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REFERENCE MANUAL FOR THE TIME-SHARING EXECUTIVE

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1.0 Introduction

The Time-sharing System, (TSS), is a system for making a single computer provide simultaneous, continuously supervisable computing power to a number of authorized users. By "simultaneous" we of course mean apparently simultaneous; it is the computer's capacity for performing tasks at tremendously high speed that gives the illusion of simultaneity. TSS is furthermore designed principally for those users who, in order to obtain fruitful results, need to guide their programs more or less continuously through the course of its execution. One example of such application is in the checking-out of a program -- wherein, at each successive catastrophe, the user is called upon to make an amendment and try again.

TSS provides the following facilities:

1. Mutual protection of the users against one another.
2. Optional partial removal of this protection so that users can communicate with one another via the computer.
3. A more-or-less equal division of computing time between the current users.
4. Software packages necessary to permit one program to control others -- with overall control by the user via peripheral equipment.
5. Software packages which permit communications between computer and peripherals without regard to the latters' special physical peculiarities.
6. A filing system for preserving user's program documentation.
7. Response to a number of requests that arise naturally in the course of a user's connection with the system.

The primary medium by which computer and user communicate is at present the teletype console, which allows input, user to computer, from a keyboard and output, computer to user, via a type-head. Paper tape and magnetic tape are also available but are generally more combersome and unsuitable for primary input. Cathode ray displays are also being developed and are likely to render manageable the input and output of graphical data.

2.0 Access to the Computing Facilities

Having performed the initial formalities of introducing himself to the programming staff as a prospective user and persuading them of the particular suitability of their computing service to the work he has in mind, the new user will be presented with, or allowed access to, a teletype console. To establish a link between it and the computer, the power switch must be turned to ONLINE and the keyboard-tape selector switched to the keyboard, (K) position. It should here be noted that, when the power switch is in the ONLINE position, there is no direct link between keyboard and typehead; any such link as may appear to exist is established through intermediate software. The TSS software, of course, arranges that the typehead respond to keyboard input in a manner appropriate to the occasion -- which usually involves echoing back to the typehead any characters input from the keyboard.

The necessary hardware connection is now made between teletype and computer and the user may, by pressing the "rubout" key, signal the computer that he requires service on the chosen teletype. A printed response, (see section 5.1), indicates that the request has been noted and the user has been connected to a built-in software package, called the Executive program or "Exec", which awaits further teletype input in the form of stylized English-language requests or commands. Via these commands the Exec will provide sufficient services to get the user into contact with all the other TSS facilities. It is itself primarily a medium for specifying memory requirements, handling user's program documentation and establishing communication between different teletypes.

3.0 Exec Command Recognition

It is appropriate here to describe the way in which Exec commands are normally recognized, i.e., in the EXPERT mode (see section. 5.7). As soon as sufficient characters have been typed in to distinguish that intended from all other permissible commands, the computer immediately responds by "taking wings" and typing back the remainder of the command. On the other hand, if the typed sequence of characters can form part of no permissible command, the computer gives a standard response, "? cr. lf. @". The Exec's anticipatory behavior is intended as a labor-saving device, but can prove the opposite to a beginner who habitually oversteps the required minimum input -- thereby invariably corrupting his command and getting an error response. There are, however, commands designed to help the beginner in this respect; these are described in section 5.7.

Note that most Exec commands await a terminating "." -- which is the user's confirmation that the command typed is as intended. The command is not implemented until this "." is received and until then may be aborted by pressing, usually, any other character or, certainly, by pressing rubout. (The Exec's behavior on receiving any other character in place of . is not well-defined and tends to depend on the context. In no case will it cause the command to be implemented. To make certain of aborting the command, however, "rubout" is recommended.)

4.0 Files and File Naming

The contents of this section is now to be found in Chapter 12 of The TSS Reference Manual (Document R21). It is recommended that the user read Sections 12.1 to 12.3 of this before trying to handle files.

5.0 The Executive Command Language

We now return to the theme of section 2.0, wherein we left the reader poised on the brink of discovering the great potential of the Exec's command language.

The functioning of the Exec is described under the following headings:

1. Entering and leaving the system.
2. Commands for handling magnetic tape.
3. Commands controlling the allocation of memory.
4. Commands relating to the interaction of teletypes.
5. Commands to control the handling of file names.
6. Commands for storing and retrieving data on files.
7. Miscellaneous commands.
8. Commands to call subsystems.
9. Priveleged commands.

5.1 Entering and leaving TSS

TSS 1.9's response on receiving the first rubout from a hitherto dead teletype is to produce the message

```
TSS 1.9 IS UP
@ ENTER
```

Before the Exec will implement any of the possible commands which may be given to it, the prospective user must now make himself known by typing his name, terminated by a dot. This name must be one of which the system is aware, i.e., the name of an authorized user. If the user himself is not authorized, he must give some authorized user's name, with the permission of that user. If a password is associated with the declared user-name a carriage return is output followed by the word

PASSWORD

The correct password (see section 5.7) must now be typed, the teletype-echo will be suppressed so that no characters are printed as the keys are pressed; the secrecy of the password is thus preserved. The password is terminated by pressing the carriage return key, and, if it has been correctly delivered, "OK, carriage return, line feed" is output followed by the date and time. Commands may now be given to the system.

To sever his connection with TSS 1.9 the user must give the command

LOGOUT < user's name >

This has the effect of causing TSS to forget everything that the user has in core memory and to delete all his drum scratch files. After printing some time-used statistics the system becomes "dead" to all input from the teletype keyboard, except rubout.

5.2 Commands to Handle Magnetic Tape

The commands described here are:

MOUNT TAPE
(SYS) DISCONNECT.
(SYS) REWIND UNIT:
(SYS) TAPE STATUS

Having entered the system it is likely that the user will want to access files on magnetic tape. If the relevant tape reel is already mounted, the files on it will automatically become accessible when the user enters, otherwise he must notify the system of his intention to mount a new tape. This is done by means of the command.

MOUNT TAPE ON UNIT: < n >.

The user must supply the logical unit number, n, - determined by looking at the position of the switch on the tape deck to be used. On delivery of a terminal dot, the tape (if any), currently on unit n will be rewound and the message MOUNT NEW TAPE printed.

The desired tape reel should now be mounted on unit n which should be switched to the ready condition. On delivering another terminal dot, his own file directory and those of all users currently accessing the tape on unit n will be updated to reflect the contents of the new tape.

The remaining magnetic tape commands are all "emergency" commands and must be prefixed by the characters S^c Y^c S^c

(SYS) DISCONNECT.

Forcibly disconnects the currently-connected magnetic tape channel from the computer's I-O buffer. It will rescue TSS 1.9 from most hang-ups arising from a malfunctioning tape unit.

(SYS) REWIND UNIT: < n >.

Causes the tape on logical unit n to be rewound. It has the side effect of reinitializing some of the system's records concerning the state of the tape unit.

(SYS) TAPE STATUS

Prints, with a heading, the current values of various parameters associated with the system's handling of the magnetic tape units.

5.3 Commands relating to the Allocation of Memory

The commands described here are:

STATUS

KILL PROGRAM.

RELEASE

RESET.

DRUM BLOCKS LEFT =

CHANGE DRUM ASG TO

UNUSED MEMORY IS

MACHINE SIZE IS

STATUS

Prints the current maps both for the user's program memory and for any subsystem the user has, followed respectively by the unused and total drum space and the unused and total core memory available to the user.

KILL PROGRAM.

Releases the up-to-16K of core memory listed as PROGRAM by the STATUS command.

RELEASE < subsystem >.

Releases the up-to-16K of core memory occupied by the subsystem the user was last using.

RESET.

Releases all memory currently assigned to the user except the single block used by the Exec for temporary storage.

DRUM BLOCKS LEFT = < n > OUT OF < m >

Prints out the number, n, of unused drum blocks in a total assignment of m blocks for the user's drum files.

CHANGE DRUM ASG TO < m >.

Allows the user to increase his drum file space to m blocks (of 255 words each).

For each user an inflexible upper limit is set to m. Further, the drum assignment will only be increased until no blocks are left in the drum-space pool.

UNUSED MEMORY IS

Prints out how many blocks of the user's total memory allocation remain unaccessed.

MACHINE SIZE IS < n > K.

The decimal number n, must be terminated by K.

A memory trap will occur if the user's programs subsequently try to make accesses to more than n/2 blocks of memory. The user cannot request that his machine size be greater than his total allowance or that it be smaller than the memory he currently has allocated to him.

5.4 Commands Relating to the Interaction of Teletypes

The commands listed in this section are:

ACCEPT MESSAGES.

ACCEPT INPUT.

REFUSE MESSAGES.

REFUSE INPUT.

LINK TO

CONSULT WITH

BREAK LINKS.

WHERE IS

WHO IS ON

Any two teletypes may be "linked" together in one of the following senses: if teletype A establishes an "input-link" with teletype B then any characters sent to A's input buffer simultaneously go to B's. Thus a program, ostensibly taking characters from B, will equally accept them from A or B.

If teletype A establishes an "output-link" with teletype B then any characters sent to A's output buffer -- this includes echoes to characters input from teletype A -- simultaneously go to B's, and hence normally are typed out both on A and B.

ACCEPT MESSAGES.
ACCEPT INPUT.
REFUSE MESSAGES.
REFUSE INPUT.

Each of these four commands can be given separately. The ACCEPT commands cause the teletype on which they are delivered (the command teletype) to be made open to any attempt to link another teletype to it -- for output (MESSAGES) or input (INPUT) respectively.

The REFUSE commands, on the other hand, block any attempts to make output (MESSAGES) or input (INPUT) links to the command teletype, except such as are made by the user's own or TSS programs.

LINK TO < name or no. >, < name or no. >, ..., < name or no. >.

Output links are set up, in both directions, between each accessible named teletype and the teletype on which the command is given. All of the named teletypes which are set to refuse messages are listed as inaccessible and no link is established either to or from them. Up to 8 teletypes may be specified in the command either directly, by number or indirectly, by the name of the user currently logged in thereon. Delivery of a number which does not correspond to an existing teletype or a name not belonging to a recognized user elicits a question mark, '?'; the name or number is ignored. Delivery of the name of a user not currently entered on any teletype elicits a message; the name is ignored. Each name or number must be terminated by a comma, carriage return or, to terminate the list, a dot; any other terminator aborts the last-delivered name or number. If 8 teletypes are specified a comma or carriage return after the last is treated as a dot. More generally, a dot delivered immediately after any comma or carriage return will serve to terminate the command.

CONSULT WITH < name or no. >.

An output link is set up in both directions between the command and named teletypes. The named teletype may be specified via its teletype number or the name of the user currently logged in on it.

Subsequently input from the user's teletype is transmitted to the linked teletype's input buffer except when enclosed between $[^c$ and$]^c$ which is echoed alternately as [or]. Other control characters are echoed by "& < char >" where < char. > is the character whose internal code is 100-octal less than that of the control character. Carriage return is echoed as carriage return, line feed.

Control may be returned to the Exec only via the rubout key.

BREAK LINKS.

All links for input and output to and from the command teletype are broken.

WHERE IS < user's name >

The number of the highest-numbered teletype on which the named user is currently entered is printed. A message is printed if the user is not currently entered. An illegal name aborts the command.

WHO IS ON < teletype no. >.

or

WHO IS ON?

The first form of the command prints the name of the user currently logged in on the specified teletype. The second form (terminated by a question mark) produces a listing of all teletypes in use, each with the name of the user currently logged in on it.

5.5 Handling File Names

The commands described here are:

FILE DIRECTORY

SET MODES FOR FILE

DEFINE NAME

DELETE NAME

USE NAME

FILE DIRECTORY

Produces a listing of information about the user's files. The extent of the listing is optional and must be specified after typing the command. The options are:

a. FOR FILE: < file name >

produces, for the name file, the following information

name

whether random (R) or sequential (S)

type

for drum files:

address of first index block

for tape files:

file length

tape system number and file position

date last opened for O-P

RO (read only) or RW (read write) to indicate the file's accessibility to the owner

- (inaccessible), PRO or PRW to indicate its accessibility to the public

G < n > if it belongs to a special group, where n is the group number

RO or RW to indicate the group accessibility

b. LONG:

Lists the above information for every file belonging to the user.

c. BRIEF:

Prints a list of all the user's file names.

d. DRUM FILES:

Prints a list of user's drum file names.

e. TAPE FILES:

Prints a list of user's tape file names.

f. GROUPS:

Produces a table showing the correspondence between group names and numbers.

g. PSEUDONYMS:

Lists all the user's pseudonyms, showing also the strings for which they stand.

SET MODES FOR FILE
NAME: > file name >

is the command whereby a file can be assigned to a read-in or special group. Its type and public, private or group accessibility can also be defined. Any of five subcommands can be typed:

TYPE - t

PUBLIC - NO or RO or RW

PRIVATE - RO or RW

GROUP - < name >, RO or RW

The type, t, must be a number in the range 0 to 7 and cannot be 4 or 5. the group name is any string of characters terminated by EOT, (which is echoed as a comma); the group accessibility must simultaneously be set, (RO or RW). The file may be removed from any group to which it belongs by typing ' - ' in place of the group name. Each subcommand may be terminated by a comma, indicating another to follow; by a dot, indicating a new file name to follow; or by D^c, to end the command.

DEFINE NAME '< new name >' AS < old name >.

< old name > must be an existing name in the user's file directory; note that < new name > must be enclosed in quotes. The command causes < new name > to be attached to the same file -- so that either of < new name > or < old name > can now be used to refer to the given file.

If < new name > is already attached to some other file a message is printed. If the command is nonetheless completed, < new name > will be detached from the old file before being attached to the file < old name >.

DELETE NAME < name >.

This command may be used to remove any entry from the file directory. The entry may be:

a) a group name, which must here be prefixed by the character >;

thus: > SPECIAL

All files belonging to the specified group are released from it and the associated group number becomes available for reassignment to another group name.

b) a Pseudonym; here the pseudonym itself is removed, not the name for which the pseudonym stands.

c) a File name; if this is the name of a peripheral, tape file or permanent drum file then some other name must have been attached to this file (by the DEFINE NAME command, or otherwise). In any other case both the name and the file information are lost.

USE '< string 1 >' FOR '< string 2 >'

This command defines string 1 to be a pseudonym for string 2. That is to say, string 1 can be used in place of string 2 as an old file name, or initial part thereof, in all the commands and system subroutines which take an old file name as an argument -- except the DEFINE & DELETE NAME commands.

Both strings are arbitrary strings of characters, enclosed between quotes, string 1 must not commence with a left parenthesis. String 2 should be an augmented file name (see R21, Chapter 12), or initial part thereof. It must not be an existing name in the user's file directory; the DEFINE NAME command can be used in that case.

The usual file-name recognition rules apply equally to pseudonyms, which may be delivered with or without quotes.

Example: The command

```
    USE    S    FOR    (SMITH SPECIAL) FILE
```

causes the commands

```
    GO     TO   (SMITH, SPECIAL) FILE 123.
    GO     TO   S123.
    GO     TO   'S'123.
```

all to be equivalent.

5.6 Handling data in files

The commands described here are:

```
        COPY FILE
        SAVE CORE FROM
        PLACE FILE
        GO TO FILE
        DUMP ON FILE
        RECOVER FROM FILE
```

COPY FROM FILE < input file name > TO < output file name >.

The content of the named input file is copied on to the output file. The output file name may be 'old', i.e., attached to some already existing file -- in which case the said previous file is lost -- or 'new', in which case a new entry in the user's file directory is created for it.

The input and output file names must be of forms accepted by BRS 15, 16 respectively. The format is described in Chap. 12, Doc. R21.

If the input (output) file name satisfies the conditions for a no-skip return from BRS 15 (BRS 16) a question mark is typed back, the name is forgotten and a new attempt may be made to type it.

The command is executed on delivery of a terminal dot. The file created will be random or sequential according as the input file is random or sequential -- but see also section 12.4 of the TSS 2.0 Reference Manual.

SAVE CORE FROM < n_1 > TO < m_1 >, < n_2 > TO < m_2 >, < n_3 > TO < m_3 >
< n_4 > TO < m_4 >, ...
....
< n_k > TO < m_k >;
ON FILE < output file name >.
or (last line)
ON FILE < output file name >, STARTING LOCATION < n >.

The contents of specified ranges of core, $[n_1,m_1]$, $[n_2,m_2]$ etc., together with the starting location, if provided, are preserved on the named output file.

The output file name must be of a form accepted by BRS 16. If it satisfies the conditions for a no-skip return from BRS 16 the name is ignored and another name must be provided. The name may be terminated by a period, thus terminating the command and causing it to be executed, or a comma, in which case a "starting address" (see also the "GO TO" command) must be typed in.

Each of the addresses n_i,m_i,n, whether core range limit or starting address, is interpreted as an octal number. The starting address, n, must be terminated by a period. Delivery of any other non-octal digit character, except rubout, aborts the address -- which must be retyped. The octal numbers, n_1,n_2 ... n_k must all be terminated by a space or tab -- any other character aborts the number, which must be retyped. Alternatively, a semicolon may be delivered in place of the number; this terminates the core-bounds list in the same way as a semicolon after the final m_k. Each m_1, m_2, ... m_k must be terminated either by a comma or semicolon or by a space or tab followed by a comma or semicolon. Any other character combination aborts both the preceding two core limits which must then be retyped. A comma indicates that another pair of core-bounds is to be expected, a semicolon indicate the end of the core-bounds list. The command accepts a maximum of 8 core-bounds pairs, whereupon it spontaneously terminates the list and prints ON FILE.

PLACE ≤ input file name >.

The contents of the named input file is transferred to the core addresses specified at the time of its creation (by BRS 93 or the 'SAVE CORE' command). It is transferred into the user's current environment, which is extended, as necessary, to accommodate it.

The file name must be in the user's file directory. If it is not, ? is printed, the name is forgotten and must be delivered anew. The file name must be terminated by a period. The file must be a core-image (type 1) file. If any of these conditions is not satisfied, the command is aborted -- as it is also if the attempted data transfer to core results in some transfer-error condition's arising.

GO TO < input file name >.

The action is initially as for the PLACE command. However, after transferring the file to core, instead of a return to the Exec, there is a branch of control into the user's own environment at the starting address specified at the time of the file's creation. If a zero starting address, or none at all, was then given, the transfer is back to the Exec, as for the PLACE command.

DUMP ON FILE < output file name >.

The entire current status of the computer, in so far as it concerns the calling user, is preserved on the named output file, which is given the Exec. type number, 4.

RECOVER FROM FILE < input file name >.

The named file must be an old, type 4 ("dump") file, i.e., it must have been created by the Exec command "DUMP ON" or by the "dump" system subroutine BRS 95. The RECOVER command restores, in its entirety, the status of that part of the machine allocated to the user at the time of creating the Dump File.

5.7 Miscellaneous Commands

These fall into none of the preceding categories. They are:

BEGINNER.

NOVICE.

EXPERT.

"

COMMANDS FROM

PASSWORD IS

TYPE PASSWORD FOR

PAUSE.

TIME USED

DATE IS

BRANCH TO

CONTINUE

WSD FOR

(SYS) TC.

(SYS) PSPAR

BEGINNER.
NOVICE.
EXPERT.

Delivery of any one of these commands sets the current mode for recognizing commands and file names (and for any uses of BRS 37 by the user).

If the current mode is BEGINNER, each command must be typed in full before it will be recognized.

If the current mode is NOVICE just so much of the command as is necessary to define it uniquely must be typed in. If there then remain 3 or less characters, these too must be typed. Four or more characters remaining will be output automatically. Characters will be ignored which are typed in while the Exec is typing back these 4 or more characters.

If the current mode is EXPERT, commands are prerecognized completely; that is to say, only so much of the command as is necessary to specify it uniquely need be typed, the rest is supplied by the Exec. Characters which are typed in when the Exec is not ready to receive them are stored in an input buffer and delivered in sequence when the Exec returns to the command recognizing mode.

"

The delivery of the command " causes the Exec to echo but otherwise ignore all input characters up to the next EOT or rubout, except that carriage return is echoed by a line feed. It is used for typing comments and messages, as, for example, when linked to another user's teletype.

COMMANDS FROM < file name >.

Subsequent input for the Exec is taken from the specified file rather than the command teletype. Output from the Exec goes to the command teletype.

PASSWORD IS < password >

< password > is an arbitrary string of characters terminated by carriage return. The command enables the user to attach a password to his name to protect against illegal entry to the system by unauthorized use of his neme. The password is used in the PAUSE command and on entering the system.

TYPE PASSWORD FOR < user's name >

This enables the user to determine the password of any specified user. This command is available to a limited number of responsible users.

PAUSE.

After delivery of this command all input, (including rubout), is ignored until the user's password terminated by carriage return, is correctly typed. In effect it enables the user to "lock" his teletype against interference by other users.

TIME USED

Produces the response

```
a:b:c  IN  x:y:z
```

where x:y:z is the total time elapsed (in hours, minutes, seconds) since the user entered the Exec, and a:b:c is the amount of time actually spent by the central processor in performing computations on the user's behalf.

DATE IS

Prints the time of day and date.

BRANCH TO < address >.

A transfer of control is made to the specified address in the user's own environment (i.e. into "PROGRAM" memory). The address (an octal number) must be terminated by a period; any other character aborts the command.

CONTINUE < subsystem >.

Causes the user to reenter the last subsystem he was using, (if any), effectively at the point at which he left it. If no subsystem has been called or the subsystem memory has been released the command is automatically aborted.

WSD FOR < subsystem name >.

This command causes a tape copy of a subsystem to replace the current working version of the subsystem.

The subsystem must be stored on tape as a Save (Type 1) file the name of which, or a pseudonym for which, must be the name of the subsystem itself, e.g. ARPAS, DDT etc.

The action of the command is to read the subsystem from the tape into the user's program memory, then to transfer the core contents to the appropriate area of the drum -- from which it may be accessed by other users.

(SYS) TC.

Causes all teletype input buffers to be instantaneously cleared. It can resolve a system hang-up following from a malfunctioning teletype.

(SYS) PSPAR

Prints the current size of the drum space pool, followed by the system's log of drum and tape transfer errors.

5.8 Subsystem Calls

Any of a number of special purpose TSS software aids, called "subsystems" can be requested simply by typing the name of the subsystem as a command. The subsystems currently available are:

QED, ARPAS, DDT, CARP, AUTO-SEC, QAS, HELP, SNOBOL, LISP,
TRAC, CAL, FTC, FOS

For full details of any subsystem, the appropriate subsystem manual should be consulted. We give here only a brief description of the facilities offered by the respective subsystems. A reference to the corresponding TSS document is given after each subsystem name.

QED (ARPA Doc. R15)

This subsystem will absorb text input from any peripheral and transform it to a fileable, internal format. There is provision for as-you-type editing as well as extensive features for the modification of existing symbolic files.

ARPAS (ARPA Doc. R26)

This is the machine-language assembly subsystem for the SDS 930. It will transform a symbolic file consisting of a 930 machine-language program into a binary file which can be loaded directly to 930 core (using the loader in the DDT subsystem). It includes a powerful mechanism for expanding user-defined macros as well as a large variety of options which include the listing, skipping and repeating of parts of the assembly.

DDT (ARPA Doc. R11)

DDT is the loading and debugging subsystem for SDS 930 programs. Binary files prepared by ARPAS can be loaded to SDS core by DDT and executed under its continuous supervision. Other facilities include interrogating and changing memory locations, scanning memory for the specified digit patterns, inserting patches and breakpoints and performing traces.

CARP (ARPA Doc. R10)

With a small amount of preparation, ARPAS can be used to assemble programs written for the PDP-5 computer. Thus the extensive features offered by ARPAS for SDS 930 machine language assembly are available also to PDP-5 users. However, the binary output produced by ARPAS is not immediately digestible by the PDP-5 binary loader and must be processed again to produce input suited to the PDP-5's 12-bits-per-word format. CARP is the subsystem which takes the binary output from ARPAS and turns it into a form suitable for input to the PDP-5.

AUTO-SEC (ARPA Doc. R2)

Is intended to assist in improving the appearance of documents. Its input will normally be a symbolic file previously processed, to ensure correct content, by QED. AUTO-SEC can then be used to improve the layout to produce final copy suitable for publication.

QAS (ARPA Doc. R6)

Provides the user with the basic machinery for constructing an on-line system for answering questions about some specific field of the user's choice. As an example of its application we have the subsystem ...

HELP (ARPA Doc. P4)

This is a question-answering service intended to obviate the necessity of referring to a manual to resolve any small difficulties which arise while using TSS. Questions about TSS may be put, via the teletype, in fairly free format, conversational English. HELP may be entered from any subsystem and is then set up to recognize and answer questions about that subsystem.

SNOBOL (ARPA Doc. R12)

Is a language whereby strings of alphanumeric characters can be manipulated. Specified strings can be input-output, scanned for the existence of possibly broken sequences of characters with specified properties, compared to be "greater than" or "less than" one another; substitutions, reversal and transplantation of groups of characters can also be done. Strings of decimal digits may be interpreted as numbers and some simple arithmetic may be done with them.

LISP (ARPA Doc. R9)

Is a general-purpose List Processing System. It can, with greater or lesser efficiency, perform user-defined operations on any set of entities capable of being represented as lists either of other lists or, ultimately, of a finite number of distinguishable elements. Problems which are recursive by nature, i.e., in which the definition of a computable entity involves the entity itself, are particularly susceptible to attack using LISP.

TRAC (Comm. of ACM - Vol. 9/No.3/March 1966)

The Text Reckoning and Compiling language is a user language for control of the computer and storage parts of a reactive teletype system. It consists of a machine independent language together with a generalized macro text processor which runs interpretively to provide versatile interaction capabilities at run time.

CAL (ARPA Doc. R23)

The "Conversational Algebraic Language" allows numerical computations to be performed interactively. That is to say, mathematical calculations can proceed under the continuous supervision of the user. Facilities are available for compiling and running complete programs delivered in a stylized semi-conversational form, as well as for carrying forward computations in short steps with printouts of intermediate results.

FTC (SDS Fortran II Ref. Man. and ARPA Doc. R7)

Is the TSS FORTRAN II compiler. It is assumed that the user is familiar with the FORTRAN II programming language. Compiled program from FTC is run under ....

FOS

The TSS FORTRAN II Operating System, which provides facilities for running and debugging FORTRAN II programs. It is possible to make references to the original Fortran code rather than to the sequences of machine code produced by the compiler.

5.9 Priveleged Commands

These commands are not available to the ordinary user. They are provided to assist the staff to interrogate and change the state of

TSS at a more basic level than that of the normal user interface described in the preceding pages. The commands are provided to investigate unusual occurrences and rescue the system from any morbid condition into which hardware or software failures sometimes lead it.

A list and brief summary of the action of the commands is given below. Every one of them, except the list, must be prefixed by the characters, $S^{c}Y^{c}S^{c}$.

NON DESTRUCTIVE	DESTRUCTIVE
EXECUTIVITY	
(SYS) DEBUG	
(SYS) LOAD PAGES	(SYS) DUMP PAGES
	(SYS) SAVE SYMBOLS
	(SYS) GO TO
(SYS) LFDBT	(SYS) RFDBT
(SYS) TUDIR	(SYS) NUNAME
(SYS) PUDIR	(SYS) SUDIR
(SYS) PPMT	(SYS) SPMT
(SYS) PSMT	(SYS) SSMT

EXECUTIVITY < n >.

If the number, n, is negative, the user's "Executivity" status is set -- thereby allowing his program access to certain special TSS facilities, in particular all the "exec-only" system subroutines.

If n is positive or zero, the executivity status of the user is reset -- thus rendering inaccessible those special facilities.

(SYS) DEBUG < n >.

Resets the current memory status, sets relabelling for the running monitor in the "program" map and enters DDT with the symbol table from band < n > of the drum. This band should, of course, have been set up with a symbol table in advance (see (SYS) SAVE SYMBOLS).

(SYS) DUMP PAGES < m > TO < n >, BAND$\begin{cases}\text{< r >.}\\ \text{< r >, PAGE < s >.}\end{cases}$

0 $\leq$ m,n $\leq$ 7 refer to page numbers in the program relabelling, thus Pages 5 to 6 refers to locations 24000 to 33777 inclusive. r is a drum band number (decimal) and s, if given, is a page number within the band (0 $\leq$ s $\leq$ 3) .- it is taken to be zero if not given. The contents of pages m to n of the program relabelling are preserved on the drum, starting at band r, page s and using as many subsequent drum pages as are required to complete the transfer. The contents of core are unaffected.

(SYS) LOAD PAGES < m > to < n> BAND$\begin{cases}\text{< r >.}\\ \text{< r >, PAGE < s >.}\end{cases}$

This reverses the action of (SYS) DUMP.. Information is transfered from the drum to the specified pages of the program relabelling. Additional memory is assigned as needed.

(SYS) SAVE SYMBOLS ON < r >.

DDT should be the current subsystem when this command is given. Its action is to write DDT's symbol table on to drum band r. 8 K of drum space is always taken, regardless of the size of the symbol table.

(SYS) GO TO < r >.

This is intended for transferring control to a new version of the system.

The contents of drum band r and the first 2 pages of its successor are transferred into the first 12K of real core and there is a branch to location 24B. The specified 1 1/2 drum bands should, of course, contain the required new version of the system.

(SYS) NUNAME "<file name>" AS $<n_1> <n_2> <n_3> <n_4>$.

Sets the file name in the file directory and attaches to it a 4-word description block, whose contents are the octal numbers n_1, n_2,n_3,n_4 respectively.

(SYS) LFDBT

Lists the bit table for file storage space on the drum.

(SYS) RFDBT

Invokes the file directory clean up routine.

This checks each entry in every user's file directory for meaningfulness and consistency. Unrecoverable entries are deleted, as is a totally unrecoverable file directory - which is replaced by a newly initialised, empty file directory.

The bit table for file storage space on the drum is recomputed.

(SYS) PUDIR.

Prints the entire user directory for all users.

(SYS) SUDIR.

Followed by a user's name. This allows each of the 7 locations in the user's user-directory data block to be interrogated and changed if required.

(SYS) TUDIR

Prints the entire user directory contents for each user satisfying a specified condition.

The command accepts three octal number, a, b, c, separated by commas and terminated by a dot. The first number ($0 \leq a \leq 6$) indexes a word, w(a), of interest in each user directory description block. The second number is used to mask both w(a) and the third number, c. The name and user directory is printed for each user for which $b \wedge w(a)$ matches $b \wedge c$.

(SYS) PPMT

Prints the user's private memory table. All assigned pseudoblocks in the user's pseudo-memory are listed.

(SYS) SPMT

Set private memory table. This enables entries to be artifically set up in the users private memory table.

(SYS) PSMT

Print shared memory table.

(SYS) SSMT

Set shared memory table.