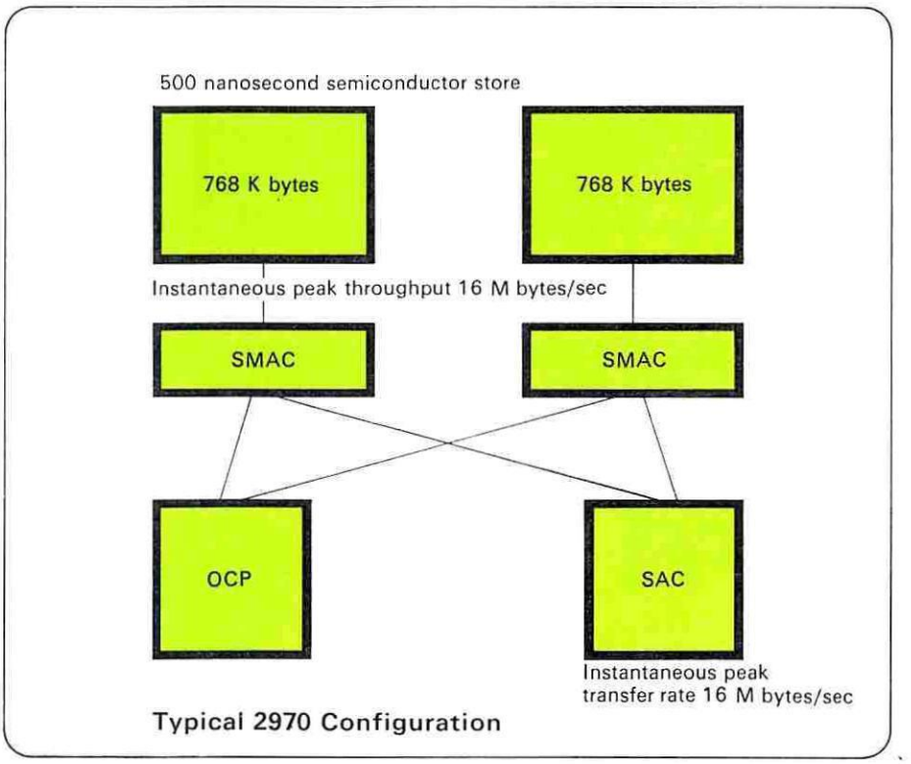
an additional store multiple access control

an additional two million bytes of main store

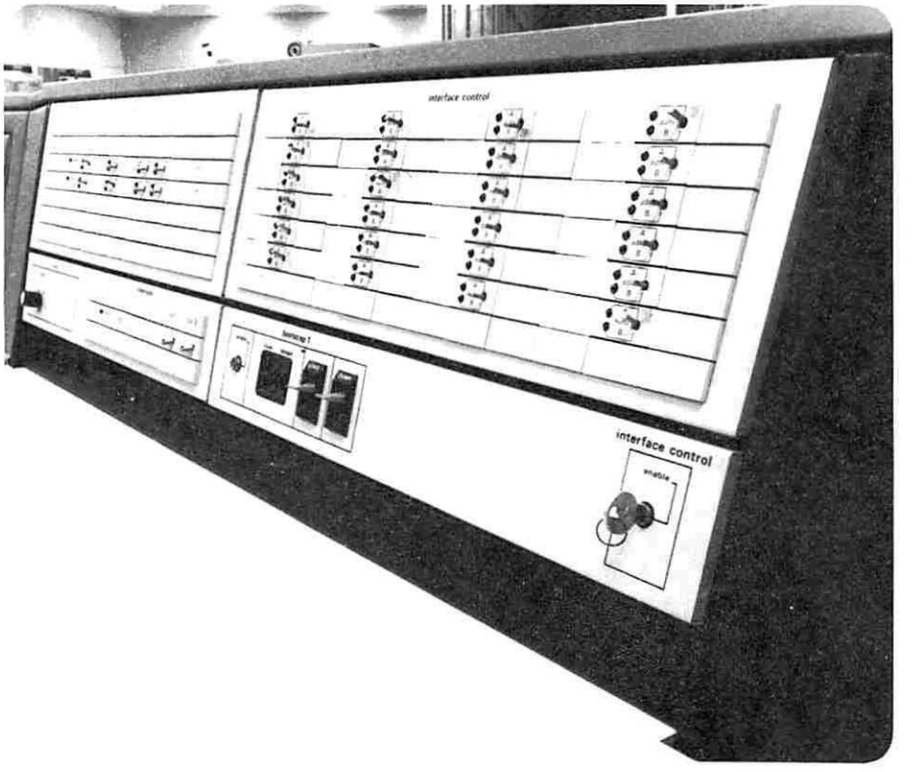
up to two microprogram emulation features to implement alien order codes

Performance
The 2960 is designed to provide the following high performance levels

POWU II 2·0 milliseconds



Typical 2970 Configuration



Instantaneous peak throughput rates

SMAC 9 Mbytes/second

SAC 9 Mbytes/second

Trunk Link $2\frac{1}{2}$ Mbytes/second

The Order Code Processor
The 2960 employs a two stage pipelining allowing simultaneous execution of more than one instruction. A slave store is used to reduce access time to fetch instructions and data. Instruction decoding is controlled by either the 2900 order code decoder or one of two alien order code decoders allowed as part of the microprogrammed emulation features.

Resilience
The 2960 offers a high level of resilience due to built-in error recovery procedures described previously and the total recon-figuration capability of the system.

Peripheral controllers
The 2900 Series' structured approach is based on the concept of logically dispersed intelligence throughout the system.

Peripheral controllers are special-purpose autonomous units, each specialising in a particular class of peripheral. All types of controller are attached to the central system via the standard trunk link.

This approach provides:

tailored systems, since the standard trunk link allows peripheral controllers to be configured in almost any combination required;

high system throughput, since the peripheral controllers can carry out peripheral activity using command chains held in main store without reference to the order code processor;

total resilience capability, because the controllers can be replicated. In a multi-processor configuration they can be switched between two SACs so as to provide a total reconfiguration capability.

All peripheral controllers are built in a modular fashion, each consisting of one common logic element and one or more peripheral interface modules. This approach provides:

the ability to connect some 1900 and System 4 devices to the 2900;

a total reconfiguration capability through switching peripherals between controllers;

the potential to interface new devices in the future, using the same peripheral controller. The users' investment in hardware is accordingly protected.

The 2900 Series includes four types of peripheral controller, each designed to handle a particular class of device and device function.

General Peripheral Controller (GPC)
Disc File Controller (DFC)
Sectored File Controller (SFC)
Communications Link Controller (CLC).

General peripheral controller

The GPC controls all serial devices including:

card equipment, paper tape equipment, line printers and graph plotters

magnetic tape clusters

the operating stations.

Disc file controller

The DFC is an advanced micro-programmed controller capable of handling up to 16 of the large and fast exchangeable disc stores available with the 2900 Series.

The DFC provides a number of advanced facilities including:

off-line seeking;
rotational position sensing;
queueing of concurrent accesses;
automatic command retry;
error logging;
maintenance and diagnostic facilities.

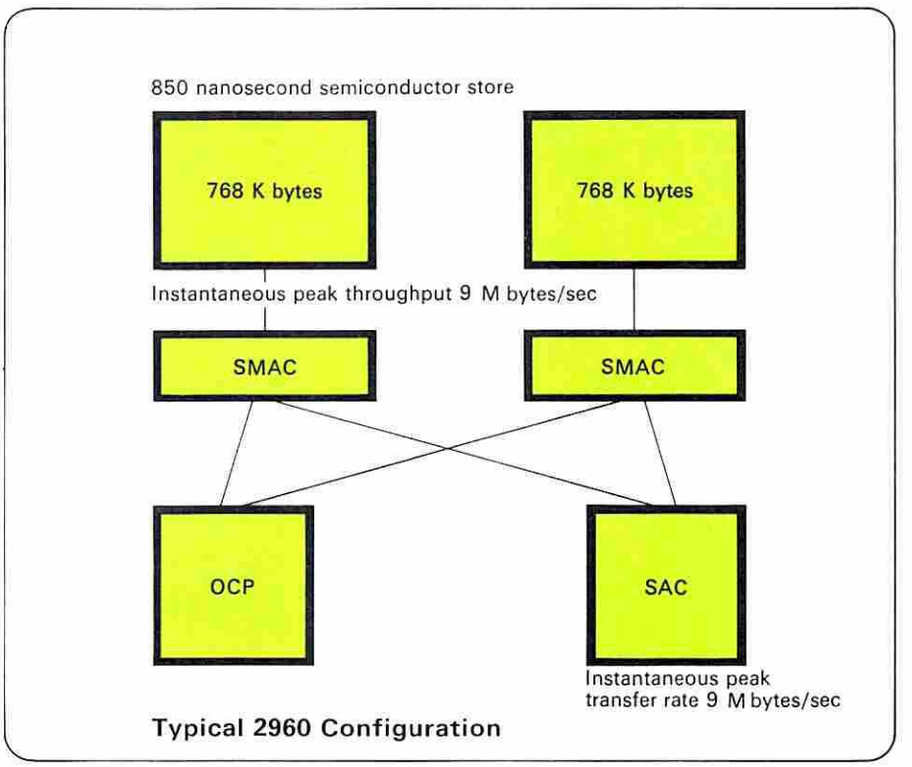
These facilities provide the user with:

optimum throughput since the controller is dedicated to a transport only during the actual transfer of data;

total system information, since the controller provides performance statistics for each device which allows the user to tune his system;

high resilience through the automatic retrying of commands without interrupting the order code processor; and the ability to detect and correct data errors through the use of a cyclic check.

It is also important that the controller can be maintained both on-line and off-line ensuring the highest up-time possible.



Typical 2960 Configuration

Sectored file controller

The SFC is a high performance microprogrammed control unit controlling up to four of the very fast fixed head discs which provide the virtual storage capability on the 2900 Series.

The SFC provides:

very high throughput as a result of rotational position sensing and the sectored layout of data on the devices;

excellent reliability through the provision of command retry, cyclic redundancy checks and the dual recording of all sector addresses.

Communications link controller

The CLC is the main method of controlling communication systems on 2960, 2970 and 2980. It consists of a microprogrammed controller and up to eight Network Interface Modules (NIMs).

Each NIM can support up to 16 channels for connection to terminal equipment so that the CLC can support up to 128 lines, driving many hundreds of directly connected and remote terminals.

The CLC also provides auto answering facilities and the capability of handling any combination of lines.

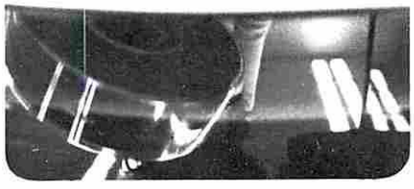
Two or more CLCs can be connected to a 2900 system to handle more lines or to provide more resilience.

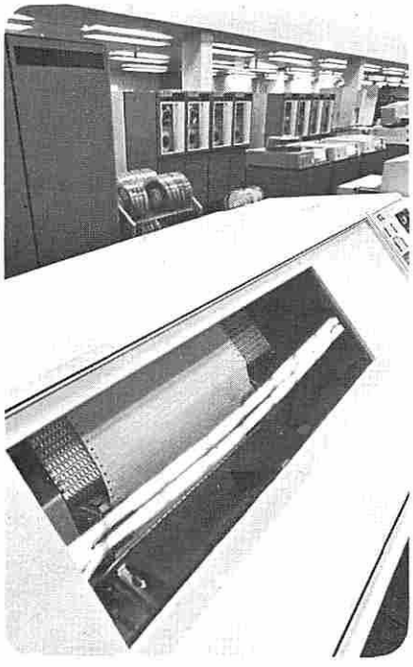
Since the CLC is a micro-programmed controller it can be enhanced so as to act as a front-end processor through the on-site addition of extra storage and a new microprogram. This enhanced controller is known as a Communications Network Processor (CNP).

Thus the user can begin with a small communication system using a single CLC, confident in the knowledge that it can be built up into a very large network based on a number of Communication Network Processors.

Peripherals

The 2900 Series provides the user with a new and expanded set of peripherals which reflect the new user requirements of transaction





processing, mixed mode working and data base handling.

Each peripheral is capable of attachment through a switched interface to two controllers—thereby providing a total resilience capability.

Fixed head storage devices

High-speed fixed head disc and drum stores have been specifically designed to support efficiently the advanced virtual memory system on 2900 Series. Rotational position sensing and sectors fixed at 1Kbyte (the same size as a page) contribute to the high transfer rate.

Exchangeable disc stores

Two large, fast exchangeable disc stores capable of holding 100 and 200 Mbytes of data are available with the 2900 Series.

Both these devices provide rotational position information for the DFC, enabling high throughput rates to be maintained. Additionally, the read/write heads may be finely adjusted, and the timing strobe advanced or retarded, to overcome transient errors.

Magnetic tape systems

The 2900 Series provides a new range of magnetic tape systems varying in speed from 120 Kbytes/second to 320 Kbytes/second.

All these new systems are based on nine-track phase-encoded recording using $\frac{1}{2}$-inch magnetic tape and are connected via their local controls to the GPC.

They provide a wide range of advanced facilities including:

NRZI option on MT–120 and MT–200;
automatic tape threading as standard;
in-flight correction of all single track errors;
optional recording in compress/expand mode for data interchange with 1900 systems;
dual channel option.

Punched card equipment

Two new card readers and one new card punch are available with the 2900 Series. The readers will accept cards both in 2900 standard mode and in card image mode, this facility being under program control.

Paper tape equipment

A new paper tape reader and a new punch are available with the 2900 Series. Both provide:

5-, 7- or 8-track paper tape handling;
integral tape dispensing and spooling mechanism;
the ability under program control to read and punch in image and hexadecimal mode.

Printing equipment

The 2900 Series printer—LP1500—is a high performance train printer. The train consists of a series of four character slugs which are held within the guides of a cartridge.

This method of printing provides:

the ability to achieve higher printing speeds by the use of cartridges containing subsets of the standard repertoire;
the ability to use different cartridges to provide output in a variety of fonts or alphabets.

Digital plotter

The digital plotter is a high-speed incremental plotter employing eight vector plotting techniques. It uses a 0·05 mm increment and operates at 1800 increments per second. It provides a wide range of facilities including three-pen selection and a manual plotting capability.

Operating station

The 2900 Series operations subsystem reflects the functional approach to operations management which is applicable in large-scale mixed mode systems environments.

It has been ergonomically designed to match exactly the information and communication requirements of operators working in such environments and allows operations information to be directed by function.

It comprises:

A master operating station. This consists of an interactive video display and a monitor display which together enable the chief operator to communicate with the system and receive reference information at the same time. It also includes a reconfiguration console allowing the processing system and the peripheral subsystems to be reconfigured from the main console.

An optional subsidiary operating station for use as an alternative to the main station or by the engineers for maintenance purposes.

Optional free-standing monitor and repeater consoles. These may be attached to either type of operating station and may be located close to peripheral subsystems or in similar areas where control information is needed, like the tape library and the operations manager's office.

A number of powerful resilience features are provided in order that the system may be kept operational. Thus, for instance:

Failure of the main console does not affect the reconfiguration console which also can be used in conjunction with the subsidiary console;

the monitor display can be used interactively to control the system if the main display fails;

in the event of a major system failure, the contents of all displays are preserved.

Communications terminals

The 2900 Series treats communications devices as standard peripherals in line with design orientation towards communications systems.

A comprehensive range of line control procedures is provided. These include both simple teletype handling and the ability to share a line between bulk and interactive devices.

Keyboard/printer devices

The 2900 Series supports various versions of both the teletypewriter and the highly successful ICL termiprinter, the latter offering a quieter, faster operation.

Visual display terminal

This terminal is a version of ICL's highly advanced 7181 Series visual display terminal, and includes such features as a 2000-character display and two character fonts, both of which can be made to flash under control from the processor.

Modular terminal systems

The 7500 Modular Terminal System comprises a range of intelligent terminal processors capable of controlling clusters of special, low-cost video terminals as well as bulk devices for remote job entry applications. Bulk devices and video terminals will be able to operate concurrently on the same line due to advanced line procedures.

Hard copy units may also be included.

The processors may be made to carry out validation and formatting of user data as required for different applications.

Summary specification

Direct access devices	Capacity	Peak transfer rate	Average access time
Fixed Head Disc Store: FHD-6 (2970, 2980)	6 Mbytes	2·8 Mbytes/second	5·2 mseconds
Fixed Head Disc Store: FHD-2 (2960)	2 Mbytes	875 Kbytes/second	10 mseconds
Exchangeable Disc Store: EDS-100	100 Mbytes	806 Kbytes/second	38·3 mseconds
Exchangeable Disc Store: EDS-200	200 Mbytes	806 Kbytes/second	38·3 mseconds

Magnetic tape systems	Recording mode	Nominal data rate	Clusters
MT-120	Phase Encoded	120 Kbytes/second	Up to 8 Transports
	NRZI	60 Kbytes/second	Integral Control
MT-200	Phase Encoded	200 Kbytes/second	Up to 8 Transports
	NRZI	100 Kbytes/second	Free-standing Control
MT-320	Phase Encoded	320 Kbytes/second	Up to 8 Transports Free-standing Control

Input/output devices	Performance
Card Reader: CR-1200	1,200 cards/minute
Card Reader: CR-2000	2,000 cards/minute
Card Punch: CP-100	100 cards/minute
Digital Plotter DP-1	1,800 increments/second (pen down)
Paper Tape Reader: PTR-1500	1,500 characters/second
Paper Tape Punch: PTP-110	110 characters/second
Line Printer: LP-1500	1,500 lines/minute (using 48-character set)

Section 2

An advanced unified architecture

All current general-purpose computer systems are based on designs suited primarily to the batch processing requirements of the 1960s. These systems are essentially computational machines designed by engineers to perform high-speed arithmetic. While they have been adapted to deal adequately with current applications, they are not capable of effectively handling the new information processing applications of the future in a way which is straightforward and cost-effective.

What is required is a new approach to computer design based on the users' requirements—not on the engineers' perception.

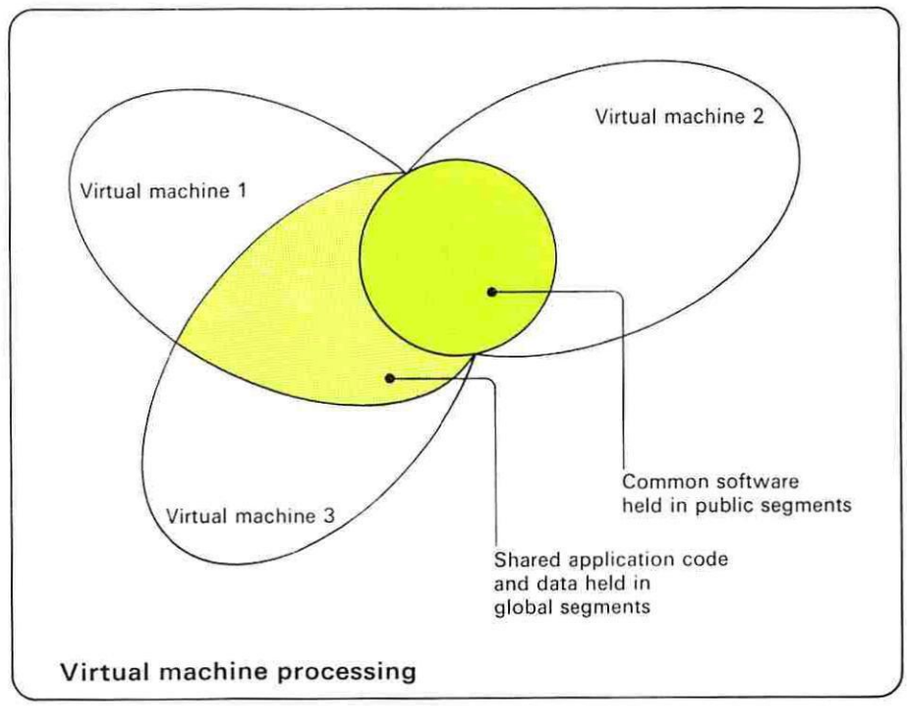
The 2900 Virtual Machine Environment (VME) is the realisation of the 2900 Series Architecture and provides a way of organising the computer that reflects the individual requirements of each user.

The 2900 Series and VME/B exploit this advanced architecture. In particular they offer:

■ **Virtual machine processing**
providing a totally protected environment in which the user is unaware of other users of the system and is provided with all the resources of the 2900 system he requires.

■ **Virtual storage**
greatly easing programming effort in the construction of large programs and the efficient execution of these programs in a multiprogramming environment

■ **Segmentation**
allowing the natural sharing of code and data and enabling a sophisticated protection system to be implemented. Segmentation supports the logical organisation of programs in an efficient implementation of virtual storage techniques.



Virtual machine processing

■ **ACR levels**
giving protection to each level of code and data within a virtual machine and ensuring the incorruptibility of operating software.

■ **Stack processing**
allowing the efficient compilation and execution of High Level Languages.

■ **An orthogonal instruction set**
making code independent of the type of data being handled and thus simplifying compilation.

The virtual machine

The virtual machine provides the user with a totally protected environment containing all the resources of the 2900 system that he requires. Although the user's program is traditionally thought of as an amalgam of its component elements—code modules, data areas, procedures and subroutines —the program cannot run in isolation in a machine. The program requires software to handle interrupts and to provide services such as input/output and spooling of bulk data.

In the past this software has not been considered to be part of a program; but logically they combine to form a single, complete unit.

The 2900 Series recognises these complete units explicitly and provides environments in which they can be executed. These environments are called virtual machines.

One of the main reasons for the efficiency of virtual machines is that requests for software services are handled within the virtual machine which requires the service. This eliminates overheads associated with passing control to logically separate parts of the supervisory software. Also, as control is always passed within a virtual machine, the user is prevented from entering other virtual machines and vice versa. In this way active virtual machines are protected absolutely from one another. Thus from a user's point of view he has all the facilities he requires in his own virtual machine and has total protection from the other users of the system.

Segmentation

Though each virtual machine contains the software it requires, it would be inefficient to replicate sets of software for each virtual machine in the system. Code and data areas can therefore be shared between two or more virtual machines, the unit of sharing being a variable length segment. Shared segments may be part of the software system or they may be common parts of an application program suite. Each segment contains one or more code or data areas.

An important feature of the 2900 Series segmentation is that code and data are always separated—that is, they are put in different segments. This has several advantages:

It enables a sophisticated protection system to be implemented to ensure that code is not overwritten or data segments executed;

it enables code and data segments to be shared easily between virtual machines, offering improved store utilisation and system throughput.

Programs can consist of pure procedures, a pure procedure being one that neither modifies itself nor stores data local to itself. Thus applications code can be shared between virtual machines.

Other implementations of virtual storage have not allowed maximum benefits to be obtained as the logical organisation of the program structures have been destroyed. The implementation of segmented virtual storage on the 2900 Series overcomes this by maintaining the logical organisation of any program in a paged environment.

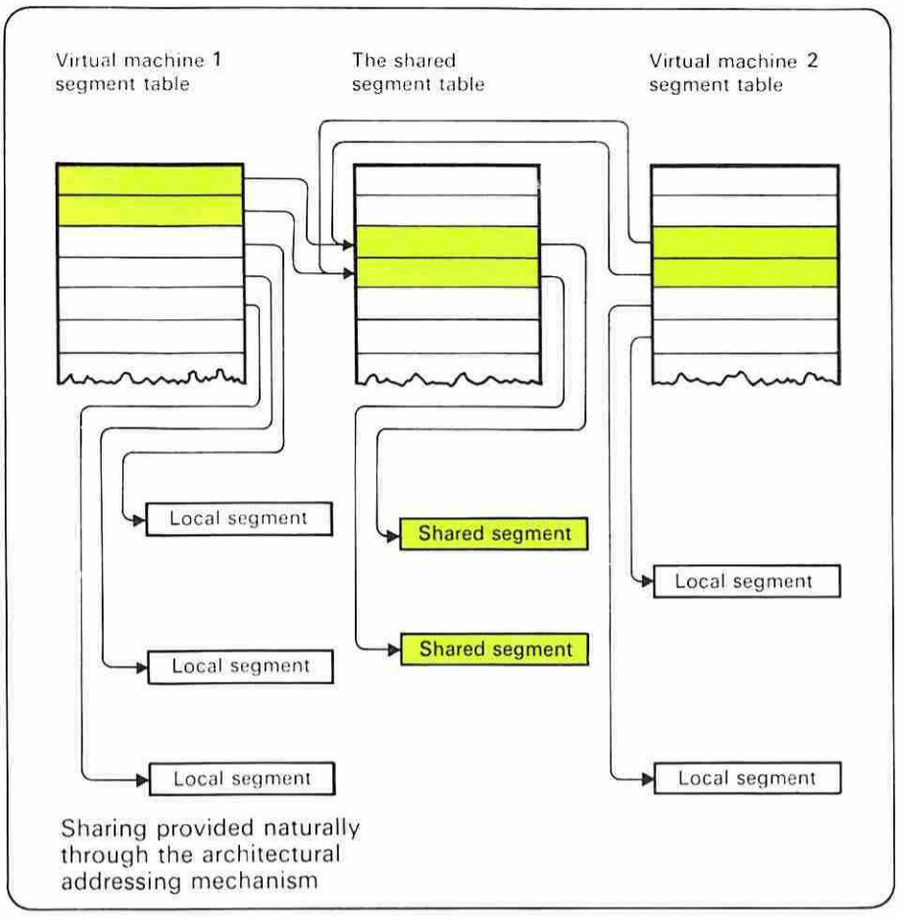
On the 2900 Series there are three types of segment defining the degree of sharing which takes place between virtual machines—Public, Global and Local.

Certain software routines are common to all virtual machines and these are held in public segments.

In addition the 2900 Series has the important facility of sharing application code and data between two or more cooperating virtual machines. An example of this is a transaction processing system in which several virtual machines share the same code but operate on different message areas. These common code areas are held in global segments. A global segment could also contain an item of software, such as a compiler, which would be shared by many multi-access users.

In those cases where there is no requirement to share the segment, the code or data is placed in local segments.

Accordingly there is explicit recognition and support for the different types of sharing required.



Sharing provided naturally through the architectural addressing mechanism

Virtual store

With many computer systems, programmers are restricted in the way they can structure their programs to achieve the most efficient solution to their application problems. This is due to the limited amount of main store available to them.

With the 2900 Series, programmers have more flexibility because they can always view their virtual machines as having all the necessary store to implement their applications. The 2900 Series feature which enables programmers to take this view is the virtual store concept, pioneered on the ICL Atlas machine and currently available on 1900 and System 4 systems. With the 2900 Series, each virtual machine has a virtual store which can be much larger than the main store of the system. This ensures that fast response transaction processing systems can be easily implemented by the automatic provision of ready access to all code needed to process whatever transaction arises next.

One current method of overcoming the restrictions of main store size is by the use of overlay techniques. This method partially solves the problem by relying very heavily on programming skills to produce efficient programs. However, because the overlay structure is built into the program, system throughput cannot be optimised to reflect a dynamically varying workload.

2900 Series virtual storage reduces the need for overlaying mechanisms with their attendant effort and allows the user to make more effective use of the system resources available to each program whenever possible, thus improving the total system throughput.

When a virtual machine is active, only segments actually required for execution are kept in main store. New segments are automatically brought in from secondary store, as required. As well as providing a segmented virtual storage system, the 2900 Series also employs a fixed length paging scheme. Main store and secondary store are divided into 1K byte units called pages. A segment is divided into one or more pages. When it is brought into store it is placed in any available (though not necessarily contiguous) free page spaces. Segments may remain unpaged if required.

Paging ensures efficient main store utilisation and is supported by fast secondary storage devices.

ACR protection levels

The 2900 Series architecture provides a unique approach to ensure that the code and data contained in each virtual machine is totally protected.

In particular it ensures that:

individual virtual machines are protected from the malfunction of other active virtual machines by the effective control of shared areas;

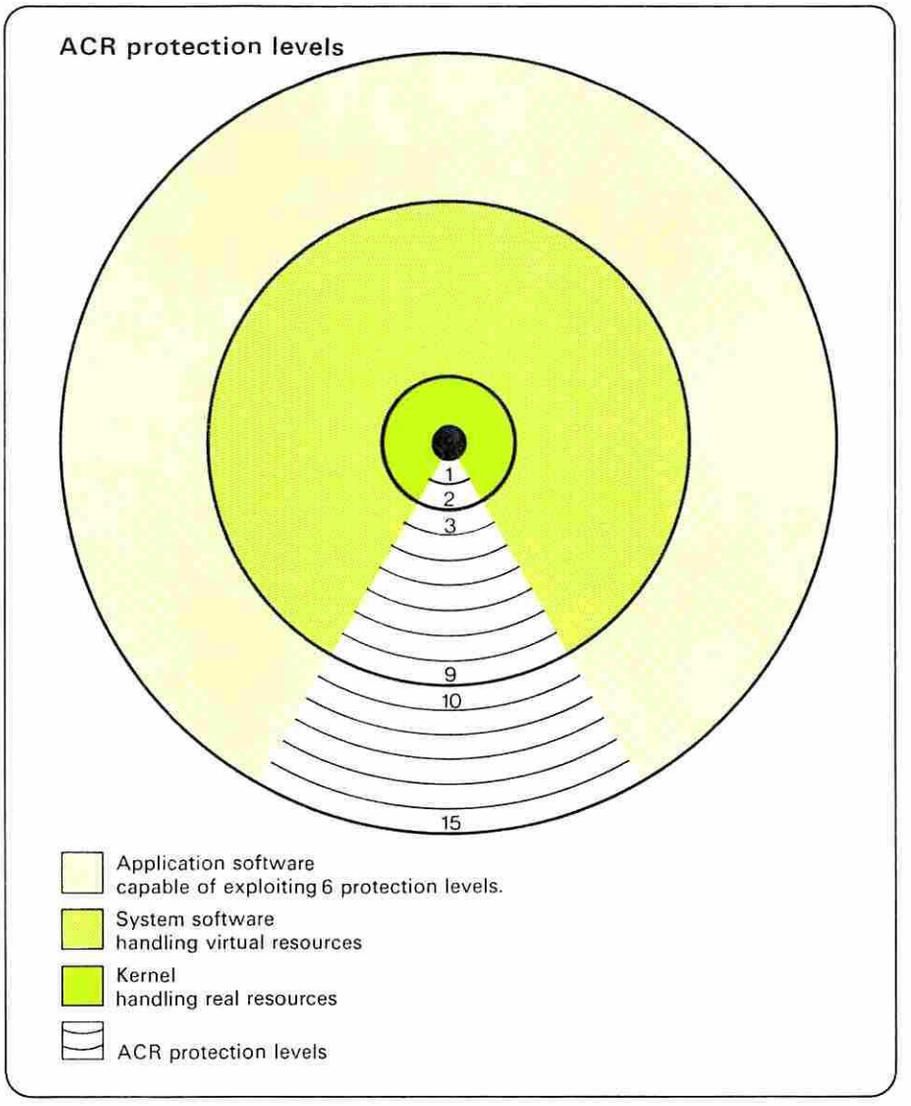
code and data in a virtual machine are protected from errors originating within it, the protection of privileged system software within each virtual machine being of special importance.

The 2900 Series protection system distinguishes between read, write and execution access. Each segment has associated with it three pieces of protection information: an Execution Permission bit, a Read Access key and a Write Access key. Only code located within segments having the Execution Permission bit set may be executed.

Whenever a process is actually in execution, a hardware register, the Access Control Register (ACR) holds a value in the range of 0 to 15 which indicates the current state of access privilege of the process. The setting varies dynamically during execution as control is passed between the different types of code in the process. Thus the code can be viewed as a series of rings or layers with each successive layer having a higher ACR setting and thereby gaining less access privilege than the previous one.

Of these 16 protection levels as many as six can be exploited by the user: This allows him, for example, to test newly developed communications systems at the same time as running a live on-line service without the fear of the code under test corrupting the operational system. The other levels are fully utilised by the system software and allow the central services and facilities of the system to be totally protected.

When store access is attempted, the basic check is to compare the current ACR setting with the appropriate read or write access key of the segment. Permission to access, however, does not depend on an exact match between ACR and the access key. Rather, there is a numerical comparison so that access is granted when the current ACR setting is less than or equal to the read access key (if read access is required), or the write access key (if write access is required), of the segment.



A well trusted procedure (one with a low ACR setting) can thus access segments which are in turn protected from less trusted procedures. The ACR level mechanism structures the system software as well as the user code within a process. Thus not only can user code be prevented from corrupting system data, but system code itself can be structured into several levels of protection to minimise the danger of corruption to vital central system code and data. Also, when program-generated faults do occur the ACR mechanism assists the earlier detection of the fault and permits a more rapid diagnosis, since the limits of the effects of the error can be properly defined. Consequently this provides a clearcut improvement in the ability to overcome the error and maintain the user service.

Thus on the 2900 Series processes are not only protected from each other by the virtual machine structure, but also protected internally by the 16 levels of the access control mechanism, providing the user's application with a much higher level of resilience than other systems currently available.

The stack

A major disadvantage of all systems which employ a fixed number of general purpose registers is their inability to provide environments for the efficient compilation and execution of High Level Language programs, or to cater effectively for the dynamic flow of a transaction processing application or mixed-mode operation.

The 2900 Series alleviates these problems through the use of a hardware-driven stack. This provides:

dynamic allocation of working space;
fast procedure calls;
fast access to 'current' data.

The stack is a set of consecutive storage locations, one such set being used by each virtual machine. It may be considered as having a vertical structure, the first location of the set being at the bottom of the stack, and the last at the top. Items may only be added to or removed from the top of the stack. It therefore operates on a last-in, first-out basis.

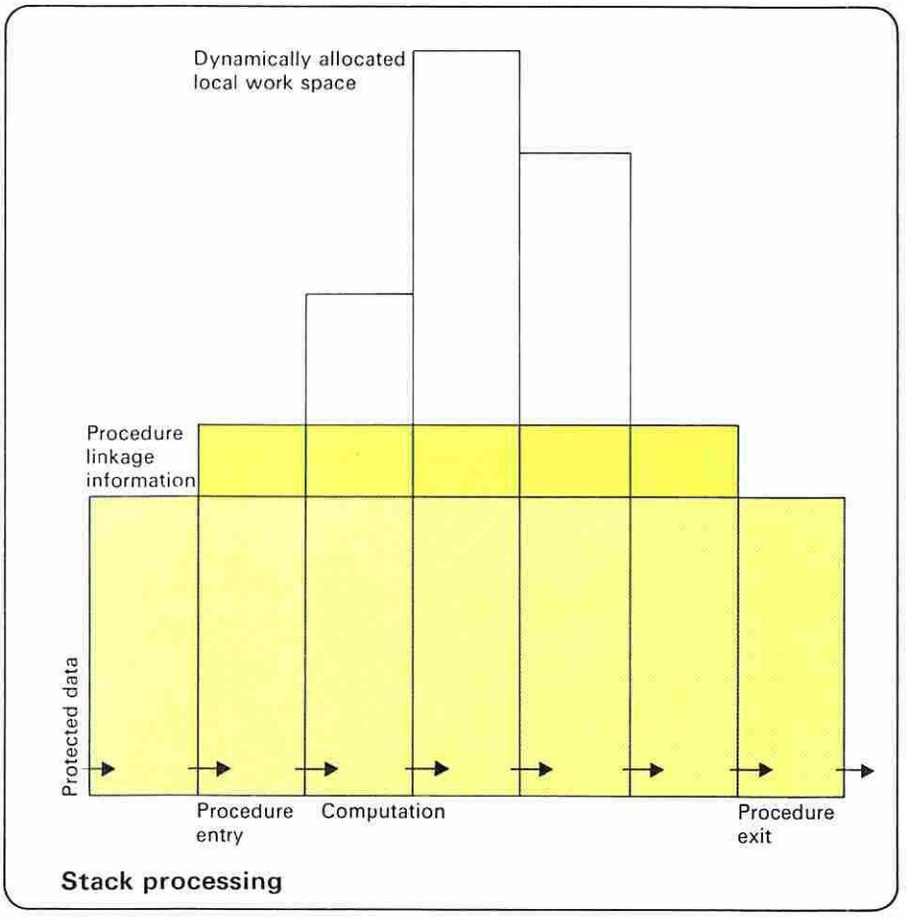
When it is active, the stack is referred to by hardware pointers. The bottom of the stack is fixed and marked by a bottom-of-stack pointer. There is also a top-of-stack pointer which refers to the first unoccupied word of the stack relative to the base.

The ability to extend the stack dynamically, by resetting the top-of-stack pointer, is particularly significant in dealing efficiently with subroutine or procedure calls. Parameters passed to the procedure can be placed on the top of the stack and then further working space can be allocated simply by moving the top-of-stack pointer up the required number of locations. On return from the procedure, when the parameters and work-space are no longer required, the top-of-stack pointer returns to point to the 'original' position.

The stack therefore reflects naturally the requirements for the dynamic provision of work space which is so vital in communication environments. The stack can also be used to provide an environment which reflects the pattern of block-structured languages. This is of particular significance with VME/B, as the operating system itself is written in a block-structured language.

The 2900 Series hardware-driven stack provides a very efficient and effective environment for implementing High Level Language compilers. For example, the compilers allocate computational workspace and descriptor lists to the stack. This produces benefits to the user in the optimum use of real store for working storage and a predominance of short instructions in the user object code.

By these means the user gains all the benefits of the 2900 architecture through the implementation of the High Level Language compilers and their generated object code.



Stack processing

Orthogonal instruction set

The 2900 Series order code is based on an orthogonal instruction set containing a wide range of instructions, each capable of handling all data types applicable to it. This makes code independent of the data-type being handled and thus simplifies compilation.
The set includes instructions for:

fixed point, floating point and decimal arithmetic;
manipulating character strings;
logical operations;
procedure entry and exit;
conditional jumping;
manipulating information contained in the stack and in the stack registers themselves.

The set also includes some special instructions such as the hardware implemented VALIDATE instruction which is used to check the validity of all addresses passed to called procedures.

The 2900 Series instructions are 16 or 32 bits in length and in the majority of cases each instruction is available in short and long form. Short instructions are normally used when operands are addressed directly in the stack and the long instructions when operands are addressed indirectly. Due to the extensive use of the stack, extremely compact code can be produced by the compilers.

The order code is designed so that each instruction can be split into independent actions, each of which can occur in parallel with other instruction operations. The hardware pipeline allows this instruction overlap with the result that several instructions can be executed simultaneously. The design of the instruction format, together with pipelining techniques, gives very high execution rates on the 2900 Series processors.

Descriptors

2900 Series descriptors are a powerful formalised mechanism for describing items of data in store such as strings of bytes and arrays. They also provide an effective means of passing control to a new code sequence, by holding the destination address of a call instruction.

The 2900 Series architecture provides four types of descriptor.

Vector descriptors:
These are used for accessing arrays. They contain control information on the item size, the modifying scale and a bound limit which automatically ensures that the bounds of the array are not exceeded.

String descriptors:
These provide fast access to character strings.

Descriptor descriptors:
These operate as vector descriptors but point to other descriptors allowing complex data structures to be handled easily and quickly.

Code Descriptors:
These refer to items of code, allowing control to be passed from the current sequence to another in the same process.

2900 Series descriptors are just one of the many fundamental aspects of the systems architecture which reflect the user's need for efficient data handling.

Special purpose registers
The 2900 Series processors contain a set of special purpose hardware registers which include the pointers used to control the stack. A special register is also provided to hold descriptors in a standard format; the descriptor may be loaded into the descriptor register as the result of an explicit instruction, or implicity as part of an instruction execution.

Two other important registers are the accumulator register (ACC) and the B-Modifier register. Both these registers can be coupled to the top of the stack.

As the stack is extendable upwards, this coupling of the accumulator means that:

as new items are loaded into the accumulator its previous contents are automatically placed on the top of the stack;

items from the top of the stack may be used directly as operands for operations in the accumulator.

Thus the space needed for storing intermediate results is directly available. The ability to link the accumulator to the top of the stack in this way is a powerful feature of the 2900 Series, since it means that:

the extra instructions needed on conventional machines to load and store arithmetic registers are redundant;

a single address is sufficient to move data to and from the stack.

The flexibility of this system is particularly important for the efficient compilation and execution of High Level Languages since by this means no constraints are imposed by a fixed number of general purpose registers as is the case on more conventional systems. On the 2900 Series the dynamic allocation of work-space for variables declared at run time together with the accumulator and B-Modifier coupling facility provides an effectively infinite register set.

Section 3

VME/B a versatile service

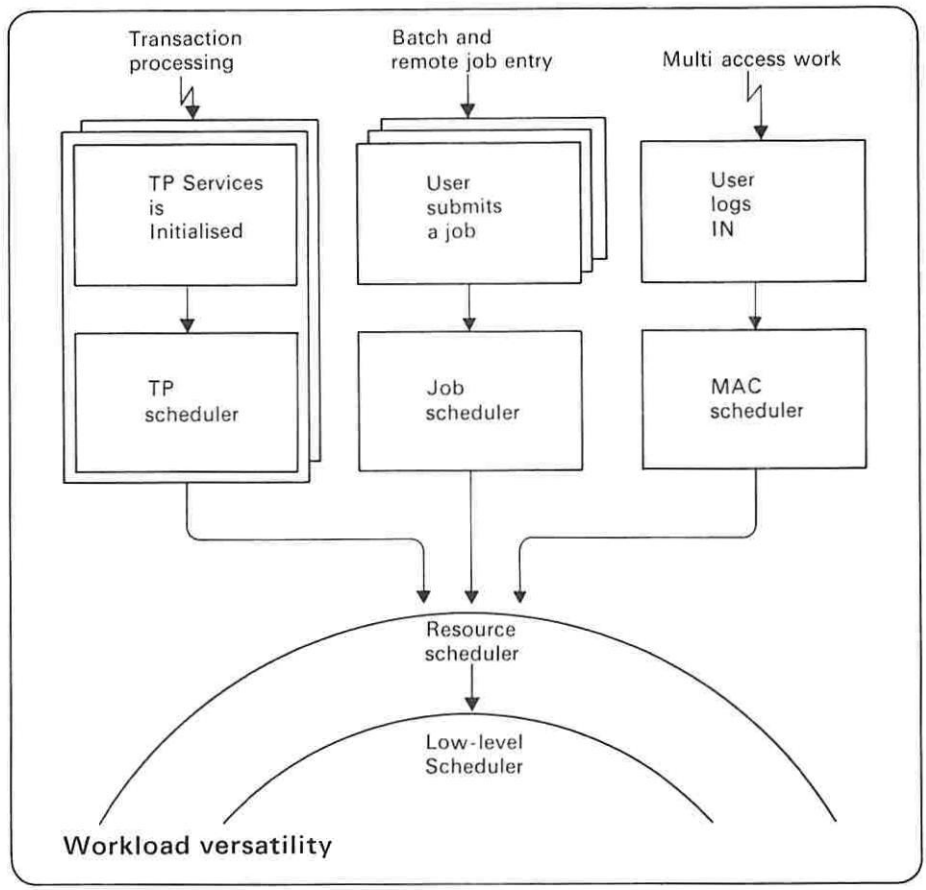
VME/B is a comprehensive operating system offering excellent facilities for the control and provision of an extensive mixed-mode computing service to a large number of end users.

In particular

- **It builds on ICL's experience in the design and implementation of operating systems**
- **It supports multiple transaction processing, multi-access and batch services simultaneously**
- **It provides a coherent, easy to use, high level interface to all users**
- **It incorporates unique features providing new levels of system resilience**
- **It offers a wide range of operational facilities to ensure high system throughput**
- **It contains an integrated filestore providing control over all filed data used by the system**
- **It provides a comprehensive set of accounting and budgeting facilities**
- **It can be tailored to the particular requirements of the installation.**

Built on ICL's experience

Through its former constituent companies, ICL has brought together a wealth of expertise in the design and construction of operating systems. Many of the earlier computer ranges produced by these British companies utilised operating systems that were world leaders in their time. In particular, it is generally accepted that the ATLAS computer system laid down the fundamental design principles upon which today's operating systems are built. It was also the first to exploit the concept of virtual storage, a concept which has been further developed on the 2900 Series.



During the last seven years extensive use has been made throughout the world of the range of operating systems available on the 1900 Series and System 4. These vary from simple batch-processing systems through to the powerful GEORGE 3 and J general purpose operating systems.

ICL Operating Systems are now being used in countries throughout the world, in commerce, industry, government and academic environments and across a number of computer systems unparalleled in their variety and purpose.

Because of the breadth of this experience ICL is, perhaps, uniquely placed to design and implement operating systems capable of fulfilling the demands placed on a modern computer system.

VME/B is the latest in the ICL range of world beating operating systems.

Effectively supports mixed mode working

The 2900 Series has been designed to handle the growing demand for effective communications systems required to support the applications of the 1980s.

ICL has recognised that this communication work will not consist entirely of transaction processing or multi-access or remote batch, but a mixture of all three.

VME/B has been designed for effective control of large mixed-mode workloads of the future, by means of built-in scheduling facilities for transaction processing and multi-access as well as batch work.

These facilities provide the system manager with excellent control over the total resource utilisation of the system; further, he can define and vary dynamically not only the proportion of resources used by the different types of workload, but also those used by different items of work within these types.

In terms of user priorities too, VME/B provides the means of ensuring an optimum job mix at all

levels of the system—whether work is waiting to start, running in main store, or ready for output.

Because of its built-in facilities, VME/B provides the user with the exceptional ability to connect into any of the services successively. In this way he might initiate a compilation, carry out a short test run on another program, and then go back and receive the results of the compilation, all in one session.

An easy to use, high level interface

All users of the system communicate with it through a natural language called the System Control Language (SCL).

This powerful language provides the facilities required to cater for all types of user from the trainee to the more experienced individual. Different classes of users, for example terminal users and operators, are provided with specialised subsets which reflect their own requirements.

This approach ensures that:

it is easy to learn;

users can use the subsets most appropriate and meaningful to them;

there is mutual understanding between different classes of users;

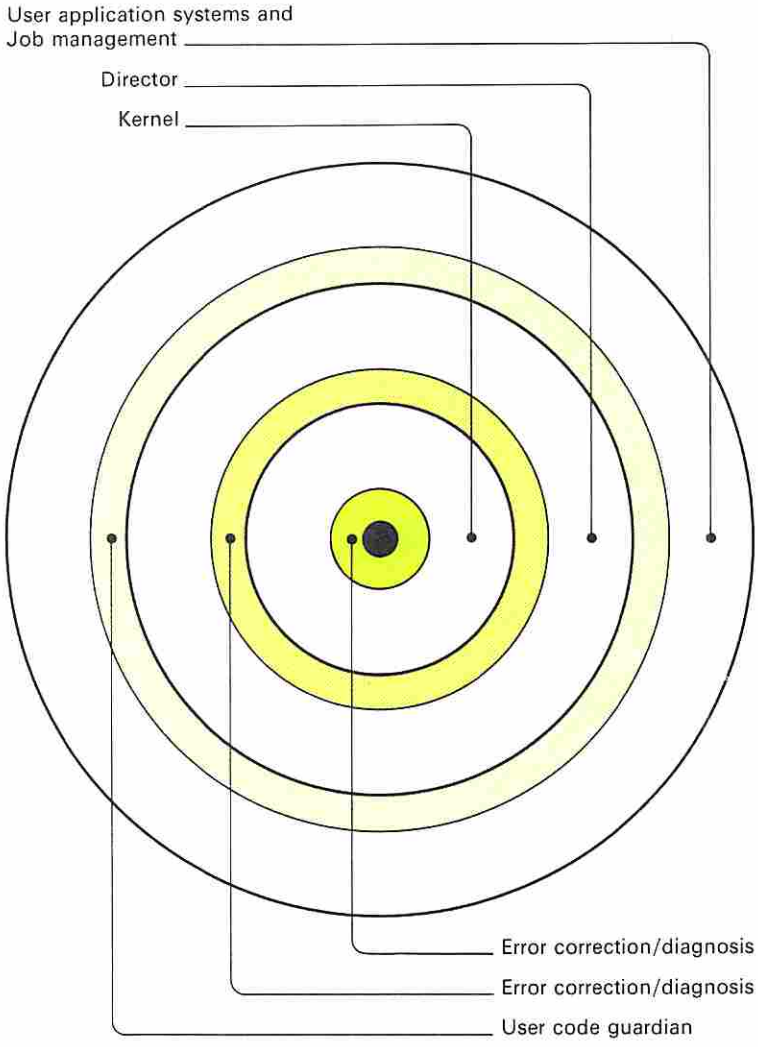
minimum training is required in moving from one area of use to another.

SCL is a block-structured language. It therefore provides a method of control which is intrinsically efficient since resources are only reserved when executing the block which needs them, such resources being released for use by other systems when this block has been completed. This contrasts with systems which reserve a resource for a whole job whether it is required for the whole of that job or not.

The language includes a number of advanced features including:

macro commands;
definition of variables;
computational facilities;
prompts;
conditional statements;
default options.

These allow the user the option of working with a very simple interface or of exercising total control over his job and its environment.



High resilience through error containment.

New levels of resilience

In all large computer systems today it is the resilience of the software, both the manufacturers' and the users', which is becoming of prime significance.

In designing and building VME/B, ICL has been pioneering new disciplined design methodologies and automated production techniques normally associated with hardware in order to significantly improve the reliability of service that 2900 systems will provide.

This new software engineering is based on an ICL system called CADES. This system provides the ICL designer with a wide variety of tools and aids, allowing him to:

animate the design prior to implementation;

assess the effects of a change to one module on the rest of the system;

automatically generate code from the design process;

generate a testing environment for any particular module.

In this way the design characteristics are validated prior to implementation, ensuring a better, more reliable product.

Another important aspect of the software engineering approach is that VME/B has been implemented using a High Level Language especially designed for the purpose, thus producing a far more stable product.

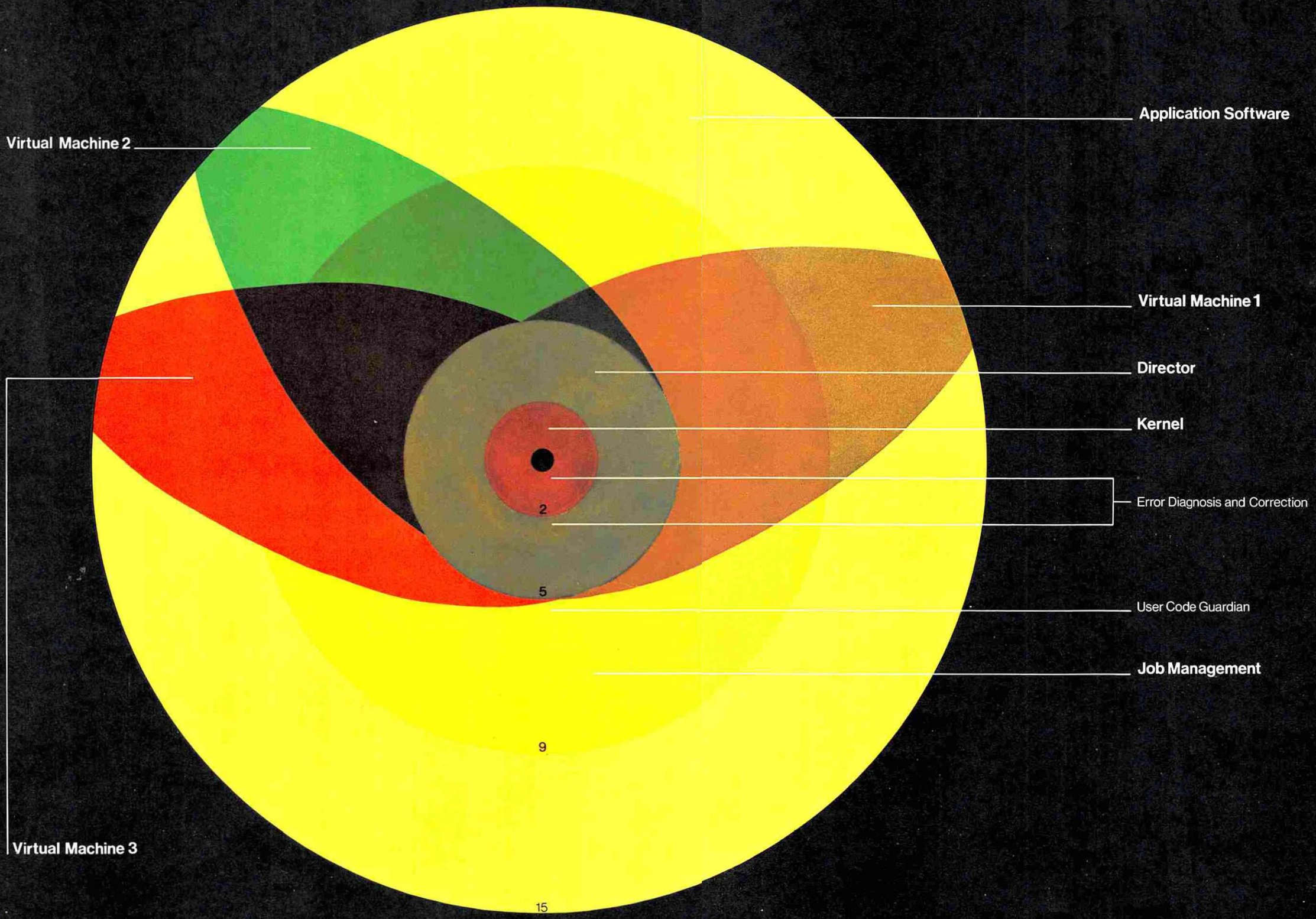
Finally, VME/B intensively exploits all the 2900 Series architectural features so as to provide a highly resilient service.

In particular, it:

utilises the ACR levels in order to provide varying degrees of protection within the supervisor;

contains error managers at every major level of the system. These are capable of identifying all errors at that level and where possible correcting them;

uses a standard calling sequence that allows all procedures to validate the parameters being passed to them. Consequently error propagation through the system is prevented.


Application Software
Virtual Machine 2
Virtual Machine 1
Director
Kernel
2
Error Diagnosis and Correction
5
User Code Guardian
Job Management
9
Virtual Machine 3
15

Integrated filestore

Information is the raw material of data processing. But the business of organising it, finding a place in backing store for it, producing it at the right time and ensuring that no one has access to it without authority—these jobs are time-consuming and distract the user from his application.

On the 2900 Series all these activities are handled by VME/B through the use of an integrated filestore which contains all the magnetic media files on the system. This filestore management system allows the user to assume responsibility for the placement of all or certain of his files. This is of particular importance in the situation where fast access to data is critical. If the user does not require this degree of control the system will optimise the use of on-line devices so as to provide the best overall service to the installation. The filestore also provides the user with a range of file back-up facilities allowing security copies of any file to be taken at time increments suited to the activity on the file. In this way only that level of security required by the installation is provided.

The control of the filestore is carried out through a special lattice file called the System Catalogue, which reflects the conceptual relationships within the filestore. This file contains information concerning not only the files in the filestore and their owners, but also those SCL environments within which each user may operate; what types of access are allowed to each file; and what events can occur in connection with each file.

The system catalogue therefore provides the system manager with total control over all the privacy and security arrangements of the installation, not only for files but for system facilities as well.

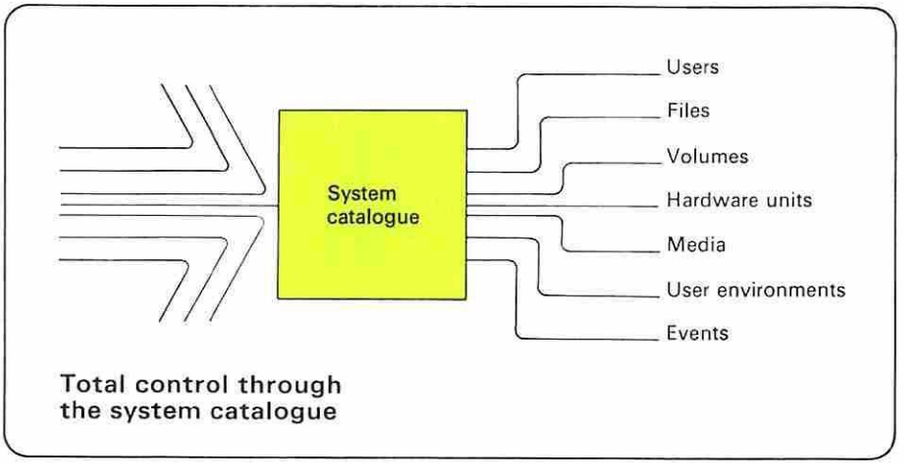
Operations facilities

All the operations facilities on the 2900 Series have been designed to enable operations departments to meet the high levels of service expected of them by their users with the most effective use of resources.

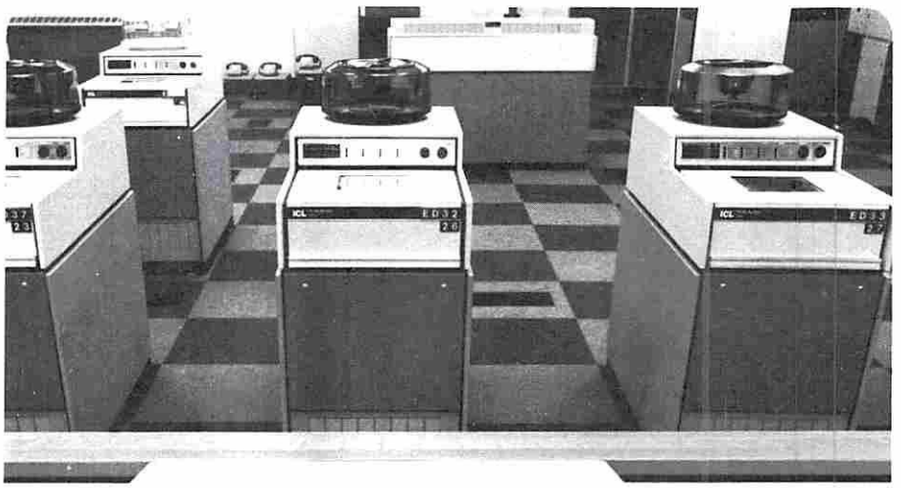
VME/B contributes as much to this as the new interactive display hardware.

In particular VME/B:

Takes over the minute-to-minute involvement in scheduling and resource allocation by the use of such techniques as priority scheduling and output spooling queues;



Total control through the system catalogue



allows the operations staff to tune and guide the system by the use of the System Control Language;

routes information to specific hardware displays according to the function of the operators using them;

displays important prompt messages to the operator one at a time;

automatically notes the change of peripheral state, say from automatic to manual, without requiring the operator to enter a message via an interactive display.

Accounting and budgeting
All computer systems require some method of allocating the systems' resources so that an optimal overall service is provided. The VME/B accounting and budgeting system provides the user with a method of performing this allocation if required.

The system offers three major accounting functions:

the collection of quantitative data at or around run time on the resources used by the job, including processing time, use of virtual store, magnetic media usage, communication device usage;

the analysis of the data collected, varying from a simple match between users and resource usage to a comprehensive analysis reflecting complex commercial contracts, including special discounts and penalty clauses;

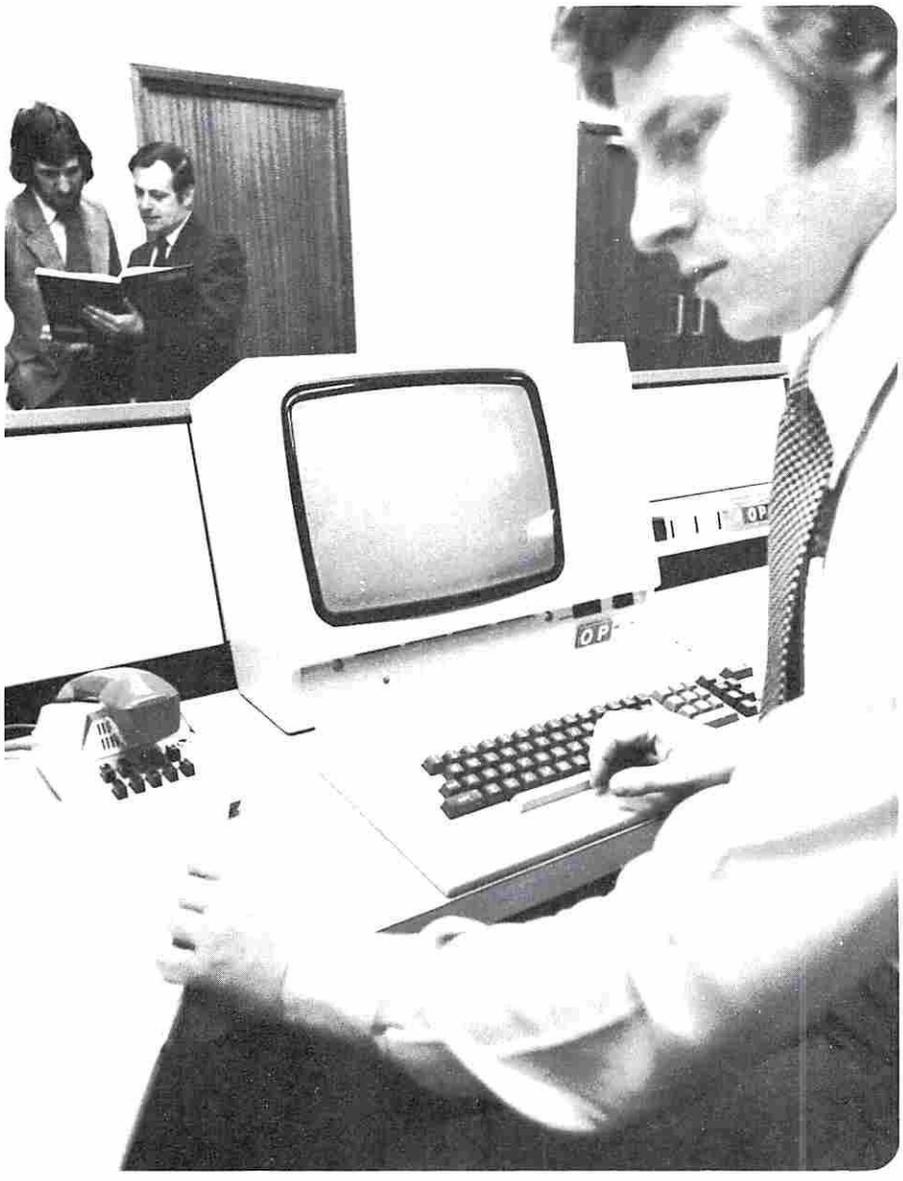
output varying from a simple list of charges through to statistical information for system tuning purposes.

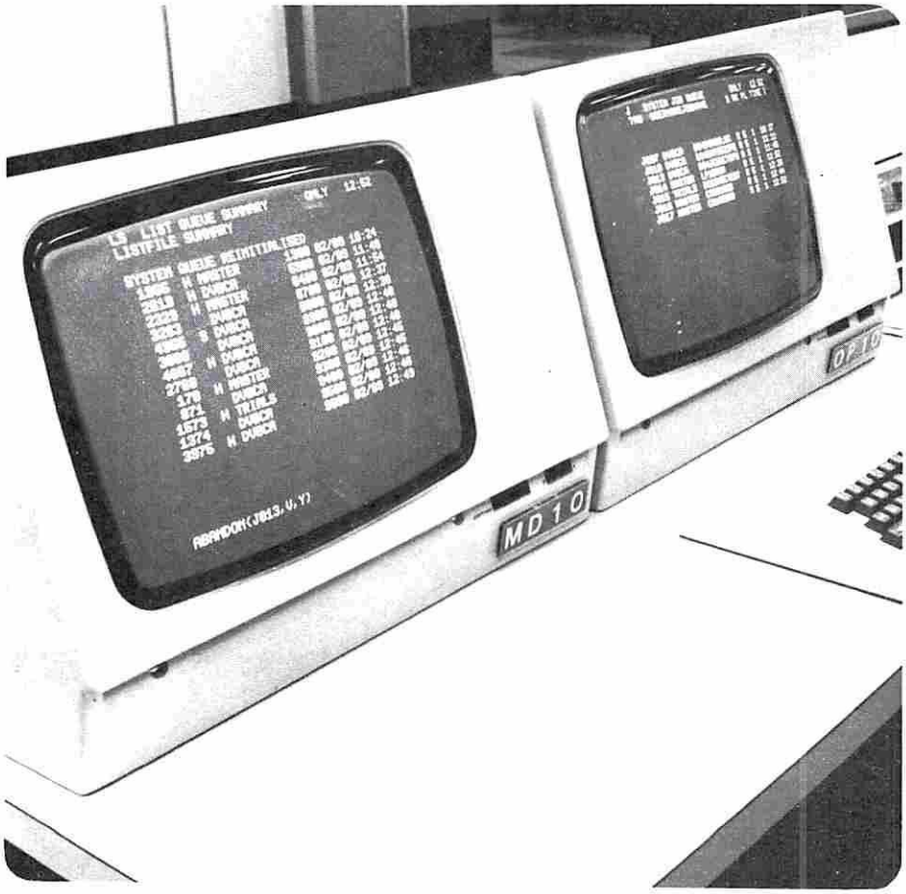
This accounting information can be charged against specific budgets in order to allow accounting by project instead of by user.

Adaptable system
Although VME/B provides a wide range of advanced facilities it is recognised that in certain circumstances users may not wish to use certain facilities.

For example, an installation manager who only wants to provide a batch and multi-access service can choose not to load the transaction processing sub-system.

Additionally an organisation with special financial requirements could modify the accounting facilities in order to take care of its special needs.





Section 4

Ease of implementation

The economics of data processing have changed over the last ten years. In the past the cost of data processing staff was relatively low whereas hardware was extremely expensive. Today people-costs are rising rapidly and the cost of hardware is falling. There is also the additional problem of the shortage of good quality staff.

The 2900 Series has been designed to meet this new situation by providing powerful hardware and software facilities to make the system easy to use and to allow, cheaper, faster application development.

In particular the 2900 Series offers

- **Comprehensive interactive and computational facilities for engineers and scientists**
- **Excellent on-line program development facilities**
- **A total High Level Language environment**
- **A comprehensive set of testing aids**
- **A new single, efficient compilation environment.**

Comprehensive interactive facilities

Research engineers and scientists have been using computers as an interactive tool for many years because it was recognised that they provided a method of optimising on their highly skilled effort as well as saving valuable time.

ICL has always provided excellent facilities in this area on both 1900 Series and System 4—for example through the use of the powerful GEORGE 3 operating system.

The 2900 Series has improved and extended this approach. Of particular importance to the scientific interactive user are the powerful facilities offered by the System Control Language. These allow the user to prepare, test and run his programs by the simple use of key words meaningful in his own particular sphere. Thus FORTRANRUN (SIMULATION) could effect the compilation, loading and execution of a simulation program.

As well as offering the user all the facilities of the System Control Language, VME/B also provides further degrees of flexibility through the ability to run:

multiple multi-access sessions, allowing the user to initiate several independent jobs concurrently from the same terminal;

interactive batch jobs, allowing the terminal operator to choose to monitor and interact with it during execution, with the option of abandoning either the last SCL command or, if necessary, the entire job;

normal batch jobs, where the user is able to monitor the status of the job. For example, is it queued, running or finished?

Mixed transaction processing and multi-access sessions, where the terminal operator can use the transaction processing facilities to look up a file of data during the development of a program and then return to multi-access working to continue program development.

The terminal user thus has complete freedom to access all of the facilities offered by the system within the constraints laid down by the installation's operations department.

The 2900 Series also provides the on-line user with the powerful BASIC interactive language, enabling many engineering and scientific problems to be solved rapidly.

In particular the 2900 Series BASIC system offers:

a very simple interface allowing work to be done quickly and easily;

powerful character-string handling and arithmetic standard functions as well as the traditional FORTRAN-like computational facilities;

on-line syntax checking;

on-line editing;

on-line alteration of the dynamic flow of the program during execution.

On-line development facilities

The increasing size, complexity and cost of application development all dictate a need for the most up-to-date methods of system and program development.

Traditionally, program development has been costly in terms of programmers' time and effort; and projects have been delayed due to 'turn-around' times measured in days.

The 2900 Series multi-access system eliminates this costly overhead by allowing the programmer and system designer to view the computer as a tool to aid them in their jobs. In particular they are provided with an interactive editor and totally re-entrant compilers. Via a keyboard terminal—visual display, hard copy or both—the programmer now amends his source-listing, compiles his program, inputs test data, and initiates and monitors the program-run all in the space of a few minutes.

During the execution of his program, the programmer receives diagnostics and error messages as well as budgeting information and the output data specified.

In the event of the terminal forming a part of a remote peripheral cluster the programmer will also be able to input and receive bulk data, and hold programs and files locally on magnetic media.

The programmer can, therefore, create exactly the type of development conditions best suited to him. Furthermore he can maintain total control over this environment as a result of the information made available to him through his job journal.

The on-line programmer has at his disposal all the facilities offered by the System Control Language including:

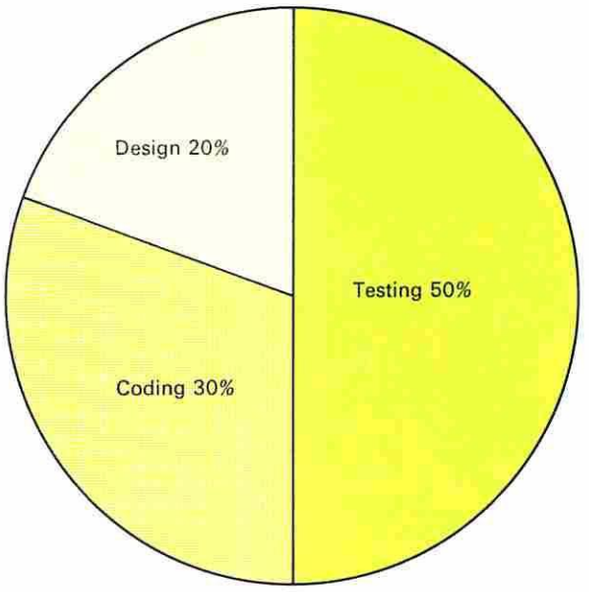
Prompts
preventing incorrect parameters being passed to a program and advising the programmer on the use of the correct keyword;

Look facilities
allowing the programmer to examine small portions of his data without needing to list the whole file;

Break-in
providing the facility to interrupt a program in order to carry out other work, like editing a file.

A total High Level Language environment

As computer applications increase in volume and complexity, a modern computing system needs to exhibit two basic characteristics.



Programming: Resource usage

It must, of course, be sufficiently powerful and versatile to carry out these applications efficiently.

Just as important, it must be convenient to use, since management, systems, programming and operating effort represent a major proportion of the total cost of a computing facility.

It has been recognised for a long time that High Level Languages have an advantage over assembly languages from the users' point of view since they are designed to solve a general class of problems, rather than being related to the structure of a particular machine. Because they are designed as problem-solving tools, written in a natural language and standard mathematical notation, programmers can learn to make efficient use of them far more quickly than they could an assembly language.

The effort required to produce and maintain error-free programs using a High Level Language is less than with an assembly language because High Level Languages are intrinsically more powerful. Also, because High Level Language programs have a logical structure, the compiler is able to detect many of the errors made by the programmer. And since High Level Languages are, to a large extent, self documenting they permit easier maintenance.

The 2900 Series is a High Level Language machine.

The internal machine code in particular allows a close mapping of high-level statements, so that, for example, a COBOL 'MOVE' statement may result in a single machine-level instruction.

The hardware stack directly supports block-structured languages and provides an almost infinite set of registers, ideally suited to High Level Language compilers.

Descriptors permit direct representation of vectors and arrays.

Services provided by the system may be called from High Level Languages (for example complex file layouts, communications systems and other functions traditionally programmed in assembly languages).

Mixed language programming is effected without formality by a simple calling statement; thus some parts of a program may be written in COBOL for data handling and others in FORTRAN or ALGOL for arithmetic calculation. The programmer chooses the language best suited to each section of his program.

Program execution traces and post mortem dumps that have, until now, usually been represented in a form only decipherable by experts (strings of octal or hexadecimal digits) are presented on the 2900 Series in source language terms. Appropriate references are made to program statements and data areas where necessary.

The 2900 Series' implementations of COBOL, FORTRAN and ALGOL are all based on the latest International Standards.

With the 2900 Series the user can develop more cost-effective applications in shorter timescales because of the system's total orientation toward the effective exploitation of High Level Languages.

Comprehensive testing aids

In the past most tools aimed at aiding program development have been concentrated at the coding stage. It is consequently true that today over 50% of application development effort is spent on testing of the application prior to live running.

The 2900 Series provides a comprehensive set of testing aids which can be integrated so that they work together. This can significantly reduce the time and effort spent on application testing.

This set of aids includes:

Test data generator (TDG)

This testing facility enables the programmer to generate, with the minimum effort, test data which will exactly mirror all the contingencies likely to arise during live running.

Stating actual values, statistical values or arithmetic expressions,the user can describe files, records and data contents using the Test Data Description Language.

So where it has previously been required of him to specify fully the contents of files, the TDG allows the content of a field to incorporate functions that generate successive records or numeric values that follow a particular distribution.

Thus the TDG considerably reduces the repetitive and tedious work necessary to produce test data on current equipment.

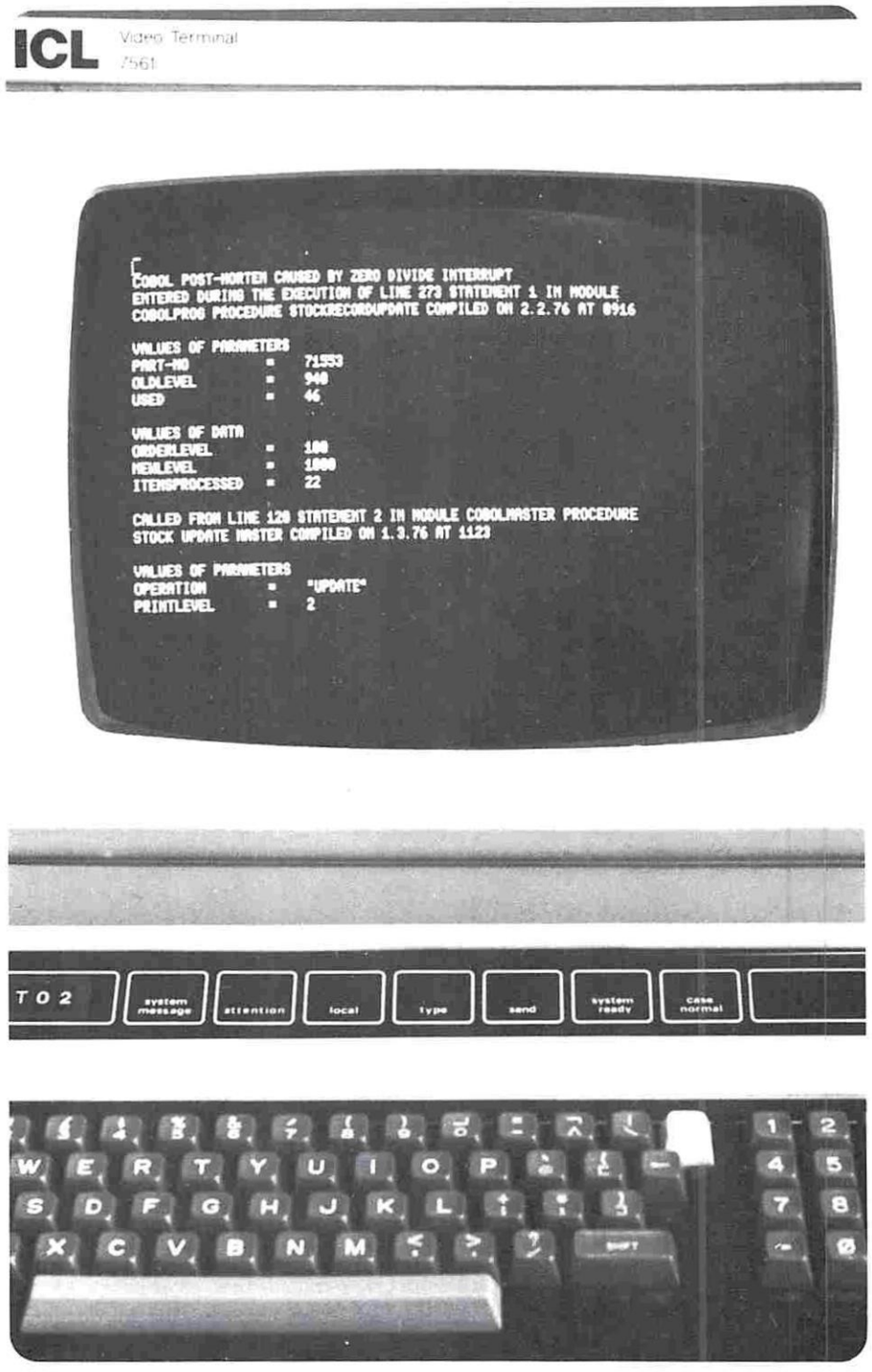
Testing envelope

Although the desirability of modular programming has been recognised for many years, the attendant difficulties in module testing prior to the whole system being written have often been a drawback.

The Testing Envelope overcomes these by providing a complete modular testing environment which allows units of a COBOL program, groups of units or the complete program to be tested.

It provides the ability not only to simulate missing modules by satisfying all calls made to them by the unit under test, but also to supply test data to the module via the Test Data Generator.

It also provides facilities for monitoring and diagnosing all program errors and the listing of input, test and output data. This allows automatic comparison of results with those expected.



Communications network simulator (CNS)

Testing is also one of the major problems met in the development of communications systems. They are difficult to test without the communications network itself and even when it is available it is often impractical to use it for testing purposes.

The Communications Network Simulator will allow:

complete testing of communications systems without the need for the network;

testing of parts of the system while the rest is in live use;

controlled performance assessment and validation.

This allows the programmer not only to determine whether the application is logically correct but also to assess present performance under normal and peak load conditions. Possible future enhancements to the network can also be assessed.

Efficient compilation and execution

All the software used in connection with program production and testing in COBOL, FORTRAN, and ALGOL operates within a consistent environment which provides the user with:

a simple interface to the operating software;

sophisticated facilities for the user who requires them;

natural mixed language programming;

similar interfaces for batch, multi-access and remote job entry environments.

The compilation environment controls the entering and editing of source code, its compilation, its collection into loadable form and execution. Since the user controls these by SCL, typically only a few macro commands are needed to invoke the entire sequence.

This compilation environment is extremely easy to use because the COBOL, FORTRAN and ALGOL compilers:

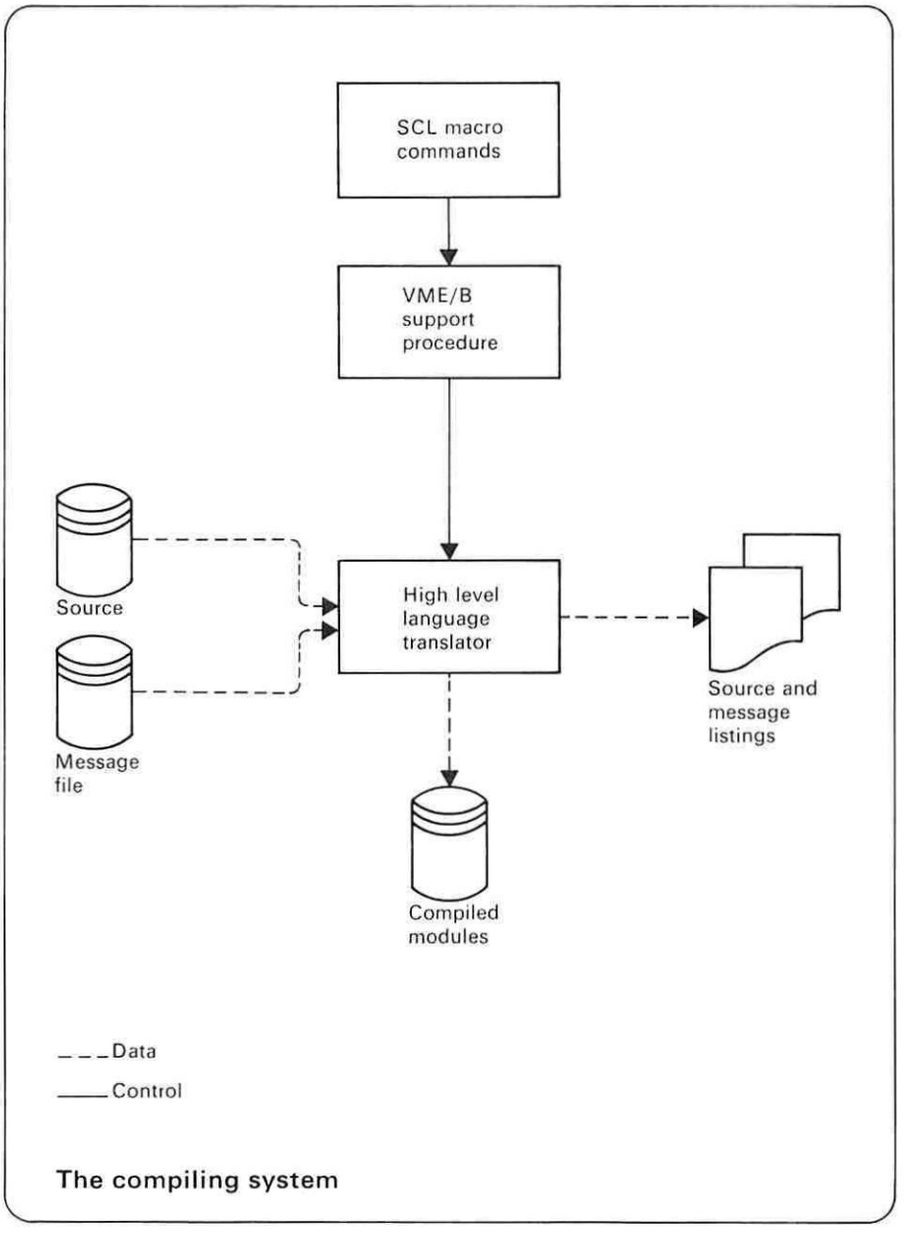
use the same library and message handling routines;

are driven by a common SCL interface;

output to a single Object Module Format, allowing natural mixed-language programming.

The System Control Language provides the user with a variety of options for control of the compilation environment. These provide the user with a choice of compiler listings, comments, warnings and error messages. Also available are various levels of post mortem and diagnostic trace information. Additionally, the user is able to control the layout of program areas in virtual store if this is required for improving execution times.

If any or all of these facilities are not specified by the user, default values set by the operations management will apply.



The compiling system

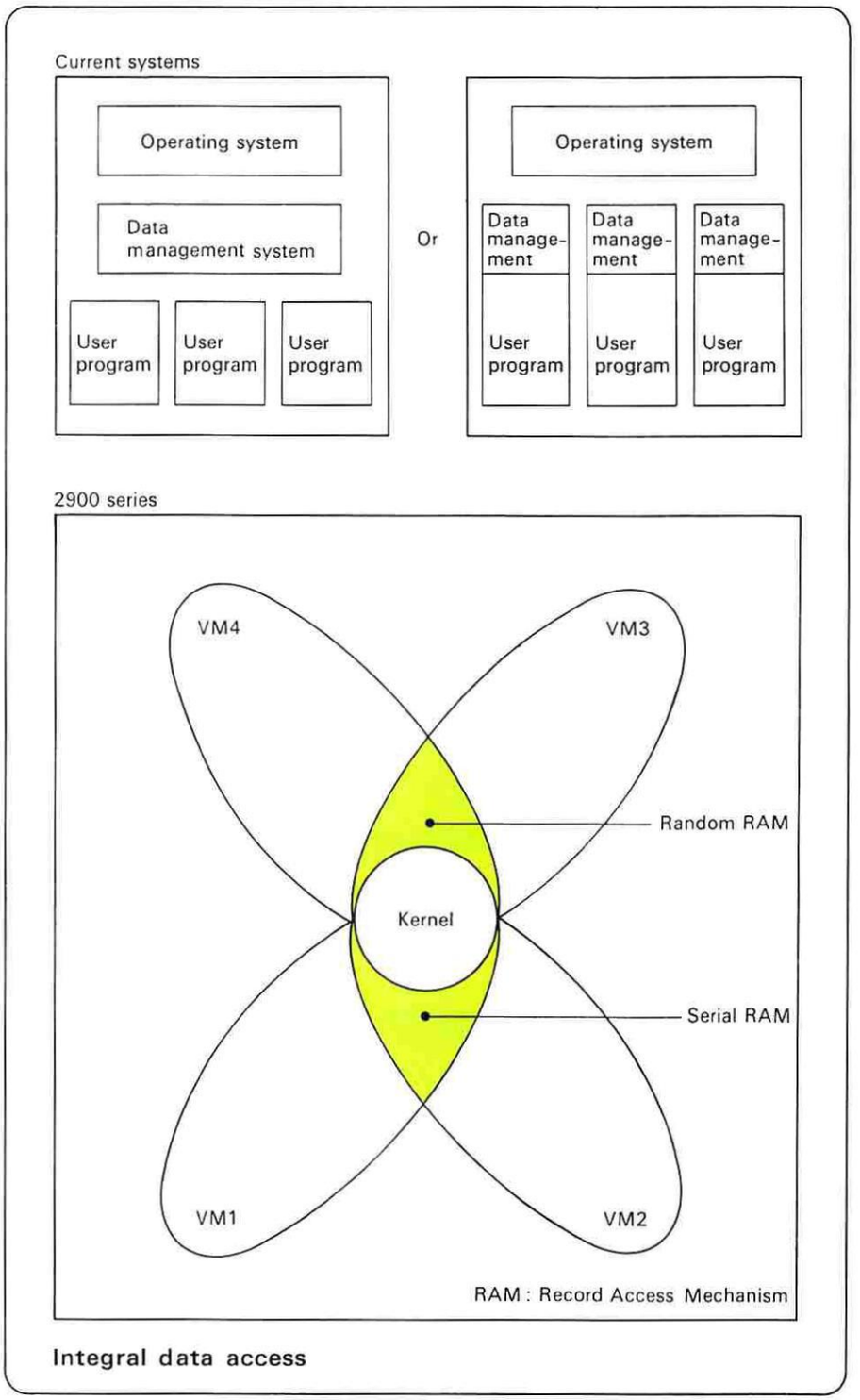
Section 5

Evolutionary data management

The 2900 Series Data Management Software (DMS) is a new approach to data handling. It allows an installation to grow in easy stages from simple information systems to complex ones without the need for reprogramming and without disturbing the end user's simple interface to his own private data.

Its most important features are:

- **It is an integral part of the 2900 system architecture providing a unified interface to all data**
- **It is used selectively providing only those facilities wanted for any particular system**
- **It provides total independence of all programs and data**
- **A wide range of aids are available for controlling the design and implementation of data bases**
- **It includes all communications handling**
- **It offers a number of levels of privacy and security**
- **A file manipulation language provides comprehensive facilities for data administration and allows simple systems to be constructed with minimal effort.**



Integral data access

Integral data access

In the past there were two ways of providing user programs with data handling facilities. The first was to compile the relevant input/output routines into the user's program, thus providing it with the right facilities but at the price of poor store utilisation and inflexibility. The other was to provide a single large piece of software in addition to the operating system which the user program called when it required input/output services. This meant that all programs had to use this software with its attendant overheads whether they required the facilities or not.

Because the architectural features of the 2900 Series allow the natural sharing of code, these deficiencies are overcome by the use of specialist shareable Record Access Mechanisms which are incorporated into the user's virtual machine at load time. These provide the user with all the facilities he requiries without the previous store overheads and within an efficient totally protected environment.

Program and data independence

The 2900 Series Data Management System provides the user with an extremely powerful Data Description Language (DDL). This, after processing by the DDL translator, allows the user to set up a library of data descriptions which can be stored independently of any application programs. If a file format is subsequently altered, the relevant application programs need only be recompiled without any changes being made to the program source. This approach also ensures that there is no duplication of data descriptions. Therefore the consistency of data within any application system is ensured.

Designing and implementing data bases

The 2900 Series Data Management Software provides the larger user with several aids for designing and implementing data bases with a high degree of efficiency, simplicity and control.

The two most important aids are

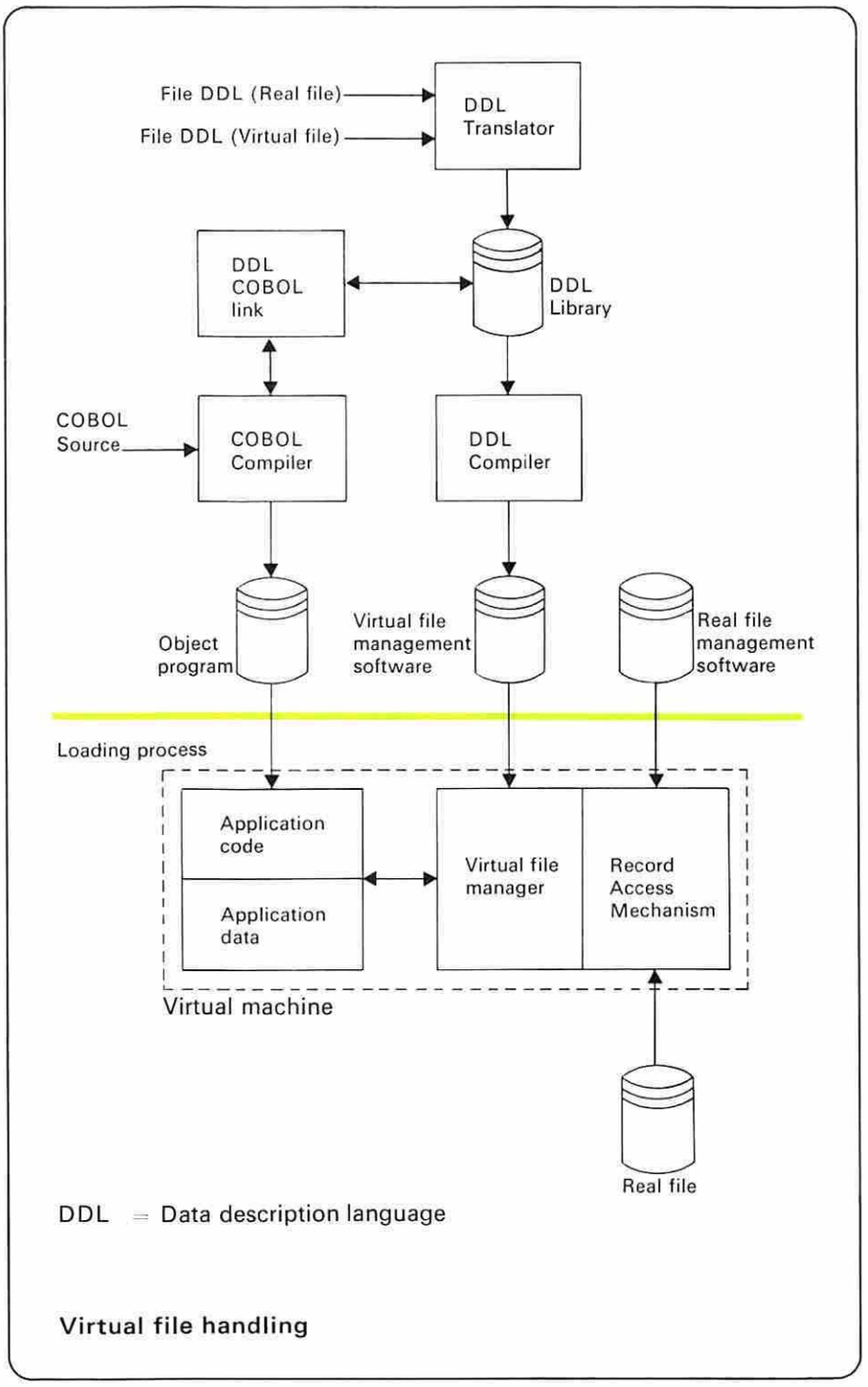
Virtual file management:
This allows each user to specify his own view of a real file, using the Virtual Data Description Language. This specification then automatically invokes virtual file management software which provides the user with the data sub-set he needs.

The database dictionary:
This contains total information about the contents of a user's database. It therefore helps him to control the design and development of his database, and to facilitate enquiries relating to the system while at the same time obviating duplication.

These facilities constitute the basic database environment. With their aid, the user can achieve the benefits of program and data independence while retaining the use of traditional serial or keyed files.

Integrated Database Management System (IDMS):
Where the application requires the presentation of more complex relationships between records, these can be supported by the CODASYL set concept, which is the prime feature of IDMS. The CODASYL set is the building block from which the hierarchic and network structures required, by such applications as parts control or order entry, can be readily constructed.

The user is therefore able to proceed through various levels of data handling to the level of complexity he requires, without invalidating his current investment in programs and data.



Virtual file handling

Communications handling

An important feature of the 2900 Series Data Management Software is that it presents the user with a single interface to all data, including that transmitted to, or received from, a communications device.

By this means the programmer need not take into account any special characteristics of such terminals when implementing a communications system.

Also the ability to make on-line enquiries of all databases on the system is natural and efficient.

Privacy and security

As more and more people come to rely on the computer for a particular service and as more and more data is made available to them, it is important to provide systems with effective methods of ensuring the privacy of information and security against loss of data.

The Data Management Software provides a number of different levels of both privacy and security allowing the user to choose the one suitable for his operation.

The facilities provided include:

access to all files controlled by the System Catalogue;

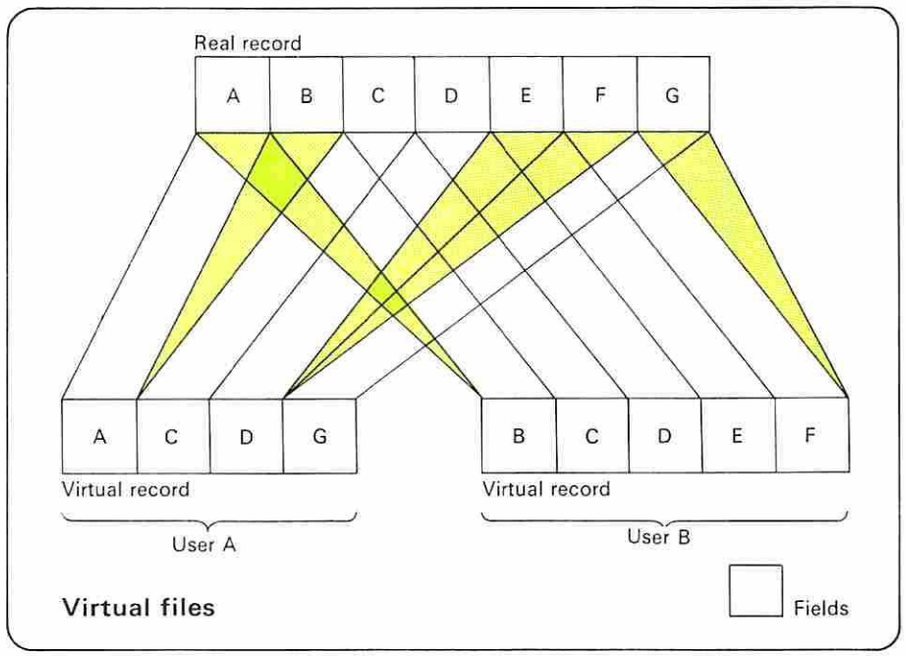
all data descriptions protected by privacy locks;

the protection of secret or sensitive data through the virtual file management system;

'before' and 'after' journalising of updates;

the prevention of unauthorised access to confidential data except from specified terminals.

All these facilities are implemented by the wide range of privacy facilities provided through the VME/B System Control Language, and the virtual file management system.



Virtual files

Data management utility system

In the design of the 2900 Series a unique approach to the totality of file manipulation functions has been adopted. This approach provides consistent facilities in the areas of:

File creation;

File amendment and updating;

File transcription and rearrangement;

Retrieval and reporting.

Each utility is invoked via the System Control Language, the parameters to the macro command specifying the operation required. Further qualification is provided by a powerful File Manipulation Language.

The utilities provided include:

Data Validate

Update

Sort

Merge

Compare

Report.

By providing various levels of use of this sophisticated system the 2900 Series Data Management Utility System can be used for:

data administration;

the development of small commercial applications;

program development (validation and analysis of test data in particular);

information retrieval and reporting, allowing both standard and ad-hoc enquiries to be made of 2900 Series data files.

Section 6

Application systems

The coherent design approach which ICL has adopted for the whole range of 2900 Series hardware and software products has been extended into the design and implementation of 2900 Series Application Systems. This approach provides a number of fundamental benefits, some of the most important being

- **Application compatibility**
- **Continuity and protection of investment**
- **Effective user tailoring**
- **Ease of use**
- **Resilience**

Application compatibility

The Application Systems provided on the 2900 Series have not been conceived on an individual, piecemeal basis but are the result of an integrated approach which exploits the facilities for sharing code and data between systems. Each Application System has been analysed and divided into its component parts or functions allowing those which are common to be shared across applications. In particular 2900 Series DMS is used extensively to provide a user interface, so that data files may be shared by Application Systems and user programs alike. Store requirements are thus reduced and organisations can exploit this flexibility in order to optimise the use of their applications.

Continuity and protection of investment

ICL has always been concerned to provide its customers with a total set of facilities. The provision of a wide range of applications software on the 1900 and System 4 series illustrates one aspect of this aim.

The 2900 Series Application Systems provide a high degree of continuity for existing users of application software previously issued. The investment based on this software is preserved by optionally allowing, in the majority of cases, the user data interface to be similar to previous interfaces.

In this way, current data files can be transferred to 2900 Series computers whilst retaining the interface to the users' business. This reflects ICL's desire to provide facilities within the 2900 Series that cater for existing users, without compromising the opportunities for exploiting the advanced features of the new equipment.

Effective user tailoring

With the 2900 Series, ICL has recognised the need for users to be able to tailor an application system in order to provide the total solution to a particular organisation problem by the addition of user-written code. Two aspects of the design of the 2900 Series Applications Systems enable this to be simply and effectively achieved.

Firstly, the adoption of a modular approach for each System allows interfaces between the various component parts to be naturally and conveniently defined, and, where appropriate, designated as optional user interfaces.

Secondly, the use of High Level Languages, such as COBOL and FORTRAN, in the production of the Application Systems, ensures that these interfaces are well documented and easily employed.

These features increase the opportunity for users to harness ICL software in meeting their own very individual requirements. Thus valuable programming resources are dedicated to maximum concentration on those parts of the problem most closely related to the user's requirements.

Ease of use

Much of the applications software that has been provided in the past by the computer industry has required rather stylised, parameter-based input in order to communicate user instructions. With the 2900 Series Application Systems, every opportunity is taken to employ natural language communications, making the software easier for all to use.

Resilience

In common with all 2900 Series products, resilience is a key feature of the Application Systems. This is achieved in several ways:

For example, all systems use the 2900 Series DMS and are thus able to exploit its extensive built-in recovery facilities. The user is therefore protected from the heavy waste of computer time which might otherwise be experienced as a result of faults arising during a long PERT or Linear Programming run.

2900 Series Application Systems

Throughout the range of 2900 Series Application Systems, the most recently evolved techniques have been incorporated into the design of both algorithmic and data handling elements. The initial Application Systems available with the earlier 2900 systems are as follows:

PERT (Project Planning and Control)

PROSPER (Financial modelling)

CREDITS (for retail and wholesale distribution)

Material Control

Bill of Materials Processor

Interactive Data Handler

Forecasting

Statistics

Matrix Handler

Linear Programming

Numerical Algorithm Library

ACSL (Advanced Control and Simulation Language)

Structural Engineering

Section 7

Communications excellence

The 2900 Series has been designed specifically to offer users the advanced communication facilities which will be required for the applications of the 1980s. This has been achieved through the adoption of a newly devised architecture which serves as the foundation for communications.

In particular the 2900 Series provides

- **Efficient handling of communication systems**
- **The ability to reduce dramatically the implementation cost and timescales of communication based systems**
- **A level of resilience and system availability commensurate with its position at the heart of a communication network**
- **A wide range of communication and terminal equipment allowing the user to grow from small systems to large networks without the loss of his initial investment**
- **A new line procedure providing the user with improved line utilisation and hence reduced network costs**

Efficient systems

The 2900 Series provides all those facilities necessary to effectively support fully integrated communication systems as an inherent part of both the hardware and software architecture.

This is in contrast with current systems where the communication facilities are added on to a system originally conceived to carry out batch processing.

The 2900 Series architecture is particularly good at supporting on-line applications because of its use of virtual machine processing. This eliminates the need for time-wasting analysis when applications systems have to call supervisory functions in a time-critical situation.

Fast response is also aided by the stack, through its ability to provide workspace dynamically whenever it is needed, without prior allowance having been made for storage allocation.

Communications support is built into the hardware design in several ways. In particular, links to the CLC and CNP communications controllers are made via the standard peripheral controller trunk link.
Similarly, communications facilities are provided throughout the operating software systems. The supervisor includes specific communication schedulers and message responders; the Data Management Software provides uniform interfaces to peripheral devices, whether they are connected via communication lines or not.

Reduction of implementation effort

In the High Level Language environment of the 2900 Series the user is able—for the first time—to implement his transaction processing systems in a problem-orientated language like COBOL.

This is possible on the 2900 Series because the hardware architecture has been designed to support the efficient compilation and execution of High Level Languages by the judicious choice of a suitable order code, and the use of such techniques as the stack and the descriptor mechanism.

In addition to this, the 2900 Series software systems provide the facilities which, with previous machines, the user had to implement himself, usually at considerable cost. Thus the 2900 Series provides comprehensive recovery procedures and scheduling mechanisms. As well as this the COBOL compiler provides the user with facilities which supersede the low level language procedures of the past.

Not only is the implementor considerably aided by all these facilities but the systems designer no longer has to concern himself with such matters as code sharing or interaction with other application systems. All such facilities are provided automatically in the 2900 Series through segmentation, the virtual machine and the ACR protection mechanism. The 2900 Series software also provides the user with a number of development aids of particular use during the implementation of transaction processing systems.

One of these—the Communications Network Simulator—allows a transaction processing application to be thoroughly tested without the actual communication network being available.

New levels of resilience
Features aimed at providing high resilience are apparent throughout the 2900 Series architecture.

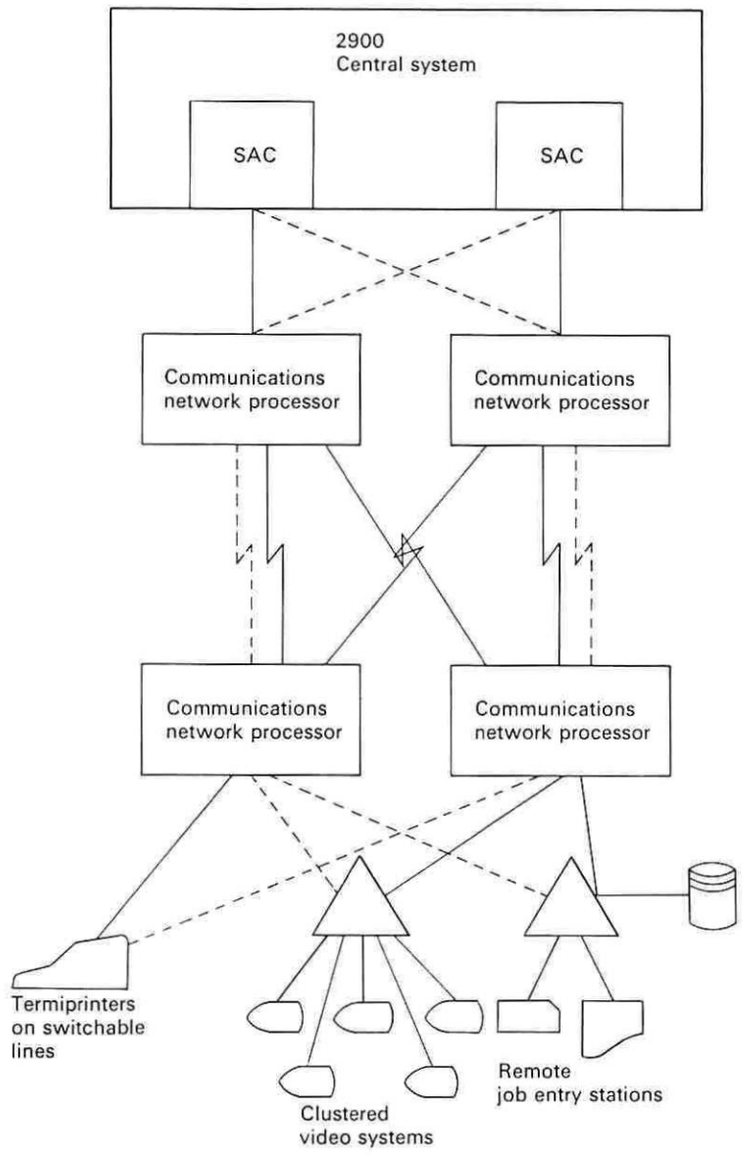
Virtual machine processing and the ACR protection levels ensure that errors occurring within a system are not only contained within that application but also within certain areas of that application.

For instance, if an error were to develop in an on-line application due to a faulty message, only that particular message would be affected, allowing the rest of the service to be maintained. This is in direct contrast with current systems where an incorrect transaction can cause the whole system to fail.

The communications hardware and software also provide a wide range of facilities: line error rates can be monitored; the number of retransmission attempts can be preset by installation management; and an early warning of impending line failure can be indicated.

In the case of a failure—or warning of such a failure—lines can be removed from the system and substitute lines dynamically brought into action by the operator. The behaviour of channels may also be monitored and action taken to overcome bottleneck situations.

The Communications Network Processor can carry out message spooling in the event of a mainframe failure and all lines may be switched or jacked between channels, on either the same or another communications controller. Modems and lines can be supported by the use of standby facilities, and switched connections can be brought into use if leased lines fail.



Total switching capability

Wide range of communications equipment
The 2900 Series provides a wide range of communications equipment allowing the user to tailor the system to suit him best.

Communications controllers
The Communications Link Controller (CLC) is the principal method of connecting remote terminals to a central 2900 System. The CLC is a microprogrammed processor capable of handling up to 128 lines at speeds varying from 50 bits/second to 9600 bits/second with the potential of handling speeds of up to 48 Kilobits/second at a later date. The CLC is a character-buffering device. It optimises queue lengths and turnround time by polling under the control of the central system. It allows lines and line speeds to be switched dynamically; and auto-answering facilities are available where applicable.
A development of the CLC is the Communications Network Processor (CNP). In addition to those facilities provided with the CLC, the CNP allows the attachment of local peripherals, including fixed and exchangeable disc stores, magnetic tape transports and line printers. The CNP allows message-buffering; and its processor capabilities can be used for message switching and other functions. The CNP is also available as a remote concentrator. In the case of CLC and local CNP the connection to the 2900 central system is via a trunk link.
7903 and 7905 communications processors may also be linked to the 2900 Series via a GPC, thus protecting the user's investment in communications hardware.

Terminals

The terminals available with the 2900 Series range from the simple teletypewriter to the sophisticated stand-alone 2903 computer system, allowing the user to arrive at the most economic solution to his network requirements.

A summary of their characteristics is as follows:

Teletypewriter
ASR or KSR, operating at up to 10 characters/second using a 64-character set. Both can operate over telegraph or telephone lines at between 75 and 110 bits/second.

Termiprinter
A quiet character printer operating at up to 30 characters/second. It offers 75 or 118 print positions using a 96-character set. It incorporates error detection facilities and operates on telephone lines at up to 300 bits/second.

Visual display terminal
The 2900 Series version of the ICL 7181/2, this terminal offers a 2,000-character screen, 96-character set and includes such features as cursor control, rack-up, protected field, optional badge-reader, 30 characters/second hard copy printer, function and alpha-numeric keyboard. It operates on lines at between 600 and 4,800 bits/second.

7500
The 7500 range of modular terminal systems is based on two mini-processors; the 7502 and 7503.

The 7503 operates at speeds up to 9600 bits/second and controls a combination of devices selected from:

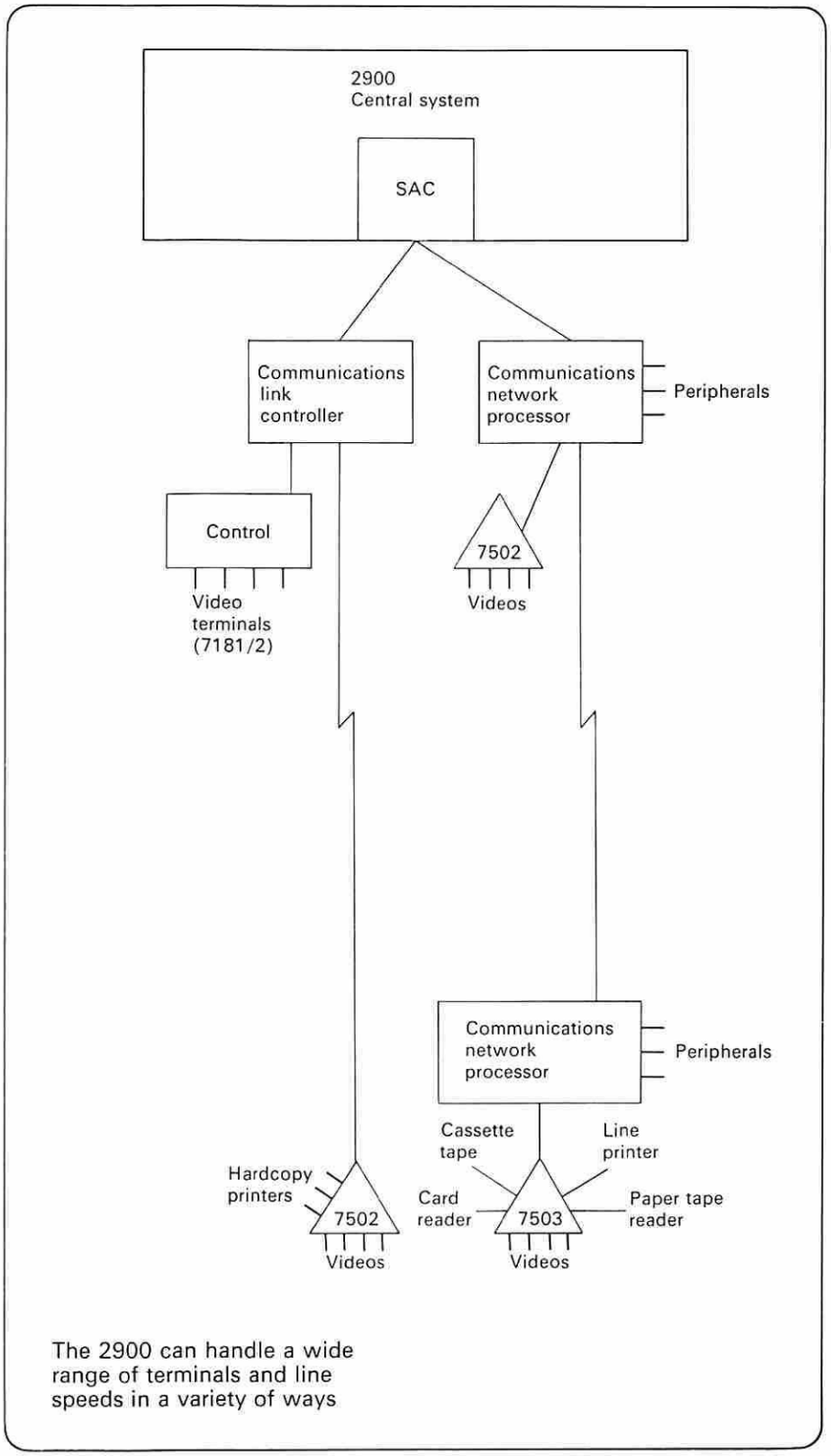
Video Terminal (VT-2000)
—up to 8
2000 character screen, 96 character set.
Personal Identification Device (PID) for security purposes.

Hard copy printer
—up to 8
118 print positions 96 character set and a speed of 60 characters/second.

Line printer
132 print positions and printing speeds of 150, 300 or 500 lines per minute.

Card reader
—300 cards per minute

Paper tape reader
—500 chars. per second



The 2900 can handle a wide range of terminals and line speeds in a variety of ways

Cassette tape drive (single or dual)

The 7502 can operate at speeds between 600 and 4800 bits/second. It has teleload facilities. Peripherals supported are up to 8 video terminals and up to 4 hard copy printers. These are to the same specification as the 7503 peripherals.

Both the 7502 and 7503 provide facilities allowing sophisticated error-detection and validation to be carried out locally.

2903
The 2903 processing system, besides offering the user a powerful, economic stand-alone system, can also be connected to the 2960, 2970 and 2980 systems for use as a remote job entry terminal.

Section

Application continuity

The 2900 Series is part of an ever-expanding range of products and services which ICL is providing worldwide to an extensive spectrum of customers . . . in government and industry, in retailing and finance, in research and commerce.
It provides:

- **An evolutionary growth path for our current users through the provision of forward compatibility standards**
- **Protection of current investment in peripheral and terminal hardware through a strategy of range independence**
- **A comprehensive set of transition aids for our current users covering both applications and data**
- **An attractive path to users of other suppliers' equipment by following the latest international standards for High Level Languages**
- **The opportunity now to develop with confidence the new large-scale applications which users will be requiring in the 1980s and beyond**

An evolutionary growth path

During the last 10 years, the 1900 and System 4 ranges have been highly successful in world markets and it is ICL's intention that they shall remain so for many years to come.

Because of this large and expanding customer base, the 2900 Series has been designed to provide users with a long-term evolutionary growth path. This allows them to continue applications development on their current systems, using a set of data and program standards which are forward-compatible with the 2900 Series. And so, as and when a user wants to tackle more advanced applications which need the facilities of the 2900 Series, his current applications will be transferable to the new machine with a minimum of effort.

Range independence

One of the reasons why the 2900 Series is able to provide users with a growth path which protects their investment in peripheral and terminal hardware, is ICL's strategy of range independence.

Since 1968 ICL has been steadily developing both the 1900 and System 4 ranges of computers towards the 2900 Series.

In particular, the EDS30 and EDS60 are common to both the 1900 and System 4 ranges of equipment. This is also true of terminal devices including the 7181 series, and the 7503 remote job entry terminal.

ICL has also been able to make available on current systems certain 2900 Series developments. These include 7503, 7502, train printer and the semiconductor store on 1900 systems.

Due to this strategy, all of the following devices can be used as peripherals on the 2900 Series.

Via DFC:
EDS30; EDS60

Via CLC:
7181/2 VDU
Termiprinter; Teletypewriter
7502; 7503

Via GPC:
9-track PE magnetic tape system (2504/5/8/9)
7-track magnetic tape system (1972/3)
2430 Train printer
1933 Line printer
7181/4 Local VDU
Local VDU cluster controller
7903 communications processor
7905 communications processor
and their current terminals

A comprehensive set of transition aids

The 2900 Series design recognises the importance of our users' investment in programs and data for both our 1900 and System 4 ranges and therefore provides a wide range of aids in order to:

run 1900 and System 4 programs on the 2900 Series allowing multi-programming of a number of 2900 jobs with several 1900 or System 4 jobs. Existing EDS and magnetic tape files can be used with these emulated jobs as well as current range card and paper tape files.

convert 1900 and System 4 programs and data in order to take advantage of all the new and advanced facilities provided on the 2900 Series.

The program and data conversion systems provide extensive facilities for bringing a user's current systems on to the latest available International Standards for High Level Languages, in particular COBOL. Source converters are provided which translate the current programs to the new International Standards and also provide full diagnostic information and documentation.

Comprehensive facilities exist to enable the transfer of data files to 2900.

The range of transition aids is as follows:

1900 FORTRAN Source Converter
1900 COBOL Source Converter
System 4 COBOL Source Converter
System 4 FORTRAN Source Converter
1900 ALGOL Source Converter
1900 (George 2) Emulation Environment Package
1900 (George 3) Emulation Environment Package
1900 George 3 Filestore Copy Utility (Runs on 1900)
System 4 (J-Level) Emulation Environment Package
1900 File Conversion System
System 4 File Transfer Utilities
System 370 File Transfer Utilities

The continued development and support of both the 1900 and System 4 ranges, particularly in the area of communications, and the comprehensive set of transition aids which ICL is providing, means that a whole range of choices are open to all users so that each can choose the development path that most exactly matches the information processing requirements of his business.

In particular, for those organisations moving into the areas of large-scale mixed-mode and transaction processing workloads, the 2900 Series provides a unique opportunity with considerable benefits in terms of

Efficiency

Cost-effectiveness

Speed of implementation.

The 2900 Series has been designed to meet the new user requirements of the 1980s.

The 2900 Virtual Machine Environment provides

Communications Excellence

Evolutionary Data Management

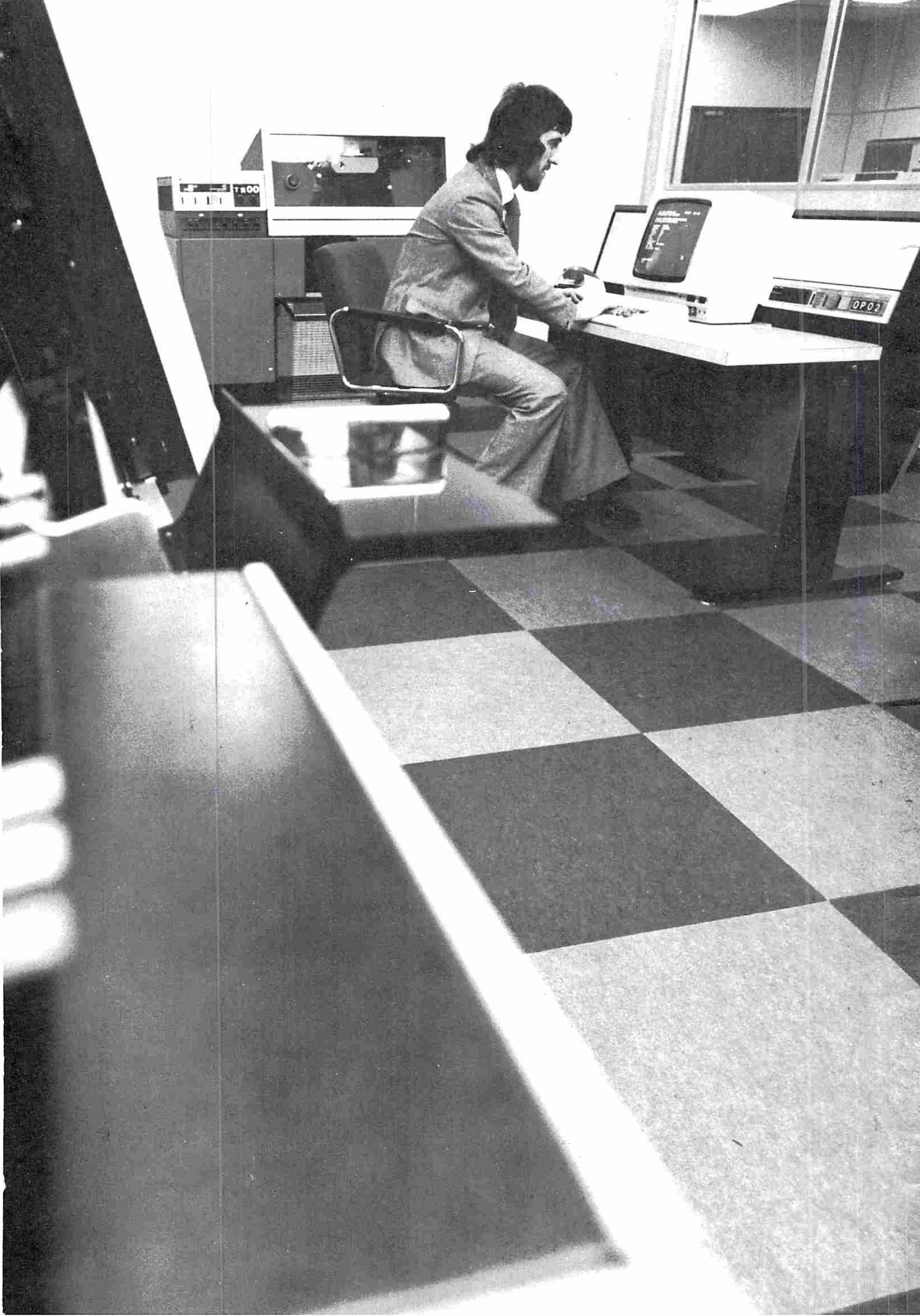
Ease of Implementation

Workload Versatility

Hardware and Software Resilience

More Usable Power

Application Continuity


T800
OP02

International Computers Limited

World Headquarters
ICL House
Putney
London, England
SW15 1SW

P1096 Printed in England 5m/3.76/TK