6. PRIORITY CONTROL ROUTINES

6.1 Priority Arrangement

Each programme is given a 'priority class' by the programmer:

Master Programme	1
'Pseudo-off-line' programmes, and programmes requiring little use of the arithmetic unit ..	2
Main programmes	3
'Filler' programmes	4

Within classes 2, 3 and 4 priority is in order of time of loading, although the operator has the facility to re-order the list, (see section 6.3). The operator may command the Master Programme to type out the 'priority list' in the log.

The priority class and identity of all programmes in the priority list are typed out (except the Master Programme).

Note: Facilities to re-order and to type the list are optional in the Master Programme.

The 'priority list' is amended whenever a programme is loaded or unloaded.

6.1.2 Priorities within the Master Programme

The Master routines are held in the following priority order:

(i) Log Routines

(ii) Operator Intervention Routines

(iii) Input/Output Control Routines

6.1.3 Special Operator Instruction

The priority list can be amended by operator command (this is an optional facility).

The positions in the priority list of the programme specified by the control data and the programme immediately above it are interchanged. A comment is typed in the log giving the identity of the specified programme.

If the specified programme has the highest position (excluding the Master Programme) the command is rejected and the operator informed.

6.2 Purpose of Priority Control Routines

The purpose of these routines is to control timesharing by ensuring that control is always with the highest priority programme that can proceed.

Control is passed to a programme of lower priority when:

1. A route required by the current programme is found to be engaged. (see section 6.3).
2. The current programme uses the Intercode 150 action and is waiting for the operator's option choice. (see section 6.4).
3. The programme is closed by operator command. This command is an optional facility.

Control is passed to a programme of higher priority when:

1. A route required by the higher programme becomes available. (see section 6.5).
2. An operator's choice of options is made for it. (see section 6.5).
3. It is opened by operator command after having been closed by command. The 'Re-open Programme' command is an optional facility.

Also included are facilities for timing programmes (see section 6.6), and routines to control use of the log routines (see section 6.7).

6.3 Action when a route is found to be engaged

When a programme requires to input or output information by a Group 4 Intercode Action, control is passed to the Input/Output Control Routines. These arrange to set up a 'test route' instruction in the appropriate control area. If the route is found to be engaged control is passed to the next programme in the priority queue. If the programme is of lowest priority an interruptible 'howl' is entered until any programme can continue.

6.4 Action when an operator decision is awaited

When a programme has used the Intercode 150 action and is waiting for the operator's choice of options, control is passed to the next programme in the priority queue. If the programme is of the lowest priority an interruptible 'howl' is entered until any programme can continue.

6.5. Action when a route becomes available or an operator decision is made

When a route which having been tested and found to be engaged becomes available, or if the operator presses the stack indicators key, or a route is set from manual to computer, a request for interruption flip-flop is set. This flip-flop is also set at intervals of one second, and is driven by the millisecond timer if this is supplied.

The computer operates in two modes, the interruptible and non-interruptible as determined by computer code actions. If the request for interruption is set, interruption will occur as soon as the computer is put into the interruptible mode, if it is not already in that mode.

Interruption sets the computer into the non-interruptible mode, resets all requests for interruption and places the contents of the sequence control register into compartment 8 of division 0. The instruction in compartment 9 of division 0 is then obeyed.

The instruction in compartment 9 is a sequence change into the priority control routines which store the contents of registers A, B and C in the program control area of the program just left by interruption, and store the contents of compartment 8 for return to that program.

The routines then determine if the log routines have information still to be output, and arrange to enter the log routines as required. If the log is not required to be used the routines determine if interruption was caused by the operator stacking indicators as a command or as a choice of options; and if it was, enters the Operator Intervention routines (see section 5). Otherwise the routines determine if a new log entry is required and arrange to enter the log routines to initiate it. If no requests for the log are set control is passed back to the highest priority program capable of continuing.

When control is passed back to the program, the required modifier group is set, registers A, B and C are restored and a sequence change made back to the program, which also sets the computer in the interruptible mode.

6.6 Timing Facilities

6.6.1 Time spent in Programs

The program timing routine is an optional facility available on all installations fitted with the hardware millisecond timer. On loading the Master Program this routine is inactive; it may be turned on or off by the start and stop timing commands. In the active state the timing routine costs an overhead of 25 % extra time in the priority control routine.

The operation of the millisecond timer is independent of the computer even when the latter is halted (e.g. by lockout). A counter is maintained in the store (division 0 compartment 157) which is stepped by 1 every millisecond.

The timing counter is cleared when entry is made to any program. On return from the program the contents of the counter are augmented to a total in its control area which thus represents the time spent in the program. For timing purposes some common routines of the Master Program are charged to the program using them. These routines are:-

1. Input/Output Control routines excluding the time spent in dealing with route alarms and delay in obtaining access to an assembler.

2. Programmed offer of options routine up to the point where control is passed to the log routine.

3. Program comment routine.

4. Unload routine up to the point where control is vested in the master routine control area.

5. Overlay routine.

Because interruption automatically occurs before the timer reaches its maximum value there is no possibility of passing through zero before augmenting the time to a programs counter.

The time is output on the typewriter as part of the END and ABDON comments in minutes and seconds rounded off.

6.6.2 Ineffective time

This time is obtained from a counter at the bottom of the priority queue. This counter counts the number of actions performed there between interruptions while waiting for some program to continue. It is converted into minutes and seconds by multiplying by a factor dependent on the action speeds of LEO III, 326 or 360. Each END and ABDON comment displays the ineffective time since the previous such comment.

For installations which do not practise a high degree of timesharing, the efficiency when sharing an assembler between more than one program can be increased by the presence of the ineffective time routine. This effect is produced by the decrease in the ratio (time spent in priority control routine between neighbouring program control areas) to (total time spent in priority control routine).

6.6.3 3 Minute delay.

The 3 minute delay routine is used by the route closed (Section 1.2.1.1) and deferred option (Section 5.3) routines. The delay is produced by setting the associated time counter in the program control area 3 minutes ahead of present time. At each entry to the program control area a comparison is made between present and associated times until the 3 minute delay is completed. Present time is as given by the Saxby Clock (Section 4.4) on installations having this hardware facility. On other installations the clock is simulated by a counter based on the number of entries to the priority queue.

6.7 Request for Use of Log Routines

When a program uses the Intercode 150 action the Priority Control routines set up a request for access to the Log routines, and arrange to return to the program at the correct point once an option choice has been made.

When a program uses the Intercode 154 action the Priority Control routines set up a request for access to the Log routines and arrange re-entry to the program.

7. ALLOCATION AND LOADING PROCEDURES

7.1 Purpose of Allocation

The computer faciltiies may be divided into two classes :

(i) those of which common use is made by all programs running at a particular time (e.g. Arithmetic Unit). Access to these is regulated by the Priority Control Routines (see section 6).

(ii) those whose use cannot be shared (e.g. an input or output route, particular store compartments). Such facilities are allocated to programs according to their requirement by reference to a table of available facilities maintained within the Master Program.

Allocation of facilities and program loading are carried out by the Program Loading Sequence which is generated by the Intercode Translator and written in front of the computer code version of every program.

7.2 Facilities Requiring Allocation

These are :

(a) Floating Point

Only one program in the computer may use the floating point facility.

(b) Modifier Groups

The computer has 12 modifier registers. These are divided into four groups each of three registers.

A computer code instruction can specify the required modifier register only within the current group, this being specified by bits 14 and 15 of register I, which can be changed only by the Master Program. Modifier Group 1 is reserved for the first program allocated, Group 2 is reserved for the second program. An optional facility exists whereby all other programs share Modifier Group 3, the current value being stored and restored as necessary. The Master Program also uses Modifier Group 3 for certain routines.

When a program which uses Modifier Group 1 or 2 reaches End, this group is given to the next program to be allocated.

One group of registers is reserved for the Master Program.

(c) Store

Every programme is divided into chapters, no chapter exceeding one division of the store (4096 words). Allocation of storage is attempted subject to the constraint that no chapter shall be broken, or lie in more than one division of the store, in order to facilitate inter-division references. No other restriction is applied, chapters may be stored in any order and may be placed between chapters of other programmes. Availability tables are maintained of the store size, peripheral equipment and other facilities.

Note: On two division installations where extra economy of store space is necessary an 'overwrite allocate' facility can be provided with the Master Programme. This makes the store space occupied by the command routines available for allocation. Once the overwrite allocate command has been given, no other command except 'store dump' is available, and the Master Programme must be reloaded before attempting to allocate the next programme.

(d) Area Modifiers

Each file has an annexe associated with it, allocated by the Master Programme. Both annexes and input/output sections specified by the programmer, must be associated with an area modifier which is used by the Interchange Area Addresses instruction (see section 1.1.2).

Note: The Intercode 42 and 43 actions must always specify an input/output section in the continuation line of the action.

(e) Peripheral Equipment

Programmes are allocated peripheral equipment and routes as required. The routes table is updated to remove the allocated equipment from the availability list.

(f) Tags

The lowest tag number available in the range 1 to 8 is allocated to each programme.

7.3 Maintenance of Records of Available Facilities

The Master Programme keeps tables of available facilities which are updated after allocation to indicate facilities becoming non-available due to allocation.

The record of storage is held as a table specifying in ascending order the length of strip of store available and the absolute address of the start of each strip. No strip may be longer than one division.

The record of peripheral equipment is held as a table specifying: route type - as on the Intercode Program Heading Sheets, associated channel, and the routes within the channel which have the specified equipment attachable.

When allocation is possible the details are recorded in these tables and in the log. When allocation is not possible the fact is noted in the log but no other record kept.

7.4 Request for Allocation

When a program is to be run, an operator command is given requesting allocation of facilities to the program. The program identity is specified on control data accompanying the command, to enable the Master Program to search for it on the magnetic tape program file. The control data also specifies whether 'normal' or 'trials' allocation is required, and, if the Multi-Route facility is chosen, the channel and route upon which the program tape is to be read. (see Appendix B.4).

Before allocation is attempted the program identity is tested to ensure that a program of the same identity is not already in the computer. If there is such a program, the allocation request is rejected.

Note: When an 'overwrite allocate' command has been given, the priority queue is tested to ensure that no program is in the computer. If there is such a program, the allocation request is rejected. If there is no program in the computer, the store table is set up to overwrite the command routines.

If allocation is successful, the program is loaded and entered without further operator command.

7.4.1 Program Control Data (see Appendix B.4 for layout)

Fifteen alpha characters can be fed on the control data for the allocate and amend run number commands. After both commands the program is entered at the initial entry point with decimal radix set, and the contents of registers A and B set as follows:

(i) If the first of the fifteen characters is a block end character, (A) and (B) are left clear.

(ii) If the first of the fifteen alpha characters is not a block end character, the first 5 are placed in A, and the second 5 in B. The remaining 5 characters specify the channel and route upon which the program tape is to be read.

7.5 Procedure

The Master Program searches for an area of store large enough to contain the first ('Unloader') chapter of the Program Loading Sequence

(360 short compartments). This area of store can be either an unoccupied area of the special chapter of a program that has reached end. If neither of these are found a rejection report is made in the log; otherwise the Master Program 'Load Chapter' subroutine loads the 'Unloader' chapter of the P.L.S.

7.5.1 Description of the Program Loading Sequence

The P.L.S. is in the form of several chapters holding allocating, loading and unloading routines. Between chapters there are data blocks used to hold the allocation requirements of the program being loaded.

Subsequent chapters overlay the first and each other.

The special chapter of all programs is used to hold permanent P.L.S. records and a parameter table, used to load the program.

The layout of the P.L.S. on the program file is as follows:

(i) Heading block
(ii) 'Unloader' chapter
(iii) 'Allocate storage' chapter
(iv) General allocation details
(v) 'Allocate routes/transit areas' chapter
(vi) Route/transit area requirements
(vii) 'Allocate floating point/modification group/tag' chapter
(viii) 'Set up switch/construct parameter table' chapter
(ix) 'Load program' chapter

When the 'Unloader' chapter of the P.L.S. has been read in, if it was read into an empty area of store it sets a modification register to search the program priority list of the Master Program for a program that has reached end (or has been abandoned). If the 'Unloader' cannot find such a program the 'Allocate storage' chapter of the P.L.S. is read onto the 'Unloader', and entered. If the 'Unloader' can find such a program, or was in fact read into the special chapter of such a program initially, it proceeds to unload this program.

In either case, the 'Unloader' first sets a switch in the program of immediate priority to bypass this latter program in the event of the higher priority program becoming engaged.

7.5.2 Unloading a Program

To unload a program, the 'Unloader' performs the following tasks:

(i) If the program used floating point, clears compartments 128 to 133 of division 0 and sets tag 14;

(ii) If the program used Modifier Group 1 or 2, the registers are set with tag 14;

(iii) restores the programme tag to the availability word;

(iv) unloads the route/transit areas by restoring the route type to the area modifier;

(v) sets the storage area with tag 14 and clears it;

(vi) deletes the unloaded programme from the priority list.

The 'Allocate storage' chapter is then read onto the 'Unloader' and entered.

7.5.3 Allocating and Loading a Programme

(i) 'Allocate Storage' Chapter

This reads and stores the general allocation details block, containing chapter lengths in chapter number order. It examines the available storage list and by taking all combinations of the chapter lengths, chooses the combination which will leave the smallest remainder when allocated to the shortest strip. The chapters thus allocated are discarded, the remaining chapters allocated by the same method to the next shortest strip, etc. until all chapters have been allocated. Should the end of the table be reached before allocation is completed, the report 'REJECT C' is made by re-entering the Master Programme.

The storage now available is sorted into order, but the Master table is not updated at this point.

Where several chapters are allocated to a strip, they are placed therein in chapter number order. Chapters are aligned to the division start or end (as appropriate) but if neither the strip start nor end is a division boundary, alignment is to the strip start.

This chapter will have calculated the special chapter start of the programme being allocated, and now alters certain parameters so that subsequent chapters of the P.L.S. are read into compartments 98 onwards of the allocated special chapter area. It also copies its results to compartments 0 to 97 of the special chapter, viz: new storage availability, general allocation details and chapter starts/end.

The next chapter is read and entered.

(ii) 'Allocate Routes' Chapter

This sets up the complete ALLOC comment in compartments 0 to 79 of the programme's first chapter and sets up the P.L.S. records in the special chapter in their final form.

It allocates routes and transit areas by searching compartments 64 to 127 for the earliest match with the given route type, searching 127 to 64 if reverse allocating. If there is no match with route type 7, a match is sought with route type 8 and vice versa, before abandoning allocation. Transit areas are allocated first on the pattern 0&&&&, then if no match, successively on route types 1, 2, 3 ... 9. An alternate route is allocated immediately after the main route, but may be on a different assembler for MT.

Should no match be found the Master Program is re-entered to make the report 'REJECT D'.

The next chapter is read in over the 'Allocate routes' chapter, and entered.

(iii) 'Allocate Floating Point/Modification Group/Tag' Chapter

This allocates floating point facilities, if required, by checking that A* has tag 14. A modification group is allocated by finding the first MR1 with tag 14, otherwise the program shares Modifier Group 3. The tag is allocated by taking the next non-zero quartet from the least significant end of the tag availability word. Failure to allocate floating point is indicated by 'REJECT A' and failure to allocate a tag by 'REJECT B'

If the installation has both high and low density magnetic tape facilities, the allocation control data contains giving the file identities of those tapes to be written in the low density mode; a match is sought with the program's file and an indicator is set corresponding to the allocated route number (while checking that the route type indicates a MT file). Failure to find a match or superfluous files on the control data is indicated by 'REJECT E'

The file details in the P.L.S. records are set up in their final form, and the next chapter is read over this one and entered.

(iv) 'Set Up Switch/Construct Parameter Table' Chapter

This chapter is only entered when the program is known to be allocatable and one of its tasks is to update all Master records for the new program. It also types the ALLOC comment, and clears the program's area before loading.

From the allocated tag T, the program's switch start is calculated

= 48 (T + 1) + contents of division 0 compartment 2

The new programme is sorted into the priority list, and the orders in the switch of the programme of immediate priority to this one, are updated. The switch working compartments are set up, including the initial value of A, B from control data; the switch is left in the 'closed' state until the programme has been loaded into the store.

The facilities tables are updated by stacking programme tag in A* and the allocated modification group, by placing the area modifier in 64 to 127, by updating the tag availability word, and by copying the new storage availability table. The programme's parameter table is constructed in 98 to 139 of the special chapter, and a DATE/TIME comment is made in the log, followed by the ALLOC comment.

The final chapter is then read into compartments 140 to 199 of the special chapter.

(v) 'Load Programme' Chapter

This loads all the initial chapters of the programme, and then sets the annexe limit words with tag 15. The programme switch is 'opened', modification group 0 is set, and the Master Programme is entered with:

division 0 compartment 26 = programme switch start

division 0 compartment 27 = programme special chapter start

7.6 Programme Control Data

Ten alpha characters can be fed to a programme on the control data for the allocation and amend run number command. After both commands the programme is entered at the initial entry point with decimal radix set and the contents of registers A and B set as follows:

(i) If the first of the ten alpha characters is a block end character (A) and (B) are cleared.

(ii) If the first of the ten alpha characters is not a block end character the first 5 are placed in A and the second 5 in B.

8. THE ABANDON ROUTINE

If a programme does not reach end it must be adandoned by operator command. If, however, the programme does reach end no further operator command is required.

In both cases the programme is closed down and an end indicator set for the Programme Loading System. If the programme is under trial the Programme Trials End routines are entered, but a final dump is only taken in the event of the programme not reaching end. A log entry is made.

When the next allocate command is given the Programme Loading System will unload any programmes which have the end indicator set.

The 5/0/1 command abandons the previous command with the appropriate comment provided that command has not been obeyed. If the previous command has been obeyed the 5/0/1 command will be rejected.

9. STORE DUMP ROUTINE

9.1 Purpose and Scope

This routine (an optional facility) and the Store Post-Mortem Printout Programme provide a means of printing a post-mortem of the store when the P.T.S. post-mortem facility is not available (e.g. when P.T.S. is not in use or when a job timeshared with a P.T.S. trial requires a post-mortem).

The Store Dump Routine produces a store post-mortem on magnetic tape which is then printed by the Store Post-Mortem Printout Programme (Volume V, Part 3, Section 6).

9.2 Data

There is no control data.

9.3 Results

(i) Store Dump Tape with heading blocks the first of which contains Master Programme identity, date and time of post-mortem. Subsequent blocks give the identity of each programme in the store and the start and end points of its chapters. The contents of all store locations are held in double alpha form in blocks of 24 words. See Appendix C for layout of tape blocks.

(ii) Log comments.

9.4 Procedure

The Store Dump Routine has three main parts, the set-up routines, the dump routines and the end routines. Entry is made by Master Programme command.

9.4.1 Set-Up Routines

The contents of certain compartments are stored in the Store Dump Transit Area (see Appendix C for details). Modification register 1 of modification group 0 is then set at the start of the Master Programme Switch Area and the Master Programme switch set to pass control to the bottom of the priority queue. The annexe start location for route 7 is stored, and those for the Store Dump route 7 and for Channel 7 route 6 (Area Modifier) are set up.

If the P.T.S. is in the store, the block serial number for route 7 is stored and the P.T.S. tape is closed for input.

The Store Dump Tape is opened and the Dump Routines entered.

9.4.2 Dump Routines

The preserved locations stored in the Store Dump Transit Area are written as the first block. Heading blocks are then set up and written, including Master Program and commercial program identities (see Appendix C). The last program block is followed by one with program identity

$\overline{15}\ \overline{15}\ \overline{15}\ \overline{15}\ \overline{15}$.

The main loop writes blocks of 24 data words. Each long word in the store is picked up, converted to double alpha form and written on the Dump Tape. A word is preceded by a special identifier if its tag number differs from that of the previous word.

9.4.3 End Routines

Entry to the End Routines is made when the store dump is completed. The Store Dump Tape is closed and unloaded, and the 'end' comment typed.

If the P.T.S. routines are in store, the P.T.S. annexe start location for route 7 is restored, and if a trial is in progress the P.T.S. tape is opened for input and realigned. The normal end of command procedure is then entered.

9.5 Operating Notes

9.5.1 Facilities Required

Store Dump	Route 7 of magnetic tape channel on which allocation is performed.

Note 1: A pool of released tapes must always be held in the Released Tapes Index.

Note 2: If the required route is being used as a program tape, the tape in question should be unloaded. After the store dump has finished, this tape should be reloaded.

9.5.2 Entry to the Routine

By Master Program command GROUP 3 FUNCTION 1

The P.T.S. dumps tape (if any) is unloaded.

9.5.3 Log Comments

RC (Ch.Ch. 7)	Store Dump tape not loaded (3-minute intervals)
LOP (Ch.Ch. 7) or HOP (Ch.Ch. 7)	Store Dump tape opened
DUMP END	Post-Mortem completed and Store Dump tape unloaded
RC (Ch.Ch. 7)	(following DUMP END P.T.S. tape required (3-minute intervals.)

10. On Line Store Post Mortem

10.1 Purpose and Scope

This routine (an optional facility) will print out the whole store including its own area or a specified part of the store in the layout given in Appendix D. This routine is permanently in store and takes up five hundred locations at the beginning of division one.

10.2 Data

There is no control data.

10.3 Results

This routine will print out the program whose tag is specified (see 10.5.3.2) together with all compartments of tag 13, 14 or 15. Zero compartments are not printed except where a tag change occurs.

10.4 Procedure

This routine is entered by "stacking and executing" a sequence change as specified in (10.5.3.1(3)).

The data in compartment 153 of division 0 is used to determine the route on which to print, whether a matrix is required, and the size of the store.

At the conclusion of the post-mortem or if the post-mortem has been abandoned, the master is re-entered through the priority queue. All programs will then continue normally, including those that have been printed out.

10.5 Operating Notes

10.5.1 Store Space Required

Division 1:- compartment 0-500

10.5.2 Route Required

Printer

10.5.3 Operating Procedure

10.5.3.1 Initiation

1. Halt
2. Check contents of compartment 153 (see Vol. V. Section 7, Appendix B)
3. "Stack and execute" a 26/0/3 order to address 178 (II:2) in division 0.
4. Single step. If interruption occurs, repeat 3, otherwise restart.

10.5.3.2 Indicator Settings

To Print Whole Store

No indicators set.

To Print a Program

The tag of the required program should be stacked on I9-11.

This will print out all the program plus all the master together with all compartments of tag 13,14,15.

To Restrict Print of Master

If I6 is stacked at any time while the master is being printed out, the master will not be printed after the end of the last program switch.

Note: This must not be stacked after finishing printing the master.

To Abandon Print

Stack I2

Notes: (i) After stacking a program tag on I9-11, it is not possible to revert to printing the whole store.

(ii) It is possible to change the tag of the program being printed out at any time.

11. Uptime Card Routines

The Master Program will handle one or two uptime card readers.

(i) Open File: The start of the program switch and the uptime route for the file are stored away. The counter of the number of uptime programs in store is updated.

(ii) Close File: The details that were stored when the file was opened are cleared. The counter for the number of uptime programs in store is updated.

(iii) Allocation and Overlay: Before the Master Program enters either the allocation or overlay routines, there is a delay if an uptime card program is in store. The purpose of this delay is to prevent the spurious rejection of cards. In allocating, these would amount to three to five cards per program on a string.

During this delay, the uptime card routes are closed, except when an uptime card program is overlaying, in which case that program's route is left open. In the delay, only uptime card programs are permitted to continue, this is to enable them to pocket-select the card which is in transit. At the end of the delay, the uptime card programs are closed. They are reopened after either the overlay or allocation is finished. Also during the delay, comments are paused and commands and options are ignored. These last two measures prevent programs being lost in the priority control.

The uptime card reader should be re-opened after the overlay or allocation is finished.