



I.C.T 1900 SERIES

EXECUTIVE for the multi-programming central processors

DESCRIPTION

'Executive' is the name given to a program which, when the Central Processor is in normal operational use, is always present in the core store, and which controls all the other programs that are in the system at any time. To distinguish them from Executive these other programs are referred to as operational programs. The main functions performed by Executive are:

1. Interpretation and execution of the operator's commands to the system, and provision of information for the operator concerning normal running incidents in operational programs and peripheral devices needing attention.
 2. Multi-programming, i.e. the allocation of the time of the Central Processor among the operational programs in the system so as to achieve maximum utilization of Central Processor and peripheral devices;
 3. Allocation of peripheral devices to operational programs that are entered in to the system, and the control of data transfers to and from peripheral devices;
 4. Monitoring of program error and peripheral device failures.
- From the point of view of the user many of the functions carried out by the Executive will appear as if carried out by the Central Processor electronics. The use of an Executive program enables many complex functions to be incorporated in the system without a corresponding increase in the amount of electronics required, and the system to be readily adaptable to changing circumstances, such as the availability of new types of peripheral devices.

General principles

Operational programs are prevented by means of the store reservation circuits from interfering with one another or with the Executive. When activating a program, the Executive sets up Datum and Limit points which define the area of store available to that program. No re-

striction is made upon the Executive itself, and it may refer to any core store location. An operational program refers to core store locations relative to its own datum point as zero, so that the absolute addresses of the store locations into which the program is loaded are of no consequence to the program. Programs can in fact be moved around in the store in the middle of a run.

An entry to the Executive can be one of two types, known as Voluntary and Involuntary. The first type occurs when an operational program obeys an instruction which calls for Executive action, for example, a peripheral transfer request or an 'extra-code' facility such as conversion between fixed and floating point. These instructions appear in the program as normal machine orders, the function codes being interpreted as calling for Executive entry. Involuntary entries, on the other hand, arise mainly because of events outside the Central Processor; normally peripheral events such as completion of a transfer, or the occurrence of a parity failure, but including also operator actions. For convenience, certain errors such as an attempt by a program to violate its store reservation are also made to give rise to Involuntary entries. With both types of entry, the Executive has means of determining the exact cause.

Operator communication

The operator may communicate with the Executive program by means of the console typewriter. This is an input/output typewriter, allocated permanently to Executive, and provided with buttons to allow the operator to indicate that he wishes to insert a message on the keyboard. Additional buttons allow the operator to instruct Executive to read prepunched messages via one of the paper tape or card readers in the system. The operator uses standard messages to load and enter programs, alter priorities, delete programs, and perform other necessary operations. The Executive reports peripheral device allocations, points requiring opera-

tor's attention such as 'card hopper empty', or 'paper out' on the printer, and any irregular occurrences such as reservation violations or peripheral device errors. The console typewriter is not available for inserting messages into the operational programs in the machine.

Loading and deleting programs

The main types of messages entered by the operator on the typewriter concern the loading, starting and deleting of programs. The user has complete freedom of choice regarding the programs scheduled for operation, and the sequence in which they are loaded, provided that adequate core storage and sufficient quantity of peripheral devices of each type are available for the needs of the programs running in the system at any one time.

When a program is to be loaded into the machine, the Executive makes a check that the core storage and certain types of peripheral devices required are in fact available, and provided that they are, it allocates them to the program. For this purpose Executive maintains a list of programs in the machine, showing their datum and limit points. It also maintains a list of all peripherals, showing which program they are allocated to. Deletion of a completed program involves returning its peripherals and store allocation to a pool. It may also involve moving other programs' areas within the store to close the gap so that there is a continuous area for new programs. A program will normally request its own deletion when it has reached the end of processing, and at this time it may also issue a message to Executive regarding the loading of a successor program. This enables the automatic sequencing of jobs to be achieved.

Peripheral device allocations

Any installation has a certain number of peripheral devices which may be allocated in any manner between the operational programs in the machine. Each operational program refers to

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individual peripheral devices of any type by means of local numbering system. Executive maintains in its peripheral device list the correspondences temporarily established between a program's local numbers and the absolute identity of the device actually allocated to the program. Allocations of slow peripherals are normally made when the program is loaded, while allocations of magnetic tape decks, or of data files occupying portions of a disc store, are made when a program actually requests them by means of 'Open File' instructions giving voluntary entries into Executive.

Peripheral transfers

All transfers of data to or from peripheral devices are requested by means of voluntary entries to Executive. While the central processor is in Executive mode certain instructions are available which enable Executive to send signals to the actual logical elements which control the peripheral devices (e.g. Start, Read, Write, Disengage), and to obtain responses from those elements which indicate the status of the devices (e.g. Busy, Transfer Ended, Parity Fail, Card Hopper Empty).

When a peripheral transfer is requested by a program, the Executive must determine from its list the actual device to be used, and also check that the store area involved in the transfer lies within the allocation for the program. Then so long as the device is not busy (i.e. not still performing the previously requested transfer) the transfer is initiated. If the device is busy Executive suspends the program. Likewise if the program reaches a point where it cannot continue until the transfer has finished, it can ask Executive to suspend it until the transfer finishes. On completion of a transfer, the device causes an involuntary Executive entry. Executive determines whether the transfer was completed correctly. If so, and if the program had been held up waiting for the transfer to finish, then Executive removes the suspension and allows the program to continue. If there was an error in the transfer, such as a parity failure on magnetic tape, or read-check

failure in a card punch, Executive arranges to repeat the transfer up to a predetermined number of times before notifying the operator. If the transfer can be correctly carried out during one of the repeat operations then the program will be allowed to proceed as if no error had occurred. In a similar way, if a program requests a peripheral transfer, and Executive determines that the transfer cannot be carried out because of conditions requiring operator attention, such as Hopper Empty on a card reader, the program is suspended and the operator notified. After the operator has taken the necessary action, he presses the appropriate button on the peripheral: an involuntary Executive entry occurs, Executive then causes the requested transfer to take place and releases the suspension of the program.

Multi-programming

Each program that is loaded on the Computer bears a priority number, and the operator has a means of varying the priorities during running if desired. The basis of the time-sharing arrangement is that a program is allowed to run until the completion of some peripheral transfer occurs. When any program suspension due to the transfer has been removed, the list of programs is scanned in priority sequence, and the first program encountered which is free to go is activated.

The process of activation includes setting the Datum and Limit points which define the store area available to the program, and re-entering the program at the point at which it was last interrupted. The program now runs until the next completion of a peripheral transfer causes it to be interrupted again by an involuntary Executive entry.

As a general rule a program which makes use of a slow peripheral (paper tape or card devices, line printer, etc.) should have a higher priority than a magnetic tape process. This is because such programs will tend to be held up at regular intervals and in fact require only a small proportion of the Central Processor time. During these hold-ups, the faster process can be activated.

On the 1904, for example, up to four programs may be handled simultaneously.

A normal pattern of multi-processing might involve a main updating program generating large volumes of printing run simultaneously with a magnetic tape sort and with a card to tape transcription.

Monitoring

The means by which Executive monitors the activities of peripheral devices, reporting incidents and failures to the operator when necessary, has already been described. Executive also performs monitoring of certain types of program errors. The action taken in all cases is to notify the operator of the error and to suspend the program awaiting an operator command to delete the program, or to continue running it, possibly from some special restart point. One type of error that is handled in this way is an attempt by a program to address a part of the store beyond the limit point assigned to it. Such errors must be prevented to avoid interference between programs. The actual detection of such an error is carried out by the reservation circuits when the error is in an internal processing instruction, and by Executive itself when a buffer area specified for a peripheral transfer request extends beyond the program limit. Another type of error detected by Executive is the attempt by a program to call for a transfer on a peripheral device of a type which is not available in the installation, or on a peripheral device not requested by, and therefore not allocated to, the program.

CONCLUSION

An Executive program is an essential requirement in advanced computer systems such as the 1900 series. It removes from the programmer the problems involved in multi-programming and in controlling a complex of peripherals and achieving maximum utilization of each unit. It warns the operator of units needing attention and provides an accurate log of the operation of the system.

This specification is subject to modification

INTERNATIONAL COMPUTERS AND TABULATORS LIMITED

Head Office I.C.T House Putney London SW15

Sales Office Bridge House Putney Bridge London SW6 Renown 3322
and local offices throughout the United Kingdom