PROMULA®

Application Development System

User's Manual and Reference

1. INTRODUCTION

1.1 Organization of the Manual

This manual is divided into five chapters:

CHAPTER 1	introduces you to the PROMULA system's features, capabilities, and requirements and tells you how to install and run PROMULA on your personal computer.
CHAPTER 2	is an introduction to the PROMULA programming environment and covers some of the language fundamentals in the context of a simple example.
CHAPTER 3	is the reference chapter for the PROMULA language. It describes, in alphabetical order, the nouns and verbs of the language. The nouns are the building blocks, the information elements, of the language. The verbs are the commands of the language; they tell PROMULA to perform various operations on the nouns.
CHAPTER 4	contains details and examples of database management and program management in PROMULA.
CHAPTER 5	describes the use of the PROMULA configuration program that may be used to set up the physical configuration of PROMULA's graphics modes.

1.2 What is PROMULA?

PROMULA (**pro**cessor of **mu**ltiple **l**anguage **a**pplications) is an application development tool for large-scale analytical applications. It is a general-purpose, high-level programming language with built-in data management, modeling, report generation, graphics, and screen management (menus and windows) capabilities. It is the ideal development tool for those who have outgrown the spreadsheets but do not want to develop applications in a third generation programming language (such as FORTRAN, PASCAL, BASIC, or C).

Though its intellectual history goes back to the late ‘60's on mainframes, PROMULA was originally developed on PCs in the early 80's as a high-level generalization of FORTRAN designed to take explicit advantage of the FORTRAN data structure (multidimensional arrays of primarily numeric, homogeneous data). It is a portable C program and offers the same character-based functionality on a number of platforms: PC DOS and DOS Extended, 386/486 UNIX, RS/6000 AIX, VAX/VMS, and Apple Macintosh.

As an application development tool, PROMULA supports the following functions:

- **Data management** (organize and selectively manipulate data)
- **Data analysis** (establish relationships in the data using an extensive library of mathematical and statistical functions)
- **Modeling** (simulate a problem and possible solutions to it)
- **"What if" analysis** (compare alternative decisions about the problem)
- **Report generation** (display results in report form)
- **Graphics** (display results in plotted form)

- **Menu management** (prepare pick, pop-up and data menus for application prototyping, program control, data entry, data editing, and data display in a character-based user interface)

- **Window management** (create applications with attractive user interfaces using windows)

- **Equation solving** (solve systems of simultaneous equations)

PROMULA's high-level, problem-oriented programming language is particularly suited for applications – as opposed to systems – programmers. It is a highly productive, and elegant, notation for developing analytical, decision-support, or simulation applications in all kinds of disciplines: business, engineering, or the sciences. PROMULA programs are easier to write, use, verify, maintain, and document than programs written in spreadsheets or third-generation languages.

In PROMULA, a "database" is a collection of variables. The source of the information in the database may be raw user input; or it may be calculated by PROMULA itself; or it may be produced by an independent applications program written in a traditional programming language (such as FORTRAN) and processed by one of the PROMULA compilers or translators (such as the PROMULA FORTRAN Compiler or the FORTRAN to C Translator).

Used in tandem with the PROMULA FORTRAN Compiler, PROMULA is also an attractive tool for upgrading the user interfaces of existing FORTRAN applications. PROMULA can deal directly with the information content of programs written in FORTRAN, without having to re-engineer or re-write such programs. Typically, FORTRAN programs are computational engines, efficient in "crunching" numeric data but lacking in the area of "user friendliness." With PROMULA, you can add a friendly user interface shell "on top" of a FORTRAN program, without having to change the FORTRAN program code by hand. This is done by an automatic restructuring process, done by the PROMULA FORTRAN Compiler, which involves the separation of a database from the computations of the program and the management of that database by PROMULA. In this context, a PROMULA database is a collection of FORTRAN variables — usually in the form of multidimensional arrays — which are manipulated by the FORTRAN computations on the one hand but can also be used independently by PROMULA for other operations (data input, data edit, report generation, graphics, etc.).

PROMULA is a transition bridge from third- to fourth-generation approaches in applications development. Because of its powerful programming capabilities, it is a superior alternative to using spreadsheets or pure database managers in large scale applications development.

1.3 PROMULA Language Highlights

1.3.1 Total Programming Environment

You can develop complete turnkey applications with PROMULA. The system is designed to capitalize on existing applications written in a variety of languages and to minimize programming time in developing new applications.

PROMULA is largely self-contained with its own screen editor, language compiler, and operating system interface.

1.3.1 Structured Notation

PROMULA is a structured language especially useful for developing applications quickly. Its elegant notation, structured concepts and built-in functions will help minimize the time required to develop serious, mainframe-size applications on your desktop computer.

For you, the problem solver, this means that PROMULA is easier to learn, easier to use and apply in problem solving, and, thus, faster in producing results. In problem solving, the choice of the right notation is almost half the solution.

PROMULA programs are easy to write and maintain because PROMULA's English-like notation and logical constructs make them almost self-documented.

1.3.2 Language Tutorial

This reference aid is an on-line, menu-driven tutorial that allows you to obtain information about PROMULA while you are programming or using an application.

1.3.3 Language Course

This learning aid is a series of PROMULA source codes designed to demonstrate the PROMULA language constructs (nouns) and the PROMULA commands (verbs).

1.3.4 Tutorial Writer

A tutorial writer lets you create your own menu-driven, application-specific tutorials by simply typing them in. It converts whole books or reports into on-line, menu-driven tutorials and/or context-specific on-line help for your applications.

1.3.5 Menu Manager

PROMULA's menu manager prepares pick and data menus for "user friendly" applications. Menu preparation is as easy as writing the menus on the screen.

1.3.6 Data Editor

A full-screen data editor facilitates data entry and update. Using techniques similar to those found in spreadsheet programs, PROMULA lets you browse through the "pages" of multidimensional arrays to change their values.

1.3.7 Report Generator

The **WRITE** commands of the language let you display information in a variety of report formats.

1.3.8 Graphics

PROMULA supports business graphics (point plots, x-y plots, bar plots, etc.) for both monochrome and color display monitors as well as a variety of printers and plotters. It is even possible to capture plotted displays on disk. High resolution color graphics are available for EGA and VGA monitors.

1.3.9 Command Mode

In command or direct mode, PROMULA accepts a statement, converts it to executable instructions which are executed by the computer, then proceeds to the next statement.

You can interrupt a program dialogue, perform local operations in command mode, and return to the same place you left the program. Not only is this a very useful debugging feature, but it also adds flexibility to your applications and greatly increases the accessibility of the data and results. You can use PROMULA to generate reports and graphics or do calculations with the data of your application without having to alter and recompile the program code.

1.3.10 Compilation Mode

In indirect, or compilation mode, PROMULA compiles a group of statements as a procedure or a program that can be run later. A procedure can be run by other procedures, including itself.

1.3.11 Conversational Mode

You can interact with a PROMULA program either in command mode or by responding to conversational prompts and menus. Conversational prompts and menus help you make it easy for others to use your program.

1.3.12 Multidimensional Data Structures

Unlike the two-dimensional view of spreadsheets, PROMULA supports multidimensional data structures. Data arrays in PROMULA can have up to ten dimensions, making it easy to define and manipulate highly structured information. Many PROMULA statements have the capability to manipulate multidimensional variables implicitly, leading to great economies of notation.

The information of a PROMULA program is structured into variables and sets. Variables are multidimensional structures of information constructed from and subscripted by sets. Variables store the information and sets define the structure of variables. PROMULA variables can be as large as your disk space allows.

1.3.13 Array or Matrix Equations

PROMULA equations are written in standard algebraic notation. The equation operands may be scalars, vectors or multidimensional arrays. Implicit and dummy subscripting allows a condensed notation for array equations. This feature is comparable to a similar capability of the APL language.

1.3.14 Equation Solver

PROMULA's equation solver gives you solutions to systems of simultaneous equations, both linear and nonlinear.

1.3.15 Variable Management System

In PROMULA, a program is information, not just a computational box. In addition to computations, each PROMULA program has a database. The database contains the input and output variables of the program as well as other supporting information. You can use the program database independently of the program code, and even interrupt a running program to work with its database.

In addition to sequential access text files and direct access binary files, PROMULA supports a unique variable management system. This is a multidimensional array management system that is ideal for managing the information usually stored in program variables.

PROMULA is different from other DBMS systems, which have limited command languages. PROMULA is a powerful, fully-featured applications programming language, and it offers you full flexibility in analyzing and using the information in your databases.

1.3.16 Program Management System

PROMULA has a program manager to help you handle large, mainframe-size programs.

The source code of a PROMULA application can be broken into separate parts, compiled independently, and then united and used as a smoothly integrated system. This capability is most useful for the implementation of applications with extensive memory requirements.

If your variables are too large or there are too many for your work space, you can store them on disk. PROMULA's variable manager lets you bring only what you need into your work space.

1.3.17 Dynamic Simulation

PROMULA has several features which facilitate the implementation of dynamic simulation applications. You can develop system dynamics models — models of systems whose variables interact with each other continuously as they evolve over time.

1.3.18 Windows

PROMULA's powerful windowing commands allow you to modify the appearance of the screen to create professional-looking and user-friendly applications. Custom-designed help screens, popup menus, and flexible color control will improve the appearance and usability of your programs.

1.3.19 Mathematical and Statistical Functions

PROMULA supports a library of mathematical and statistical functions as well as a number of array (matrix) operations, such as summation, product, minimum/maximum, sorting, etc.

1.3.20 Command-Line Recall

A buffer stores all commands entered at the keyboard so that they may easily be recalled for modification and reentry. This feature greatly enhances the utility of PROMULA's Command Mode and its Text and Data Editors.

1.3.21 Multi-platform Performance

PROMULA runs on most of the major computer platforms including IBM/MSDOS, VAX/VMS, Apple Macintosh, IBM/AIX, SUN/UNIX, IBM/TSO, and platforms supporting the X Window System. Your PROMULA applications can be used, without modification, wherever PROMULA runs.

2. PROMULA BASICS

This chapter is intended to introduce computer users with little programming experience and no familiarity with PROMULA to the basics of the PROMULA language and the PROMULA Application Development System. The first part of the chapter illustrates how to use the PROMULA application development shell to create and use applications; the second part of the chapter covers the fundamentals of the PROMULA language in the context of a simple example.

2.1. The PROMULA Application Development System

The following sections describe how to create and manage executable applications using PROMULA. For example, suppose you wish to create a simple application that will let you enter monthly sales and cost figures then compute and report the monthly profits and the average monthly profit. We have written such a program for you, it is called `DEMO.PRM` and it is on the PROMULA distribution disk. The dialog produced by running this program is displayed below:

```
             Please enter the monthly sales figures.
               ? 13200 12100 14800 16200 15200 17200 18060 18960 19900 20900
               ? 21950 23050
             Please enter the monthly cost figures.
               ? 9200 8600 10400 11300 10700 12100 12700 13350 14000 14700
               ? 15440 16210

                             Monthly Profit and Loss Figures ($)

                                         Sales       Costs      Profit

                       January           13,200       9,200       4,000
                       February          12,100       8,600       3,500
                       March             14,800      10,400       4,400
                       April             16,200      11,300       4,900
                       May               15,200      10,700       4,500
                       June              17,200      12,100       5,100
                       July              18,060      12,700       5,360
                       August            18,960      13,350       5,610
                       September         19,900      14,000       5,900
                       October           20,900      14,700       6,200
                       November          21,950      15,440       6,510
                       December          23,050      16,210       6,840

             Average monthly Profit ($) 5,235.00
```

Figure 2-1: Dialog produced by DEMO.XEQ

The source code for `DEMO.PRM` is displayed below.

```
  OPEN SEGMENT    "DEMO.XEQ"      STATUS=NEW
  DEFINE PROGRAM "A Demo Program"

  DEFINE SET
    month(12)       "Months of the Year"
    acnt(3)         "Profit and Loss Ledger Accounts"
  END SET

  DEFINE VARIABLE
    mp(month,acnt) "Monthly Profit and Loss Figures ($)" TYPE=REAL(10,0)
    amp            "Average Monthly Profit ($)"          TYPE=REAL(10,2)
    mn(month)      "Month Names"                         TYPE=STRING(12)
    acn(acnt)      "Profit and Loss Account Names"       TYPE=STRING(12)
  END VARIABLE

  DEFINE RELATION
    ROW(month,mn)
    COLUMN(acnt,acn)
    KEY(acnt,acn)
  END RELATION

  READ mn
  January
  February
  March
  April
  May
  June
  July
  August
  September
  October
  November
  December

  READ acn:6
  Sales Costs Profit

  DEFINE PROCEDURE profits
    SELECT acnt(Sales)
      WRITE"Please enter the monthly sales figures."
      READ mp(acnt,month)
    SELECT acnt(Costs)
      WRITE"Please enter the monthly cost figures."
      READ mp(acnt,month)
    SELECT acnt*
      mp(m,3) = mp(m,1) - mp(m,2)
      amp = SUM(m)(mp(m,3)/12)
      WRITE mp
      WRITE amp
  END PROCEDURE profits

END PROGRAM, DO profits
```

Figure 2-2: Source Code of DEMO.PRM

This code defines a complete, interactive application that can help its user enter monthly sales and costs figures and compute and report the monthly profits and the average monthly profit.

2.1.1. Starting PROMULA

Typically you will start PROMULA from the DOS prompt by entering the word "PROMULA". You may include any PROMULA statement after the word "PROMULA" on the command line. Several examples of this are shown below:

1.
```
PROMULA
SELECT FOREGROUND=GREEN COMMA=OFF GRAPHICS=HIGH
```

This will load PROMULA, set the foreground color to green, turn the comma option for numeric displays off, and select the **HIGH** graphics mode. PROMULA will start in command mode, not with the PROMULA Main Menu.

2. PROMULA RUN COMPILER "myprog.prm" LIST=DISK "myprog.lst" PAUSE=ON

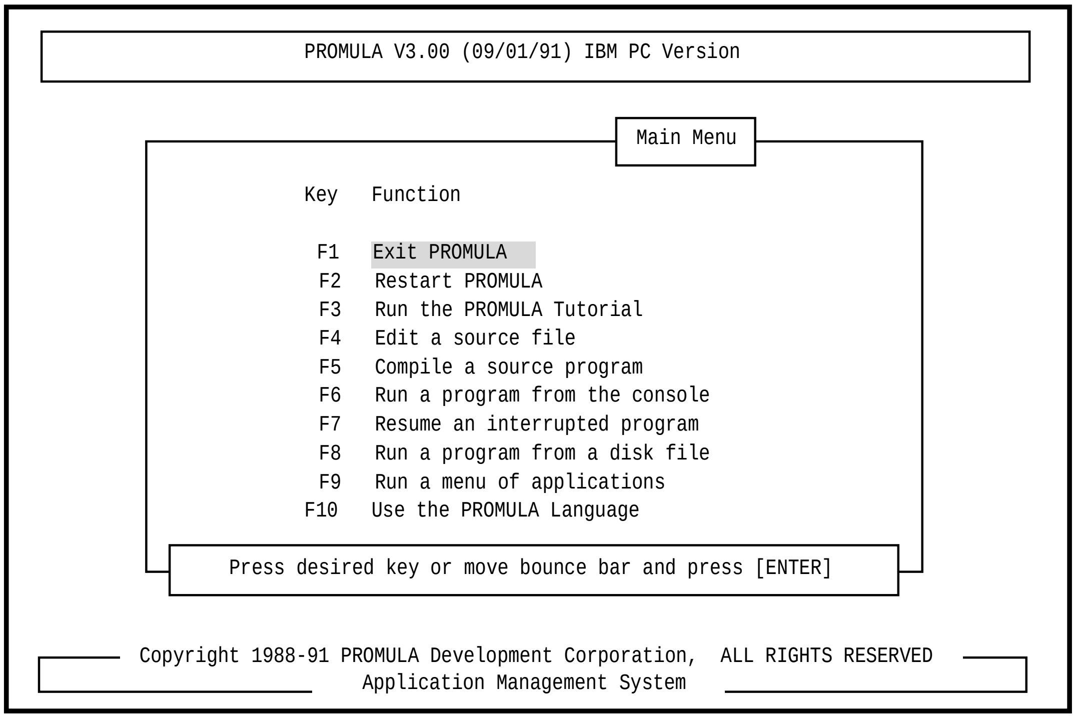
This will load PROMULA and compile the statements in the file `myprog.prm`. The statements in `myprog.prm` and any output they generate will be saved on disk in the file `myprog.lst`. After compiling the file, PROMULA will be in command mode.

3. `PROMULA RUN PROGRAM "myprog.xeq"`

This will load PROMULA and start the PROMULA application contained in the file `myprog.xeq`.

2.1.2. The PROMULA Main Menu

If you start PROMULA with no command line statement, PROMULA will load into memory and display its Main Menu. The PROMULA Main Menu is designed to give you direct access to a variety of program development functions.



```
                PROMULA V3.00 (09/01/91) IBM PC Version

                                         Main Menu

                      Key   Function

                       F1   Exit PROMULA
                       F2   Restart PROMULA
                       F3   Run the PROMULA Tutorial
                       F4   Edit a source file
                       F5   Compile a source program
                       F6   Run a program from the console
                       F7   Resume an interrupted program
                       F8   Run a program from a disk file
                       F9   Run a menu of applications
                      F10   Use the PROMULA Language

          Press desired key or move bounce bar and press [ENTER]

   Copyright 1988-91 PROMULA Development Corporation,  ALL RIGHTS RESERVED
                     Application Management System
```

To begin the desired function, simply press the corresponding function key. On the IBM Personal Computer the function keys are the ten shaded keys at the left (or at the top) of the keyboard. Alternatively, you may press the numeric keys on your keyboard or highlight the desired option and press the **Enter** key.

2.1.2.1. F1 -- Exit PROMULA

Selecting Main Menu option 1 gets you out of PROMULA and returns control to the operating system. All PROMULA files which are open at this time are automatically closed. Any PROMULA information contained within the memory of the computer which has not been saved on a disk file, is lost. In addition to closing its open files, PROMULA clears the screen before ending.

2.1.2.2. F2 -- Restart PROMULA

Selecting Main Menu option 2 restarts PROMULA. Before the restart, PROMULA closes all application files, clears all application information from the memory of the computer, and clears the screen.

This is a convenient feature to use when you wish to move from one PROMULA application to another without having to go back to the operating system.

2.1.2.3. F3 -- Run the PROMULA Tutorial

The PROMULA Tutorial is the reference chapter of this User's Manual in on-line, menu-driven form. The program that controls the tutorial is called **PROMULA.TUT**.

You can use the Tutorial in various ways:

1. Browse through the entire Tutorial once to obtain an overview of PROMULA.

2. Select a particular topic in the Tutorial when you have a particular question.

To get to the Tutorial while executing a program, press the **Esc** key to suspend the program and display the Main Menu; then select Main Menu option 3 to browse the Tutorial and the topic of interest. When you wish to leave the tutorial, press the **End** key; this returns you to the Main Menu. You may then return to the interrupted program by selecting Main Menu option 7.

2.1.2.4. F4 -- Edit a Source File

This clears the screen and initiates the PROMULA Text Editor, which is a fast, full-screen text editor that may be used from the Main Menu, from command mode, and from inside your applications via the **RUN EDITOR** statement.

On-line help for the editor is in the dialog file **EDITOR.TUT** and is accessible by pressing **Alt-H**.

For example, to edit the demo file `DEMO.PRM` shown in Figure 2-2, simply press **Alt-E** and enter the file name `DEMO.PRM`.

2.1.2.5. F5 -- Compile a Source Program

PROMULA accepts statements in either of two modes: direct and indirect. Main Menu option 5 is used to put PROMULA into indirect mode. In indirect, or compilation mode, PROMULA converts the statements of an entire "source" file to an "executable" form, which may be saved on disk for later execution.

Use Main Menu option 5 when you wish to compile a file containing the PROMULA source code. If the results of the compilation are saved in a segment file, it can be executed either interactively (i.e., directly from the console), using Main Menu option 6, or in batch mode from a text input file using Main Menu option 8 .

"Compiling a program" means converting it from source instructions to executable instructions. **Source instructions** are the statements of a program as you write them for PROMULA to understand and compile, i.e., convert to executable instructions. **Executable instructions** in turn are instructions that PROMULA converts to **machine instructions** which the computer can execute at run time.

To compile the demo program `DEMO.PRM`, select Main Menu option 5 and respond to the system prompts, as shown in the dialog below:

```
     Enter the filename of the program to be compiled
            ? DEMO.PRM
     Where do you want the compilation listing? N)one, C)onsole, P)rinter, or D)isk
            ? P
```

```
      Do you want the compiler to pause on errors? Y)es or N)o
             ? Y
```

The dialog above tells PROMULA to compile the source program stored in file `DEMO.PRM`, to list the results of the compilation on the printer, and to pause if any errors are detected.

In the dialog above, the questions are issued by PROMULA while the responses (following the ? prompt) are entered by the user.

The first question asks for the name of the file containing the source code to be compiled. Any filename which is valid for the operating system is a valid entry for this question. The default extension for source file names is **.PRM**.

The second question asks where PROMULA should send the compilation listing. The listing may be viewed on the screen, sent to the printer, saved in a file on disk, or turned off. Viewing the listing on the screen or printer may slow the compilation down but may make it easier to understand compilation errors. If the listing is sent to the printer, then the printer needs to be turned on and ready to go before the response to this question is entered. PROMULA does not check to ensure that this is true and will compile the program without sending it to the printer if you fail to turn the printer on. If the listing is to be saved on a disk file, you must specify the name of the disk file in response to the next question, as shown in the second example below. If you want the code to compile as fast as possible, and do not need to view the listing as the program is compiled enter **N** for the **`N)one`** option.

The third question asks whether or not PROMULA should pause when a compilation error is encountered:

1. If you respond Y for "yes" to the question, then each time an error is encountered, PROMULA will display the appropriate error message and will pause with the following message:

   ```
   Press any key to continue
   ```

   At this point, if you press the **Esc** key, the compilation will end and you will return to the Main Menu. If you press any other key, the compilation will continue.

2. If you respond N for "no" to the question, then an error message will be displayed for each error, but PROMULA will continue compiling. Note that the result of any compilation which was continued despite an error will probably not be well formed.

A similar dialog occurs if you wish to save the compilation output on a disk file:

```
       Enter the filename of the program to be compiled
              ? DEMO.PRM
       Where do you want the compilation listing? N)one, C)onsole, P)rinter, or D)isk
              ? D
       Enter a filename for the compilation listing
              ? DEMO.LST
       Do you want the compiler to pause on errors? Y)es or N)o
              ? Y
```

The objectives of this example are to compile the source program `DEMO.PRM` and to save the compilation listing on a disk file named `DEMO.LST` for later viewing or printing.

In the compilation example shown above, three files are involved:

1. The program source file, `DEMO.PRM`

2. The compilation listing saved on file `DEMO.LST`

3. The executable file resulting from the compilation was saved on file `DEMO.XEQ`, as specified in the **OPEN SEGMENT** statement of the source file. It is this file that you may execute interactively, using Main Menu option 6, or execute in batch mode, using Main Menu option 8.

2.1.2.6. F6 -- Run a Program from the Console

An executable program may be run in one of two ways: interactively or in batch. Interactive execution proceeds as follows: the program issues prompts via menus, **ASK** statements, and other interactive commands on the console and expects a response from the user before it continues execution. In batch mode, on the other hand, program execution proceeds without pausing for user input from the keyboard. In this mode, all of your responses are expected to have been saved in a disk file, called the "batch input file".

Main Menu option 6 is used to execute a compiled PROMULA program interactively, i.e., directly from the console and the keyboard. Selecting Main Menu option 6 results in a dialog such as the one shown below:

```
             Enter the filename of the program to be executed
                    ? DEMO.XEQ
```

`DEMO.XEQ` is the name of the executable program that was produced by compiling the `DEMO.PRM` source program using Main Menu option 5. The default extension for executable file names is **.XEQ**. Execution of `DEMO.XEQ` results in the following dialogue:

```
             Please enter the monthly sales figures.
               ? 13200 12100 14800 16200 15200 17200 18060 18960 19900 20900
               ? 21950 23050
             Please enter the monthly cost figures.
               ? 9200 8600 10400 11300 10700 12100 12700 13350 14000 14700
               ? 15440 16210

                             Monthly Profit and Loss Figures ($)

                                         Sales       Costs      Profit

                       January          13,200       9,200       4,000
                       February         12,100       8,600       3,500
                       March            14,800      10,400       4,400
                       April            16,200      11,300       4,900
                       May              15,200      10,700       4,500
                       June             17,200      12,100       5,100
                       July             18,060      12,700       5,360
                       August           18,960      13,350       5,610
                       September        19,900      14,000       5,900
                       October          20,900      14,700       6,200
                       November         21,950      15,440       6,510
                       December         23,050      16,210       6,840

             Average monthly Profit ($) 5,235.00
```

Figure 2-3: Dialog produced by DEMO.XEQ

While running an application in interactive mode, you may suspend program execution by pressing the **Esc** key at a program pause. To resume execution at the point where you exited, select option 7 from the Main Menu.

2.1.2.7. F7 -- Resume an Interrupted Program

You can interrupt an executing program by pressing the **Esc** key in response to any program prompt. This gets you out of the program and returns you to the Main Menu. At this point, you have direct access to the program information and procedures. From the Main Menu you can perform a number of useful operations, like using the editor or using PROMULA in direct mode (by selecting Main Menu option 10) to perform diagnostic or debugging operations. In direct mode, you may audit the contents of the program selectively or make other adjustments before resuming execution. This is a very useful feature for developing and testing programs.

To return to the precise point of execution where you exited the program select option 7 off the Main Menu.

2.1.2.8. F8 -- Run a Program from a Disk File

An executable program may be run in one of two ways: interactively or in batch mode. Interactive execution proceeds as follows: the program issues prompts, pauses after each prompt, and expects a response from you before continuing execution. The program issues its prompts on the console and you enter your responses with the keyboard or mouse, one at a time. In batch mode, on the other hand, program execution proceeds without pause for user input from the keyboard. In this mode, all of your responses are expected to have been saved "in batch" on a text file, called the batch input file. For more information about preparing batch input files, see the section entitled **Running Interactive Programs in Batch**.

It is often inconvenient to execute a program directly from the console. It might be that the program is executed very often with minor or no data changes. Alternatively, the program might execute very slowly, or an exact record of each execution might be desired. Whatever the reason, batch execution provides the capability to execute a program in a non-interactive, file-driven mode. During batch execution, your program reads from a batch input file. The batch input file is a standard text file produced by any text editor. It contains the responses to the various program prompts in the precise order and form that they would be entered directly on the keyboard.

Main Menu option 8 is used to execute a compiled PROMULA program in batch mode, i.e., via commands in a "batch input file" on disk. In contrast, Main Menu option 6 is used to execute a compiled PROMULA program interactively, i.e., directly from the console. Selecting Main Menu option 8 results in the sample dialog shown below:

```
Enter the filename of the batch input file
       ? DEMO.INP
Where do you want the batch output listing? C)onsole, P)rinter, D)isk
       ? D
Enter a filename for the batch output listing
       ? DEMO.OUT
Enter the filename of the program to be executed
       ? DEMO.XEQ
```

`DEMO.INP` is a file containing the responses required by the program `DEMO.XEQ` and its contents are shown below:

```
13200 12100 14800 16200 15200 17200 18060 18960 19900 20900 21950 23050
9200 8600 10400 11300 10700 12100 12700 13350 14000 14700 15440 16210
```

`DEMO.OUT` is the disk file where the output is saved. This file is shown in Figure 2-4 and can be printed later or browsed using a text editor. The "batch" output shown here is the same as the output produced by running `DEMO.XEQ` interactively and spooling the run directly to the file `DEMO.OUT`.

```
            Please enter the monthly sales figures.
              ? 13200 12100 14800 16200 15200 17200 18060 18960 19900 20900
              ? 21950 23050
            Please enter the monthly cost figures.
              ? 9200 8600 10400 11300 10700 12100 12700 13350 14000 14700
              ? 15440 16210

                            Monthly Profit and Loss Figures ($)

                                  Sales       Costs      Profit

                      January     13,200       9,200       4,000
                      February    12,100       8,600       3,500
                      March       14,800      10,400       4,400
                      April       16,200      11,300       4,900
                      May         15,200      10,700       4,500
                      June        17,200      12,100       5,100
                      July        18,060      12,700       5,360
                      August      18,960      13,350       5,610
                      September   19,900      14,000       5,900
                      October     20,900      14,700       6,200
                      November    21,950      15,440       6,510
                      December    23,050      16,210       6,840

            Average monthly Profit ($) 5,235.00
```

Figure 2-4: Contents of File DEMO.OUT

2.1.2.9. F9 -- Run a Menu of Applications

Main Menu option 9 is used to start the application **PROMULA.XEQ**. A default **PROMULA.XEQ** program is distributed with PROMULA. This application displays a menu from which you may access either the PROMULA course or any of the sample programs provided with your PROMULA package. The sample programs and the course can help you learn to write and use your own PROMULA programs.

PROMULA.XEQ is a standard PROMULA executable (its source code is contained in the file **PRMDEMO.PRM**) and it may be replaced by a program you create that supports a menu of your own applications. To do this, create a PROMULA executable called **PROMULA.XEQ**. Note that the name of the executable file launched by selecting Main Menu option 9 is hardwired in the system and must be **PROMULA.XEQ**.

2.1.2.10. F10 -- Use the PROMULA Language

Selecting Main Menu option 10 (numeric key 0) puts PROMULA into direct or Command Mode. In this mode, PROMULA accepts a single statement of source instructions, converts it to executable instructions which are executed by the computer, and proceeds to the next statement.

Pressing the **Esc** key or entering the **STOP** statement gets you out of direct mode and returns you to the Main Menu.

In direct mode, PROMULA issues the prompt

```
      PROMULA?
```

and expects you to enter a statement on the same line of the screen. To enter a statement, simply type it in and press the **Enter** key. After entering a statement, PROMULA will execute it and prompt you again for a new statement.

Some PROMULA statements have a beginning, an end, and a number of other line entries inbetween. For such a structured statement, PROMULA issues the short question mark prompt

```
?
```

until the end of the statement is entered. The short prompt is intended to remind you that you have not yet ended a structured statement that you started in an earlier entry line. For example, entering in direct mode the set definitions of Figure 2-2 would result in the following interaction:

```
PROMULA? DEFINE SET
       ?   month(12)     "12 Months of the Year"
       ?   acnt(3)       "3 Profit and Loss Ledger Accounts"
       ? END SET
PROMULA?
```

Any program compiled in batch using the Main Menu (option 5) can also be entered directly from the keyboard in command mode. The result is the same as compiling in batch mode.

2.1.3. Running Interactive Programs in Batch

PROMULA programs may be executed interactively or in batch. During **interactive execution**, any questions or prompts presented by the program are answered by a person using the keyboard and/or mouse. The person responding to the program is referred to as the **user**. During **batch execution**, any questions or prompts presented by the program are "answered" by one or more lines of text in a file on disk. The file containing the responses is referred to as the **batch input file** or **batch script**.

A batch script can describe any sequence of inputs that PROMULA might expect from a program user. The responses in a batch script are usually a mixture of batch commands and data for the program. The batch commands may also be used by persons running PROMULA interactively on a terminal that does not support non-printing keys such as **Home**, **End**, and **Escape**.

In order to prepare batch input files correctly, it is necessary to understand PROMULA's input model. PROMULA accepts inputs in one of two forms: **Keypresses** and **Records**.

Keypresses are single keystrokes or simultaneous keystroke combinations (e.g., **Alt-H**). Almost all keypresses are input by pressing some non-printable key on the keyboard. Keypresses may also be input by "pointing and clicking" on specific areas of the screen with a mouse. Examples of keypresses are pressing the **Page-Down** key to move to the next page of a display, pressing the **End** key to finish browsing or editing a display, and pressing a key to make a selection from a pick menu.

Records are strings of printable characters that represent data or responses to program prompts. Most records are input by reading them from a text file, or by typing them in and pressing the Enter key. Examples of records are PROMULA statements entered in command mode, and data entered in response to an **ASK** or **READ** statement. Another example of a record is the value entered in response to the

Enter Value or **End?**

prompt generated by PROMULA's various **EDIT** statements.

When you prepare a batch script, you have to know exactly what happens when the program runs interactively. You also have to keep track of when the program expects keypresses and when it expects records. If the program is expecting a record, type it on the next line of the script. If the program is expecting a keypress, type the batch command for the keypress on the next line of the script.

The batch commands are the simple one-character codes shown in Table 2-1 below:

Table 2-1: The PROMULA Batch Language Commands

CODE	MEANING	INTERACTIVE KEYPRESS*	NOTES
s	Display the screen image	None	1
m	Escape to main menu	Esc	2
e	End	End	2
r	Move right one position	Right arrow	2
l	Move left one position	Left arrow	
b	Backspace	Backspace	
a	Move to beginning of current line	Ctrl-Left Arrow	
z	Move to end of current line	Ctrl-Right Arrow	
x	Delete current character	Del	
i	Toggle insertion characteristics	Ins	
t	Tab right	Tab	3
j	Tab left	Shift-Tab	3
u	Move up one position	Up arrow	3
d	Move down one position	Down arrow	3
f	First page	Home	3
p	Previous page	PgUp	3
n	Next page	PgDn	3
h	Help	Alt-H	
1...	Function key 1...	F1...	
11...	Shift+Function key 11...	Shift-F1...	
!	Explicit Return or Enter	Return or Enter	4

* The interactive keypresses presented above correspond to keys on a standard IBM PC-Compatible keyboard. Keyboard tables for other platforms are included with the PROMULA installation instructions.

Table 2-2 Notes:

(1) Most screen output is suspended during batch execution. The show command(s) may be used to display the screen. If the run is being saved on disk or printed, the screen will be written to the output file or printed.

(2) The **\E** and **\R** batch commands for Escape and Resume an application are no longer compatible with PROMULA's batch command language. They have been replaced with Main Menu selections so that the batch scripts can more closely parallel interactive runs. For example, the new and old methods of escaping and resuming from a batch run are illustrated below:

OLD WAY PROMULA VERSIONS 2.XX AND EARLIER	NEW WAY PROMULA VERSIONS 3.XX AND LATER

```
batch statements.                    batch statements.
.                                    .
.                                    .
\E                                   m   (or #m as a record)
                                     10  (Main Menu option 10)
"command mode" statements
.                                    "command mode" statements
.                                    .
\R                                   .
                                     #m
.                                    7  (Main Menu option 7)
.                                    .
more batch statements                .
                                     more batch statements
```

(3) During batch execution, the command-line buffer is not active, so the use of these keys to control it is not supported.

(4) The exclamation point (!) may be used to indicate that the Return or Enter key is to be pressed when PROMULA is waiting for a keypress. The enter command is useful for putting PROMULA into data entry mode during batch execution of an **EDIT** statement. Use of the exclamation point to signify the return used to enter a record is not required or allowed.

Notice that the batch commands are printable characters and therefore look like records. If the program is expecting a record, and you want to enter a keypress, precede the keypress code with a **pound sign** (#). For example, if the program is expecting a record, and you want to escape from the application to the main menu, enter *#m*. If you put just an *m*, the program will read *m* as the value of the record.

There is one exception to these guidelines: if the program is expecting a keypress that is also used as a batch command, you must precede the keypress with a pound sign. For example, if the program has a popup pick menu option with selection key *m* and you want to select the *m* option in your batch script, put a *#m* on the next line of the batch script. If you put just an *m*, the program will escape to the main menu instead of selecting the program menu's *m* option.

The easiest way to prepare a batch script is to run the program interactively and make careful notes of the keypresses and records that are entered. Next, translate the keypresses into batch commands using the relationships in **Table 2-1**. Each record is placed on a line in the script just as it would be typed during interactive execution. Optionally, some data records may be replaced by PROMULA commands. For example, instead of trying to use batch commands to respond to an **EDIT** statement, escape from the application and use equations, **READ** statements, and procedure calls to assign values to the variables. Of course, this method requires that you know the names of the items contained in the program.

There should be a close parallel between the interactive keypresses and records entered during interactive mode and the commands and data in the batch script. Plots are the one exception to this rule: during an interactive run, PROMULA pauses for a keypress after generating a plot; however, during a batch run, PROMULA does not pause after a plot, so no keypress is needed.

There are two ways to run an application in batch: start the application using Main Menu option 8, or compile the statements that start the application using Main Menu option 5 or a **RUN** statement. For example, compiling the following statements start a batch run of the application contained in the segment file `test.xeq`; execution starts with the first statement of the procedure called `proc`.

```
OPEN SEGMENT "test.xeq" STATUS=OLD
READ SEGMENT MAIN, DO proc
.
  batch commands
.
```

Example:

The program **batche.prm** shown below will be used as an example for the batch run.

```
OPEN SEGMENT "BATCHE.XEQ" STATUS=NEW
DEFINE PROGRAM "BATCH TEST"

DEFINE VARIABLE
  opt    "menu option"
  b      "b variable" TYPE=REAL(12,3)
  a      "a variable" TYPE=REAL(12,3)
  x      "x variable" TYPE=REAL(12,6)
END VARIABLE

DEFINE WINDOW
  sw(01,01,28,20, WHITE/BLACK, FULL/SINGLE/WHITE/BLACK)
  mw(32,01,78,20, WHITE/BLACK, FULL/SINGLE/WHITE/BLACK)
  pw(01,23,78,23, WHITE/BLACK, FULL/SINGLE/WHITE/BLACK)
END WINDOW

DEFINE MENU picmnu POPUP(SW,PW)
  \EDIT\
  \COMPUTE\
  \DISPLAY\
  \QUIT\
END
FIELD 1, SELECT=E, HELP=0, ACTION=1
  EDIT VALUES
END
FIELD 2, SELECT=C, HELP=0, ACTION=2
  COMPUTE VALUES
END
FIELD 3, SELECT=D, HELP=0, ACTION=3
  DISPLAY VALUES
END
FIELD 4, SELECT=Q, HELP=0, ACTION=4
  QUIT
END
END picmnu

DEFINE MENU datmnu
    ENTER INPUTS
    A = @@@@@@@@@@@@@@@
    B = @@@@@@@@@@@@@@@
END
```

batche.prm (continued)

```
DEFINE PROCEDURE ctrl
SELECT picmnu(opt)
DO IF opt EQ 4
  BREAK ctrl
ELSE opt EQ 1
  EDIT datmnu(a,b)
ELSE opt EQ 2
  x = a * b
ELSE opt EQ 3
  WRITE CENTER (a " * " b " = " x // "PRESS A KEY TO CONTINUE") CLEAR(-1)
END
ctrl
END PROCEDURE ctrl

DEFINE PROCEDURE start
```

```
        OPEN mw MAIN
        OPEN pw PROMPT
        ctrl
        CLEAR MAIN
        CLEAR PROMPT
        WRITE CLEAR(0)
        END PROCEDURE start

        END PROGRAM, DO start
```

Let's assume we want to run this program using Main Menu option 5 for two different sets of inputs. The first set of inputs is `(a=1.5, b = 4.0)`; the second set of inputs is `(a=1.2, b = 6.0)`.

BATCH SCRIPT	COMMENTS
`OPEN SEGMENT "batche.xeq"`	Open the segment file containing the program.
`READ SEGMENT MAIN`	Read the program into memory, execution starts with procedure `start`.
`m`	`SELECT picmnu(opt):` expecting a keypress; escape to Main Menu
`10`	Main Menu: select option 10 to go to command mode.
`a = 1.5`	Command mode statement: `a = 1.5`
`b = 4.0`	Command mode statement: `b = 4.0`
`#m`	PROMULA expecting a card, escape to Main Menu
`7`	Main Menu: select option 7 to resume an interupted application.
`#c`	`SELECT picmnu(opt):` expecting a keypress; choose option C, Compute.
`#d`	`SELECT picmnu(opt):` expecting a keypress; choose option D, Display.
`!`	`WRITE ... CLEAR(-1):` Press any key (e.g., Enter)
`#e`	`SELECT picmnu(opt):` expecting a keypress; choose option E, Edit
`!`	`EDIT datmnu(a,b):` press enter for data entry mode.
`1.2`	Provide data card for first field of menu `(a = 1.2).`
`!`	`EDIT datmnu(a,b):` press enter for data entry mode
`6.0`	Provide data card for second field of menu `(b = 6.0).`
`e`	`EDIT datmnu(a,b):` press end to exit.
`#C`	`SELECT picmnu(opt):` expecting a keypress; choose option C, Compute.
`#D`	`SELECT picmnu(opt):` expecting a keypress; choose option D, Display.
`!`	`WRITE ... CLEAR(-1):` Press any key (e.g., Enter)
`#Q`	`SELECT picmnu(opt):` expecting a keypress; choose option Q, Quit.

2.1.4. PROMULA Keyboard Conventions

Depending on context, special keys have various effects. Local PROMULA prompts describe what the actions of the various keystrokes are. Most special keys are used in browsing and editing operations or in picking from menus.

The **PgUp**, **PgDn** and **Home** keys are used for paging through multi-screen displays (browsing). The **Ctrl** key is used with the **PrtSc** key to toggle the printer on and off.

The function keys (or numeric keys) are used for making selections off pick menus. The function keys are also used for interactively paging through the dimensions of multidimensional reports. The **Alt** (or **Shift**) key is used with the function keys to make selections off pick menus that have more than ten options; it is also used with most keystrokes of the PROMULA Text Editor.

The **Backspace**, **Del** and **Ins** keys are used in line editing. The **Ins** and **Del** keys are also used in tagging and untagging elements of lists during execution of the **SELECT SET** statement.

The **Return** or **Enter** key is the "end of record/line feed" signal and completes each PROMULA statement or data record.

The Arrow keys, **Home**, **PgUp**, and **PgDn** keys are used to move through selection lists, data menus, array variable displays and for file browsing.

The **End** key is used to end most interactive processes such as variable browsing and editing, menu editing, selection lists, etc.

See the description of Line Editing and the interactive PROMULA statements for more information on PROMULA's keyboard conventions.

PROMULA displays a prompt describing the relevant key actions whenever an interactive statement is executed.

2.1.4.1. Esc -- Escape to the PROMULA Main Menu

The **Esc** key enables you to suspend a PROMULA application and return to the PROMULA Main Menu. The information in your working space at the point of interruption is still available to you, and you may access it in command mode by selecting Main Menu option 10. While the program is suspended, you may browse the PROMULA tutorial, show intermediate results, perform various debugging operations, or even add new procedures and variables to the interrupted application by typing them in or by using the **RUN COMMAND** statement to read them from a file.

To return to the interrupted application, press the **Esc** key again to return to the PROMULA Main Menu and then select Main Menu option 7 — Resume an interrupted program.

2.1.4.2. Alt-H -- Get Context-sensitive Help

Pressing the **Alt-H** keys simultaneously will give you context-sensitive help, i.e., it will give you access to that topic within a help file that is pertinent to the particular point of the application that you are currently working with. This kind of local, context-sensitive help for the user has to be programmed in advance, i.e., a help file must be available and the logic to access a particular help topic must be coded into the procedure that you are working with. See **DEFINE DIALOG** for instructions on how to build help files, **BROWSE DIALOG** and **BROWSE TOPIC** for instructions on accessing help files, and **DO IF HELP** and **DO IF ERROR VALUE** for instructions on how to detect a call for help and branch to field-specific help accordingly.

2.1.5. Line Editing

When using PROMULA in direct mode or responding to prompts generated by the PROMULA editor, **READ**, **EDIT**, or **ASK** statements, you will use PROMULA's line editor. All information entered while in the line editor is saved in the line editor's buffer so that you may recall previously entered commands and data for modification and re-entry.

The following key conventions are used by the PROMULA line editor:

KEY	ACTION
Enter	Enter a line for processing and put it on the bottom of the line editor's buffer
Up-arrow	move up line editor's buffer (recall previous entries)

Down-arrow	move down line editor's buffer
Home	clear the input line
PgUp	move to top of line editor's buffer
PgDn	move to bottom of line editor's buffer
Tab	move cursor 8 spaces to the right
Shift-tab	move cursor 8 spaces to the left
Right-arrow	move cursor 1 space to the right
Left-arrow	move cursor 1 space to the left
Ctrl Right-arrow	move cursor to end of line
Ctrl Left-arrow	move cursor to beginning of line
Delete	delete the character over the cursor
Backspace	delete character to left and move cursor 1 space to left
Insert	toggle insert/overwrite mode

2.1.6. Printer Control

You can send output to your printer by doing the following:

1. Issue the command **SELECT PRINTER=ON**. This will send all PROMULA output to the printer until you issue the command **SELECT PRINTER=OFF**.

2. On an IBM compatible computer, simultaneously press the **Ctrl** key and the **PrtSc** key. This will send all PROMULA output to the printer until you turn the print toggle off by simultaneously pressing **Ctrl-PrtSc** again.

3. On an IBM compatible computer, simultaneously press the **Shift** key and the **PrtSc** key. This will send to the printer the contents of the current screen.

Other printer control options are discussed in Chapter 3 under the **SELECT option** statement.

Some printer control commands will not work unless your printer is on and properly connected to the computer.

If a **SELECT OUTPUT** statement is executed before a **SELECT PRINTER=ON**, output will be saved in the specified disk file.

2.2. PROMULA Application Programming

The following sections describe how to write the source code for a PROMULA application program.

An application program is an ordered set of instructions that tell the computer how to solve a particular problem, or perform a particular function, operation, or procedure. The instructions of a program — sometimes called commands, statements, or source code — are written in a human-readable notation, and describe how the program should work. Every statement should perform one or more of the following basic functions:

1. **Data Definition**

   This includes creating a framework for program information that is convenient and logical to work with.

2. **Program Control**

   This includes constructing procedures, loops, conditional branches, and other structures that control the sequence of events that take place during execution of the program.

3. **Data Manipulation**

   This includes putting information into a data framework and manipulating it in various ways. Operations such as performing calculations, reading data, sorting, selecting subsets of data, and doing other operations that transform the inputs of a program into useful information fall into this category.

4. **Report Generation**

   This includes producing displays of input data and output information. Once a program has transformed the input data into useful results, it is desirable to produce a report. The report may be text or graphics displayed on the screen, printed with a printer, or saved in an external file on disk.

5. **Interface Design**

   This includes creating a functional, attractive interface through which others can use the program easily and effectively.

In the following discussion, these five basic programming tasks and other important concepts of application programming are introduced in the context of a simple example called **The Budget Program**. This simple application helps its user determine how much extra money he/she will have after paying all of his/her expenses each month. The budget program is smaller than the typical PROMULA application, but it can serve to illustrate PROMULA's basic programming constructs and techniques.

2.2.1. Data Definition

KEY TOPICS:

1. Variables — Scalars and Arrays
2. Planning the Data Structures for an Application
3. Defining Sets
4. Defining Variables
5. Relating Sets and Variables

2.2.1.1. Variables -- Scalars and Arrays

One of the most essential steps in creating an application program is data definition — the process of creating a framework for program inputs and outputs that is convenient and logical to work with. To do this, the programmer must specify the types of information the application will manipulate and must determine an efficient framework for storing this information.

The basic unit of information storage in PROMULA, and most other computer programming languages, is called a **variable**. The information stored in a variable may be in the form of letters, numbers, or other characters, and may be a single value or a group of values.

Consider for example the value shown in Figure 2-5 below.

```
         Average Monthly Expense ($) 1,001.33
```

Figure 2-5: A Scalar Variable

The value, 1,001.33, could be stored in a single PROMULA variable. A single-valued variable like this one is sometimes referred to as a **scalar**. A numeric scalar variable is the simplest and smallest type of variable that can be defined in PROMULA.

Now consider the list of values shown below:

```
                               Average Expenses by Expense Category ($)

                                   RENT                          409.00
                                   FOOD                          275.24
                                   CAR SERVICE                   126.18
                                   UTILITIES                      88.44
                                   CAR INSURANCE                  45.00
                                   PHONE                          57.48
```

Figure 2-6: A One-dimensional Array Variable

The six values above could also be stored in a single PROMULA variable. Since this variable contains a group of values, it is referred to as an **array**. Variables with a one-dimensional list structure like the one shown above are sometimes called **vectors**. You may be familiar with statistical analysis packages that treat all variables like vectors. The values of this vector are classified by expense category. This means that the "rows" of the variable are the "expense category" dimension. They are a set of six elements, the expense categories: rent, food, car service, utilities, car insurance, and phone. The vector's values would be difficult to interpret if the vector and its rows were not well defined.

Finally, consider the table of values below:

```
                              Monthly Expenses by Category ($)

                 RENT         FOOD CAR SERVICE   UTILITIES     CAR INS        PHONE
       JAN     409.00       286.64      143.71       86.87       45.00        57.30
       FEB     409.00       276.76      166.28       84.78       45.00        50.21
       MAR     409.00       280.81      134.35       96.84       45.00        65.53
       APR     409.00       294.05       99.55       98.06       45.00        61.30
       MAY     409.00       286.98       88.13       86.77       45.00        58.03
       JUN     409.00       275.43      152.85       98.06       45.00        56.45
       JUL     409.00       269.81      103.88       87.47       45.00        56.45
       AUG     409.00       289.93      127.67       72.28       45.00        50.61
       SEP     409.00       261.35      171.10       76.47       45.00        55.64
       OCT     409.00       258.71      127.52       88.28       45.00        58.33
       NOV     409.00       250.12      105.25       91.41       45.00        69.28
       DEC     409.00       272.28       93.81       93.93       45.00        50.67
```

Figure 2-7: A Two-dimensional Array Variable

The 72 values above could also be contained in a single PROMULA variable. Variables with this "row by column" structure are sometimes referred to as **two-dimensional arrays**. You may be familiar with the two-dimensional worksheets that most spread sheet and financial modeling programs manipulate. The array values above are classified by month and expense category. The "rows" of the variable are the "month" dimension; they are a set of 12 elements, the months January through December. The "columns" of the array are the "expense category" dimension. They are a set of six elements, the expense categories: rent, food, car service, utilities, car insurance, and phone. Like the vector above, the array's values would be meaningless if the array and its rows and columns were not well defined.

This progression can be carried further. For example a three–dimensional array can be thought of as a group of two-dimensional arrays or tables. PROMULA arrays may have up to 10 dimensions, and the PROMULA language is designed to make it easy for programmers and users to work with this type of highly structured information.

2.2.1.2. Planning the Data Structures for an Application

In PROMULA you must organize your information into array and scalar variables before your program can manipulate them. Often it is useful to categorize the variables as being either inputs and/or outputs. For example, the budget program will manipulate the following inputs and outputs.

BUDGET PROGRAM INPUTS

The essential inputs of the budget program are the worker's monthly expenses and income.

Monthly expenses: For each month, the worker must specify his/her monthly expenses. Since the program is intended to determine the amount of *extra* money the worker will have at the end of each month, only those expenses that the worker *must* pay each month will be included. The monthly expenses will be divided into six categories: rent, food, car service, utilities, car insurance, and phone.

For each month, the program will compute the worker's **Monthly Income** from several other inputs:

Hourly Wage Rate ($/hr.)	the dollars earned per hour (before taxes),
Payable Hours per Month	the number of hours the worker expects to work each month,
Pay Lost to Taxes	the fraction of wages lost to taxes,
Monthly Income Bonus ($)	a dollar amount earned by the worker independent of the number of hours worked or the tax rate. If the worker is salaried, this is the worker's monthly take-home pay.

BUDGET PROGRAM OUTPUTS

The worker's total monthly income and expenses will be computed from the program inputs. The monthly expenses will be subtracted from the monthly income to give a monthly balance, or the amount of money that will be left over each month for saving or spending on luxury items or emergencies. In addition, the annual totals and averages will be computed.

Having determined the inputs and outputs required for our program, we may use PROMULA to create a framework for this information. The figure below shows the PROMULA statements that can create the essential input and output variables of the budget program.

```
       DEFINE SET
         mons(12) "Months"
         exps(6)  "Expense Categories"
       END SET

       DEFINE VARIABLE
       **
       ** INPUTS
       **
         expns(mons,exps) TYPE=REAL(10,2) "Monthly Expenses by Category ($)"
         payhr(mons)      TYPE=REAL(10,0) "Payable Hours per Month (hr.)"
         bonus(mons)      TYPE=REAL(10,2) "Monthly Income Bonus"
         taxes            TYPE=REAL(10,4) "Fraction of Pay Lost to Taxes"
```

```
        wager             TYPE=REAL(10,2) "Hourly Wage Rate ($/hr.)"
      **
      **  OUTPUTS
      **
        incom(mons)       TYPE=REAL(10,2) "Monthly Income ($)"
        expnm(mons)       TYPE=REAL(10,2) "Monthly Expenses ($)"
        balns(mons)       TYPE=REAL(10,2) "Monthly Balance ($)"
        aincom            TYPE=REAL(10,2) "Average Monthly Income  "
        aexpnm            TYPE=REAL(10,2) "Average Monthly Expense "
        abalns            TYPE=REAL(10,2) "Average Monthly Balance "
      END VARIABLE
```

Figure 2-8: Definition of the Inputs and Outputs of the Budget Program

The code above illustrates the basic elements of data definition in the PROMULA language. The PROMULA statements displayed above are discussed in the following sections.

2.2.1.3. Defining Sets

In PROMULA, a **Set** is an ordered list of elements that can serve as an index for and define the structure of array variables. In other words, sets are classification schemes for information. For example, the values in Figure 2-7 are classified by month and expense category; these two classification schemes could be defined as sets in PROMULA.

In PROMULA, sets are created with the **DEFINE SET** statement. The sets required to structure the budget program's inputs and outputs are described in the table below.

Table 2-2: The DEFINE SET Statement for the Budget Program

Set Identifier	Number of Elements (Size)	Descriptor
mons	12	Months
exps	6	Expense Categories

Each set definition includes the set's identifier, size, descriptor, and other optional information. The set **identifier** is a short, symbolic name for the set, and is used to refer to the set in other statements of the program. The set **size** specifies the range of the set indices and the number of items which may be indexed by the set. The set **descriptor** is optional and is used to describe the set for documentation and program interface purposes.

By default, the elements of a set are ordered from 1 to N, where N is the size of the set. In addition, each set element has a **Label** and a sequence number. The default labels for sets are formed from the set identifiers and the element sequence numbers in parentheses as shown below.

```
                Labels for set mons       Labels for set exps

                  MONS(1)                   EXPS(1)
                  MONS(2)                   EXPS(2)
                  MONS(3)                   EXPS(3)
                  MONS(4)                   EXPS(4)
                  MONS(5)                   EXPS(5)
                  MONS(6)                   EXPS(6)
                  MONS(7)
                  MONS(8)
                  MONS(9)
                  MONS(10)
```

```
                    MONS(11)
                    MONS(12)
```

The default element labels may be changed to other more (or less) descriptive ones by reading values into the set, or by using a **DEFINE RELATION** or **SELECT RELATION** statement to specify user-defined labels for the elements. See "Relating Sets to Variables" below.

For more information about sets, refer to Chapter 3 of this manual, especially the sections covering the PROMULA noun **set** and the **DEFINE SET**, **DO set**, **SELECT SET**, **SELECT ENTRY**, and **SELECT set** statements.

2.2.1.4. Defining Variables

Variables are structures that store program information. It is in terms of variables that the data manipulations performed by a program are expressed.

In PROMULA, variables are created with the **DEFINE VARIABLE** statement. Each variable definition must include a unique identifier, and may also include a structure, type, descriptor, and other options for the variable. The variable definitions for the budget program are shown in Figure 2-8 and are described in Table 2-2 below.

Table 2-3: The DEFINE VARIABLE Statement of the Budget Program

Variable Identifier	Set Structure	No. of Values	Value Type	Format (w,d)	Descriptor
expns	mons,exps	72	REAL	0,2	Monthly Expenses by Category ($)
incom	mons	12	REAL	10,2	Monthly Income ($)
payhr	mons	12	REAL	10,0	Payable Hours per Month (hr.)
bonus	mons	12	REAL	10,2	Monthly Income Bonus
taxes	-- (scalar)	1	REAL	10,4	Fraction of Pay Lost to Taxes
wager	-- (scalar)	1	REAL	10,2	Hourly Wage Rate ($/hr.)
expnm	mons	12	REAL	10,2	Monthly Expenses ($)
balns	mons	12	REAL	10,2	Monthly Balance ($)
aincom	-- (scalar)	1	REAL	10,2	Average Monthly Income ($)
aexpnm	-- (scalar)	1	REAL	10,2	Average Monthly Expense ($)
abalns	-- (scalar)	1	REAL	10,2	Average Monthly Balance ($)

The variable **identifier** is a short, symbolic name for the variable and is used to refer to the variable in the program. The variable **structure** is the scheme according to which its contents are organized and is usually expressed in terms of program sets. The variable **descriptor** is a description or label for the variable and is supplied for program documentation and user interface purposes. The variable **format type** specifies the kind of values the variable contains and their default display format.

If no type specification is included with the variable definition, it will have format type **REAL(8,0)** by default. This means that when the variable is displayed, each of its values will fill a width of 8 characters and will be rounded to the nearest whole number (0 decimal digits).

Missing from the above definitions are the contents, or values, of the variables. These may be introduced by the **READ** statements or by equations. See "Reading in Data" and "Writing Equations" below. PROMULA initially sets the values of variables to zero when they are defined unless a **VALUE** parameter is included with the variable definition. It is also possible for a variable to obtain its values from a database. See Chapter 4 for details.

The following figure shows the default displays of some of the program variables defined above. Notice how PROMULA uses the type specification and other information in the variable definitions to control the displays generated by the **WRITE variable** statement:

```
WRITE expns
                         Monthly Expenses by Category ($)

                  EXPS(1)   EXPS(2)   EXPS(3)   EXPS(4)   EXPS(5)   EXPS(6)
MONS(1)              0.00      0.00      0.00      0.00      0.00      0.00
MONS(2)              0.00      0.00      0.00      0.00      0.00      0.00
MONS(3)              0.00      0.00      0.00      0.00      0.00      0.00
MONS(4)              0.00      0.00      0.00      0.00      0.00      0.00
MONS(5)              0.00      0.00      0.00      0.00      0.00      0.00
MONS(6)              0.00      0.00      0.00      0.00      0.00      0.00
MONS(7)              0.00      0.00      0.00      0.00      0.00      0.00
MONS(8)              0.00      0.00      0.00      0.00      0.00      0.00
MONS(9)              0.00      0.00      0.00      0.00      0.00      0.00
MONS(10)             0.00      0.00      0.00      0.00      0.00      0.00
MONS(11)             0.00      0.00      0.00      0.00      0.00      0.00
MONS(12)             0.00      0.00      0.00      0.00      0.00      0.00

WRITE payhr
                            Payable Hours per Month (hr.)

             MONS(1)                 0   MONS(2)                 0
             MONS(3)                 0   MONS(4)                 0
             MONS(5)                 0   MONS(6)                 0
             MONS(7)                 0   MONS(8)                 0
             MONS(9)                 0   MONS(10)                0
             MONS(11)                0   MONS(12)                0

WRITE taxes
Fraction of Pay Lost to Taxes 0.0000

WRITE wager
Hourly Wage Rate ($/hr.) 0.00
```

Figure 2-9: Display of some of the variables defined in the Budget Program

For a more comprehensive discussion of variables, refer to Chapter 3 of this manual, especially the sections covering the PROMULA Noun **Variable** and the **DEFINE VARIABLE** statement.

2.2.1.5. Relating Sets and Variables

Although the variables defined above are fully functional, the displays in Figure 2-9 are not complete because the default labels for the elements of sets `mons` and `exps` need to be replaced with more meaningful ones.

There are several methods of relating descriptive information to program sets. One simple and flexible way is to define a vector variable that is dimensioned by the set whose elements you want to label, then assign appropriate set element descriptions to the values of the variable and relate the variable to the set. Let's do this for set `mons`.

First, define a vector variable to contain the set element labels:

```
DEFINE VARIABLE
  monsn(mons) TYPE=STRING(4) "Month Names"
END VARIABLE
```

The statement above defines a vector of 12 values called `monsn`. The format type of this variable's values is **STRING(4)**. String type variables can contain alphanumeric data (letters, numbers, and other characters.) The default display format for the values of variable `monsn` has a width of four characters.

Second, read in the values to be used as labels for set `mons` using the **READ variable** statement. In this case, we will use three-letter abbreviations for each month.

```
READ monsn:4
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
```

The statement **READ monsn:4** tells PROMULA to start reading in column one of the next line and to read four characters for each of the 12 values of the vector variable `monsn`. The values of `monsn` after the read are displayed below:

```
                                 Month Names

               MONS(1)         JAN   MONS(2)         FEB   MONS(3)         MAR
               MONS(4)         APR   MONS(5)         MAY   MONS(6)         JUN
               MONS(7)         JUL   MONS(8)         AUG   MONS(9)         SEP
               MONS(10)        OCT   MONS(11)        NOV   MONS(12)        DEC
```

Third, relate the variable `monsn` to the set `mons` using a **DEFINE RELATION** statement.

```
DEFINE RELATION
  ROW(mons,monsn)
END RELATION
```

There are four types of relations between sets and variables in PROMULA: **ROW**, **COLUMN**, **KEY**, and **TIME**. These are described in the discussion of the **DEFINE RELATION** statement in Chapter 3. The **ROW** relation is used to specify the primary descriptor for a set's elements. The values of the primary descriptor are used to label the elements of the set in displays of the set and in displays of variables whose rows are classified by the set.

Now, create labels for the elements of set `exps`. First, define a vector variable to contain the set element labels:

```
DEFINE VARIABLE
  expsn(exps) TYPE=STRING(16) "Expense Categories"
END VARIABLE
```

Second, assign values to be used as labels for the elements of set `exps`. In this case, we will do this with equations.

```
expsn(1) = "RENT"
expsn(2) = "FOOD"
expsn(3) = "CAR SERVICE"
expsn(4) = "UTILITIES"
expsn(5) = "CAR INS"
expsn(6) = "PHONE"
```

Third, relate the variable `expsn` to the set `exps` using a **DEFINE RELATION** statement.

```
DEFINE RELATION
  COLUMN(mons,monsn)
END RELATION
```

A **COLUMN** relation between a set and a variable tells PROMULA to use the variable's values to label columns classified by the set in displays of array variables.

After defining, initializing, and relating labels to the program sets, a display of any variable dimensioned by the sets is much more meaningful. For example, the display of variable `expns` is shown in the dialog below as an example:

```
WRITE expns

                          Monthly Expenses by Category ($)

              RENT          FOOD CAR SERVICE   UTILITIES      CAR INS        PHONE
JAN           0.00          0.00        0.00        0.00         0.00         0.00
FEB           0.00          0.00        0.00        0.00         0.00         0.00
MAR           0.00          0.00        0.00        0.00         0.00         0.00
APR           0.00          0.00        0.00        0.00         0.00         0.00
MAY           0.00          0.00        0.00        0.00         0.00         0.00
JUN           0.00          0.00        0.00        0.00         0.00         0.00
JUL           0.00          0.00        0.00        0.00         0.00         0.00
AUG           0.00          0.00        0.00        0.00         0.00         0.00
SEP           0.00          0.00        0.00        0.00         0.00         0.00
OCT           0.00          0.00        0.00        0.00         0.00         0.00
NOV           0.00          0.00        0.00        0.00         0.00         0.00
DEC           0.00          0.00        0.00        0.00         0.00         0.00
```

For more information about relations between sets and variables, refer to Chapter 3 of this manual, especially the sections covering the PROMULA noun **Relation** and the **READ set**, **DEFINE RELATION**, and **SELECT RELATION** statements.

2.2.2. Program Control

KEY TOPICS:

1. Procedures
2. Linear Flow
3. Conditional Branches
4. Looping

One of the most important tasks facing an application programmer is setting up structures to control the sequence of events that take place during program execution. The efficiency of a program and the accuracy of its results are highly dependent on the correct implementation of these structures. Fortunately, only three types of control structures are needed to handle the control requirements of any application program. These are **Linear Flow structures**, **Conditional Branch structures**, and **Looping structures**. In addition, a fourth type of control structure, the **Procedure** is often used to help modularize the activities of a program into subunits that work together.

2.2.2.1. Procedures

A large computer program is like a complex machine; it can have many parts. The most fundamental of these parts are the program's statements. Each statement performs a specific predefined task. In addition to the statements that are available in the PROMULA language, it is possible to create your own. In PROMULA, a programmer-defined statement is called a **Procedure**. A procedure is a set of statements that are executed as a group when the procedure's name is used as a program statement. This is referred to as "calling" or "invoking" the procedure.

Defining procedures gives programmers the ability to break the programming process into simpler steps. Each procedure creates a functional program unit that can later be integrated with the other procedures to create the full program.

When PROMULA encounters a procedure name in a program, it executes the statements of the procedure. When execution of a procedure finishes, processing continues with the statement following the procedure call. Procedures can call other procedures including themselves.

For more information on procedures, see the **DEFINE PROCEDURE** statement in Chapter 3 of this manual.

2.2.2.2. Linear Flow

PROMULA applications use linear control as the primary means of directing their course of action. This means that executable operations are performed in the order in which they are defined. Thus, execution of a program begins with the first statement of the first procedure of the program and proceeds to follow the program instructions one-by-one toward the last statement of the program. After execution of the last statement, the program ends. A schematic of linear program flow is shown in the diagram below:

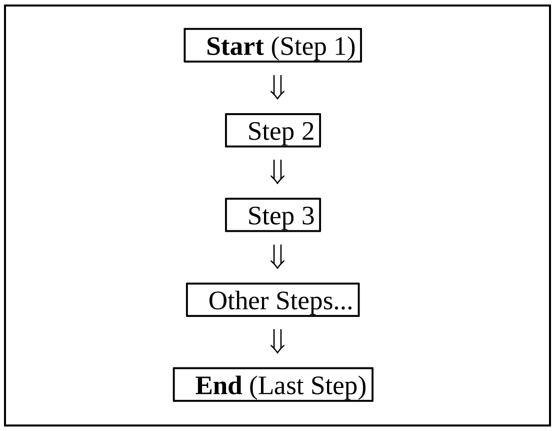


Figure 2-10: Linear Program Flow

Any one of these steps may be a simple statement, a procedure call, or another control structure.

2.2.2.3. Conditional Branches

A linear flow of action through a program in which every statement from the first to the last is executed in sequence is often inflexible and inefficient. Even worse, it may lead to errors if the data put into the program does not fit the linear logic defined by the code. In order to efficiently manage complex problems and data, your programs will require flexibility. The basic element of all complex control structures is the **Conditional Branch**. Conditional branches are program statements that can redirect linear flow and create more flexible and responsive execution paths. A schematic of a conditional branch is shown in the figure below:

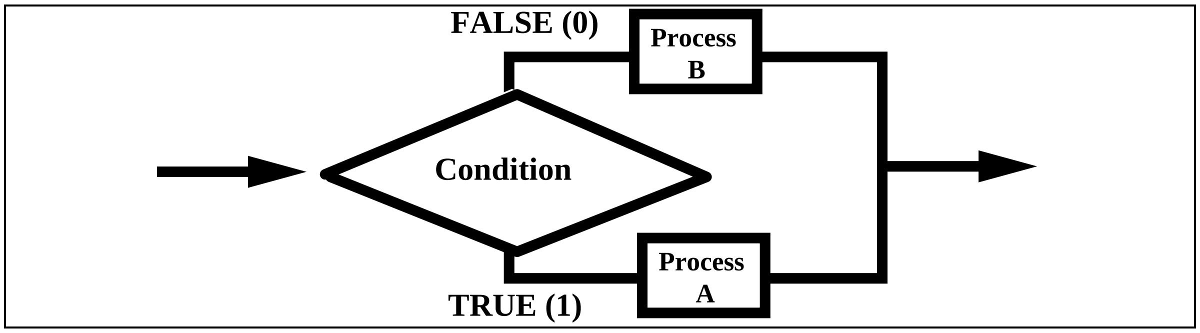


Figure 2-11: A Simple Conditional Branch

Conditional branch statements are often referred to as "IF-THEN-ELSE" statements. For example, the diagram above illustrates a simple conditional branch that can be read as "**If** the Condition is true, **then** do Process A; **else** (the Condition is false), do Process B". Process A and/or Process B may also contain Conditional branches.

An IF-THEN-ELSE statement that might be used in the budget program would check the value of the `taxes` variable to make sure it "makes sense." Recall that variable `taxes` is used by the budget program to make a simple adjustment on the worker's earnings to reflect the fraction of pay lost to taxes. The program expects this value to be between 0.5 and one. In PROMULA, the **DO IF** statement is used to create logical branches.

An example of the **DO IF** statement that could be used to check the value of `taxes` and write an error message if the value does not fit the expectations of the program is shown below:

```
DO IF taxes GT 1

  WRITE ("The value of taxes should be less than one.")

ELSE  taxes LE 0

  WRITE ("The value of taxes should be greater than or equal to zero.")

ELSE  taxes GT 0.50

  WRITE ("The value of taxes should be less than 0.5)

END IF
```

For more information on Branching refer to the sections covering the **DO IF** statement and the nouns **Boolean Expression** and **Relational Expression** in Chapter 3 of this manual.

2.2.2.4. Looping

Looping refers to the process of repeatedly performing a set of operations. The basic components of a loop are the body of the loop, and the DO condition for the loop. The **body** of the loop is simply the set of instructions that are executed on each pass through the loop. The **DO condition** for the loop is a true-false expression that is evaluated before each iteration of the loop to determine if the instructions in the body of the loop should be performed. PROMULA supports several types of looping control structures; these include the **DO WHILE**, **DO UNTIL**, **DO file**, and **DO set** statements, and **recursion**.

DO WHILE loops execute the instructions in the body of the loop while the DO condition is true.

DO UNTIL loops execute the instructions in the body of the loop until the DO condition is false.

DO file loops are used with text or random files. They execute the instructions in the body of the loop once for each record of the file and exit when the end of file is reached.

The **DO set** loop is unique to PROMULA; it is a set-controlled looping structure that executes the instructions in the body of the loop once for each element of the set's selection vector. A set's selection vector contains the currently active elements of the set. Thus, the order and range of a **DO set** loop can be controlled by sorting and/or selecting the elements of the set. **DO set** loops are an extremely powerful tool for manipulating PROMULA's set-based array variables.

Recursion is a looping control structure that does not use one of PROMULA's **DO loop** statements explicitly. It is used to execute a procedure repeatedly until some "exit" condition occurs. Recall that a procedure is a group of statements that are executed as a unit when the procedure's name is used as a statement. Recursion occurs when one of the statements in the procedure is a call to the procedure itself. A procedure that calls itself is referred to as a recursive procedure.

A simple example of a recursion loop is a procedure that offers the user selections from a menu repeatedly until the user selects the exit option.

An example is procedure `recurs` shown below:

```
DEFINE MENU pickmenu

  1 \Exit Procedure\

  2 \Action A\
  3 \Action B\
  4 \Action C\
END

DEFINE VARIABLE
 choice
END VARIABLE

DEFINE PROCEDURE recurs
SELECT pickmenu(choice)
DO IF PICK EQ 1              ⇐ Here is the test of the DO condition.
  BREAK recurs
ELSE  PICK EQ 2
  Statements of Action A
ELSE  PICK EQ 3
  Statements of Action B
ELSE  PICK EQ 4
  Statements of Action C
END IF
recurs                ⇐ Here, the procedure recurs calls itself.
END PROCEDURE recurs
```

Notice that the last statement in procedure `recurs` is a call to itself. The DO condition for the recursion loop becomes false when the user selects option 1 from the menu. The recursion loop is broken when the **BREAK procedure** statement is executed. All other menu selections will allow the procedure to be called recursively.

For more information on looping, see the **DO WHILE**, **DO UNTIL**, **DO set**, and **DO file**, statements in Chapter 3.

2.2.3. Data Manipulation

KEY TOPICS:

1. Reading in data
2. Selecting the Elements of a Set
3. Sorting the Elements of a Set
4. Writing Equations

Data manipulation is another fundamental programming task that includes loading information into program variables and manipulating them to create output information.

2.2.3.1. Reading in Data

Getting data into its variables is a basic requirement of all computer programs. One of the easiest ways to read a fixed amount of information into a variable is to use PROMULA's **READ variable** statement. This statement is used to read free format data from the source code of your program or from the keyboard into a variable. Free format means that the format of the data values does not have to be specified, and the values may be in a variety of arrangements. For numeric data, the values need only be separated by blanks or commas, or be on separate lines, and there must be enough values to fill all active cells of the variable.

For example, the 12 values of the monthly bonus variable defined in Figure 2-8 could be loaded with the values 100, 200, 300, ..., 1200 using any of the following **READ variable** statements.

```
READ bonus\5
JAN  100
FEB  200
MAR  300
APR  400
MAY  500
JUN  600
JUL  700
AUG  800
SEP  900
OCT  1000
NOV  1100
DEC  1200
```

```
READ bonus
100 200 300 400 500 600 700

800 900 1000 1100 1200
```

```
READ bonus
100 200 300
400 500 600
700 800 900 1000 1100 1200
```

```
READ bonus
100 200 300 400 500 600 700 800 900 1000 1100 1200
```

The **READ variable** statement may also be used for scalars. For example, the worker's Hourly Wage Rate ($/hr.), variable `wager`, and the fraction of Pay Lost to Taxes, variable `taxes`, could be read in with the following two statements:

```
READ wager
10.0

READ taxes
0.30
```

Or, both scalar variables could be read in with a single statement:

```
READ (wager, taxes)
10.0  0.30
```

Reading in a multidimensional array like variable `expns` is a little trickier. As mentioned in the section on defining variables, PROMULA uses the order of sets in an array variable's definition to control how its data values are read in by a **READ variable** statement.

The first set is assumed to index the rows of data values.
The second set is assumed to index the columns of data values.
The third set is assumed to index the two-dimensional blocks of data.
The fourth set is assumed to index the three-dimensional blocks of data, and so on.

For example, the array `expns` is defined with set `mons` as its first (row) dimension, and set `exps` as its second (column) dimension. Therefore, array `expns` could be assigned values identical to those displayed in Figure 2-7 with the following **READ** statement:

```
READ expns
409 286.64 143.71 86.87 45 57.30
409 276.76 166.28 84.78 45 50.21
409 280.81 134.35 96.84 45 65.53
409 294.05 99.55 98.06 45 61.30
409 286.98 88.13 86.77 45 58.03
409 275.43 152.85 98.06 45 56.45
409 269.81 103.88 87.47 45 56.45
```

Expense Categories go across (the columns)
Months go down (the rows)

```
409 289.93 127.67 72.28 45 50.61
409 261.35 171.10 76.47 45 55.64
409 258.71 127.52 88.28 45 58.33
409 250.12 105.25 91.41 45 69.28
409 272.28 93.81 93.93 45 50.67
```

If the data values were rotated relative to the definition of array `expns`, sets could be included with the **READ variable** statement to explicitly indicate the rows and columns of the input data. Again, the first set is assumed to index the rows of data values, the second set is assumed to index the columns of data values; the third set is assumed to index the two-dimensional blocks of data; the fourth set is assumed to index the three-dimensional blocks of data, and so on.

```
READ expns(exps,mons)
409 409 409 409 409 409 409 409 409 409 409 409
286.64 276.76 280.81 294.05 286.98 275.43 269.81 289.93 261.35 258.71 250.12 272.28
143.71 166.28 134.35 99.55 88.13 152.85 103.88 127.67 171.10 127.52 105.25 93.81
86.87 84.78 96.84 98.06 86.77 98.06 87.47 72.28 76.47 88.28 91.41 93.93
45 45 45 45 45 45 45 45 45 45 45 45
57.30 50.21 65.53 61.30 58.03 56.45 56.45 50.61 55.64 58.33 69.28 50.67
```

There is no need for formats or loops to read in the values of an array variable. The definition of the variable contains all the information needed to control the read so that the data values are put into the appropriate cells of the array.

The examples above are simplistic and are based on reading from the source code of your program or from the keyboard. PROMULA can also read data from complicated fixed and variable length text and binary (random) files. These techniques are discussed in Chapter 3 in the sections covering the **READ variable**, **READ variables**, and **READ file** statements.

2.2.3.2. Selecting Sets

A common programming requirement is the selection of a subset of your data. For example,

1. to select the values of an array indexed by particular set sequence numbers before using the array in calculations or input/output operations,

2. to select only those values of a variable that meet a given criteria,

3. to put the values of an array into an order that is not directly possible by using PROMULA's **SORT** statement.

Whatever your needs, having access to sets as the indexes of multidimensional data gives you a powerful and flexible means of selecting and sorting subsets of your data.

The **SELECT set** statement is used to select the elements of a set. This is also called changing a **Set selection vector**.

The simplest set selection uses a literal specification of set element numbers to specify the elements of the set that are to remain active. For example, to select the fall and spring months, the following statement could be used:

```
SELECT mons(9-11,3-5)
```

The statement above tells PROMULA to change the range and order of set `mons` to the fall and spring months — September to November and March to May. In other words, the set's selection vector now contains the following values: 9, 10, 11, 3, 4, and 5 in that order. This means that all actions involving set `mons` will be performed only on values indexed by these elements of the set. For example, the statement `WRITE expns` would produce the following display:

```
                         Monthly Expenses by Category ($)

               RENT         FOOD CAR SERVICE   UTILITIES     CAR INS       PHONE
     SEP     409.00       261.35      171.10       76.47       45.00       55.64
```

```
       OCT      409.00      258.71      127.52      88.28      45.00      58.33
       NOV      409.00      250.12      105.25      91.41      45.00      69.28
       MAR      409.00      280.81      134.35      96.84      45.00      65.53
       APR      409.00      294.05       99.55      98.06      45.00      61.30
       MAY      409.00      286.98       88.13      86.77      45.00      58.03
```

To restore a set to its default size and order, use the **SELECT set*** statement.

Variables may also be used to indicate the elements to be selected. For example, in order to select the months October through December, and March, the following statements could be used:

```
DEFINE VARIABLE
  m1
  m2
  m3
END VARIABLE

m1=10
m2=12
m3=3

SELECT mons(m1-m2,m3)
```

You can reverse the order of a set by using a set selection that specifies a range from the last element to the first element.

```
SELECT mons(12-1)
```

If a variable is related to a set by a **KEY** relation, the variable values may be used to specify set selections. For example, the statements

```
SELECT KEY(mons,monsn)
SELECT mons(JAN,FEB,MAY)
```

will select the months January, February, and May from the set of months. Here, `mons` is a string variable containing the three-letter month name abbreviations (see **Relating Sets and Variables**).

It is also possible to select the elements of a set if the values of a variable dimensioned by the set meet a given criterion. The **SELECT set IF** statement is used for these types of selections. For example, in order to select the elements of set `mons` that index values of monthly income that are greater than 1500 dollars, the following expression could be used:

```
SELECT mons IF incom GT 1500
```

Here, `incom` is a numeric variable, the monthly income values.

For more information on selecting set elements, see the discussions of the PROMULA noun **Set** and the PROMULA statements **SELECT set**, **SELECT SET**, **SELECT ENTRY**, **SELECT set IF**, and **SELECT VARIABLE**.

2.2.3.3. Sorting Sets

One of the most common data manipulation tasks is sorting. PROMULA provides a straight forward and flexible means of sorting of multidimensional data. For example, in order to sort the months of the year (set `mons`) using the monthly income values (variable `incom`) in ascending order, the following statement can be used:

```
SORT mons USING incom
```

The statement above tells PROMULA to sort set mons in ascending order using the values of variable incom. In order for the **SORT** statement to work, the variable used as the key for the sort must be dimensioned by the set being sorted.

To sort the set in descending order based on income, use the keyword **DESCENDING** after the word **SORT**:

```
        SORT DESCENDING mons USING incom
```

To restore a set to its default order, use the **SELECT set*** statement.

It is also possible to use multidimensional arrays as the key for a sort as well. For example, in order to sort the months of the year using the monthly food expense values, the following statements can be used:

```
        SELECT exps(2)
        SORT mons USING expns
```

The first statement above selects the second column of array expns; this column of the array contains the monthly food expense values. The second statement tells PROMULA to sort set mons using the values of variable expns. Since the second column of the set is selected before the sort, the values in the second column of array expns are used to order the set mons.

For more information and examples of sorting information, see the discussion of the **SORT** statement in Chapter 3 of this manual.

2.2.3.4. Writing Equations

Equations are PROMULA statements that can change the values of variables. Equations may involve numeric or string constants, variables, arithmetic and user-defined functions, and arithmetic and relational operators. For example, the variable expns could be initialized with the following six equations that use PROMULA's built-in **RANDOM** number function:

Equation	**Description**
`expns(m,1) = 409`	`Rent is $409 per month`
`expns(m,2) = RANDOM(250,300)`	`Food varies between $250 and $300 per month`
`expns(m,3) = RANDOM(85,175)`	`Car Service varies between $85 and $175 per month`
`expns(m,4) = RANDOM(70,100)`	`Utilities vary between 70 and 100 per month`
`expns(m,5) = 270/6`	`Car Insurance is $270 for 6 months`
`expns(m,6) = RANDOM(50,70)`	`Phone varies between $50 and $70 per month`

The equations above use the **dummy subscript**, m, to drive equations over the elements of set mons. This means the letter m in the above equations causes each equation to be performed once for each active element of set mons. Recall that the variable expns is defined as a two-dimensional array classified by month and expense category. The first dimension of the variable is the "months" dimension; it is a set of 12 elements: the months January to December. The second dimension of the array is the "expense category" dimension. It is a set of six elements, the expense categories: rent, food, car service, utilities, car insurance, and phone.

The "column" of the array (expense category) to which each equation applies is indicated explicitly by the number following the subscript m in the parentheses. The first column of array expns (Rent) is constant at $409/month. Expense categories 2, 3, 4, and 6 are random values within different ranges; PROMULA's **RANDOM** function is used with upper and lower limits to simulate random expenditures in these expense categories. The fifth column of array expns (Car Insurance) is assigned to the result of the division of 270 by 6 or $45 per month.

Here is a second example. The monthly income values will be computed by the budget program using the following equation:

```
incom = payhr * wager * (1-taxes) + bonus
```

The equation above uses **implicit subscripting**. This means that all 12 values of variable `incom` will be computed from the single equation above without **DO loops** or dummy subscripts. PROMULA "knows" that it should perform the expression for each month because the `incom` variable was dimensioned by set `mons` in its definition. Furthermore, the variables `payhr` and `bonus` are also dimensioned by set month, and the correspondence between the month elements of these two vectors and those of variable `incom` is maintained automatically by PROMULA when the equation is processed. Thus, the single equation above is equivalent to the following 12 equations:

```
incom(1)  = payhr(1)  * wager * (1-taxes) + bonus(1)
incom(2)  = payhr(2)  * wager * (1-taxes) + bonus(2)
incom(3)  = payhr(3)  * wager * (1-taxes) + bonus(3)
incom(4)  = payhr(4)  * wager * (1-taxes) + bonus(4)
incom(5)  = payhr(5)  * wager * (1-taxes) + bonus(5)
incom(6)  = payhr(6)  * wager * (1-taxes) + bonus(6)
incom(7)  = payhr(7)  * wager * (1-taxes) + bonus(7)
incom(8)  = payhr(8)  * wager * (1-taxes) + bonus(8)
incom(9)  = payhr(9)  * wager * (1-taxes) + bonus(9)
incom(10) = payhr(10) * wager * (1-taxes) + bonus(10)
incom(11) = payhr(11) * wager * (1-taxes) + bonus(11)
incom(12) = payhr(12) * wager * (1-taxes) + bonus(12)
```

The income equation tells PROMULA that the monthly income is equal to the number of hours worked per month (`payhr`) times the hourly wage (`wager`) adjusted for taxes plus the monthly bonus.

Another example of an equation that uses implicit subscripting is the calculation of the difference between the monthly income and monthly expense values to give the monthly balance figures:

```
balns = incom - expnm
```

An important point to remember when writing equations is that a variable may appear on both sides of an equation. In such equations, the value of the expression on the right hand side of the equals sign is evaluated then passed to the variable on the left hand side of the equals sign. For example, if the worker plans to work about six hours out of each working day and five days out of each week, the number of payable hours each month can be estimated by the following statements:

```
READ payhr
31 28 31 31 31 30 31 31 30 31 30 31
payhr = 6 * payhr * 5/7
```

The first statement above reads into `payhr` the total number of days in each month. The second statement converts the days per month to hours worked per month and stores the results in variable `payhr`.

PROMULA equations also may use PROMULA's extensive collection of functional operators. One of the most useful of these is the array summation function, **SUM**, which can be used to sum up the values of multidimensional arrays. For example, to compute the monthly total expenditures, it is necessary to sum over the expense categories of variable `expns` and save the results in a vector indexed by month, `expnm`.

```
expnm(m) = SUM(e)(expns(m,e))
```

The expression above uses two dummy subscripts to drive the month and expense category dimensions. The single equation above is functionally equivalent to the following 12 equations:

```
expnm(1) =expns(1,1) +expns(1,2) +expns(1,3) +expns(1,4) +expns(1,5) +expns(1,6)
expnm(2) =expns(2,1) +expns(2,2) +expns(2,3) +expns(2,4) +expns(2,5) +expns(2,6)
```

```
       expnm(3) =expns(3,1) +expns(3,2) +expns(3,3) +expns(3,4) +expns(3,5) +expns(3,6)
       expnm(4) =expns(4,1) +expns(4,2) +expns(4,3) +expns(4,4) +expns(4,5) +expns(4,6)
       expnm(5) =expns(5,1) +expns(5,2) +expns(5,3) +expns(5,4) +expns(5,5) +expns(5,6)
       expnm(6) =expns(6,1) +expns(6,2) +expns(6,3) +expns(6,4) +expns(6,5) +expns(6,6)
       expnm(7) =expns(7,1) +expns(7,2) +expns(7,3) +expns(7,4) +expns(7,5) +expns(7,6)
       expnm(8) =expns(8,1) +expns(8,2) +expns(8,3) +expns(8,4) +expns(8,5) +expns(8,6)
       expnm(9) =expns(9,1) +expns(9,2) +expns(9,3) +expns(9,4) +expns(9,5) +expns(9,6)
       expnm(10)=expns(10,1)+expns(10,2)+expns(10,3)+expns(10,4)+expns(10,5)+expns(10,6)
       expnm(11)=expns(11,1)+expns(11,2)+expns(11,3)+expns(11,4)+expns(11,5)+expns(11,6)
       expnm(12)=expns(12,1)+expns(12,2)+expns(12,3)+expns(12,4)+expns(12,5)+expns(12,6)
```

The final example illustrates how the annual averages will be computed for the budget program's summary report:

Average Monthly Income :	`aincom = SUM(m)(incom(m)) / mons:N`
Average Monthly Expense :	`aexpnm = SUM(m)(expnm(m)) / mons:N`
Average Monthly Balance :	`abalns = SUM(m)(balns(m)) / mons:N`

Recall that the arithmetic average of a set of values is the sum of the values divided by the number of values used in the sum. The three equations above do just that; they sum up the monthly values and divide the sum by the number of months used in the sum. The notation `mons:N` has a value equal to the number of elements in the selection vector for set `mons` (which may be changed by a set selection statement).

It is also possible to define your own functions in PROMULA to use in equations. Defining functions in PROMULA is done with the **DEFINE FUNCTION**, and **DEFINE LOOKUP** statements.

For more information on writing equations, see the discussion of the PROMULA nouns **Equation** and **Expression** and the **COMPUTE** statement.

2.2.4. Report Generation

KEY TOPICS:

1. Writing Variables
2. Saving Reports on Disk
3. Plotting Variables

Report generation is a critical part of any application program. An application must be able to generate reports that are of interest to someone or it is not worth writing. PROMULA provides several report generation statements that can manage multidimensional data for you, as well as a flexible **WRITE** statement that can be used for complicated or fancy text report generation. There is also a **PLOT** statement that can be used to generate a variety of graphic reports.

2.2.4.1. Writing Variables

The budget program computes the monthly expenses, income, and balance as well as the annual total and average expense, income, and balance. These values can all be displayed in a single one page summary report.

There are several ways to generate such a report. The technique used in the budget program is to collect the values of the three monthly variables in a two-dimensional (12 x 3) array. The rows of this array are classified by the months of the year, the columns of the array are classified by the three output categories: Income, Expenses, and Balance. The statements required to define this array are shown below:

```
       DEFINE SET
         mons(12) "Months"
         colm(03) "Report table Columns"
       END SET

       DEFINE VARIABLE
```

```
  rtabl(mons,colm) TYPE=REAL(15,2) "Summary Table"
  monsn(mons)      TYPE=STRING(4)  "Month Names"
END VARIABLE

READ colm KEY(1,10,10)
INCOME
EXPENSES
BALANCE

READ monsn:4
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

SELECT KEY(mons,monsn)
```

The **DEFINE SET** and **DEFINE VARIABLE** statements above define a two-dimensional variable called `rtabl`, and a variable for the month labels called `monsn`. A **READ set** statement is used to assign labels to the elements of set `colm`. A **READ variable** statement is used to read in labels for the elements of set `mons`. Finally, a **SELECT RELATION** statement relates the month labels to the set `mons`.

After computing the values of the output variables, they can be passed to the variable `rtabl` using the following equations.

```
rtabl(m,1) = incom(m)
rtabl(m,2) = expnm(m)
rtabl(m,3) = balns(m)
```

The three equations above initialize all 36 values of variable `rtabl`: the first column picks up the values of variable `incom`; the second column picks up the values of variable `expnm`; and the third column picks up the values of variable `balns`.

The output report variable is now loaded and ready to be displayed. The final report is produced by the **WRITE variable** statement below:

```
WRITE rtabl,
TOTAL(mons),
TITLE("Budget Summary"//,
aincom:L"="aincom/,
aexpnm:L"="aexpnm/,
abalns:L"="abalns)
```

The **WRITE variable** statement above includes the **TITLE** and **TOTAL** options.

The **TOTAL** option tells PROMULA to report the specified totals along with the variable's values. In this case, only the totals over set `mons` are desired so the `mons` set is indicated in parentheses following the keyword, **TOTAL**.

The **TITLE** option tells PROMULA to replace the default title for the variable (i.e., the variable's descriptor) with the title specification enclosed in the parentheses. In this case a five-line title is specified: the first line of the title contains the words "Budget Summary"; the second line of the title is blank as indicated by the two slashes (//) — a slash character tells PROMULA to go to the next line; the third, fourth, and fifth lines of the title contain the descriptors and values (separated by equal signs) of the three annual average variables: `aincom`, `aexpnm`, `abalns`. The notation `aincom:L` is used to identify the descriptor of the variable `aincom` in titles and other **WRITE** statements.

A typical budget program report (produced by the statement above) is displayed below:

```
                     Budget Summary

           Average Monthly Income  =  1,565.00
           Average Monthly Expense =  1,001.33
           Average Monthly Balance =    563.67
```

```
                        INCOME        EXPENSES         BALANCE
         Total       18,780.00       12,016.02        6,763.98
         JAN          1,580.00        1,028.52          551.48
         FEB          1,490.00        1,032.03          457.97
         MAR          1,580.00        1,031.54          548.46
         APR          1,580.00        1,006.96          573.04
         MAY          1,580.00          973.91          606.09
         JUN          1,550.00        1,036.79          513.21
         JUL          1,580.00          971.61          608.39
         AUG          1,580.00          994.50          585.50
         SEP          1,550.00        1,018.56          531.44
         OCT          1,580.00          986.85          593.15
         NOV          1,550.00          970.06          579.94
         DEC          1,580.00          964.70          615.30
```

Figure 2-12: Typical report produced by the Budget Program

PROMULA automatically computes and displays the columns totals, and centers the title and the table of values on the screen. The formatting of the table values (i.e., a width of 15 characters with two decimal digits) is also done automatically according to the format type specified in the definition of variable `rtabl`.

It is possible to rotate the dimensions of the **WRITE variable** display by specifying a set order different from the one used in the definition of `rtabl`. For example, the report table could be displayed with months as the columns and the report categories as the rows by the following statement:

```
WRITE rtabl\10:10(mons,colm), TOTAL(mons), TITLE("Budget Summary"//,
aincom:L"="aincom/,
aexpnm:L"="aexpnm/,
abalns:L"="abalns)
```

This **WRITE variable** statement is almost exactly like the last one except that it includes a local format and set order specification that will override the ones in the definition of variable `rtabl`. The format specification `\10` means that the row descriptors should have a width of 10 characters, and `:10` means that each column should have a width of 10 characters. The resulting display is shown below:

```
                              Budget Summary

                   Average Monthly Income  =  1,565.00
                   Average Monthly Expense =  1,001.33
                   Average Monthly Balance =    563.67

               Total       JAN       FEB       MAR       APR       MAY       JUN
INCOME     18,780.00  1,580.00  1,490.00  1,580.00  1,580.00  1,580.00  1,550.00
EXPENSES   12,016.02  1,028.52  1,032.03  1,031.54  1,006.96    973.91  1,036.79
BALANCE     6,763.98    551.48    457.97    548.46    573.04    606.09    513.21

                     JUL       AUG       SEP       OCT       NOV       DEC
     INCOME     1,580.00  1,580.00  1,550.00  1,580.00  1,550.00  1,580.00
     EXPENSES     971.61    994.50  1,018.56    986.85    970.06    964.70
     BALANCE      608.39    585.50    531.44    593.15    579.94    615.30
```

For more information on writing reports, refer to Chapter 3 of this manual, especially the **WRITE variable**, **WRITE TABLE**, **WRITE text**, and **WRITE menu** statements. See also the **DO DESCRIBE**, **DO CORRELATE**, and **DO REGRESS** statements for information about PROMULA's Statistical Report Generator.

2.2.4.2. Saving a Report on Disk

There are two ways of saving textual information on disk. One is by writing fixed format to a disk file using the **WRITE file** statement. The other is by codirecting screen output to a disk file using the **SELECT OUTPUT** statement.

Using the **WRITE file** statement has the advantage that what is sent to the output file is not simultaneously displayed on the screen. The disadvantage is that the **WRITE file** statement cannot be used with PROMULA's automatic report generation statements like **WRITE variable**, and more explicit instructions are required to format the output. For example, in order to write the values of the `expns` array to a text file with the **WRITE file** statement, the following code would be required:

```
DEFINE FILE
  tf TYPE=TEXT "A Text File"
END FILE

OPEN tf "expns.dat" STATUS=NEW
DO mons
  WRITE tf((exps)(expns(mons,expns))
END mons
WRITE tf(aincom/aincom/abalns)
CLEAR tf
```

The contents of file `expns.dat` after execution of the above code is displayed below.

```
              409.00    286.44    115.39     97.18     45.00     66.71
              409.00    269.90    160.10     81.95     45.00     55.94
              409.00    291.50    172.05     77.12     45.00     55.24
              409.00    269.86    111.38     95.15     45.00     67.92
              409.00    295.66     89.88     96.78     45.00     50.37
              409.00    295.24    146.84     94.36     45.00     50.98
              409.00    260.47    142.10     95.11     45.00     52.52
              409.00    255.69    141.09     91.46     45.00     56.32
              409.00    289.86     87.59     92.76     45.00     65.28
              409.00    287.99    135.75     73.38     45.00     64.77
              409.00    269.20     96.19     95.47     45.00     61.09
              409.00    273.29    145.37     72.39     45.00     63.61
             1565.00
             1565.00
              555.77
```

This file would be useful as an input file for another program, but it is not very interesting to look at.

If you want to take advantage of PROMULA's automatic report generation statements **WRITE variable**, **WRITE menu**, and the Statistical Report Functions for the creation of report files, you may use the **SELECT OUTPUT** statement. This statement can be used to create any text file that can be created with the **WRITE file** statement, and it can also be used to send the results of any text display produced by PROMULA, including character graphics, multidimensional displays, and data menu screens to a text file on disk. The disadvantage of this type of report generation is that output appears on the screen as it is being sent to disk (although this problem can be gotten around with some sneaky windowing.)

For example, the statements required to reproduce the file `expns.dat` shown above are simply:

```
OPEN SELECT OUTPUT "expns.dat" PRINTER=ON

DO mons
  WRITE (exps)(expns(mons,expns))
END mons
WRITE (aincom/aincom/abalns)
```

```
        SELECT PRINTER=OFF
```

The statements required to capture the typical budget program report in a file called `budget.rpt` are

```
        OPEN SELECT OUTPUT "budget.rpt" PRINTER=ON

        WRITE rtabl,
        TOTAL(mons),
        TITLE("Budget Summary"//,
              aincom:L"="aincom/,
              aexpnm:L"="aexpnm/,
              abalns:L"="abalns)

        SELECT PRINTER=OFF
```

For more information about saving a report on disk, refer to Chapter 3 of this manual, especially the **WRITE variable**, **WRITE TABLE**, **WRITE menu**, **WRITE file** and **SELECT OUTPUT** statements.

2.2.4.3. Plotting Variables

PROMULA's **PLOT** statement is used to generate graphs and charts. For example, the statement

```
        PLOT BAR balns TITLE("Budget Program -- "balns:L/abalns:L" = "abalns)
```

will display a bar chart of the monthly balance variable, `balns`.

This sample PROMULA bar plot is displayed below.

The **PLOT** function has many options and is fully discussed in Chapter 3 of this manual.

2.2.5. Interface Design

KEY TOPICS:

1. Interactive and Noninteractive Programs
2. Selections
3. Editing Data
4. Multi-page Displays and Windowing

2.2.5.1. Interactive and Noninteractive Programs

The interface of a program is the way in which it interacts with its users (i.e., how it receives and transmits information). Application program interfaces can be classified as being interactive, noninteractive, or a mixture of the two.

Noninteractive applications are controlled by the instructions they receive from an external text file. These files usually contain information that tells the program what to do and what data values to use as inputs. Noninteractive programs can be inflexible because they can only be told to do things that they can read from their command files. They may also be hard to use if they require the user to create complicated control files. On the other hand, noninteractive programs are sometimes more convenient than interactive ones since they can run without a user present.

Interactive applications are typically controlled by commands entered with a keyboard or mouse. Such programs conduct a dialog with the user by displaying menus, asking questions, presenting screens to the user and reacting to the user's responses. Interactive programs can be more responsive and permissive than noninteractive ones, and they are often easier for non-programmers to use effectively.

Noninteractive applications usually require only four of the five basic programming tasks: data definition, program control, data manipulation, and report generation. The fifth basic programming task, interface design, is optional and is needed only if you want to create interactive applications.

Interface design involves setting up the screens through which program users can control the program and implementing the structures that control these screens.

There are two basic actions that an interactive program interface must support: displaying information on the screen and getting information from the user. These two tasks are often intimately related since the program may display information on the screen in order to instruct the user about what information is required and how it should be provided. Furthermore, the course of action through the program depends on the user's responses. Getting information from the user usually takes one of two forms: letting the user make selections, and letting the user enter data.

2.2.5.2. Selections

Most selections fall into one of the following categories:

1. selecting from a fixed number of options,
2. selecting a program variable for input or output purposes,
3. selecting one or more elements from a variable number of options.

2.2.5.2.1   Selecting from a Fixed Number of Options

Most interactive programs require the user to select from a fixed set of options. PROMULA provides several ways to do this. The simplest is with the **ASK** statement. The **ASK** statement is an interactive conditional branch statement that asks the user to enter a choice then branches according to the response. For example, a simple program interface may offer the following options: edit inputs, calculate results, view outputs, and exit. The following procedure contains an **ASK** statement that could be used to let the user select one of these options and branch accordingly:

```
DEFINE PROCEDURE askit
WRITE ("E>dit inputs; C>alculate; V>iew outputs; or press [End] to exit"/)
ASK "Please enter your selection." END
  BREAK askit
ELSE E
*      statements for editing inputs
ELSE C
*      statements for calculations
ELSE V
*      statements for viewing outputs
END ASK
askit
END PROCEDURE askit
```

Another simple way of letting the user select from a fixed set of options is with a **Pick Menu**. The code below illustrates how to implement a pick menu that offers the same options as procedure `askit` above.

```
DEFINE VARIABLE
  choice
END VARIABLE

DEFINE MENU pickmenu
  1 \Exit \
  2 \Edit inputs\
  3 \Calculate\
  4 \View outputs\
END
```

```
DEFINE PROCEDURE menuit
SELECT pickmenu(choice)
DO IF PICK EQ 1
  BREAK menuit
ELSE  PICK EQ 2
*                   statements for editing inputs
ELSE  PICK EQ 3
*                   statements for calculations
ELSE  PICK EQ 4
*                   statements for viewing outputs
END IF
menuit
END PROCEDURE menuit
```

2.2.5.2.2 Selecting Variables

Often it is desirable to help the user select a program variable for input or output operations. PROMULA has two constructs that may be used to implement this type of selection. The first is an extension of the **ASK** statement; the second is the **SELECT indirect** statement.

For example, assume your program has three variables `a`, `b`, and `c`, and you want to help the user select one of the variables for display on the screen. The simplest way to do this is with a **SELECT indirect** statement. The statements required to use the **SELECT indirect** statement in this capacity are listed below:

```
DEFINE VARIABLE
  a       "a"
  b       "b"
  c       "c"
  indir*  "An Indirect Variable"
END VARIABLE

DEFINE PROCEDURE selvar
SELECT indir(a,b,c)
DO IF END
  BREAK selvar
END
WRITE indir
END PROCEDURE selvar
```

You may notice that the definition of variable `indir` looks different from other variables defined in this chapter — it has an asterisk (*) at the end of its identifier. This tells PROMULA that `indir` is an indirect. Indirects can "point" to other variables. Once they are pointing at a variable, statements using the indirect will use the variable it points to instead of the indirect itself. The PROMULA statements that can use indirects in this manner are the **WRITE variable**, **BROWSE variable**, **EDIT variable**, **READ variable**, **SORT, SELECT set IF**, and **PLOT** statements. Thus, one indirect can be used for the general input/output needs of many program variables.

The statement `SELECT indir(a,b,c)` will clear the Main Screen (see Advanced Windowing) and list the identifiers and descriptors of variables `a`, `b`, and `c` for selection. A prompt will appear at the bottom of the screen describing how to select a variable by moving to the desired variable with the arrow keys and pressing the Enter key.

The second way to let the user select from a list of variables is to use the **ASK** statement with a **VARIABLE = indirect** option. This method also assigns an indirect to the selected variable, but the Main Screen is not automatically cleared, and the variables are not automatically listed for selection. The statements required to implement a variable selection routine using the **ASK** statement are shown below:

```
DEFINE VARIABLE
  a       "a"
  b       "b"
```

```
          c       "c"
          indir*  "An Indirect Variable"
        END VARIABLE

        DEFINE PROCEDURE askvar
        AUDIT VARIABLE(a,b,c)
        ASK "Enter desired variable name or Press End to Exit" END
          BREAK askvar
        ELSE VARIABLE=indir
          WRITE indir
        END ASK
        END PROCEDURE askvar
```

Procedure `askvar` above uses the **AUDIT VARIABLE** statement to list the identifiers and descriptors of variables `a`, `b`, and `c` on the screen. The **ASK** statement supplies the prompt indicating how to select a variable, picks up the user's selection, and assigns it to `indir`.

2.2.5.2.3 Selecting Set Elements

Frequently, it is useful to let the user make selections from program sets, and there are several PROMULA statements that can be used to implement this type of selection. These include the **SELECT ENTRY**, **SELECT SET**, **SELECT VARIABLE**, and **ASK** statements.

The **SELECT ENTRY** statement is the simplest of these and is used to help the user pick a single element of a PROMULA set from an interactive selection list.

The **SELECT SET** statement is similar to **SELECT ENTRY** except it allows the user to pick several elements of a PROMULA set from an interactive selection list.

The **SELECT VARIABLE** statement automatically prompts the user to make selections from all the sets dimensioning a specified variable.

The **ASK** statement with the **SET=set** option can be used to allow the user to make selections from the specified set.

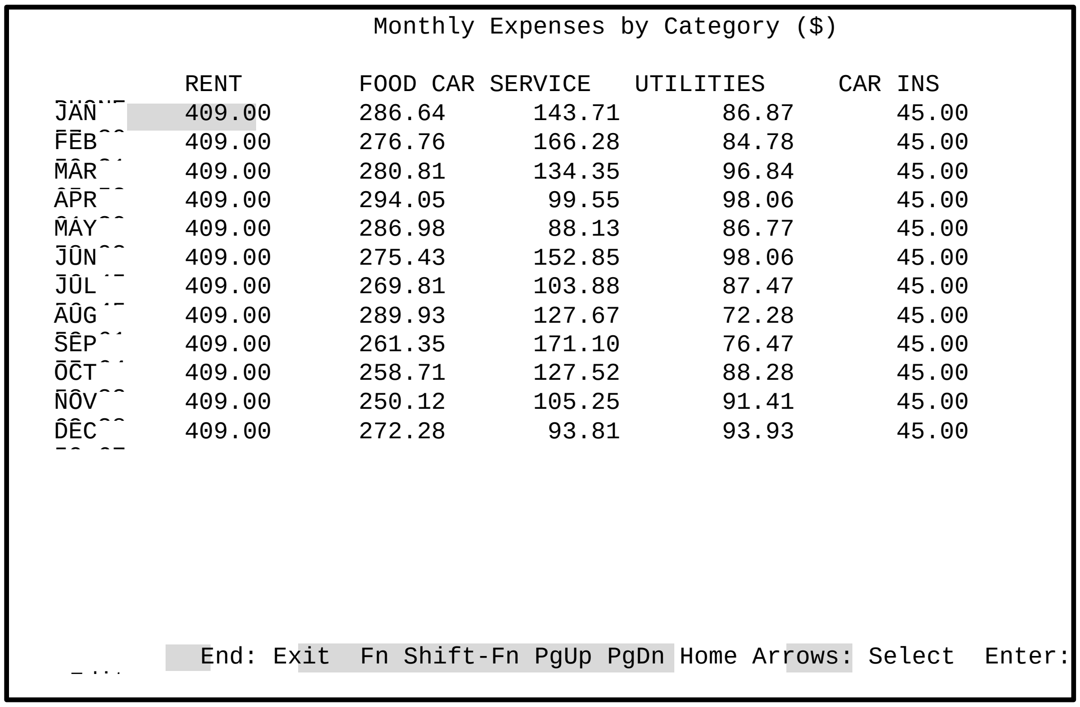
More information and examples of these statements are available in Chapter 3.

2.2.5.3. Editing Data

One of the most critical of all interface functions is editing data. PROMULA offers a general purpose data editor that facilitates interactive data editing for PROMULA's multidimensional array variables. For example, the statement

```
        EDIT expns
```

will display the array variable `expns` for interactive spread-sheet style data editing. The editing screen is displayed below.



```
                        Monthly Expenses by Category ($)

          RENT        FOOD CAR SERVICE   UTILITIES     CAR INS
JAN       409.00      286.64      143.71       86.87       45.00
FEB       409.00      276.76      166.28       84.78       45.00
MAR       409.00      280.81      134.35       96.84       45.00
APR       409.00      294.05       99.55       98.06       45.00
MAY       409.00      286.98       88.13       86.77       45.00
JUN       409.00      275.43      152.85       98.06       45.00
JUL       409.00      269.81      103.88       87.47       45.00
AUG       409.00      289.93      127.67       72.28       45.00
SEP       409.00      261.35      171.10       76.47       45.00
OCT       409.00      258.71      127.52       88.28       45.00
NOV       409.00      250.12      105.25       91.41       45.00
DEC       409.00      272.28       93.81       93.93       45.00







            End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows: Select  Enter:
```

Note that, like the **WRITE variable** statement, the **EDIT variable** statement uses the information in the variable's definition to control the appearance of the report.

In addition, your application can use data menus for data entry. Data menus make data entry easier and improve the appearance of the application. PROMULA's **DEFINE MENU** statement lets you create data menus simply by typing them into your source code. The **EDIT menu** statement is then used to help the user interactively edit information in the menu.

To help the user edit several variables at once, you may use the **EDIT table** statement.

2.2.5.4. Multi-Page Displays and Windowing

The typical computer terminal is only large enough to display 24 or 25 lines of 80 characters. This can make it difficult to let the user view large arrays or reports on the screen. Fortunately, PROMULA has several statements which can make this difficult task easier.

The **BROWSE variable** statement can be used to let the program user interactively view a multidimensional array variable. This statement manages a display similar to the one generated by the **EDIT variable** statement except it does not let the user change data values

If you want to let the user browse more than one variable on the screen at the same time, the **BROWSE TABLE** or **BROWSE menu** statement can be used.

The **BROWSE FILE** statement can be used to let the program user view multi-page free form textual reports contained in external files on disk. The **RUN EDITOR** command can be used to load a text file into the PROMULA Text Editor.

If you want to create dynamic, multi-color, multi-window displays, you may use PROMULA's **DEFINE WINDOW** and **OPEN WINDOW** statements. To find out more about PROMULA's windowing statements see the discussions of **Basic** and **Advanced Windowing**, and the PROMULA statements **DEFINE WINDOW**, **OPEN WINDOW**, and **CLEAR WINDOW**.

2.2.6. Application Programming Summary

The discussion of application programming above is not intended to teach you how to program or to present the elements of good programming style. These skills can only be developed through experience and practice.

From here, you should play with the source and executable versions of the budget program. These are included on the PROMULA Sample Applications Disk in the files `BUDGET.PRM` and `BUDGET.XEQ`. You should also browse through the contents of Chapter 3, the PROMULA language reference. Refer to Table 3-3 for a brief description of all the statements of PROMULA. Once you have an idea of the statements available to you, try writing your own applications. Before you start writing large scale applications, refer to Chapter 4 for a discussion of database management and program management issues in PROMULA.

3. PROMULA LANGUAGE REFERENCE

The purpose of this chapter is to provide the detailed information you need to use the statements of PROMULA and write PROMULA applications. It is your reference chapter for the structural elements of the PROMULA language — its nouns and verbs — and it describes the syntax and use of PROMULA statements. The chapter is divided into two sections:

1. **The PROMULA Nouns**

   This section defines the nouns, or objects, of PROMULA and gives some information about their use in PROMULA programs.

2. **The PROMULA Statements**

   This section discusses the purpose, syntax, and other information relevant to the PROMULA statements. Most of the statements are illustrated by examples. The contents of each section are presented in alphabetical order.

3.1 The PROMULA Nouns

The nouns, or objects, of the PROMULA language are listed in Table 3-1. These are the structural elements of PROMULA programs. The information of a PROMULA program is stored in these elements.

Table 3-1: The Nouns, or Objects, of the PROMULA Language

Equation	An identity relationship between one variable and an expression of other variables and/or constants involving arithmetic, relational, functional, and logical operators.
File	A place on disk for storing information. PROMULA uses three types of files: **data files** for storing variables, **segment files** for storing code segments, and **dialog files** for storing tutorials.
Function	An intrinsic or user-defined operator which returns a single value depending on the values of its arguments. The returned value is computed according to the functional relationships of the operator.
Menu	A screen template designed to help its user either pick from a list of options or view and/or edit program variables. There are two types of menus: **pick menus** and **data menus.**
Parameter	A variable that allows the transfer of values between a program variable and a procedure.
Procedure	An ordered set of statements that is compiled and executed as a unit.
Program	An ordered set of statements.
Relation	A relationship between a set and a variable. Its purpose is to assign descriptors to the set elements.
Segment	A program segment that may be saved on disk for later execution. Segments are usually linked into hierarchical tree structures to form large programs that would not otherwise fit in the working space.
Set	An ordered set of elements. Sets are used to dimension the values of array variables. Sets are also used for sorting and selecting ranges of array values.
Statement	A complete instruction in a PROMULA program.

Table 3-1: The Nouns, or Objects, of the PROMULA Language

System	A system of n real equations with n unknowns whose solution is obtained by solving simultaneously for the unknowns. The equations may be linear or nonlinear.
Table	A tabular display or report showing the values of several variables.
Variable	A storage structure for information. Variables are manipulated by the statements of a program and are related to one another by the equations of a program.
Window	A display area for program input and/or output. Basic Windowing supports two functional screens: the **Action** Window (upper half of the screen) and the **Comment** Window (lower half of the screen). Advanced Windowing supports a system of four functional screens: **Main**, **Prompt**, **Comment**, and **Help**. The appearance, location, and behavior of each functional screen is set by defining and opening a specific window for it.

3.1.1 Equation

Purpose:

Makes the value (or values) of a variable equal to the value (or values) of a numeric or character expression.

Syntax:

```
var[(subs)]=expression[(subs)]
```

Remarks:

`var`	is a variable identifier.
`subs`	is a list of set identifiers, set element codes or numbers, or dummy subscripts. These subscripts are usually used with array variables to denote multiple equations that apply to the cells of the multidimensional arrays.
`expression`	is a numeric or character expression.

Examples:

1. Single-valued equations

   Below, `a`, `b` and `c` are scalars because there are no sets used in their definitions. Each equation is only done once, and only one value is assigned.

   ```
   DEFINE VARIABLE
     a
     b
     c
   END VARIABLE
   ```

   `a = b + c    :` a is equal to the sum of `b` and `c`
   `a = b*EXP(c):` a is equal to `b` times the exponential of `c`
   `a = b LT c   :` a is equal to `1` if `b` is less than `c;` otherwise a is equal to 0

2. Multiple-valued equations using implicit subscripts

Below, A and B are both arrays containing six values.

```
DEFINE SET
  row(3)
  col(2)
END SET

DEFINE VARIABLE
  A(row,col)
  B(row,col)
END VARIABLE
```

The equation

```
A = 1
```

makes all six values of array A equal to 1. The subscripts row and col are implicit.

Similarly, the equation

```
A = B
```

makes all six values of array A equal to the corresponding values of array B. It does the same work as the following six equations.

```
A(1,1) = B(1,1)  A(1,2) = B(1,2)
A(2,1) = B(2,1)  A(2,2) = B(2,2)
A(3,1) = B(3,1)  A(3,2) = B(3,2)
```

3. Multiple-valued equations using dummy subscripts

The equation

```
A(r,c) = B(r,c)
```

makes all six values of the A array equal to the corresponding values of the B array. The subscripts r and c are dummy subscripts that stand for the row and col sets.

4. A Character Equation

Given the following definitions and data:

```
DEFINE VARIABLE
  A     TYPE=STRING(20)
  B     TYPE=STRING(20)
  C     TYPE=STRING(40)
END VARIABLE

READ A
The cow jumped ov
READ B
er the moon.
```

the equation

```
C = A+B
```

will put the concatenation of strings A and B into variable C.

```
WRITE C
The cow jumped over the moon.
```

5. A Mixed Character and Numeric Variable Equation

PROMULA is a "loose" typing language. This means that you may mix variables of different types in your expressions; PROMULA will make the appropriate conversions for you. For example it is possible to write expressions using variables of type **STRING** or **DATE** with variables of the numeric types: **REAL**, **INTEGER**, and **MONEY**. If a numeric variable is on the left-hand side of an expression, any string type variables on the right-hand side of the expression containing all numerals will be converted to their numeric values when the result is computed. Similarly, if a string variable is on the left-hand side of an expression, the results of numeric expressions on the right-hand side are computed then converted to their numeral string values before they are passed to the left hand side.

```
DEFINE SET
  pnt(4)
END SET

DEFINE VARIABLE
  str1(pnt)  TYPE=STRING(20) "String Result"
  num1(pnt)  TYPE=REAL(10,3) "1st Number"
  num2(pnt)  TYPE=REAL(10,3) "2nd Number"
END VARIABLE

num1(i) = i*2
num2(i) = i*3
str1(i) = num1:-3:0(i) +" PLUS "+ num2:-3:0(i) +" = "+(num1(i)+num2(i))
```

Given the definitions and assignments made above, the statement

```
WRITE str1:-40
```

produces the output below.

```
                                   String Result

                 PNT(1)         2   PLUS 3   = 5.000
                 PNT(2)         4   PLUS 6   = 10.00
                 PNT(3)         6   PLUS 9   = 15.00
                 PNT(4)         8   PLUS 12  = 20.00
```

3.1.2 Expression -- Arithmetic

Definition:

A numeric expression involving at least one arithmetic operator. The operands of arithmetic expressions may be variables, constants, functions, and other expressions.

Remarks:

The arithmetic operators in order of precedence are:

OPERATOR	EXPRESSION	PRECEDENCE	MEANING
**	A ** B	1	Raise A to the B power

*	A * B	2	Multiply A times B
/	A / B	2	Divide A by B
–	A – B	3	Subtract B from A
+	A + B	3	Add A to B

The above precedence may be altered by parentheses. In cases of equal precedence the order of evaluation is from left to right. The **SELECT HIERARCHY=ON** statement causes operator precedence to be determined by the (left to right) order of operators in the expression..

Arithmetic expressions may have other numeric expressions as operands.

3.1.3 Expression -- Boolean

Definition:

An expression involving variables, constants, functions, relational and logical operators, and other expressions. A Boolean expression is either true or false. If true, it has the value 1; if false, it has the value 0.

Remarks:

The relational operators are:

OPERATOR	EXPRESSION	MEANING
LT	A LT B	A less than B
LE	A LE B	A less than or equal to B
EQ	A EQ B	A equal to B
NE	A NE B	A not equal to B
GE	A GE B	A greater than or equal to B
GT	A GT B	A greater than B

The logical operators are:

OPERATOR	EXPRESSION	MEANING
NOT	NOT A	if A is false; 0 otherwise
AND	A AND B	if A and B are true; 0 otherwise
OR	A OR B	if A or B is true; 0 if both are false

A and B may be Boolean variables or Boolean expressions.

3.1.4 Expression -- Character

Definition:

A formula consisting of character variables and character operators.

Remarks:

A character expression has character operands. Some character expressions have character values; others have numeric values.

PROMULA has the following character operators:

OPERATOR	EXPRESSION	MEANING
+	A+B	Concatenate B to A
COMPARE	**COMPARE**(A,B)	Compare string A to string B; return the value 1 if A equals B, otherwise return the value 0.
Relational	A GT B, A GE B, A EQ B, A NE B, A LE B, A LT B	Evaluates the relationship between A and B, the result is 1 if the relationship is true, otherwise the result is 0.

Here, A and B are string or numeric expressions. If either A or B is a character expression, the result is the string concatenation of B to A. If both A and B are numeric expressions, the result is the arithmetic sum of A and B.

Examples:

The dialog below illustrates some examples of character expressions and of mixed (numeric/character) expressions.

```
DEFINE VARIABLE
  A     TYPE=STRING(20)
  B     TYPE=STRING(20)
  C     TYPE=STRING(40)
  V     TYPE=REAL(8,0)
END VARIABLE

READ A
The cow jumped ov
READ B
er the moon.

C = A+B

WRITE C
The cow jumped over the moon.

V = 10
C = V*20 + V

WRITE C
210
```

The equation

```
V = COMPARE(A,B)
```

returns `V = 0,` since string `A` is not equal to string `B`.

It is also possible to use PROMULA's **COMPARE** function with a quoted string as illustrated in the example below.

```
DEFINE VARIABLE
  rsp TYPE=STRING(8)
END VARIABLE

DEFINE PROCEDURE comp
   WRITE "Do you agree? (Y/N)"
   READ rsp
   DO IF COMPARE(rsp,"Y")
      WRITE ("Why do you agree?")
   ELSE COMPARE(rsp,"N")
      WRITE ("Why don't you agree?")
   END IF
END PROCEDURE comp
```

NOTE: The **COMPARE** function is obsolete; it is retained for compatibility with older versions of PROMULA. It is now possible to use the relational operators EQ, NE, LT, etc. to compare string expressions.

PROMULA is a "loose" typing language. This means that it is allowed to mix character variables and numeric variables in the same expression. In fact, you may use character variables that contain numeric data as if they were numeric variables. Although there are some limitations on the use of these mixed expressions, one useful application is the generation of numbered lists.

```
DEFINE SET
  row(8)
END SET

DEFINE VARIABLE
  str(row) TYPE=STRING(10)
  val(row) TYPE=INTEGER(1)
END VARIABLE

val(i) = i

str="team # " + val

WRITE str
```

```
ROW(1)    team # 1   ROW(2)       team # 2
ROW(3)    team # 3   ROW(4)       team # 4
ROW(5)    team # 5   ROW(6)       team # 6
ROW(7)    team # 7   ROW(8)       team # 8
```

3.1.5 Expression -- Functional

Definition:

An expression involving at least one functional operator.

Remarks:

The built-in functional operators of PROMULA are of three types:

1. Arithmetic functions
2. File management functions
3. The **INDIRECT** function

Also, you may define your own functions by using the **DEFINE PROCEDURE** statement and parameters, or by using the **DEFINE FUNCTION** statement.

3.1.5.1 Arithmetic Functions

The built-in arithmetic functional operators of PROMULA are listed in Table 3-2 below

Table 3-2: The Arithmetic Functional Operators of PROMULA

Functional Expression	**MEANING**
ABS(x)	Absolute value of x
ARCCOS(x)	Angle (in radians) whose cosine is x
ARCSIN(x)	Angle (in radians) whose sine is x
ARCTAN(x)	Angle (in radians) whose tangent is x
COMPARE(x,y)	Compare string x to string y; returns the value 1 if x=y, otherwise it returns the value 0. (Note: COMPARE is obsolete; use (x EQ y)
COS(x)	Cosine of x (x in radians)
COTAN(x)	Cotangent of x (x in radians)
EXP(x)	Exponential of x (e^x)
FLOOR(x)	Integer nearest to x that does not exceed x
IFIX(x)	Integer nearest to x that does not exceed the magnitude of x
LN(x)	Natural logarithm of x, base e (e = 2.718282)
LOG(x)	Common logarithm of x, base 10
MAX(i)(x(i))	Maximum element of vector x(i)
MIN(i)(x(i))	Minimum element of vector x(i)
PRODUCT(subs)(x(subs))	Multiply over the elements of x, where x is an array or array expression subs is a list of subscripts classifying the elements of x.
RANDOM(arg)	Random number. Result depends on number of parameters specified in arg.
ROUND(x)	Integer nearest to x
SIN(x)	Sine of x (x in radians)
SQRT(x)	Square root of x
SUM(subs)(x(subs))	Sum over the elements of x, where x is an array or array expression subs is a list of subscripts classifying the elements of x.
TAN(x)	Tangent of x (x in radians)
XMAX(x,y,...)	Maximum of x,y,...
	Minimum of x,y,...

Examples:

1. The **ROUND**, **FLOOR**, and **IFIX** functions are illustrated in the example below. These three functions are similar in that they all return integers, but they have subtle differences.

   FLOOR(x)   Returns the integer nearest to x that does not exceed x.

IFIX(x) Returns the integer nearest to x that does not exceed the magnitude of x. In other words, **IFIX(x)** truncates the decimal part of x.

ROUND(x) Returns the integer nearest to x.

```
DEFINE VARIABLE
  x
  a
  b
  c
END VARIABLE

DEFINE PROCEDURE calc
  a = FLOOR(x)
  b = ROUND(x)
  c = IFIX(x)
  WRITE (x:5:2 a:12:2 b:12:2 c:12:2/)
END PROCEDURE calc

DEFINE PROCEDURE test
  WRITE "x         FLOOR(x)    ROUND(x)      IFIX(x)"
  WRITE "------------------------------------------"
  x = -2.25
  calc
  x = -2.50
  calc
  x = -2.75
  calc
  x = 2.25
  calc
  x = 2.50
  calc
  x = 2.75
  calc
END PROCEDURE test
```

The output of procedure `test` is displayed below.

```
x         FLOOR(x)    ROUND(x)      IFIX(x)
------------------------------------------
-2.25        -3.00        -2.00        -2.00

-2.50        -3.00        -3.00        -2.00

-2.75        -3.00        -3.00        -2.00

 2.25         2.00         2.00         2.00

 2.50         2.00         3.00         2.00

 2.75         2.00         3.00         2.00
```

2. Using the **SUM** Operator

The **SUM** operator is used to sum the values of multidimensional expressions.

```
DEFINE SET
  row(3)
```

```
    col(2)
    page(2)
  END SET

  DEFINE VARIABLE
    AAA(row,col,page)  "A 3-dimensional Array" VALUE = 1
    AA(row,col)        "A 2-dimensional Array"
    A(row)             "A vector"
    S                  "Sum of AAA"
  END VARIABLE
  *
  * For each row and col, sum AAA over page and place the result in AA.
  *
    AA(r,c) = SUM(p)    (AAA(r,c,p))
  *
  * For each row, sum AAA over col and page and place the result in A.
  *
    A(r) = SUM(c,p)  (AAA(r,c,p))
  *
  * Sum AAA over row, col and page and place the result in S.
  *
    S = SUM(r,c,p)(AAA(r,c,p))
```

The results of the definitions and expressions above are illustrated in the dialog below.

```
WRITE AA
                         A 2-dimensional Array

                             COL(1)  COL(2)

                        ROW(1)         2       2
                        ROW(2)         2       2
                        ROW(3)         2       2

WRITE A
                               A Vector

                            ROW(1)         4
                            ROW(2)         4
                            ROW(3)         4


WRITE S
Sum of AAA  12
```

3. Using the **MIN** and **MAX** Functions

The **MIN** and **MAX** operators may be used to find the minimum and maximum values of multidimensional expressions respectively. This is demonstrated in the dialog below.

```
READ A
1 2 3 4 5 6 7 4 3 2

S = MIN(r)(A(r))
WRITE(/"The minimum value in vector A is  ",S/)

The minimum value in vector A is   1

S = MAX(r)(A(r))
```

```
          WRITE(/"The maximum value in vector A is  ",S/)

          The maximum value in vector A is   7
```

4. Writing Your Own Functions

```
DEFINE PROCEDURE mod
DEFINE PARAMETER
  a
  b
  c
END PARAMETER
c = a / b
c = (c - IFIX( c ) )*b
END PROCEDURE mod
```

The procedure mod defined above computes the value of the first parameter modulus the second parameter, and returns the result in the third parameter. A sample dialog with procedure mod is shown below.

```
          DEFINE VARIABLE
            avar
            bvar
            cvar
          END VARIABLE

          avar=27
          bvar=11
          MOD(avar,bvar,cvar)
          WRITE(/avar:0:2" MOD "bvar:0:2" = "cvar/)

          27.00 MOD 11.00 =        5

          avar=47
          bvar=13
          MOD(avar,bvar,cvar)
          WRITE(/avar:0:2" MOD "bvar:0:2" = "cvar/)

          47.00 MOD 13.00 =        8

          avar=35
          bvar=3
          MOD(avar,bvar,cvar)
          WRITE(/avar:0:2" MOD "bvar:0:2" = "cvar/)

          35.00 MOD 3.00 =        2
```

5. Using the **RANDOM** Function.

The **RANDOM** function can take zero to three arguments.

NUMBER OF ARGUMENTS	EXPRESSION	VALUE RETURNED

0	x=RANDOM	a random number between 0 and 1 using the current seed.
1	x=RANDOM(p1)	a random number between 0 and 1 using p1 as the seed.
2	x=RANDOM(p1,p2)	a random number between p1 and p2 using the current seed.
3	x=RANDOM(p1,p2,p3)	a random number between p1 and p2 using p3 as the seed.

The parameters (p1,p2,p3) may be numeric constants or variables. The seed is an internal PROMULA variable used by the **RANDOM** function. The first time the random function is executed, the seed is zero.The **RANDOM** function always returns the same value for a given seed and changes the internal seed each time it is executed. Several examples are shown in the dialog below.

```
DEFINE VARIABLE
  x "X=" TYPE=REAL(10,5)
  p1 VALUE=1000
  p2 VALUE=2000
  p3 VALUE=3000
END VARIABLE

x=RANDOM
WRITE x
X= 0.73275

x=RANDOM
WRITE x
X= 0.53517

x=RANDOM(p1)
WRITE x
X= 0.71217
```

Using the same seed, `p1`, gives the same result every time

```
x=RANDOM(p1)
WRITE x
X= 0.71217

x=RANDOM(p1,p2)
WRITE x
X= 1,403.12500
```

With two parameters, **RANDOM** returns a random number between `p1` and `p2` using the internal seed.

```
x=RANDOM(p1,p2)
WRITE x
X= 1,009.17900

x=RANDOM(p1,p2,p3)
WRITE x
X= 1,671.02100
```

With three parameters, **RANDOM** returns a random number between `p1` and `p2` using `p3` as the seed.

```
x=RANDOM(p1,p2,p3)
WRITE x
X= 1,671.02100
```

6. Procedure `functs` below shows how a variety of PROMULA's arithmetic functions behave.

```
DEFINE VARIABLE
 xvar "xvar = "
 avar "avar = "
 bvar "bvar = "
 cvar "cvar = "
 drg  "Factor Converting Degrees to Radians"
END
drg=3.1415 / 180

DEFINE PROCEDURE functs
  cvar = 6
  avar = EXP(cvar)
  WRITE("The Exponential of"cvar\30:0:2,46" = "avar:0:4)
  cvar = LN(avar)
  WRITE("The Natural Logarithm of"avar\30:0:4,46" = "cvar:0:4)
  cvar = 30
  avar = SIN(cvar*drg)
  WRITE("The Sine Function of"cvar\30:0:2" degrees",46" = "avar:0:4)
  cvar = ARCSIN(avar) / drg
  WRITE("The ArcSine Function of"avar\30:0:2,46" = "cvar:0:2" degrees")
  avar = COS(cvar*drg)
  WRITE("The Cosine Function of"cvar\30:0:2," degrees"46" = "avar:0:4)
  cvar = ARCCOS(avar) / drg
  WRITE("The ArcCosine Function of"avar\30:0:4,46" = "cvar:0:2" degrees")
  cvar = 45
  avar = TAN(cvar*drg)
  WRITE("The Tangent Function of"cvar\30:0:2," degrees"46" = "avar:0:4)
  cvar = ARCTAN(avar) / drg
  WRITE("The ArcTangent Function of"avar\30:0:4,46" = "cvar:0:2" degrees")
  cvar = 2
  avar = SQRT(cvar)
  WRITE("The Square Root of"cvar\30:0:2,46" = "avar:0:4)
  avar = cvar**0.5
  WRITE("The 1/2 Power of"cvar\30:0:2,46" = "avar:0:4)
  bvar = 3
  avar = XMIN(bvar,cvar)
  WRITE("The Minimum of"bvar\30:0:1" and "cvar:0:1,46" = "avar:0:2)
  avar = XMAX(bvar,cvar)
  WRITE("The Maximum of"bvar\30:0:1" and "cvar:0:1,46" = "avar:0:2)
END PROCEDURE functs
```

The output of procedure `functs` is displayed below.

```
          The Exponential of            6.00              = 403.4288
          The Natural Logarithm of      403.4288          = 6.0000
          The Sine Function of          30.00 degrees     = 0.5000
          The ArcSine Function of       0.50              = 30.00 degrees
          The Cosine Function of        30.00 degrees     = 0.8660
          The ArcCosine Function of     0.8660            = 30.00 degrees
          The Tangent Function of       45.00 degrees     = 1.0000
          The ArcTangent Function of    1.0000            = 45.00 degrees
          The Square Root of            2.00              = 1.4142
          The 1/2 Power of              2.00              = 1.4142
          The Minimum of                3.0 and 2.0       = 2.00
          The Maximum of                3.0 and 2.0       = 3.00
```

3.1.5.2 File Management Functions

PROMULA has six functional operators that can help you manage files.

FILEDELETE	takes a file specification in quotes or a string variable containing a file specification as its argument and deletes the file and returns 1 if the file was found or 0 if the file was not found in the current directory.
FILEEXIST	takes a file specification in quotes or a string variable containing a file specification as its argument and returns 1 if the file was found or 0 if the file was not found in the current directory.
FILEEXT	takes a file specification in quotes or a string variable containing a file specification as its argument and returns the file extension.
FILENAME	takes a file specification in quotes or a string variable containing a file specification as its argument and returns the file name.
FILEPATH	takes a file specification in quotes or a string variable containing a file specification as its argument and returns the file path.
FILESIZE	takes the identifier of a random file as its argument and returns the number of records in the file.
GETDIR	takes a file specification in quotes or a string variable containing a file specification (wild card characters work here) as its argument and generates a selection list in the main screen if any files are found. The user's selection is stored in the string variable that is assigned to the function. This value can be systematically disassembled into its components by the **FILEEXT**, **FILENAME**, and **FILEPATH** functions.

Example:

The **FILEEXIST**, **FILEDELETE**, and **FILESIZE** functions are illustrated by the examples below:

```
* Create and open two array files and one random file.
DEFINE FILE
  file1  TYPE=ARRAY
  file2  TYPE=ARRAY
  file3  TYPE=RANDOM
END FILE
OPEN  file1 "file1.dba" STATUS = NEW
OPEN  file2 "file2.dba" STATUS = NEW
OPEN  file3 "file3.ran" STATUS = NEW
DEFINE VARIABLE
  fexist       "File Exist Status = "
  fdelete      "File Delete Status = "
  records      "Number of records in a random file = "
  fname        TYPE=STRING(20) "File Name"
END VARIABLE
```

Check whether or not a file exists — The **FILEEXIST** Function

```
fname = "file1.dba"
fexist = FILEEXIST( fname )
WRITE fexist
File Exist Status =  1

fexist = FILEEXIST( "file1.xxx")
WRITE fexist
File Exist Status =  0
```

Delete a file — The **FILEDELETE** Function

```
fdelete = FILEDELETE( fname )
WRITE fdelete

File Delete Status =  1

fdelete = FILEDELETE( "file2.xxx")
WRITE fdelete

File Delete Status =  0
```

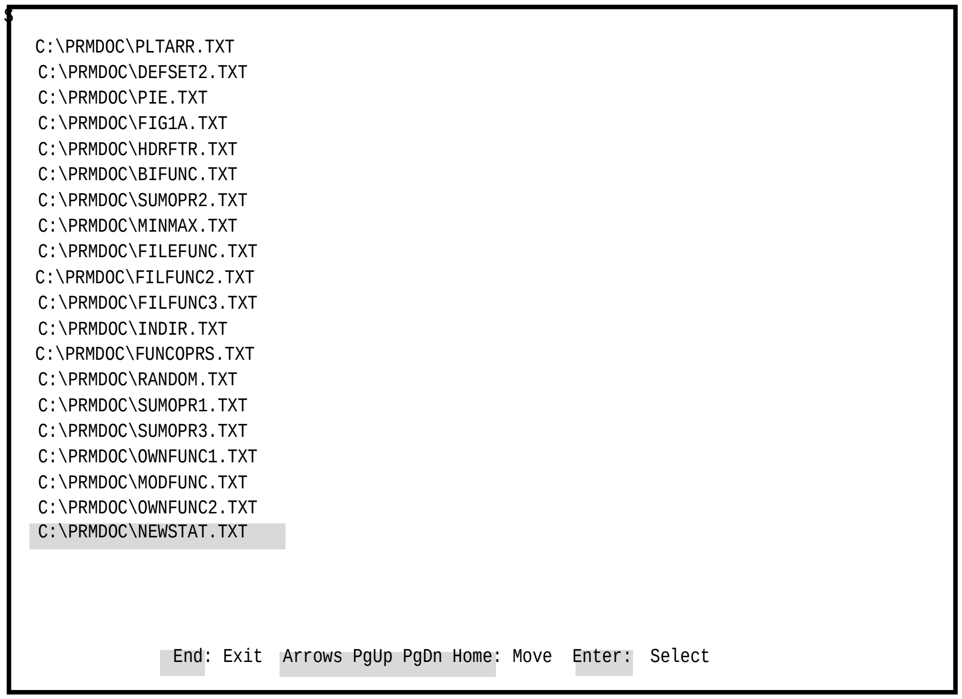
Size of a random file — The **FILESIZE** Function. `file3` is empty so it has a size of zero

```
records = FILESIZE(file3)
WRITE records

Number of records in a random file =  0
```

The **GETDIR**, **FILEEXT**, **FILENAME** and **FILEPATH** functions are illustrated by procedure `filefunc` in the example below:

```
DEFINE VARIABLE
   srch   TYPE=STRING(25) "Search Path                  = "
   fspec  TYPE=STRING(25) "Selected File Specification = "
   fpath  TYPE=STRING(25) "Selected File Path           = "
   fname  TYPE=STRING(9)  "Selected File Name           = "
   fextn  TYPE=STRING(4)  "Selected File Extension      = "
 END VARIABLE

 DEFINE PROCEDURE filefunc
   srch  = "*.txt"
   fspec = GETDIR(srch)
   DO IF NULL
      WRITE("NO FILES MATCH") CLEAR(-1)
      filefunc
   END
   DO IF END
      WRITE("NO FILE SELECTED") CLEAR(-1)
      BREAK filefunc
   END
   fpath = FILEPATH(fspec)
   fname = FILENAME(fspec)
   fextn = FILEEXT(fspec)
   WRITE srch:-25
   WRITE fspec:-25
   WRITE fpath:-25
   WRITE fname:-10
   WRITE fextn:-4
   WRITE CLEAR(-1)
   filefunc
 END PROCEDURE filefunc
```

The **GETDIR** function searches the specified directory for files that match the search mask. If any files are found, the Main Screen is cleared and the files are displayed for selection. The user can browse up and down this list then press the enter key to select a file.



```
C:\PRMDOC\PLTARR.TXT
C:\PRMDOC\DEFSET2.TXT
C:\PRMDOC\PIE.TXT
C:\PRMDOC\FIG1A.TXT
C:\PRMDOC\HDRFTR.TXT
C:\PRMDOC\BIFUNC.TXT
C:\PRMDOC\SUMOPR2.TXT
C:\PRMDOC\MINMAX.TXT
C:\PRMDOC\FILEFUNC.TXT
C:\PRMDOC\FILFUNC2.TXT
C:\PRMDOC\FILFUNC3.TXT
C:\PRMDOC\INDIR.TXT
C:\PRMDOC\FUNCOPRS.TXT
C:\PRMDOC\RANDOM.TXT
C:\PRMDOC\SUMOPR1.TXT
C:\PRMDOC\SUMOPR3.TXT
C:\PRMDOC\OWNFUNC1.TXT
C:\PRMDOC\MODFUNC.TXT
C:\PRMDOC\OWNFUNC2.TXT
C:\PRMDOC\NEWSTAT.TXT



            End: Exit  Arrows PgUp PgDn Home: Move  Enter:  Select
```

You can use the **DO IF NULL** statement to test if any matches for the **GETDIR** search were found, and you can use the **DO IF END** statement to test if the user pressed the **End** key instead of pressing **Enter** to make a file selection.

Assuming the user selects `NEWSTAT.TXT` from the list, the filename functions will break down the selected file specification into its component parts and return the results to string variables on the left-hand side of the equations. The **WRITE** statements in procedure `filefunc` display the following results.

```
Search Path                  =  *.txt
Selected File Specification =  C:\PRMDOC\NEWSTAT.TXT
Selected File Path           =  C:\PRMDOC
Selected File Name           =  NEWSTAT
Selected File Extension      =  TXT
```

3.1.5.3 The INDIRECT Function

PROMULA allows you to assign place-holder variables to other variables using the **ASK** statement and the **SELECT indirect** statement. These place-holder variables are called **indirects**. Indirects are defined as scalar variables that have an asterisk (*) following their identifier. The **INDIRECT** function is used to determine if an indirect is assigned to a variable. It is a useful accessory to both the **ASK** statement and the **SELECT indirect** statement. The syntax and use of this function are described below:

Syntax:

```
INDIRECT(indir[,varlist])
```

Remarks:

`indir`	is the identifier of an indirect variable.
`varlist`	is a list of variable identifiers.

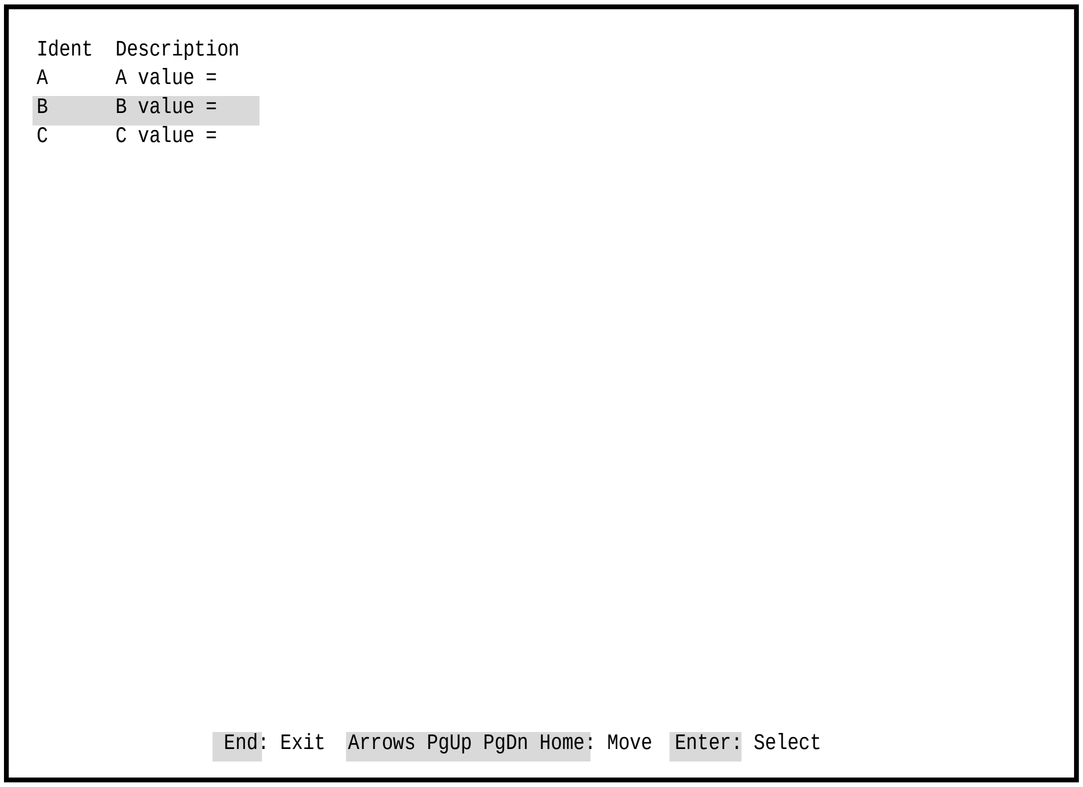
The **INDIRECT** function returns a one if `indir` is assigned to a variable in `varlist`; otherwise it returns a zero.

Example:

Here is an example of using the **INDIRECT** function.

```
DEFINE VARIABLE
  a   "A value ="  TYPE=REAL(10,4) VALUE=1
  b   "B value ="  TYPE=REAL(10,4) VALUE=2
  c   "C value ="  TYPE=REAL(10,4) VALUE=3
  indir*
END VARIABLE

DEFINE PROCEDURE selvar
SELECT indir
DO IF END
  BREAK selvar
END
DO IF INDIRECT(indir,a)
   WRITE ("You have selected variable A"/)
ELSE  INDIRECT(indir,b,c)
   WRITE ("You have selected variable B or variable C"/)
END IF INDIRECT
WRITE indir
WRITE (indir:L)
WRITE (/"Press any key to continue") CLEAR(-1)
selvar
END PROCEDURE selvar
```

Execution of procedure `selvar` and selection of variable `b` produce the following results:



```
Ident  Description
A      A value =
B      B value =
C      C value =
```

```
You have selected variable B or variable C

B value = 2.0000
B value =

Press any key to continue
```

3.1.6 Expression -- Logical

Definition:

A numeric expression involving at least one logical operator. A logical operator operates on true-false expressions to produce the value 1 if the resultant expression is true, or the value 0, if the resultant expression is false.

The logical operators, in order of precedence, are:

OPERATOR	EXPRESSION	MEANING
NOT	NOT A	1 if A is false; 0 otherwise
AND	A AND B	1 if A and B are true; 0 otherwise
OR	A OR B	1 if A or B is true; 0 if both are false

A and B are evaluated as true-false expressions.

3.1.7 Expression -- Numeric

Definition:

A formula for computing a numeric value or values. It consists of a sequence of operands and operators. The operands may be variables, constants, and other expressions. The operators specify the operation to be performed on the operands.

Remarks:

In order of precedence, the operators are shown in Table 3-3.

Operations at the same level of precedence in the list are performed in left to right order. To alter the order in which operations are performed, use parentheses. Operations within parentheses are performed first. Inside parentheses, the above order of operations is maintained. To force left-to-right precedence for all operators, execute a **SELECT HIERARCHY=OFF** statement.

Table 3-3: The Precedence of Operators in PROMULA

OPERATOR	EXPRESSION	PRECEDENCE	MEANING
Functional			
f( )	f(x)	1	Evaluate the function f(x)
Arithmetic			
**	A**B	2	Raise A to the B power
*	A*B	3	Multiply A times B
/	A/B	3	Divide A by B
–	A-B	4	Subtract B from A
+	A+B	4	Add A to B
–	–A	5	Take the negative of A
Relational			
LT	A LT B	6	A less than B
LE	A LE B	6	A less than or equal to B
NE	A NE B	6	A not equal to B
EQ	A EQ B	6	A equal to B
GE	A GE B	6	A greater than or equal to B
GT	A GT B	6	A greater than B
Logical			
NOT	NOT A	7	Not A
AND	A AND B	8	A and B
OR	A OR B	9	A or B

3.1.8 Expression -- Relational

Definition:

A numeric expression involving at least one relational operator. A relational expression compares two operands and is either true, if the result of the comparison is true, or false, if the result of the comparison is false. It has either the value 1, if true, or the value 0, if false.

Remarks:

The relational operators are:

OPERATOR	EXPRESSION	MEANING
LT	A LT B	A less than B
LE	A LE B	A less than or equal to B
EQ	A EQ B	A equal to B
NE	A NE B	A not equal to B
GE	A GE B	A greater than or equal to B
GT	A GT B	A greater than B

Examples:

1. The expression `5 LT 7` has the value 1 (TRUE); the expression `5 GT 7` has the value 0 (FALSE).

2. Given the following definitions:

```
DEFINE VARIABLE
  A(10)
  B(10)
END VARIABLE

A(i) = i
```

the equation

```
B = A LT 5
```

produces the following results:

```
 A       A LT 5     B=A LT 5

 1       True          1
 2       True          1
 3       True          1
 4       True          1
 5       False         0
 6       False         0
 7       False         0
 8       False         0
 9       False         0
10       False         0
```

3.1.9 File

Definition:

A place on disk that stores information.

Remarks:

Files allow you to extend the storage available to your programs beyond the central memory of the computer. Files also allow you to save information on disk for use at a later time. In addition, files are one means by which you may transfer data to and from other programs or computers.

Your computer has two kinds of memory:

1. Primary memory (also known as system memory, central memory, RAM (Random Access Memory), on-line memory, core, or working space).

2. Secondary memory (also known as disk memory, off-line memory, peripheral memory, or mass storage).

Since the access time for primary memory is faster than disk memory, primary memory is more expensive than disk memory and, thus, it is available in relatively small quantities. At the time of this printing, a system memory of one Megabyte (enough to store about one million characters) is average for a typical personal computer. Disk memory, on the other hand, is relatively inexpensive and comes in the form of removable diskettes or fixed disks, which can hold many megabytes of data; the smallest disk drives can hold ten Megabytes of data; the largest can hold several thousand Megabytes.

The extension of your programs to disk memory is inevitable, and for large-scale programing applications necessary. The reasons for this are:

1. Programs written and compiled now need to be saved for use later.

2. Large-scale programs are usually data intensive, often manipulating millions of data values during a single execution cycle. It is usually impossible to store all of these values within the central memory of the machine, so off-line disk storage is needed to extend the data storage area required by the execution of the program.

3. PROMULA data files need to be used by other software systems or programs written in other languages.

4. PROMULA programs need to use data created by other software or programs written in other languages.

PROMULA has a database manager and a program segment manager to help you manage your program if it becomes so large that it does not fit in your working space.

Large program management is achieved by using files. PROMULA files can be classified as falling into one of the three functional types:

1. **Data files** for storing data in text or binary form.

2. **Segment files** for storing the executable code and data of PROMULA applications.

3. **Dialog files** for storing on-line help libraries.

The above three types of files, used alone or in combination, give you the flexibility and power to develop and manage large-scale applications.

3.1.9.1 Data Files

Data files are used for the storage and retrieval of program data or variables; thus, they extend the data storage available to a program.

Data files are of four types:

1. **Text** files of sequential-access records

2. **Random** files of direct-access records

3. **Inverted** files that index the records of random files

4. **Array** files of value-addressable multidimensional variables.

3.1.9.1.1 Text Files

Text files are files that contain text and may be created and/or changed by a text editor. Text consists of ASCII codes; thus, text files are also known as "ASCII files".

Text files are sequential-access files of variable-length text records. Each record consists of data items that are laid out in lines of variable length (up to a maximum of 255 characters).

Sequential access means that in order to access the $(N+1)^{th}$ record in the file you must first access the $(N)^{th}$ record.

The items in a text record may be laid out by a person using a text editor, or by a computer program.

The **DEFINE FILE** statement defines a text file.

The **OPEN file** statement opens a text file for use.

The **READ file** statement reads data from a text file.

The **WRITE file** statement writes data to a text file.

The **CLEAR file** statement physically closes a text file, saving its current contents.

The **DO file** statement allows you to access all records of a text file in sequential order (from Record 1 to Record N, where N is the last record of the file).

3.1.9.1.2 Random Files

Random files are random-access files of fixed-length binary records. Each record consists of a fixed number of variables. The variables of a random file may be scalar items that each fill a single field and/or multidimensional arrays that fill many fields. Random files may be used to build "relational databases" (i.e., with a tabular structure) in PROMULA.

Random-access means that you may access any record in the file arbitrarily without having to access all records before it in the file. In this respect, they are more efficient than text files.

A record number is associated with each record in a random file. This number varies from 1 to N, where N is the total number of records in the file. It is via the record number that you can access any record of the file in random-access fashion.

The **DEFINE FILE** statement defines a random file.

The **DEFINE VARIABLE** statement defines the record structure, i.e., the variables, of a random file.

The **OPEN file** statement opens a random file for use.

The **READ file** statement reads one complete record of data from a random file.

The **WRITE file** statement writes one complete record of data to a random file.

The **CLEAR file** statement physically closes a random file saving its current contents.

The **SELECT file** statement allows you to access at random any record in the file by specifying the desired record number. It is this feature that distinguishes random files from text files.

The **DO file** statement allows you to access all records of a random file in sequential order (from Record 1 to Record N, where N is the last record of the file).

PROMULA random files may be used directly by programs written in languages such as FORTRAN and C. For example, the FORTRAN READ statement can read PROMULA random files, provided you specify three parameters: the file name (or number), the record number, and the record length (in bytes). The length of a record is simply the number of values in the variables of the record multiplied by 4 (note that each character in a STRING type variable is considered as a value, so that a variable with TYPE=STRING(10) has a length of 40 bytes).

3.1.9.1.3 Inverted Files

Inverted files offer a means to make rapid selections from a random file based on the values of variables in the records of the random file.

Inverted files are used only by PROMULA, and are closely related to random files.

The **DEFINE FILE** statement defines an inverted file.

The **OPEN file** statement opens an inverted file for use.

The **READ file** statement reads data from an inverted file.

The **WRITE file** statement writes data to an inverted file.

The **SELECT file** statement makes selections from an inverted file.

The **CLEAR file** statement physically closes an inverted file, saving its current contents.

The **DO file** statement sequentially accesses the selected records of an inverted file.

The definition and use of Inverted files is illustrated in the examples given in the **SELECT file** statement.

3.1.9.1.4 Array Files

Array files are value-addressable, random-access files that contain indexed, multidimensional arrays of data. Though stored on disk, the variables of array files are defined via the **DEFINE VARIABLE** statement in the same way as program variables that are stored in your working space. Obviously disk variables can store many more values than standard program variables.

Though unique to PROMULA, array files may be converted to text data (ASCII files) for transfer to other programs or other computers, using the **COPY file** and **WRITE** statements.

Moreover, the values of array files can also be used directly by programs written in other languages, such as C or FORTRAN.

The method of access for array files is direct — any array or any connected subset of an array may be accessed at random. Array files are value-addressable; if desired, you may access information by single cell (or value).

The **DEFINE FILE** statement defines an array file.

The **DEFINE VARIABLE** statement defines the array structure, i.e., the variables, of an array file.

The **OPEN file** statement opens an array file for use.

The **READ DISK** statement reads data from an array file.

The **WRITE DISK** statement writes data to an array file.

The **CLEAR file** statement physically closes an array file, saving its current contents.

The **COPY file** statement allows you to display the contents of an array file or to copy an array file into another array file or into a text file for transfer to other programs.

The **AUDIT file** statement allows you to list the contents of an array file.

A virtual access method is also available via the **DISK** option of the **DEFINE VARIABLE** statement. This allows you to use the variables of array files without using explicit **READ DISK** and **WRITE DISK** statements. See Chapter 4 for examples of this.

3.1.9.2 Segment Files

The code of any PROMULA program may be divided into a hierarchy. This is particularly useful when the program is large, which happens when either the program code, the program data, or both, become larger than your working space.

Segment files are used for the storage and retrieval of program segments. They are needed primarily so that previously written program segments can be saved and loaded for later use.

Segment files contain not only the executable code of a program, but also the values associated with the variables of the program. By breaking a program into segments, you partition both the code space and the data (value) space for the variables in the code, thus extending both.

The **OPEN SEGMENT** statement opens a segment file on disk.

The **DEFINE PROGRAM** and **DEFINE SEGMENT** statements mark the beginning of a program segment.

The **READ SEGMENT** statement reads the information in a segment file from disk.

The **END PROGRAM** and **END SEGMENT** statements write a segment file to disk.

The **READ VALUE** and **WRITE VALUE** statements allow you to retrieve and update the variable values in a program segment without explicitly accessing the variables themselves.

3.1.9.3 Dialog Files

Dialog files are on-line help files that can be accessed in a menu-driven or random manner. A dialog file is defined as a collection of topics. Each dialog topic definition consists of:

1. A short title (up to 25 characters)

2. The topic text (which can have as many characters as you wish)

Upon execution, a dialog file will display its contents to the user in a menu-driven, conversational format — hence its name.

Dialog files provide a powerful method of generating on-line, conversational help systems for your applications. They provide a menu-driven framework for tutorials; all you need to do is type in the topic headers and the tutorial text.

A dialog file is initially defined as a series of topics via the **DEFINE DIALOG** statement.

Upon execution of the **BROWSE DIALOG** statement, the topic titles form a menu from which you may select and browse the topic texts. A specific topic may be displayed with the **BROWSE TOPIC** statement.

Dialog files are demonstrated in the examples given in the **DEFINE DIALOG** statement.

3.1.9.4 Access Methods

PROMULA supports three basic ways to access the contents of a datafile:

1. **Sequential access** — In text files. Here, information is accessed in terms of variable length text records. The records are accessed in sequence, one record at a time, starting at 1 and ending at N, where N is the last record in the file. Before accessing the (N+1)th record, you must first access the (N)th record.

2. **Random access** — In random files. Here, information is accessed in terms of structured fixed length binary records. The records are accessed at random, one record at a time, by simply specifying the record number or by using an inverted file to select the records of the file that contain a field that matches a specified key.

3. **Direct access** — In array files. Here, information is accessed in terms of variables, the notion of record does not apply. The variables may be either single-valued (scalars) or multi-valued (arrays). Array file variables are value-addressable, i.e., you may access single data cells (values) in them or any connected subset of their values.

   For example, if **A** is a four-dimensional variable classified by row, column, page, and year, then you have the following direct access options:

   1. You can access all values of **A.**

   2. You can access a three-dimensional part of it, say, all the rows, columns and pages for a particular year.

   3. You can access a two-dimensional part of it, say, all the rows and columns for a particular page and year.

   4. You can access a one-dimensional part of it, say, all the years for a particular row, column and page.

   5. You can access a single cell of it, say, the value for row=3, column=2, page=2, and year=10.

   This kind of selectivity is particularly useful when you have very large arrays in your disk database that do not fit in your working space. In addition to the direct access method, variables in array files may be accessed **virtually** or **dynamically** via local variables. See Chapter 4 for details of this.

3.1.9.5 File Names

Each file has two names: a logical name and a physical name.

The **logical name** is the name by which the file is referenced in a PROMULA program. A logical name can be any string of alphanumeric characters whose first character is alphabetic. Only the first six characters are significant.

The logical name for a segment file is introduced via the **DEFINE SEGMENT** statement. For unsegmented programs, the **DEFINE PROGRAM** statement introduces a segment file with the logical name **MAIN**.

The logical name for a data file is introduced via the **DEFINE FILE** statement.

The **physical name** is the name by which the file is known to the operating system. A physical file name must be specified according to the file naming conventions of the particular operating system that you are using.

Before a given file can be accessed, it must be opened, i.e., declared to the operating system via its physical file name.

The physical name of a segment file is specified via the **OPEN SEGMENT** statement.

The physical name of a data file is specified via the **OPEN file** statement.

3.1.9.6 Interface PROMULA Files with Other Software

PROMULA text files may be used directly by other software or programs written in other languages, such as FORTRAN and C.

In the case of text files, this interface is automatic. By definition, a text file is a file that may be treated as text. To show its contents, for example, you may use the TYPE, COPY, or PRINT command of your operating system. To change the contents of a text file, you may use a text editor.

It is through text files that PROMULA communicates with other software, such as electronic spreadsheets, word processors, and database managers.

To access PROMULA text files by programs written in other languages, such as FORTRAN or C, you need to use the appropriate **OPEN**, **READ**, and **WRITE** statements of these languages.

Users of the virtual data management capabilities of the PROMULA language translators or the PROMULA Virtual Memory Management Library may create C or FORTRAN programs that can access PROMULA's array databases.

3.1.10 Function

Definition:

A function is a curve on the (x,y) plane. It is defined by a set of points whose coordinates are given by the values of two array variables, the x-variable and the y-variable.

Remarks:

The table of values below defines a function **f(x)**:

A FUNCTION f(X)

X-VARIABLE	Y-VARIABLE
x(1)	y(1)
x(2)	y(2)
x(3)	y(3)
.	.

```
          .          |          .
          .          |          .
        x(n)         |        y(n)
```

For an arbitrary argument x the function f(x) returns the value on the curve defined by the above table of points. The value of the function is computed by using two-point linear interpolation between the points defining the function.

PROMULA allows multidimensional arrays to be used as function value vectors provided that both arrays have the same set classifying their first dimension.

Functions may be used in equations and conditional expressions.

The **DEFINE FUNCTION** and **DEFINE LOOKUP** statements define a function.

Expressions that act on their X and Y variables modify a function.

The **READ function** statement modifies a function and its X and Y variables.

The **WRITE function** and **BROWSE function** statements display a function in tabular form.

The **PLOT** statement displays a function in graphical form.

3.1.11 Menu

Definition:

A screen template which is designed to help its user to either pick from a list of options or view and/or edit the values of program variables.

Depending on content and intended use, there are two kinds of menus:

1. Pick menus for helping the user select an option
2. Data menus for helping the user view and/or edit program variables

Menus are manipulated by several statements:

DEFINE MENU	Defines a menu
SELECT menu	Helps the user make a selection from a pick menu
EDIT menu	Helps the user enter information into a data menu
READ menu	Helps the user enter information into a data menu
WRITE menu	Displays a data menu
BROWSE menu	Draws a data menu then pauses until the next user event (keypress or mouse click)
SELECT PULLDOWN	Creates and displays a pulldown pick menu for selection
SELECT FIELD	Modifies the selection fields of a simple or popup pick menu

3.1.11.1 Pick Menus

Depending on thier definition and behavior, there are three types of pick menus:

1. Simple, one-window pick menus defined with a basic **DEFINE MENU** statement
2. Popup, two-window pick menus defined with a **DEFINE MENU POPUP** statement
3. Pulldown pick menus defined with a **SELECT PULLDOWN** statement

Simple and Popup pick menus are executed by the statement:

```
        SELECT menu(option)
```

where `menu` is the name of the menu, and `option` is a variable that will contain the number of the selection picked.

Pulldown pick menus are executed by the statement:

```
        SELECT PULLDOWN option = menudesc
```

where `menudesc` is the description of the pulldown menu, and `option` is a variable that will contain the number of the selection picked.

In both cases, the value of `option` may be used to determine alternative execution paths.

When displayed, all pick menus contain a number of **selection field**s. You may highlight the desired field by pressing the arrow keys. To execute your selection, press the **Enter** key. For all pick menus, you may also chose an option by positioning the mouse sprite over the desired field and clicking the mouse button. Simple and popup pick menu fields may also be selected by single keypresses as described below.

Simple pick menus allow you to easily create a simple selection display. In these menus, a number of selection fields are laid-out on a single screen template. Each selection field in the menu is text that is bracketed by two backslashes (\) in the menu template. The selection fields are ordered from 1 to n as you go from left to right and from top to bottom of the menu template.

When a simple pick menu is used in a **SELECT menu** statement, PROMULA clears the window opened to the Main Screen, displays the menu, and highlights the first selection field. Selections may be made using the function keys (or the numeric keys) directly. The **F1** (numeric 1) key picks the first selection in the menu, the **F2** (numeric 2) key picks the second selection, and so forth. If you have more than ten selection fields, then press the **Alt** or **Shift** key together with one of the ten Function keys to get up to twenty selections. For example, pressing **Alt-F1** picks the 11th selection.

Popup menus give you the ability to define a network of menus that function as a unit. They also allow you to create menus that use any printable key for selections, and to define context sensitive help for each selection field. A popup menu definition consists of a top level menu definition and zero or more submenu definitions. Each menu definition consists of a **selection screen** and a group of **FIELD statements**. Each selection screen in a popup menu contains a number of selection fields. Each selection field in the menu is text that is bracketed by two backslashes (\). The selection fields are ordered from 1 to n as you go from left to right and from top to bottom of the menu template.

Each selection field in the selection screen of a popup menu requires a **FIELD** statement. The **FIELD** statement contains the following information:

1. a descriptor for the selection field,
2. a key code that allows the user to select the field with a single keystroke,
3. an optional reference to field-specific on-line help,
4. and an action code that is used to branch to alternate execution paths depending on the user's selection.

When defined, a popup menu is associated with a pair of windows: The first window will display the selection screen(s); the second window will display the field descriptions.

Pulldown menus are displayed in a dynamic system of windows that drop-down from a user-defined menu bar window. The menu bar window, the values of the selection field labels, and the action codes returned by menu selections are all defined by the parameters of the **SELECT PULLDOWN** statement when it is executed. The field labels and action codes of the **SELECT PULLDOWN** statement may be variables or constants. Pulldown menu selections may only be made by highlighting the desired selection field and pressing enter or by pointing and clicking with a mouse.

3.1.11.2 Data Menus

Data menus contain a number of fields to be displayed and/or edited by the user. Each field in the menu is denoted by a series of contiguous *at signs*, @, or contiguous *tilde characters* (~). The number of field characters should be equal to the desired number of characters in the data value that will be displayed in the field. The fields are ordered from left to right and from top to bottom of the menu template. Fields defined with at signs will be editable and are referred to as data fields, fields defined with tilde characters will not be editable and are referred to as display-only fields.

To execute a data menu, enter the following statement:

```
EDIT menu(vars)
```

where `menu` is the name of the data menu, and `vars` is a list of variables that correspond to the fields of the menu. The variables in the list must be arranged in the same order as the fields in the menu to which they correspond.

Upon execution, the data menu becomes a screen display that has the first data field highlighted by the bounce bar. Use the movement keys to move the bounce bar to the desired data field. To edit the highlighted data field, press the Enter key and enter the new value, as prompted at the bottom of the menu.

Examples:

The definition and use of menus are illustrated in the examples given with the **DEFINE MENU**, **SELECT PULLDOWN**, and **SELECT FIELD** statements.

3.1.12 Numeric Precision

PROMULA stores **REAL** numbers with six significant digits and **INTEGER**s with ten significant digits.

REAL numeric expressions are evaluated in double precision to maintain **at least six** significant digits.

INTEGER and **MONEY** expressions are evaluated to ten significant digits of accuracy.

PROMULA allows mixed-mode arithmetic. A real variable is rounded to the nearest integer when equated to an integer variable.

On the IBM PC, Reals less than ABS(8.43E-37) cause underflows in calculations. Real values greater than ABS(3.37E+38) cause overflows. Integers are valid in the range ($-2^{31} - 3$, $+2^{31} + 3$), about ± 2.1 billion. Integers outside this range cause overflows and cannot be processed by the system. Money type variable values are valid in the range ($-2^{31} - 3$, $+2^{31} + 3$), about ± 2.1 billion cents or 21 million dollars. Overflows and underflows in calculations cause errors.

The value zero, of course, is valid, except in denominators of divisions where it does not make sense, or in logarithms.The PROMULA system can be configured to allow these types of math errors; see the **SELECT MATHERROR** statement.

Examples:

1. Given the following definitions:

```
DEFINE VARIABLE
  A          "A real value"
  B          "An integer value"    TYPE=INTEGER(8)
END

A=10.6
```

the equation `B = A` rounds the value of `A` to yield the value

```
B = 11
```

2. The equation `B = IFIX(A)` on the other hand, truncates the value of `A` to yield

```
B = 10
```

3.1.13 Parameter

Definition:

A parameter is a numeric variable which is used locally within a procedure and is used to transfer data values to and from the procedure.

Parameters are used to transfer data values to and from procedures.

Parameters may be scalars or multidimensional arrays, but they cannot be passed as string type variables.

A parameter identifier cannot be defined or referenced outside a procedure.

See **DEFINE PARAMETER** and **DEFINE PROCEDURE** for more details and examples.

3.1.14 Procedure

Definition:

A procedure is a group of statements that are compiled as a unit under a unique identifier for later reference and execution.

Remarks:

A procedure definition or compilation is initiated with the **DEFINE PROCEDURE** statement and is terminated by the **END** statement.

Procedure execution is initiated by entering the procedure identifier, optionally preceded by the word **DO**. When a procedure is called, its statements are executed sequentially in the same order as they are defined.

Procedure execution ends after the last statement of the procedure is executed or when a **BREAK procedure** statement is executed. After ending, execution continues with the statement after the original procedure call that started the procedure.

3.1.15 Program

A PROMULA program is an ordered set of statements that allows you to transform input data to output information. A statement is a complete instruction in a PROMULA program. Input data is given or known information which you "read into" the program; output information is what the program computes and "writes out" for you.

A PROMULA program has two states: **source** and **executable**. When you first write it, the program is in its source state. From its source state, the program is transformed to its executable state by the process of compilation. In its source state, a program can be modified with a text editor and compiled but not executed. The computer can execute a program only if it has been successfully compiled and is in an executable state.

The two main operations of the PROMULA system are **program compilation** and **program execution**. Both of these operations can be performed either directly, with interactive input from the console (Options 10 and 6 of the Main Menu), or indirectly, with batch input from disk (Options 5 and 8 of the Main Menu).

To write and/or edit PROMULA source programs, you can use your own text editor or PROMULA's Text Editor — Main Menu option 4 .

3.1.16 Relation

Definition:

A relation is a rule of correspondence between the elements of a set and the contents of a variable indexed (subscripted) by that set.

A set is a classification scheme and as such it is an abstraction. Its elements are usually ordered from 1 to n, where n is the size of the set. However, if related to a variable of n values the elements of the set take on a less abstract meaning.

For example, the set `month` is an ordered set of the numbers 1, 2, ..., 12. The string variable `mn(month)` contains 12 values that are the month names January, February, ..., December. If the set `month` and the variable `mn` are related, then the elements of the set `month` and the values of the variable `mn` have the following correspondence:

Set **`month`**	Variable **`mn`**
1	January
2	February
.	.
.	.
.	.
12	December

PROMULA supports four kinds of relations:

ROW	specifies the variable whose values will serve as the primary descriptor for a set's elements. The primary descriptor values are used to label rows of values classified by the set in **WRITE**, **BROWSE**, and **EDIT** statements. They are also used in bar plots, page headings, and displays of the set itself.
COLUMN	specifies the variable whose values will serve as the column descriptor for a set's elements. The column descriptor values are used to label columns of values classified by the set in **WRITE**, **BROWSE**, and **EDIT** statements.
KEY	specifies the variable whose values will serve as the codes for a set's elements. If no **ROW** relation for the set is specified, the code values, also referred to as **keys**, are used as the primary descriptors for the set. If no **COLUMN** relation for the set is specified, the code values are used as column descriptors. In addition, set codes may function as set element identifiers in displays of the set and in coded set selections.
TIME	specifies the variable whose values will serve as the time values for a set's elements. If no **ROW** relation for the set is specified, the time values, also referred to as **keys**, are used as the primary descriptors for the set. If no **COLUMN** relation for the set is specified, the time values are used as column descriptors. In addition, time values may function as set element identifiers in displays of the set and in coded set selections. If a set has a **TIME** relation, it becomes a **Time Series Set**.

A related feature is PROMULA's **TYPE=set** option for variables. A variable of this type displays the row descriptor of the set element which corresponds to its value. For example, if a variable, `ms`, has the type specification `TYPE=month(15)`, and `ms` contains the value 2, then the statement

```
    WRITE (ms)
```

would display the word `February` with a width of 15 characters. Furthermore, if `ms` is assigned any value that is not between 1 and 12, (the range of set `month`) it is given the value zero instead.

See **DEFINE RELATION** and **SELECT RELATION** for more details.

3.1.17 Segment

Definition:

The segment is a part of a program that may be saved on disk for later loading and execution.

Remarks:

A program segment is bounded by a **DEFINE SEGMENT** statement at its beginning and an **END SEGMENT** statement at its end.

A large program may be segmented into a hierarchical tree structure of segments.

For simple one-segment programs, the program segment should be initiated by a **DEFINE PROGRAM** statement and ended with an **END PROGRAM** statement. The enclosed program segment is given the default name **MAIN**.

Chapter 4 describes program segmentation in detail.

3.1.18 Set

Definition:

A finite set of discrete elements that are ordered from 1 to N, where N is the size of the set.

Remarks:

A set has the following characteristics:

A unique identifier
A size
An optional descriptor
An optional format specification for displays of the set and arrays dimensioned by the set
An optional disk reference to descriptors of the set's elements

Sets are used primarily as subscripts of array variables and serve to build their multidimensional structure. They may also be used to control program flow and to provide descriptive information for reports.

The descriptors associated with the elements of a set classify the values of variables subscripted by the set and serve as the row, column, and page headings of such variables.

The default descriptors of the elements of a set are:

```
SET(1), SET(2),..., SET(N)
```

where `SET` is the set identifier.

A set is defined by the **DEFINE SET** statement.

The contents of a set may be displayed via the **WRITE set** and **BROWSE set** statements.

The sets of a program may be listed via the **AUDIT SET** and **BROWSE SET** statements.

The order and range of a set may be modified by the **SELECT set**, **SELECT set IF**, and **SORT** statements. The current range and order of a set's elements are stored in a structure referred to as the set's **selection vector**.

The elements of a set may be selected interactively via the **SELECT SET**, **SELECT ENTRY**, **ASK...ELSE SET**, and the **SELECT VARIABLE** statements.

Sets may be used to drive **DO loops** with the **DO set** statement.

Descriptive information may be associated with set elements with the **DEFINE RELATION**, **SELECT RELATION**, and **READ set** statements.

The descriptors of a set may be displayed as the values of a variable by using the **TYPE=set** type specification in the variable's definition.

PROMULA has some special notation for use with sets that can be useful in working with sets and multidimensional variables. This notation is discussed below.

set:M	A scalar containing the maximum size of **set**. This is the value of N used in defining the set.
set:N	A scalar containing the current size of **set**.
set:S[(i)]	A vector containing the element sequence numbers of the selection vector of **set**. The (i) subscript is optional and is used to indicate which element of the selection vector is being referenced. The default is i = 1. **Set:S** is useful as an iteration counter in a **DO set** loop or as a switch between alternate execution paths. In addition, **set:S(1)** contains the sequence number of the element corresponding to the minimum (maximum) value of a vector after a **SORT** (**DESCENDING**) statement.
set:R	A scalar containing the current range of **set**. Initially, **set:R** = **set:M**.
set:V[(i)]	A vector containing the values associated with a **TIME** related **set**. This variable is useful in dynamic simulation applications.

Normally, you will not assign values to these variables. However, if you want to make your own assignments, you will have to use the PROMULA verb, **COMPUTE**. For example, it is possible to change the default range of a set to 1 through `m` with the following statements:

```
COMPUTE set:R = m
SELECT set*
```

You should not increase the size of a set above its definition size, as this can result in loss of program information.

To restore the range of a set to its default, use the statements

```
COMPUTE set:R = set:M
SELECT set*
```

Examples:

1. Defining a Set

```
DEFINE SET
  month(12) "Set of 12 Months"
  acnt(3)   "Account"
END
```

2. Using Sets as Subscripts to Define Array Variables

```
DEFINE VARIABLE
  md(month,acnt) "Data by Month and Account"
END VARIABLE
```

3. Selecting Set Elements

```
SELECT month(1,6,9-12)
SELECT month*
SELECT SET (month)
SELECT ENTRY (month)
SELECT VARIABLE (md)
SELECT month IF md GT 4
```

4. Special Set Notation:

   Some of the special notations for sets (set:M, set:R, set:N, set:S) are illustrated in the dialog below.

```
DEFINE SET
  pnt(4)
END SET
DEFINE VARIABLE
  x  "X="
END VARIABLE

DO pnt
  WRITE (pnt)
END pnt
PNT(1)
PNT(2)
PNT(3)
PNT(4)

x=pnt:M
WRITE x
X= 4

x=pnt:R
WRITE x
X= 4

x=pnt:N
WRITE x
X= 4

SELECT pnt(3,2,4)
x = pnt:S(3)
WRITE ("pnt:S(3) = "x)
pnt:S(3) =        4

DO pnt
  x=pnt:S
  WRITE ("pnt:S = "x)
  x=pnt:N
  WRITE ("pnt:N = "x)
END
pnt:S =        3 Note that within a DO set loop, the size of the set
(set:N)
pnt:N =        1 is one element.
pnt:S =        2
pnt:N =        1
```

```
          pnt:S =        4
          pnt:N =        1

          x=pnt:N
          WRITE x
          X= 3
```

5. Using sets directly from a database.

   Sets may be defined as part of the structure of an array file (see **DEFINE SET**). These disk sets may be accessed directly — without having the database definition in memory by using the file:set notation. For example, the following code creates a database with three sets.

```
DEFINE FILE
  af TYPE=ARRAY
END

OPEN af "test.dba" STATUS=NEW

DEFINE SET af
  rec(1000)
  fld(8)
  pag(10)
END SET af

... The rest of the database definition (e.g., variables and relations).

CLEAR af
```

   The sets in file `test.dba` can be manipulated by PROMULA by opening the array file — **STATUS=OLD**, then using the `file:set` notation.

   For example `af:rec` is the identifier of the 1000 element set in the array file `test.dba`.

3.1.19 Statement

Definition:

A complete instruction in a PROMULA program.

Remarks:

There are two types of statements: line and structured. Line statements are entered on a single line which may be continued to additional lines according to the rules of line continuation. Structured statements, on the other hand, require more than one line of code; they start in one line and end in another with a number of other lines in-between. A structured statement may contain other line or structured statements in it. All structured statements end with an **END** statement.

Examples:

The statement

```
WRITE a
```

is a line statement.

The statement

```
DEFINE VARIABLE
  a
  b
END
```

is a structured statement.

All PROMULA statements begin with one of the verbs of the language, except for equations which begin with the optional verb **COMPUTE**, procedure execution statements which begin with the optional verb **DO**, and data lines.

All definition statements are structured. They begin with the verb **DEFINE** and end with the verb **END**.

PROMULA statements have no line numbers and may begin anywhere on an input line.

Blanks or commas must be used to separate distinct statement parts.

A statement may be as long as you wish; however, if it is longer than 80 characters it is good style to continue the statement on the next input line by using a comma at the end of the current line. You may use as many continuation lines as you wish.

3.1.20 System

Definition:

A system of n equations and n unknowns.

A system has a name, n parameters (or unknowns), and n equations. The number of equations in a system, n, can be as large as you can fit in your working space.

The system is defined by the **DEFINE SYSTEM** statement.

Equations are written in the usual algebraic notation:

```
f(x1, x2,...) = g(x1, x2,...)
```

where `f` and `g` are arbitrary real, continuous functions of `x1, x2,...`

The solution of a system is obtained by an iterative process which you start by making an initial guess for all of the unknowns.

A system `sys` with parameters `x1, x2,...` may be solved by simply entering its name and specifying an ordered list of scalar variables `a1, a2,...` corresponding to the parameter list. The number and order of variables in the variable list must agree with the number and order of the parameters as defined in system `sys`:

```
sys(a1,a2,...)
```

The solution of system `sys`, if it exists, will be returned as the values of the variables `a1, a2,...`

If the attempt to solve system `sys` does not converge after a reasonable number of iterations, then you are given the message to try another starting guess for the unknowns.

A diagnostic is also given if the system does not have a real solution.

See also the **DO LSOLVE** statement which may be used to solve systems of linear equations.

Examples:

An example of system definition and system solution is given in the **DEFINE SYSTEM** statement.

3.1.21 Table

Definition:

A tabular report (or display) of several variables.

A table has a body and an optional title and format. The body of the table contains the names of the variables whose values will be displayed as the 'body' of the table. The format specifies the width of the rows and columns of the table.

The values of the variables in a table are classified by a common set. This common set classifies the columns of the table.

You may include as many variables as you wish in the body of a table.

A table may be 'browsed' by using the **BROWSE TABLE** statement. This allows you to browse the pages of a table one at a time.

A table may be 'written' by using the **WRITE TABLE** statement. This allows you to display or print the table in its entirety.

A table may be 'edited' by using the **EDIT TABLE** statement. This allows you to browse the pages of a table one at a time and change its values.

Tables may also be defined using the **DEFINE TABLE** statement.

3.1.22 Time Parameters

Definition:

In PROMULA, the words **TIME**, **DT**, **BEGINNING**, and **ENDING** are reserved keywords that name four scalar parameters that are used mainly in dynamic simulation applications. Such applications contain procedures involving time series variables and time integration algorithms.

These four internal variables are used with the dynamic simulation subsystem of PROMULA where they are used explicitly with the level and rate statements to specify approximate (first order) integrations of level variables over time:

```
        level(TIME + DT) = level(TIME)  +  DT * rate(TIME)
```

Here, the value of a variable at time `(TIME + DT)` is equal to its value at time `TIME` plus the product of `DT` times the rate of change of the variable at time `TIME`.

In the dynamic simulation, these parameters have the following meanings:

TIME	The **TIME** variable
DT	A time increment for the **TIME** variable
BEGINNING	The beginning value of **TIME**
ENDING	The ending value of **TIME**

Some of the sample programs on the PROMULA Demo Disk are dynamic simulation models converted to PROMULA and contain examples that use these parameters.

See the **RATE**, **LEVEL**, and **TIME** statements as well as the discussion of **Dynamic procedures** in this Chapter for more information on these constructs.

3.1.23 Variable

Definition:

A place for storing numeric or character information. A variable may have a single value or a number of values. A single-valued variable is called a **scalar**. A variable with many values is called an **array**.

Remarks:

A variable has the following characteristics:

A unique identifier
A structure
A value or values
A format type
An optional descriptor
A storage type

The **identifier** of a variable is its symbolic name. It may have up to six alphabetic and numeric characters, the first being alphabetic. No special characters are allowed. Any characters over six are ignored. Two variables may not share the same identifier.

The **structure** of an array variable is defined by the sets or numeric constants classifying its dimensions. An array may have up to ten dimensions or subscripts. A scalar variable has no internal structure, since it only has one value.

The **values** of a variable are the pieces of information it contains. The number of values in a scalar variable is one. The number of values in an array variable is equal to the product of the sizes of the sets structuring it. These values are arranged in rows, columns, and pages. The **rows** are classified by the first set of the variable; the **columns** are classified by the second set; the **pages** by the third set, and so forth.

The **Format Type** of a variable is the kind of information that it contains. PROMULA has eight format types:

REAL	contains real numbers (numbers with decimal digits) in the ranges: (-3.37E+38,-8.43E-37) 0 (+8.43E-37,+3.37E+38) Reals outside these ranges are not valid and cause underflows or overflows in calculations, which result in errors.
INTEGER	contains integer numbers (whole numbers) in the range: (-2^{31}-3,+2^{31}-3) about ± 2.1 billion Integers outside this range cause overflows and cannot be processed by the system.
STRING	contains character values, i.e., strings of characters.
CODE	contains codes. Codes are short character strings that are used for set selections. For example, **JAN** and **FEB** may be used to select the months of January and February.

MONEY	contains money values (dollars and cents). This type is useful for accounting arithmetic where one-cent accuracy is important. Money variables maintain ten significant digits of accuracy. The range of **MONEY** type variables is (-2**31-3,+2**31-3) about ± 2.1 billion cents or 21 million dollars.
DATE	contains date values. Dates are values of the form **mm/dd/yy**, where **mm** is a month number, **dd** is a day number, and **yy** is a year number. Internally, the date value is stored as a numeric quantity equal to **yymmdd**. Alternative date formats (e.g., dd/mm/yy or mm/dd/yyyy) are available by executing a **SELECT DATE** statement.
UPPERCASE	contains string values that are automatically converted to uppercase when they are input from the keyboard.
set	contains integers from 0 to N. If the values of the **set** type variable are within the range of **set**, the descriptors of **set** are displayed, otherwise, the variable is assigned and displays the value 0. This type of variable is useful for helping the user enter or verify categorical data.

Details and examples of using the various format types are presented with the discussion of the **DEFINE VARIABLE** statement.

The **descriptor** of a variable is a string of characters that will be used as a default title when the variable is displayed by the report generator.

Variable descriptors and identifiers can be displayed in write statements and in titles through use of the **:I**, **:L**, **:D** operators.

The notation **variable:I** can be used to indicate that the identifier of a variable is to be displayed.

The notation **variable:L** can be used to indicate that the descriptor of a variable is to be displayed.

The notation **variable:D** can be used to indicate that the identifier, followed by a colon, a space, and the descriptor for the variable is to be displayed.

These operators may be used with indirects to display the identifier and/or descriptor of the variable that the indirect is "pointing" at.

For example, given the following definition

```
DEFINE VARIABLE
  pop  "POPULATION SIZE"
END VARIABLE
```

the following relations are true

```
pop:L  =      POPULATION SIZE
pop:D  =      POP: POPULATION SIZE
pop:I  =      POP
```

The **storage type** of a variable determines where it resides, in RAM memory, or on disk, and whether or not its values can be cleared from memory. Depending on where their values are stored, variables are of three types: **fixed**, **scratch**, and **disk**. In addition, there are two pseudo-storage types: **virtual** and **dynamic** associated with disk access. Additional information about the storage types is presented in Chapter 4.

The **DEFINE VARIABLE** statement creates new variables and databases.

The **READ** statements put values into variables from a file or the keyboard.

The **EDIT** statements allow a program user to interactively modify variable values.

The **WRITE**, **BROWSE**, and **PLOT** statements display variables in tabular or graphical form.

Equations modify the values of variables.

Functions define relationships between pairs of variables.

Relations define relationships between sets and variables.

The **DO IF**, **DO UNTIL**, and **DO WHILE** statements use the values of variables to control program flow.

The **Statistical Functions** generate statistical reports based on the values of selected variables.

Examples:

1. Defining fixed variables in memory

```
DEFINE VARIABLE
  A(row,col)   "A 2-Dimensional Array"
  B            "A Scalar"
  C            "A String Variable"  TYPE=STRING(8)
  D            "A Date"             TYPE=DATE(8)
  M            "A Money Variable"   TYPE=MONEY(10)
END VARIABLE
```

2. Defining scratch variables in memory

```
DEFINE VARIABLE SCRATCH
  scr          "A Scratch Variable"
END VARIABLE
```

3. Defining disk variables on a file

```
DEFINE VARIABLE file
  dsk          "A Disk Variable"
END VARIABLE file
```

4. Defining virtual variables in memory

```
DEFINE VARIABLE
  dd  "A fixed Disk Variable"  DISK(file,dsk)
END VARIABLE
```

5. Using variables in equations

```
B = SUM(r,c)( A(r,c) )
B = PRODUCT(r,c)( A(r,c) )
```

6. Putting values into a variable with an equation

```
A=1
A=RANDOM(1000,2000)
A(i,j)=j*i+(i-1)*(j EQ 1)
```

7. Reading values into a variable

```
DEFINE SET
```

```
        row(3)
        col(2)
      END

      DEFINE VARIABLE
        a(row,col)  "A 2-Dimensional Array"
      END VARIABLE

      READ A
      1 2
      3 4
      5 6
```

8. Displaying a variable

```
      WRITE a

                                A 2-Dimensional Array

                                            COL(1)  COL(2)
                           ROW(1)                1       2
                           ROW(2)                3       4
                           ROW(3)                5       6

      WRITE a::2(col,row) TITLE("Display of "a:L)

                           Display of A 2-Dimensional Array

                                        ROW(1)  ROW(2)  ROW(3)
                       COL(1)             1.00    3.00    5.00
                       COL(2)             2.00    4.00    6.00
```

9. Using disk variables directly off an array database — The file:variable notation

   Suppose you have created an array database and you wish to access one of its variables. The name of the database is `array.dba` and the name of the variable is `sales`. The example below shows how to browse the variable `sales` directly.

```
      DEFINE FILE
        f1
      END

      OPEN f1 "array.dba"
      BROWSE f1:sales
```

   The syntax for such direct reference of disk variables is: **file:var**, where **file** is the array file containing the variable **var** that you wish to access. Disk variables may also be accessed directly off an array database by using the **COPY file, IMAGE** command.

3.1.24 Window -- Basic

PROMULA lets you split the screen into two sections. The upper section is called the **Action window**; it is used for interactive displays such as data editing and selection menus and lists; the lower section is called the **Comment window**; it is normally used for providing comments about what is happening in the Action window.

The default length of the Action window is 25 lines; the default length of the Comment window is 0 lines. To set the length of the Comment window, use a **SELECT COMMENT=n** statement, where **n** is the number of lines desired in the Comment window.

Windows provide the means for writing tutorial programs. In such programs you show the execution of something in the Action window and provide comments about it in the Comment window.

The statements of Basic Windowing are:

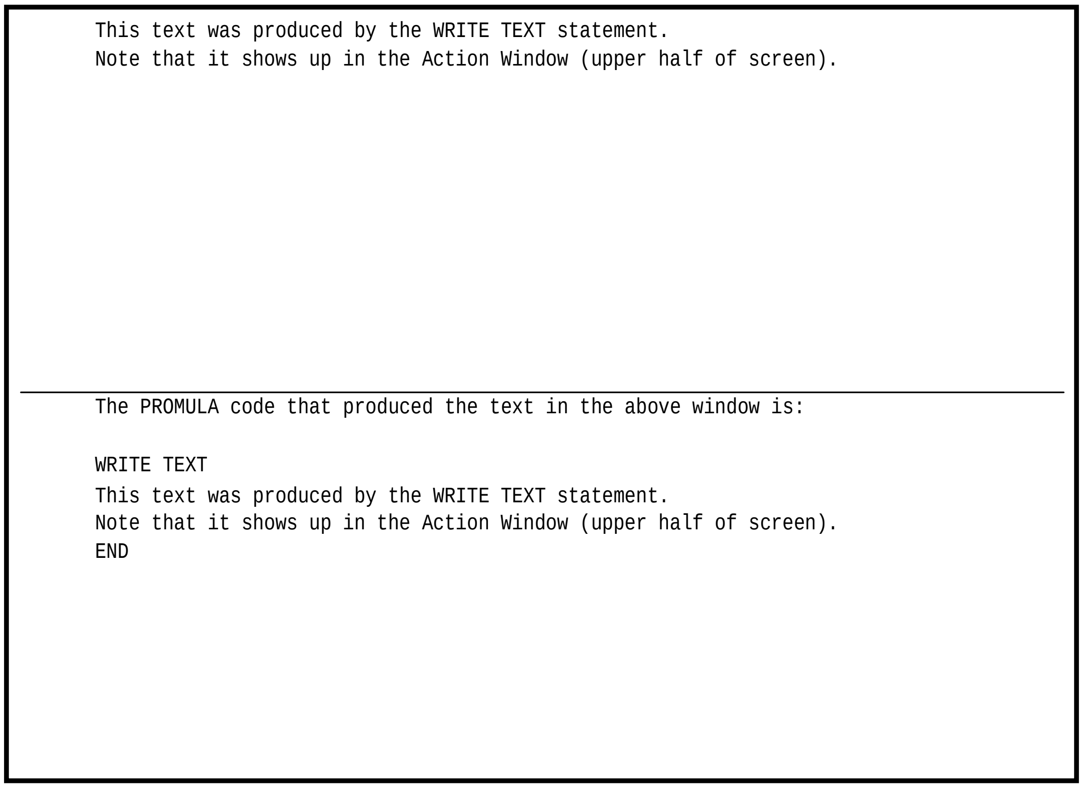
SELECT COMMENT=n	starts windowing mode, sets the length of the Comment window to n lines, where n is an integer in the range 1 to 22, and splits the screen by drawing a dividing line that is n spaces from the bottom.
SELECT COMMENT=0	gets you out of Basic windowing mode and closes the Comment window.
WRITE COMMENT	writes text in the Comment window without prompting for browsing.
BROWSE COMMENT	writes text in the Comment window with prompting for browsing.

The displays of all other input/output statements are shown in the Action window.

The following procedure is an example of Basic Windows:

```
DEFINE PROCEDURE window
SELECT COMMENT=12
WRITE TEXT
  This text was produced by the WRITE TEXT statement.
  Note that it shows up in the Action Window (upper half of screen).
END
BROWSE COMMENT
   The PROMULA code that produced the text in the above window is:

   WRITE TEXT
   This text was produced by the WRITE TEXT statement.
   Note that it shows up in the Action Window (upper half of screen).
   END

END
WRITE COMMENT
  This text was produced by the WRITE COMMENT statement.
  Note that it shows up in the Comment Window (lower half of screen).
END
BROWSE TEXT
  The PROMULA code that produced the text in the window below is:

  WRITE COMMENT
    This text was produced by the WRITE COMMENT statement.
    Note that it shows up in the Comment Window (lower half of screen).
  END
END
END PROCEDURE window
```

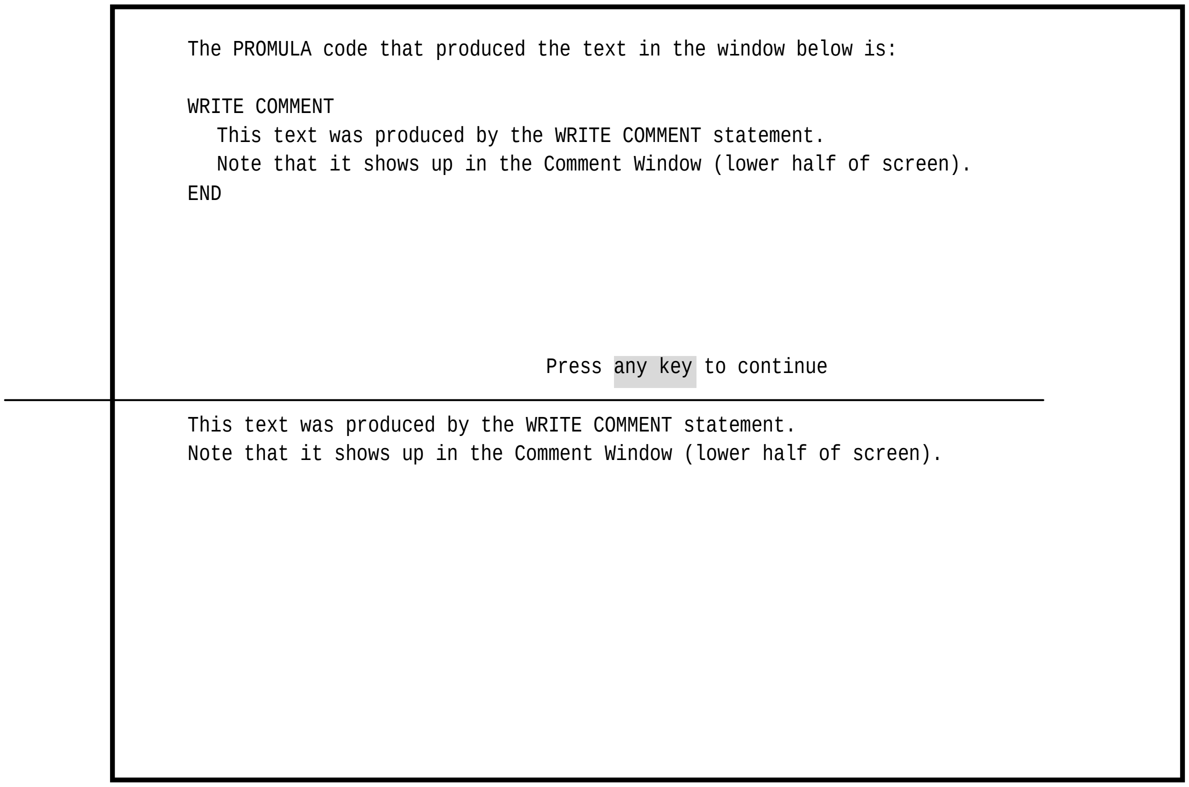
Upon execution of this procedure, the following display results:



```
This text was produced by the WRITE TEXT statement.
Note that it shows up in the Action Window (upper half of screen).
```

```
The PROMULA code that produced the text in the above window is:

WRITE TEXT
This text was produced by the WRITE TEXT statement.
Note that it shows up in the Action Window (upper half of screen).
END
```

After pressing any key, the following display results:



```
The PROMULA code that produced the text in the window below is:

WRITE COMMENT
  This text was produced by the WRITE COMMENT statement.
  Note that it shows up in the Comment Window (lower half of screen).
END



                        Press any key to continue
```

```
This text was produced by the WRITE COMMENT statement.
Note that it shows up in the Comment Window (lower half of screen).
```

3.1.25 Window -- Advanced

The windowing capabilities discussed in the previous section are the most basic type of windowing available to PROMULA users. For users who wish to create a truly professional-looking user interface for their applications, the Advanced Windowing capabilities are available.

In PROMULA the custom design of the screen is specified using the **DEFINE WINDOW** and **OPEN WINDOW** statements. The **DEFINE WINDOW** statement allows you to create windows. The **OPEN WINDOW** statement allows you to assign one of your custom-designed windows to handle a specific set of display functions.

The **OPEN WINDOW** statement takes two parameters:

1. The functional type of the **screen** to which you want to assign the window.
2. The name of a **window** that you want to use for the screen of this functional type.

These two parameters are discussed below.

The **screen** parameter of the **OPEN WINDOW** statement specifies the functional screen to be assigned a window. PROMULA supports five types of **functional screens**; each one is used for a particular set of operations. The five types of screens: **MAIN**, **PROMPT**, **COMMENT**, **ERROR**, and **HELP**, are discussed below:

1. **MAIN**

   The **Main Screen** is used for most of the input/output operations done by an application. These operations are performed by the following statements:

   ASK...ELSE
   AUDIT / BROWSE / EDIT / WRITE variable
   AUDIT / BROWSE / SELECT SET
   AUDIT / BROWSE / SELECT VARIABLE
   AUDIT / BROWSE / WRITE / set
   AUDIT / COPY file
   BROWSE / EDIT / SELECT / WRITE menu
   BROWSE / EDIT / WRITE TABLE
   BROWSE / WRITE function
   BROWSE / WRITE TEXT
   BROWSE FILE
   PLOT (in character mode)
   SELECT ENTRY
   SELECT indirect
   Statistical Functions
   table
   variable = GETDIR(filespec)
   WRITE text

   The PROMULA Text Editor uses the colors of the Normal Text in the Main Screen.

2. **PROMPT**

   The **Prompt Screen** is used for displaying the prompts produced by the following PROMULA statements.

   ASK CONTINUE
   ASK...ELSE
   BROWSE / SELECT VARIABLE
   BROWSE / EDIT variable
   BROWSE / SELECT SET
   BROWSE set
   BROWSE FILE
   BROWSE / EDIT / SELECT menu
   BROWSE function
   BROWSE / EDIT TABLE
   BROWSE TEXT
   SELECT ENTRY
   SELECT indirect
   variable = GETDIR(filespec)

   PROMULA's command mode prompt uses the Prompt Screen.

   If a user-defined window is not opened to the Prompt Screen, PROMULA displays prompts at the bottom of the Main Screen.

If a window is opened as the Prompt Screen, it will automatically appear on the screen whenever PROMULA needs to display prompts.

3. **COMMENT**

   The **Comment Screen** is used for displaying the output of the **WRITE COMMENT** and **BROWSE COMMENT** statements.

   If a user-defined window is not opened to the Comment Screen, PROMULA displays comments in the Main Screen.

4. **ERROR**

   The **Error Screen** is used for displaying execution error messages.

   If a user-defined window is not opened to the Error Screen, PROMULA displays an error message in the Main Screen.

5. **HELP**

   The **Help Screen** is used to display on-line help. The Help Screen will contain the display produced by the **BROWSE DIALOG** and **BROWSE TOPIC** statements.

   In addition, on-line help in response to an **Alt-H** is displayed in the Help Screen.

   If a window is not opened to the Help Screen, PROMULA uses the Main Screen for displaying on-line help.

   If a window is opened as the Help Screen, it will automatically appear on the screen whenever PROMULA needs to display the output of help statements.

The **window** parameter of the **OPEN WINDOW** statement specifies which user-defined window should be assigned to a functional screen. A Window is a rectangular section of the screen. The name, location, appearance, and popup type of the rectangle are specified by a **DEFINE WINDOW** statement.

The popup type of window determines what happens to information on the screen that is covered when the window is opened. There are two popup types, **Static** and **Popup**.

When a **static window** is associated with a functional screen, it is immediately displayed on the screen. Any text that gets covered by the static window is lost and cannot be restored (unless it is written to the screen again). A static window, including its borders and contents, will remain on the screen even after it is closed by a **CLEAR WINDOW** statement. This feature makes static windows useful for creating a backdrop for your application or displaying instructions or comments about a running program. A window will be static if it does not have the optional keyword **POPUP** in its definition.

When a **popup window** is associated with a functional screen, it is not immediately displayed. A popup window is only displayed while the functional screen associated with it is in use. The window is opened whenever a statement that uses the associated functional screen is executed. After execution of such a statement, the window is removed from the display, and any text that was covered by the window is automatically redrawn. Popup windows are useful for displaying on-line help or other messages that will only be shown briefly. A window is of type **Popup** if it has the optional keyword **POPUP** in its definition.

The **DEFINE WINDOW** statement is used to define the name, location, appearance, and popup type of a window.

The **OPEN WINDOW** statement is used to open a window on a specific functional screen.

The **CLEAR WINDOW** statement is used to end the association between a window and a functional screen.

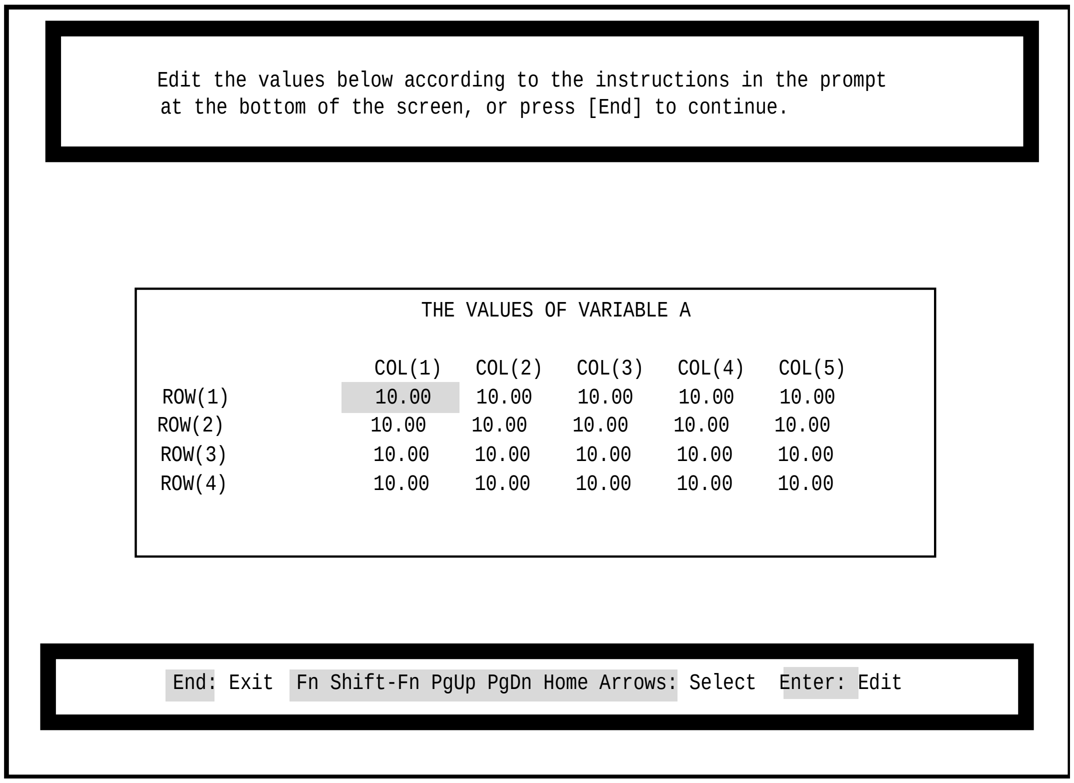
Screen areas can also be assigned to serve as the display areas for popup and pulldown pick menus. This feature is described in the context of the **DEFINE MENU** and **SELECT PULLDOWN** statements respectively.

Examples:

The code below is a simple example of Advanced Windowing .

```
DEFINE WINDOW
  cwind(1,1,78,4,   WHITE/BLACK,FULL/HEAVY /WHITE/BLACK)
  mwind(10,10,69,18,WHITE/BLACK,FULL/SINGLE/WHITE/BLACK,BLACK/WHITE)
  pwind(1,23,78,23, WHITE/BLACK,FULL/HEAVY/WHITE/BLACK,BLACK/WHITE) POPUP
END WINDOW

DEFINE SET
  row(4)
  col(5)
END SET

DEFINE VARIABLE
  A(row,col)  "THE VALUES OF VARIABLE A" TYPE=REAL(9,2) VALUE=10
END VARIABLE

DEFINE PROCEDURE demo
OPEN cwind COMMENT
OPEN pwind PROMPT
OPEN mwind MAIN
WRITE COMMENT

       Edit the values below according to the instructions in the prompt
       at the bottom of the screen, or press [End] to continue.
END
EDIT A
END PROCEDURE demo
```

Procedure `demo` produces the following screen.



```
Edit the values below according to the instructions in the prompt
at the bottom of the screen, or press [End] to continue.

                     THE VALUES OF VARIABLE A

                COL(1)   COL(2)   COL(3)   COL(4)   COL(5)
ROW(1)           10.00    10.00    10.00    10.00    10.00
ROW(2)           10.00    10.00    10.00    10.00    10.00
ROW(3)           10.00    10.00    10.00    10.00    10.00
ROW(4)           10.00    10.00    10.00    10.00    10.00

End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows: Select  Enter: Edit
```

3.2 Statement Format

In general, PROMULA is a free-form language. Its statements may start anywhere on the input line, and as many blanks or commas as desired may be inserted between the various parts of the statement to improve readability.

PROMULA statements are not identified by line number; thus, PROMULA programs have no GO TO statements.

Comment lines may be inserted almost anywhere in the source code and are identified by having an asterisk in column 1. It is possible to include in-line comments with some statements — for example after the procedure name in a **DEFINE PROCEDURE** statement.

Full-line comments (i.e., those introduced by an asterisk in column 1) are not recognized as comments in two places: free form text blocks like those used for the **DEFINE MENU** and **BROWSE/WRITE TEXT/COMMENT** statements, and in the data lines for the **READ variable** statement. The slash character (/) in column one may be used to insert comments into the data lines for the **READ variable** statement

3.3 Commas and Blanks

Commas or blanks play an important role in the syntax of PROMULA statements. They are delimiters and are used to separate the different parts of a statement. Multiple delimiters are treated as a single delimiter, except when they are part of a character string.

3.4 Line Length

An input line in PROMULA may contain up to 255 characters. Pressing the **Enter** key enters the line. Given the width of most screens or printers, keeping each statement no longer than 80 characters will make your programs easier to read and work with.

3.5 Line Continuation

If a statement is too long to fit on a single line, you may continue it on the next line. Continuation of a statement may be indicated in one of three ways, depending on context:

1. If you are entering a character string, then continuation is automatic. The first character of the next line is concatenated directly behind the last character of the preceding line, except that multiple trailing blanks are reduced to a single blank.

2. If you are entering an equation, then continuation to the next line is indicated by the last non-blank character of the current line, which must be a comma or an arithmetic, relational, or logical operator.

3. In all other cases, continuation to the next line is indicated by entering a comma as the last non-blank character of the current line.

3.6 Format of PROMULA Statement Descriptions

The following sections describe the statements of PROMULA. Each statement description consists of four parts:

1. The purpose of the statement

2. The general syntax of the statement

3. Remarks about the syntax and the statement

4. Examples demonstrating the syntax and use of the statement.

The notation for the syntax follows these rules:

1. Words in capital letters are PROMULA keywords and must be entered as shown. They may be entered in any combination of uppercase and lowercase. PROMULA converts all words to uppercase (unless they are character data or part of a quoted string).

2. You must supply any items in lowercase letters.

3. Items in square brackets ([ ]) are optional.

4. An ellipsis (...) on a line by itself under an item indicates that you may repeat the item as many times as you wish, on separate lines.

For example, the notation

```
DEFINE SET
  set(n) ["desc"]
  ...
END [comment]
```

describes the syntax of the **DEFINE SET** statement, and says the following:

1. Enter the words `DEFINE SET` to begin the definition.

2. Enter a set identifier, `set`, followed by a left parenthesis, `(`, followed by an integer, `n`, followed by a right parenthesis, `)`, followed by an optional descriptor, `desc`. If you include a descriptor, it must be enclosed in quotes, `"`.

3. You may enter as many set definitions as you wish. This is denoted by the ellipsis, ...

4. Enter the word **END** to end the set definitions. This may be followed by a **comment**, if you wish.

An ellipsis (...) in a line after an item indicates that you may repeat the item as many times as you wish, on that line or on lines with the appropriate continuation character.

For example, the notation

```
PLOT (var1[,var2,...])
```

indicates that you may include one or more `var` specifications in the argument of the **PLOT** statement.

The meanings of the lowercase items that you must enter to form a statement are described in the **Remarks** of each statement description.

3.7 The PROMULA Statements

3.7.1 ASK CONTINUE

Purpose:

Interrupts execution and issues the message

Press any key to continue?

Syntax:

```
ASK CONTINUE
```

Remarks:

You may insert this statement anywhere inside a procedure to stop execution and give the user of the procedure the option to continue execution or exit to the Main Menu. If the user presses the **Esc** key he is returned to the main menu; any other key (or clicking the mouse button) results in continued execution.

This statement is a simple pause and is a useful feature for conversational applications or debugging.

To execute a pause without issuing the prompt, use a **WRITE CLEAR(-1)** statement.

3.7.2 ASK...ELSE

Asks the user something and executes a group of statements depending on the response.

Syntax:

```
ASK "prompt", response
 statement
 ...[ELSE [response]
 statement
```

```
  ...]
END
```

Remarks:

`prompt`	is a message or prompt for the user.
`response`	is a possible user response to `prompt`. Possible responses are of three types:

[WORD =] `code`
SET = `set`
VARIABLE = `indir[(vars)]`

where

`code`	is a string of characters which must be entered in upper or lower case to qualify as a valid response. PROMULA recognizes only the first six characters of `code` as a valid response; the rest are ignored.
`set`	is a set identifier and allows the user to make set selections (see Example 2 below).
`indir`	is the identifier of an indirect variable which acts as a pointer to other variables and allows the user to select a variable for subsequent input/output operations. You must put an asterisk (*) after the identifier of `indir` in its definition to tell PROMULA that it will be used as an indirect variable. Calculations with indirect variables are not allowed. (See Example 3 below).
`vars`	is a list of variables from which the user is expected to make a selection. The selected variable is transferred to `indir` for the input/output purposes of the **ASK** statement only. If this list is omitted, all variables in the program are included in the list. (See Example 3 below).

`statement`	is any executable statement (i.e., no definitions), including other **ASK** statements.

The **ASK** statement behaves like the **DO IF** statement, i.e., it provides an alternative path of execution if a condition is met. The conditions of an **ASK** statement are satisfied if a user response matches one of the allowed responses specified either by the **ASK** statement or by one of the **ELSE** statements included in the **ASK**.

A user response is checked against the responses of the **ASK** statement sequentially from top to bottom. When a match occurs, program execution proceeds to the statements following the matched response until the next **ELSE** or **END** statement, whichever comes first.

The **`SET=set`** option allows the user to make set selections. Appropriate user responses are set sequence numbers, set codes, or scalar variables with values in the set range. The **SELECT SET**, **SELECT ENTRY**, and **SELECT VARIABLE** statements provide alternative means of helping the user make a set selection.

The **VARIABLE=indir** option allows the user to select a program variable for input/output purposes by entering the variable identifier. The **SELECT variable** statement and the **INDIRECT** function are also useful tools for helping the user select a variable and working with interactive variable selections.

A null **ELSE** statement, i.e., one with a blank response, is executed only if all the other preceding **ELSE** statements fail. For this reason, the null **ELSE** statement is usually the last one.

NOTE: The **ASK** statement is not case sensitive.

ASK statements may be nested to any depth.
ASK statements are allowed only inside procedures.

Examples:

1. The following is a procedure containing a simple **ASK** statement.

```
DEFINE PROCEDURE yesno
   ASK "Do you wish to continue? (yes/no)", yes
      WRITE("Continue")
      yesno
   ELSE no
      WRITE("Stop")
   END ask
END PROCEDURE yesno
```

The purpose of the procedure is to issue the question **`"Do you wish to continue? (yes/no)"`** and take one of two execution paths depending on user response. A sample dialog with procedure `yesno` is displayed below.

```
yesno
Do you wish to continue? (yes/no) An invalid response causes the
xxx                               question to be asked again.
Do you wish to continue? (yes/no)
yes
Continue
Do you wish to continue? (yes/no)
no
Stop
```

The **`yes`** path writes the message **`Continue`** and issues the prompt **`Do you wish to continue?`**, thanks to the recursive nature of PROMULA procedures. The **`no`** path issues the message **`Stop`** and exits the **ASK** statement. Any other user response causes the prompt **`Do you wish to continue?`** to be issued again. Exit from this **ASK** statement is only possible if you respond **`no`**.

2. The example below shows how to use the **`SET=set`** option in order to make alternative set selections. The procedure `selmon` allows you to make various selections from the elements of the set `month` by entering set codes, variable identifiers, or set element sequence numbers. The definitions and initializations of the example variables are shown below.

```
DEFINE SET
  month(12)
END SET

DEFINE VARIABLE
  mv(month)  "Month Value"
  mc(month)  "Month Code"    TYPE=CODE(5)
  mn(month)  "Month Name"    TYPE=STRING(12)
  x          "x Value"
  y          "y Value"
  indir*     "An Indirect Variable"
END VARIABLE

DEFINE RELATION
  KEY(month,mc)
  ROW(month,mn)
```

```
END RELATION

DEFINE PROCEDURE selmon
  ASK "Select months or LIST or END" END
  ELSE LIST
    WRITE month
    selmon
  ELSE SET=month
    WRITE("The selected months are")
  WRITE mv
  END ask
END PROCEDURE selmon

READ mv
1 2 3 4 5 6 7 8 9 10 11 12

READ mc
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

READ mn
January
February
March
April
May
June
July
August
September
October
November
December
```

Given the definitions and initializations above, we can execute procedure `selmon` to demonstrate the behavior of the **ASK** statement for making set selections. A sample dialog with procedure `selmon` is shown below.

```
selmon
Select months or LIST or END
       ? LIST
Member      Description
JAN         January
FEB         February
MAR         March
APR         April
MAY         May
JUN         June
JUL         July
AUG         August
SEP         September
OCT         October
NOV         November
DEC         December
Select months or LIST or END
       ? may,dec
The selected months are
                               Month Value

                                        (1)
                      May                 5
                      December           12
selmon
Select months or LIST or END
```

```
              ? 6-9
        The selected months are
                                    Month Value
                                               (1)
                              June               6
                              July               7
                              August             8
                              September          9

        x = 5
        y = 7
        selmon
        Select months or LIST or END
              ? x,y
        The selected months are
                                    Month Value

                                               (1)
                              May                5
                              July               7
```

3. This example shows how to use the **VARIABLE=indir** option in order to select a program variable. Here, `indir` is an indirect variable that serves as a substitute for other selected variables.

```
DEFINE PROCEDURE selvar
  ASK "Select variable or LIST or END", END
  ELSE LIST
    AUDIT VARIABLE
    selvar
  ELSE VARIABLE=indir
    WRITE indir
    selvar
  END ask
END PROCEDURE selvar
```

The procedure `selvar` allows you to select one of the variables of a program by entering the variable's identifier in response to an **ASK** statement. A sample dialog with procedure `selvar` is shown below.

```
      DO selvar
        Select variable or LIST or END
              ? LIST
        Identifier Description
        MV         Month Value
        MC         Month Code
        MN         Month Name
        X          X Value
        Y          Y Value
        INDIR      An Indirect Variable
        Select variable or LIST or END
              ? mv
                                         Month Value

                                                       (1)
                                     January             1
                                     February            2
                                     March               3
                                     April               4
                                     May                 5
```

```
                                 June                    6
                                 July                    7
                                 August                  8
                                 September               9
                                 October                10
                                 November               11
                                 December               12
        Select variable or LIST or END
               ? x
        x Value 5
        Select variable or LIST or END
               ? end
```

3.7.3 AUDIT file

Purpose:

Produces a listing of the sets and variables in an array file.

Syntax:

```
AUDIT file
```

Remarks:

`file` is the identifier of the array file you wish to audit.

Examples:

The following code illustrates the **AUDIT file** statement:

```
DEFINE FILE
  arr1 TYPE=ARRAY   "A Primary Array Data File"
END FILE

OPEN arr1 "arr1.dba", STATUS=NEW
DEFINE SET arr1
  yrs(10)   "Year"
  pag(03)   "Pages"
  sic(5)    "SIC Codes"
END SET arr1

DEFINE VARIABLE arr1
DUR(yrs)     TYPE=REAL(8,0)  "Manufacturing Durables Employment"
EMP(pag,yrs) TYPE=REAL(8,0)  "Employment by Industry"
EMPT(yrs)    TYPE=REAL(8,0)  "Total Employment"
WSEMP(yrs)   TYPE=REAL(8,0)  "Total Wage and Salary Employment"
SICST(sic)   TYPE=STRING(30) "Names for Industrial Categories"
YEAR(yrs)    TYPE=STRING(5)  "Years"
END VARIABLE arr1
```

The statement `AUDIT arr1` produces the listing below.

```
        Identifier Description
        YRS        Year
        PAG        Pages
        SIC        SIC Codes
```

```
             DUR         Manufacturing Durables Employment
             EMP         Employment by Industry
             EMPT        Total Employment
             WSEMP       Total Wage and Salary Employment
             SICST       Names for Industrial Categories
             YEAR        Years
```

3.7.4 AUDIT SET

Purpose:

Produces a full or partial listing of the sets in a program.

Syntax:

```
       AUDIT SET[(sets)]
```

Remarks:

`sets` is a list of set identifiers. If omitted, all program sets are listed.

The **AUDIT SET** statement lists the identifiers and descriptors of the program sets. If `sets` is omitted, the sets are listed in the order in which they were defined; otherwise, they are listed in the order specified by `sets`.

Examples:

The dialog below demonstrates the **AUDIT SET** statement.

```
             DEFINE SET
               month(12)   "12 Months"
               row(3)      "3 Rows"
               col(10)     "10 Columns"
             END SET

             AUDIT SET
             Identifier     Descriptor
             month          12 Months
             row            3 Rows
             col            10 Columns
```

3.7.5 AUDIT VARIABLE

Purpose:

Produces a full or partial listing of the variables in a program.

Syntax:

```
       AUDIT VARIABLE[(vars)]
```

Remarks:

`vars` is a list of variable identifiers. If omitted, all program variables are listed.

The **AUDIT VARIABLE** statement lists the identifiers and descriptors of the program variables. If `vars` is omitted the variables are listed in the order in which they were defined; otherwise, the sets are listed in the order specified by `vars`.

Examples:

The dialog below demonstrates the **AUDIT VARIABLE** statement.

```
DEFINE VARIABLE
  x  "The x-values"
  y  "The y-values"
END VARIABLE

AUDIT VARIABLE
Identifier    Descriptor
x             The x-values
y             The y-values
```

3.7.6 BREAK procedure

Purpose:

Escapes from the current procedure.

Syntax:

```
BREAK proc
```

Remarks:

`proc` is the name of the procedure that contains the **BREAK procedure** statement.

Upon execution, the **BREAK procedure** statement escapes from the current procedure and returns control to the program unit which called the procedure. After returning, execution continues with the statement after the procedure call that originally executed `proc`.

Examples:

The following example illustrates use of the **BREAK** statement to escape from a **DO UNTIL** loop.

```
DEFINE VARIABLE
  x "x = "
END VARIABLE

DEFINE PROCEDURE proc
  DO UNTIL x GT 10
     x = x + 1
     WRITE x
     DO IF x GT 5
        WRITE "Leaving proc"
        BREAK proc
     END IF
  END UNTIL
END PROCEDURE proc

DEFINE PROCEDURE call
  DO proc
  WRITE "Back from proc"
```

```
END PROCEDURE call
```

Executing procedure `call` generates the output shown below.

```
DO call
x =  1
x =  2
x =  3
x =  4
x =  5
x =  6
Leaving proc
Back from proc
```

3.7.7 BROWSE COMMENT

Purpose:

Displays text for browsing in the "Comment" window (Basic Windows) or the active Comment Screen (Advanced Windows).

Syntax:

```
BROWSE COMMENT
  text
  ...
END
```

Remarks:

`text`	is any text that you enter. The text will be clipped to the width of the window opened to the Main or Comment Screen or the Comment Window. No more than 255 lines (approximately 40 pages) of text may be stored in a single **BROWSE COMMENT** statement.

The keyword **END** must be entered starting in column 1 and must be capitalized.

The text will be shown by page in the Comment Screen of the display. A prompt at the bottom of the Prompt Screen will describe how to browse the text.

For more details, see the sections on Basic Windows and Advanced Windows.

See also the **BROWSE menu** statement.

3.7.8 BROWSE DIALOG

Purpose:

Displays a dialog menu for browsing the topics of a dialog file.

Syntax:

```
BROWSE DIALOG filespec
```

Remarks:

`filespec` is a quoted string or string variable containing the name of the physical disk file where the dialog file that you want to browse is stored. This name is formatted according to the file naming conventions for your operating system.

Upon execution, the **BROWSE DIALOG** statement displays a menu whose selection fields are the titles of the topics contained in the dialog file. From this menu, you may browse any of the topics. The display will be shown in the window opened to the Help Screen if one is active.

Examples:

The use of this statement is demonstrated in the context of the example given in the **DEFINE DIALOG** statement.

3.7.9 BROWSE FILE

Purpose:

Displays a text file for browsing.

Syntax:

```
BROWSE FILE filename
```

Remarks:

`filename` is a quoted string or string variable containing the name of the text file to be displayed for browsing. This name is any valid file specification and is used to identify the file to the operating system.

Upon execution, PROMULA clears the Main Screen and displays the specified text file for browsing. A prompt in the Prompt Screen will tell the user how to browse the file.

NOTE: On the IBM PC, the size of the files you can browse is limited to 32K or less. To browse larger files you may invoke the PROMULA Text Editor or use the RUN DOS command to invoke your own file viewing system. See the **RUN EDITOR** and **RUN DOS** statements.

The display will be clipped to the width of the window opened to the Main screen.

Examples:

1. The statement

```
BROWSE FILE "demo.prm"
```

will display the file `demo.prm` for browsing.

2. Similarly, the following statements

```
DEFINE VARIABLE
  fname TYPE=STRING(12) "File Name"
END

fname="demo.prm"

BROWSE FILE fname
```

will display the file `demo.prm` for browsing. Here, `fname` is a string variable containing the string `demo.prm`.

3.7.10 BROWSE function

Purpose:

Displays the values of a function in tabular form for browsing.

Syntax:

```
BROWSE func[fmt] [TITLE(text)]
```

Remarks:

`func` is the identifier of a function defined by the **DEFINE FUNCTION** or **DEFINE LOOKUP** statement.

`fmt` is a format specification of the form `\p:w:d` to indicate the position of the display, the width of the values displayed, and the number of decimals in real values, where

- `p` is an integer indicating the width in characters of the row descriptors for the display.
- `w` is an integer indicating the width of the columns of values. A negative width parameter left justifies the values in each column.
- `d` is an integer indicating the number of decimal places to be displayed for each value. If `d` is an "E", the values will be displayed in exponential notation.

For functions defined by the **DEFINE LOOKUP** statement, the default format is `p=10, w=8` and `d=2`**.**

For functions defined by the **DEFINE FUNCTION** statement, `w` and `d` have the values specified in the **DEFINE VARIABLE** statement for the function variables, and `p` is the width specified in the definition of the row descriptors of the set subscripting the function.

`text` is a title for the display and can contain text, variables, and other formatting characters as described in the **WRITE text** statement.

Upon execution, the **BROWSE function** statement clears the Main Screen and displays the values of the function in tabular form for browsing. A prompt in the Prompt Screen will tell the user how to browse the function.

Examples:

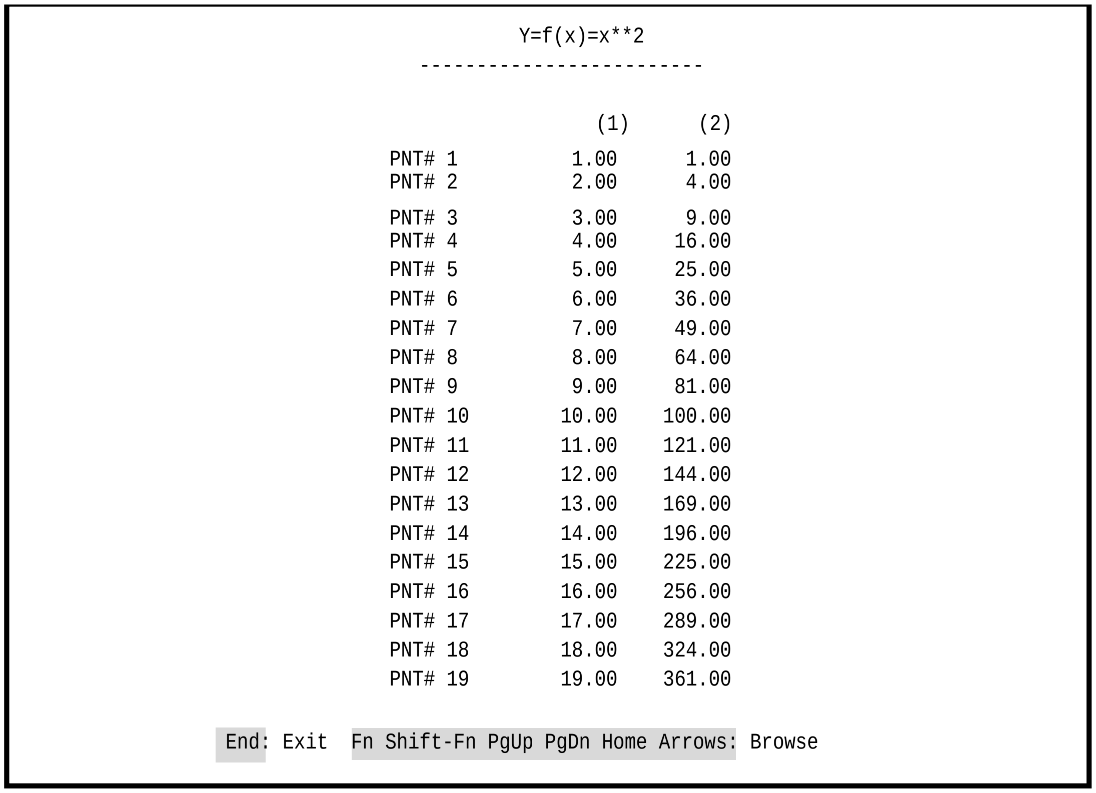
The **BROWSE function** statement is illustrated below:

```
DEFINE SET
  pnt(60)
END SET

DEFINE VARIABLE
  x(pnt) "The X values"
  y(pnt) "The Y values"
  p(pnt) "PNT Names"   TYPE=STRING(10)
END VARIABLE
x(i) = i
y(i) = i**2
p(i) = "PNT# "+i
SELECT ROW(pnt,p)

DEFINE FUNCTION
  fx(x,y)
END FUNCTION
```

Given the definitions above, the statement

```
        BROWSE fx:10:4,
        TITLE("Y=f(x)=x**2"/"------------------------")
```

would clear the Main Screen and produce a tabular display of function `fx` for browsing as shown below.



```
                    Y=f(x)=x**2
               ------------------------


                          (1)      (2)
           PNT# 1         1.00     1.00
           PNT# 2         2.00     4.00
           PNT# 3         3.00     9.00
           PNT# 4         4.00    16.00
           PNT# 5         5.00    25.00
           PNT# 6         6.00    36.00
           PNT# 7         7.00    49.00
           PNT# 8         8.00    64.00
           PNT# 9         9.00    81.00
           PNT# 10       10.00   100.00
           PNT# 11       11.00   121.00
           PNT# 12       12.00   144.00
           PNT# 13       13.00   169.00
           PNT# 14       14.00   196.00
           PNT# 15       15.00   225.00
           PNT# 16       16.00   256.00
           PNT# 17       17.00   289.00
           PNT# 18       18.00   324.00
           PNT# 19       19.00   361.00

   End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows: Browse
```

3.7.11 BROWSE menu

Purpose:

Displays a "data" menu including the values of its data fields. This statement is useful for displaying a screen of text and data.

Syntax:

```
        BROWSE menu(vars)
```

Remarks:

`menu` is the identifier of a data menu. A data menu is a screen template which is designed to help its user to edit and display data. The fields in a data menu are previously defined in a **DEFINE MENU** statement.

`vars` is a list of variable identifiers that contain the values of the data fields to be displayed. The variables in the list must be in the same order as the data fields in the menu (from left to right and top to bottom) to which they correspond.

Data menus contain a number of **data fields** to be displayed by the user. In the **DEFINE MENU** statement, each data field is denoted by a series of contiguous "at signs", @, or "tilde signs", ~, equal in number to the desired number of digits in the data field. The data fields are ordered from left to right and from top to bottom of the menu template.

Upon execution, the data menu is displayed in the Main Screen. The values of the variables are displayed in the places marked by @ or ~ characters. Execution pauses, and the user is allowed to view, but not modify, the values in the menu. When the user is ready to continue, he/she presses a key or clicks the mouse button.

The use of the **BROWSE menu** statement is especially helpful if you want to show a data menu in read-only mode.

3.7.12 BROWSE SET

Purpose:

Produces a full or partial listing of the sets in a program for browsing.

Syntax:

```
        BROWSE SET[(sets)]
```

Remarks:

`sets` is a list of set identifiers. If `sets` is omitted, all the program sets are listed in the order in which they were defined; otherwise, selected sets are listed in the order specified by `sets`.

Upon execution, PROMULA clears the Main Screen and lists the identifiers (codes) and descriptors of the specified sets. A prompt appears in the Prompt Screen describing how to browse the list.

Examples:

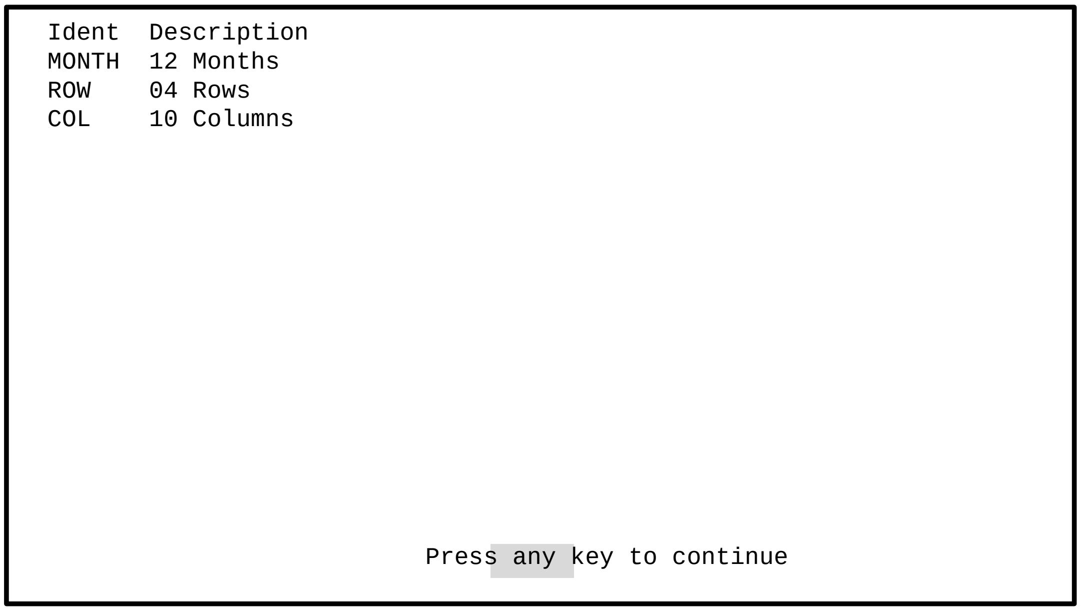
Given the folowing definitions

```
        DEFINE SET
          month(12)    "12 Months"
          row(04)      "04 Months"
          col(10)      "10 columns"
        END
```

the statement

```
        BROWSE SET
```

produces the display below for browsing.



```
Ident  Description
MONTH  12 Months
ROW    04 Rows
COL    10 Columns












                          Press any key to continue
```

3.7.13 BROWSE set

Purpose:

Shows the selection keys, descriptors, order, and range of the currently active elements of a set.

Syntax:

```
        BROWSE set
```

Remarks:

`set` is the identifier of the set being shown.

Upon execution, the **BROWSE set** statement clears the Main Screen and lists the elements of `set` for browsing.

Examples:

```
        DEFINE SET
          month(12)
        END SET
        DEFINE VARIABLE
          mn(month)  "Month Name"    TYPE=STRING(12)
        END VARIABLE
        READ mn:4
        JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
        SELECT ROW(month,mn)
```

Given the definitions and relations above, the statement `BROWSE month`, produced the display below.

3.7.14 BROWSE TABLE

Purpose:

Displays a table of several variables on the screen to let you browse their values by page.

Syntax:

```
    BROWSE TABLE(sets) [,TITLE(title)] [,FORMAT(rw,cw)]
    BODY(["text1",] var1[fmt1] [,"text2",] var2[fmt2],...)
```

Remarks:

`sets`	is a list of the identifiers of the sets classifying columns and pages of the variables in the table. The first set will classify the columns of the table; the other sets, if any, will classify the pages of the table. Sets dimensioning table variables which are missing from the list will classify the rows of the table. The `sets` list `sets` must contain at least one set (or the number 1 for browsing a group of scalar variables) and must be missing those set identifiers which will classify the rows of the multidimensional table variables.
`title`	is text you wish to show as a title for the table.
`text1`	is any text that you wish to use as a subtitle for the values of `var1`. This text may not contain variables.
`var1`	is the identifier of the first variable in the table.
`fmt1`	is the desired format for the values of `var1`.
`text2`	is any text that you wish to use as a subtitle for the values of `var2`. This text may not contain variables.
`var2`	is the identifier of the second variable in the table.
`fmt2`	is the desired format for the values of `var2`.
`rw`	is the width in characters of row descriptors.
`cw`	is the width in characters of table columns.

Upon execution, the **BROWSE TABLE** statement clears the Main Screen, displays the first page of the table, and issues the following prompt at the bottom of the Prompt Screen:

```
End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows:  Browse
```

The highlighted portions of the message represent the following keypress options:

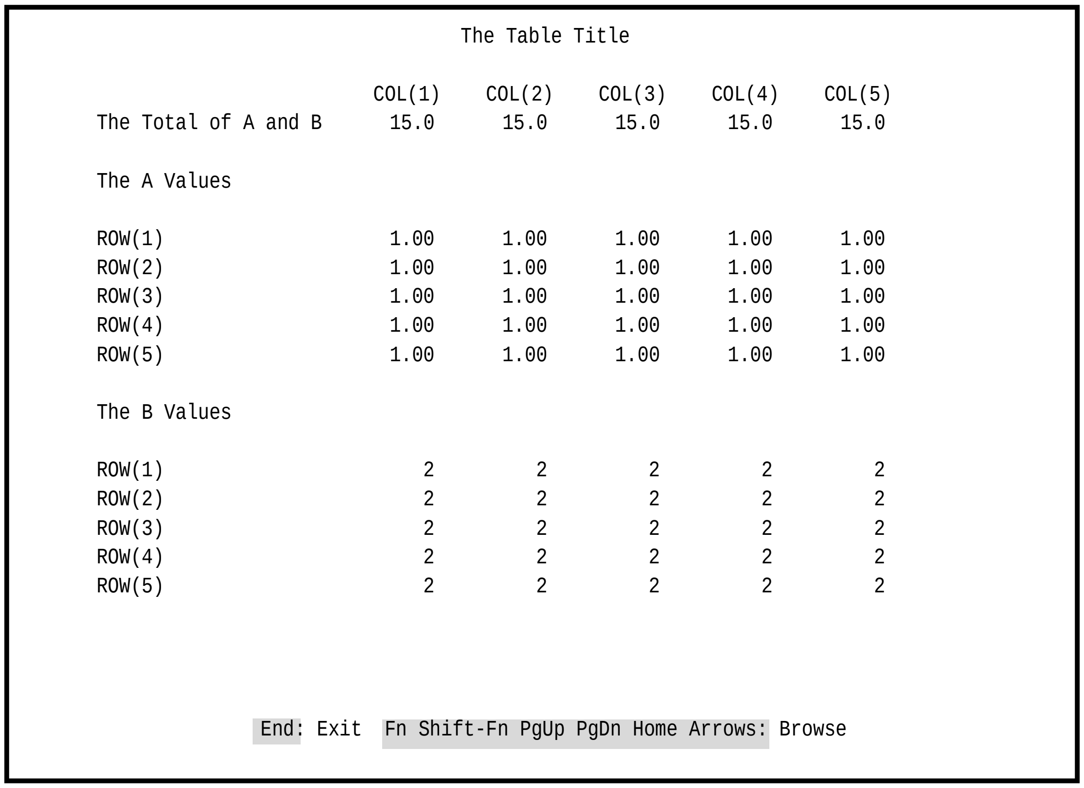
Fn	press the Fn function key to browse up the nth dimension of the array, where n varies from 1 to 10. The **F1** key browses up the 1st dimension, the **F2** key browses up the 2nd dimension, and so forth.
Shift-Fn	press simultaneously the **Shift** and **Fn** keys to browse down the nth dimension of the array. The **Shift-F1** key browses down the 1st dimension, the **Shift-F2** key browses down the 2nd dimension, etc.
Browsing keys	The four movement arrows at the right-hand section of the keyboard allow you to move the cursor to the desired value. The PgUp and PgDn keys are used to move up and down the pages of the display.
Home	moves the cursor to the "top" of the display, which is the first value on the screen.
End	press the **End** key to exit editing mode or to exit browsing mode.

Examples:

The following program demonstrates the **BROWSE TABLE** statement:

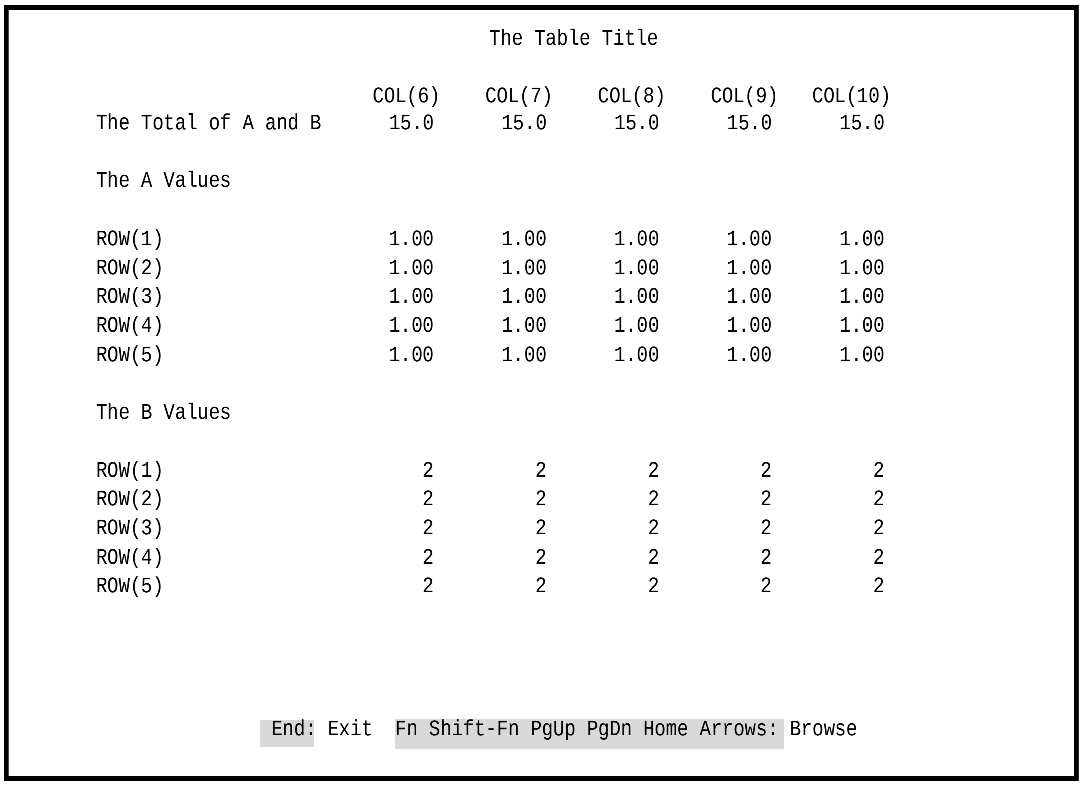
```
DEFINE SET
  row(5)
  col(10)
END SET

DEFINE VARIABLE
  a(row,col) "A Data Set"
  b(row,col) "B data set"
  tot(col)   "The Total of A and B"
END VARIABLE

DEFINE PROCEDURE brstab
SELECT WIDTH=70
BROWSE TABLE(col),
       TITLE("The Table Title"),
       FORMAT(20,10),
       BODY(tot:0:1/"The A Values"/,a:0:2,/"The B Values"/,b)
END PROCEDURE brstab

a = 1
b = 2
tot(c) = SUM(r)( a(r,c) + b(r,c) )
```

Executing procedure `brstab` produces the display below.



```
                              The Table Title

                          COL(1)    COL(2)    COL(3)    COL(4)    COL(5)
The Total of A and B       15.0      15.0      15.0      15.0      15.0


The A Values

ROW(1)                     1.00      1.00      1.00      1.00      1.00
ROW(2)                     1.00      1.00      1.00      1.00      1.00
ROW(3)                     1.00      1.00      1.00      1.00      1.00
ROW(4)                     1.00      1.00      1.00      1.00      1.00
ROW(5)                     1.00      1.00      1.00      1.00      1.00

The B Values

ROW(1)                        2         2         2         2         2
ROW(2)                        2         2         2         2         2
ROW(3)                        2         2         2         2         2
ROW(4)                        2         2         2         2         2
ROW(5)                        2         2         2         2         2




               End: Exit   Fn Shift-Fn PgUp PgDn Home Arrows: Browse
```

Pressing the **F2** key, "browses up" the column or second dimension, as shown in the screen below:



```
                              The Table Title

                              COL(6)     COL(7)     COL(8)     COL(9)    COL(10)
        The Total of A and B    15.0       15.0       15.0       15.0       15.0

        The A Values

        ROW(1)                  1.00       1.00       1.00       1.00       1.00
        ROW(2)                  1.00       1.00       1.00       1.00       1.00
        ROW(3)                  1.00       1.00       1.00       1.00       1.00
        ROW(4)                  1.00       1.00       1.00       1.00       1.00
        ROW(5)                  1.00       1.00       1.00       1.00       1.00

        The B Values

        ROW(1)                     2          2          2          2          2
        ROW(2)                     2          2          2          2          2
        ROW(3)                     2          2          2          2          2
        ROW(4)                     2          2          2          2          2
        ROW(5)                     2          2          2          2          2



                      End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows: Browse
```

Note that this page shows columns six through ten of the table. Note also that the primary descriptors of set `row` are used as the row descriptors of the table. This is because set `row` was deliberately omitted from the `sets` specification in the **BROWSE TABLE** statement for this example.

See also the **DEFINE TABLE**, **EDIT TABLE**, and **WRITE TABLE** statements.

3.7.15 BROWSE TEXT

Purpose:

Displays text for browsing in the Action Window (Basic Windows) or the Main Screen (Advanced Windows).

Syntax:

```
BROWSE TEXT
  text
  ...
END
```

Remarks:

`text` is any text that you enter.

The keyword **END** must be entered starting in column 1 and must be capitalized.

Upon execution, the text will be shown by page in the Action Window or the current Main Screen of the display. A prompt at the bottom of the Prompt Screen will let you browse the text. The text will be clipped to the width of the window opened to the Main Screen or the Action Window. No more than 255 lines (approximately 40 pages) of text may be stored in a single **BROWSE TEXT** statement.

For more details, see the discussion of the PROMULA noun **Window**.

3.7.16 BROWSE TOPIC

Purpose:

Browse a specific topic from a dialog file.

Syntax:

```
        BROWSE TOPIC filespec n
```

Remarks:

`filespec` is a quoted string or string variable containing the name of the physical disk file where the dialog file that you desire to browse is stored. This name is formatted according to the file naming conventions for your operating system.

`n` is the dialog topic sequence number, as defined by its place in the dialog file, of the specific topic you wish to browse.

Upon execution, the **BROWSE TOPIC** statement displays the specified topic for browsing.

Examples:

The use of this statement is demonstrated in the context of the example given in the **DEFINE DIALOG** statement.

3.7.17 BROWSE VARIABLE

Purpose:

Produces a full or partial listing of the variables in a given program for browsing.

Syntax:

```
        BROWSE VARIABLE [(vars)]
```

Remarks:

`vars` is a list of variable identifiers. If `vars` is omitted, the variables are listed in the order in which they were defined; otherwise, the sets are listed in the order specified by `vars`.

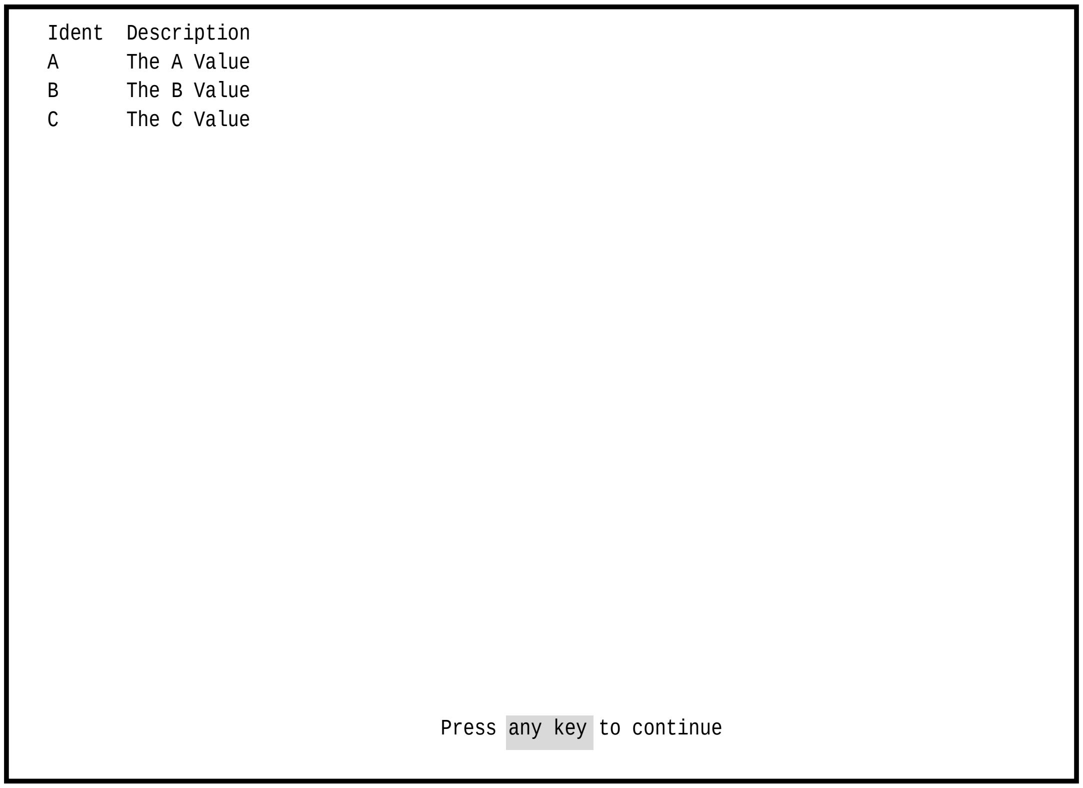
The **BROWSE VARIABLE** statement differs from the **AUDIT VARIABLE** statement in that it lets you interactively browse a "long" list of variables while the audit does not.

Examples:

Given the definitions below:

```
        DEFINE VARIABLE
          a "The A Value"
          b "The B Value"
          c "The C Value"
        END VARIABLE
```

the statement **BROWSE VARIABLE** produces the following display.



```
Ident  Description
A      The A Value
B      The B Value
C      The C Value

                                        Press any key to continue
```

3.7.18 BROWSE variable

Purpose:

Displays a multidimensional variable on the screen and lets you browse its values by page.

Syntax:

```
       BROWSE var[fmt][[ORDER](sets)][TITLE(title)][DISPLAY(dvar)][option][TRANSPOSE]
```

Remarks:

`var` is the identifier of the variable you wish to browse.

`fmt` is a format specification indicating the width of row descriptors, the width of the columns displayed, and the number of decimals in real values, as follows:

`\p:w:d`

where

`p` is an integer specifying the width in characters for row descriptors. The default width is the width specifications of the row descriptors related to the set subscripting the rows of the display.

`w` is an integer specifying the width in characters for each column of values. The default is the width specification in the definition of `var`. A negative width parameter left justifies the values of `var` in each column**.**

d is an integer specifying the number of decimals to display for real numeric values. The default is the decimal specification (if applicable) in the definition of var. If d is an "E", the values of var will be displayed in exponential notation (base-10), and will show seven digits and six decimal places.

If omitted, w and d are the parameters specified in the **TYPE** specification for var, and p is the width specifications of the row descriptors related to the set sub-scripting the rows of the display.

sets is a list of the sets classifying the values of var. The order in which the sets are listed specifies the structure of the display: the first set classifies the rows of the display, the second set classifies the columns, and the third to last set classify the pages of the display. The keyword **ORDER** is optional. If it is omitted, sets specification must follow immediately after the optional format specification.

title is any text you wish to show as a title for the table. The title may include variables, and other format characters according to the rules defined in the **WRITE variables** statement.

dvar is a variable used to control the display of variable var. dvar should be subscripted by the set that defines the rows of the display. PROMULA will display values of var only for those rows corresponding to elements of dvar that contain nonzero values. See Example 4 below.

option is one of the following mutually exclusive **BROWSE variable** options:

TOTAL[(sets**)]** displays totals over the selected sets for browsing along with values of var. If sets is omitted, all the marginal and grand totals for var will be displayed.

PERCENT(set**)** displays the percent distribution of the total over set of var.

CHANGE(n**)** The **CHANGE** option allows the user to show a table of percent change in time series data for a previously defined time series variable. A time series variable is one which is subscripted by a time series set.

The percent change for time t is computed from values for time t and t-1, where t and t-1 are two consecutive selections of the time set. The selections depend on the current local setting of the set. They may or may not be consecutive time points. There may be more than one time unit between them.

Following the keyword, **CHANGE**, a real number within parentheses is required. It represents the number of time units to be used in computing percent change. Internally it is divided by the difference in time values for selections t and t-1.

Suppose values for 1970 and 1975 are used in computing the percent change. That is, the user has selected these years for computation and output generation. Also, he wants to compute an annual percent change, so one time unit (a year) is designated on the CHANGE option (CHANGE(1)). The change for 1975 is computed as the difference in values for 1970 and 1975, divided by the 1970 value, and multiplied by 1/5 (for annual change). A factor of 100 gives the percent change from 1970 to 1975 in one year increments.

In the tabular display the words, **Percent Change in**, are placed in front of the original descriptor (from the variable definition). If the **TITLE** option is used with the **CHANGE** option, no words are prefixed.

GROWTH(n**)** The **GROWTH** option allows the user to show a table of growth rates in time series data for a previously defined time series variable. n is an integer constant that specifies the number of time units with which each change is associated. A time series dataset or array is one which is subscripted by a time series set. The growth rate for time t is computed from values for time t and t-1.

Following the keyword, **GROWTH**, a real number within parentheses is required and stands for the number of time units between each pair of values for which growth rate will be computed. Internally, it is divided by the difference in time values for selected `t` and `t-1`.

Suppose the user has selected 1970 and 1975 and wishes to show annual growth rates `(GROWTH(1)).` The growth rate for 1975 is computed as a quotient — value for 1975 divided by value for 1970 — raised to the power 1/5 (1.0/(1975-1970)). One is subtracted from this quantity to get a growth rate, and a factor of 100 gives the final result as a percent rate from 1970 to 1975 in one year increments.

In the tabular display, the words, **Growth Rate in**, are placed in front of the original title unless a **TITLE** option is specified.

MOVING(`n`) The **MOVING** option allows the user to show a table of moving averages in time series data for a previously defined time series array. Following the keyword `MOVING`, an integer, `n`, within parentheses, gives the number of single unit time increments over which the moving average is computed. The moving av-erage for time `t` is computed from values for time `t,...,t`$_{(n-1)}$, where the `t's` are consecutive time points. They are not consecutive time set selections, based on a local setting of the time set. Rather, they are time points as defined by the time values related to the set subscripting `var`.

In the tabular display the words, **Moving Average for**, are placed in front of the original title unless the **TITLE** option is specified.

If the keyword **TRANSPOSE** is included with the statement and the structure for the display is not explicitly specified, the display will be transposed. This means that the first and last dimensions of the default display will be swapped.

Upon execution, the **BROWSE variable** statement clears the screen, displays the first page of the array and issues the following message at the bottom of the display:

```
 End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows:  Browse
```

The highlighted portions of the message represent the following options:

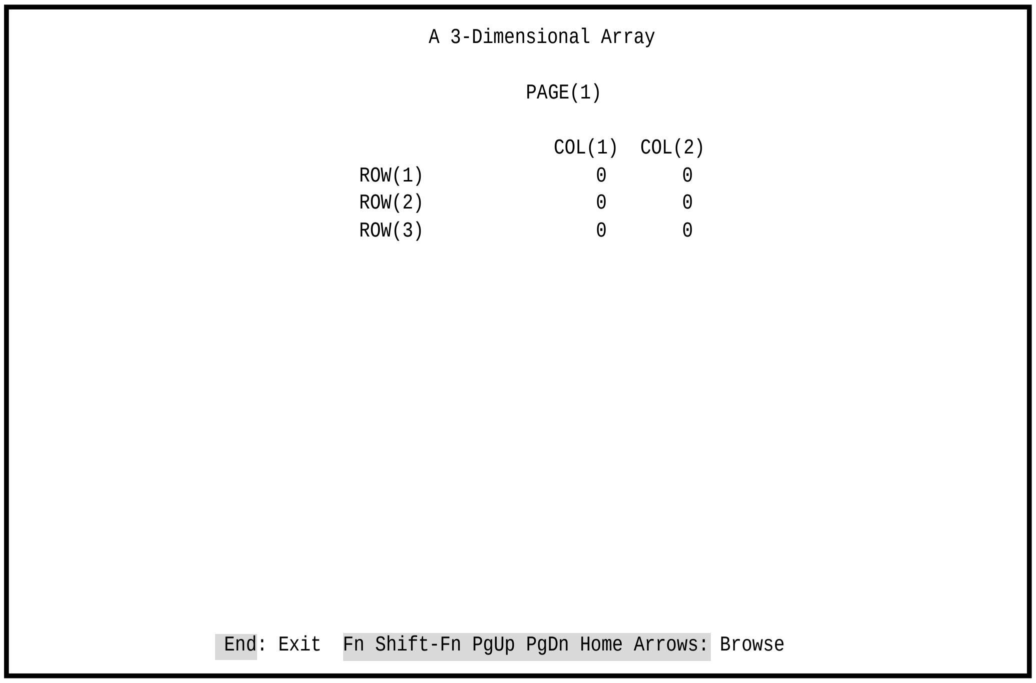
Fn	press the **Fn** function key to browse up the nth dimension of the array, where n varies from 1 to 10. The **F1** key browses up the 1st dimension, the **F2** key browses up the 2nd dimension, and so forth.
Shift-Fn	simultaneously press the **Shift** and **Fn** keys to browse down the nth dimension of the array. The **Shift-F1** key browses down the 1st dimension, the **Shift-F2** key browses down the 2nd dimension, etc.
Browsing keys	The four movement arrows at the right-hand section of the keyboard allow you to move the cursor to the desired value. The PgUp and PgDn keys are used to move up and down the pages of the display.
Home	moves the cursor to the "top" of the display, which is the first value on the screen.
End	press the **End** key to exit editing mode or to exit browsing mode.

Examples:

1. Given the following definitions:

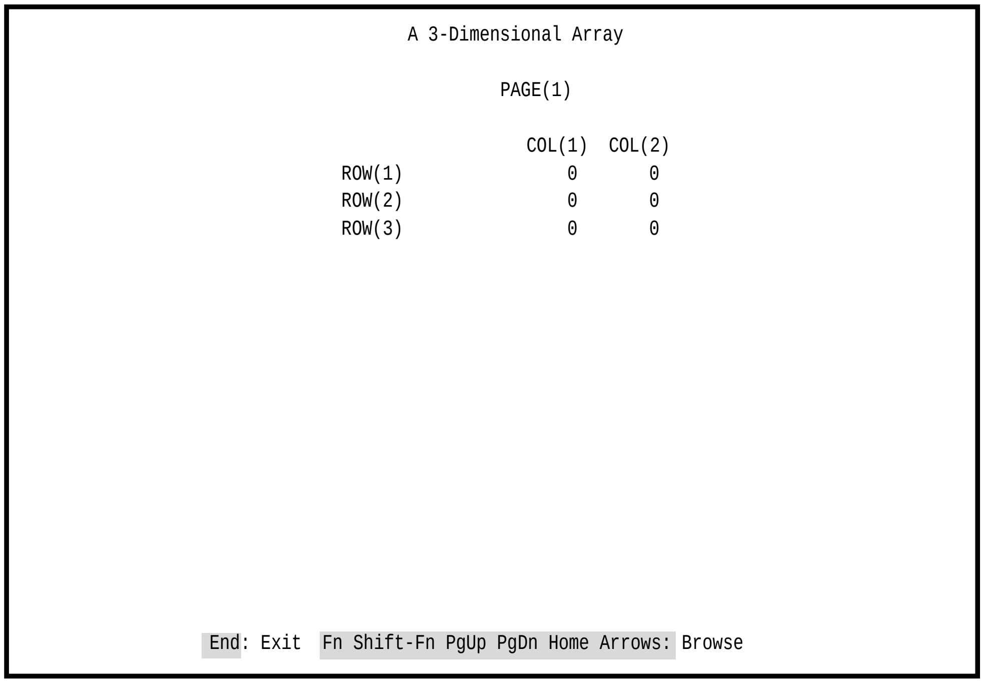
```
DEFINE SET
  row(3)
  col(2)
  page(2)
END SET
DEFINE VARIABLE
  a(row,col,page) "A 3-Dimensional Array"
END VARIABLE
```

the statement `BROWSE a` clears the screen and produces the following display:



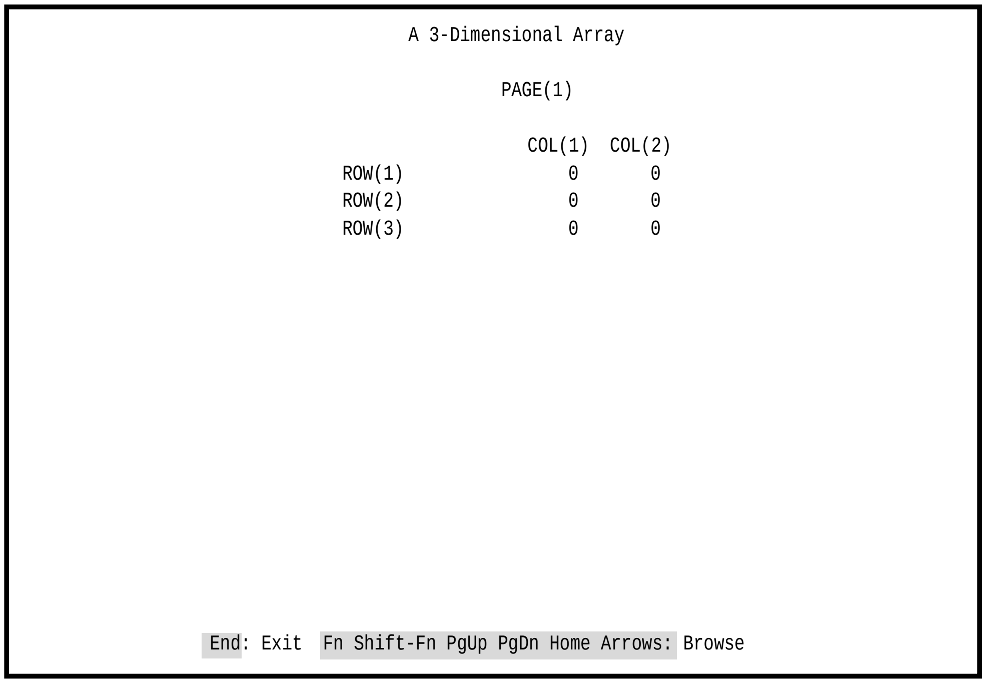
```
                    A 3-Dimensional Array

                            PAGE(1)

                               COL(1)  COL(2)
             ROW(1)                 0       0
             ROW(2)                 0       0
             ROW(3)                 0       0










    End: Exit   Fn Shift-Fn PgUp PgDn Home Arrows: Browse
```

Pressing the **F3** key, "browses up" the page or third dimension, as shown in the screen below:



```
                    A 3-Dimensional Array

                           PAGE(1)

                              COL(1)  COL(2)
  ROW(1)                           0       0
  ROW(2)                           0       0
  ROW(3)                           0       0



End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows: Browse
```

Pressing the **Shift** and **F3** keys simultaneously, "browses down" the third dimension, as shown in the screen below:



```
                    A 3-Dimensional Array

                           PAGE(1)

                              COL(1)  COL(2)
  ROW(1)                           0       0
  ROW(2)                           0       0
  ROW(3)                           0       0



End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows: Browse
```

NOTE: Pressing the **F1** and **F2** keys do not have any effect in this example, since all elements of both the "row" and "column" dimensions of the array fit within the screen.

2. The following dialog illustrates the **BROWSE variable** options.
\

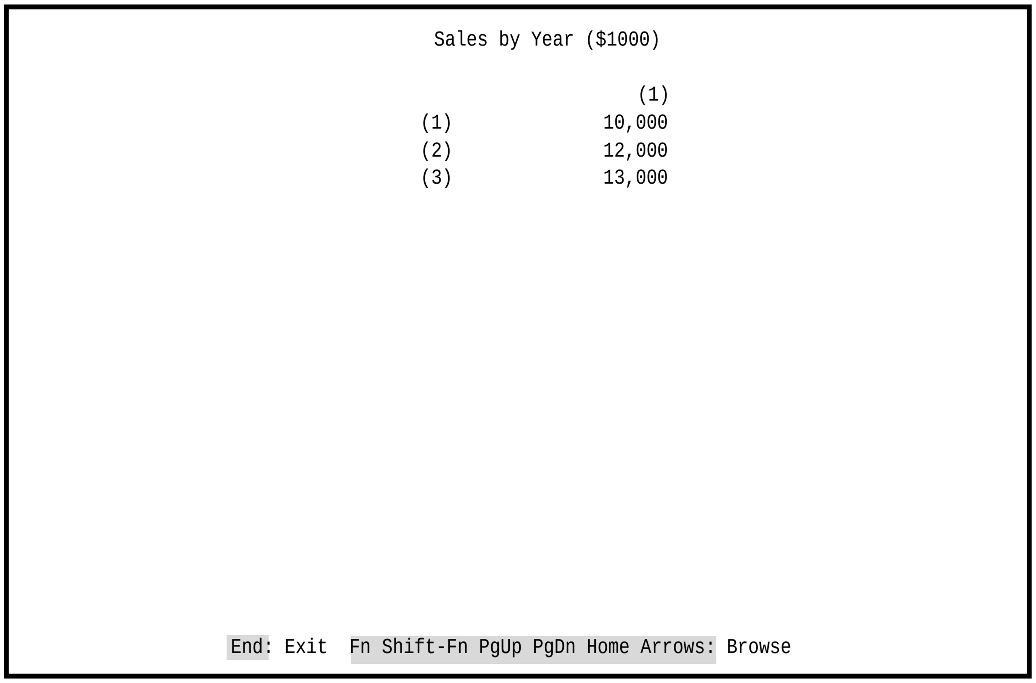
```
          DEFINE SET
          yr(5), "The Years"
        END SET

        DEFINE VARIABLE
          yval(yr)   "The Year Values"
          value(yr)  "A Time Series"  TYPE=REAL(30,2)
        END VARIABLE

        DEFINE RELATION
          TIME(yr,yval)
        END RELATION

        yval(y)  = 69 + y
        value(y) = 10 * y

        BROWSE value TOTAL
                                         A Time Series

                         Total                                      150.00
                         70                                          10.00
                         71                                          20.00
                         72                                          30.00
                         73                                          40.00
                         74                                          50.00

        BROWSE value PERCENT(yr)
                             Percent Distribution of A Time Series

                         Total                                      100.00
                         70                                           6.67
                         71                                          13.33
                         72                                          20.00
                         73                                          26.67
                         74                                          33.33

        BROWSE value GROWTH(1)
                                Growth Rate in A Time Series

                         71                                         100.00
                         72                                          50.00
                         73                                          33.33
                         74                                          25.00



      BROWSE value CHANGE(1)
                               Percent Change in A Time Series

                         71                                         100.00
                         72                                          50.00
                         73                                          33.33
                         74                                          25.00

        BROWSE value MOVING(2)
                               Moving Average for A Time Series

                         71                                          15.00
                         72                                          25.00
                         73                                          35.00
                         74                                          45.00
```

3. The example below illustrates how to browse a variable directly from an array disk file.

   Suppose you have created an array database and you wish to access one of its variables. The name of the database is `array.dba` and the name of the variable is `sales`. The example below shows how to browse the variable `sales` directly. In fact, the `file:variable` notation may be used to access any variable in an array file. See Chapter 4 for more information on working with PROMULA's array files.

```
DEFINE FILE
  f1
END

OPEN f1 "array.dba"
```

   Once the array file is opened, its variables may be accessed directly using the file:variable notation. For example, the statement `BROWSE f1:sales` displays the disk variable `sales` on file `f1` as shown below.



```
                    Sales by Year ($1000)

                                  (1)
                   (1)         10,000
                   (2)         12,000
                   (3)         13,000




              End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows: Browse
```

   The syntax for such direct reference of disk variables is: `file:var`, where `file` is the array file containing the variable `var` that you wish to access. The notation `file:set` may be used to refer to sets on an array file.

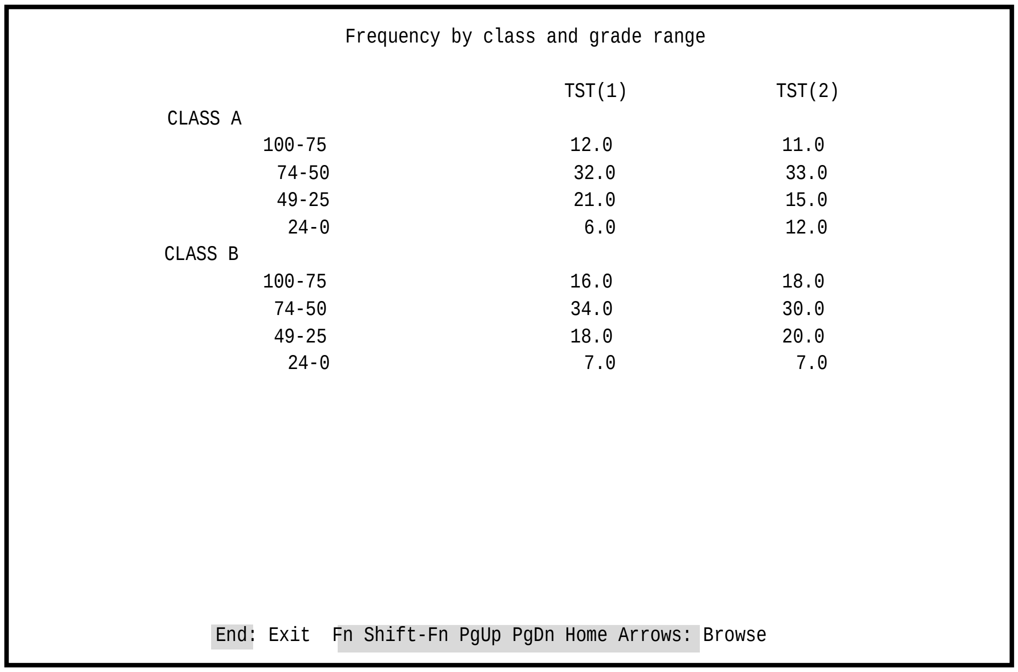
   Variables on a disk file may also be browsed directly by using the **COPY file IMAGE** statement.

4. The example below illustrates the **DISPLAY** option of the **BROWSE variable** statement. There are no values shown for rows 1 and 6 of the display because variable `dvar` contains a zero in these rows.

```
DEFINE SET
  tst(2)  "Tests"
  grd(10) "Grade Ranges"
END SET

DEFINE VARIABLE
  cnt(grd,tst) TYPE=REAL(8,1)   "Frequency by class and grade range"
  grdn(grd)    TYPE=STRING(20)  "Grade Range Names"
  dvar(grd)    TYPE=REAL(8,0)   "Display Flag" VALUE=1
END

DO grd
```

```
  READ (grdn:13)
END grd
CLASS A
       100-75
        74-50
        49-25
         24-0
CLASS B
       100-75
        74-50
        49-25
         24-0
READ cnt(tst,grd)
0 12 32 21 6  0 16 34 18 7
0 11 33 15 12 0 18 30 20 7
dvar(1)=0
dvar(6)=0

SELECT KEY(grd,grdn)
```

The statement `BROWSE cnt:20:1 DISPLAY(dvar)` produces the display below.



```
                     Frequency by class and grade range

                                          TST(1)            TST(2)
          CLASS A
                100-75                     12.0              11.0
                 74-50                     32.0              33.0
                 49-25                     21.0              15.0
                  24-0                      6.0              12.0
          CLASS B
                100-75                     16.0              18.0
                 74-50                     34.0              30.0
                 49-25                     18.0              20.0
                  24-0                      7.0               7.0







                 End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows: Browse
```

3.7.19 CLEAR file

Purpose:

Saves the contents of an open file on disk and then closes the file.

Syntax:

```
CLEAR file
```

Remarks:

`file` is the logical identifier of the open file that you wish to save and close.

A logical file identifier is created by the **DEFINE FILE** statement. A file is physically opened with the **OPEN file** statement.

See the description of the PROMULA noun **File** for more information about PROMULA's file system.

3.7.20 CLEAR variable

Purpose:

Clears scratch variables from memory.

Syntax 1:

```
CLEAR *
```

Clears all scratch variables from memory.

Syntax 2:

```
CLEAR (vars)
```

Clears only specified scratch variables from memory.

Remarks:

`vars` is the list of those variable identifiers that are to be cleared.

The values of a scratch variable are not stored permanently in memory; they can be cleared or scratched from memory when you need to make room for the values of other variables. This statement gives you the power to do what is sometimes called "dynamic memory allocation." This is discussed in more detail in Chapter 4.

Examples:

The code below defines variables of four types:

```
DEFINE VARIABLE
  fixd, "A Fixed Variable"
END VARIABLE

DEFINE VARIABLE SCRATCH
  scr, "A Scratch Variable"
END VARIABLE

DEFINE SET
  row(3)
END SET

DEFINE FILE
  filea TYPE=ARRAY
END FILE

OPEN filea "filea.dba",STATUS=NEW
DEFINE VARIABLE filea
  dsk(row), "A Disk Variable on 'filea'"
END VARIABLE
```

```
DEFINE VARIABLE
  rp
  dd, "A Dynamic Disk Variable", DISK(filea,dsk(rp))
END VARIABLE
```

The variable `fixd` occupies a fixed space in memory and cannot be cleared by the **CLEAR** statement.

The variable `scr` is a scratch variable and can be cleared from memory by the **CLEAR** statement.

The variable `dsk` is a disk variable, its three values are permanently stored on disk, in a file named `filea.dba`.

The variable `dd` is a dynamic scalar subset of the disk variable `dsk`; its single value is related to one of the three values of the variable `dsk`. Variable `dd` may be cleared from memory by the **CLEAR** statement.

The dialog below shows that the four variables initially have the value zero:

```
WRITE fixd
A Fixed Variable 0

WRITE scr
A Scratch Variable 0

WRITE dsk

                     A Disk Variable on 'filea'

         ROW(1)      0   ROW(2)        0   ROW(3)        0

WRITE dd
A Dynamic Disk Variable 0
```

The following statements:

```
fixd = 10
scr  = 20
READ dsk
1 2 3

rp = 2
READ DISK dd
```

put values into the variables:

```
WRITE fixd
A Fixed Variable 10

WRITE scr
A Scratch Variable 20

WRITE dsk

                     A Disk Variable on 'filea'

         ROW(1)      1   ROW(2)        2   ROW(3)        3

WRITE dd
```

```
             A Dynamic Disk Variable 2
```

The statement

```
CLEAR*
```

clears the values of the scratch variable, `scr`, from memory; the fixed variable `fixd`, and the disk variable, `dsk`, are not effected as can be verified in the dialog below:

```
WRITE fixd
A Fixed Variable 10

WRITE scr
A Scratch Variable 0

WRITE dsk

                       A Disk Variable on 'filea'

           ROW(1)      1   ROW(2)         2   ROW(3)         3
```

The treatment of dynamic variables, such as `dd`, is a little more difficult to illustrate. `dd` is cleared from memory by the **CLEAR** statement, but as soon as it is referenced in an expression, such as a **WRITE** statement, or used in the right-hand-side of an equation, PROMULA automatically reads it in from disk. The dialog below illustrates this behavior.

STATEMENTS	MEANING

`dd = 100`
`WRITE dd`
`A Dynamic Disk Variable 100`
	Variable `dd` is given a value via an equation.

`rp = 2`
`READ DISK dd`
`WRITE dd`
`A Dynamic Disk Variable 2`
	Variable `dd` is given a value via an **explicit** READ DISK statement.

`rp = 3`
`WRITE dd`
`A Dynamic Disk Variable 2`
`CLEAR dd`
`WRITE dd`
`A Dynamic Disk Variable 3`
	Variable `dd` is given a value via an **implicit** read disk operation that occurs after it is CLEARed from memory then used in a WRITE statement.

`rp = 1`
`CLEAR dd`
`scr = dd`
`WRITE scr`
`A Scratch Variable 1`
`WRITE dd`
`A Dynamic Disk Variable 1`
	Variable `dd` is given a value via an **implicit** read disk operation that occurs after it is CLEARed from memory then used on the right-hand-side of an equation.

3.7.21 CLEAR WINDOW

Purpose:

Tells PROMULA to stop using a user-defined window as the display area for a functional screen.

Syntax:

```
CLEAR type
```

Remarks:

`type` is the type of functional screen to be returned to its default behavior, and can be one of the following:

MAIN	the Main input/output Screen
PROMPT	the Prompt Screen
COMMENT	the Comment Screen
ERROR	the Error Screen
HELP	the Help Screen

This statement ends the association between a window and a functional screen that was started by a previous **OPEN WINDOW** statement.

The effect of this statement depends on the popup type of the window that was opened to the functional screen being cleared.

Clearing a screen that was opened to a popup window (i.e., a window that was defined with the **POPUP** option), immediately removes the window from the display. Furthermore, any text that was covered by the window will be redrawn.

Clearing a screen area that was opened to a static window only ends the association between the window and the screen. The window and its contents remain on the screen.

To permanently erase a static window from the display after closing it, you must clear the display with the statements

```
CLEAR MAIN
WRITE CLEAR(0)
```

Alternatively, you may "erase" a window by opening a static window on top of it (i.e., by covering it up).

See also **DEFINE WINDOW** and **OPEN WINDOW** statements, and the discussion of Advanced Windows.

3.7.22 [COMPUTE] Equation

Purpose:

Makes the value (or values) of a variable equal to the value (or values) of a numeric or character expression.

Syntax:

```
[COMPUTE] var[(subs)] = expression[(subs)]
```

Remarks:

`var`	is a variable identifier.
`subs`	is a list of set identifiers or dummy subscripts. When used, such subscripts denote multiple equations that apply to the cells of multidimensional arrays.
`expression`	is a numeric or character expression.

Examples:

The verb **COMPUTE** is required for use with the expressions involving the set colon operators. For example, given the definition below

```
DEFINE SET
  rec(100)
END SET
```

the statements

```
COMPUTE rec:R = 50
SELECT rec*
```

will redefine the default size of set `rec` changing it from 100 to 50.

The length of the `rec`'s selection vector may be set to 10 elements by the statement

```
COMPUTE rec:N = 10
```

The set may be restored to its original size by the statements

```
COMPUTE rec:R = rec:M
SELECT rec*
```

There are many examples of equations in the discussion of the PROMULA nouns **Equation** and **Expression**.

3.7.23 COPY

Purpose:

1. Copies the data and structure of an array file into another array file, or copies the definition, and optionally the data, of an array file to a text file or to an output device, such as the screen or the printer.

2. Copies the definition of an array file into memory so its variables can be directly accessed by PROMULA without having to include the file structure definition or any disk variable definitions in your program. See the discussion of data management in Chapter 4.

Syntax 1:

```
COPY file1 [INTO file2] [varspec] [DATA] [RAW]
```

Remarks:

Syntax 1 is typically used to make full or partial copies of an array database or to generate a listing of its structure and/or data.

`file1`	is the identifier of the source (input) file. This must be an existing array file, i.e., has been opened with **STATUS=OLD**
`file2`	is the identifier of the target (output) file. This must be a new array or text file, i.e., has been opened with **STATUS=NEW**. If the **INTO** `file2` option is omitted, the results of the copy will be written to the current output device(s), screen and/or printer.
`varspec`	a list of variables in `file1` to be copied and may take one of the following forms.

INCLUDE(vars) specifies a partial copy to file2 that *includes* only selected variables from file1. Where vars is the list of variables in file1.

EXCLUDE(vars) specifies a partial copy to file2 that *excludes* selected variables from file1. Where vars is the list of variables in file1.

If varspec is omitted, all the variables in the dataset are included in the copy.

The varspec option may only be used with array files.

DATA indicates that both the structure and values of selected variables in file1 are to be copied. Here, structure means the set, variable, and relation definitions in file1.

When making a text copy of an array file using the DATA option, local set selections are obeyed and the relevant **SELECT set** statements are written in the output. See Example 5.

RAW indicates that you wish to make a raw copy of file1 in file2. This copy works like your operating system's generic file copy command. This is the quickest mode of the **COPY** statements and may not be used with any other options.

Syntax 2:

```
COPY file IMAGE
```

Remarks:

file is the identifier of the array file containing the data you wish to access.

Syntax 2 reads the set, variable, and relation definitions of an array file into memory giving PROMULA direct access to the information in the file.

This is an alternative to using local variables to virtually access disk variables in an array file.

Although this feature requires less programming, it does not give you full control over how large array variables are "paged" into memory for processing. The variables remain on disk and are accessed directly, (i.e., the values of the variables are accessed on disk and are not read into memory.)

In summary, the **COPY** statement allows four types of copy operations:

1. Copy from one binary data file to another. This is an efficient way to make copies of binary (array and random) files for direct use by PROMULA. If a full copy of structure and data is desired, use the **RAW** option for maximum copying speed.

2. Copy from an array to a text file. This is a way to convert binary data files into text data files that may be used as text data by other PROMULA programs or by other software.

3. Copy an array file to an output device — the console or printer.

4. Copy an array file definition into memory for direct access using an **IMAGE** copy.

Examples:

The following examples of the **COPY** statement make copies of a database called original.dba. The definition of this database is shown below.

```
DEFINE FILE
  orignl TYPE=ARRAY  "Original Database"
END FILE

OPEN orignl "original.dba" STATUS=NEW

DEFINE SET orignl
  rec(4)
  col(6)
END SET orignl

DEFINE VARIABLE orignl
  a(rec,col) TYPE=REAL(10,1) "The A Matrix"
  b(rec,col) TYPE=REAL(10,1) "The B Matrix"
  recn(rec)  TYPE=STRING(10)
  coln(col)  TYPE=STRING(10)
END VARIABLE orignl

DEFINE RELATION orignl
  ROW(rec,recn)
  COLUMN(col,coln)
END RELATION orignl

recn(i)= "ROW # " + i
coln(i)= "COL # " + i
a(i,j) = i+10*j
b(i,j) = i+10*j
```

Example 1: Copy to the Console

Given the definition of file `original.dba` above, the statement

```
COPY orignl
```

will display the full definition of file `original.dba` on the console. This output shows the names of the sets, variables and relations stored in the original database.

```
DEFINE FILE
ORIGNL, TYPE=ARRAY
END
OPEN ORIGNL"ORIGNL.dba", STATUS=NEW
DEFINE SET ORIGNL
REC(4)
COL(6)
END
DEFINE VARIABLE ORIGNL
A(REC,COL), TYPE=REAL(10,1), "The A Matrix"
B(REC,COL), TYPE=REAL(10,1), "The B Matrix"
RECN(REC), TYPE=STRING(10)
COLN(COL), TYPE=STRING(10)
END
DEFINE RELATION ORIGNL
ROW(REC,RECN)
COLUMN(COL,COLN)
END
```

The statement

```
        COPY orignl EXCLUDE (a,b) DATA
```

will display a partial definition of file `original.dba`. The **EXCLUDE** option tells PROMULA to exclude the variables `a` and `b` from the report, and the **DATA** option causes the values of the remaining variables to be displayed along with their definitions.

```
             DEFINE FILE
             ORIGNL, TYPE=ARRAY
             END
             OPEN ORIGNL"ORIGNL.dba", STATUS=NEW
             DEFINE SET ORIGNL
             COL(6)
             REC(4)
             END
             DEFINE VARIABLE ORIGNL
             COLN(COL), TYPE=STRING(10)
             RECN(REC), TYPE=STRING(10)
             END
             DEFINE RELATION ORIGNL
             COLUMN(COL,COLN)
             ROW(REC,RECN)
             END
             READ COLN:10
             COL # 1   COL # 2   COL # 3   COL # 4   COL # 5   COL # 6
             READ RECN:10
             ROW # 1   ROW # 2   ROW # 3   ROW # 4
```

Example 2: Full Copy — array file to array file

The next example illustrates how to make a full copy of the database in a separate disk file. This option is most useful for making working or backup copies of your databases. The copy will behave exactly as the original.

The **DATA** option is required to have the values in the original file copied with the definitions.

After copying `orignl` into `fulcpy`, the **COPY** statement is used to display the contents of `fulcpy` on the console.

```
        DEFINE FILE
          fulcpy TYPE=ARRAY "Full Copy of Original Database"
        END FILE

        OPEN orignl "original.dba" STATUS=OLD
        OPEN fulcpy "fullcopy.dba" STATUS=NEW

        COPY orignl INTO fulcpy DATA
```

After copying `orignl` into `fulcpy`, the **COPY** statement is used to display the contents of `fulcpy` on the console.

```
        COPY fulcpy DATA

             DEFINE FILE
             FULCPY, TYPE=ARRAY
             END
             OPEN FULCPY"FULCPY.dba", STATUS=NEW
             DEFINE SET FULCPY
             REC(4)
             COL(6)
             END
             DEFINE VARIABLE FULCPY
             A(REC,COL), TYPE=REAL(10,1), "The A Matrix"
```

```
B(REC,COL), TYPE=REAL(10,1), "The B Matrix"
RECN(REC), TYPE=STRING(10)
COLN(COL), TYPE=STRING(10)
END
DEFINE RELATION FULCPY
ROW(REC,RECN)
COLUMN(COL,COLN)
END
READ A:12:E
  1.100000E1  2.100000E1  3.100000E1  4.100000E1  5.100000E1  6.100000E1
  1.200000E1  2.200000E1  3.200000E1  4.200000E1  5.200000E1  6.200000E1
  1.300000E1  2.300000E1  3.300000E1  4.300000E1  5.300000E1  6.300000E1
  1.400000E1  2.400000E1  3.400000E1  4.400000E1  5.400000E1  6.400000E1
READ B:12:E
  1.100000E1  2.100000E1  3.100000E1  4.100000E1  5.100000E1  6.100000E1
  1.200000E1  2.200000E1  3.200000E1  4.200000E1  5.200000E1  6.200000E1
  1.300000E1  2.300000E1  3.300000E1  4.300000E1  5.300000E1  6.300000E1
  1.400000E1  2.400000E1  3.400000E1  4.400000E1  5.400000E1  6.400000E1
READ RECN:10
ROW # 1   ROW # 2   ROW # 3   ROW # 4
READ COLN:10
COL # 1   COL # 2   COL # 3   COL # 4   COL # 5   COL # 6
```

The **RAW** copy is also useful for making a full working or backup copies of your databases and it is the fastest copy mode. The copy will behave exactly as the original.

Example 3: COPY EXCLUDE, COPY INCLUDE

The next example illustrates how to make a partial copy of your database in a separate disk file.

The first copy uses the **EXCLUDE** option to exclude variable a from the copy. The second copy uses the **INCLUDE** option to include only variables `coln` and `recn` in the copy. Notice that without the **DATA** option, the values in the original file are not copied into the new file.

```
DEFINE FILE
  prtcpy TYPE=ARRAY "Partial Copy of Original Database"
END FILE

OPEN prtcpy "prtcpy.dba" STATUS=NEW
COPY orignl INTO prtcpy EXCLUDE(a)
```

After the copy, the statement `COPY prtcpy DATA` may be used to verify the results as displayed below.

```
DEFINE FILE
PRTCPY, TYPE=ARRAY
END
OPEN PRTCPY"PRTCPY.dba", STATUS=NEW
DEFINE SET PRTCPY
REC(4)
COL(6)
END
DEFINE VARIABLE PRTCPY
B(REC,COL), TYPE=REAL(10,1), "The B Matrix"
RECN(REC), TYPE=STRING(10)
COLN(COL), TYPE=STRING(10)
END
DEFINE RELATION PRTCPY
ROW(REC,RECN)
COLUMN(COL,COLN)
END
```

```
         READ B:12:E
           0.000000E0  0.000000E0  0.000000E0  0.000000E0  0.000000E0  0.000000E0
           0.000000E0  0.000000E0  0.000000E0  0.000000E0  0.000000E0  0.000000E0
           0.000000E0  0.000000E0  0.000000E0  0.000000E0  0.000000E0  0.000000E0
           0.000000E0  0.000000E0  0.000000E0  0.000000E0  0.000000E0  0.000000E0
         READ RECN:10

         READ COLN:10


         CLEAR prtcpy

         OPEN prtcpy "prtcpy.dba" STATUS=NEW
         COPY orignl INTO prtcpy INCLUDE(coln,recn) DATA
         COPY prtcpy DATA
         DEFINE FILE
         PRTCPY, TYPE=ARRAY
         END
         OPEN PRTCPY"PRTCPY.dba", STATUS=NEW
         DEFINE VARIABLE PRTCPY
         RECN(REC), TYPE=STRING(10)
         COLN(COL), TYPE=STRING(10)
         END
         READ RECN:10
         ROW # 1   ROW # 2   ROW # 3   ROW # 4
         READ COLN:10
         COL # 1   COL # 2   COL # 3   COL # 4   COL # 5   COL # 6
```

Example 4: Full Copy — array file to text file

The following example shows how to make a copy of a database definition in a text file on disk.

```
       DEFINE FILE
         txtcpy TYPE=TEXT "TEXT File For Copy"
       END FILE

       OPEN orignl "original.dba" STATUS=OLD
       OPEN txtcpy "textcopy.prm"  STATUS=NEW

       COPY orignl INTO txtcpy DATA

       CLEAR txtcpy
       CLEAR orignl
```

The file `textcopy.prm` is shown below. This text file could be edited or used directly to create a copy of the original database.

```
            DEFINE FILE
            ORIGNL, TYPE=ARRAY
            END
            OPEN ORIGNL"ORIGNL.dba", STATUS=NEW
            DEFINE SET ORIGNL
            REC(4)
            COL(6)
            END
            DEFINE VARIABLE ORIGNL
            A(REC,COL), TYPE=REAL(10,1), "The A Matrix"
            B(REC,COL), TYPE=REAL(10,1), "The B Matrix"
            RECN(REC), TYPE=STRING(10)
```

```
             COLN(COL), TYPE=STRING(10)
             END
             DEFINE RELATION ORIGNL
             ROW(REC,RECN)
             COLUMN(COL,COLN)
             END
             READ A:12:E
               1.100000E1  2.100000E1  3.100000E1  4.100000E1  5.100000E1  6.100000E1
               1.200000E1  2.200000E1  3.200000E1  4.200000E1  5.200000E1  6.200000E1
               1.300000E1  2.300000E1  3.300000E1  4.300000E1  5.300000E1  6.300000E1
               1.400000E1  2.400000E1  3.400000E1  4.400000E1  5.400000E1  6.400000E1
             READ B:12:E
               1.100000E1  2.100000E1  3.100000E1  4.100000E1  5.100000E1  6.100000E1
               1.200000E1  2.200000E1  3.200000E1  4.200000E1  5.200000E1  6.200000E1
               1.300000E1  2.300000E1  3.300000E1  4.300000E1  5.300000E1  6.300000E1
               1.400000E1  2.400000E1  3.400000E1  4.400000E1  5.400000E1  6.400000E1
             READ RECN:10
             ROW # 1   ROW # 2   ROW # 3   ROW # 4
             READ COLN:10
             COL # 1   COL # 2   COL # 3   COL # 4   COL # 5   COL # 6
```

Example 5: Partial Copy — array file to text file using local set selections

The following example shows how to make a partial copy of a database definition in a text file on disk. In this case, local set selections will restrict which data elements are be output by the DATA option. In order to use this feature, the sets on the database and the local sets must have the same identifiers.

```
DEFINE FILE
  txtcpy TYPE=TEXT "TEXT File For Copy"
END FILE

OPEN orignl "original.dba" STATUS=OLD
OPEN txtcpy "textcopy.prm"  STATUS=NEW

DEFINE SET
  rec(4)
  col(6)
END SET

SELECT rec(1-2) col*
COPY orignl INTO txtcpy DATA

CLEAR txtcpy
CLEAR orignl
```

The file `textcopy.prm` is shown below. This text file could be edited or used directly to create a partial copy of the original database.

```
           DEFINE FILE
           ORIGNL, TYPE=ARRAY
           END
           OPEN ORIGNL "ORIGNL.dba", STATUS=NEW
           DEFINE SET ORIGNL
           REC(4)
           COL(6)
           END
           DEFINE VARIABLE ORIGNL
           A(REC,COL)TYPE=REAL(10,1), "The A Matrix"
```

```
          B(REC,COL)TYPE=REAL(10,1), "The B Matrix"
          RECN(REC)TYPE=STRING(10)
          COLN(COL)TYPE=STRING(10)
          END
          DEFINE RELATION ORIGNL
          ROW(REC,RECN)
          COLUMN(COL,COLN)
          END
          SELECT REC(1,2)
          SELECT COL(3,5,6)
```

Notice that PROMULA inserts set selection statements here, and also restricts the range of data values for the READs.

```
          READ A:12:E
            3.100000E1  5.100000E1  6.100000E1
            3.200000E1  5.200000E1  6.200000E1
          READ B:12:E
            3.100000E1  5.100000E1  6.100000E1
            3.200000E1  5.200000E1  6.200000E1
          READ RECN:10
          ROW # 1   ROW # 2
          READ COLN:10
          COL # 3   COL # 5   COL # 6
```

Example 6: IMAGE Copy

The dialog below illustrates the use of the **COPY IMAGE** statement. The file `arr1org.dba` is an array file on disk.

```
            DEFINE FILE
              demo TYPE=ARRAY
            END FILE
            OPEN demo "arr1org.dba" STATUS=OLD
            COPY demo

            DEFINE FILE
            DEMO, TYPE=ARRAY
            END
            OPEN DEMO"DEMO.dba", STATUS=NEW
            DEFINE SET DEMO
            YRS(4), "yrs"
            SIC(4), "SIC"
            END
            DEFINE VARIABLE DEMO
            EMP(SIC,YRS), TYPE=REAL(8,0), "Employment by Industry"
            SICST(SIC), TYPE=STRING(30), "Names for Industrial Categories"
            YEAR(YRS), TYPE=STRING(5), "Years"
            END
            DEFINE RELATION DEMO
            KEY(YRS,YEAR)
            KEY(SIC,SICST)
            END

            * Notice no sets or variables are available before the COPY IMAGE

            AUDIT SET
            AUDIT VARIABLE

            * The COPY demo IMAGE statement will read in the set, variable and
            * relation definitions in the array file for virtual access
            COPY demo IMAGE

            * Notice all the sets and variables in arr1org.dba are now
            * available for use after the COPY IMAGE

            AUDIT SET
            Ident  Description
            YRS    yrs
            SIC    SIC

            AUDIT VARIABLE
            Ident  Description
            YEAR   Years
            SICST  Names for Industrial Categories
            EMP    Employment by Industry

            WRITE emp
                                     Employment by Industry

                                      1990    1991    1992    1993
                     TRANSPORTATION      1       2       3       4
                     AGRICULTURE         2       4       6       8
                     INFORMATION         3       6       9      12
                     BANKING             4       8      12      16
```

3.7.24 DEFINE DIALOG

Purpose:

Defines a dialog file for later use as on-line help or menu driven documentation.

Syntax:

```
      DEFINE DIALOG "filespec"
        intro
        ...
      END
      TOPIC "title1"
        text1
        ...
      END
      TOPIC "title2"
        text2
        ...
      END
        ...
      END [DIALOG]
```

Remarks:

`filespec`	is the name of the physical disk file that will store the dialog file. This name is formatted according to the file naming conventions for your operating system.
`intro`	is the text introducing the dialog menu.
`title1`	is the title for the first topic (up to 25 characters).
`text1`	is the text of the first topic.

`title2` is the title for the second topic.

`text2` is the text of the second topic.

The keyword **END** must be entered starting in column 1 and must be capitalized.

You may specify as many topics as you wish provided the resultant dialog file menu fits in the Help Screen that will be active when the dialog file is browsed.

Dialog files are PROMULA programs which consist of text organized into one or more topics. Each topic consists of:

1. A short title (up to 25 characters)
2. The topic text

The **BROWSE DIALOG** statement allows you to browse a dialog file. Upon execution of the **BROWSE DIALOG** statement, the topic titles form a menu from which you may browse the topic texts in a menu-driven, conversational format — hence its name.

The **BROWSE TOPIC** statement displays a specific topic for browsing.

The PROMULA Tutorial is a collection of dialog files which you may browse by selecting option 3 off the Main Menu.

Examples:

1. The following program illustrates the definition of a dialog file. This file has three topics, entitled:

   ```
   Introduction
   Lesson 1
   Lesson 2
   ```

   All topics have text associated with them.

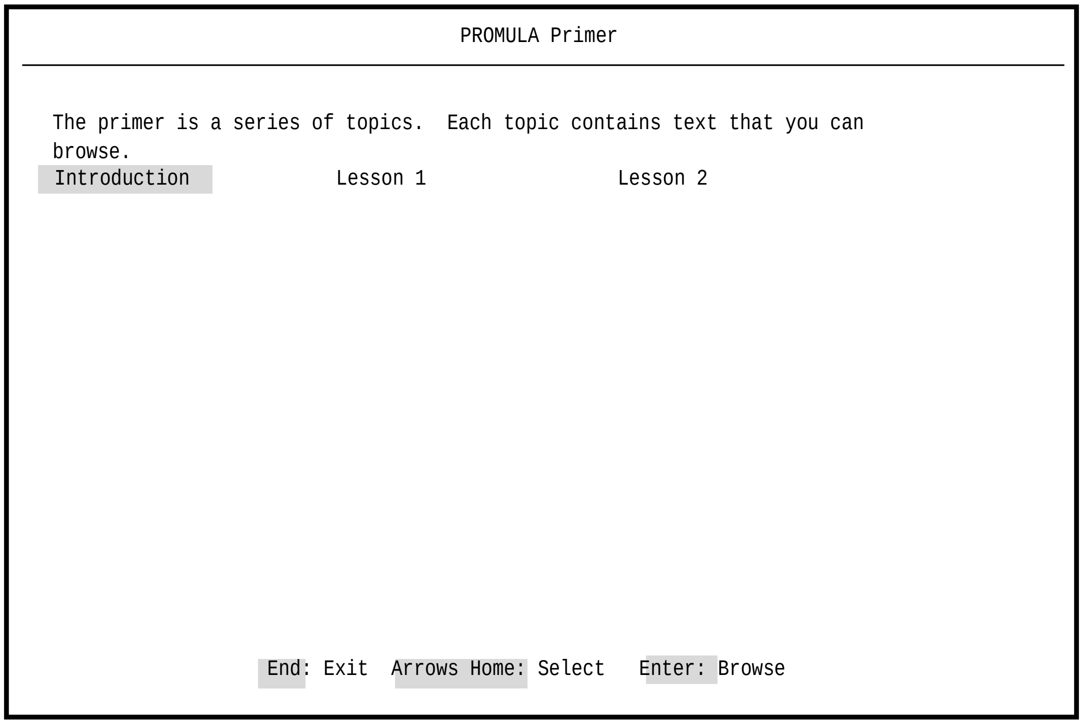
   The executable file is stored on a disk file named `b:dialog.tut`.

```
DEFINE DIALOG "b:dialog.tut"
                              PROMULA Primer
________________________________________________________________________________

  The primer is a series of topics.  Each topic contains text that you can
  browse.
END
TOPIC "Introduction"
  The primer is a series of lessons. The lessons are designed to show you
  how to write PROMULA programs. Though arranged in order of increasing
  complexity, the lessons may be run in any order.

  Sometimes the information displayed does not fit in the windows. Use the
  movement keys at the right end of your keyboard to browse long messages. The
  up and down arrows let you scroll one line at a time. The PgDn key displays
  the next page. The PgUp key displays the previous page. The Home key brings
  you back to the first page of the message.
END
TOPIC "Lesson 1"
  In this lesson, we discuss the DEFINE PROGRAM statement.

  In case you don't know, a "program" is a sequence of instructions that tell
```

```
          PROMULA what to do. A PROMULA instruction is called a "statement" or a
          "command."
        END
        TOPIC "Lesson 2"
          In this lesson we discuss the DEFINE VARIABLE statement, which is
          used to define the variables in your program.
        END
        END DIALOG
```

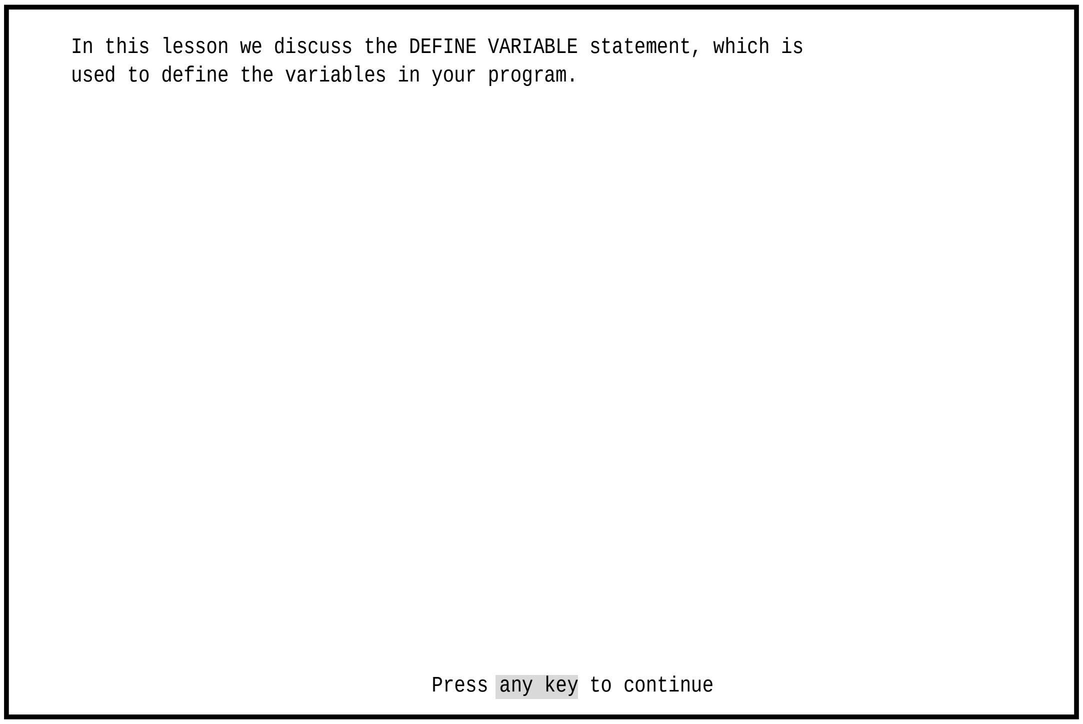
3.7.24.1 Executing the BROWSE DIALOG Statement

The statement `BROWSE DIALOG "b:dialog.tut"` produces the following display:



```
                              PROMULA Primer
 ------------------------------------------------------------------------------

   The primer is a series of topics.  Each topic contains text that you can
   browse.
   Introduction             Lesson 1                 Lesson 2


                  End: Exit  Arrows Home: Select   Enter: Browse
```

In this menu, the topic **`Introduction`** is highlighted first. Use the movement keys to select a topic, and press the **Enter** key to pick a topic for browsing. If you select the **`Lesson 2`** topic, the screen below is displayed.



```
In this lesson we discuss the DEFINE VARIABLE statement, which is
used to define the variables in your program.




















                                Press any key to continue
```

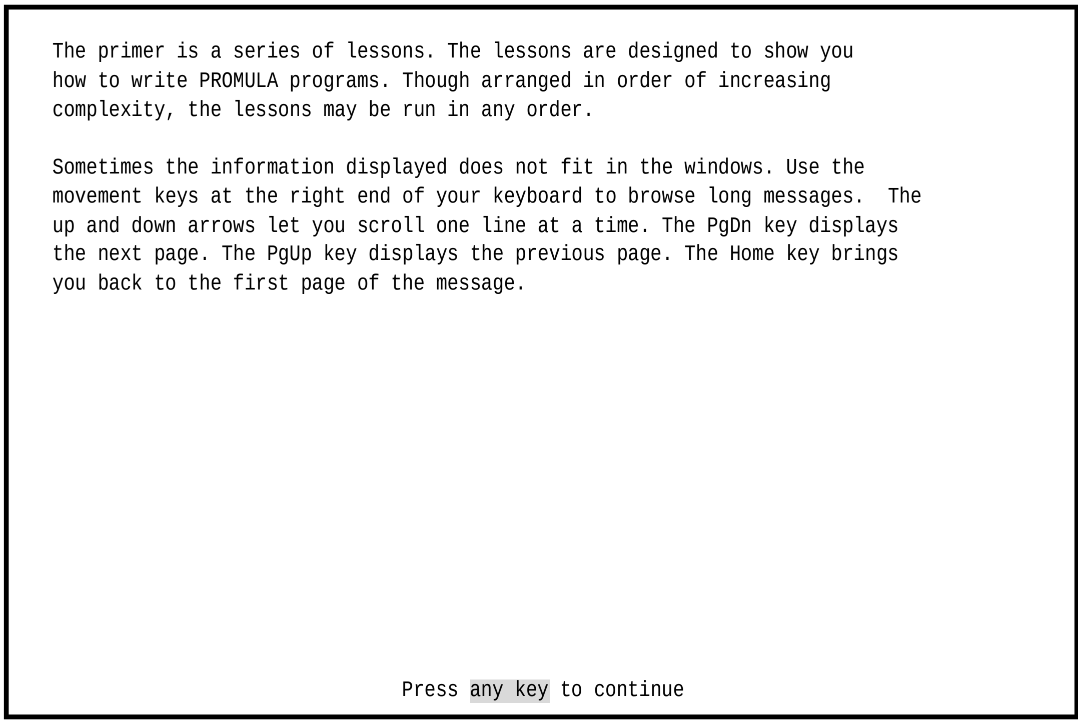
3.7.24.2 Executing the BROWSE TOPIC Statement

The **BROWSE TOPIC** statement displays a specific topic from a dialog file.

To display the first topic in the dialog file use the following statement:

```
BROWSE TOPIC "b:dialog.tut", 1
```

This produces the following display:



```
The primer is a series of lessons. The lessons are designed to show you
how to write PROMULA programs. Though arranged in order of increasing
complexity, the lessons may be run in any order.

Sometimes the information displayed does not fit in the windows. Use the
movement keys at the right end of your keyboard to browse long messages.  The
up and down arrows let you scroll one line at a time. The PgDn key displays
the next page. The PgUp key displays the previous page. The Home key brings
you back to the first page of the message.

                              Press any key to continue
```

3.7.25 DEFINE FILE

Purpose:

Defines a file that may be used as a program database, an input datafile, or an output report file.

Syntax:

```
DEFINE FILE
  file [TYPE=type] ["desc"]
  ...
END
```

Remarks:

`file`	is the file identifier.
`type`	is the file type, and can be one of the following:

ARRAY	for a random-access file of sets, variables, and relations. You can include as many sets, variables, and relations per file as you wish (within the capacity of your disk space). Array files are unique to PROMULA, they are especially well suited for the storage and retrieval of multidimensional information.
TEXT	for a sequential-access file of variable-length text records. Each record consists of items (or fields or scalar variables) that are laid out in lines of variable length (up to a maximum of 255 characters per line).
RANDOM	for a random-access file of fixed-length binary records. Each record consists of a fixed number of variables. The variables of a random file may be scalar items, or multidimensional arrays. You can specify as many variables per record as you wish (within the capacity of your

working space). You can include as many records as you wish (within the capacity of your disk space).

INVERTED(`n`) for a random-access file of user-specified keys associated with the records of a random file. An inverted file provides a fast and efficient way to search a random file with symbolic keys. `n` is an efficiency parameter that should equal your best estimate for the number of records that will match a given key. The safest but probably not the most efficient value for `n` is the number of records in the random file. Inverted files with a larger `n` require more disk space but they usually require less time to search.

If the **TYPE** clause is omitted from the file definition, the file will be assumed to be an array file.

`desc` is a file descriptor. This descriptor is only useful for program documentation purposes; it is an inline comment.

For an **ARRAY** or **RANDOM** file, the variables whose values are stored on file are defined by means of the **DEFINE VARIABLE file** statement.

The **OPEN file** statement physically opens a file to the place on disk where the data that you want to access through `file` is stored. Existing files should be opened **STATUS=OLD**, new files should be opened **STATUS=NEW**. A file must be opened before it can be used.

The **CLEAR file** statement closes the disk file that was assigned to a file by a previous open.

The **READ DISK** and **WRITE DISK** statements allow you to explicitly transfer information between your program memory space and the variables in an array file.

The **READ file** and **WRITE file** statements allow you to physically transfer information between your program memory space and the variables in text and random files.

Examples:

The following statements

```
DEFINE FILE
  txt   "TEXT file"      TYPE=TEXT

  dbf  "RANDOM File"     TYPE=RANDOM

  dba  "ARRAY File"      TYPE=ARRAY

  dbi  "INVERTED File"   TYPE=INVERTED(10)
END FILE
```

define three files: `txt`, which is a text file that may be used for test input and output, `dbf`, which is a random type file, and `dba`, which is an array file.

The structure of the array file, `dba`, could be used to contain weather data by the following code:

```
OPEN dba "wthr.dba" STATUS=NEW

DEFINE SET dba
  days(31) "Day"
  mons(12) "Month"
  year(10) "Year"
END SET dba

DEFINE VARIABLE dba
  wthdsc(days,mons,year) TYPE=STRING(20) "Description"
```

```
          hitemp(days,mons,year) TYPE=REAL(10,1) "High Temp"
          lotemp(days,mons,year) TYPE=REAL(10,1) "Low Temp"
          hihumd(days,mons,year) TYPE=REAL(10,2) "High Humidity"
          lohumd(days,mons,year) TYPE=REAL(10,2) "Low Humidity"
          hibarp(days,mons,year) TYPE=REAL(10,2) "High Barometric Pressure"
          lobarp(days,mons,year) TYPE=REAL(10,2) "Low Barometric Pressure"
        END VARIABLE dba

        CLEAR dba
```

Notice that an array file must be physically opened before its structure can be defined. This is because PROMULA physically initializes the entire file when its structure is defined for the first time.

To add variables to an existing array file, open the file **STATUS=OLD**.

Alternatively, this weather data coud be set up with random and inverted files as follows:

```
        DEFINE VARIABLE dbf
          wthdsc TYPE=STRING(20) "Description"
          hitemp TYPE=REAL(10,1) "High Temp"
          lotemp TYPE=REAL(10,1) "Low Temp"
          hihumd TYPE=REAL(10,2) "High Humidity"
          lohumd TYPE=REAL(10,2) "Low Humidity"
          hibarp TYPE=REAL(10,2) "High Barometric Pressure"
          lobarp TYPE=REAL(10,2) "Low Barometric Pressure"
          wthdat TYPE=DATE(10)   "Date"
        END VARIABLE dbf

        DEFINE VARIABLE dbi
          datekey   TYPE=DATE(10)      "Date Key"
          daterec   TYPE=INTEGER(10)   "Record"
        END VARIABLE dbi
```

Notice that random and inverted type files do not have to be opened when their structure is defined. Of course, they have to be opened when they are accessed.

For examples of using random and inverted files, see the **SELECT file** statement.

For examples of reading and writing to text files, see the **READ file** and **WRITE file** statements.

For additional examples on the use of array file databases in transferring data to and from disk, see Chapter 4.

See also the **COPY** statement and the discussion of the file management functions **FILEDELETE**, **FILEEXIST**, **FILESIZE**, **FILENAME**, **FILEEXT**, **FILEPATH**, and **GETDIR**.

3.7.26 DEFINE FUNCTION

Purpose:

Defines a single-valued function as the **linear interpolation** between points defined on the x-y plane. A function expresses an arbitrary relationship of one variable, the y-variable, to another variable, the x-variable. It is defined in terms of two arrays or variables. The first array contains the values of the x-variable while the second contains the values of the y-variable. These variable values are the x-y coordinates of the points defining the function.

Syntax:

```
        DEFINE FUNCTION
          func(arrx,arry)
          ifunc(arry,arrx)
```

```
      ...
    END
```

Remarks:

`func` is the function identifier.

`ifunc` is the identifier of the **inverse of function** `func`. Note, the order of `arrx` and `arry` is reversed.

`arrx` is the identifier of the real fixed or scratch variable containing the x-coordinates of the points defining the function.

`arry` is the identifier of the real fixed or scratch variable containing the y-coordinates of the points defining the function.

`arrx` and `arry` must be local variables: they may not be disk variables or variables used to access disk variables.

`arrx` and `arry` must have the same set as their first dimension. This is the set that "indexes" the function. The second and higher dimensions of `arrx` and `arry` will be fixed at the first element of their respective selection vectors when the value of the function is computed.

Although it is allowed for the sets dimensioning the second and higher dimensions of `arrx` to be different from those dimensioning `arry`, doing so will interfere with the displays produced by the **WRITE**, **BROWSE**, and **PLOT** function statements.

Functions are used in conditional expressions and in arithmetic expressions on the right-hand side of equations to yield the y-value corresponding to some x-value argument.

The value of a function for an arbitrary argument is obtained by 2-point linear interpolation between the points defining the function. For an argument outside its domain, the function returns the y-value of the function's nearest end point.

The argument of a function may be a constant, a scalar, a multidimensional variable, an arithmetic expression of many variables, or another function.

A function of x, y=func(x), gives you the value of y for a given value of x. The inverse function of x, x=ifunc(y), gives you the value of x for a given value of y (see Example 2 below).

In addition to their computational use, functions may be displayed in tabular form with the **BROWSE function** and **WRITE function** statements, and may be viewed in plotted form via the **PLOT** statement.

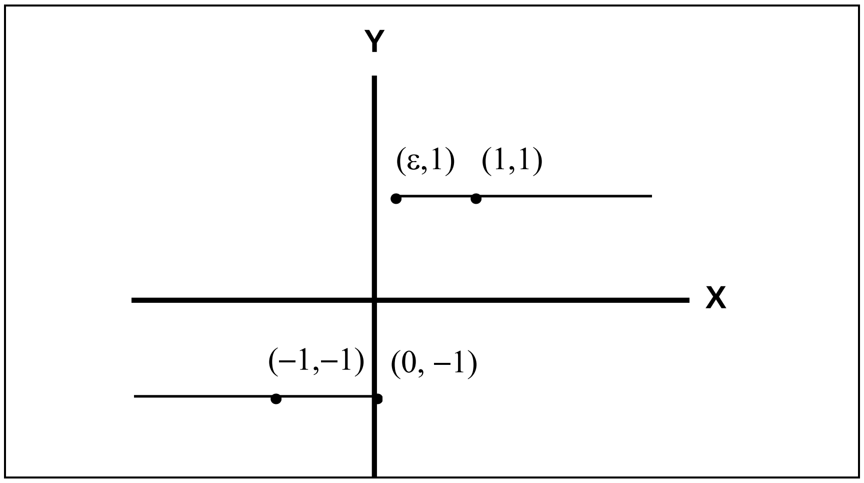
Examples:

1. The statements

```
    DEFINE SET
      point(4)
    END SET

    DEFINE VARIABLE
      a(point)   "x-coordinates"
      b(point)   "y-coordinates"
      x
      y
    END VARIABLE

    DEFINE FUNCTION
      stepf(a,b)
    END FUNCTION

    READ a
```

```
-1  0  .00001 1
READ b
-1 -1       1 1
```

define the step function `y=stepf(x)` shown below:



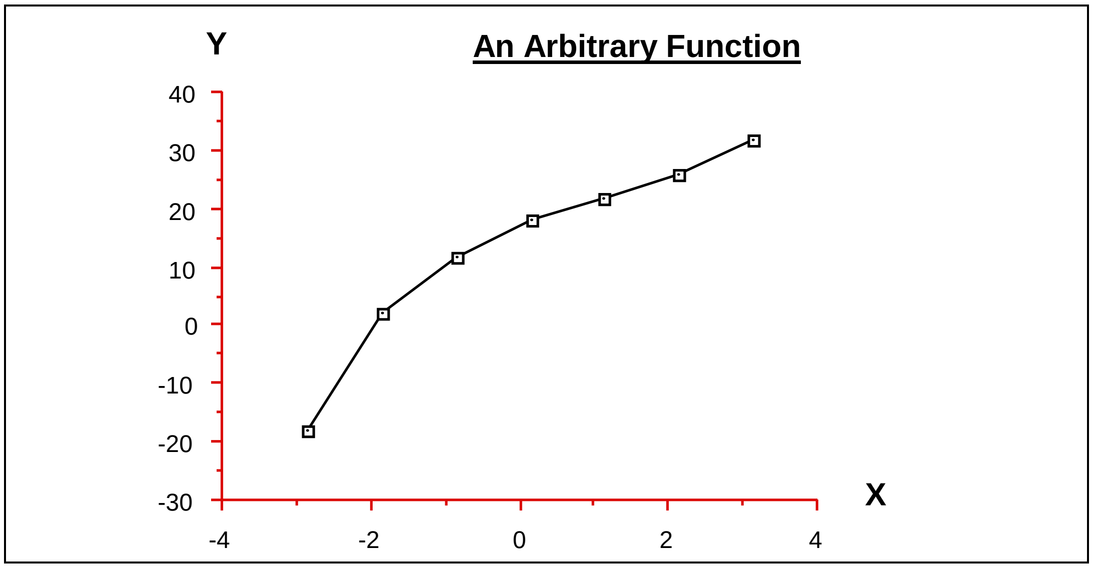
The step discontinuity at `(0,0)` is represented approximately to within ε=0.00001. For an arbitrary argument `x`, the expression `y=stepf(x)` yields a value `y`, as follows:

```
y = +1   IF x > 0.00001
y = -1   IF x = 0.0
y = -1   IF x < 0.0
```

This is illustrated by the dialog below.

```
x = -10
y = stepf(x)
WRITE y
-1

x = +10
y = stepf(x)
WRITE y
1
```

2. Consider the arbitrary function shown below.



What are the values of y when x is -4, 1.5, or 2.6? What are the values of x when y is 18.2, 22, or 34? The dialog below shows how to answer these questions.

```
    DEFINE SET
      dpnt(7)  "Points Defining Function"
      xpnt(3)  "Arbitrary Points"
    END SET
    DEFINE VARIABLE
      fx(dpnt) "Function X Values"   TYPE=REAL(10,2) VALUE(-3,-2,-1,0,1,2,3)
      fy(dpnt) "Function Y Values"   TYPE=REAL(10,2) VALUE(-20,0,10,16,20,24,30)
      x(xpnt)  "Arbitrary X Values"  TYPE=REAL(10,2)
      y(xpnt)  "Arbitrary Y Values"  TYPE=REAL(10,2)
    END VARIABLE
    DEFINE FUNCTION
      fun(fx,fy)  "An Arbitrary Function"
      ifun(fy,fx) "The Inverse of an Arbitrary Function"
    END

    DEFINE PROCEDURE shofun
     WRITE            TABLE(xpnt)            TITLE("Function            Values,
  y=fun(x)"),BODY(x,y),FORMAT(20,10)
    END
    READ x
    -4 +1.5 +2.6
    y=fun(x)
    shofun
                             Function Values, y=fun(x)
                                        XPNT(1)   XPNT(2)   XPNT(3)
                 Arbitrary X Values       -4.00      1.50      2.60
                 Arbitrary Y Values      -20.00     22.00     27.60
    READ y
    18.2 22 34
    x=ifun(y)
    shofun
                             Function Values, y=fun(x)
                                        XPNT(1)   XPNT(2)   XPNT(3)
                 Arbitrary X Values        0.55      1.50      3.00
                 Arbitrary Y Values       18.20     22.00     34.00
```

3.7.27 DEFINE LOOKUP

Purpose:

Defines a functional relationship between two sets of numbers.

Syntax:

```
DEFINE LOOKUP
  name(np) [xyoption]
END LOOKUP
```

Remarks:

`name`	is the identifier of the function
`np`	is the number of X-Y pairs that define the function.
`xyoption`	is used to specify values for the ordered pairs in the function and is of the form

`[X](`X_1`,`X_2`,...`X_{np}`),Y(`Y_1`,`Y_2`,...,`Y_{np}`)`

The X-Y option on the **DEFINE LOOKUP** statement is used to specify the independent, X, and dependent, Y, values associated with the function.

Each list of values must contain the number of points defined for the function, `np`. The X- and Y-values that define a function may also be specified via the **READ function** statement.

Functions defined by the **DEFINE LOOKUP** statement behave very much like functions defined by the **DEFINE FUNCTION** statement. Both types of functions are used primarily on the right-hand-side of equations or in conditional expressions. They yield, by linear interpolation or extrapolation, the Y-value corresponding to the specified argument, or X-value. In this sense, a function is viewed as a set of ordered pairs of numbers that specify the X- and Y-coordinates of the points defining the function. The argument used in the function call may be a numeric constant, a variable, or an arithmetic expression.

The important difference between the two types of functions is that functions defined by the **DEFINE FUNCTION** statement are related to a set that defines the number of X-Y pairs for the function and may contain descriptive information for the X-Y pairs, and to a pair of arrays that contain the X-Y values. Changes in the set or in the X or Y arrays changes the appearance and behavior of the function. Functions defined by the **DEFINE LOOKUP** statement, on the other hand, are not related to sets or variables; they contain a fixed set of paired numbers which are identified only as part of the function, and can only be changed by the **READ function** statement.

The value of a function for an arbitrary argument is obtained by 2-point linear interpolation between the points defining the function. For an argument outside its domain, the function returns the y-value of the function's nearest end point.

The argument of a function may be a constant, a scalar, a multidimensional variable, an arithmetic expression of many variables, or another function.

In addition to their computational use, functions may be displayed in tabular form with the **BROWSE function** and **WRITE function** statements, and may be viewed in plotted form via the **PLOT** statement.

Examples:

The following example illustrates the **DEFINE LOOKUP** statement.

```
DEFINE LOOKUP
```

```
           f1(10) X(1.0,2.0,3.0,4.0,5.0,6.0,7.0, 8.0, 9.0,10.0),
                  Y(1.2,2.3,3.8,4.5,5.5,6.9,9.9,12.0,14.5,15.9)
           f2(10)
         END LOOKUP
```

Here, the **DEFINE LOOKUP** statement is used to create two functions. `f1`, which gets initial values in its definition with an `xyoption`; and `f2` which has its initial values equal to zero. Both of these functions have 10 ordered X-Y pairs.

See also the **READ function**, **WRITE function**, **BROWSE function**, **PLOT** and **DEFINE FUNCTION** statements for more information on functions.

3.7.28 DEFINE MENU

Purpose:

Defines a screen menu for later use.

A screen menu is a type of program interface designed to help its user either to pick from a list of options or to display and/or edit data values.

Depending on content, intended use, and appearance, there are two kinds of menus:

1. **Pick menus** to help the user make a selection from a set of options using the **SELECT menu** statement. There are three types of pick menus: (1) Simple, one-window pick menus defined with a basic **DEFINE MENU** statement, (2) Popup, two-window pick menus defined with a **DEFINE MENU POPUP** statement, and (3) Pulldown pick menus defined with a **SELECT PULLDOWN** statement

2. **Data menus** to create screens for data entry or display using the **EDIT menu** statement

This section describes the **DEFINE MENU** statement. For additional information and examples of using menus, refer to the examples at the end of this section and to the sections covering the **SELECT menu**, **EDIT menu**, **SELECT PULLDOWN**, and **SELECT FIELD** statements.

Syntax 1: Simple Pick Menu Definition

```
DEFINE MENU menu [VARIABLE]
text...
 ...
text... \choice1\  \choice2\ text...
text... \choice3\  \choice4\ text...
 ...
END
```

Remarks:

`menu`	is the menu identifier.
`text`	is arbitrary text that you may enter anywhere in the menu template to describe menu selection fields. To produce fancy menu displays, you may use any character that you can enter with your text editor including those that are not shown explicitly on the keyboard.
`choicen`	is the label for the nth selection field in the pick menu. The selection fields are ordered from 1 to n as you go from left to right and from top to bottom of the menu. Up to 20 selection fields may be defined.

The `text` and `choicen` elements may contain any character except:

the backslash character (\), which is reserved to set off the selection fields of the menu

the at character (@), which is reserved to set off data fields to be edited in data menus
the tilde character (~), which is reserved to set off display-only fields in data menus.

`VARIABLE` is a keyword labeling the pick menu as a **VARIABLE** pick menu. This keyword is only required if you intend to use the **SELECT FIELD** statement to modify the menu at runtime.

Simple pick menus are much simpler to define than popup pick menus, but are not as flashy or flexible as popup or pulldown pick menus.

Syntax 2: Popup Pick Menu Definition

```
DEFINE   MENU   menu1,   POPUP(swind,twind)    MENU HEADER
[VARIABLE]

text...                                        SELECTION SCREEN
text... \choice1\  \choice2\ text...           DEFINITION
text... \choice3\  \choice4\ text...
 ...
END

FIELD    n,    SELECT=char,    HELP=topic,     FIELD STATEMENT
ACTION=code
desc
 ...
END
 ...
MENU menu2                                     SUBMENU DEFINITION
text...
text... \choice11\  \choice12\ text...
text... \choice13\  \choice14\ text...
 ...
END
FIELD    n,    SELECT=char,    HELP=topic,
ACTION=code
desc
 ...
END
...
END menu1
```

Remarks:

A popup menu definition consists of a top level menu definition and several optional submenu definitions. Each menu definition consists of a **selection screen** and a group of **FIELD statements**. The keyword **POPUP** following the identifier of a menu indicates to PROMULA that the menu is a popup pick menu.

`menu1` is the identifier of the menu.

`swind` is the name of the screen area defined via a **DEFINE WINDOW** statement that will display the selection screens when the menu is executed.

`twind` is the name of the screen area defined via a **DEFINE WINDOW** statement that will display the description of each selection field as it is highlighted during menu execution.

`text` is arbitrary text that you may enter anywhere in the menu template to describe menu selection fields. To produce fancy menu displays, you may use any character that you can enter with your text editor including those that are not shown explicitly on the keyboard.

`choicen` is the label for the nth selection in the pick menu. The selection fields are ordered from 1 to n as you go from left to right and from top to bottom of the menu template.

The `text` and `choicen` elements may contain any character except:

the backslash character (\), which is reserved to set off the selections in pick menus
the at character (@), which is reserved to set off data fields to be edited in data menus
the tilde character (~), which is reserved to set off data fields to be displayed but not edited in data menus.

`n` is an integer that indicates to which selection field the **FIELD** statement corresponds.

`char` is a character that can be used to select the desired field. Any printable character may be used.

`topic` is the sequence number, as defined by its place in a dialog file, of a specific topic containing information relevant to the selection field. The dialog file used is determined by a **SELECT HELP** statement. Pressing **Alt-H** will select this topic from the program's help file and display it in the Help Screen. If no help has been defined, you can enter a 0 for this parameter.

`code` is a number between 0 and 255 or the name of a submenu defined in this **DEFINE MENU** statement. If `code` is a number, the value will be returned when the field is selected; if code is a submenu name, the submenu will be displayed for selection.

`desc` is text that describes the selection field.

`menu2` is the identifier of a submenu. Each submenu is defined in the same way as the top level menu except that the submenu header only includes the name of the submenu.

`VARIABLE` is a keyword labeling the pick menu as a **VARIABLE** pick menu. This keyword is only required if you intend to use the **SELECT FIELD** statement to modify the menu at runtime.

Syntax 3: Data Menu Definition

```
DEFINE MENU menu
text...
 ...      ~~~~~     ~~~~~~~
text...   @@@@@     @@@@@@@ text...
text...   @@@@@     @@@@@@@ text...
 ...
END
```

Remarks:

`menu` is the menu identifier.

`text` is arbitrary text that you may enter anywhere in the menu template to describe menu selection fields. To produce fancy menu displays, you may use any character that you can enter with your text editor including those that are not shown explicitly on the keyboard.

This text may contain any character except:

the backslash character (\), which is reserved to set off the selections in pick menus
the at character (@), which is reserved to set off data fields to be edited in data menus
the tilde character (~), which is reserved to set off data fields to be displayed but not edited in data menus.

`@@@@@@@@` marks the space in the template where the value of a program variable will be displayed for editing.

`~~~~~~~~` marks the space in the template where the value of a data field will simply be displayed and will not be available for editing.

Data menus contain a number of fields to be viewed and/or edited by the user. Each field in the menu is denoted by a series of contiguous "at signs", `@`, equal in number to the desired number of characters in the data field. The fields are ordered from left to right and from top to bottom of the menu template.

Examples:

The following example illustrates the definition and use of one screen pick and data menus; it illustrates the **DEFINE MENU** statement as well as the **SELECT menu** and the **EDIT menu** statements.

Define several variables for use with the example.

```
DEFINE VARIABLE
  a             "A value"
  b             "B value"
  tot           "Sum of A + B"
  date          "Date"                       TYPE=DATE(8)
  name          "Name"                       TYPE=STRING(10)
  option        "Menu selection"
END VARIABLE
```

Define a Data Menu.

```
DEFINE MENU data

   ********************************* A Data Menu ******************************
   *                                                                          *
   *   Enter/Edit Inputs                                                      *
   *                                                                          *
   *                                                                          *
   *   Name   : @@@@@@@@@@                        Date: @@@@@@@@              *
   *                                                                          *
   *   A Value: @@@@@@@@                                                      *
   *                                                                          *
   *   B Value: @@@@@@@@                                                      *
   *                                                                          *
   ****************************************************************************
END
```

Define a Pick Menu.

```
DEFINE MENU pick

   ********************************* A Pick Menu *******************************
   *                                                                           *
   *    Main Selection Menu                                                    *
   *                                                                           *
   *                                                                           *
   *                                                                           *
   *                               Press the desired Function key              *
   *      F1 \Return to PROMULA\                                               *
   *                               or                                          *
   *      F2 \Edit Input Values\                                               *
   *                             1. Press the UP and DOWN arrow keys           *
```

```
      *      F3 \Calculate Totals\          to move the bounce bar               *
      *                                                                          *
      *      F4 \Display Results\       2. Press the Enter key to pick           *
      *                                                                          *
      ****************************************************************************
   END
```

Define a procedure to control the execution of menu "pick" and menu "data"

```
   DEFINE PROCEDURE start
   * Select from Menu "pick"
   SELECT pick(option)
   * Edit a Data Menu
   DO IF option EQ 2
      EDIT data(name,date,a,b)
      start
   END option 2
   * Compute Totals
   DO IF option EQ 3
     tot=a+b
     start
   END option 3
   * Display Results
   DO IF option EQ 4
      WRITE ("Name      ","Date      ","A Value   ","B Value   ","Sum of A + B")
      WRITE (name\1,date\11,a\21,b\31,tot\41)
      ASK CONTINUE
      start
   END option 4
   END start
```

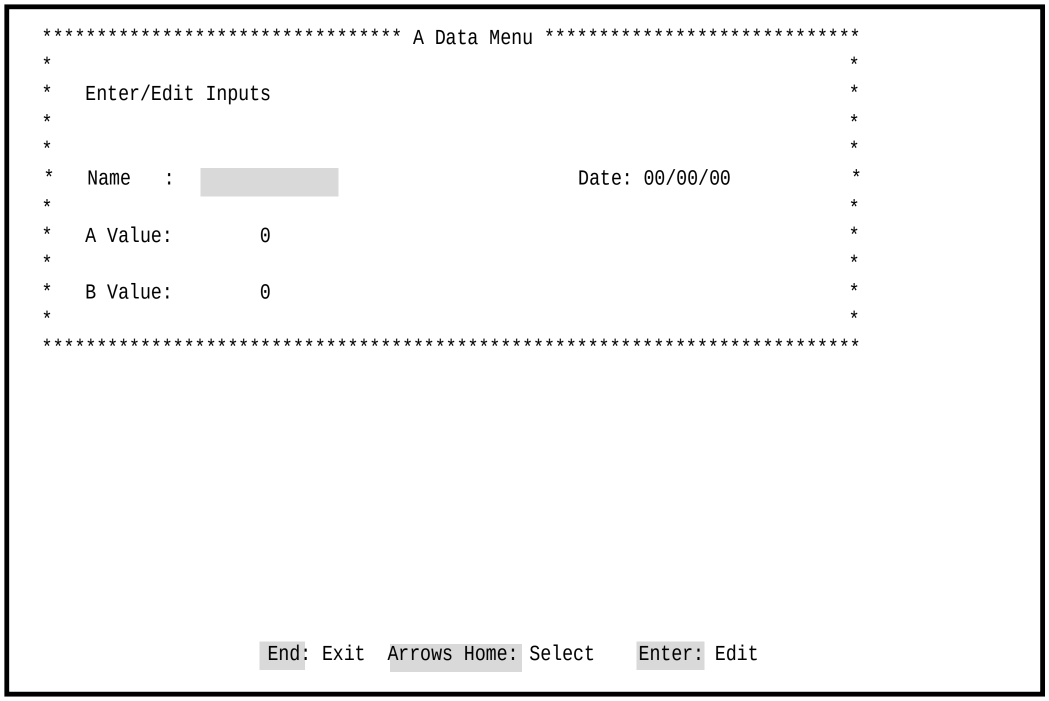
The statement **SELECT pick(`option`)** in procedure `start` produces the display below:

```
*************************************      A      Pick      Menu
*************************************
*
*
*                        Main          Selection            Menu
*
*
*
*
*
*
*
*
*                                          Press  the  desired
```

A bounce bar highlights the first selection **Return to PROMULA**, which is the text between the first two backslashes in the definition of menu `pick`. You may make a selection by

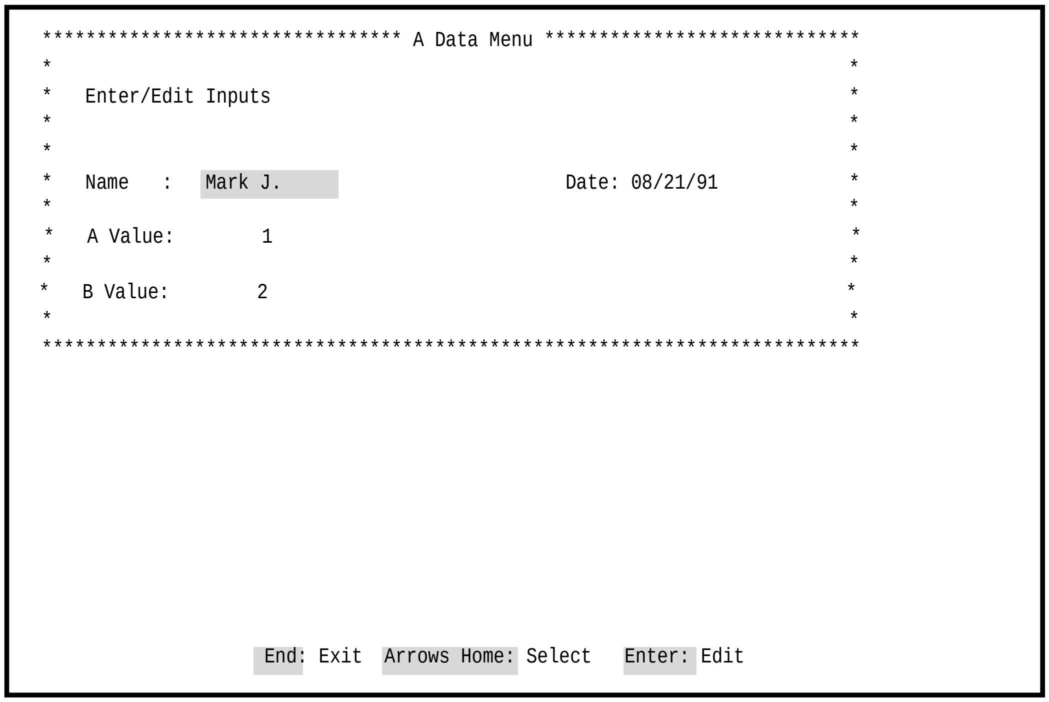
1. pressing a function key **F1**, **F2**, **F3**, or **F4** (or a numeric key 1,2,3,or 4).
2. using the movement keys and the Enter key to pick a selection.
3. pointing and clicking in the selection field (between the back slashes) with a mouse or other pointer device.

If you select option 2 — **Edit Input Values** — PROMULA will execute the statement `EDIT data(name,date,a,b)` and will display the following **EDIT menu** display:



```
********************************* A Data Menu ****************************
*                                                                        *
*   Enter/Edit Inputs                                                    *
*                                                                        *
*                                                                        *
*   Name   :                              Date: 00/00/00                 *
*                                                                        *
*   A Value:       0                                                     *
*                                                                        *
*   B Value:       0                                                     *
*                                                                        *
**************************************************************************

                      End: Exit  Arrows Home: Select    Enter: Edit
```

Here, the bounce bar is highlighting the ten spaces following the text "`Name      :`". By pressing the **Enter** key, you may introduce a particular name for this data field. By using the movement keys, you may edit the rest of the data fields to produce the following display:



```
********************************* A Data Menu ****************************
*                                                                        *
*   Enter/Edit Inputs                                                    *
*                                                                        *
*                                                                        *
*   Name   :  Mark J.                    Date: 08/21/91                  *
*                                                                        *
*   A Value:       1                                                     *
*                                                                        *
*   B Value:       2                                                     *
*                                                                        *
**************************************************************************

                      End: Exit  Arrows Home: Select    Enter: Edit
```

The following example illustrates the definition and use of Popup pick menus. First, the structural entities of the program: variables, windows, and menus are defined.

```
        DEFINE VARIABLE
```

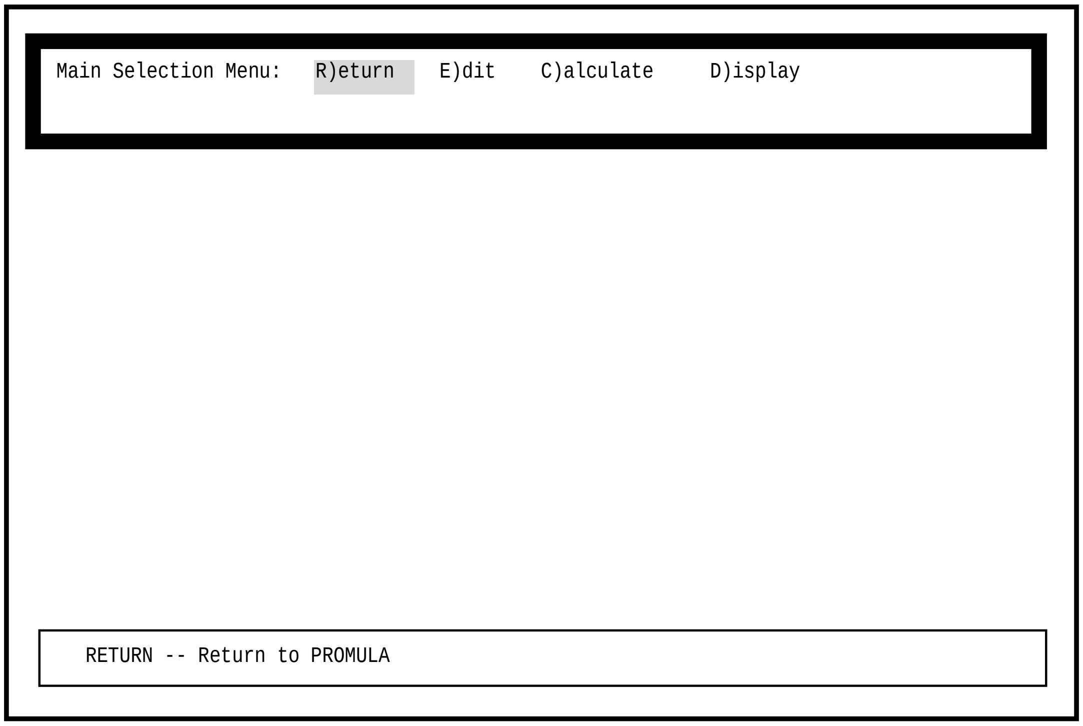
```
  a              "A value"
  b              "B value"
  prd            "Product of A * B"
  date           "Date"                       TYPE=DATE(8)
  name           "Name"                       TYPE=STRING(10)
  option         "Menu selection"
END VARIABLE

DEFINE WINDOW
  wwind(0,5,79,21,WHITE/BLACK,NONE)
  swind(1,1,78,3,WHITE/BLACK,FULL/HEAVY)
  twind(1,23,78,23,WHITE/BLACK,FULL/SINGLE)
END WINDOW

DEFINE MENU pick, POPUP(swind,twind)
Main Selection Menu:  R)eturn  E)dit  C)alculate   D)isplay
END
FIELD 1, SELECT=R, HELP=0, ACTION=10
  RETURN -- Return to PROMULA
END
FIELD 2, SELECT=E, HELP=0, ACTION=20
  EDIT -- Edit Input Values
END
FIELD 3, SELECT=C, HELP=0, ACTION=menu2
  CALCULATE -- Calculate Totals
END
FIELD 4, SELECT=D, HELP=0, ACTION=40
  DISPLAY -- Display Results
END
************** Define of a submenu called menu2
MENU menu2
Calculations Menu: R)eturn C)ompute
END
FIELD 1, SELECT=R, HELP=0, ACTION=pick
  RETURN -- Return to Main Selection Menu
END
FIELD 2, SELECT=C, HELP=0, ACTION=30
  COMPUTE -- Compute the product of A and B
END
END pick


DEFINE MENU data

   ********************************* A Data Menu *****************************
   *                                                                         *
   *   Enter/Edit Inputs                                                     *
   *                                                                         *
   *                                                                         *
   *   Name   : @@@@@@@@@@                           Date: @@@@@@@@          *
   *                                                                         *
   *   A Value: @@@@@@@@                                                     *
   *                                                                         *
   *   B Value: @@@@@@@@                                                     *
   *                                                                         *
   ***************************************************************************
END
```

Next, a procedure to control the program is defined.

```
DEFINE PROCEDURE ctrl
SELECT pick(option)
DO IF option EQ 10
```

```
* Exit procedure
  BREAK ctrl
ELSE  option EQ 20
* Edit a Data Menu
  EDIT data(name,date,a,b)
ELSE  option EQ 30
* Compute Product
  prd = a * b
ELSE  option EQ 40
* Display Results
  WRITE ("Name      ","Date      ","A Value   ","B Value   ","Product of A * B")
  WRITE (name\1,date\11,a\21,b\31,prd\41)
  WRITE (/"Press any key to continue.") CLEAR(-1)
END option
ctrl
END ctrl
```

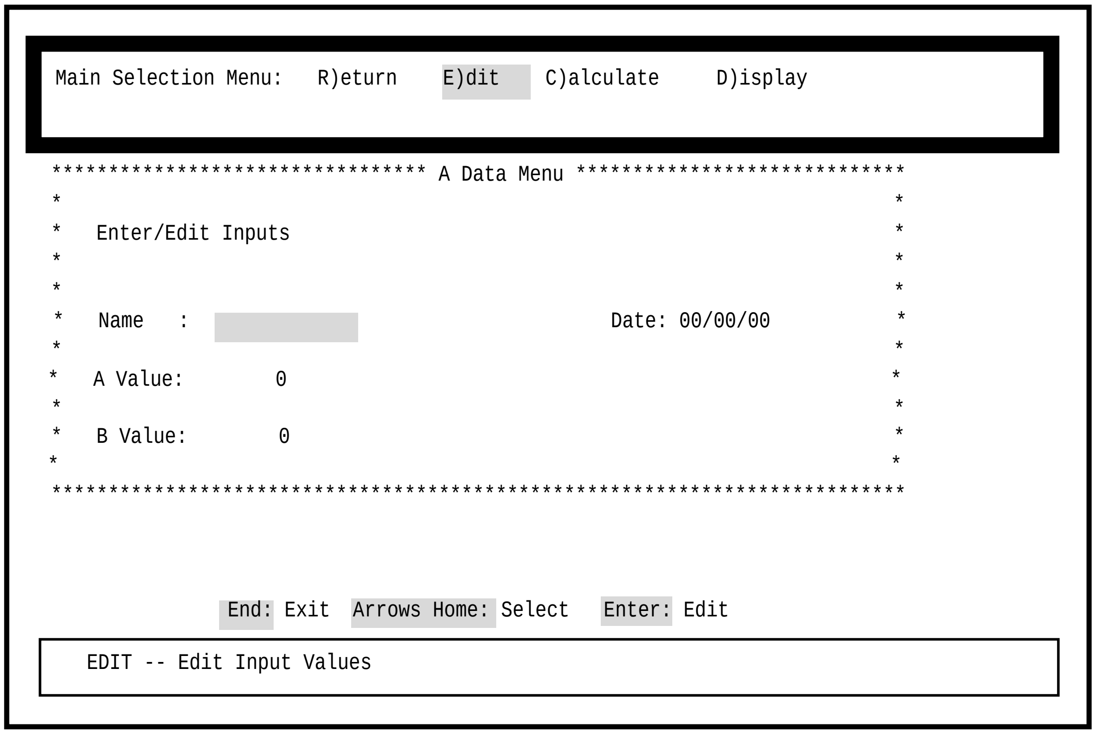
Before using the menu, you must open up a window to the main screen using the statement `OPEN wwind MAIN`. Executing procedure `ctrl` produces the display below:



```
Main Selection Menu:   R)eturn   E)dit    C)alculate     D)isplay

   RETURN -- Return to PROMULA
```

A bounce bar highlights the 1st selection **`R)eturn`**, which is the text between the two backslashes in the definition of menu `pick`. The descriptions of the selection fields appear in the screen area, `twind`. You may press the selection characters `R`, `E`, `C`, or `D` to make a selection, or use the movement keys and the Enter key to pick a selection.

Pressing the **E** key will execute the statement `EDIT data(name,date,a,b)` which produces the following screen:



```
Main Selection Menu:   R)eturn    E)dit    C)alculate     D)isplay

********************************* A Data Menu *****************************
*                                                                         *
*   Enter/Edit Inputs                                                     *
*                                                                         *
*                                                                         *
*   Name   :                                   Date: 00/00/00             *
*                                                                         *
*   A Value:        0                                                     *
*                                                                         *
*   B Value:        0                                                     *
*                                                                         *
***************************************************************************



                End: Exit  Arrows Home: Select   Enter: Edit

    EDIT -- Edit Input Values
```

Here, the bounce bar is highlighting the ten spaces following the text "`Name      :`". By pressing the **Enter** key, you may introduce a particular name for this data field. By using the movement keys, you may edit the rest of the data fields to produce the following display:

After editing, you will return to the menu below, from which you can calculate the product of `A` and `B`, and display results in the Main Screen.

3.7.29 DEFINE PARAMETER

Purpose:

Defines numeric parameters for procedures. Parameters are used to transfer data values to and from procedures.

Syntax:

```
DEFINE PARAMETER
  param[(sets)]["desc"][TYPE=type]
  ...
END
```

Remarks:

`param`	is the parameter identifier.
`sets`	is a list of sets that define the structure of the parameter.
`desc`	is a parameter descriptor.
`type`	is the type of the parameter and may be one of the following:

REAL	to specify real values

INTEGER	to specify integer values
MONEY	to specify money values.

Other types of parameters are allowed, but they are of limited use because their values cannot be passed to or from the actual arguments of the procedure.

A parameter is a numeric variable which is used locally within a procedure. Parameters may be scalars or multidimensional arrays. A parameter identifier cannot be defined or referenced outside a procedure.

A procedure `proc` with parameters `a`, `b`, `c`,`...` may be called into execution by simply entering its name and specifying an ordered list of variables (often referred to as the **actual arguments** of the procedure) corresponding to the parameter list. The type and order of variables in the variable list must agree with the type and order of the parameters as defined in procedure `proc`.

```
proc(x,y,z,...)
```

If the parameters are multidimensional arrays, the variable arguments of the procedure must be followed by the identifiers of the sets that dimension them.

```
proc(x(set1,set2,...),y(set1,set2,...),z(set1,set2,...),...)
```

NOTE: The values of parameters do not use any storage, nor do they retain their values between procedure calls.
Examples:

The procedure `minx` defined below has three parameters:

```
DEFINE PROCEDURE minx
  DEFINE PARAMETER
    a     "Value to be compared with b"
    b     "Value to be compared with a"
    c     "Min of (a,b)"
  END PARAMETER
  c = a
  DO IF b LT c
    c = b
  END IF
END PROCEDURE minx
```

The purpose of this procedure is to compare the value of `b` with the value of `a` and to return the minimum of the two values in parameter `c`.

This procedure, when called by another procedure `cmin`, compares two variables, `x` and `y`, and returns the minimum of the two in variable `z`, as shown in the dialog below:

```
DEFINE VARIABLE
  x
  y
  z
END VARIABLE

DEFINE PROCEDURE cmin
  minx(x,y,z)
  WRITE ("x=",x,"  ","y=",y,"  ","MIN(x,y)=",z)
END PROCEDURE cmin

x = 3
y = 4
cmin
x=3  y=4  MIN(x,y)=3
```

Procedure `cmin` calls into execution procedure `minx`. The calling statement is:

```
minx(x,y,z)
```

From this, you can see that variable `x` corresponds to parameter `a`, variable `y` corresponds to parameter `b`, and variable `z` corresponds to parameter `c`.

Procedure `stats` takes as its argument a two-dimensional array of values. It displays the values of each column of the array in ascending order and computes and displays the number of values, the total, and the mean of each column.

```
DEFINE SET
pnt(5)
col(2)
END SET

DEFINE VARIABLE
xval(pnt,col) TYPE=REAL(10,2) "X VALUES"
END VARIABLE

DEFINE PROCEDURE stats
DEFINE PARAMETER
  vec(pnt,col)  "Input Table"
  n             "Number of Values"
  tot           "Total of Input Vector"
  ave           "Average of Input Vector"
END PARAMETER
DO col
  SORT pnt USING vec
  n=col:s
  WRITE CENTER("INPUT VECTOR #"n:-2/"------------------")
  DO pnt
     WRITE CENTER(vec:6:2)
  END
  SELECT pnt*
  tot = SUM(i) vec(i)
  n   = pnt:N
  ave = tot/n
  WRITE CENTER("    n = "n:-5,"TOTAL = "tot:-10:2,"MEAN = "ave:-10:3/)
END col
END PROCEDURE stats

READ xval(col,pnt)
31 11 21 91 41
32 42 52 12 12
```

Given the defintions above, the statement

```
stats( xval(pnt,col) )
```

produces the report below.

```
                                INPUT VECTOR #1
                               ------------------
                                      11.00
                                      21.00
                                      31.00
                                      41.00
                                      91.00
                    n = 5    TOTAL = 195.00    MEAN = 39.000
```

```
                                    INPUT VECTOR #2
                                   ------------------
                                          12.00
                                          12.00
                                          32.00
                                          42.00
                                          52.00
                            n = 5     TOTAL = 150.00    MEAN = 30.000
```

3.7.30 DEFINE PROCEDURE

Purpose:

Defines a group of statements for later execution as a single unit.

Syntax:

```
DEFINE PROCEDURE proc [comment]
  statement
 ...
END comment
```

Remarks:

`proc`	is the procedure identifier.
`statement`	is any executable statement.
`comment`	is optional text you wish to enter as an in-line comment.

Definitions are not allowed within procedures, except for the **DEFINE PARAMETER** statement, which defines procedure parameters. Similarly, data for a **READ** statement is not allowed in a procedure.

A procedure is executed by the [**DO**] **procedure** statement, i.e., by simply entering its name.

PROMULA supports recursive procedures, i.e., a procedure can call itself into execution. A procedure can call other defined procedures into execution.

Examples:

1. The following statements

```
DEFINE PROCEDURE hello -- write a greeting
  WRITE "Hello there!"
END PROCEDURE hello
```

define the procedure `hello` whose sole purpose is to issue the message `Hello there!`, as shown in the dialog below

```
DO hello
Hello there!
```

2. The following procedures `rdsales` and `tsales`

```
DEFINE PROCEDURE rdsales
  WRITE "Enter Monthly Sales"
```

```
    READ sales
  END PROCEDURE rdsales

  DEFINE PROCEDURE tsales
    rdsales
    total = SUM(month)( sales(month) )
    WRITE ("Total Annual Sales  ",total)
  END PROCEDURE tsales
```

execute as follows:

```
tsales
Enter Monthly Sales
1000 1100 1200 1150 1300 1350
1400 1600 1000 1100 1570 1600
Total Annual Sales  15,370
```

Above, procedure `tsales` calls procedure `rdsales` into execution to produce the same results as those of Example 2.

3. The following is a procedure with parameters

```
DEFINE PROCEDURE xmax
  DEFINE PARAMETER
    a
    b
    c "Max of (a,b)"
  END PARAMETER
  DO IF a GE b
    c = a
  ELSE
    c = b
  END IF
END PROCEDURE xmax
```

The purpose of this procedure, `xmax`, is to compare two values and return the larger of the two, as shown in the dialog below:

```
DEFINE PROCEDURE callxmax
  xmax(x,y,z)
END PROCEDURE callxmax

x = 2
y = 3
callxmax
WRITE z
3
```

3.7.30.1 Dynamic Procedures

Dynamic procedures are used in dynamic simulations. In dynamic simulations modeling, variables interact with each other and change over time. PROMULA has several features that facilitate the development of dynamic models: these include time series sets, system Time parameters, the **TIME**, **RATE**, and **LEVEL** statements, and dynamic procedures.

Dynamic procedures contain **RATE** and **LEVEL** statements which divide the procedure into three separate sections.

1. **The Initial section**. Here, all time parameters have the values that were assigned by the last **TIME** statement. The variables **DT**, **BEGINNING**, and **ENDING** maintain these original values throughout the run of the dynamic procedure. The Initial section includes all the statements in the procedure preceding the **RATE** section and its equations are evaluated once — at the beginning time point (or interval) of the simulation period.

2. **The RATE section**. The start of the **RATE** section is indicated by the **RATE** statement. The **RATE** section is the second section of a dynamic procedure and its equations are evaluated at each time point (or interval) of the simulation run. In contrast to **LEVEL** equations, both sides of **RATE** equations are evaluated at the same time point (or interval). At the end of the **RATE** section, the value of the time parameter **TIME** is examined. If **TIME+DT** exceeds the value of **ENDING**, the execution of the procedure ends. If **TIME+DT** does not exceed the value of **ENDING**, then **TIME** is incremented by **DT**, and the execution of the procedure proceeds to the **LEVEL** section.

3. **The LEVEL section**. The start of the **LEVEL** section is indicated by the **LEVEL** statement. The **LEVEL** section follows the **RATE** section and its equations are also evaluated at each time point (or interval) of the simulation. The lefthand side of each **LEVEL** equation, however, is evaluated at **TIME+DT** in terms of the time variables on the righthand side which are evaluated at **TIME** — the previous time point (or interval). It is the equations of the **LEVEL** section which move the dynamic variables through time. After execution of the statements in the **LEVEL** section, execution returns to the beginning of the **RATE** section.

Examples:

An example of a dynamic procedure is shown below:

```
DEFINE PROCEDURE DYNAM1
** Begin Initial Section
  WRITE CENTER("Initial Section. Time=",TIME)
  POPT=100000
** End Initial Section / Begin Rate Section
RATE (BRTYR=BRTV, MRTYR=MRTV)
  WRITE CENTER(/"Rate Section. Time=",TIME)
  DRGV  = DRG(TIME)
  BTHS  = POPT * BR * BRTV
  MGNTS = POPT * MR * MRTV
  DTHS  = POPT * DR * DRGV
  WRITE POPT
  WRITE BTHS
  WRITE MGNTS
  WRITE DTHS
  WRITE BRTV::4
  WRITE MRTV::4
  WRITE DRGV::4
** End Rate Section / Begin Level Section
LEVEL ( POPYR=POPT, BTHYR=BTHS, DTHYR=DTHS, MGTYR=MGNTS)
  WRITE CENTER (/"Level Section, Time=", TIME)
  POPT = POPT + (DT * BTHS) + (DT * MGNTS) - (DT * DTHS)
  WRITE POPT
END PROCEDURE DYNAM1
```

In procedure `DYNAM1`, the population size is set to 100,000 in the initial section. The **RATE** section computes local variables `BRTV`, and `MRTV` by linear interpolation of the values of the exogenous time series variables `BRTYR` and `MRTYR` and uses these values to compute time-specific values for `BTHS`, and `MGNTS`. The value of `DRGV` is computed via function `DRG` then used in computing `DTHS`. In the **LEVEL** section, the results are transferred from the endogenous scalar variables, `POPT`, `BTHS`, `DTHS`, and `MGNTS` to the output time series variables, `POPYR`, `BTHYR`, `DTHYR`, `MGTYR` as specified in the **LEVEL** statement; and the value of `POPT` is computed to reflect the changes that occurred during the last time interval.

The code required to implement the procedure above to model population values over time is displayed below.

```
DEFINE SET
  timeb(3) "Set of Years for Birth Rate Trend"     TIME(1990,1995,2000)
  timem(4) "Set of Years for Migration Rate Trend" TIME(1990,1993)
  year(16) "Set of Years to Be Modeled"            TIME(1990,2005)
END SET
```

```
DEFINE VARIABLE
  BR           "Annual Birth Rate            " VALUE = 0.0065
  DR           "Annual Death Rate            " VALUE = 0.05
  MR           "Annual Migration Rate        " VALUE = 0.001
  BRTV         "Birth Rate Trend Value       "
  MRTV         "Migration Rate Trend Value "
  DRGV         "Death Rate Graph Value       "
  BRTYR(timeb) "Birth Rate Trend"              VALUE(1,0.8,0.8)
  MRTYR(timem) "Migration Rate Trend"          VALUE(1,1,-1,-1)
  POPT         "Total Population             "
  BTHS         "Births per Year              "
  DTHS         "Deaths per Year              "
  MGNTS        "Net Migrants per Year        "
  POPYR(year)  "Total Population"
  BTHYR(year)  "Births"
  DTHYR(year)  "Deaths"
  MGTYR(year)  "Net Migrants"
END VARIABLE

DEFINE LOOKUP
  DRG(3),X(1990,1995,2005), Y(1,0.8,0.7)
END LOOKUP

DEFINE TABLE
  tab(year), FORMAT(20,10), BODY(POPYR,BTHYR,DTHYR,MGTYR)
END REPORT

DEFINE PROCEDURE dynam1
  WRITE CENTER("Initial Section. Time=",TIME)
  POPT=100000
RATE (BRTYR=BRTV,MRTYR=MRTV)
  WRITE CENTER(/"Rate Section. Time=",TIME)
  DRGV  = DRG(TIME)
  BTHS  = POPT * BR * BRTV
  MGNTS = POPT * MR * MRTV
  DTHS  = POPT * DR * DRGV
  WRITE POPT
  WRITE BTHS
  WRITE MGNTS
  WRITE DTHS
  WRITE BRTV::4
  WRITE MRTV::4
  WRITE DRGV::4
LEVEL ( POPYR=POPT,BTHYR=BTHS, DTHYR=DTHS, MGTYR=MGNTS)
  WRITE CENTER (/"Level Section, Time=", TIME)
  POPT = POPT + (DT * BTHS) + (DT * MGNTS) - (DT * DTHS)
  WRITE POPT
END PROCEDURE dynam1
```

Given the definitions above, the statements

```
TIME(1, 1990, 1993),SIZE(5,0)
dynam1
SELECT year(1-4)
tab TITLE "Results for Dynamic Simulation (DT = 1 Year)"
```

generate the following report as the population simulation procedure `DYNAM1` "moves through time".

```
                              Initial Section. Time= 1990
```

```
                                Rate Section. Time=1,990
          Total Population           (1990) 100,000
          Births per Year            (1990) 650
          Net Migrants per Year      (1990) 100
          Deaths per Year            (1990) 5,000
          Birth Rate Trend Value     (1990) 1.0000
          Migration Rate Trend Value (1990) 1.0000
          Death Rate Graph Value     (1990) 1.0000

                                    Level Section, Time=1,991
          Total Population           (1991) 95,750

                                     Rate Section. Time=1,991
          Total Population           (1991) 95,750
          Births per Year            (1991) 597
          Net Migrants per Year      (1991) 96
          Deaths per Year            (1991) 4,596
          Birth Rate Trend Value     (1991) 0.9600
          Migration Rate Trend Value (1991) 1.0000
          Death Rate Graph Value     (1991) 0.9600

                                    Level Section, Time=1,992
          Total Population           (1992) 91,847

                                     Rate Section. Time=1,992
          Total Population           (1992) 91,847
          Births per Year            (1992) 549
          Net Migrants per Year      (1992) -92
          Deaths per Year            (1992) 4,225
          Birth Rate Trend Value     (1992) 0.9200
          Migration Rate Trend Value (1992) -1.0000
          Death Rate Graph Value     (1992) 0.9200

                                    Level Section, Time=1,993
          Total Population           (1993) 88,080




                                  Rate Section. Time=1,993
          Total Population             (1993) 88,080
          Births per Year              (1993) 504
          Net Migrants per Year        (1993) -88
          Deaths per Year              (1993) 3,876
          Birth Rate Trend Value       (1993) 0.8800
          Migration Rate Trend Value (1993) -1.0000
          Death Rate Graph Value       (1993) 0.8800

                   Results for Dynamic Simulation (DT = 1 Year), 1990 to 1993

                                         1990      1991      1992      1993
                  Total Population    100,000    95,750    91,847    88,080
                  Births                  650       597       549       504
                  Deaths                5,000     4,596     4,225     3,876
                  Net Migrants            100        96       -92       -88
```

3.7.31 DEFINE PROGRAM

Purpose:

Defines the beginning of a program and an optional program descriptor. Physically, it clears working space and is the first instruction of the default executable program segment called **MAIN**.

Syntax:

```
        DEFINE PROGRAM ["desc"]
          statement
          ...
        [END PROGRAM] [DO proc]
        STOP
```

Remarks:

`desc` is a descriptor for the program. Tabular reports produced by the program have `desc` as part of their page heading. The **SELECT HEADING** statement turns the heading on and off.

`proc` is the identifier of a procedure that should be executed at startup of the program — when the program segment is loaded.

The **DEFINE PROGRAM** statement is optional, i.e., you do not have to use it; if you do use it, however, it must be the first statement of your program.

If you plan to save the program on disk for later execution, then you must use the **DEFINE PROGRAM** statement to specify the beginning of the executable program, and the **OPEN SEGMENT** statement to open a file on disk in which to store the program.

The **END PROGRAM** statement specifies the end of an executable program and writes it to a previously opened segment file. The default segment identifier of a saved executable program is **MAIN**.

The **STOP** statement simply stops execution of a program and returns control to the PROMULA Main Menu or to command mode depending on how the program was started.

Examples:

```
        OPEN SEGMENT "sample.xeq" STATUS=NEW
        DEFINE PROGRAM "A Sample Program"
        DEFINE PROCEDURE start
          WRITE CENTER(/////"Hello World!")
        END PROCEDURE start
        END PROGRAM, DO start
        STOP
```

The code above defines a short "hello world" program. The program will be saved on disk as the file `sample.xeq`. The title, `A Sample Program`, will appear with the current date and a page number at the upper right-hand corner of all subsequent displays produced by the **WRITE variable** statement, unless you turn it off with the **SELECT HEADING = OFF** statement.

3.7.32 DEFINE RELATION

Purpose:

Defines a relation between the elements of a set and the contents of a vector variable structured by that set.

Syntax:

```
        DEFINE RELATION [file]
```

```
          type (set,vec)
          ...
        END
```

Remarks:

`file` is the identifier of an array file that has been opened to a location on disk with the **OPEN file** statement. If `file` is specified, the relation will become part of the array file structure.

`set` is the identifier of the set whose elements are to be related to the values of the vector `vec`.

`vec` is the identifier of the vector variable whose values are to be related to the elements of the `set`.

`type` is the type of relation between `set` and `vec` and may be one of the following:

ROW	specifies the variable whose values will serve as the primary descriptor for a set's elements. The primary descriptor values are used to label rows of values classified by the set in **WRITE**, **BROWSE**, and **EDIT** statements. They are also used in bar plots, page headings, and displays of the set itself.
COLUMN	specifies the variable whose values will serve as the column descriptor for a set's elements. The column descriptor values are used to label columns of values classified by the set in **WRITE**, **BROWSE**, and **EDIT** statements.
KEY	specifies the variable whose values will serve as the codes for a set's elements. If no **ROW** relation for the set is specified, the code values, also referred to as **keys**, are used as the primary descriptors for the set. If no **COLUMN** relation for the set is specified, the code values are used as column descriptors. In addition, set codes may function as set element identifiers in displays of the set and in coded set selections.
TIME	specifies the variable whose values will serve as the time values for a set's elements. If no **ROW** relation for the set is specified, the time values, also referred to as **keys**, are used as the primary descriptors for the set. If no **COLUMN** relation for the set is specified, the time values are used as column descriptors. In addition, time values may function as set element identifiers in displays of the set and in coded set selections. If a set has a **TIME** relation, it becomes a **Time Series Set**.

A relation is not valid unless `vec` is an array variable having `set` as its first dimension.

The **SELECT RELATION** statement may also be used to define relations between sets and variables.

Examples:

The following example illustrates using variables and relations to create descriptors for sets and array variables:

```
        DEFINE SET
          row(3)
          col(2)
          state(2)
          year(2)
        END SET

        DEFINE VARIABLE
          rows(row)              "Row Descriptors"             TYPE=STRING(20)
          cols(col)              "Column Headings"             TYPE=STRING(8)
          stcode(state)          "State Codes"                 TYPE=CODE(5)
          yearv(year)            "Year Values"                 TYPE=INTEGER(5)
          vara(row,col,state,year) "A 4-Dimensional Array"     VALUE(1)
        END VARIABLE
```

Given these definitions, the statement `WRITE vara` produces the display below.

```
                                    A 4-Dimensional Array

                                      STATE(1), YEAR(1)

                                                COL(1)  COL(2)

                             ROW(1)                  1       1
                             ROW(2)                  1       1
                             ROW(3)                  1       1

                                      STATE(1), YEAR(2)

                                                COL(1)  COL(2)

                             ROW(1)                  1       1
                             ROW(2)                  1       1
                             ROW(3)                  1       1

                                      STATE(2), YEAR(1)

                                                COL(1)  COL(2)

                             ROW(1)                  1       1
                             ROW(2)                  1       1
                             ROW(3)                  1       1

                                      STATE(2), YEAR(2)

                                                COL(1)  COL(2)

                             ROW(1)                  1       1
                             ROW(2)                  1       1
                             ROW(3)                  1       1
```

Note here that the `row`, `column`, and `page` descriptors of `vara` are the default descriptors of the sets `row`, `column`, `state`, and `year`. In order to replace these labels with more meaningful ones, the **DEFINE RELATION** statement may be used as shown below.

```
        DEFINE RELATION
          ROW(row,rows)
          COLUMN(col,cols)
          KEY(state,stcode)
          TIME(year,yearv)
        END RELATION

        rows(i) = "This is Row " + i

        cols(i) = "Column " + i

        READ stcode
        NY CA
```

```
READ yearv
1981 1982
```

After defining the relations and initializing the label variables, the `WRITE vara` report is more meaningful.

```
                       A 4-Dimensional Array

                             NY, 1981

                                  Column 1 Column 2

                 This is Row 1           1        1
                 This is Row 2           1        1
                 This is Row 3           1        1

                             CA, 1981

                                  Column 1 Column 2
                 This is Row 1           1        1
                 This is Row 2           1        1
                 This is Row 3           1        1

                       A 4-Dimensional Array

                             NY, 1982

                                  Column 1 Column 2
                 This is Row 1           1        1
                 This is Row 2           1        1
                 This is Row 3           1        1

                             CA, 1982

                                 Column  1 Column 2
                 This is Row 1           1        1
                 This is Row 2           1        1
                 This is Row 3           1        1
```

Note here that the contents of the variables `rows`, `cols`, `stcode`, and `yearv` have now become the row, column, and page descriptors of the multidimensional array `vara`.

Set descriptors and keys may also be specified by the **READ set** statement, and changed by the **SELECT relation** statement.

3.7.33 DEFINE SEGMENT

Purpose:

Defines a program segment as part of a hierarchical tree structure of segments.

Syntax:

```
DEFINE SEGMENT seg ["desc"]
  statement
  ...
END SEGMENT seg [DO(proc)]
```

Remarks:

`seg`	is the identifier of the segment.
`desc`	is an optional descriptor for the segment.
`statement`	is any PROMULA statement including other segment definitions. Segments may be nested to any desired level of nesting.
`proc`	is a procedure defined within the segment. This procedure is automatically called into execution when the segment is read into your working space.

Segments are the components into which a large program is organized in order to fit within a limited amount of working space. The segments of a program are stored on disk. Together with array database files, program segmentation provides the means for constructing large programs that are not limited by the size of your working space.

A segment contains both executable code and data. The data is stored in the variables of the segment. The code of the segment stores the equations and procedures that act on the segment variables.

The **END SEGMENT** statement serves three purposes:

1. It marks the end of the segment started with a previous **DEFINE SEGMENT** statement.

2. It writes the segment onto the disk file specified previously by an appropriate **OPEN SEGMENT** or **DEFINE PROGRAM** statement**.**

3. It specifies the identifier of a procedure that will be executed by default when the segment is read in.

To bring a segment into your working space from disk, use the **OPEN SEGMENT** and **READ SEGMENT** statements. This brings in both the executable code and the data values stored in the variables of the segment. If the segment you wish to bring in is part of the currently open segment file, only a **READ SEGMENT** statement is needed.

To bring only the data values of a segment into your working space, use the **READ VALUE segment** statement.

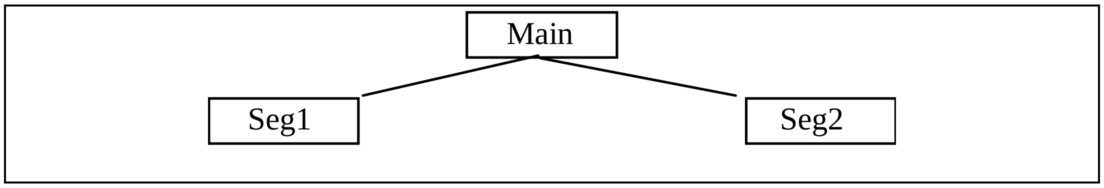
To write to disk the data values of a segment, use the **WRITE VALUE segment** statement.

Examples:

The following program skeleton

```
DEFINE PROGRAM "A Segmented Program"
OPEN SEGMENT "prog.xeq", STATUS=NEW
  statements of MAIN
  ...
  DEFINE SEGMENT seg1
    statements of seg1
    ...
    DEFINE PROCEDURE one
      statements of one
      ...
    END one
  END SEGMENT seg1, DO(one)
  DEFINE SEGMENT seg2
    statements of seg2
    ...
  END SEGMENT seg2
END PROGRAM
STOP
```

defines a program with the following segment structure:



This program is physically stored on a disk file whose file name is `prog.xeq`. The program is entitled `A Segmented Program` and has three components: the top segment **MAIN** and the two segments `seg1` and `seg2` that are subordinate to **MAIN**. That is, whereas **MAIN** can call into execution `seg1` and `seg2`, `seg1` and `seg2` cannot call into execution **MAIN**. Neither can the segments `seg1` and `seg2` be in your working space simultaneously. When `seg1` is in working space with **MAIN**, `seg2` remains on disk in the segment file `prog.xeq`, and vice versa.

When `seg1` is read into working space by **MAIN** the procedure `one` is automatically called into execution.

A more detailed example of program segmentation is given in Chapter 4. See also **DEFINE PROGRAM**, **END PROGRAM**, **OPEN SEGMENT**, **READ SEGMENT**, and **END SEGMENT**.

3.7.34 DEFINE SET

Purpose:

Defines an enumerated set of elements.

Syntax:

```
DEFINE SET [file]
  set(n)[,"desc"][option]
  ...
END
```

Remarks:

`file`	is the identifier of an array file that has been physically opened to a location on disk with the **OPEN file** statement. If `file` is specified, the set definition will become part of the array file structure.
`set`	is the set identifier.
`n`	is the number of elements in the set.
`desc`	is a descriptor for the set.
`option`	is used to associate information with the set elements and is one of the following:

TIME(`a,b`) or **TIME**(`m1,m2,...,mn`)

Where

`a`	is a positive number specifying the beginning point of the time series.
`b`	is a positive number greater than `a` specifying the ending point of the time series.
`m1,m2,...,mn`	are increasing positive values for the time series.

The **TIME** option on the **DEFINE SET** statement is used to create time series sets. The values specified in the **TIME** option define values which are set in one-to-one correspondence with the set elements. The list of values associated with the **TIME** option is processed as though it were fixed length; therefore, if the values' points are evenly spaced, they may be specified via the beginning and ending values `a` and `b`; the system will calculate the remaining values via interpolation.

The time values serve two very important functions.

1. They facilitate communication with program users. In the **SELECT VARIABLE** and **ASK...ELSE SET=set** statements, the user may enter the time values to specify set elements rather than using the element sequence numbers. Time values are also used in forming titles, subheadings, row labels, and column labels for displays of variables subscripted by time series sets and in displays of the sets generated by the **WRITE set**, **BROWSE set**, **SELECT ENTRY**, **SELECT SET**, and **SELECT VARIABLE** statements. The time values may also be used to make set selections in the **SELECT set** statement and to indicate subscript values in array expressions.

2. They are used in calculations involving time-series variables. Several PROMULA statements use the arithmetic values of the time points in performing their functions. The **RATE** and **LEVEL** statements use the time values to interpolate time series data for each time point within a dynamic simulation, or to save time series data at the time points during the simulation. The **BROWSE** and **WRITE variable** statements use the time point values to calculate growth rates, percent change, and moving averages for time series data. The **REGRESS** and **CORRELATE** statements use the time values when time series are being analyzed as a function of **TIME**.

Time series sets have a special PROMULA notation associated with them, `set:V`. This notation refers to the vector of values subscripted by `set` which contain the time series values.

KEY(`w[,diskopt]`)

Where

`w`	is the maximum width in characters for codes associated with the set.
`diskopt`	is a reference to a database variable that contains the code values.

The **KEY** option on the **DEFINE SET** statement is one way to specify that short keys (codes) are to be associated with set elements.

The information supplied with the **KEY** option specifies the maximum width in characters of each code and, optionally, the location of those codes on a database.

Codes may get their values from a `diskopt` parameter, a **READ set** statement, or a relation to a variable on disk or in the program via the **SELECT RELATION** or **DEFINE RELATION** statements.

The set element codes are used in several ways. In the **ASK...ELSE**, **SET=set** and **SELECT VARIABLE** statements the user may enter the set codes to specify their selections rather than entry sequence numbers. Another use of set codes is displays of set elements by the **SELECT ENTRY**, **SELECT SET**, **WRITE set** and **BROWSE set** statements. The code values may also be used to make set selections in the **SELECT set** statement and to indicate subscript values in array expressions.

ROW(`w[,diskopt]`)

Where

`w`	is the maximum width in characters for codes associated with the set.

`diskopt`	is a reference to a database variable that contains the code values.

The **ROW** option on the **DEFINE SET** statement is one way to specify that row labels (stubs) are to be associated with set elements.

The information supplied with the **ROW** option specifies the maximum width in characters of each stub and, optionally, the location of those stubs on a database.

Stubs may get their values from a `diskopt` parameter, a **READ set** statement, or a relation to a variable on disk or in the program via the **SELECT RELATION** or **DEFINE RELATION** statements.

Set stubs are the primary labels for set elements. They are used by the **BROWSE**, **EDIT** and **WRITE variable** statements to form titles, subheadings, and row labels for the various reports. They also appear in **BAR** and **PIECHART** plots, plots of multi-dimensional variables, and in displays of sets generated by the **SELECT ENTRY**, **SELECT SET**, **WRITE set**, and **BROWSE set** statements.

COLUMN(`w,l[,diskopt]`)

Where

`w`	is the maximum width in characters for column headings associated with the set.
`l`	is the number of lines in each column heading associated with the set.
`diskopt`	is a reference to a database variable containing the set column heading values.

The **COLUMN** option on the **DEFINE SET** statement is one way to specify that column headings (spanners) are to be associated with set elements.

The information supplied with the **COLUMN** option specifies the width in characters, the number of lines for each spanner and, optionally, the location of those spanners on disk.

Spanners may get their values from a `diskopt` parameter, a **READ set** statement, or a relation to a variable on disk or in the program via the **SELECT RELATION** or **DEFINE RELATION** statements.

The set column headings are used by the **BROWSE**, **EDIT**, and **WRITE** statements to label the columns of multidimensional arrays

`diskopt` — The DISK Suboption

As discussed above, the user has the option to specify a **DISK** suboption for the **KEY**, **ROW**, or **COLUMN** options associated with a set definition. This suboption is used when the values to be used for the option are located in an array file on disk. The syntax of the disk option is

```
DISK(filid,varid)
```

Where

`filid`	is the identifier of an array file.
`varid`	is the identifier of the vector variable whose values will be used for the stubs, spanners, or codes for `set`.

At run time, `filid` is opened to the array file which contains the variable `varid` that contains the values to be used for the **KEY**, **ROW**, or **COLUMN** option.

Examples:

```
        DEFINE SET
          product(6) "6 products"
          month(12)  "12 Months"
        END SET
```

The set `product` has six elements and is used to classify the product dimension of data. The set `month` has twelve elements and classifies monthly data. The sets `product` and `month` classify arrays of data organized by product and/or by month. For example, the statements

```
        DEFINE VARIABLE
          sales(product,month)  "Monthly Sales by Product"
          msales(month)         "Total Monthly Sales"
        END VARIABLE
```

define two variables, `sales` and `msales`. Variable `sales` is a two-dimensional array that has six rows classified by the `product` set, and 12 columns classified by the `month` set. Variable `msales` is a vector variable of 12 monthly values.

The `file` option of the **DEFINE SET** statement is used to put set definitions into the structure of an array file.

```
        DEFINE FILE
          fil1  TYPE=ARRAY
        END FILE

        OPEN fil1 "array.dba" STATUS=NEW
        ©
        DEFINE SET fil1
          row(10) "SET ROW"
          col(10) "SET COL"
        END SET

        DEFINE VARIABLE fil1
          a(row,col) TYPE=REAL(10,3) "THE A MATRIX"
          b(row,col) TYPE=REAL(10,3) "THE B MATRIX"
        END VARIABLE

        CLEAR fil1
```

Given the array file definition above, the statement

```
        COPY fil1
```

produces the following report.

```
             DEFINE FILE
             FIL1, TYPE=ARRAY
             END
             OPEN FIL1"FIL1.dba", STATUS=NEW
             DEFINE SET FIL1
             ROW(10), "SET ROW"
             COL(10), "SET COL"
             END
             DEFINE VARIABLE FIL1
             A(ROW,COL), TYPE=REAL(10,3), "THE A MATRIX"
             B(ROW,COL), TYPE=REAL(10,3), "THE B MATRIX"
             END
```

Note that the sets `row` and `col` are on file `fil1` along with the variables they subscript.

3.7.35 DEFINE SYSTEM

Purpose:

Defines a system of n equations and n unknowns for later solution, where n can be as large as you can fit in your working space.

Syntax:

```
DEFINE SYSTEM sys
DEFINE PARAMETER
 x1[,"desc1"]
 x2[,"desc2"]
 ...
 xN[,"descn"]
END
 eqn1
 eqn2
 ...
 eqnN
END [sys]
```

Remarks:

`sys`	is the system identifier.
`x1`	is the identifier of the 1st unknown.
`x2`	is the identifier of the 2nd unknown.
`xN`	is the identifier of the Nth unknown.
`desc1`	is a descriptor for the 1st unknown.
`desc2`	is a descriptor for the 2nd unknown.
`eqn1`	is the 1st equation of the system.
`eqn2`	is the 2nd equation of the system.
`equN`	is the Nth equation of the system.

Equations are written in the usual algebraic notation:

```
f(x1,x2,...) = g(x1,x2,...)
```

where `f()` and `g()` are arbitrary real, continuous functions of `x1, x2,...`

A system `sys` with parameters `x1, x2,...` may be solved by simply entering its name and specifying an ordered list of scalar variables `a1, a2,...` containing guesses for the unknowns.

```
sys(a1,a2,...)
```

The number and order of variables in the variable list must agree with the number and order of the parameters as defined in system `sys`.

The solution of a system is obtained by an iterative process base. If it exists, the solution of system `sys`, will be returned as the values of the variables `a1, a2,....` If the attempt to solve system `sys` does not converge after a reasonable number of iterations, then an error message is displayed and you may try another starting guess for the unknowns. A diagnostic is also given if the system does not have a real solution.

Examples:

The following program demonstrates how to define and solve a system of 3 equations and 3 unknowns.

Define a system of 3 equations with 3 unknowns.

```
DEFINE SYSTEM sys1
  DEFINE PARAMETER
    x, "1st unknown"
    y, "2nd unknown"
    z, "3rd unknown"
  END
  1*x + y*y = 1/z
  x*y - y/z = -8
  5*z - x*1 = y - 2
END sys1
```

Make an initial guess for the solution of system `sys1` and solve.

```
DEFINE VARIABLE
  a1   "  1st Unknown"  TYPE=REAL(10,5)
  a2   "  2nd Unknown"  TYPE=REAL(10,5)
  a3   "  3rd Unknown"  TYPE=REAL(10,5)
END VARIABLE

a1 = 1
a2 = 1
a3 = 1
sys1(a1,a2,a3)
```

Write the solution values for system `sys1`.

```
WRITE a1
  1st Unknown -5.00000
WRITE a2
  2nd Unknown 2.00000
WRITE a3
  3rd Unknown -1.00000
```

Procedure `solv1` solves system `sys1` and displays the solutions repeatedly by trying different initial guesses.

```
DEFINE VARIABLE
  iter "Iteration Counter"
END VARIABLE

DEFINE PROCEDURE solv1
  WRITE "Enter 3 values as your initial guess for the solution of 'sys1'"
  READ (a1,a2,a3)
  iter = 1
  DO WHILE iter LE 3
    sys1(a1,a2,a3)
    WRITE(/, "A solution for 'sys1' is:")
    WRITE a1
    WRITE a2
```

```
         WRITE a3
         a1 = a1+1
         a2 = a2+1
         a3 = a3+1
         iter = iter+1
       END WHILE
     END solv1
```

Running the `solv1` procedure produced the following dialog.

```
solv1
Enter 3 values as your initial guess for the solution of 'sys1'
1 1 1

A solution for 'sys1' is:
1st Unknown -5.00000
2nd Unknown 2.00000
3rd Unknown -1.00000

A solution for 'sys1' is:
1st Unknown 1.00000
2nd Unknown 2.00000
3rd Unknown 0.20000

A solution for 'sys1' is:
1st Unknown -5.00000
2nd Unknown 2.00000
3rd Unknown -1.00000
```

3.7.36 DEFINE TABLE

Purpose:

Defines a multi-variable tabular report for the program.

Syntax:

```
DEFINE TABLE
  tabl(sets) [,TITLE(text)][,FORMAT(rw,cw)],
  BODY(["text1",] var1[fmt1] [,"text2",] var2[fmt2],...)
  ...
END
```

Remarks:

`tabl`	is the identifier of the table.
`sets`	is a list of the identifiers of the sets dimensioning the variables in the table. Upon display, the descriptors of the first set become the column headings of the table; the descriptors of the other sets, if any, classify the pages of the table. The descriptors of all sets missing from the list become the row descriptors of the table. This list must contain at least one set.
`text`	is any text you wish to show as a title for the table. The title may include variables and other format characters according to the rules defined in the **WRITE text** statement.
`text1`	is any text that you wish to use as a subtitle for the values of `var1`. This text may not contain variables.

`var1`	is the identifier of the first variable in the table.
`fmt1`	is the desired format for the values of `var1`. Usually, this is used to specify the number of decimal digits for `var1`.
`text2`	is any text that you wish to use as a subtitle for the values of `var2`. This text may not contain variables.
`var2`	is the identifier of the second variable in the table.
`fmt2`	is the desired format for the values of `var2`.
`rw`	is the width in characters for row descriptors.
`cw`	is the width in characters for table columns.

A table definition includes a structure specification, in terms of sets, a body, and an optional title and format. The body of the table contains the names of the variables whose values will be displayed as the 'body' of the table. You may include as many variables as you wish in the body of a table. The format specifies the width of the row descriptors and columns of the table.

Typically, the values of the variables in a table are classified by a common set which will classify the columns of the table. To define a table of scalars, let `sets` equal 1.

To display a table, use the table's identifier as a program statement.

By default, tables defined by the **DEFINE TABLE** statement are written to the output device (screen, or printer) when they are called (i.e., they behave like a **WRITE table** statement.) You may override this default and use the same table for interactive data browsing or data entry by executing a **SELECT BROWSE** statement. See the **SELECT option** statement for details.

Tables may be written in a disk file by using a **SELECT OUTPUT** statement.

The title defined for a table may be locally overridden with a custom title by including a title specification with the call to the table. For example, when displaying a table called `tabl`, the statement

```
tabl TITLE(newtext)
```

will display `tabl` with the title specified by `newtext` instead of the title specified in the definition of `tabl`.

Examples:

The following example illustrates use of the **DEFINE TABLE** statement.

First, a group of financial variables and several other variables that will be used to construct a financial summary report are defined and initialized. The data for the financial variables were obtained from a database (not shown). See the **FPLAN.PRM** example on the PROMULA Demo Disk for details.

```
DEFINE SET
  col(13)
END SET

DEFINE VARIABLE
*
* TABLE DATA VARIABLES
```

```
*
  netsal(col) "Net Sales"                             TYPE=REAL(8,1)
  empcos(col) "Employment Costs"                      TYPE=REAL(8,1)
  msrvce(col) "Materials and Service"                 TYPE=REAL(8,1)
  dep(col)    "Depreciation"                          TYPE=REAL(8,1)
  taxes(col)  "Income Taxes"                          TYPE=REAL(8,1)
  tcosts(col) "Total Costs"                           TYPE=REAL(8,1)
  opinc(col)  "Operating Income"                      TYPE=REAL(8,1)
  intinc(col) "Interest, Dividends and Other Income"  TYPE=REAL(8,1)
  intexp(col) "Interest and Other Debt Charges"       TYPE=REAL(8,1)
  clcost(col) "Estimated Plant Closedown Costs"       TYPE=REAL(8,1)
  othexp(col) "Other Expenses"                        TYPE=REAL(8,1)
  ibtax(col)  "Income (Loss) Before Income Taxes"     TYPE=REAL(8,1)
  itax(col)   "Income Taxes"                          TYPE=REAL(8,1)
  netinc(col) "Net Income (Loss)"                     TYPE=REAL(8,1)
*
* TABLE SUPPORT VARIABLES
*
  cdesc(col)  "The Column Descriptions"               TYPE=STRING(7)
  sub1(col)
  dash(col) TYPE=STRING(10)
  eqls(col) TYPE=STRING(10)
END VARIABLE

SELECT KEY(col,cdesc)
dash="  --------"
eqls="  ========"
cdesc(i)=1977+i
cdesc(11)="1978-82"
cdesc(12)="1983-87"
cdesc(13)="1978-87"
```

The code below defines a table called `report` and a procedure that computes and displays the table.

```
DEFINE TABLE
  report(col),
  FORMAT(40,10),
  TITLE("ACME Corporation"/,
        "Ten-Year Financial Summary"/,
        "(Million Dollars)"/),
  BODY(eqls / netsal /,
      "Costs and Expenses:",
      empcos msrvce dep taxes dash sub1 dash opinc/,
      "Other Income (Expense):",
      intinc intexp clcost othexp dash ibtax itax dash netinc eqls)
END TABLE

DEFINE PROCEDURE wrrep
  SELECT col(11-13)
  sub1=empcos+msrvce+dep+taxes
  SELECT LINES=60,ZERO=DASHES,HEADING=OFF,COMMA=ON,MINUS=PARENTHESES
  report
  SELECT col*
  SELECT LINES=25,ZERO=ON,HEADING=ON,COMMA=OFF,MINUS=LEADING
END PROCEDURE wrrep
```

The report produced by running procedure `wrrep` is shown below.

```
                                    ACME Corporation
                               Ten-Year Financial Summary
```

```
                                    (Million Dollars)


                                                        1978-82   1983-87   1978-87
                                                       ========  ========  ========

              Net Sales                                18,334.7  28,795.2  47,129.9

              Costs and Expenses:
              Employment Costs                          7,864.1  12,208.4  20,072.5
              Materials and Service                     7,740.1  13,476.9  21,217.0
              Depreciation                                902.1   1,483.1   2,385.2
              Income Taxes                                298.6     371.7     670.3
                                                       --------  --------  --------
                                                       16,804.9  27,540.1  44,345.0
                                                       --------  --------  --------
              Operating Income                          1,529.8   1,255.1   2,784.9

              Other Income (Expense):
              Interest, Dividends and Other Income        195.9     276.4     472.3
              Interest and Other Debt Charges           (199.0)   (389.0)   (588.0)
              Estimated Plant Closedown Costs              --     (650.0)   (650.0)
              Other Expenses                               --      (51.0)    (51.0)
                                                       --------  --------  --------
              Income (Loss) Before Income Taxes         1,526.7     441.5   1,968.2
              Income Taxes                                630.8    (86.2)     544.6
                                                       --------  --------  --------
              Net Income (Loss)                           895.9     527.7   1,423.6
                                                       ========  ========  ========
```

See the **WRITE table**, **BROWSE table**, and **EDIT table** statements for more details on the use of multi-variable reports.

3.7.37 DEFINE VARIABLE

Purpose:

Defines a local variable.

Syntax

```
DEFINE VARIABLE [SCRATCH] [file]
  var[(sets)][,"desc"][,TYPE=type] [values] [diskrel]
  ...
END
```

Remarks:

`var`	is the identifier of the variable. This is the name by which you refer to the variable in your programs. `var` may contain letters and numbers, but the first character must be a letter. Each variable identifier must be different from all other identifiers in a given program segment. Only the first six characters of the identifier are significant. If the identifier is followed by an asterisk (*), the variable may be used as an indirect for general purpose input/output operations.
`SCRATCH`	is a keyword indicating that the variable is to reside in scratch storage.

`file`	is the identifier of an arrray or random file. If `file` is specified, `var` will be treated as a disk variable and its values will be contained in the disk file that `file` is physically opened to. See the **SELECT file** statement for a discussion of random files, and Chapter 4 for a discussion of array files.
	NOTE: If `file` is specified, the `SCRATCH`, `values`, and `diskrel` options are not allowed.
`sets`	is a list of set identifiers or numeric constants specifying the dimensions of the variable. If omitted, the variable is a scalar, i.e., it has a single value.
	In default input and output operations, the first set will classify the rows of values, the second set will classify the columns of values, the third set will clasify the two-dimensional blocks of values, etc.
`desc`	is a descriptor for the variable. It shows up as the title of subsequent displays of the variable produced by the report generation statements **WRITE**, **BROWSE**, **EDIT**, **PLOT**.
`type`	is the type format specification of the variable and may be one of the following:

REAL(`w`,`d`)	contains real numbers in the ranges: (-3.37E+38,-8.43E-37) 0 (+8.43E-37,+3.37E+38) Reals outside these ranges are not valid and cause underflows or overflows in calculations, which result in errors.
INTEGER(`w`)	contains integer numbers in the range: (-2^{31}–3,+2^{31}–3) about ± 2.1 billion Integers outside this range cause overflows and cannot be processed by the system.
STRING(`w`)	contains character values, i.e., strings of characters.
CODE(`w`)	contains codes. Codes are short character strings that are used for set selections. For example, `JAN` and `FEB` may be used to select the months of January and February.
MONEY(`w`)	contains money values (dollars and cents). This type is useful for accounting arithmetic where one-cent accuracy is important. Money variables maintain ten significant digits of accuracy. The range of **MONEY** type variables is (-2**31-3,+2**31-3) about ± 2.1 billion cents or 21 million dollars.
DATE(`w`)	contains date values. Dates are values of the form **`mm/dd/yy`**, where **`mm`** is a month number, **`dd`** is a day number, and **`yy`** is a year number. Internally, the date value is stored as a numeric quantity equal to **`yymmdd`**. Alternative date formats (e.g., `dd/mm/yy` or `mm/dd/yyyy`) are available by executing a **SELECT DATE** statement.
UPPERCASE(`w`)	contains string values that are automatically converted to uppercase when they are input from the keyboard.

set(w) contains integers from 0 to N. If the values of the **set** type variable are within the range of **set**, the descriptors of **set** are displayed, otherwise, the variable is assigned and displays the value 0. This type of variable is useful for helping the user enter or verify categorical data.

Where

w is an integer denoting the width (in characters) of subsequent displays of the values of var. The maximum width for a code type variable is 6 characters.

d is an integer denoting the number of decimal digits in subsequent displays of the values of real variables. If d is 10 or greater, the number will be shown in exponential notation — base 10. The value will show six decimal places.

If type is omitted, the variable will have type **REAL(8,0)**

values is a value specification defining initial values for var. Use of this option is restricted to local, **REAL** type variables. values may take one of four different forms:

VALUE(a) or **VALUE**=a	assigns the value a to all the cells of the variable.
VALUE(a,b)	assigns the first value to a, the last value to b, and interpolates the remaining cells of the variable.
VALUE(a,b,c...)	assigns the values a,b,c... in order. If too many values are specified, the extra values are ignored. If too few are specified, the remaining values are set to zero. In order to simplify the specification of multiple values, the *N*VALUE* notation may be used. Thus,

```
VALUE(50*99.9, 30*99.0, 10*95.0, 5*90.0, 5*80.0)
```

would be a quick way to specify 100 values.

If values is omitted, the variable will be initialized by PROMULA: numeric variables are initialized with the value zero, and string type variables are initialized with "empty strings".

diskrel is a **disk relation** indicating that the variable is to be used for virtual or dynamic access of a disk variable.

Variables are storage places for information. Depending on how their values are stored, variables are of three types: fixed, scratch, and disk.

Fixed Fixed variables are accessed from a fixed space in primary memory (RAM). They are defined with a **DEFINE VARIABLE** statement.

The values of fixed variables may be saved in a segment file on disk by the **END SEGMENT, END PROGRAM,** and **WRITE VALUE segment** statements.

Using fixed variables in calculations will result in the fastest execution speed.

Fixed variables are sometimes referred to as local variables.

Scratch Scratch variables are accessed from a scratch space in primary memory. They are defined with a **DEFINE VARIABLE SCRATCH** statement.

Their values can be cleared from memory with a **CLEAR** statement to make room for other scratch variables. The values of scratch variables cannot be saved in a segment file on disk.

Computations using scratch variables will be slower than using fixed variables because PROMULA must do more internal calculations to access their values.

Scratch variables are sometimes referred to as local variables.

Disk Disk variables are stored on disk in an array file. They are defined with a **DEFINE VARIABLE file** statement. Disk variables are also referred to as database variables.

The values of disk variables may be accessed directly on disk and they may be accessed dynamically or virtually in memory via scratch or fixed variables which are related to them.

See Chapter 4 for a discussion of relating local and disk variables.

Example: The set type variable

When displayed, a **set(w)** type variable will show the contents of the set element whose index value it contains. This correspondence is only valid for index values between 1 and the size of the set, all other values are converted to 0. The following example illustrates the **TYPE=set(w)** option.

```
DEFINE SET
 emp(4)
END SET

DEFINE VARIABLE
  empn(emp) "Employee Names" TYPE=STRING(10)
  emps(emp) "Employee List"  TYPE=emp(40)
  empc      "An Employee"    TYPE=emp(10)
END VARIABLE

DEFINE RELATION
   row(emp,empn)
END RELATION

READ empn
George
Fred
Lois
Mark
```

Given the above defintions, the set type variable may be used for displaying categorical data as illustrated in the dialog below.

```
          WRITE emps
                                   Employee List

                           George                               0
                           Fred                                 0
                           Lois                                 0
                           Mark                                 0

            emps(i) = i
            WRITE emps
                                   Employee List

                           George                          George
                           Fred                              Fred
```

```
                             Lois                                              Lois
                             Mark                                              Mark

             WRITE empc
             An Employee          0

             empc = 4
             WRITE empc
             An Employee       Mark
```

3.7.38 DEFINE WINDOW

Purpose:

Define a window.

Syntax:

```
DEFINE WINDOW
  name(area[,text][,border][,bar]) [POPUP]
  ...
END
```

Remarks:

`name` is the logical identifier of the window.

`area` is a list of four numbers defining the location and size of the window. The syntax of this list is

`X1,Y1,X2,Y2`

where

X1	defines the leftmost column of the window
Y1	defines the topmost row of the window
X2	defines the rightmost column of the window
Y2	defines the bottom-most row of the window

For a 25 row by 80 column text screen, row values must be in the range 0 to 24 and column values must be in the range 0 to 79. Any window area that is off the screen or is overlapped by another window will not be visible.

`text` is a list of up to four keywords separated by slashes that define the appearance of normal text in the window. The syntax of this list is

`foregr/backgr[/BRIGHT][/BLINK]`

where

foregr	defines the foreground color
backgr	defines the background color
BRIGHT	causes the foreground to be bright
BLINK	causes the text to blink

Valid colors are **BLACK**, **WHITE**, **GREEN**, **RED**, **YELLOW**, **BLUE/CYAN**, **PURPLE/MAGENTA**, **NAVY/DARK BLUE**.

`border` is a list of up to six keywords separated by slashes that define the appearance of a border for the window. The syntax of this list is

```
type/style/foregr/backgr[/BRIGHT][/BLINK]
```

where

`type` defines the location of a border for the window and may be one of the following:

NONE	for no border
TOP	for a top border
BOTTOM	for a bottom border
BANDED	for a top and bottom border
FULL	for a complete border
HEADER	for a header border
FOOTER	for a footer border

`style` defines the style of the border and may be one of the following:

SINGLE	for a single line border
DOUBLE	for a double line border
HEAVY	for a heavy line border

`foregr`	defines the foreground color
`backgr`	defines the background color
`BRIGHT`	causes the foreground to be bright
`BLINK`	causes the text to blink

Valid colors are **BLACK**, **WHITE**, **GREEN**, **RED**, **YELLOW**, **BLUE/CYAN**, **PURPLE/MAGENTA**, **NAVY/DARK BLUE**.

The border is displayed one character outside of the area defined by the `area` parameter of the window definition.

`bar` is a list of up to three sets of up to four keywords separated by slashes that define the appearance of highlighting in highlighted prompts, pick and popup menus, **EDIT** statements, and the list selection statements **SELECT indirect**, **SELECT ENTRY**, and **SELECT SET**, and the **GETDIR** function.

The syntax of the `bar` specification is

```
colors1,colors2,colors3
```

where

`colors1` defines the colors of standard highlighting in the window.

These colors will be used for highlighting and prompts generated by various PROMULA statements and for the currently highlighted but not selected elements in selection lists. The default colors are black on cyan.

`colors2` defines the colors of a selected but not currently highlighted element in the **SELECT SET** statement. The default colors are black on green.

`colors3`	defines the colors of a currently highlighted and selected element in the **SELECT SET** statement. The default colors are black on red.

Each color specification has the following form:

```
foregr/backgr[/BRIGHT][/BLINK]
```

where

`foregr`	defines the foreground color
`backgr`	defines the background color
`BRIGHT`	causes the foreground to be bright
`BLINK`	causes the text to blink

Valid colors are **BLACK**, **WHITE**, **GREEN**, **RED**, **YELLOW**, **BLUE/CYAN**, **PURPLE/MAGENTA**, **NAVY/DARK BLUE**.

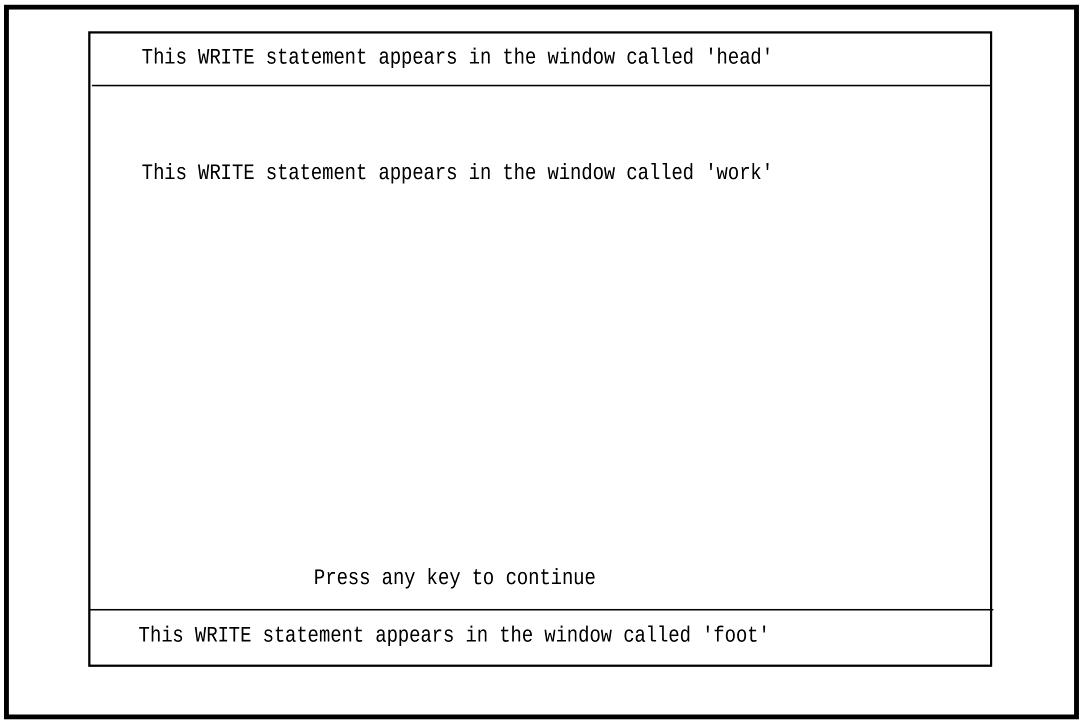
`POPUP`	is the optional keyword **POPUP**. When present, the window will behave as a "popup" window; i.e., when the window is closed, the contents of the screen that was on the screen in the window area before the popup window was opened will be redrawn. Popup windows are often used to provide on-line help or warning messages.

Examples:

The following example illustrates how to use header and footer style windows. A static "frame" window is needed to make the sides of the box that will contain the Main Screen. This frame will be opened first, then the static header and footer windows will be opened on top of it. Finally, the window to be used as the Main Screen that fits inside the "box" created by the first three windows is opened.

```
DEFINE WINDOW
   head(01,01,78,03,WHITE/BLACK,HEADER/SINGLE)
   fram(01,01,78,24,WHITE/BLACK,FULL/SINGLE)
   foot(01,23,78,23,WHITE/BLACK,FOOTER/SINGLE)
   work(02,05,77,21,WHITE/BLACK,NONE)
END WINDOW

OPEN fram MAIN
OPEN head MAIN
WRITE CENTER(/"This WRITE statement appears in the window called 'head'")
OPEN foot MAIN
WRITE CENTER(/"This WRITE statement appears in the window called 'foot'")
OPEN work MAIN
WRITE CENTER(/"This WRITE statement appears in the window called 'work'")
ASK CONTINUE
```

The code above produces the following display:



```
This WRITE statement appears in the window called 'head'

This WRITE statement appears in the window called 'work'

                    Press any key to continue

This WRITE statement appears in the window called 'foot'
```

See also the **OPEN WINDOW** and **CLEAR WINDOW** statements as well as Advanced Windows in Chapter 1 for more information on the use of windows. See also the sample applications distributed on the PROMULA Demo Disk.

3.7.39 DO CORRELATE

Purpose:

Produces a report of one or more correlation matrices for all pairings of specified variables. The correlation coefficients (R) are computed by the following formula:

$$R = \frac{\sum_i (x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_i (x_i - \overline{x})^2}\sqrt{\sum_i (y_i - \overline{y})^2}}$$

where x_i and y_i are the variables to be correlated and $\overline{x}$ and $\overline{y}$ are their respective means.

Syntax:

```
DO CORRELATE [(sets)] (vars)
```

Remarks:

`sets` is a list of set identifiers subscripting the arrays to be correlated.

The specification of `sets` defines the index of the observations and the order of report pages produced. The last set in `sets` specifies the index of the observations to be correlated, any preceding sets specify the order in which pages of the report are displayed. The generation of report pages corresponds to the specification of the sets in `sets` from left to right — left varying the fastest.

The default value for `sets` is the reverse of the set specification used in defining the highest dimensional variable (i.e., the variable having the greatest number of dimensions) in `vars` with the first set in this definition indexing the observations, and the remaining sets heading report pages.

`vars` is a list of variable identifiers specifying the arrays to be correlated. The list may also contain the time parameter **TIME** if all the variables in `vars` share a time series set as one of their indexes (a time series set is a set which has a **TIME** specification in its definition or which shares a **TIME** relation with a variable.) This list must contain at least two variables. Inclusion of TIME will include the time series value vector as one of the variables in the correlation matrix.

One-dimensional arrays (vectors), are used in correlation calculations directly. Two- and higher-dimensional arrays are partitioned into sets of observations, and a separate matrix is generated for each active "page" and "column" of the highest dimensional array in `vars`. The variables specified in `vars` should have at least one set in common.

A title — **Correlation Matrix** — is printed at the top of each page. Subtitles including the row descriptors for sets specified in `sets` appear when more than one report page is generated.

Examples:

The following code illustrates the **DO CORRELATE** statement.

```
DEFINE SET
  grp(2)   "Test Groups"
  tim(10)  "Time Points" TIME(0,9)
END SET

DEFINE VARIABLE
  rspv(tim,grp) "Response by Group and Time"
  dosv(tim,grp) "Dose at Each Time Point"
END VARIABLE

READ dosv(grp,tim)
0.5   1.0   1.5   2.0   2.5  15.0  17.5  20.0  22.5  25.0
0.5   1.0   1.5   2.0   2.5  15.0  17.5  20.0  22.5  25.0
READ rspv(grp,tim)
1.3   2.1   3.5   6.0   6.6   6.1   6.0  11.2   5.7   5.7
0.3   1.9   3.6   6.2   5.3   3.3   2.7  10.7   5.5   9.7
```

Given the definitions above, the statement

```
DO CORRELATE(grp,tim) (dosv,rspv,TIME)
```

produces the display below.

```
                          Correlation Matrix, 0 to 9

                                    GRP(1)

                                  DOSV     RSPV     TIME
                        DOSV      1.000    0.581    0.948
                        RSPV      0.581    1.000    0.687
                        TIME      0.948    0.687    1.000


                                    GRP(2)

                                  DOSV     RSPV     TIME
```

```
                                    DOSV       1.000    0.603    0.948
                                    RSPV       0.603    1.000    0.738
                                    TIME       0.948    0.738    1.000
```

3.7.40 DO DESCRIBE

Purpose:

Produces a report of one or more tables of 12 descriptive statistics for specified variables. The statistics are as follows:

1. Number of observations
2. Number of excluded observations
3. Number of valid observations
4. Arithmetic mean
5. Variance
6. Standard error
7. Standard deviation
8. Skewness
9. Kurtosis
10. Range
11. Minimum value, and
12. Maximum value.

Syntax:

```
DO DESCRIBE [(sets)] (vars[::fmt])
```

Remarks:

`sets` is a list of set identifiers subscripting the array(s) to be described.

The specification of `sets` controls the analysis of the variables specified in `vars` by defining the index of the observations and the order of report pages produced. The last set in `sets` specifies the index of the observations, any preceding sets specify the order in which pages of the report are written. The ordering of report pages corresponds to the specification of the sets in `sets` from left to right — left varying the fastest.

The default value for `sets` is the reverse of the set specification used in defining each variable in `vars` with the first set in this definition indexing the observations, and the remaining sets heading report pages.

`vars` is a list of variable identifiers specifying the arrays to be described.

One-dimensional arrays (vectors), are treated as a single set of observations. Two- and higher-dimensional arrays are partitioned into sets of observations.

`fmt` is an integer specifying the number of decimal digits for the reported statistics. The default `fmt` is the number of decimals specified by the **TYPE** specification in the definition of the variable(s) specified in `vars`. The report generator uses the following number of decimal digits for each statistic:

Format of reports produced by the DO DESCRIBE statement

STATISTIC	NUMBER OF DECIMALS DIGITS
1. Number of observations	`0`
2. Number of excluded observations	`0`
3. Number of valid observations	`0`
4. Arithmetic mean	`fmt`
5. Variance	`fmt`
6. Standard error	`fmt+1`
7. Standard deviation	`fmt+1`

8. Skewness	`fmt+2`
9. Kurtosis	`fmt+2`
10. Range	`fmt`
11. Minimum value	`fmt`
12. Maximum value	`fmt`

A title — **Descriptive Statistics for** `vardesc` — is printed at the top of each page (`vardesc` is the descriptor of the array being described). Subtitles that consist of the row descriptors for sets specified in `sets` appear when more than one report page is produced.

Examples:

The following code illustrates the **DO DESCRIBE** statement. First, a three-dimensional variable, `a`, is defined and displayed:

```
DEFINE SET
  row(4)
  col(2)
  pag(2)
END SET

DEFINE VARIABLE
  a(row,col,pag) "VALUES BY ROW AND COL"
END VARIABLE

a=RANDOM(5000,9999)
```

The values of variable `a` may be displayed by the statement, `WRITE a`.

```
                          VALUES BY ROW AND COL

                                  PAG(1)

                                      COL(1)  COL(2)
                         ROW(1)        6,079   6,825
                         ROW(2)        8,046   5,052
                         ROW(3)        8,567   8,882
                         ROW(4)        8,988   7,825

                                  PAG(2)

                                      COL(1)  COL(2)
                         ROW(1)        7,007   6,409
                         ROW(2)        6,613   7,083
                         ROW(3)        6,611   9,819
                         ROW(4)        5,152   5,168
```

The report produced by the statement

```
DO DESCRIBE(col,row) (a::2)
```

is shown below. Set `row` is the last set in `sets` so it indexes the observations, set `col` is used to partition the data for each table. Set `pag` is not specified in `sets` so its descriptors do not appear in the titles of the tables and the statistics reported correspond to the first level of `pag`.

```
                 Descriptive Statistics for VALUES BY ROW AND COL
```

```
                               COL(1)

               No of Observations                    4
               Number Excluded                       0
               Valid Observations                    4
               Arithmetic Mean                7,919.92
               Variance                   1,241,510.00
               Standard Error                1,286.603
               Standard Deviation            1,114.231
               Skewness                        -0.8583
               Kurtosis                        -0.8961
               Total Range                    2,909.62
               Minimum Value                  6,078.70
               Maximum Value                  8,988.32

           Descriptive Statistics for VALUES BY ROW AND COL

                               COL(2)

               No of Observations                    4
               Number Excluded                       0
               Valid Observations                    4
               Arithmetic Mean                7,146.30
               Variance                   1,990,345.00
               Standard Error                1,629.047
               Standard Deviation            1,410.796
               Skewness                        -0.3267
               Kurtosis                        -1.1999
               Total Range                    3,935.86
               Minimum Value                  5,052.46
               Maximum Value                  8,988.32
```

The statement `DO DESCRIBE(a::2)` would use the default value for `sets` (i.e., (`pag,col,row`)) and would produce tables of statistics for variable `a` indexed by `row` for all combinations of `pag` and `col` in the following order:

```
PAG(1), COL(1)
PAG(2), COL(1)
PAG(1), COL(2)
PAG(2), COL(2)
```

The statement `DO DESCRIBE(row) (a::2)` would produce a table of statistics for variable `a` indexed by `row` for the first active elements of sets of `pag` and `col`. No `pag` or `col` descriptor subtitle would appear in the report title.

The statement `DO DESCRIBE(col,row) (a::2)` would produce a table of statistics for variable `a` indexed by `row` for each level of set `col` and the first active element of set `pag`. Set `col`'s row descriptors would be used as a subtitle in the report titles.

```
COL(1)
COL(2)
```

The statement `DO DESCRIBE(col,pag,row) (a::2)` would produce tables of statistics for variable `a` indexed by `row` for all combinations of `pag` and `col` in the following order:

```
COL(1), PAG(1)
COL(2), PAG(1)
COL(1), PAG(2)
COL(2), PAG(2)
```

3.7.41 DO DIRECTORY

Purpose:

Executes a group of statements once for each file in the current directory that matches a given file specification.

Syntax:

```
DO DIRECTORY filespec INTO fname
  statement
  ...
END
```

Remarks:

`filespec`	is a string variable or a quoted string containing the file specification that you wish to search for; wild card characters are allowed.
`fname`	is the name of the string variable that will be assigned each file name that matches the file specification.
`statement`	is any executable statement, including other **DO** statements, except definitions.

The statements from **DO DIRECTORY** `statement` is an example of a "**DO loop**."

Examples:

The following example demonstrates the **DO DIRECTORY** statement.

```
* Create three files on disk
DEFINE FILE
  file1
  file2
  file3
END

OPEN file1 "file1.fil" STATUS = NEW
OPEN file2 "file2.fil" STATUS = NEW
OPEN file3 "file3.fil" STATUS = NEW
CLEAR file1
CLEAR file2
CLEAR file3

DEFINE VARIABLE
  fname      "File Name"  TYPE=STRING(15)
END VARIABLE
```

The **DO DIRECTORY** loop below finds all files that match the specification `*.fil`, passes each one to the string variable `fname`, and writes the value of `fname`.

```
DO DIRECTORY "*.fil" INTO fname
  WRITE fname
END DO DIRECTORY
```

The output of the loop above was

```
File Name       FILE1.FIL
File Name       FILE2.FIL
File Name       FILE3.FIL
```

3.7.42 DO file

Purpose:

Accesses sequentially all the records of a text file or a random file.

Syntax:

```
DO file
  statement
  ...
END
```

Remarks:

`file`	is the identifier of a text or random file.
`statement`	is any executable statement, including other **DO** statements, except definitions.

The statements from **DO file** to **END** are an example of a "**DO loop**."

The statements of the **DO file** loop are executed repeatedly as many times as there are records in the file. The order of iterations through the DO loop is 1,2,...N, where N is the number of the last record in the file. At each iteration a new record in the file is accessed, and the statements within the DO loop are executed.

If file is type **TEXT**, an explicit **READ file(variables)** statement is required to transfer data from the text file to program variables. If file is type **RANDOM**, the data in the record is automatically passed to the variables of the random file as each record is accessed.

Examples:

1. Copy a text file to a random file

```
DEFINE FILE
  txt1 TYPE=TEXT
  ran1 TYPE=RANDOM
  arr1 TYPE=ARRAY
END FILE

OPEN ran1 "ran1.ran", STATUS=NEW
DEFINE VARIABLE ran1
  item1 "Item 1"   TYPE=REAL(8,0)
  item2 "Item 2"   TYPE=STRING(8)
  item3 "Item 3"   TYPE=DATE(8)
END VARIABLE

OPEN txt1 "txt1.txt", STATUS=OLD
DO txt1
  READ txt1(item1:8,item2:8,item3:8)
  WRITE ran1
END txt1
```

2. Copy a text file to an array file

```
OPEN arr1 "arr1.arr", STATUS=NEW

DEFINE SET
  rec(100)  "Records"
```

```
END SET

DEFINE VARIABLE arr1
  var1(rec) "Variable 1"         TYPE=REAL(8,0)
  var2(rec) "Variable 2"         TYPE=STRING(8)
  var3(rec) "Variable 3"         TYPE=DATE(8)
END VARIABLE

DEFINE VARIABLE
  rn         "Record Number"
END VARIABLE

rn=1
DO txt1
  READ txt1(var1(rn),var2(rn),var3(rn))
  rn=rn+1
END txt1
```

3. Copy a random file to an array file

```
rn=1
DO ran1
  var1(rn) = item1
  var2(rn) = item2
  var3(rn) = item3
  rn=rn+1
END ran1
```

4. Copy an array file to a random file

```
rn = 1
DO rec
  SELECT ran1(rn)
  item1 = var1
  item2 = var2
  item3 = var3
  WRITE ran1
  rn=rn+1
END rec
```

5. List a random file

```
DO ran1
  WRITE(item1:8,item2:8,item3:8)
END ran1
```

3.7.43 DO IF

Purpose:

Executes a group of statements once if a condition is met.

Syntax:

```
DO IF condition
  statement
  ...
[ELSE [condition]
  statement
  ...]
END
```

Remarks:

`condition` is any Boolean expression, i.e., an expression that is either true or false. If true, the statements immediately following are executed until the next **END** or **ELSE** statement, whichever is first. If false, the statements immediately following are not executed and execution proceeds to the next **ELSE** or **END** statement, whichever is first.

`statement` is any executable statement (no definitions), including another **DO** statement. The group of executable statements between the **DO IF** and the next **ELSE** (or **END**) statement, or between an **ELSE** and the next **ELSE** (or **END**) statement, is called a branch of the **DO IF** statement.

A branch is executed only if all previous conditions are false and the condition of the branch is true; otherwise, execution proceeds to the evaluation of the condition of the next branch.

DO IF statements may be nested to any depth.

DO IF statements may have multiple **ELSE** statements. In a **DO IF** with multiple **ELSE** statements, the conditions of the **ELSE** statements are evaluated sequentially from top to bottom: if the first condition is false the second condition is evaluated, and so forth, until a true condition is found or the **END** is encountered.

If an **ELSE** statement has no condition specified, it is assumed to be the complement of all previous conditions. That is, if all the previous conditions are false, the null **ELSE** statement is true. For this reason, a null **ELSE** statement, if desired, should always be specified last.

Examples:

```
DEFINE VARIABLE
  x
  y
END VARIABLE

DEFINE PROCEDURE doif
  DO IF x GT y
    WRITE("x=  ",x:5:2,", y=  ",y:5:2/"x is greater than y")
  ELSE x EQ y
    WRITE("x=  ",x:5:2,", y=  ",y:5:2/"x is equal to y")
  ELSE
    WRITE("x=  ",x:5:2,", y=  ",y:5:2/"x is less than y")
  END IF
END PROCEDURE doif
```

A dialog with procedure `doif` is displayed below.

```
x = 1.2
y = 3.4
doif
x=  1.20, y=  3.40
x is less than y

x = 4.5
doif
x=  4.50, y=  3.40
x is greater than y

x = 3.4
doif
x=  3.40, y=  3.40
x is equal to y
```

In this example, the procedure `doif` checks whether the variable `x` is less than, equal to, or greater than the variable `y`, and issues a message appropriately.

3.7.44 DO IF END

Purpose:

Executes a group of statements once if the user presses the **END** key in response to a prompt or pick menu.

Syntax:

```
DO IF END
  statement
  ...
END
```

Remarks:

`statement` is any executable statement (no definitions), including another **DO** statement.

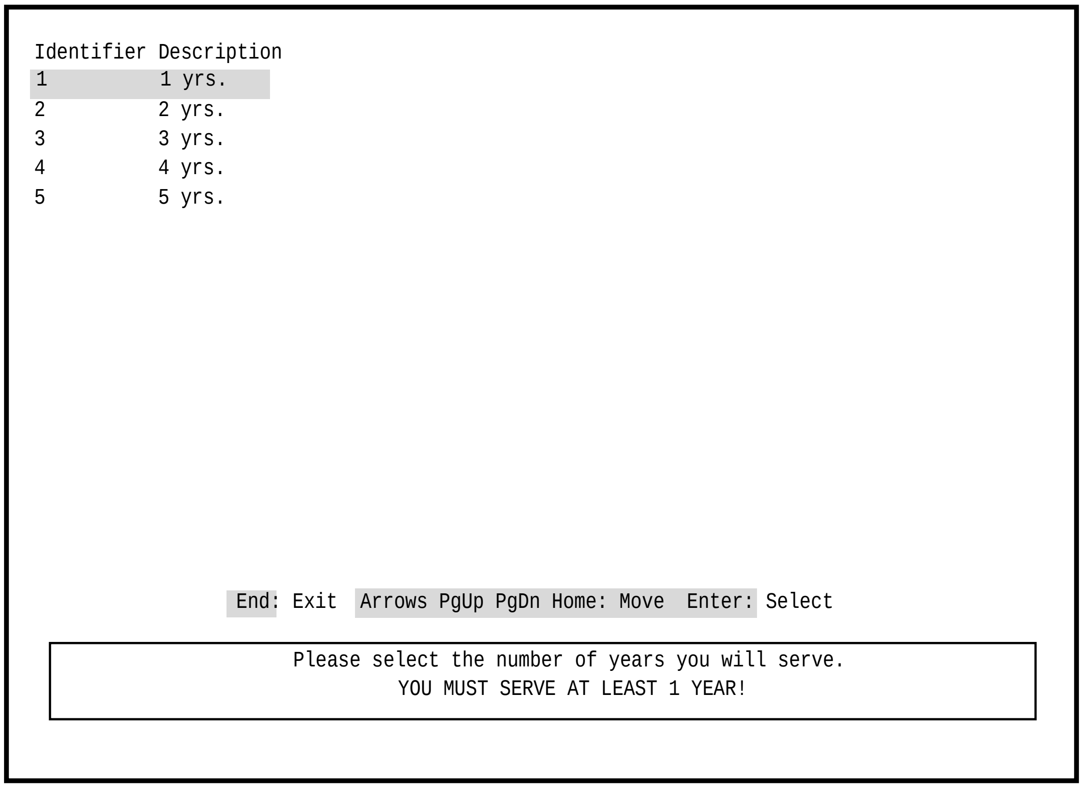
The group of executable statements between the **DO IF END** and the **END** statement are executed if the user presses the **END** key in response to a prompt or menu, typically from a **SELECT SET**, **SELECT ENTRY**, **SELECT indirect, SELECT variable** or **SELECT menu** statement that uses the **End** key as an escape. This test can help you avoid complications that may come up when the user ends from a selection statement without making a valid selection. After these statements are executed, PROMULA automatically re-executes the statement preceding the **DO IF END** block.

Examples:

1. The procedure below uses a **DO IF END** statement to force the user to make a set selection via the **SELECT ENTRY** statement.

```
DEFINE SET
  yrs(5)
END SET

DEFINE WINDOW
 cwind(1,22,78,23,white/black/bright,full/single,yellow/black),POPUP
 mwind(0,0,79,20,green/black,none,white/black,yellow/red/bright)
END WINDOW

DEFINE VARIABLE
  yrsn(yrs) "Year Names"  TYPE=STRING(10)
  yrsv(yrs) "Year Values"
END VARIABLE

yrsv(i) = i
yrsn(i) = yrsv+" yrs."
SELECT ROW(yrs,yrsn)

DEFINE PROCEDURE getyrs
  OPEN cwind, COMMENT
  OPEN mwind, MAIN
  WRITE COMMENT
                Please select the number of years you will serve.
                       YOU MUST SERVE AT LEAST 1 YEAR!
```

```
END
  SELECT ENTRY(yrs)
  DO IF END
    getyrs
  END IF END
  yrsv = yrs:S
  WRITE ("Your must serve ",yrsv:-2,"years!  THANK YOU!")
END PROCEDURE getyrs
```



```
Identifier Description
1          1 yrs.
2          2 yrs.
3          3 yrs.
4          4 yrs.
5          5 yrs.

                End: Exit  Arrows PgUp PgDn Home: Move  Enter: Select

                     Please select the number of years you will serve.
                              YOU MUST SERVE AT LEAST 1 YEAR!
```

2. The **DO IF END** statement may also be used to detect a null set selection. This usage is obsolete; it is available only to keep PROMULA compatible with previous versions. Use the **DO IF NULL** statement instead.

```
DEFINE SET
  mn (12)  "12 Months"
END SET

DEFINE VARIABLE
  lmt    "Lower Limit value"
  mv(mn) "Monthly values"
END VARIABLE

mv(i) = i*10

DEFINE PROCEDURE null
  WRITE ("Enter the Lower Limit.")
  READ lmt
  SELECT mn IF mv GT lmt
  DO IF END
    WRITE("There are no months with value greater than"lmt)
    WRITE("Try again.")
    null
  END IF END
  WRITE mv:40
```

```
END PROCEDURE null
```

A dialog with procedure `null` is shown below.

```
null
Enter the Lower Limit.
        ? 200

There are no months with value greater than     200
Try again.

Enter the Lower Limit.
        ? 100


                              Monthly values

              MN(11)                                      110
              MN(12)                                      120
```

3.7.45 DO IF ERROR

Purpose:

Executes a group of statements if a specific error is generated by the previous statement.

Syntax:

```
DO IF ERROR n
  statement
  ...
END
```

Remarks:

`n`	is the number of the error. The error messages and their numbers are listed in Chapter 6 of this manual.
`statement`	is any executable statement (no definitions), including another **DO** statement.

If the specified error occurs during execution of the statement immediately preceding the **DO IF ERROR** statement, PROMULA will execute the group of executable statements between the **DO IF ERROR** and the **END** then re-execute the statement immediately preceding the **DO IF ERROR** statement.

Example:

Procedure `chkval` uses the **DO IF ERROR** statement to detect an arithmetic overflow or underflow.

```
DEFINE PROCEDURE chkval
  WRITE "Please enter a value."
  READ val
  ans = 100/val
  DO IF ERROR 538
    WRITE ("Please enter a nonzero value.")
    READ val
  END IF ERROR
  WRITE ("The answer is ",ans:-8:3)
END PROCEDURE chkval
```

Error 538 is caused by an arithmetic overflow or underflow.

A dialog with procedure `chkval` is shown below.

```
             DO chkval
             Please enter a value.
                    ? 0
             Please enter a nonzero value.
                    ? 10
             The answer is 10.000
```

3.7.46 DO IF ESCAPE

Purpose:

Executes a group of statements if the user pressed the **Esc** key in response to a prompt generated by the previous statement.

Syntax:

```
      DO IF ESCAPE
        statement
        ...
      END
```

Remarks:

`statement`	is any executable statement (no definitions), including another **DO** statement.

If the user presses **Esc** in response to a prompt (or selection menu), PROMULA will execute the group of executable statements between the **DO IF ESCAPE** and the **END** statement then re-execute the statement immediately preceding the **DO IF ESCAPE** statement.

This statement is usually used to help prevent complications that can result if the user escapes from an application instead of giving a valid response to a prompt.

Example:

Procedure `noesc` uses the **DO IF ESCAPE** statement to trap and escape.

```
      DEFINE PROCEDURE noesc
        WRITE "Please enter the value."
        READ val
        DO IF ESCAPE
          WRITE ("There is no escape!")
        END IF ESCAPE
        WRITE ("The value is ",val:-8:3)
      END PROCEDURE noesc
```

A dialog with procedure `noesc` is shown below.

```
             DO noesc
             Please enter the value.
                    ? [Esc]
             There is no escape!
                    ? 100
             The value is 100.000
```

3.7.47 DO IF HELP

Purpose:

Executes a group of statements if the user presses the **Alt** and **H** keys simultaneously in response to a prompt.

Syntax:

```
DO IF HELP
  statement
  ...
END
```

Remarks:

`statement`	is any executable statement (no definitions), including another **DO** statement.

When the user enters **Alt-H** in response to a prompt, PROMULA executes the group of executable statements between the **DO IF HELP** and the **END** statement then re-executes the statement immediately preceding the **DO IF HELP** statement.

This statement is usually used to provide the user with information relating to a Data menu or a Pick menu.

This statement and the **SELECT HELP** statement are useful for customizing on-line help for your applications.

Pressing **Alt-H** in response to a Popup pick menu will cause PROMULA to display a specific topic of a dialog file as indicated in the definition of the pick menu.

Examples:

In the example shown on the next page the dialog file `dohelp1.hlp` provides context-specific help for the user editing the data menu `data`.

The **DO IF ERRORVALUE** statement is used to branch according to location of the currently highlighted field on the data menu.

If you press **Alt-H** when the cursor is on the field `wt` — which is the 3rd field in the data menu — you will get the message "Please enter your weight in kilograms." — which is the 3rd topic in the dialog file `dohelp1.hlp`.

ERRORVALUE is an internal PROMULA variable that contains the sequence number of the currently highlighted field in data and pick menus.

Define a dialog file with help messages.

```
DEFINE DIALOG "dohelp1.hlp"

                     Data Entry Help Messages

Select the desired message by using the movement keys.
  Press [ENTER] to access the desired (highlighted) message.
  Press [END] to return to the previous menu.
  Press [ESC] to exit to the PROMULA Main Menu.

END
```

```
        TOPIC "NAME"
          Please enter your last name in all CAPITAL letters.
        END
        TOPIC "AGE"
          Please enter your age in years.
        END
        TOPIC "WEIGHT"
          Please enter your weight in kilograms.
        END
        END
```

Define a procedure for editing a data menu and providing field-specific help for the data variables in the data menu.

```
        DEFINE VARIABLE
          name    "User Name" TYPE=STRING(12)
          age     "User Age (years)"
          wt      "User Weight (Kilograms)"
        END VARIABLE

        DEFINE MENU data
                              Data Entry Menu

          Name   :  @@@@@@@@@@     Please enter the information.
          Age    :  @@@@@@@@@@
          Weigh  :  @@@@@@@@@@     Press   Alt-H   if   you   have   any
          t                        questions.

        END


        DEFINE PROCEDURE getdata
          EDIT data(name,age,wt)
          DO IF HELP
             DO IF ERRORVALUE EQ 1
               BROWSE TOPIC "DOHELP1.HLP", 1
             ELSE ERRORVALUE EQ 2
               BROWSE TOPIC "DOHELP1.HLP", 2
             ELSE ERRORVALUE EQ 3
               BROWSE TOPIC "DOHELP1.HLP", 3
             END IF ERRORVALUE
          END DO IF HELP
        END PROCEDURE getdata
```

3.7.48 DO IF KEYPRESS

Purpose:

Executes one or more statements if the user presses a prespecified key in response to a prompt.

Syntax:

```
        stat1
        DO IF KEYPRESS(keyid)
          statement
          ...
        END
```

Remarks:

`stat1`	is an interactive statement; for example, an **ASK**, **SELECT**, **BROWSE** or **EDIT** statement.
`keyid`	is a keypress name (See Appendix C).
`statement`	is any executable statement (no definitions), including another **DO** statement.

The **DO IF KEYPRESS** statement is an extension of the **DO IF ESCAPE** capability and behaves in the same manner. If the user presses the key named by `keyid` in response to an interactive statement, PROMULA will execute the group of executable statements between the **DO IF KEYPRESS** and the **END** statement then re-execute `stat1`.

There are two limitations of this capability:

1. No more than five **DO IF KEYPRESS** blocks may follow a single statement.

2. The keypress identified by `keyid` must be available and defined for the current keyboard (See Appendix C).

Be warned that use of the **DO IF KEYPRESS** statement is inherently nonportable, and your application will require source code changes if it is moved across the various platforms on which PROMULA runs.

Example:

Procedure `test` uses the **DO IF KEYPRESS** statement to trap keypresses during an **EDIT variable** statement.

```
DEFINE SET
  row(20)
  col(10)
END

DEFINE VARIABLE
  var(row,col) "A variable matrix"
  dvar(row,col) "Difference in variable matrix"
  filen,  TYPE=STRING(20)
END

var(r,c) = r + c * 100

DEFINE PROCEDURE prt
  filen = "var.out"
  SELECT OUTPUT filen LINES=100 width=132 PRINTER=ON
  WRITE var
  SELECT LINES=25 WIDTH=80 PRINTER=OFF
END

DEFINE PROCEDURE dif
  dvar(y,c) = var(y,c) - var(y,1)
  BROWSE dvar  TITLE(var:D, "Differences from base case")
END

DEFINE PROCEDURE test
EDIT var TITLE(var:D//,
"Press ALT-P to save    ",/.
:Atd-D to see difference")
DO IF KEYPRESS(ALTP)
  prt
END
DO IF KEYPRESS(ALTD)
  dif
END
END
```

3.7.49 DO IF NULL

Purpose:

Executes a group of statements once if a null condition occurs.

Syntax:

```
DO IF NULL
  statement
  ...
END
```

Remarks:

`statement` is any executable statement (no definitions), including another **DO** statement.

The **DO IF NULL** statement, can be used to detect a null set selection resulting from a **SELECT set IF** statement. It may also be used to detect if the **GETDIR** function did not find any files matching the search specification.

A **SELECT set IF condition** statement results in a null condition if the selection condition is false for all elements of the set. When this occurs, PROMULA does not select a null set; it selects the complete set. The **DO IF NULL** statement allows you to detect the null selection and take appropriate action and prevent subsequent abnormal calculations, or other undesirable effects.

A **GETDIR** function results in a null condition if no files matching the search specification are found.

After the statements in the **DO IF NULL** block are executed, the **SELECT set IF** or **GETDIR** statement that caused the null selection is re-executed.

Examples:

The following example illustrates the use of the **DO IF NUL**L statement to detect a null set selection.

```
DEFINE SET
  mn (12)  "12 Months"
END SET

DEFINE VARIABLE
  lmt    "Lower Limit value"
  mv(mn) "Monthly values"
END VARIABLE

mv(i) = i*10

DEFINE PROCEDURE null
  WRITE ("Enter the Lower Limit.")
  READ lmt
  SELECT mn IF mv GT lmt
  DO IF NULL
    WRITE("There are no months with value greater than"lmt)
    WRITE("Try again.")
    null
  END IF NULL
  WRITE mv:40
END PROCEDURE null\
```

A dialog with procedure `null` is shown below.

```
             null
             Enter the Lower Limit.
                     ? 200

             There are no months with value greater than     200
             Try again.

             Enter the Lower Limit.
                     ? 100


                                           Monthly values

                           MN(11)                                        110
                           MN(12)                                        120
```

See the section on file management functions for an example of how to use the **DO IF NULL** statement to detect a "no match" condition from the **GETDIR** function.

3.7.50 DO INVERT

Purpose:

Compute the inverse of a matrix.

Syntax:

```
DO INVERT(row,col) arr
```

Remarks:

`row`	is the identifier of a set dimensioning the matrix to be inverted.
`col`	is the identifier of a set dimensioning the matrix to be inverted.
`arr`	is the square subarray to be inverted. `arr` must be dimensioned by the sets `row` and `col`. The results of the inversion will overwrite `arr`.

The ranges of `row` and `col` must be equal in size when **DO INVERT** is called, and the solution process will be restricted to the first selected entry of the remaining sets subscripting `arr`.

Example:

```
DEFINE SET
  arow(3)
  acol(3)
  brow(3)
  bcol(3)
  page(2)
END SET

DEFINE VARIABLE
  a (page,arow,acol)   "A matrix"     TYPE=REAL(10,6)
  ia(page,arow,acol)   "INVERT(A)"    TYPE=REAL(10,6)
  um(page,brow,bcol)   "UNIT MATRIX"  TYPE=REAL(10,6)
END VARIABLE
```

```
SELECT page(1)
READ a(arow,acol,page)
1 2 3
2 2 3
3 3 3
a(2,arow,acol) = a(1,arow,acol) * 2
SELECT page*

DEFINE PROCEDURE test
DO page
*
* Set IA equal to A
*
  ia = a
*
* Invert IA and display the result.
*
  DO INVERT (arow,acol) ia
  WRITE ia(arow,acol,page) TITLE(/"INVERT (arow,acol) a")

*
* Verify result by computing and displaying the matrix product of A and IA.
*
  um(p,i,k) = SUM(j) ( a(p,i,j) * ia(p,j,k) )
  WRITE um(brow,bcol,page) TITLE(/"VERIFY:  UNIT MATRIX?")
END page
END PROCEDURE test

SELECT HEADING=OFF
```

The results of procedure `test` are displayed in the dialog below.

```
          test

                                        INVERT (arow,acol) a

                                              PAGE(1)

                                             ACOL(1)   ACOL(2)   ACOL(3)
                           AROW(1)         -1.000000  1.000000  0.000000
                           AROW(2)          1.000000 -2.000000  1.000000
                           AROW(3)          0.000000  1.000000 -0.666667

                                       VERIFY:  UNIT MATRIX?

                                              PAGE(1)

                                             BCOL(1)   BCOL(2)   BCOL(3)
                           BROW(1)          1.000000  0.000000  0.000000
                           BROW(2)          0.000000  1.000000  0.000000
                           BROW(3)          0.000000  0.000000  1.000000

                                        INVERT (arow,acol) a

                                              PAGE(2)

                                             ACOL(1)   ACOL(2)   ACOL(3)
                           AROW(1)         -0.500000  0.500000  0.000000
                           AROW(2)          0.500000 -1.000000  0.500000
                           AROW(3)          0.000000  0.500000 -0.333333

                                       VERIFY:  UNIT MATRIX?
```

```
                                  PAGE(2)

                               BCOL(1)   BCOL(2)   BCOL(3)
             BROW(1)          1.000000  0.000000  0.000000
             BROW(2)          0.000000  1.000000  0.000000
             BROW(3)          0.000000  0.000000  1.000000
```

3.7.51 DO LSOLVE

Purpose:

Solve one or more systems of linear equations.

Syntax:

```
DO LSOLVE(row,col [,pag1,pag2,...]) (amat, bmat)
```

Remarks:

`row`	is the identifier of a set dimensioning both `amat` and `bmat`.
`col`	is the identifier of a set dimensioning `amat`.
`pag1,pag2,...`	are the identifiers of sets subscriprting `bmat`.
`amat`	is the identifier of the coefficient matrix.
`bmat`	is the identifier of the result matrix.

The statement

```
DO LSOLVE (i,j,p) (A,B)
```

will compute the solution vectors `X(j,p)` for the system of linear equations

```
A11 * X1p + a12*X2p + ... + a1j * Xjp = b1p
A21 * X1p + a22*X2p + ... + a2j * Xjp = b2p
...

Ai1 * X1p + ai2*X2p + ... + aij * Xjp = bip
```

The solution vectors `X(j,p)` will overwrite the `B(i,p)` values.

The ranges of `i` and `j` must be equal in size when **DO LSOLVE** is called, and the solution process will be restricted to the active range of the sets subscripting the arguments.

Example:

```
DEFINE SET
  arow(3) "Linear Equation"
  acol(3) "Product Term"
  page(2) "Page of System"
END SET
```

```
DEFINE VARIABLE
  a(arow,acol) "Coefficient Matrix"
  b(arow,page) "Result Vectors"
  x(arow,page) "Solution Vectors"
  y(arow,page) "Test Result Vectors"
END VARIABLE

READ a
1 2 3
2 2 3
3 3 3
READ b
6 14
7 15
9 18

DEFINE PROCEDURE test
*
* Copy the result vectors B(i,page) into the vectors X(i,page).
*
  x = b
*
* Solve system of linear equations for each page.
*
  DO LSOLVE(arow,acol,page) (a, x)
*
* Verify the Results.  A(i,j) . X(i,p) = should equal B(i,p).
*
  y(i,p) = SUM(j) ( a(i,j) * x(j,p) )

  WRITE a::2
  WRITE b::2
  WRITE x::2
  WRITE y::2
END PROCEDURE test
```

The results of procedure `test` are displayed in the dialog below.

```
          test
                              Coefficient Matrix

                                   ACOL(1) ACOL(2) ACOL(3)
                    AROW(1)           1.00    2.00    3.00
                    AROW(2)           2.00    2.00    3.00
                    AROW(3)           3.00    3.00    3.00

                                Result Vectors

                                       PAGE(1) PAGE(2)
                        AROW(1)           6.00   14.00
                        AROW(2)           7.00   15.00
                        AROW(3)           9.00   18.00

                               Solution Vectors

                                       PAGE(1) PAGE(2)
                        AROW(1)           1.00    1.00
                        AROW(2)           1.00    2.00
                        AROW(3)           1.00    3.00

                             Test Result Vectors
```

```
                                      PAGE(1) PAGE(2)
                        AROW(1)          6.00   14.00
                        AROW(2)          7.00   15.00
                        AROW(3)          9.00   18.00
```

.7.52 [DO] procedure

Purpose:

Executes a procedure.

Syntax:

```
[DO] proc [,SUBTITLE "text"]
```

Remarks:

`proc`	is the identifier of a procedure.
`text`	is a string of characters that will be appended to the titles of reports produced by procedure `proc`.

Example:

This example illustrates several title modification options and the **variable:L** notation. Notice that the displayed title `TITLE` parameter first, followed by the scenario name, the run identifier, the subtitle, and finally, the time interval.

```
DEFINE SET
  row(2)
  run(2)
  tim(10) TIME(1990,1999)
END SET
DEFINE VARIABLE
  a(row,tim) TYPE=REAL(5,1)   "THE A MATRIX"
  sname      TYPE=STRING(12)
END VARIABLE
a(i,j)=i*j
sname="SCENARIO x"

READ row
row 1
row 2
READ run
RUN 1
RUN 2

DEFINE PROCEDURE proc
  SELECT run(2)
  SELECT RUNID=run SCENARIO=sname
  WRITE a\7:7 TITLE(a:L)
END PROCEDURE proc
```

The statement

```
DO proc SUBTITLE "This is the subtitle"
```

produces the display below

```
                                 THE A MATRIX
                  SCENARIO x, RUN 2, This is the subtitle, 1990 to 1999

                1990    1991    1992    1993    1994    1995    1996    1997    1998    1999
      row 1      1.0     2.0     3.0     4.0     5.0     6.0     7.0     8.0     9.0    10.0
      row 2      2.0     4.0     6.0     8.0    10.0    12.0    14.0    16.0    18.0    20.0
```

3.7.53 DO REGRESS

Purpose:

Produces a report of one or more pages of the results of multivariate least-squares regression for specified variables by finding the best fit for the following model:

$$Y = \beta o + \beta_1 * X_1 + \beta_2 X_2 + , \ldots , + \beta_n X_n$$

Y is the dependent variable, the X_i are the independent predictor variables, and the β_i are the regression coefficients.

Syntax:

```
DO REGRESS [(sets)] (vars) [output]
```

Remarks:

`sets` is a list of set identifiers subscripting the array(s) to be regressed.

The specification of `sets` controls the analysis of the variables specified in `vars` by defining the index of the observations and the order of pages produced. The last set in `sets` specifies the index of the observations, the preceding sets specify the order in which pages of the report are displayed. The ordering of report pages corresponds to the specification of the sets in `sets` from left to right — left varying the fastest. The default value for `sets` is the reverse of the set specification used in defining the highest dimensional variable in `vars` with the first set in the definition indexing the observations, and the remaining sets heading report pages.

`vars` is a list of variable identifiers specifying the arrays to be regressed. The list may also contain the time parameter **TIME** if all the variables in `vars` have a time series set as one of their indexes. The first variable specified in `vars` will be treated as the dependent variable (Y), the remaining variables will be treated as the independent regressors (X_i). `vars` must contain at least two variables. One-dimensional arrays (vectors), are used in regression calculations directly. Two- and higher-dimensional arrays are partitioned into sets of observations, and a separate report is generated for each page and column of the highest dimensional array in `vars`.

`output` is a list of output specifiers that allow the storage of regression results in program variables. If *any* output is stored in variables, no report is displayed. `output` may consist of one or more of the following:

`COEFF  = cf`	to store the regression coefficients in variable `cf`
`TVALUE = tv`	to store the Student's t statistic for the regression coefficients in variable `tv`
`STDERR = se`	to store the standard errors of regression coefficients in array variable `se`
`STDDEV = sd`	to store the standard deviation(s) of regression model(s) in variable `sd`
`RSQUAR = rs`	to store the R-Square(s) of regression model(s) in variable `rs`

The output variables should be dimensioned so that they can pick up the desired regression results; see the example below.

The following values may be reported/stored:

1. The regression coefficient (β_i), Student's t statistic, and standard error, for each independent variable in the model and for the intercept, β_o (referred to as `CONS` in the report).

2. The overall variance and standard deviation of the regression model.

3. The adjusted coefficient of correlation between the observed and predicted values of the dependent variable.

A title — **Regression Analysis Results** — is printed at the top of each page. Subtitles consisting of the row descriptors for sets specified in `sets` appear when more than one report page is produced.

Examples:

```
DEFINE SET
  grp(2)   "Test Groups"
  tim(12)  "Time Points" TIME(1,12)
  trm(3)  "Regression Terms (Independent Variables + CONSTANT)"
END SET

DEFINE VARIABLE
*
* REGRESSEION INPUTS
*
  rsp(tim,grp) "Response Variable By Group and And Time"
  iv1(tim,grp)  "Independent Variable 1 by Group and Time"
  iv2(tim,grp)  "Independent Variable 2 by Group and Time"

*
* REGRESSION OUTPUTS
*
  cf(trm,grp)    "Coefficients of the Regression Terms"
  tv(trm,grp)    "T-Value for the Coefficients of the Regression Terms"
  se(trm,grp)    "Stderr Errror for the Coefficients of the Regression Terms"
  sd(grp)        "Standard Deviation of Regression Model"
  rs(grp)        "R-Square of Regression Model"
END VARIABLE

SELECT grp(1)
READ iv1(grp,tim)
16.7 17.4 18.4 16.8 18.9 17.1 17.3 18.2 21.3 21.2 20.7 18.5
READ iv2(grp,tim)
30.0 42.0 47.0 47.0 43.0 41.0 48.0 44.0 43.0 50.0 56.0 60.0
READ rsp(grp,tim)
210  110  103  103  91   76   73   70   68   53   45   31
iv1(t,2) = iv1(t,1)
iv2(t,2) = iv2(t,1)
rsp(t,2) = rsp(t,1)
SELECT grp*

READ TRMS ROW(1,6)
IV1
IV2
CONS

DEFINE PROCEDURE doregr
*
* Regression -- Report
*
DO REGRESS(grp,tim) (rsp,iv1,iv2)
*
```

```
* Regression -- Save Output
*
DO REGRESS(grp,tim) (rsp,iv1,iv2),
  COEFF  = cf,
  TVALUE = tv,
  STDERR = se,
  STDDEV = sd,
  RSQUAR = rs
WRITE TABLE(grp,trm) TITLE(///"Regression Results") FORMAT(50,10),
BODY(cf::4 tv::4 se::4 sd::4 rs::4)
END PROCEDURE doregr
```

The output of procedure `doregr` is displayed below

```
                            Regression Analysis Results, 1 to 12

                                           GRP(1)

                        Term       Coefficient   T-Value         S.E.
                        IV1          -6.592777    -1.357      4.859254
                        IV2          -4.503562    -4.204      1.071156
                        CONS        415.113000     5.031     82.517400
                                     Variance=598.0237
                                Standard Deviation=24.45452
                                  Adjusted R-Square=0.7164

                                           GRP(2)

                        Term       Coefficient   T-Value         S.E.
                        IV1          -6.592777    -1.357      4.859254
                        IV2          -4.503562    -4.204      1.071156
                        CONS        415.113000     5.031     82.517400
                                     Variance=598.0237
                                Standard Deviation=24.45452
                                  Adjusted R-Square=0.7164


                                     Regression Results

                                            IV1

                                                                  GRP(1)    GRP(2)
            Coefficients of the Regression Terms                 -6.5928   -6.5928
            T-Value for the Coefficients of the Regression Ter   -1.3567   -1.3567
            Stderr Errror for the Coefficients of the Regressi    4.8593    4.8593
            Standard Deviation of Regression Model               24.4545   24.4545
            R-Square of Regression Model                          0.7164    0.7164

                                            IV2

                                                                  GRP(1)    GRP(2)
            Coefficients of the Regression Terms                 -4.5036   -4.5036
            T-Value for the Coefficients of the Regression Ter   -4.2044   -4.2044
            Stderr Errror for the Coefficients of the Regressi    1.0712    1.0712
            Standard Deviation of Regression Model               24.4545   24.4545
            R-Square of Regression Model                          0.7164    0.7164

                                            CONS

                                                                  GRP(1)    GRP(2)
            Coefficients of the Regression Terms                415.1130  415.1130
            T-Value for the Coefficients of the Regression Ter    5.0306    5.0306
            Stderr Errror for the Coefficients of the Regressi   82.5174   82.5174
```

```
              Standard Deviation of Regression Model               24.4545   24.4545
              R-Square of Regression Model                          0.7164    0.7164
```

3.7.54 DO set

Purpose:

Executes repeatedly a group of statements. The number and order of iterations is determined by the number and order of the elements of the set, as defined by the set's current selection vector.

Syntax:

```
DO set
  statement
  ...
END
```

Remarks:

`set`	is the identifier of a set.
`statement`	is any executable statement (no definitions), including other **DO** statements.

The statements from **DO set** to **END** are usually called a "**DO set loop**".

The statements between the **DO set** and **END** statements are executed once for each element in the current set selection vector for `set`. By default, the set selection vector contains N elements ordered from 1 to N; where N is the size of `set` as specified in its definition. The order and range of the elements of the selection vector may be modified by the various set selection statements and the **SORT** statement.

Within an iteration of the **DO set** loop, the range of `set` is fixed to a single element, and vectors subscripted by `set` are treated as scalars in calculations and other expressions; multidimensional array variables subscripted by `set` are evaluated at the current value of the subscript `set`.

If a **DO set** loop executes properly for each active element in `set`, the range and order of `set` after the loop will be the same as before the loop started. However, if execution of the loop aborts abnormally, the range of `set` will be fixed at the element that was active when the abort occurred.

Examples:

In this example, the procedure `doset` contains a **DO set** loop. The statements between the `DO month` statement and the `END DO month` statement are executed once for each active element in the selection vector for set `month`.

The variable `month:S` has the value of the current selection of the `month` set. Similarly, the variable `mv` has the value `mv(m)`, where `m` is a scalar subscript which will be assigned the current value of the `month` subscript.

```
DEFINE SET
  month(12)
END SET

DEFINE VARIABLE
  m          "Month Number"
  mv(month) "Monthly Value"
END VARIABLE
```

```
DEFINE PROCEDURE doset
  DO month
    m  = month:S
    mv = m * 10
    WRITE CENTER("The current month number is " m:-5 " The monthly value is " mv:-5)
  END month
END PROCEDURE doset
```

Executing procedure `doset` produces the output below.

```
                      The current month number is 1     The monthly value is 10
                      The current month number is 2     The monthly value is 20
                      The current month number is 3     The monthly value is 30
                      The current month number is 4     The monthly value is 40
                      The current month number is 5     The monthly value is 50
                      The current month number is 6     The monthly value is 60
                      The current month number is 7     The monthly value is 70
                      The current month number is 8     The monthly value is 80
                      The current month number is 9     The monthly value is 90
                      The current month number is 10    The monthly value is 100
                      The current month number is 11    The monthly value is 110
                      The current month number is 12    The monthly value is 120
```

The number of iterations as well as the order of execution is dictated by the current selection vector of the set controlling the **DO set** loop. For example the statements

```
SELECT month(1,12,6)
doset
```

produce the output below

```
                      The current month number is 1     The monthly value is 10
                      The current month number is 12    The monthly value is 120
                      The current month number is 6     The monthly value is 60
```

3.7.55 DO UNTIL

Purpose:

Executes repeatedly a group of statements until a given condition is met.

Syntax:

```
DO UNTIL condition
  statement
  ...
END
```

Remarks:

`condition` is any Boolean expression, i.e., an expression that is either true or false. If false, the statements between the **DO UNTIL** and the **END** statement are executed; if true, the statements between the **DO** and **END** are not executed.

`statement` is any executable statement (no definitions), including a **DO** statement.

The group of statements together with the **DO** and **END** statements is called a **DO UNTIL loop**. DO loops may be nested to any depth.

The value of `condition` is computed before each iteration of the **DO loop**.

Examples:

The following dialog demonstrates the execution of a **DO UNTIL** loop:

```
DEFINE VARIABLE
    x
  END VARIABLE

  x = 0
  DO UNTIL x GT 3
    WRITE (x,"Top of the loop")
    x = x+1
    WRITE (x,"Bottom of the loop")
  END UNTIL
  0  Top of the loop
  1  Bottom of the loop
  1  Top of the loop
  2  Bottom of the loop
  2  Top of the loop
  3  Bottom of the loop
  3  Top of the loop
  4  Bottom of the loop
```

From this example, you can see how easy it is to construct infinite loops — simply remove the equation `x = x+1`.

3.7.56 DO WHILE

Purpose:

Executes repeatedly a group of statements while a given condition is met.

Syntax:

```
DO WHILE condition
  statement
  ...
END
```

Remarks:

`condition`	is any Boolean expression, i.e., an expression that is either true or false. If true, the statements between the **DO WHILE** and the **END** statement are executed; if false, the statements between the **DO** and **END** are not executed.
`statement`	is any executable statement (no definitions), including a **DO** statement.

The group of statements together with the **DO WHILE** and **END** statements is called a **DO WHILE** loop. **DO** loops may be nested to any depth.

The value of `condition` is computed before each iteration of the **DO** loop.

Examples:

The following dialog demonstrates the execution of a **DO WHILE** loop:

```
DEFINE VARIABLE
    x
  END VARIABLE

  x = 0
  DO WHILE x LT 3
    WRITE (x,"Top of the loop")
    x = x+1
    WRITE (x,"Bottom of the loop")
  END WHILE
  0  Top of the loop
  1  Bottom of the loop
  1  Top of the loop
  2  Bottom of the loop
  2  Top of the loop
  3  Bottom of the loop
```

3.7.57 EDIT menu

Purpose:

Displays a data menu for editing.

Syntax:

```
EDIT menu(vars)
```

Remarks:

`menu`	is the identifier of a data menu.
`vars`	is a list of variable identifiers that contain the values of the data fields being edited. The variables in the list must be arranged in the same order as the menu data fields to which they correspond.

Data menus contain a number of **data fields** to be edited by the user. In the **DEFINE MENU** statement, each data field is denoted by a series of contiguous 'at' (@) or 'tilde' (~) characters, equal in number to the width of the data field. The data fields are ordered from left to right and from top to bottom of the menu.

Upon execution, the data menu becomes a screen display that has the first data field highlighted. Use the movement keys to highlight the desired data field. To edit the highlighted data field, press the **Enter** key and enter the new value, as prompted at the bottom of the screen.

Data fields may also be selected by "point and click" operations with a mouse.

The menu display will be clipped by the boundaries of the window opened to the Main Screen.

Examples:

The use of the **EDIT menu** statement is illustrated in the context of the example given in the **DEFINE MENU** statement.

3.7.58 EDIT TABLE

Purpose:

Displays a table of several variables on the screen to let you interactively edit their values.

Syntax:

```
EDIT TABLE(sets)[,TITLE(title)][,FORMAT(rw,cw)],
BODY(["text1",] var1[fmt1] [,"text2",] var2[fmt2],...), option
```

Remarks:

`sets`	is a list of the identifiers of the sets classifying columns and pages of the variables in the table. The first set will classify the columns of the table; the other sets, if any, will classify the pages of the table. Sets dimensioning table variables which are missing from the list will classify the rows of the table. The `sets` list `sets` must contain at least one set (or the number 1 for browsing a group of scalar variables) and must be missing those set identifiers which will classify the rows of the multidimensional table variables.
`title`	is any text you wish to show as a title for the table. The title may include variables and other format characters according to the rules defined in the **WRITE variables** statement.
`text1`	is any text that you wish to use as a subtitle for the values of `var1`. This text may not contain variables.
`var1`	is the identifier of the first variable in the table.
`fmt1`	is the desired format for the values of `var1`. Usually, this is used to specify the number of decimal digits for `var1`.
`text2`	is any text that you wish to use as a subtitle for the values of `var2`. This text may not contain variables.
`var2`	is the identifier of the second variable in the table.
`fmt2`	is the desired format for the values of `var2`.
`rw`	is the width in characters of row descriptors.
`cw`	is the width in characters of table columns.
`option`	is one of the following:

BY ROW	to edit values by row (entering a value moves the bounce bar to the right)
BY COLUMN	to edit values by column (entering a value moves the bounce bar down)
BY VALUE	to edit values by single value (bounce bar does not move automatically). This is the default

A table is a display or report of several variables whose values are classified by a common set (or sets). The common sets classify the columns and pages of the table.

A table has a body and an optional title and format. The body of the table contains the identifiers of the variables whose values will be displayed as the body of the table.

You may include as many variables as you wish in the body of a table.

You may include slash characters "/" between the specifications of variables and descriptive text to insert blank lines in the display.

If you wish to 'write' an entire table, instead of 'editing' it by page, use the **WRITE TABLE** statement.

Upon execution, the **EDIT TABLE** statement clears the Main Screen, displays the first page of the table and issues the following message at the bottom of the display:

```
End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows: Select Enter: Edit
```

The highlighted portions of the message represent the following options:

Fn press the Fn function key to browse "up" the nth dimension of the array, where n varies from 1 to 10. The **F1** key browses "up" the 1st dimension, the **F2** key browses "up" the 2nd dimension, and so forth.

Shift-Fn press simultaneously the **Shift** and **Fn** keys to browse "down" the nth dimension of the array, where **n** varies from 1 to 10. The **F1** key browses "up" the 1st dimension, the **F2** key browses "up" the 2nd dimension, and so forth. The **Shift-F1** key browses "down" the 1st dimension, the **Shift-F2** key browses "down" the 2nd dimension, etc.

Arrows
PgUp
PgDn The four movement arrows at the right-hand section of the keyboard allow you to move the cursor to the desired value. The Page-Up and Page-Down keys may be used to move up and down the pages of the display.

Home moves the cursor to the "top" of the display, which is the first value on the first page.

Enter press the **Enter** key to initiate editing mode. This causes the following:

1. highlights the value to be edited with a block cursor
2. issues the following message at the lower left-hand corner of the Prompt Screen:

```
Enter value or End?
```

At this point you may change the marked value by entering a new one and pressing the **Enter** key. The cursor moves to the next value to edit, and so forth.

End press the **End** key to exit editing mode or to exit browsing mode.

The **WRITE TABLE** statement and tables defined by the **DEFINE TABLE** statement will behave like the **EDIT TABLE** statement if a **SELECT BROWSE=VALUES \ ROW \ COLUMN** statement has been executed.

Examples:

See the descriptions of the **BROWSE TABLE** and **DEFINE TABLE** statements for an example of a table.

3.7.59 EDIT variable

Purpose:

Displays a variable on the screen to let you

1. browse the variable by page

2. change its values in screen-editing mode.

Syntax:

```
EDIT var[fmt][ORDER(sets)][TITLE(title)][DISPLAY(dvar)][option]
```

Remarks:

`var` is the variable identifier.

`fmt` is a format specification indicating the width of row descriptors, the width of the columns displayed, and the number of decimals in real values, as follows:

```
\p:w:d
```

where

- `p` is an integer specifying the width in characters for row descriptors. The default width is the width specifications of the row descriptors related to the set subscripting the rows of the display.
- `w` is an integer specifying the width in characters for each column of values. The default is the width specification in the definition of `var`. A negative width parameter left justifies the values of `var` in each column**.**
- `d` is an integer specifying the number of decimals to display for real numeric values. The default is the decimal specification (if applicable) in the definition of `var`. If `d` is an "E", the values of `var` will be displayed in exponential notation (base-10), and will show seven digits and six decimal places.

  If omitted, `w` and `d` are the parameters specified in the **TYPE** specification for `var`, and `p` is the width specifications of the row descriptors related to the set subscripting the rows of the display.

`sets` is a list of the sets classifying the values of `var`. The order of the sets in this list specifies the structure of the display: the first set classifies the rows of the display, the second set classifies the columns, and the third to last set classifies the pages of the display. The keyword **ORDER** is optional; if omitted, `sets` must immediately follow the optional format specification.

`title` is any text you wish to show as a title for the table. The title may include variables, and other format characters according to the rules defined in the **WRITE text** statement.

`dvar` is a variable used to control the display of variable `var`. `dvar` should be indexed by the set that defines the rows of the display. PROMULA will display values of `var` only for those rows corresponding to elements of `dvar` that contain nonzero values. See Example in the section on the **BROWSE variable** statement.

`option` is one of the following:

BY ROW	to edit values by row (entering a value moves the bounce bar to the right).
BY COLUMN	to edit values by column (entering a value moves the bounce bar down).
BY VALUE	to edit values by single value (bounce bar does not move automatically). **BY VALUE** is the default.

Upon execution, the **EDIT variable** statement clears the Main Screen, displays the first page of the array and issues the following message at the bottom of the display:

```
End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows: Select Enter: Edit
```

The highlighted portions of the message represent the following options:

Fn press the Fn function key to browse "up" the nth dimension of the array, where n varies from 1 to 10.

Shift-Fn press simultaneously the **Shift** and **Fn** keys to browse "down" the nth dimension of the array, where **n** varies from 1 to 10. The **F1** key browses "up" the 1st dimension, the **F2** key browses "up" the 2nd dimension, and so forth. The **Shift-F1** key browses "down" the 1st dimension, the **Shift-F2** key browses "down" the 2nd dimension, etc.

Arrows
PgUp
PgDn The four movement arrows at the right-hand section of the keyboard allow you to move the cursor to the desired value. The Page-Up and Page-Down keys may be used to move up and down the pages of the display.

Home moves the cursor to the "top" of the display, which is the first value on the first page.

Enter press the **Enter** key to initiate editing mode. This causes the following:

1. highlights the first value to be edited with a block cursor

2. issues the following message at the left-hand corner of the Prompt Screen:

```
    Enter value or End?
```

At this point you may change the marked value by entering a new one and pressing the **Enter** key. The cursor moves to the next value to edit, and so forth.

End press the **End** key to exit editing mode or to exit browsing mode.

Examples:

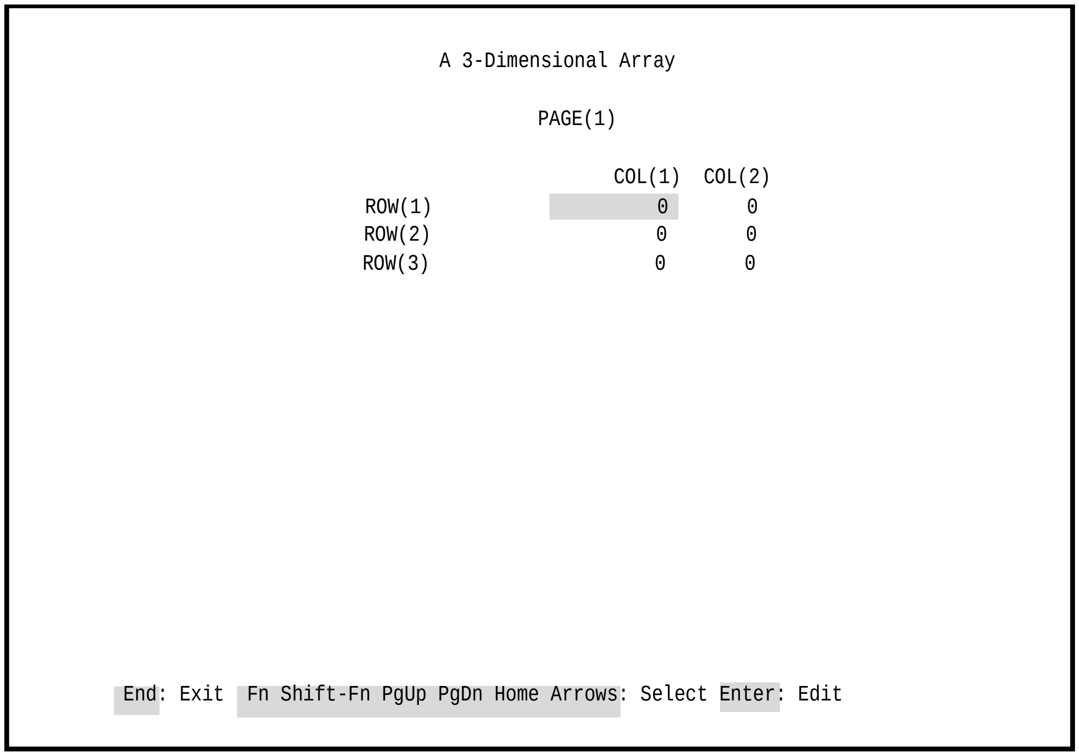
Given the following definitions:

```
DEFINE SET
  row(3)
  col(2)
  page(2)
END SET

DEFINE VARIABLE
  a(row,col,page) "A 3-Dimensional Array"
END VARIABLE
```

the statement

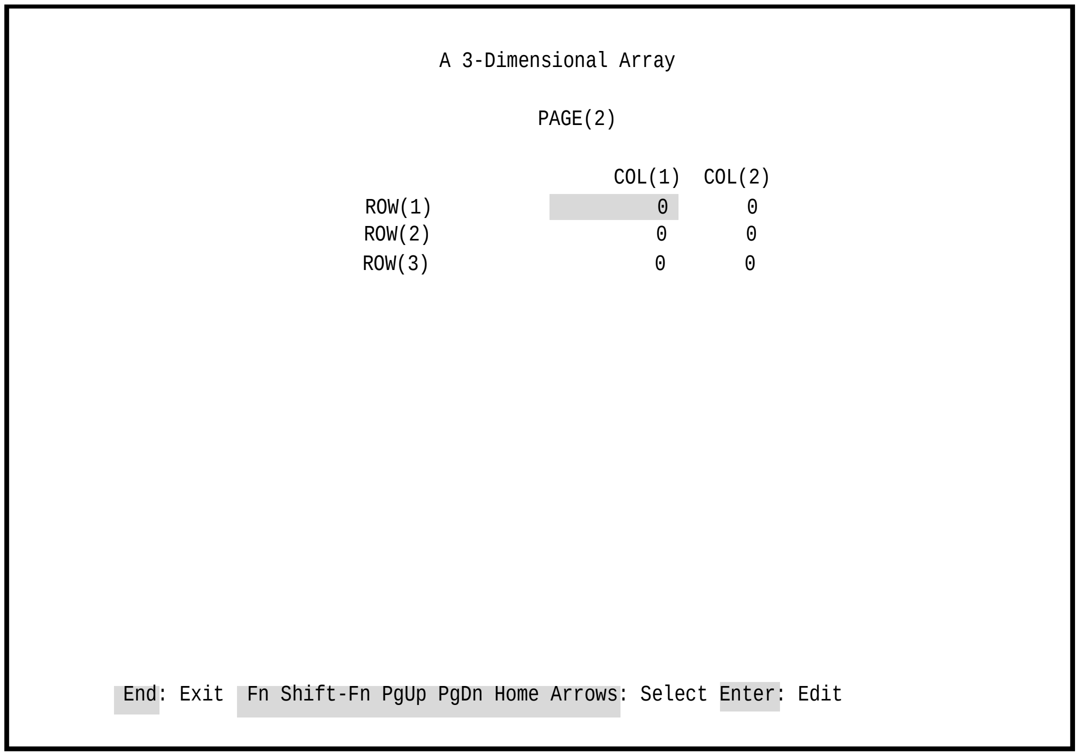
```
EDIT a
```

clears the screen and produces the following display:



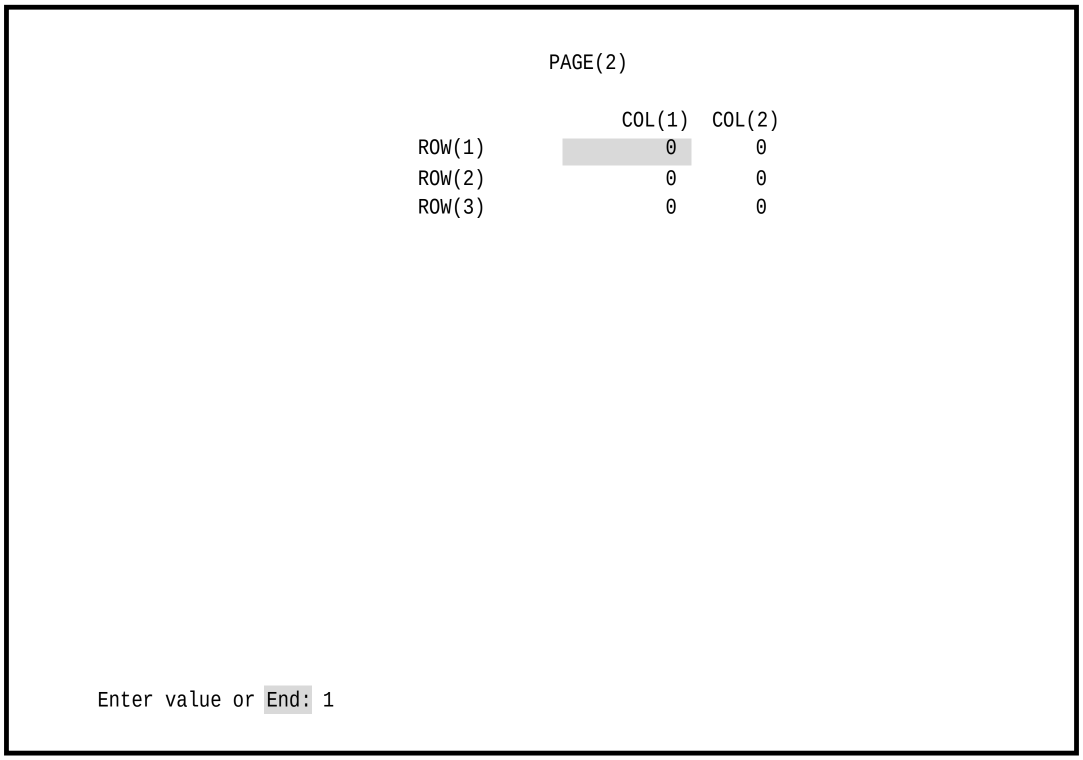
```
                         A 3-Dimensional Array

                               PAGE(1)

                                  COL(1)  COL(2)
          ROW(1)                       0       0
          ROW(2)                       0       0
          ROW(3)                       0       0











   End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows: Select Enter: Edit
```

To browse "up" the pages or third dimension, press the **F3** key to get the following display:



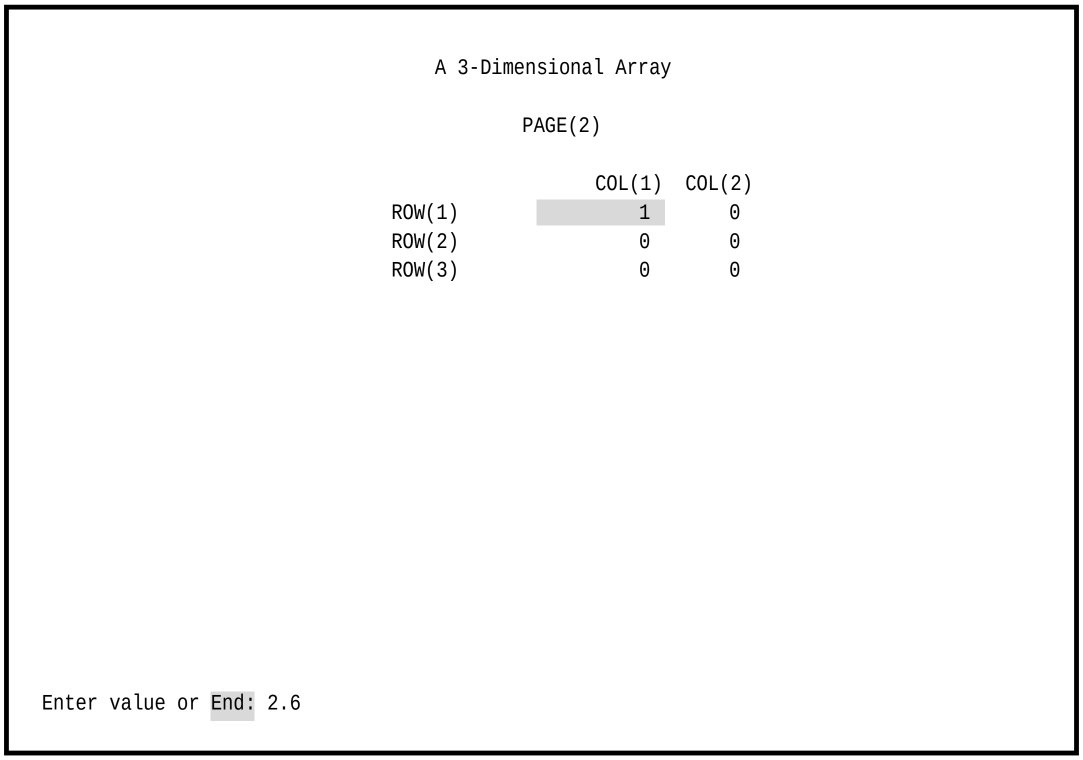
```
                         A 3-Dimensional Array

                               PAGE(2)

                                  COL(1)  COL(2)
          ROW(1)                       0       0
          ROW(2)                       0       0
          ROW(3)                       0       0











   End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows: Select Enter: Edit
```

You may now begin editing the array. The value in cell `ROW(1), COL(1)` is highlighted. Press the **Enter** key to change the value in this cell. The following display results:



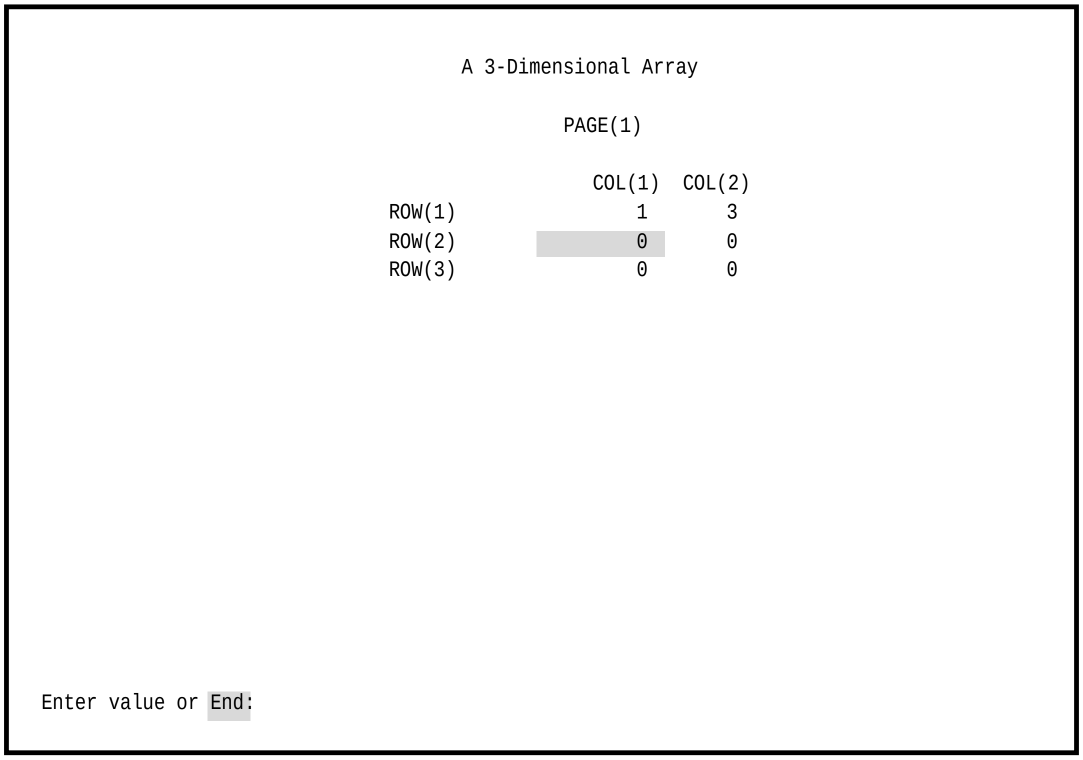
```
                              PAGE(2)

                                   COL(1)  COL(2)
                   ROW(1)               0       0
                   ROW(2)               0       0
                   ROW(3)               0       0






   Enter value or End: 1
```

Enter the value 1 and press the **Enter** key. The following display results:



```
                      A 3-Dimensional Array

                             PAGE(2)

                                COL(1)  COL(2)
                ROW(1)               1       0
                ROW(2)               0       0
                ROW(3)               0       0











Enter value or End: 2.6
```

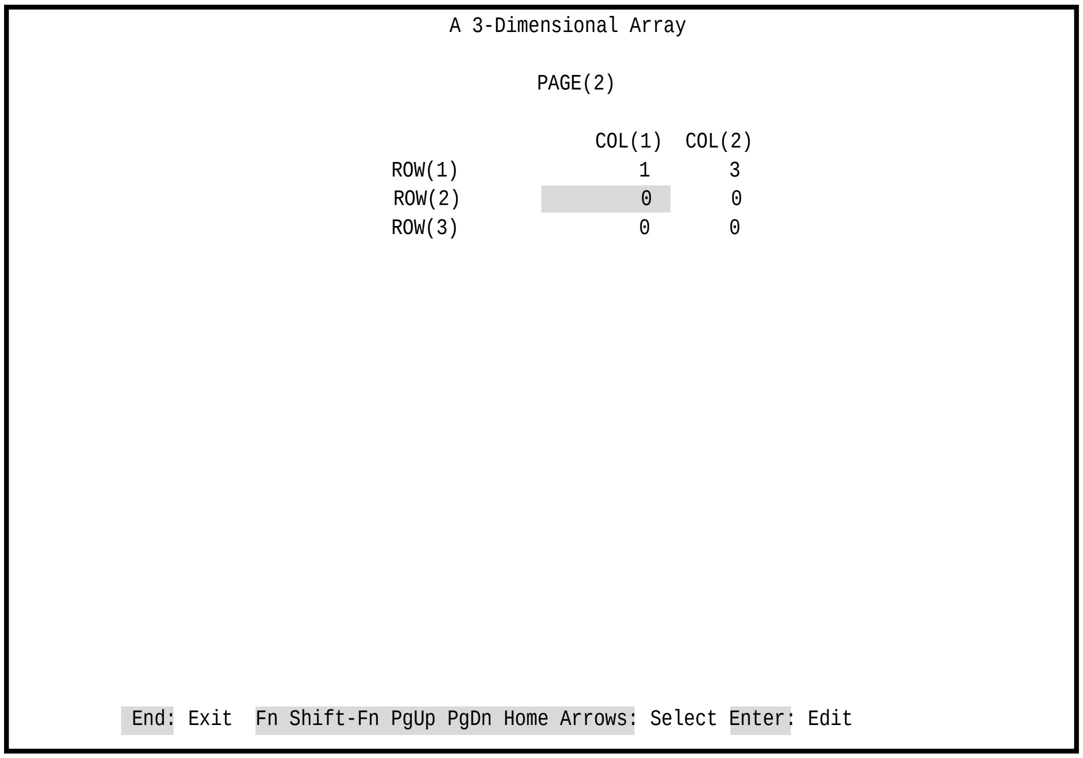
The cursor now highlights the value in the `ROW(1), COL(2)` cell. Type the value 2.6 and press the **Enter** key. The following display results:



```
                       A 3-Dimensional Array

                              PAGE(1)

                                COL(1)  COL(2)
                ROW(1)               1       3
                ROW(2)               0       0
                ROW(3)               0       0











Enter value or End:
```

The value 2.6 is rounded up to 3 because variable a was defined with the default type, **REAL(8,0)**. Internally, however, the value is stored correctly as 2.6. This is verified below.

Press the **End** key. The following display results:



```
                       A 3-Dimensional Array

                              PAGE(2)

                                  COL(1)  COL(2)
                  ROW(1)               1       3
                  ROW(2)               0       0
                  ROW(3)               0       0




 End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows: Select Enter: Edit
```

Press the **End** key again. This gets you out of editing mode.

To verify the above editing, the following dialog shows the values of a by column, row and page, with two decimal digits:

```
WRITE a(col,row,page):10:2

                      A 3-Dimensional Array

                            PAGE(1)

                             ROW(1)   ROW(2)   ROW(3)

            COL(1)             0.00     0.00     0.00
            COL(2)             0.00     0.00     0.00

                            PAGE(2)

                             ROW(1)   ROW(2)   ROW(3)

            COL(1)             1.00     0.00     0.00
            COL(2)             2.60     0.00     0.00
```

3.7.60 END

Purpose:

Ends a structured group of statements.

Syntax:

```
        END [comment]
```

Remarks:

`comment` is an optional comment that you may wish to use in order to distinguish one **END** statement from another.

The following statements require an **END** statement:

ASK...ELSE
* **BROWSE COMMENT**
* **BROWSE TEXT**
DEFINE DIALOG
DEFINE FILE
DEFINE FUNCTION
* **DEFINE MENU**
DEFINE PARAMETER
DEFINE PROCEDURE
DEFINE RELATION
DEFINE SET
DEFINE SYSTEM
DEFINE VARIABLE
DEFINE WINDOW
DO DIRECTORY
DO FILE
DO IF...ELSE
DO IF END
DO IF ERROR
DO IF ESCAPE
DO IF HELP
DO IF KEYPRESS
DO IF NULL
DO set
DO UNTIL
DO WHILE
* **FIELD (in Popup Menu definitions)**
* **TOPIC (In Dialog files)**
* **WRITE COMMENT**
* **WRITE TEXT**

* These structured statements contain free form text; therefore, the **END** statement must be capitalized and start in column 1, to distinguish it from other occurrences of the word "end" in the text. No comment is allowed after these **END** statements.

The **END SEGMENT** and **END PROGRAM** statements are special cases of the **END** and are discussed in the following two sections.

3.7.61 END PROGRAM

Purpose:

Ends a program and writes the executable code and data to the currently open segment file on disk. The logical identifier of the segment is "**MAIN**". Both the program code and the data values of its variables are saved on disk.

Syntax:

```
        END PROGRAM [MAIN] [,DO(proc)]
```

Remarks:

`MAIN`	is the default identifier of any executable program module.
`proc`	is the identifier of a procedure in segment **MAIN**. When the program is read in, this procedure is executed automatically.

Upon compilation, this statement terminates the program and writes on a disk file the information of the program. The start of the program is the **DEFINE PROGRAM** statement. The program is written on the disk file specified on the last **OPEN SEGMENT** statement. To execute the program, use the **OPEN SEGMENT** and **READ SEGMENT** statements.

Examples:

The statements below define a program, named by default **MAIN**, and write the executable program code on a disk file named `hello.xeq`:

```
        OPEN SEGMENT "hello.xeq", STATUS=NEW
        DEFINE PROGRAM "A Program"

        DEFINE PROCEDURE proc
          WRITE("Hello, World!")
        END proc

        END PROGRAM, DO(proc)
```

To read this program for execution, use the statements

```
        OPEN SEGMENT "hello.xeq"
        READ SEGMENT MAIN
```

or the statement

```
        RUN PROGRAM "hello.xeq"
```

The procedure `proc` is executed automatically at program startup.

This program could also be started by selecting option 6 from the PROMULA Main Menu and specifying "hello" as the name of the program to be executed.

3.7.62 END SEGMENT

Purpose:

Ends the definition of a program segment and writes the segment code and data to the currently open segment file.

Syntax:

```
        END SEGMENT seg [,DO(proc)]
```

Remarks:

`seg`	is the identifier of a segment as it appeared on the **DEFINE SEGMENT** statement that began the segment.
`proc`	is the identifier of a procedure in segment `seg`. When the segment is loaded, this procedure is executed automatically.

Upon compilation, this statement writes on a disk file the information of the segment. The start of the segment is the **DEFINE SEGMENT seg** statement. The segment is written in the disk file specified on the last **OPEN SEGMENT** statement.

To load the segment for execution, use the **READ SEGMENT** statement.

Examples:

The statements below define a two segmented program, the program contains the top-level segment, `MAIN`, and two level-one segments named `seg1` and `seg2`. The code and data of all three segments are saved on a disk file named `program.xeq`:

```
OPEN SEGMENT "program.xeq", STATUS=NEW
DEFINE PROGRAM "MAIN"

  DEFINE PROCEDURE start
    READ SEGMENT seg1
    READ SEGMENT seg2
  END PROCEDURE start

  DEFINE SEGMENT seg1
    DEFINE PROCEDURE proc
      WRITE ("Hello from seg1")
    END proc
  END SEGMENT seg1, DO(proc)

  DEFINE SEGMENT seg2
    DEFINE PROCEDURE proc
      WRITE ("Hello from seg2")
    END proc
  END SEGMENT seg2, DO(proc)

END PROGRAM DO start
```

To read this program for execution, use the statement

```
RUN PROGRAM program.xeq
```

The procedure named `start` in segment **MAIN** executes automatically because it is indicated in the **DO** clause of the **END PROGRAM** statement. Procedure `start` then uses the **READ SEGMENT** statement to load `seg1` and `seg2` in sequence. When each segment is loaded, the procedure `proc`, defined in the segment executes automatically.

3.7.63 LEVEL

Purpose:

Is used in dynamic simulation procedures and has two functions.

1. It signals the start of the **LEVEL** section of a dynamic procedure.

2. It declares the endogenous time series variables to be computed and stored at the fixed time points of the time series sets classifying the output time series.

Syntax:

```
        LEVEL (ots1 = ev1 [, ots2 = ev2, ...] )
```

Remarks:

`ots1`	is an output time series (i.e., an array variable that is indexed by a time series set.)
`ev1`	is an endogenous variable that is used explicitly in the **LEVEL** (and/or **RATE**) sections of a dynamic procedure.
`ots2`	is an output time series variable for a second **LEVEL** statement equation.
`ev2`	is an endogenous variable for a second **LEVEL** statement equation.

The equations of the **LEVEL** statement form a list of correspondence between output time series and endogenous variables that are used locally in the equations of the **LEVEL** (and/or **RATE**) section of a dynamic procedure. Based on this equivalence, the values of the output time series will be computed and stored at the fixed time points of the time index classifying the series.

Only those endogenous variables that are intended to be saved for later use as a time series need to be included in the endogenous variables list of the **LEVEL** statement.

The values of an output time series at each time point of the time series set are set equal to the values of the local endogenous variable corresponding to the nearest simulation time point plus or minus **DT/2**, where **DT** is the time parameter **DT**. The value of an output series at a time point `t` is set equal to the computed value of the corresponding endogenous variable that is associated with the interval (`t`–**DT/2**, `t`+**DT/2**). This interval is closed at –**DT/2** and open at `t`+**DT/2**. If `t` is the exact midpoint of the interval, then the `t`–**DT/2** value applies.

Execution of a **LEVEL** statement causes the **TIME** parameter to be incremented by **DT** units from its value in the preceding **RATE** section.

The **LEVEL** statement may only be used inside a procedure; it cannot be used in command mode.

Examples:

For more information on dynamic simulation with PROMULA, see the discussion of **Dynamic Procedures** in the **DEFINE PROCEDURE** section of this chapter and the discussion of the **RATE** statement.

3.7.64 OPEN file

Purpose:

Opens a disk file for physical write/read operations of data to/from disk.

Syntax:

```
        OPEN file filespec [STATUS=status] [READONLY]
```

Remarks:

`file`	is the identifier of a file in your program.
`filespec`	is a quoted string or string variable containing the name of the disk file to be opened. `filespec` may contain any filename that is valid for your operating system.

`status`	is one of the following options:

NEW	to open a new file of any type. When using the **OPEN file** statement with **STATUS=NEW**, any file with the same name as `filespec` will be deleted before the new file is opened.
OLD	to open an existing file of any type. Attempting to open a non-existing file with **STATUS=OLD** will cause an execution error. You may use the **FILEEXIST** function to test if a file exists. **OLD** is the default status.
DYNAMIC	to open an existing array file for automatic dynamic access. When an array file is opened with **DYNAMIC** status, PROMULA attempts to read the entire contents of the file into memory. If there is enough memory, the variables in the file may be accessed from memory — with a significant reduction in access time. If there is not enough memory to load the file, PROMULA will report an execution error. When the file is closed, its entire contents will be written out to disk. Automatic dynamic access is generally limited to small databases or machines with large and/or virtual memory.
VIRTUAL	to open an existing array file for paged virtual access. When an array file is opened with **VIRTUAL** status, PROMULA attempts to read/write large sections of the data. If there is enough memory, the variables in the file may be accessed from memory — with a significant reduction in access time. If there is not enough memory to "page-in" the file, PROMULA will report an execution error. When the file is closed, its entire contents will be written out to disk. The **VIRTUAL** status requires less memory than **DYNAMIC** status, but it is generally limited to small databases or machines with large and/or virtual memory.

If the keyword **READONLY** is included with the **OPEN file** statement, the file is given read only status by the operating system; it may be read from but not modified, and it may be accessed by more than one user at the same time.

Examples:

1. In this example, the array file, `file1`, is created on disk as the file `file1.dat`. A database of 1000 records each containing 10 fields of 20 characters of information is built in `file1.dat`.

```
DEFINE FILE
  file1
END FILE

OPEN file1 "file1.dat", STATUS=NEW

DEFINE SET file1
  rec(1000)
  fld(10)
END SET

DEFINE VARIABLE file1
  data(rec,fld) TYPE=STRING(20) "A Disk Variable"
END VARIABLE file1

CLEAR file1
```

2. To use `file1` created in Example 1 you need to enter the following statement:

```
OPEN file1 "file1.dat" STATUS=OLD
```

See Chapter 4 for details on database management.

3.7.65 OPEN SEGMENT

Purpose:

Opens a segment file on disk for physical write/read operations.

Syntax:

```
OPEN SEGMENT filespec [,STATUS=status]
```

Remarks:

`filespec`	is a quoted string or string variable containing the name of the segment file to be opened. `filespec` may contain any filename that is valid for your operating system.
`status`	is one of the following options:

NEW	to mean a new file. A new file is one which does not yet exist.
OLD	to mean an existing file.

If omitted, the default is **STATUS=OLD**.

CAUTION! When using the **OPEN file** statement with **STATUS=NEW**, any file on the current directory with the same name as `filespec` will be deleted before the new file is opened.

An old file is one which already exists. You may read from an old segment file and modify existing data values, but you cannot add new data to it.

Once opened under the **STATUS=NEW** option, you may write to a new file using the **DEFINE PROGRAM** and **DEFINE SEGMENT** statements. The actual write operation is done at the conclusion of the segment definition, i.e., it is initiated by the **END SEGMENT** or **END PROGRAM** statement.

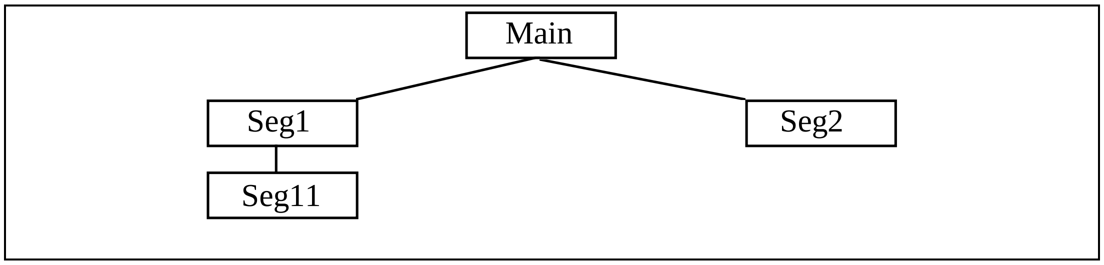
Once opened, you may load program segments into your working space with the **READ SEGMENT** statements.

Examples:

1. Define a segmented program.

```
OPEN SEGMENT "program.xeq", STATUS=NEW
DEFINE PROGRAM  "Segmented Program"
   statements of MAIN
   ...
   DEFINE SEGMENT seg1
      statements of seg1
      ...
      DEFINE SEGMENT seg11
         statements of seg11
         ...
      END SEGMENT seg11
   END SEGMENT seg1
   DEFINE SEGMENT seg2
      statements of seg2
      ...
   END SEGMENT seg2
END PROGRAM
```

In the above code, the file `program.xeq` was opened on disk and a number of program segments were written in it. These segments are organized into the following hierarchical tree structure:



The **DEFINE PROGRAM** and **END PROGRAM** statements define the beginning and end, respectively, of the **MAIN** segment of the tree.

The **DEFINE SEGMENT** and **END SEGMENT** statements define the beginning and end, respectively, of the other segments in the above tree.

Note that segments `seg1` and `seg2` are subordinate to **MAIN** at level 1. Segment `seg11`, at level 2, is subordinate to segment `seg1`.

2. The statements

```
OPEN SEGMENT "program.xeq" ,STATUS=OLD
READ SEGMENT MAIN
```

allow you to use the segment file created in Example 1.

3.7.66 OPEN WINDOW

Purpose:

Tells PROMULA to associate a user-defined window with a specific type of functional screen.

Syntax:

```
OPEN wind TYPE
```

Remarks:

`wind`	is the identifier of the window that you wish to open. This window must be previously defined in a **DEFINE WINDOW** statement.
`TYPE`	is the type of functional screen that will be shown in the window, and can be one of the following:

MAIN	the Main Screen
PROMPT	the Prompt Screen
COMMENT	the Comment Screen
ERROR	the Error Screen
HELP	the Help Screen

Upon execution, the **OPEN WINDOW** statement will open the window called `name` to serve as the display area for the logical screen `TYPE`.

If `wind` is a static window, it will be drawn on the screen upon execution of the **OPEN**. If `wind` is a popup window, it will not be displayed until an operation requiring a screen of type `TYPE` is executed.

See also **DEFINE WINDOW** and **CLEAR window** statements as well as the discussion of Advanced Windows in this chapter.

3.7.67 PLOT

Purpose:

Produces graphic displays of program variables and functions.

Syntax 1:

```
        PLOT [type](varx,vary1[,vary2,...]) [,option]
```

Remarks:

There are five different syntaxes for the **PLOT** statement, depending on what type of information you want to plot.

Syntax 1 produces X-Y line plots in which one or more Y variables are plotted against an X variable. The maximum number of `varys` that can be plotted simultaneously is six.

`type` is the type of line plot desired and may be one of the following:

LINE	for a line plot
POINTS	for a scatter point plot
VALUES	for a line plot with only those X-Y points marked that coincide with the intersections of the vertical and horizontal tic mark/coordinates

If `type` is omitted, the result is a line plot with the points marked. If you have configured PROMULA's graphics to do so, each line in **LINE** and **VALUES** plots will be shown in a different color, so that the lines may be distinguished from one another. If only black and white graphics are available, the lines will have different patterns. See Chapter 5, for a discussion of specifying line colors and patterns and other aspects of configuring PROMULA graphics.

`varx` is the identifier of the variable whose values are the x-coordinates of the points being plotted.

`vary1` is the identifier of the variable whose values are the y-coordinates of the points on the first curve being plotted.

`vary2` is the identifier of the variable whose values are the y-coordinates of the points on the second curve being plotted.

`varx` and the `vary's` must be subscripted by the same set

Syntax 2:

```
        PLOT btype(vary1[,vary2,...]) [,option]
```

Remarks:

Syntax 2 produces bar plots in which one or more variables are used to form a display of bars whose lengths are proportional to the magnitude of the variables' values. The maximum number of variables that can be plotted simultaneously is six. The number of bars displayed depends on the resolution of the monitor. The **ROW** descriptors of the set that subscripts the first variable being plotted will appear as labels for the x-axis tic marks.

`btype` is the type of bar plot desired and may be one of the following:

BAR	for a parallel bar plot
STACK	for a stacked bar plot

`vary1` is the identifier of the variable whose values define the lengths of the first set of bars plotted.

`vary2` is the identifier of the variable whose values define the lengths of the second set of bars plotted.

Syntax 3:

```
PLOT [type or btype]([set:V,]tvar) [,option]
```

Remarks:

Syntax 3 produces plots of variables which are subscripted by a time series set. Both line and bar plots can be specified by Syntax 3. The difference is that line plots can be generated without specifying a variable to scale the x-axis; the values of the time-series set will be used to define the x-coordinates of the points being plotted.

`type` specifies the type of line plot and is described above in Syntax 1.

`btype` specifies the type of bar plot and is described above in Syntax 2.

`set:V` is a special notation for the vector of values associated with the time series set, `set`.

`tvar` is the identifier of a variable subscripted by a time series set.

Syntax 4:

```
PLOT [type or btype](func) [,option]
```

Remarks:

Syntax 4 produces plotted displays of PROMULA functions. Both line and bar plots can be specified by Syntax 4. In line plots, the X values of the function will be the x-coordinates of the points being plotted, and the Y values of the function will be the y-coordinates. In bar plots, the X and Y values will be plotted on the same graph.

`type` specifies the type of line plot and is described above with Syntax 1.

`btype` specifies the type of bar plot and is described above with Syntax 2.

`func` is the identifier of a function defined by the **DEFINE FUNCTION** or **DEFINE LOOKUP** statement.

Syntax 5:

```
PLOT PIECHART (vary) [,TITLE(text)]
```

Remarks:

Syntax 5 produces pie charts.

`vary` is the identifier of the array variable whose values define the size of the sectors of the pie chart. Up to nine sectors may be displayed on a given pie chart. The row descriptors of the set that subscripts `vary` will appear in a legend for the chart, the percent of the pie for each sector will also be computed and displayed in the legend.

NOTE: Printing pie charts on some high resolution laser printers may not work because the image is too complex and may overload the printer's memory.

PLOT Statement Options

Syntaxes 1 through 4 above, have an `option` parameter associated with them which allows you to customize the appearance of the plot. The `option` parameter is a list of additional specifications for the plot and may be one or all of the following:

BROWSE(`set1, set2,...`**)**	to allow the user to browse the "pages" of a plot of one or more multidimensional arrays. If applicable, `set1` will be incremented/decremented by pressing **F1/Shift-F1**; `set2` will be incremented/decremented by pressing **F2/Shift-F2**; and so on. A prompt describing how to browse the plots will appear at the bottom of the screen.
GRID=`type`	to define a grid for the plot. Here, `type` is one of the following:

HORIZONTAL	for horizontal lines between the tic marks on the Y-axis
VERTICAL	for vertical lines between the tic marks on the X-axis
BOTH	for horizontal and vertical lines

LEGEND(`leg1,leg2,...`**)**	to define a legend for the plot. Here, `leg1` is a string variable or quoted string containing a short legend for `vary1`, the first variable of the plot. `leg2` is a legend for `vary2`, the second variable of the plot, and so forth.
LINE(`pat1,pat2,...`**)**	to define alternative line patterns for unmarked line plots. Here, `pat1` is a string variable or quoted string containing 16 characters which defines a repeating pattern for the `vary1` line; `pat2` defines a repeating pattern for the `vary2` line, and so forth. The defaults are defined by PROMULA's graphics configuration program.
OVER(`set`**)**	to automatically create a multi-line or multi-bar plot for a y-variable dimensioned by set. Up to six lines or bars, one for each dataset corresponding to an active element of `set`, will be displayed.
POINT(`pnt1,pnt2,...`**)**	to define alternative line patterns for marked-point plots. Here, `pnt1` is a string variable or quoted string containing 1 character which defines the character to use for marking points of `vary1`; `pnt2` defines a point character `vary2`, and so forth. The default characters are *, +, &, @, $, and #.
TITLE(`text`**)**	to display a title for the plot. This title may include variables, text, and other formatting characters according to the rules described in the **WRITE text** statement. The default title is the descriptor of `vary1`. For plots of two or higher dimensional arrays, the descriptors of all sets (except the set classifying the x-axis) dimensioning the variables plotted are also part of the title. For plots of time series variables, the beginning and ending values of the time interval associated with the time series are appended to the title of the plot.
XLABEL(`xlabel`**)**	to display a label for the x-axis. `xlabel` may include variables and/or quoted text. The default is no x-label.
YLABEL(`ylabel`**)**	to display a label for the y-axis. `ylabel` may include variables and/or quoted text. The default is no y-label.
XRANGE(`xrange`**)**	to define a scale for the x-axis. Here `xrange` is one of the following:

```
xmin,xmax,xtics
xmin,xmax
xtics
```

The `XRANGE` option will scale the x-axis from a minimum of `xmin` to a maximum of `xmax`. `xtics` is the number of tic-marks for the x-axis. The default values for `xmin`, `xmax`, and `xtics` are computed by PROMULA using the extremes of the variables scaling the x-axis. The values may be literal numeric constants or numeric variables.

YRANGE(`yrange`**)** to define a scale for the y-axis. The specification of `yrange` is analogous to the specification of `xrange`.

The values labeling the tic marks or legends of the plot may be formatted according to the syntax:

```
var:w:d
```

where `w` is width and `d` is the number of decimal digits.

PROMULA supports four Graphics Modes.

CHARACTER The default for **CHARACTER** mode is an 80 column by 25 row monochrome plot that is composed entirely of standard ASCII characters. The width and height of **CHARACTER** plots can be modified by the **SELECT WIDTH** and the **SELECT LINES** statements. They can be sent to a disk file with the **SELECT OUTPUT** statement.

MEDIUM The default for **MEDIUM** mode is CGA medium resolution three-color pixel graphics.

HIGH The default for **HIGH** mode is CGA high resolution monochrome pixel graphics.

PLOTTER The **PLOTTER** mode is intended to be used to define the manner in which graphics are plotted. The default for **PLOTTER** mode is an IBM/Epson dot matrix printer, high resolution, landscape mode.

To specify the desired graphics mode, use the **SELECT GRAPHICS** statement.

You may change the default configuration for **MEDIUM**, **HIGH**, and **PLOTTER** graphics modes for your system, and PROMULA even lets you create your own graphics configurations. See Chapter 5, for a discussion of configuring PROMULA graphics.

To print medium- and high-resolution plots, execute the **SELECT PRINTER=ON** statement before you generate the plot; the graphic will appear on the screen while it is being printed.

Examples:

In the code below, the procedure `plotdemo`, when executed, produces plots of the following four types:

1. A point plot
2. A line plot with its points marked
3. A parallel bar plot
4. A stacked bar plot

These four high-resolution plots are shown on the following pages.

```
DEFINE SET
  year(10)
```

```
END SET

DEFINE VARIABLE
  yv(year)     "Year Values"
  ts(year)     "Time Series Values"      TYPE=REAL(8,1)
  tl(year)     "Log of the Time Series"  TYPE=REAL(8,1)
  name         "Run name"                TYPE=STRING(40)
END VARIABLE

DEFINE RELATION
  time(year,yv)
END RELATION

READ yv
70 72 74 76 78 80 82 84 86 88
READ ts
3.1 3.2 3.9 4.5 5.1 4.9 4.5 4.1 4.0 3.5
tl = LN(ts)

DEFINE PROCEDURE plotdemo

   PLOT POINTS(yv,ts,tl),
              XLABEL"T i m e",
              YLABEL"Time Series Values",
              TITLE"A Scatter Plot of Actual and Log Values",
              LEGEND("Absolutes","Log of Absolute")

   PLOT(yv,ts,tl),
        XLABEL"T i m e",
        YLABEL"Time Series Values",
        TITLE"An XY Plot with Marked Observations Of the Absolute and Log",
        LEGEND("Actual value","Log of Value")

   PLOT BAR (ts,tl),
          XLABEL"T i m e",
          TITLE"A Parallel Bar Chart of Actual and Log Values of a Time Series",
          LEGEND("Actual","Log")

   PLOT STACK(ts,tl),
          XLABEL"T i m e",
          TITLE"A Stacked Bar Chart of Actual and Log Values of a Time Series"
          LEGEND("Actual","Log")

END PROCEDURE plotdemo
```

A Point Plot

A Line Plot With Its Points Marked

A Parallel Bar Plot

A Stacked Bar Plot

The code below generates a pie chart of variable y. PROMULA pie charts can have up to nine sectors. The variable that has a **ROW** relation to the set subscripting the variable being plotted will be used for the legend. The percentage of each sector is automatically calculated and displayed.

```
DEFINE SET
  pnt(9)
END SET

DEFINE VARIABLE
  x(pnt)    "X Values"
  y(pnt)    "Y Values"     TYPE=REAL(8,2)
  pntn(pnt) "Point Names"  TYPE=STRING(15)
  pntl(pnt) "Point Legend" TYPE=STRING(15)
END VARIABLE

x(i) = i
y(i) = i * 10
READ pntn:4
GEJ FKG MEJ LCC DLY USA IOU PRM XEQ

DEFINE PROCEDURE test
  pntl=pntn+" = "+y
  SELECT ROW(pnt,pntl)
  PLOT PIECHART(y) TITLE("PIE CHART OF VARIABLE Y")
  SELECT ROW(pnt,pntn)
END PROCEDURE test
```

A Pie Chart

PROMULA supports two-dimensional graphics, and variables specified in the plot will usually be one-dimensional vectors. If you want to plot two- or higher-dimensional arrays, you should follow these guidelines:

1. Reduce two- or higher-dimensional variables to a one-dimensional form by selecting a single value for all the sets structuring the variables being plotted *except* the one you wish to use as the x-axis of the plot.

   PROMULA can determine which sets have been restricted and which have more than one active element. When the variables are plotted, the values of variable varx across the set with more than one active element will be used to scale the x-axis and the descriptors of the other sets will appear in a subtitle for the plot.

2. For X-Y plots (**Syntax 1**), the Y variables should all be structured by the set that will scale the X axis.

The following example illustrates how PROMULA handles array variables with more than one dimension in plots.

```
DEFINE SET
  row(10)  "10 row"
  col(6)   "06 col"
  pag(2)   "04 pag"
END SET

DEFINE VARIABLE
  x(row,col,pag) TYPE=REAL(10,0) "X MATRIX"
  y(row,col,pag) TYPE=REAL(10,0) "Y MATRIX"
END VARIABLE

x(i,j,k)=(i+10*j+100*k)/10
y(i,j,k)=(i*j*k)

DEFINE PROCEDURE plotarr
SELECT GRAPHICS=HIGH
SELECT row* col(3) pag(2)
```

```
          PLOT LINE(x,y) TITLE("PLOT OF X=(i+10*j+100*k)/10 versus Y=(i*j*k)")
          PLOT BAR (x,y) TITLE("BAR PLOT OF X=(i+10*j+100*k)/10 and Y=(i*j*k)")
        SELECT row(2) col* pag(2)
          PLOT LINE(x,y) TITLE("PLOT OF X=(i+10*j+100*k)/10 versus Y=(i*j*k)")
          PLOT BAR (x,y) TITLE("BAR PLOT OF X=(i+10*j+100*k)/10 and Y=(i*j*k)")
        END PROCEDURE plotarr
```

The resultant plots are shown on the following pages.

In the first two plots, the ranges of sets `col` and `pag` are restricted to single values, so the values of variable `x` as subscripted by set `row` are used to scale the x-axis.

In the next two plots, the ranges of sets `row` and `pag` are restricted to single values, so the values of variable `x` as subscripted by set `col` are used to scale the x-axis.

3.7.68 RATE

Purpose:

Is used in dynamic simulation procedures and has two functions.

1. It signals the start of the **RATE** section of a dynamic procedure.

2. It declares the time dependent variables to be computed at each time point of the simulation by linear interpolation or extrapolation from specified exogenous time series variables.

Syntax:

```
RATE (ets1 = lv1 [, ets2 = lv2, ...] )
```

Remarks:

`ets1`	is an exogenous time series variable (i.e., an array variable indexed by a time series set.)
`lv1`	is a local variable that is used explicitly in the **RATE** section of a dynamic procedure model and is computed at every time point of the simulation.
`ets2`	is the exogenous time series variable for a second **RATE** statement equation.
`lv2`	is a local variable for a second **RATE** statement equation.

The equations of the **RATE** statement form a list of correspondence between previously defined exogenous time series variables and time-dependent variables that must be used locally in the **RATE** section of a dynamic simulation model.

Based on this equivalence, the values of the local variable will be computed at the arbitrary time point of the dynamic simulation by linear interpolation or extrapolation that is based on the fixed time points defining the exogenous time series.

The **RATE** section is the second section of a dynamic model (after the **INITIAL** section) and its equations are evaluated at each time point (or interval) of the simulation run. In contrast to **LEVEL** equations, both sides of rate equations are evaluated at the same time point (or interval).

The **LEVEL** section follows the **RATE** section and its equations are also evaluated at each time point (or interval) of the simulation. The LHS of each **LEVEL** equation, however, is evaluated at **TIME+DT** in terms of the time variables on the

RHS which are evaluated at **TIME**, the previous time point (or interval). It is the equations of the **LEVEL** section which move the dynamic variables through time.

Only those exogenous time series that are used explicitly in the **RATE** or **LEVEL** section need be included in the exogenous variables list of the **RATE** statement.

The **RATE** statement may only be used inside a procedure. That is, it must not be used in command mode.

For more information on dynamic simulation with PROMULA, see the discussion of **Dynamic Procedures** in the **DEFINE PROCEDURE** section of this chapter and the discussion of the **LEVEL** statement.

3.7.69 READ DISK

Purpose:

Transfers data from a disk variable in an array file to a local variable in the dynamic access method.

Syntax:

```
READ DISK(vars)
```

Remarks:

`vars`   is a list of dynamic variables.

A dynamic variable is a scratch or fixed variable (also called a local variable) that has a dynamic relationship to a disk variable. Local variables may be related to disk variables through the **DISK** option of the **DEFINE VARIABLE** statement. See chapter 4 for a detailed description of disk access methods.

Examples:

The following code

```
DEFINE FILE
  filea
END FILE

OPEN filea "test.dba" STATUS=NEW
DEFINE SET
 rec(1000)  "Record"
END SET

DEFINE VARIABLE filea
  dsk(pnt), "A Disk Variable on 'filea'"
END VARIABLE filea

DEFINE VARIABLE
  pp  "Record Pointer"
  scr "A dynamic variable for accessing a single element of dsk",DISK(filea,dsk(pp))
END VARIABLE
```

defines two variables: `dsk` and `scr`. The disk variable, `dsk`, is a vector of 1000 elements on the disk file named `test.dba`. The variable, `scr`, is a dynamic local variable that is related to `dsk`. The **READ DISK** and **WRITE DISK** statements transfer a specific value from and to disk as illustrated in the dialog below.

```
scr = 0
dsk(i) = i
pp = 4
READ DISK(scr)
```

```
WRITE scr
A Scratch Variable in Memory 4
scr = 6
WRITE DISK(scr)

WRITE (dsk:L," ",dsk(pp))
A Disk Variable on 'filea' 6
```

3.7.70 READ file

Purpose:

Read data from a text file or a random file.

Syntax 1: Read the values of all variables in a record of a random file

```
READ file
```

Syntax 2: Read from a text file

```
READ file (var1 [,fmt1] [,var2 [,fmt2]] [...] )
```

Remarks:

`file` is the identifier of the file whose records you are reading.

`var1` is the identifier of the variable whose data is first on each data record.

`fmt1` is the format specification for `var1` and has the following syntax:

```
\p:w
```

where

`p` is an integer indicating the starting column on each data line where the value for `var1` begins. Thus, the backslash means: "start reading in column `p`". If omitted, the reading begins in column 1.

`w` is an integer indicating the width of the value and it means "read the next `w` columns". If omitted, the default width is the width specified in the definition of `var1`.

The format specification may be omitted, in which case the data may be entered in free form. In free form, the values of variables may be entered anywhere on an input line provided they are separated by commas or blanks.

`var2` is the identifier of the variable whose data is second on each data record.

`fmt2` is the format specification for `var2` and may have the same form as `fmt1` above. If `p` is omitted from `fmt2`, reading begins in the column following the last character of the last value read.

Examples:

1. Read from a text file and write to a random file

```
DEFINE FILE
  txt1 TYPE=TEXT
  ran1 TYPE=RANDOM
  arr1 TYPE=ARRAY
END FILE

OPEN ran1 "ran1.ran", STATUS=NEW
DEFINE VARIABLE ran1
  item1 "Item 1"   TYPE=REAL(8,0)
  item2 "Item 2"   TYPE=STRING(8)
  item3 "Item 3"   TYPE=DATE(8)
END VARIABLE ran1

OPEN txt1 "txt1.txt", STATUS=OLD
DO txt1
  READ txt1(item1:8,item2:8,item3:8)
  WRITE ran1
END txt1
```

2. Read from a text file and write to an array file

```
DEFINE SET
  rec(100)  "Records"
END SET

OPEN arr1 "arr1.arr", STATUS=NEW
DEFINE VARIABLE arr1
  var1(rec) "Variable 1"         TYPE=REAL(8,0)
  var2(rec) "Variable 2"         TYPE=STRING(8)
  var3(rec) "Variable 3"         TYPE=DATE(8)
END VARIABLE arr1

DEFINE VARIABLE
  rn        "Record Number"
END VARIABLE

rn = 1
DO txt1
  READ txt1(var1(rn):8,var2(rn):8,var3(rn):8)
  rn = rn+1
END txt1
```

3. Read from a random file and write to a text file

```
DO ran1
  WRITE txt1(item1:8,item2:8,item3:8)
END ran1
```

4. Read from a random file and write to an array file

```
rn = 1
DO ran1
  var1(rn) = item1
  var2(rn) = item2
  var3(rn) = item3
  rn = rn+1
END ran1
```

5. Read a two-dimensional array from a text file using a **DO set** loop to drive the row dimension and a set identifier in the read statement to drive the column dimension. Given the following data file (with physical file name `smn.txt`):

```
               11     15     11     17     10     12     10     14     20     25     27     28
               22     31     50     32     41     19     21     17     19     38     56     67
               47     57     73     55     72     38     27     19     35     51     79     76
              156    211    267    203    273    155    109     89    142    230    286    264
              494    620    730    646    775    504    433    402    525    760    817    734
              478    496    468    539    499    521    493    481    592    623    618    584
```

The following code will read the two dimensional data set.

```
DEFINE FILE
  inpt          "Data Input File"       TYPE=TEXT
END FILE

DEFINE SET
  stratum(6)    "6 Usage Strata"
  month(12)     "12 Months"
END SET

DEFINE VARIABLE
  smn(stratum,month) "Customers by Stratum and Month"  TYPE=REAL(12,0)
END VARIABLE

OPEN inpt "smn.txt" STATUS=OLD

DO stratum
   READ inpt( (month) (smn:6:0(stratum,month)))
END stratum

CLEAR inpt
```

3.7.71 READ function

Purpose:

Reads values into a function.

Syntax:

```
READ func
x1 x2 ... xn
y1 y2 ... yn
```

Remarks:

`func`	is the identifier of a function defined by a **DEFINE FUNCTION** or **DEFINE LOOKUP** statement.
`x1 x2 ... xn`	are values to be read into the X variable of the function.
`y1 y2 ... yn`	are values to be read into the Y variable of the function.

Examples:

```
DEFINE SET
  pnt(4)
END SET

DEFINE VARIABLE
  x(pnt) "The X values"
  y(pnt) "The Y values"
END VARIABLE
```

```
DEFINE FUNCTION
  fx(x,y) "Y=f(x)"
END FUNCTION

READ fx
10 20 30 40 50 60
101 202 303 404 505 606
```

Given the above definitions, the value of the function and its X and Y value vectors may be displayed via WRITE statements as shown in the dialog below.

```
            WRITE fx

                                                     (1)     (2)
                                          PNT(1)      10     101
                                          PNT(2)      20     202
                                          PNT(3)      30     303
                                          PNT(4)      40     404
            WRITE x
                                              The X values

                   PNT(1)       10    PNT(2)       20    PNT(3)       30    PNT(4)       40
            WRITE y
                                              The Y values

                   PNT(1)      101    PNT(2)      202    PNT(3)      303    PNT(4)      404
```

3.7.72 READ menu

Purpose:

Displays a "data" menu to let you "read" values into all the data fields of the menu. This command is used when the values of all the data fields in the menu are to be changed.

A data menu is a screen display which is designed to help its user to edit data. The fields in a data menu are previously defined in a **DEFINE MENU** statement.

Syntax:

```
READ menu(vars)
```

Remarks:

`menu`	is the identifier of a data menu.
`vars`	is a list of variable identifiers that contain the values of the data fields being edited. The variables in the list must be arranged in the same order as the data fields in the menu to which they correspond.

Data menus contain a number of **data fields** to be edited by the user. In the **DEFINE MENU** statement, each data field is denoted by a series of contiguous "at signs", (@), or tilde signs (~), one for each character of the data value. The data fields are ordered from left to right and from top to bottom of the menu template.

Upon execution, the data menu becomes a screen display that has the first data field highlighted by the bounce bar. The system is now in edit mode and is ready to accept new data for the data fields in the menu. To begin editing of the first highlighted data field, press the **[Enter]** key and enter the new value as prompted at the bottom of the menu. Continue this process until all the data fields have been edited.

Remarks:

The use of the **READ menu** command is similar to the **EDIT menu** command, except that the **READ menu** puts the user in batch or automatic edit mode where he/she is not allowed to pick the data fields to edit. He/She must edit the data fields sequentially and in the order that they appear on the menu. After the last field is edited, execution of the program automatically proceeds with the statement following the **READ menu** statement.

3.7.73 READ SEGMENT

Purpose:

Reads an executable program segment into your working space for execution. A program segment includes both code and data. To read data values only, use the **READ VALUE segment** statement.

Syntax:

```
READ SEGMENT seg [,DO(proc)]
```

Remarks:

`seg`	is the identifier of the segment as it appears on the corresponding **DEFINE SEGMENT** and **END SEGMENT** statements. The default identifier of the top segment of any program is **MAIN**.
`proc`	is the identifier of a procedure in `seg`. Upon execution, this procedure is executed automatically.

The segment `seg` is read in from the disk file specified on the **OPEN SEGMENT** statement.

Examples:

The following statements open and read in for execution the segment `seg1`:

```
OPEN SEGMENT "a:program.xeq", STATUS=OLD
READ SEGMENT seg1
```

If segment `seg1` is subordinate to another segment, say **MAIN**, then the following sequence must be entered:

```
OPEN SEGMENT "program.xeq"  STATUS=OLD
READ SEGMENT MAIN
READ SEGMENT seg1
```

where `program.xeq` is the name of the segment file on disk containing segment **MAIN**.

3.7.74 READ set

Purpose:

Reads in labels for a set.

Syntax:

```
READ set [opt]
data
```

Remarks:

`set` is the set identifier.

`data` are the data lines for the read. One data line is needed for each active element in `set`.

`opt` defines what types of labels are to be read. The default value for `opt` is ROW(1,20). `opt` can be one or more of the following:

ROW[(`ic,lc`**)]**

to specify that set row descriptors (sometimes called stubs) are to be read.

`ic` is a positive integer defining the initial column on each data line where the stub entry begins. The default is `ic=1`.

`lc` is a positive integer (`lc` > or = `ic`) defining the last column on each data line where the stub entry ends. The default is `lc=15`.

Only one stub per data line is permitted. Note that, if `set` was defined with a **ROW** option, the total width of the field may not exceed the width defined in that option.

COLUMN[(`ic,lc,nc`**)]**

to specify that set column descriptors (sometimes called spanners) are to be read.

`ic` is a positive integer defining the initial column on each data line where the spanner entry begins. The default is `ic=1.`

`lc` is a positive integer (`lc` > or = `ic`) defining the last column on each data line where the spanner entry ends. The default is `lc=15`.

`nc` is a positive integer defining the number of columns or characters (including blanks) in each section of the spanner. The following exact relationship must be satisfied:

```
(lc - ic + 1)/nc = nl
```

where `nl` is a positive integer denoting the number of lines that each column heading will have. The default is `nc=1`.

The specification `ic, lc, nc` can be read as, "read in each spanner from column `ic` to column `lc` in steps of `nc`." Thus if `ic=1`, `lc=30`, `nc=10`, each data line should contain 30 characters that will form a three line `(nl=(30-1+1)/10=3)` column heading with 10 characters on each line.

Only one spanner per data line is permitted. Note that, if `set` was defined with a **COLUMN** option, the format of the spanner data field must conform with the format specified in that option.

KEY[(`ic,lc`**)]**

to specify that set codes are to be read.

`ic` is a positive integer defining the initial column on each data line where the code entry begins. The default is `ic=1`.

`lc` is a positive integer (`lc > or = ic`) defining the last column on each data line where the code entry ends. The default is `lc=20`.

Only one code descriptor per data line is permitted. Note that if the set was defined with a **KEY** option, the total width of the code field may not exceed the defined width.

The set codes are used for three separate purposes. First, if no row descriptors are supplied, then the codes are used in their place for displays of arrays that are classified by `set`. Second, if no column headings are supplied, then the codes are used. Third, when the user wishes to refer to particular set elements, he may use the codes in place of the element sequence numbers. See the **ASK...ELSE** and **SELECT VARIABLE** statements for a discussion of how set elements are selected with their codes and sequence numbers.

Only one code per data line is permitted. Note that, if `set` was defined with a **KEY** option, the total width of the field may not exceed the width defined in that option. The maximum width of a code is 6 characters.

Examples:

The following example illustrates the **READ set** statement. Stubs, spanners, and codes are read in for set `sta`; the codes appear as the identifiers of the set elements in the **WRITE set** display. Notice that the default, `AGE(n)`, descriptors are used as labels for columns classified by set `age` since no spanners or codes are related to set `age`. Set `yer` gets its descriptor values from the **TIME** option in its definition.

```
DEFINE SET
  age(3)    "AGE"   ROW(8)
  yer(2)    "YEAR"  TIME(1920,2000)
  sta(3)    "STATE" ROW(10) KEY(2) COLUMN(10,3)
END SET

DEFINE VARIABLE
  a(age,sta,yer) "VALUES BY AGE, STATE, AND YEAR"
END VARIABLE
a=RANDOM(2000,9000)

READ sta KEY(21,22) ROW(21,29) COLUMN(1,30,10)
STATE     OF        OHIO
STATE     OF        FLORIDA
STATE     OF        ILLINOIS

READ age ROW(1,6)
00-20
21-40
41-60
```

Given the definitions and data above, the values for the set labels may be displayed by the various WRITE statements as shown in the dialog below.

```
WRITE sta
Identifier Description
OH         OHIO
FL         FLORIDA
IL         ILLINOIS

SELECT yer(1)
WRITE a
                         VALUES BY AGE, STATE, AND YEAR

                                      1920
```

```
                                    STATE      STATE      STATE
                                       OF         OF         OF
                                     OHIO    FLORIDA   ILLINOIS
                     00-20          5,160      7,664      6,141
                     21-40          6,456      2,334      5,625
                     41-60          7,295      2,024      7,480
      WRITE a(sta,age,yer)
                         VALUES BY AGE, STATE, AND YEAR

                                      1920

                                     AGE(1)  AGE(2)  AGE(3)
                       OHIO           5,160   6,456   7,295
                       FLORIDA        7,664   2,334   2,024
                       ILLINOIS       6,141   5,625   7,480
```

See the **DEFINE SET**, **DEFINE RELATION**, and **SELECT RELATION** statements for more information on set descriptors.

3.7.75 READ VALUE segment

Purpose:

Reads the information of a program or program segment from disk. Only the values of the segment variables are read. To read both code and data values, use the **READ SEGMENT** statement.

Syntax:

```
READ VALUE seg
```

Remarks:

`seg`	is the identifier of the segment whose values are being read from disk.

Use the **OPEN SEGMENT** statement before using the **READ VALUE segment** statement.

Examples:

The code below opens a segment file on disk called `wrvalseg.xeq`. This segment is given the default name **MAIN** since it is a top-level segment. Segment **MAIN** contains the single variable, a.

```
OPEN SEGMENT "wrvalseg.xeq" STATUS=NEW

DEFINE PROGRAM
  DEFINE VARIABLE
    a "The value of variable A ="
  END VARIABLE
END PROGRAM
```

The effect of the **WRITE VALUE segment** and **READ VALUE segment** are illustrated in the dialog below.

```
a=10
WRITE a
The value of variable A = 10
```

The statement, **WRITE VALUE MAIN**, writes the values of segment **MAIN** variables (in this case only variable `a`) in the segment file on disk called `wrvalseg.xeq`.

```
             WRITE VALUE MAIN
```

The value of a variable can be changed by an expression.

```
             a=20
             WRITE a
             The value of variable A = 20
```

The **READ VALUE MAIN** statement will read in the values of the segment **MAIN**'s variables that were stored by the last **WRITE VALUE MAIN** statement.

```
             READ VALUE MAIN
             WRITE a
             The value of variable A = 10
```

3.7.76 READ variable

Purpose:

Reads data into a variable.

Syntax:

```
      READ var [fmt] [(sets)] [FROM file]
       ...
       data
       ...
```

Remarks:

`var`	is the identifier of the variable whose data is being entered.
`sets`	is an ordered list of the identifiers of the sets subscripting `var`. The sets may be listed in any order. If omitted, the order of the sets is that which appears in the definition of `var`. For multidimensional variables, this order is important: the first set in this list defines the rows of the data following, the second set classifies the columns of the data following, the third set classifies the two-dimensional pages of the data following, the fourth set classifies the three-dimensional sections of the data following, etc. The current order and range of the elements of the sets specified in `sets` controls the assignment of data to variable values.
`fmt`	is the format specification for the read operation and has the following syntax:

```
\p:w
```

where

p is an integer indicating the starting position of the read, i.e, the column on each data line where the reading begins. The backslash means: "start reading in column `p`". If omitted, the reading begins in column 1.

w is an integer indicating the width of the read operation and it means "read the next `w` columns".

The format specification may be omitted, in which case the data may be entered in free form. In free form, the values of variables may be entered anywhere on an input line provided they are separated by commas or blanks.

`data` are the data values associated with `var`. The data values are entered on input lines which can have a maximum width of 255 characters each. The input lines and the data values on them must be arranged so that they agree with the internal structure of the variable, as defined by the **DEFINE VARIABLE** statement or by `sets`, and the format specifications of the **READ variable** statement (see examples below). The data may be stored in an external text file if the **FROM** option is used.

`file` is the identifier of a logical file of type **TEXT** that contains the data for variable `var`. You must open `file` to the text file on disk that contains the data before executing the **READ variable** statement.

You may read data for more than one variable in a single read operation by using the **READ variables** statement.

Examples:

1. Given the definitions

```
DEFINE SET
  row(4)
  col(3)
  page(2)
END SET

DEFINE VARIABLE
  a(row,col,page) "A 3-Dimensional Array"
END VARIABLE
```

You may enter data in array `a` via the following **READ** statement:

```
READ a
111 121 131
211 221 231
311 321 331
411 421 431
112 122 132
212 222 232
312 322 332
412 422 432
```

This order of the data entry is according to the order of the sets defining array `a`. You may verify this by using the `WRITE a` statement:

```
      WRITE a

                           A 3-Dimensional Array

                                  PAGE(1)

                                   COL(1)  COL(2)  COL(3)

                     ROW(1)           111     121     131
                     ROW(2)           211     221     231
```

```
                                                   ROW(3)              311      321      331
                                                   ROW(4)              411      421      431

                                                                  PAGE(2)

                                                                   COL(1)   COL(2)   COL(3)

                                                   ROW(1)              112      122      132
                                                   ROW(2)              212      222      232
                                                   ROW(3)              312      322      332
                                                   ROW(4)              412      422      432
```

2. You may read by `col` the same data as in Example 1 by using the following statement:

```
READ a(col,row,page)
111 211 311 411
121 222 321 421
131 231 331 431
112 212 312 412
122 222 322 422
132 232 332 432
```

3. You may read selected data values by using the **SELECT set** statement before the **READ** statement:

```
SELECT row(1)
SELECT page(1)
READ a
111 121 131
```

This read operation is restricted to the first `row` and the first `page` of variable `a`. The values 111, 121, and 131 are assigned to the first, second, and third columns respectively.

4. As is the case for other **READ** statements, numeric data values may be specified with the **N*VALUE** notation as in the example below.

```
DEFINE SET
  row(3)
  col(10)
END SET

DEFINE VARIABLE
  x(row,col) TYPE=REAL(11,3) "-------------- THE X ARRAY --------------"
END

READ x
2*1 2*2 2*3 2*4 2*5
2*6 2*7 2*8 2*9 2*10
2*11 2*12 2*13 2*14 2*15
```

The data values may be displayed by the statement `WRITE x`. The output of this statement is shown below.

```
                                      -------------- THE X ARRAY --------------

                                            COL(1)      COL(2)      COL(3)      COL(4)      COL(5)
                    ROW(1)                   1.000       1.000       2.000       2.000       3.000
                    ROW(2)                   6.000       6.000       7.000       7.000       8.000
                    ROW(3)                  11.000      11.000      12.000      12.000      13.000
```

```
                             COL(6)     COL(7)     COL(8)     COL(9)    COL(10)
          ROW(1)              3.000      4.000      4.000      5.000      5.000
          ROW(2)              8.000      9.000      9.000     10.000     10.000
          ROW(3)             13.000     14.000     14.000     15.000     15.000
```

3.7.77 READ (variables)

Purpose:

Read data into more than one variable.

Syntax:

```
READ(var1[,fmt1][(sets)] [,var2[,fmt2][(sets)] [,...])
 ...
 data
 ...
```

Remarks:

`var1` is the identifier of the variable whose data is first on each data line.

`fmt1` is the format specification for `var1` and has the following syntax:

`\p:w`

where

`p` is an integer indicating the starting column on each data line where the value for `var1` begins. The backslash means: "start reading in column `p`". If omitted, the value begins in column 1.

`w` is an integer indicating the width of the value and it means "read the next `w` columns." If omitted, the default width is the width of `var1` as specified in its definition.

The format specification may be omitted, in which case the data may be entered in free form. In free form, the values of variables may be entered anywhere on an input line provided they are separated by commas or blanks.

`sets` is an ordered list of the identifiers of the sets subscripting `var1`. The sets may be listed in any order. If omitted, the order of the sets is that which appears in the definition of `var1`.

`var2` is the identifier of the variable whose data is second on each data line.

`fmt2` is the format specification for `var2` and may have the same form as `fmt1` above. Here, if the format specification, `p`, is omitted, reading begins at the character immediately following the last character of the preceding value.

`data` are the data values for `var1, var2,....` The data values are entered on input lines which can have a maximum width of 255 characters each. Numeric data may be expressed using the **N*VALUE** notation.

The **DO set** statement may be used with the **READ variables** statement to read data for array variables.

Examples:

Given the definitions

```
DEFINE SET
  month(12)
END SET

DEFINE VARIABLE
  A                "A Value = "
  B                "B Value = "
  C                "C Value = "
  D                "D Value = "
  mc(month)        "Month Codes"
  mn(month)        "Month Names"
END VARIABLE
```

you may enter the values 1 and 200, for `A` and `B` respectively, as follows:

```
  READ(A:8,B\10:10)
          1      200
```

The following reads data for the vectors `mc` and `mn`:

```
DO month
   READ(mc:3,mn\5:12)
END month
JAN  January
FEB  February
MAR  March
APR  April
MAY  May
JUN  June
JUL  July
AUG  August
SEP  September
OCT  October
NOV  November
DEC  December
```

The following read uses the **N*VALUE** notation to specify repeated values in the data.

```
READ(A,B,C,D)
2*1234567 2*9876543
```

After the read, the data may be displayed by a **WRITE TABLE** statement. For example the statement

```
WRITE TABLE(1) BODY(a,b,c,d) TITLE("Table of scalars") FORMAT(10,20)
```

produces the following output.

```
                                         Table of Scalars

                                  A Value =           1,234,567
                                  B Value =           1,234,567
                                  C Value =           9,876,543
                                  D Value =           9,876,543
```

3.7.78 RUN

Purpose:

Compiles a PROMULA source file or runs a PROMULA executable.

Syntax:

```
        RUN file
```

Remarks:

`file` is a string (optionally in quotes) or a string variable containing the name of the disk file where the code that you wish to compile or execute is stored.

The **RUN** statement is similar to the **RUN PROGRAM** statement for executing PROMULA programs from inside a running application; and to the **RUN COMPILER**, **RUN SOURCE**, and **RUN COMMAND** statements for compiling PROMULA source codes. But there are several subtle differences:

RUN and **RUN PROGRAM** may both be used to run PROMULA executable programs. When `file` is an executable PROMULA application, the **RUN** statement will suspend execution of the current application and hide its information before running `file`. Since the current application stays resident, there must be enough room for both `file` and the original application in memory for this to work properly. The original application will be automatically reloaded when execution of `file` is complete and a **STOP** statement is executed. The **RUN PROGRAM** statement, clears the original application from memory before loading `file`. In addition, **RUN** can be executed from inside a procedure; **RUN PROGRAM** cannot.

RUN and **RUN COMPILER** may both be used to compile PROMULA source codes. When `file` is a PROMULA source code, the **RUN** statement will suspend execution of the current application and hide its information before compiling `file`. The original application will be automatically reloaded when compilation of `file` is complete and a **STOP** statement is executed. The **RUN COMPILER** statement clears the current application from memory before compiling `file`. In addition, **RUN** can be executed from inside a procedure, **RUN COMPILER** cannot.

The **RUN SOURCE** `file` statement can be used for compiling PROMULA source codes only. It behaves like the **RUN** statement in this role except that **RUN SOURCE** displays the compilation listing on the screen.

The **RUN COMMAND** `file` statement can only be used for compiling PROMULA source codes. **RUN COMMAND** behaves like the **RUN** statement except that it does not suspend execution of the current application or hide its information. The statements in `file` may use, but not redefine, structures defined in the current application, and any structures defined in `file` remain resident with your application after its compilation is complete and control is returned to the current application.

Examples:

The statement

```
        RUN "program.prm"
```

will compile the PROMULA program stored in the source file `program.prm`. The compilation listing will not be shown on the screen but PROMULA will pause on errors. To have more control over the compilation of PROMULA source codes from the command line, use the **RUN COMPILER** statement.

3.7.79 RUN COMMAND

Purpose:

Compiles a PROMULA source code from within a running application. This allows you to temporarily perform equations, read in data, and define procedures, variables and other PROMULA structures while running a PROMULA application. The **RUN COMMAND** gives you the means to execute a batch file of statements from command mode.

Syntax:

```
RUN COMMAND file
```

Remarks:

`file` is a quoted string or a string variable that contains the name of a text file containing PROMULA statements.

Upon execution, PROMULA will compile the code contained in `file`. If the code is well formed and compatible with the current application (i.e., no redefinitions), the new executable code will become resident with the current application.

Using this statement is like escaping the current application and using PROMULA in command mode. The main differences are (1) PROMULA reads the statements from a text file instead of from the keyboard, and (2) statements are executed in batch mode.

If you want to add any interactive input or output statements to the running application, you should put them in a procedure in a file, then process the file using the **RUN COMMAND** statement. The procedure may then be executed by escaping from your application, getting into command mode (**F10** from the Main Menu), and entering the procedure name.

WARNING: If there is a **DEFINE PROGRAM** statement in `file`, you will clear the current application from memory and replace it with the code in `file`.

The last statement in `file` should be a **STOP**. This will get you out of batch compilation mode and return control to the calling program.

Examples:

The source code of `PRM2.PRM` is shown below. It defines two variables: `c` and `d`. The **STOP** statement returns control to the calling program.

```
DEFINE VARIABLE
c
d
END
STOP
```

The variables defined in `PRM2.PRM` can be batch loaded using the code shown below. The code below defines two variables: `a` and `b`, and a procedure, `runcmd` that runs `PRM2.PRM`.

```
DEFINE VARIABLE
a
b
END

DEFINE PROCEDURE runcmd
  RUN COMMAND "prm2.prm"
  AUDIT VARIABLE
END PROCEDURE runcmd
```

Execution of procedure `runcmd` produces the following dialog.

```
             DO runcmd
             Ident    Description
             A
             B
             C
             D
```

The **AUDIT VARIABLE** statement in procedure `runcmd` shows that variables `c` and `d` are now present with variables `a` and `b`. Other PROMULA structures, including procedures, can be added using similar code.

3.7.80 RUN COMPILER

Purpose:

Compiles a PROMULA source code.

Syntax:

```
RUN COMPILER source LIST = output PAUSE = option
```

Remarks:

`source`	is a string (optionally in quotes) or a string variable containing the name of the file to be compiled (the extension .PRM is assumed if none is specified).
`output`	directs the compilation listing and is one of the following

NONE	to turn off the listing; this option provides the fastest compilations.
CONSOLE	to display the listing on the screen.
DISK file	to save the listing on disk. `file` is a string or a string variable containing the name of the file where the listing is to be saved.
PRINTER	to send the listing to the printer.

`option`	controls whether or not PROMULA should pause compilation when an error is detected and is one of the following:

ON	to issue an error message and pause on errors
OFF	to issue an error message and continue on errors
EJECT	to end processing and return to the operating system on errors

The **RUN COMPILER** statement clears the current application from memory before compiling `file`. Control returns to PROMULA command mode when the compilation is complete.

The **RUN COMPILER** statement cannot be executed inside a procedure.

Examples:

The statement

```
        RUN COMPILER "program.prm" LIST=DISK "program.lst" PAUSE=ON
```

will compile the PROMULA code stored in `program.prm`; the compilation listing will be saved in `program.lst`.

3.7.81 RUN DOS

Purpose:

Runs an operating system command. This allows you to access the operating system from within a PROMULA program, perform an OS operation, and return to your program.

Syntax:

```
        RUN DOS command
```

Remarks:

`command` is a quoted string or a string variable containing any command that is valid for your operating system.

When the **RUN DOS** statement is executed, PROMULA will write itself and the current application to disk in a file called **PROMULA.000**; this is often a rather large file (300-500 Kbytes). PROMULA then clears itself from RAM and proceeds with the OS command. When the OS command finishes, PROMULA reloads itself, deletes the **PROMULA.000** file and returns to the application. Note, on machines with a virtual operating system where much more memory is available, PROMULA will not write itself to disk.

You should not use the **RUN DOS** statement to load RAM resident programs.

Be warned that some uses of the **RUN DOS** statement are inherently non-portable and your application may require source code changes if it is moved across the various platforms on which PROMULA runs.

Examples:

The statement

```
        RUN DOS "dir b:"
```

will produce a directory listing for the files on drive b:

Similarly, the statement

```
        RUN DOS "edit myfile.txt"
```

will run the program `edit` with a command line argument of `myfile.txt`.

3.7.82 RUN EDITOR

Purpose:

Loads a file into the PROMULA Text Editor for editing.

Syntax:

```
        RUN EDITOR [filename]
```

Remarks:

`filename` is a string (optionally in quotes) or a string variable containing the name of the text file you wish to edit.This name is the file specification you use to identify the file to the operating system.

Upon execution, the text file is brought into your work space for editing using the text editor. The normal text colors for the Main Screen will be used by the editor.

You may also use the editor while running a PROMULA application by pressing the **Esc** key to interrupt the application and, then selecting Main Menu option 4, load the editor.

NOTE: The amount of memory (capacity) available to the text editor is limited by the amount of memory used by the application you are running. Thus, if you want to edit a very large file, it is best to clear your application from memory before using the editor.

Examples:

1. The statement **RUN EDITOR demo.prm** or **RUN EDITOR "demo.prm"** will load the file `demo.prm` into the editor for editing.

2. Similarly, the following statements will bring `demo.prm` into your work space for editing.

```
DEFINE VARIABLE
   fname  TYPE=STRING(20)
END VARIABLE

fname="demo.prm"
RUN EDITOR fname
```

   Where `fname` is a string variable.

3.7.83 RUN PROGRAM

Purpose:

Runs a PROMULA executable file.

Syntax:

```
RUN PROGRAM file
```

Remarks:

`file` is a string (optionally in quotes) or a string variable containing the name of the file where the program that you wish to execute is stored (the extension .XEQ is assumed if none is specified).

The **RUN PROGRAM** statement clears the current application from memory before executing `file`. Control returns to PROMULA command mode when the execution of `file` is complete. Alternatively, a **STOP PROMULA** statement in the application may be used to exit to the operating system.

The **RUN PROGRAM** statement cannot be executed inside a procedure.

Examples:

The statement

```
RUN PROGRAM "program.xeq"
```

will clear the current application from memory and execute the PROMULA program stored in the executable file `program.xeq`.

See the **RUN** statement for more information on PROMULA's run statements.

3.7.84 RUN SOURCE

Purpose:

Compiles a PROMULA source code and displays the listing on the console.

Syntax:

```
        RUN SOURCE filename
```

Remarks:

`filename` is the name of a text file containing PROMULA statements.

Upon execution, PROMULA will compile the code contained in the file named by `filename`. The compilation will be shown on the screen.

After a successful compilation, control can be returned to the calling program by a **STOP** statement. The **RUN SOURCE** statement can be a convenient alternative to using the dialog driven compiler (**F5** from the Main Menu). It is most useful for recompiling all the segments in a multisegment program which should be done whenever the top-level segment is changed and recompiled.

You can also compile PROMULA source files using the simple **RUN** statement, but this will not show the compilation on the console.

3.7.85 SELECT ENTRY

Purpose:

Allows the user to make a selection from a list of set elements.

Syntax:

```
        SELECT ENTRY set
```

Remarks:

`set` is the identifier of a set.

Upon execution, the **SELECT ENTRY** statement clears the Main Screen and displays the elements of `set` for browsing. The display contains the set element codes and their row descriptors. A prompt at the bottom of the Prompt Screen describes how to browse the list and make a selection. The keyboard action during execution of this statement is described below:

Browsing keys	Pressing the arrow keys or the **PgUp** and **PgDn** keys moves a highlight bar through the list of set elements.
Enter key	Pressing the **Enter** key selects the currently highlighted set element, clears the screen, and allows execution to continue.
End key	Pressing the **End** key allows the user to exit without making a selection.

See also **SELECT set**, **SELECT VARIABLE**, and **SELECT SET** statements.

Examples:

The following example demonstrates the **SELECT ENTRY** statement:

```
DEFINE SET
  dir(4) "4 Directions"
END SET

DEFINE VARIABLE
  dirn(dir) "ROW LABELS" TYPE=STRING(10)
END VARIABLE

READ dirn:8
NORTH   SOUTH   EAST    WEST

DEFINE PROCEDURE selent
  SELECT ROW(dir,dirn)
  SELECT ENTRY dir
  WRITE dir
END PROCEDURE selent
```

Execution of procedure `selent` and selecting the first element of set `dir` produces the displays below:

```
Identifier Description
1          NORTH
2          SOUTH
3           EAST
4           WEST



            End: Exit  Arrows PgUp PgDn Home: Move  Enter: Select
```

```
Identifier Description
1            NORTH
```

3.7.86 SELECT FIELD

Purpose:

Vary the information associated with a pick menu field.

Syntax:

```
SELECT FIELD menu FIELD = fldnum [, DESCRIPTION = flddsc ]
```

Remarks:

`menu` is the name of the pick menu that is to be modified.

`menu` must refer to a pick menu that was labeled **VARIABLE** when it was defined.

`fldnum` is an integer expression providing the sequence number of the field in `menu` that is to be modified. `fldnum` may be a numeric constant or a numeric variable.

`flddsc` is a quoted string or string variable containing a new label for the field to be modified. The text will be left justified and truncated to fit in the space allocated for the field in the definition of `menu`. If the **DESCRIPTION** clause is omitted, then the field label is blanked and the bounce bar will never go to the field.

See also the **DEFINE MENU** statement.

Examples:

The code fragment below may be used to experiment with the **SELECT FIELD** statement.

```
DEFINE WINDOW
  sw(00,00,79,22,white/black,none)
  pw(01,24,79,24,white/black,top/single/navy/black)
END WINDOW

DEFINE MENU pickit, VARIABLE, POPUP(sw,pw)
    Your Options are as follows:
    ----------------------------
    \[ 1 ]  First option       \
    \[ 2 ]  Second option      \
    \[ 3 ]  Third option       \
    \[ 4 ]  Fourth option      \
    \[ 5 ]  SELECT FIELD       \
END
FIELD 1, SELECT=1, ACTION=1
  FIELD 1
END
FIELD 2, SELECT=2, ACTION=2
  FIELD 2
END
FIELD 3, SELECT=3, ACTION=3
  FIELD 3
END
FIELD 4, SELECT=4, ACTION=4
  FIELD 4
END
FIELD 5, SELECT=5, ACTION=5
  SELECT FIELD
END
```

```
END MENU

DEFINE VARIABLE
  pick     "Selection = "
  fldno    "Field Number"
  flddes   "Field Description"  TYPE=STRING(25)
END VARIABLE


DEFINE PROCEDURE selfld
ASK "Would you like to change a Menu field: Y or N",Y
    WRITE "Enter Field Number (1 thru 9)"
    READ fldno
    ASK "Would you like to blank or change the field: B or C",B
        SELECT FIELD pickit, FIELD=fldno
    ELSE C
        WRITE "Enter new field descriptor (up to 25 characters)"
        READ flddes
        SELECT FIELD pickit, FIELD=fldno,DESCRIPTOR=flddes
    END
    selfld
ELSE N
END
END

DEFINE PROCEDURE demo
SELECT pickit(pick)
WRITE GOTOXY(0,10)
DO IF pick EQ 5
  selfld
ELSE
  WRITE ("SELECTION = "pick)
END IF
demo
END PROCEDURE demo
```

3.7.87 SELECT file

Purpose:

Selects a record of a random file for data access, or selects one or more records from an inverted file for data access.

Syntax:

```
SELECT file(key)
```

Remarks:

`file` is the identifier of the inverted or random file you are accessing.

`key` is the sequence number, or the scalar variable whose value is the sequence number of the record you wish to access. Alternatively, `key` is a code used for selecting the records of an inverted file.

If `file` is of type **RANDOM**, the record with sequence number `key` is selected. If `file` is of type **INVERTED**, all records containing `key` are selected.

Examples:

1. Select the second record in a random file and copy its data to a text file.

```
DEFINE FILE
  txt1 TYPE=TEXT
  ran1 TYPE=RANDOM
END FILE

OPEN ran1 "b:ran1.ran", STATUS=OLD
DEFINE VARIABLE ran1
  item1 "Item 1"   TYPE=REAL(8,0)
  item2 "Item 2"   TYPE=STRING(8)
  item3 "Item 3"   TYPE=DATE(8)
END VARIABLE ran1

OPEN txt1 "b:txt1.txt", STATUS=NEW
SELECT ran1(2)
READ ran1
WRITE txt1(item1:8,item2:8,item3:8)
```

NOTE: At the beginning of the reading, the record pointer is at the beginning of the second record; at the end, the pointer has advanced to the beginning of the third record in file `ran1`. No advancement will take place if the record pointer is at the last record.

2. It is possible to select the records of a random file based on a specific search key by using an **inverted file**. An example of this is illustrated below.

```
*  purtrx is a random file containing 9 transactions records

DEFINE FILE
  purtrx      TYPE=RANDOM,       "Purchase transaction file"
END FILE

* Structure of the purtrx record

DEFINE VARIABLE purtrx
  transno            "TRANSACTION NO."           TYPE=REAL(5,0)
  stkcode            "STOCK CODE"                TYPE=STRING(5)
  stkdesc            "STOCK DESCRIPTION"         TYPE=STRING(32)
  stkqty             "STOCK QUANTITY"            TYPE=REAL(5,0)
  stkcost            "STOCK UNIT COST"           TYPE=MONEY(11)
END VARIABLE purtrx

* Display entire random file

DEFINE PROCEDURE shotrx
  OPEN purtrx "purtrx.ran"
  DO purtrx
    WRITE (transno,stkcode:7,stkdesc,stkqty,stkcost)
  END purtrx
END PROCEDURE shotrx
```

Execution of procedure `rdtrx` produces the output below.

```
     100   ADP3      Adapter, 3" Galv Steel URD    5       1.20
     101   ADP5      Adapter, 5" Galv Steel URD   10     100.95
     102  ADPAU                Adapter, Amp URD    8       4.80
     103  BLTCA       Bolts, Carriage 1/2" X 6"   50       0.80
     104  BLTOE      Bolts, Oval Eye 5/8" X 12"   15       2.89
     105   ADP5      Adapter, 5" Galv Steel URD   10     100.95
     106  BLTCA       Bolts, Carriage 1/2" X 6"  100       0.80
     107  CAB12            Cable, #12 solTWwire  200       0.04
     108   ADP5      Adapter, 5" Galv Steel URD   10     100.95
```

3. Read a single record in a random file using a numeric record number

```
DEFINE VARIABLE
  rn "Record Number"
END

DEFINE PROCEDURE seltrx
  SELECT purtrx(rn)
  READ purtrx
  WRITE (transno,stkcode:7,stkdesc,stkqty,stkcost)
END PROCEDURE seltrx
```

The third record of file `purtrx` may be displayed using procedure `seltrx` as shown in the dialog below.

```
rn = 3
seltrx
  102  ADPAU                Adapter, Amp URD    8       4.80
```

4. Select records from a random file using an inverted (index) file.

Build an inverted file. Make "Stock Code" key postings. The key values from `purtrx` are stored in the random file along with record sequence numbers. `purinv` is an inverted file used for searching the "direct" file `purtrx` with symbolic keys.

```
DEFINE FILE
  purinv      TYPE=INVERTED(10), "Inverted file"
END FILE

DEFINE VARIABLE purinv
  purkey             "Stock code key"            TYPE=string(5)
  purseq             "Transaction record number" TYPE=integer(5)
END VARIABLE purinv

OPEN purinv "purinv.ran", STATUS = NEW

purseq = 0
DO purtrx
  purkey = stkcode
  purseq = purseq + 1
  WRITE purinv
END purtrx
CLEAR purinv
```

Procedure `selkey` may be used to search a random file by key and display the records which match.

```
DEFINE VARIABLE
  key           "User defined stock code"        TYPE=string(5)
END VARIABLE
OPEN purinv "purinv.ran", STATUS = OLD

DEFINE PROCEDURE selkey
  SELECT purinv(key)
  DO purinv
    SELECT purtrx(purseq)
    READ purtrx
    WRITE(transno\1,stkcode\7,stkdesc\15:0:0,stkqty\50,stkcost\60)
  END DO purinv
```

```
      END PROCEDURE selkey
```

A sample dialog with procedure `selkey` is shown below

```
* Select all records with a stock code "ADP5"
key = "ADP5"
selkey
101   ADP5    Adapter, 5" Galv Steel URD         10        100.95
105   ADP5    Adapter, 5" Galv Steel URD         10        100.95
108   ADP5    Adapter, 5" Galv Steel URD         10        100.95

* Select all records with a stock code "CAB12"
key = "CAB12"
selkey
107   CAB12   Cable, #12 solTWwire               200       0.04

* Select all records with a stock code "BLTCA"
key = "BLTCA"
selkey
103   BLTCA   Bolts, Carriage 1/2" X 6"          50        0.80
106   BLTCA   Bolts, Carriage 1/2" X 6"          100       0.80
```

3.7.88 SELECT indirect

Purpose:

Allows selection of a program variable for subsequent input/output operations.

Syntax:

```
      SELECT indir(varlist)
```

Remarks:

`indir`	is the identifier of an indirect variable. Indirects may be used with the **WRITE**, **BROWSE**, and **EDIT variable, SORT, DO DESCRIBE,** and **PLOT** statements. Indirects should not be used in calculations, **SELECT SET IF**, or the **WRITE text** statements.
`varlist`	is a list of variable identifiers. If `varlist` contains a single identifier, `indir` will be assigned to it and no variable selection screen will be displayed. If `varlist` is omitted, the selection list will display all the variables in the program except `indir`.

Upon execution, the **SELECT indirect** statement clears the Main Screen and displays the list of variables in `varlist` for selection. The display contains the variables' identifiers and descriptors as defined in their definitions. A prompt at the bottom of the Prompt Screen describes how to browse the list and make a selection.

The following keys are active during execution of this statement:

Browsing keys	Pressing the arrow keys or the **PgUp** and **PgDn** keys moves a highlight bar that highlights the current variable.
Enter key	Pressing the **Enter** key selects the current variable, clears the screen, and allows execution to continue.
End key	Pressing the **End** key allows the user to exit without making a selection.

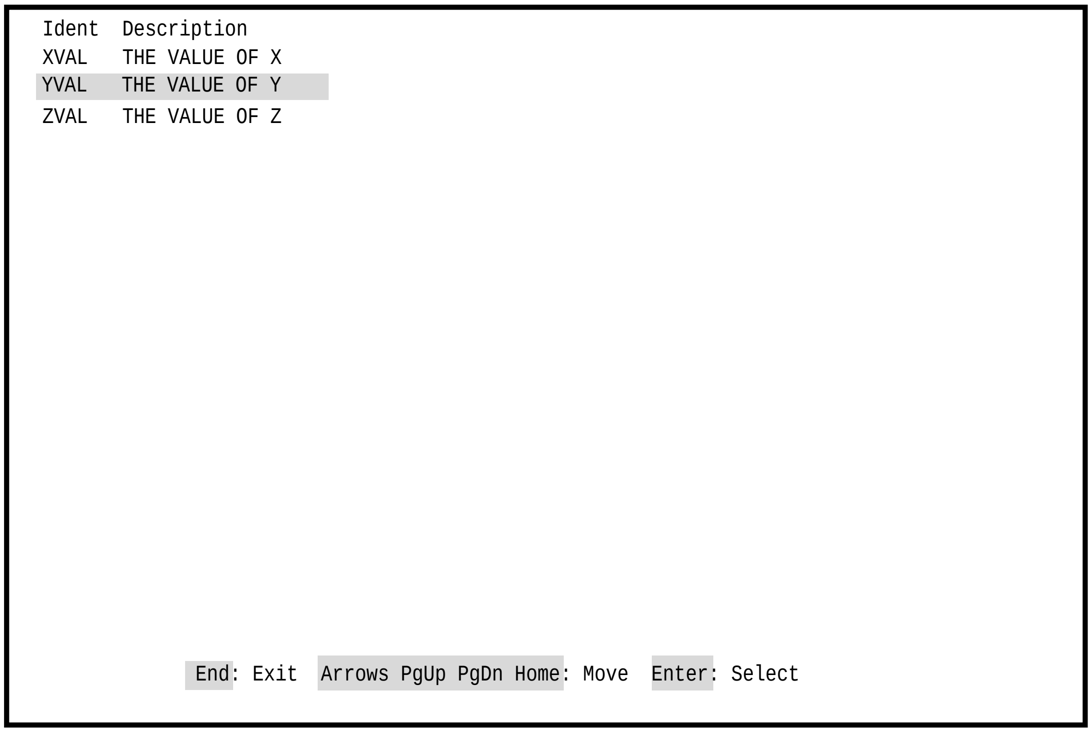
See also the **ASK...ELSE** statement and the **INDIRECT** function.

Examples:

The following example demonstrates the **SELECT indirect** statement:

```
DEFINE VARIABLE
  indir*
  xval "THE VALUE OF X" VALUE=10
  yval "THE VALUE OF Y" VALUE=20
  zval "THE VALUE OF Z" VALUE=30
END VARIABLE

DEFINE PROCEDURE selvar
  SELECT indir(xval,yval,zval)
  DO IF END
     WRITE "Goodbye"
     BREAK selvar
  END IF
  WRITE (indir:L,indir) CLEAR(-1)
  selvar
END PROCEDURE selvar
```

Execution of procedure `selvar` and selection of variable `yval` produces the following displays:



```
Ident  Description
XVAL   THE VALUE OF X
YVAL   THE VALUE OF Y
ZVAL   THE VALUE OF Z

          End: Exit  Arrows PgUp PgDn Home: Move  Enter: Select
```

```
             THE VALUE OF Y    20
```

3.7.89 SELECT menu

Purpose:

Displays a pick menu for making a selection.

Syntax:

```
        SELECT menu(option)
```

Remarks:

`menu` is the identifier of a pick menu.

`option` is a variable that will pick up the number (or action code) of the selection picked. The value of `option` may be used to determine alternative execution paths.

A pick menu is a screen display which is designed to help its user pick from a set of selection fields that have been previously laid out with a **DEFINE MENU** statement. Two types of pick menus may be used with the **SELECT menu** statement: simple, and popup pick menus.

When a simple pick menu is used in a **SELECT menu** statement, PROMULA clears the window opened to the Main Screen, displays the menu, and highlights the first selection field.

Simple pick menu selections may be made by using the arrow keys to highlight the desired field and then pressing the **Enter** key, or by using the function keys (or the numeric keys) directly. The **F1** (numeric 1) key picks the first field in the menu, the **F2** (numeric 2) key picks the second field , and so forth. If you have more than ten selection fields, then press the **Alt** or **Shift** key together with one of the ten Function keys to get up to twenty selections. For example, pressing **Alt-F1** picks the 11th selection. When a field is selected, the sequence number of the field (as defined by its relative position on the menu) will be stored in the variable `option`, and execution will continue with the statement following the **SELECT menu** statement.

When a popup pick menu is used in a **SELECT menu** statement, PROMULA displays the selection screen for the popup pick menu in the menu's selection screen window, and displays the field description for the currently highlighted field in the menu's field description window. The last selected option is highlighted. The first time the menu is executed, the first selection is highlighted.

Popup pick menu selections may be made by using the arrow keys to highlight the desired field and then pressing the **Enter** key. To minimize keystrokes, you may enter a `char` as defined in one of the **SELECT**=`char` parameters of the menu definition. The **SELECT menu** statement does not distinguish between upper and lower case alphabetic keypresses; thus, if **SELECT=A**, the user may select the field either by pressing the 'A' or 'a' key. When a popup menu selection is made, the value of `code`, as defined in the appropriate **ACTION**=`code` parameter of the menu definition, will be returned to PROMULA. If `code` is the name of a submenu defined in the popup menu, the submenu will be displayed for selection. If `code` is a number, its value will be stored in the variable `option`, and execution will continue with the statement following the **SELECT menu** statement.

The user may return from a popup pick menu submenu by pressing the **End** key.

If your system supports a pointer device (such as a mouse), you may make a pick menu selection by positioning the pointer in the desired selection field and clicking the pointer/mouse button.

Examples:

An example of the **SELECT menu** statement is given with the discussion of the **DEFINE MENU** statement.

A third type of pick menus, **pulldown pick menus**, are executed with the **SELECT PULLDOWN** statement.

3.7.90 SELECT option

Purpose:

Selects PROMULA system options.

Syntax:

```
        SELECT option
```

Remarks:

`option` is a list of any or all of the following options.

BACKGROUND=BLACK/ WHITE / NAVY / GREEN / BLUE / RED / PURPLE / YELLOW

to change the color of the Main Screen background.

BROWSE=ON / OFF / ROW / COLUMN / VALUE

to control the behavior of the **WRITE variable** and **WRITE table** statements, and tables defined by the **DEFINE TABLE** statement.

When **BROWSE=OFF**, the above statements write the complete variable or table then proceed with the next statement without pausing. This option is useful for short reports on screen or output that is to be captured on disk (using the **WRITE file** or **SELECT OUTPUT** statements) or sent to a printer. **BROWSE=OFF** is the default.

When **BROWSE=ON**, the above statements generate displays which may be viewed in a controlled interactive mode as if a **BROWSE variable** or **BROWSE table** statement had been executed. This option is useful for viewing longer reports on screen.

When **BROWSE=ROW, COLUMN,** or **VALUE**, the above statements may be used for interactive data editing as if an **EDIT variable** or **EDIT table** statement with a **BY ROW, COLUMN** or **VALUE** option had been executed.

COMMA=ON/OFF

to show commas in displays of numeric values denoting thousands (e.g., 1,500,000; 1,200.) The default is **ON**.

DATE=MMDDY2 / MMDDY4 / DDMMY2 / DDMMY4

to select alternative formats for the **DATE** type variable.

When **DATE=MMDDY2** (the default) dates are treated as 8-character strings of the form mm/dd/yy for input-output purposes. Internally, the date is stored as a numeric quantity of the form yymmdd. For example February 14, 1966 may be entered or displayed as 2/14/66 and is internally stored as 660214.

When **DATE=MMDDY4** dates are treated as 10 character strings of the form mm/dd/yyyy for input-output purposes. Internally, the date is stored as a numeric quantity of the form yyyymmdd.

When **DATE=DDMMY2** dates are treated as 8-character strings of the form dd/mm/yy for input-output purposes. Internally, the date is stored as a numeric quantity of the form yymmdd.

When **DATE=DDMMY4** dates are treated as 10-character strings of the form dd/mm/yyyy for input-output purposes. Internally, the date is stored as a numeric quantity of the form yyyymmdd.

Note, if you plan to do math on the 10-character date formats, you should pass the date variable to a variable of **TYPE=INTEGER(10)** in order to retain at least 10 significant digits.

DEBUG=ON / OFF

to control whether or not PROMULA pauses after encountering an error during compilations.

When **DEBUG=ON**, PROMULA issues an error message upon encountering an error in compilation and pauses the compilation at that point. This is the default.

When **DEBUG=OFF**, PROMULA issues an error message but does not pause.

ECHOR `filespec`

to specify a file in which to save an audit trail of PROMULA statements executed from command mode. The syntax of this statement is exactly like the **SELECT OUTPUT** statement, but, instead of capturing the output generated by PROMULA in a text file, this statement causes the PROMULA command mode statements to be captured. It is not necessary to **SELECT PRINTER=ON/OFF** to activate/deactivate the command capture.

`filespec` is a quoted string or string variable containing the name of the file to be used for command capture.

To turn the statement capture off and close the file, execute a **SELECT ECHOR** "" statement.

FACTOR=`var`

to specify a variable whose value(s) should be used as a scaling factor for all numeric data reports displayed by the **WRITE variable**, and **BROWSE variable** statements.

To deactivate the **FACTOR** option, execute a **SELECT FACTOR = *** statement.

`var` is the identifier of the variable to be used as the scaling factor. The value(s) of the scaling factor is multiplied times each value to be displayed, and the resultant product is shown. If `var` is a multidimensional array, the set correspondence (if applicable) is maintained between `var` and the variable displayed. The default value for `var` is one.

FOREGROUND=BLACK / WHITE / NAVY / GREEN / BLUE / RED / PURPLE / YELLOW

to change the color of the Main Screen foreground.

GHEADING=ON / OFF

to turn page headings on plots on or off. The headings will only be produced if a **SELECT HEADING=ON** statement has also been executed. The default is ON.

GFORMAT=ON / OFF

to turn the gformat feature of the report generator on or off. When **GFORMAT=ON**, numeric quantities that are too large to fit in the specified display width are written in exponential notation. When **GFORMAT=OFF**, numeric quantities that are too large are written as asterisks. The default is OFF.

GRAPHICS=CHARACTER / MEDIUM / HIGH / PLOTTER

To select the mode for PROMULA graphics.

When **GRAPHICS=CHARACTER**, PROMULA's **PLOT** statement will produce character plots. **CHARACTER** mode is appropriate for both monochrome and graphics monitors. This is the default.

When **GRAPHICS=MEDIUM**, medium-resolution plots are produced. The default **MEDIUM** graphics mode is three-color medium resolution CGA graphics.

When **GRAPHICS=HIGH**, high-resolution plots are produced. The default **HIGH** graphics mode is monochrome high resolution CGA graphics.

When **GRAPHICS=PLOTTER**, plots will be sent to the printer/plotter. The default **PLOTTER/PRINTER** graphics mode is high-resolution monochrome graphics on an Epson-compatible dot-matrix printer.

The actual behavior of each of the graphics modes depends on PROMULA's graphics configuration. The information above applies to PROMULA's default configuration. See Chapter 6 for a discussion of configuring graphics.

HEADING=ON / OFF / EJECT

to control the page heading used by PROMULA's report generator. The report generator controls displays of multivariate information including writing multidimensional arrays, writing tables, and displaying results of the statistical functions. The headings will also appear at the top of plots generated in batch mode.

When **HEADING=ON**, a page feed character and a header is written at the top of each page. This header includes the descriptor for the program (if available), the current date (in the form MM/DD/YY), and the word "Page" followed by the page number which is incremented by 1 as a new page is shown. This is the default.

When **HEADING=OFF** no header or page feed character is written at the top of each page.

When **HEADING=EJECT**, only a page feed character is written in the header.

HELP `filespec`

to select a dialog file to serve as an on-line help file.

`filespec` is a quoted string or string variable containing the name of the physical disk file that contains the dialog file you want to use as an on-line help file.

When the user presses **Alt-H** in response to a prompt, PROMULA looks for a **DO IF HELP** statement immediately following the statement that generated the prompt. If a **DO IF HELP** block is found, PROMULA executes statements in the block. If no **DO IF HELP** block is found, PROMULA checks to see if a dialog file has been specified with the **SELECT HELP** statement. If so, PROMULA will display the dialog file for browsing.

If you have opened a window to the Help Screen, the dialog file will be shown in this window; otherwise, the Main Screen is used. See the **DEFINE WINDOW** and **OPEN WINDOW** statements and the discussion of windowing for details of this feature.

Popup menus have an optional **HELP** parameter as part of their field statements. This parameter specifies a topic (by its sequence number) in a dialog file. When the user presses **Alt-H** in response to a **POPUP** menu, PROMULA opens the file specified with the **SELECT HELP** statement and displays the TOPIC whose sequence number matches the help code of the currently highlighted field in the **POPUP** menu.

HIERARCHY=ON / OFF

to control the interpretation of equations.

When **HIERARCHY=ON,** operator precedence rules are turned on and expressions are evaluated using algebraic hierarchy precedence. This is the default.

When **HIERARCHY=OFF**, operator precedence rules are turned off and expressions are evaluated using left-to-right (linear) precedence.

LINES=`page`

to change the number of lines per page to `page`. The default page length is 25 lines. The length of **CHARACTER** mode plots can be controlled by using the **SELECT LINES** statement. The number of lines written by the **WRITE menu** statement also is controlled by the **SELECT LINES** statement.

`page` is an integer constant or a numeric variable.

MAP=ON / OFF

to produce a memory map with the compilation listing.

When **MAP=OFF** no memory map is produced with the listing. This is the default.

When **MAP=ON** a memory map is produced with the listing.

Each statement line of this listing has four columns of sequence numbers:

The first number, in Column **Value**, is the relative address of the next available word of "value storage". Depending on the size of your computer system memory, this number cannot exceed a certain maximum. If it does, you have to use program segmentation or database management to make your program fit within your working space (see Chapter 4).

The second number, in Column **Def**, is the relative address of the next available word of "definition storage". You need concern yourself with this number only if its value exceeds a certain maximum.

The third number, in Column **Proc**, is the relative address of the next available word of "procedure storage". This, too, cannot exceed a certain maximum determined by the size of your computer memory. The **Proc** numbers are also reported as the **Statement address** during execution errors, and you may locate the statement generating the error by looking up the statement in a mapped compilation listing.

The fourth number, in Column **Line#**, is the sequence number of the statement within the source listing.

Figure 3-1 shows the output produced by the PROMULA compiler for a source program that has the **MAP=ON** option in effect.

```
SELECT MAP=ON
Storage Allocation
Value   Def  Proc Line#   PROMULA Source Statement
   11    24    20     2   OPEN SEGMENT    "DEMO.XEQ"       STATUS=NEW
   11    24    20     3   DEFINE PROGRAM  "A Demo Program"
   11    24    25     4   DEFINE SET
   11    24    25     5     month(12)     "Months of the Year"
   11    54    25     6     acnt(3)       "Profit and Loss Ledger Accounts"
   11    78    25     7   END SET
   11    78    25     8   DEFINE VARIABLE
   11    78    25     9   mp(month,acnt) TYPE=REAL(12,2) "Profit & Loss Figures ($)"
   47    98    25    10   mn(month)      TYPE=STRING(12) "Month Names"
   83   114    25    11   acn(acnt)      TYPE=STRING(12) "Profit & Loss Accounts"
   92   135    25    12   amp            TYPE=REAL(10,2) "Average Monthly Profit ($)"
   93   154    25    13   END VARIABLE
   93   154    25    14   DEFINE RELATION
   93   154    25    15     KEY(month,mn)
   93   154    25    16     KEY(acnt,acn)
   93   154    25    17   END RELATION
   93   154    25    18   READ mn:4
   93   154    34    19   JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
   93   154    25    20   READ acn:6
   93   154    34    21   Sales Costs Profit
   93   154    25    22   DEFINE PROCEDURE profits
   93   160    25    23     SELECT acnt(Sales)
   93   160    29    24       EDIT mp TITLE("Please enter the monthly sales.")
   93   160    46    25     SELECT acnt(Costs)
   93   160    50    26       EDIT mp TITLE("Please enter the monthly costs.")
   93   160    67    27     SELECT acnt*
   93   160    70    28       mp(m,3)=mp(m,1)-mp(m,2)
   93   160    89    29       amp=SUM(m)(mp(m,3)/12)
   93   160   101    30       WRITE mp
   93   160   106    31       WRITE amp
   93   160   111    32       STOP
   93   160   112    33   END profits
   93   160   113    34   END PROGRAM, DO(profits)
   93   160   113    35   STOP
```

Figure 3-1: Compilation Output to Printer with SELECT MAP=ON

MATHERROR=ON / OFF

to control math error processing during execution of calculations.

When **MATHERROR=ON**, PROMULA will stop program execution if it attempts to do a division by zero, a logarithm of a negative number, or a fractional power of a negative number. This is the default condition. Like all the **SELECT option** statements, the **SELECT MATHERROR** affects the entire program; however, it is possible to implement local error processing using the **DO IF ERROR** statement. When **MATHERROR=OFF**, PROMULA will give a zero result for these abnormal calculations, and will continue with program execution.

MINUS=LEADING / PARENTHESES

to control the display of negative numbers.

When **MINUS=LEADING**, negative values are displayed with a leading minus sign. This is the default. When **MINUS=PARENTHESES**, negative values are displayed enclosed in parentheses, e.g., the value -10.0 is displayed as (10.0).

NS=`code`**, ND**=`code`**, NA**=`code`**,** or **ERR**=`code`**.**

to specify a code value to use for the input or output of special values. An alternative syntax is **SELECT NS(**`code`**), ND(**`code`**), NA(**`code`**), ERR(**`code`**)** where `code` is up to to six alphanumeric characters. See the discussion of **SELECT SPECIAL** below.

OUTPUT `filespec`

to select a file for subsequent output operations.

`filespec` is a quoted file name or a string variable that contains the name of a file in which you want to save the results of output statements. Output will also be displayed on the screen even if another device has been selected.

To use the **SELECT OUTPUT** statement, follow it with a **SELECT PRINTER=ON** statement, and any other options you may want to set for text report generation.

```
SELECT OUTPUT "report.out" PRINTER=ON WIDTH=132
```

After selecting output, most displays produced by PROMULA will be written to the specified disk file. The affected statements include **WRITE tex**t, **WRITE variable**, **COPY file**, **WRITE function**, **WRITE table**, **table**, **PLOT** (in **CHARACTER** mode), **WRITE menu**, **WRITE TEXT**, and the statistical function reports. To close the file and inactivate the **SELECT OUTPUT** statement, execute a **SELECT PRINTER=OFF** statement.

PAGE=`number`

to change the value of PROMULA's internal page counter to `number`. The current page count is displayed in display headings produced by the report generator.

PATH `pathspec`

to indicate what the path of the data drive is. Here, `pathspec` is a valid path specification or a string variable whose value is a valid path specification, including subdirectory parameters.

You can turn pathing off by executing a **SELECT PATH ""** statement.

You may locally override the path to pathspec by using an **S:** as a "drive designation" before file names. For example if you enter the statement `OPEN file "S:mydata.dta" STATUS=OLD`, PROMULA will ignore the path designated by `pathspec` and look in the current system path for `mydata.dta`. You cannot turn pathing off by selecting option 2 from the Main Menu.

PRINTER=ON / OFF

to turn the printer on or off.

The statement **SELECT PRINTER=ON** has the same effect as the simultaneous pressing of the **Ctrl** key and the **PrtSc** key on the IBM PC. You may also print text while in PROMULA by simultaneously pressing the **Shift** key and the **PrtSc** key, this will send the contents of the current screen to the printer.

The **SELECT PRINTER=ON/OFF** statement is also used to start/stop the spooling of output to a disk file previously specified by a **SELECT OUTPUT** statement.

QUOTES=ON / OFF

to control the placement of quotes around row labels, column labels, and page headings in displays produced by the **WRITE variable** statement. When **QUOTES=ON**, double quotes are placed around these descriptors; this may be useful for setting up data to import into an external spreadsheet program. The default is **QUOTES=OFF**.

RUNID=`set`

to specify a character string that will be appended to the variable descriptor during display statements (**WRITE**, **PLOT**, **EDIT**, etc.).

`set` is the identifier of a set whose first selected row descriptor will be appended to display titles.

SCENARIO `titlespec`

to specify a character string that will be appended to the title of displays produced by the text report generator and plots.

`titlespec` is a quoted string or a string variable whose value you want to appear as part of the title of all display titles.

SPECIAL=ON / OFF

to activate PROMULA's special value processing.

When **SPECIAL=ON**, PROMULA will process the following codes as special data values: **NS** = Not specified, **NA** = Not available, **ND** = Not disclosed. These codes will appear in reports and in results of expressions involving variables containing special values.

When **SPECIAL=OFF**, PROMULA will treat values of arrays containing special values as if they were zero. This is the default.

STEP = ON / OFF

to activate/deactivate step mode during execution of a program. When **STEP = ON**, PROMULA will enter command mode after each statement, at this point, you may enter any command or do debugging operations as needed. When you are ready to execute the next statement, press the Escape key. In the default mode, **STEP = OFF**, execution proceeds from statement to statement without pausing.

STRING (`len`**)**

to change the maximum length of descriptors to `len`, an integer. The default length is 800 characters per descriptor.

STORE=RAW / VIRTUAL / DYNAMIC

to change the default behavior of the **STATUS=OLD** option of the **OPEN file** statement. If **STORE=RAW**, files opened with **STATUS=OLD** or with no explicit status specification are opened with the **OLD** status. If **STORE=VIRTUAL**, files opened with **STATUS=OLD** or with no explicit status specification are opened with the **VIRTUAL** status. If **STORE=DYNAMIC**, files opened with **STATUS=OLD** or with no explicit status specification are opened with the **DYNAMIC** status. See Chapter 4 for more information.

TRANSPOSE=ON / OFF

to control the orientation of array variable displays produced by PROMULA. Setting **TRANSPOSE=ON** specifies that arrays should be displayed in column-major order. For example, if **TRANSPOSE=ON**, a one-dimensional array will be displayed across the columns instead of down the rows, a two-dimensional array will be displayed with its first set dimensioning the columns and the second set dimensioning the rows, a three-dimensional array will be displayed with its third set dimensioning the rows and the first set dimensioning the pages. In other words, multidimensional arrays will be displayed as if they had been defined with their first and last sets switched. The **SELECT TRANSPOSE** statement affects the displays produced by the **WRITE**, **BROWSE**, and **EDIT variable** statements. The **WRITE, BROWSE,** and **EDIT variable** statements can take a local **TRANSPOSE** option to override the global setting of **TRANSPOSE** locally. If an explicit set order is included with any of these statements, any global or local **TRANSPOSE** settings are ignored.

UNITS=`var`

to specify a variable whose value(s) should be used to perform unit conversions for all numeric data reports displayed by the **WRITE variable**, and **BROWSE variable** statements.

`var` is the identifier of the variable to be used as the conversion factor. The value(s) of the conversion factor is multiplied times each value to be displayed, and the resultant product is shown. If `var` is a multidimensional array, the set correspondence is maintained between `var` and the variable displayed. The default value for `var` is one.

To deactivate the **UNITS** option, execute a **SELECT UNITS=*** statement.

WIDTH=`width`

to change the width of display lines to `width`, an integer. The default `width` is 80 characters per line. The width of **CHARACTER** mode plots can be controlled by using the **SELECT WIDTH** statement.

`width` is a numeric variable or a numeric constant.

ZERO=BLANK / DASHES / ON

to control the display of zero displays produced by PROMULA.

When **ZERO=BLANK**, zero values in displays are shown as blanks.

When **ZERO=DASHES**, zero values in displays are shown as a pair of dashes.

When **ZERO=ON**, zero values in displays are shown as zeros. This is the default.

3.7.91 SELECT PULLDOWN

Purpose:

Defines and displays a pulldown pick menu for selection.

Syntax:

```
SELECT PULLDOWN option = wind (menudesc)
```

Remarks:

`option` is a variable that will pick up the action code of the selection picked. The value of `option` may be used to determine alternative execution paths.

`wind` is the identifier of the window that will be used to contain the menu-bar for the pulldown menu. The color scheme and border style for `wind` will also be used by any submenus defined in the `menudesc`. `wind` should be a **POPUP** type window.

`menudesc` is the description of the pulldown menu. The syntax of `menudesc` is as follows:

```
(fldlbl1, fldcod1 [,fldlbl2, fldcod2] [,fldlbl3, fldcod3] [, ... ]  )
```

where

`fldlbln` is a label for the nth menu item. Each `fldlbln` may be either a quoted string or string variable.

`fldcodn` is either a numeric action code or a submenu description for the nth menu item. If `fldcodn` is a numeric action code, its value will be stored in `option` when the field is selected and execution will continue with the code following the **SELECT PULLDOWN** statement. If `fldcodn` is a submenu description the submenu will be displayed for selection.

If `fldcodn` is followed by a slash (/) in a submenu definition, a line will be drawn across the submenu.

Each submenu description has the same general form as `menudesc`.

The fields of the top-level menu are displayed in a row across `wind`. The fields of any second level submenu drop down from their parent field. The fields of any third level submenu are displayed to the right of their parent field. The size of the "window" used to display a submenu is determined by PROMULA according to the number of fields it contains and the length of its longest field label.

Examples:

The example below illustrates the use of the **SELECT PULLDOWN** statement.

```
DEFINE WINDOW
  w1(1,1,78,1,WHITE/BLACK,FULL/SINGLE/NAVY/BLACK,WHITE/NAVY),POPUP
END WINDOW

DEFINE VARIABLE
  pick     "The menu selection"
  f(10)    "Promula menu fields"  TYPE = STRING(12)
  v(10)    "Promula menu selection values"
  bar(10)  "Promula menu fields"  TYPE = STRING(12)
END VARIABLE

bar(1) = "File"
bar(2) = "Edit"
bar(3) = "MainMenu"
bar(4) = "Help"
f(1) = "Exit"
f(2) = "Restart"
f(3) = "Tutorial"
f(4) = "Editor"
f(5) = "Compile"
f(6) = "Xeq"
f(7) = "Resume"
f(8) = "Offline >"
f(9) = "Applications"
f(10) = "Language"
v(i) = i + 11


DEFINE PROCEDURE test
SELECT PULLDOWN pick = w1(
    bar(1)  (
        "New",              1,
         /,
        "Open >", (
            "Source",       101,
            "Xeq",          102,
            "Prm",          103),
        "Save",             2,
        "Save as",          3
        "Print",            4,
         /,
        "Exit",             5),
    bar(2)  (
        "Undo",             6,
        "Cut",              7,
        "Copy",             8,
        "Paste",            9,
        "Delete",           10),
    bar(3)      (
        f(1),               v(1),
        /,
        f(2),               v(2),
        f(3),               v(3),
        f(4),               v(4),
        f(5),               v(5),
        f(6),                v(6),
        f(7),                v(7),
        f(8) (
            "Fred",          201,
            "George",        202,
            "Mark",          203,
            "Lois",          204),
        f(9),                v(8),
        /,
        f(10),               v(9)),
    bar(4)  (
        "Help for field",    22,
        "Extended help",     23,
        "Keys help",         24,
        "Help index",        25,
        "Tutorial",          26,
        "About P90",         27),
    )
WRITE CLEAR(0) (////pick)
test
END PROCEDURE test
```

3.7.92 SELECT RELATION

Purpose:

Defines a relation between the elements of a set and the contents of an array variable indexed or subscripted by that set.

Syntax:

```
SELECT TYPE(set,vec)
```

or

```
SELECT TYPE(set,*)
```

Remarks:

`set`	is the identifier of the set whose elements are related to the values of the vector `vec`.
`vec`	is the identifier of the vector whose values are related to the elements of the `set`. `vec` is usually a STRING TYPE variable
`TYPE`	is the type of relation between `set` and `vec` and may be one of the following:

ROW	to define row descriptors for the `set`.
COLUMN	to define column descriptors for the `set`.
KEY	to define codes for the `set`: this type of relation will cause `vec` to serve as both column and row descriptors for `set` and will allow you to make selections from `set` using the values of a **CODE** or **STRING** type variable. See the example program in the discussion of the **ASK...ELSE** section in this chapter for an illustration of this feature.
TIME	to define time values for the `set`. This type of relation is used in dynamic simulations modeling.

A relation is not valid unless `vec` is a vector variable indexed by `set`.

To restore the set relation to that specified in a previous **DEFINE RELATION** statement, use the **SELECT type(set,*)** statement.

Examples:

The effect of the **SELECT RELATION** statement is demonstrated by the following program:

```
DEFINE SET
  year(2)          "2 Years"
  acnt(3)          "Profit and Loss Ledger Accounts"
END SET
DEFINE VARIABLE
  mp(year,acnt)     "Profit and Loss Figures ($)"        TYPE=REAL(10,0)
  yn(year)          "Year Names"                         TYPE=STRING(12)
  acn(acnt)         "Profit and Loss Account Names"      TYPE=STRING(12)
  acc(acnt)         "Profit and Loss Account Names"      TYPE=STRING(12)
END VARIABLE

DEFINE RELATION
  ROW(year,yn)
  KEY(acnt,acn)
END RELATION

READ yn:5
1987 1988
READ acn:7
Sales  Costs  Profit
READ acc:7
ACNT-1 ACNT-2 ACNT-3
```

The dialog below shows how the **SELECT RELATION** statement can change the column descriptors for set `acnt`.

```
WRITE mp
                          Profit and Loss Figures ($)

                                   Sales       Costs      Profit
                1987              50,000      48,000       2,000
                1988              91,000      86,000       5,000

* Change the column labels for set acnt using a SELECT COLUMN statement
SELECT COLUMN(acnt,acc)
WRITE mp
                          Profit and Loss Figures ($)

                                  ACNT-1      ACNT-2      ACNT-3
                1987              50,000      48,000       2,000
                1988              91,000      86,000       5,000

* The ROW relation between variable acn and set acnt is still in place
WRITE acc:40
                         Profit and Loss Account Names

              Sales                                         ACNT-1
              Costs                                         ACNT-2
              Profit                                        ACNT-3

* Restore the COLUMN relation between acnt and acn
SELECT COLUMN(acnt,*)
WRITE mp
                          Profit and Loss Figures ($)
```

```
                                  Sales        Costs       Profit
                   1987          50,000       48,000        2,000
                   1988          91,000       86,000        5,000
```

3.7.93 SELECT set

Purpose:

Selects elements of a set.

Syntax:

```
SELECT set(list) or SELECT set*
```

Remarks:

`set` is the identifier of the set whose elements are selected.

`list` is a list of element selections and may be of the form:

```
k,l,m-t
```

where the notation `m-t` means "from `m` to `t`" and where `k`,`l`,`m`, and `t` are any of the following:

1. integers from 1 to N, where N is the size of the set
2. identifiers of scalar variables whose values are in the range from 1 to N
3. the values of **CODE** or **STRING** type variables that have been related to `set` through a **KEY** relation.
4. time values that have been related to the elements of the set through a **TIME** relation.

`*` is an asterisk that means clear the present set selection and restore the set to its default size and order as defined by the **DEFINE SET** statement. A set will be restored to a size other than its default size if you have executed a **COMPUTE set:R** statement before the restore (see the discussion of sets in Chapter 1).

In its normal setting, a set has a number of elements N that are ordered sequentially from 1 to N. The **SELECT set** statement allows you to change both the range and the relative ordering of the set elements.

A set selection is in effect until a new set selection is specified. Following a set selection, all expressions involving variables that are subscripted by that set are restricted by the range and ordering of the set selection.

A set selection is valid only if it has values between 1 and N, the size of the set.

Examples:

1. The statement

   ```
   SELECT month(1,6,9)
   ```

   selects the 1st, 6th, and 9th element of the set `month`, i.e., the months January, June and September. All subsequent calculations or input/output instructions involving variables subscripted by `month` will be restricted to the selected months.

2. The statement

   ```
   SELECT month(JAN-JUN)
   ```

   selects the first six months, January through June, of the set `month`. Here, `JAN` and `JUN` are codes that have been related to the `month` set by a **KEY** relation.

3. The statements

   ```
   x = 1
   y = 6
   SELECT month(x-y)
   ```

   have the same effect as the statement of Example 2. Here, `x` and `y` are real variables that select the first six months, January through June, of the set `month`.

4. The statement

   ```
   SELECT month(JAN-JUN), year(1980-1984)
   ```

   selects the elements of more than one set.

5. The statement

   ```
   SELECT month*, year*
   ```

   resets the sets `month` and `year` to their default sizes and orders.

3.7.94 SELECT SET

Purpose:

Allows the user to make several selections from a list of set elements.

Syntax:

```
SELECT SET set
```

Remarks:

`set` is the identifier of a set

Upon execution, the **SELECT SET** statement clears the Main Screen and displays the elements of `set` for browsing. The display contains the set element codes/numbers and their descriptors as defined by a **DEFINE RELATION** or a **SELECT relation** statement. A prompt at the bottom of the Prompt Screen describes how to browse and make selections from the list.

The keyboard action during execution of this statement is described below:

Browsing keys	Pressing the arrow keys or the **PgUp** and **PgDn** keys moves a highlight bar through the list of set elements. The current set element is highlighted in cyan if it has not been selected, or in red if it has already been selected. These default colors can be modified by a **DEFINE WINDOW** and **OPEN WINDOW** statement.

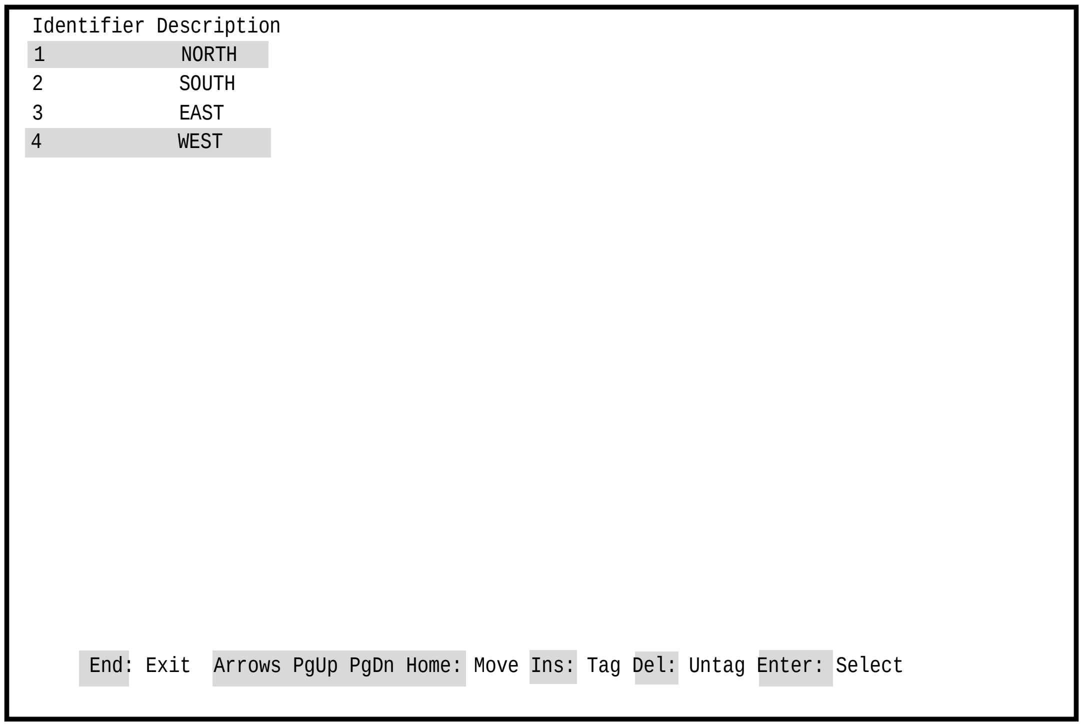
Ins key	Pressing the **Ins** key inserts a set element into the selection vector, and causes its sequence number to be marked by highlighting it in green or in a color defined via a previous **DEFINE WINDOW** statement.
Del key	Pressing the **Del** key cancels a previous selection.
Enter key	Pressing the **Enter** key activates selection of the currently highlighted set elements, and allows the execution to continue. If no elements are high-lighted when Enter is pressed, the set remains in the same state it was in before the **SELECT SET** statement.
End key	Pressing the **End** key allows the user to exit without making any selections.

Examples:

The following example demonstrates the **SELECT SET** statement:

```
DEFINE SET
  dir(4) "4 Directions"
END SET

DEFINE VARIABLE
  dirn(dir) "ROW LABELS" TYPE=STRING(10)
END VARIABLE

READ dirn:8
NORTH   SOUTH   EAST    WEST

DEFINE PROCEDURE selset
  SELECT ROW(dir,dirn)
  SELECT SET dir
  WRITE dir
END PROCEDURE selset
```

Execution of procedure `selset` and selection of the first and fourth elements of set `dir` produce the following two displays:



```
Identifier Description
1             NORTH
2             SOUTH
3             EAST
4             WEST

     End: Exit  Arrows PgUp PgDn Home: Move Ins: Tag Del: Untag Enter: Select
```

```
Identifier Description
1             NORTH
4             WEST
```

3.7.95 SELECT set IF

Purpose:

Select elements of a set according to a condition on a variable indexed by the set.

Syntax:

```
        SELECT set IF condition
```

Remarks:

`set`	is the identifier of the set whose elements are being selected.
`condition`	is any true-false expression involving one or more array variables subscripted by `set`. Only those elements for which `condition` is true are selected. If `condition` is false for all elements, the selection is null and all elements of `set` are selected.

To detect and correct for a null set selection use the **DO IF NULL** statement immediately after the **SELECT SET IF** statement. An example of this feature is in the section related to the **DO IF NULL** statement.

The selections made by **SELECT set IF** are made from the current selection vector of `set`. Thus a cascading, nested selection may be made by executing several **SELECT set IF** statements in series.

Examples:

```
DEFINE SET
  month(12)
END SET

DEFINE VARIABLE
  mv(month)     "Vector by Month"
END VARIABLE

READ mv
1,0,0,1,0,0,1,0,0,1,0,1

SELECT month IF mv NE 0
```

After the selection, the selected values of the set may be illustrated by writing a variable subscripted by the set.

```
WRITE mv

                          Vector by Month

                           MONTH(1)      1
                           MONTH(4)      1
                           MONTH(7)      1
                           MONTH(10)     1
                           MONTH(12)     1
```

The **SELECT** statement above selects only those months for which the value of variable `mv` is not equal to zero.

3.7.96 SELECT VARIABLE

Purpose:

Asks the user a series of set selection questions based on the sets structuring a specified variable.

Syntax:

```
SELECT VARIABLE var
```

Remarks:

`var` is the identifier of an array variable that will serve to define a series of set selection questions. The order and identity of set selection questions will be defined by the order and identity of sets structuring `var`.

This statement provides an alternative to the **ASK** statement as a way of allowing the user to make set element selections. Upon execution, the **SELECT VARIABLE** statement will pose a series of set selection questions to the user for each set dimensioning `var`.

Each question will be of the form

```
Which setdesc entry(s) do you want?
```

Where `setdesc` is the descriptor of the set being selected. If no set descriptor was specified when the set was defined, the set identifier (in capital letters) will be used.

PROMULA will check the validity of the user's responses to ensure that selections are in the range of the set.

In addition to set codes or element numbers, the following keywords may be entered in response to the **SELECT VARIABLE** statement's prompts:

ALL to select all elements in the range of the set being selected.

LIST to display the element numbers or codes and descriptors of all active elements of the set being selected.

END to exit the **SELECT VARIABLE** statement set selection process.

Example:

The behavior of the **SELECT VARIABLE** statement is illustrated in the example below. First, two sets are defined: `year`, a time series set, and `state`. Notice that set `year` has no descriptor and that set `state` has a strange looking descriptor specifically for use with the set selection question generated by the **SELECT VARIABLE** statement. Next, two variables are defined: `pop` is a two-dimensional array that will be used in the **SELECT VARIABLE** statement to control the order of set selections, `staten` is a code type variable that can be used to specify selections from set `state`. Next, variable `staten` is related to set `state` and the variables are initialized. Finally, procedure `slcvar` is defined to run the **SELECT VARIABLE** statement and display the results.

```
DEFINE SET
  year(4)  TIME(1990,2020)
  state(3) "of the 3 state"
END SET

DEFINE VARIABLE
  val(state,year)  TYPE=REAL(15,0)  "State Values"
  staten(state)    TYPE=CODE(2)     "State Names"
END VARIABLE

SELECT KEY(state,staten)

READ staten:3
OH CA IL

val(i,j)=i*j*100000

DEFINE PROCEDURE slcvar
  SELECT VARIABLE val
  WRITE val
END PROCEDURE slcvar
```

A sample dialog with procedure `slcvar` is shown below:

```
DO slcvar
Which of the 3 state entry(s) do you want?
list
Identifier Description
1          OH
2          CA
3          IL
Which of the 3 state entry(s) do you want?
CA
Which YEAR entry(s) do you want?
1990-2010

                           State Values, 1990 to 2010

                             1990           2000           2010
                  CA      200,000        400,000        600,000
```

3.7.97 SORT

Purpose:

Sorts the elements of a set based on the values of a variable subscripted by that set.

Syntax:

```
SORT [order] set USING var
```

Remarks:

`order` is the order in which the set will be sorted and may be one of the following:

ASCENDING	sorts the specified set according to the values of `var` ordered from low to high. This is the default order.
DESCENDING	sorts the specified set from high to low.

`set` is the identifier of the set whose elements are being sorted.

`var` is the identifier of a variable whose values are used to determine the order of the set. The variable `var` must be classified by `set`, i.e., it must have `set` as one of its subscripts; thus, it cannot be a scalar.

The variable `var` may be multidimensional, i.e., it may have additional subscripts other than `set`. In such case, the sorting is done over the dimension corresponding to the `set` with all the other sets dimensioning the array fixed at a single element. If not otherwise specified by a **SELECT set** statement, all dimensions other than `set` are fixed at the first element of their selection vector.

After a sort operation, the sorted order of `set` remains in effect until a **SORT** or **SELECT SET** statement is executed.

If `var` is a string variable, the elements of `set` are sorted alphabetically.

Examples:

The following program illustrates the **SORT** statement.

```
DEFINE SET
  row(10)
  col(5)
END SET

DEFINE VARIABLE
  var1(row)        "A 1-Dimensional Array"
  var2(row,col)    "A 2-Dimensional Array"
END VARIABLE

READ var1
3 45 56 19 21 34 97 89 52 21

READ var2
24  5 56 34 21
98 76 34 27 14
11 23 41 17 32
```

```
54 10 99  2 20
 1 22  3  4 35
51 49 48 47 46
11 31 33 22 11
33 15 67 22 44
79 21 59 85 69
33 99  1 98 49
```

The variable values in their default orders may be displayed by **WRITE variable** statements.

```
WRITE var1

                           A 1-Dimensional Array

ROW(1)               3   ROW(2)               45   ROW(3)               56
ROW(4)              19   ROW(5)               21   ROW(6)               34
ROW(7)              97   ROW(8)               89   ROW(9)               52
ROW(10)             21

WRITE var2

                           A 2-Dimensional Array

                           COL(1)  COL(2)  COL(3)  COL(4)  COL(5)
          ROW(1)               24       5      56      34      21
          ROW(2)               98      76      34      27      14
          ROW(3)               11      23      41      17      32
          ROW(4)               54      10      99       2      20
          ROW(5)                1      22       3       4      35
          ROW(6)               51      49      48      47      46
          ROW(7)               11      31      33      22      11
          ROW(8)               33      15      67      22      44
          ROW(9)               79      21      59      85      69
          ROW(10)              33      99       1      98      49
```

The use of the **SORT** statement is illustrated in the dialogs below.

Sort the elements of set `row` in ascending order using the values of variable `var1`.

```
SORT ASCENDING row USING var
WRITE var1

                           A 1-Dimensional Array

ROW(1)               3   ROW(4)               19   ROW(5)               21
ROW(10)             21   ROW(6)               34   ROW(2)               45
ROW(9)              52   ROW(3)               56   ROW(8)               89
ROW(7)              97
```

Sort the elements of set `row` in descending order using the values of variable `var1`.

```
SORT DESCENDING row USING var1
WRITE var1

                           A 1-Dimensional Array

ROW(7)              97   ROW(8)               89   ROW(3)               56
```

```
          ROW(9)                    52   ROW(2)                    45   ROW(6)                    34
          ROW(10)                   21   ROW(5)                    21   ROW(4)                    19
          ROW(1)                     3
```

Sort the elements of set `row` in ascending order using the values of the 3rd column of variable `var2`.

```
          SELECT col(3)
          SORT ASCENDING row USING var2
          SELECT col*
          WRITE var2

                                       A 2-Dimensional Array

                                       COL(1)  COL(2)  COL(3)  COL(4)  COL(5)
                    ROW(10)                33      99       1      98      49
                    ROW(5)                  1      22       3       4      35
                    ROW(7)                 11      31      33      22      11
                    ROW(2)                 98      76      34      27      14
                    ROW(3)                 11      23      41      17      32
                    ROW(6)                 51      49      48      47      46
                    ROW(1)                 24       5      56      34      21
                    ROW(9)                 79      21      59      85      69
                    ROW(8)                 33      15      67      22      44
                    ROW(4)                 54      10      99       2      20
```

Sort the elements of set `row` in descending order using the values of the 5th column of variable `var2`.

```
        SELECT col(5)
        SORT DESCENDING row USING var2
        SELECT col*
        WRITE var2

                                     A 2-Dimensional Array

                                     COL(1)  COL(2)  COL(3)  COL(4)  COL(5)
                  ROW(9)                 79      21      59      85      69
                  ROW(10)                33      99       1      98      49
                  ROW(6)                 51      49      48      47      46
                  ROW(8)                 33      15      67      22      44
                  ROW(5)                  1      22       3       4      35
                  ROW(3)                 11      23      41      17      32
                  ROW(1)                 24       5      56      34      21
                  ROW(4)                 54      10      99       2      20
                  ROW(2)                 98      76      34      27      14
                  ROW(7)                 11      31      33      22      11
```

Sort the elements of set `col` in ascending order using the values of the 8th row of variable `var2`.

```
        SELECT row(8)
        SORT ASCENDING col USING var2
        SELECT row*
        WRITE var2

                                     A 2-Dimensional Array

                                     COL(2)  COL(4)  COL(1)  COL(5)  COL(3)
```

```
                   ROW(1)                 5       34       24       21       56
                   ROW(2)                76       27       98       14       34
                   ROW(3)                23       17       11       32       41
                   ROW(4)                10        2       54       20       99
                   ROW(5)                22        4        1       35        3
                   ROW(6)                49       47       51       46       48
                   ROW(7)                31       22       11       11       33
                   ROW(8)                15       22       33       44       67
                   ROW(9)                21       85       79       69       59
                   ROW(10)               99       98       33       49        1
```

Sort the elements of set `col` in descending order using the values of the 2nd row of variable `var2.`

```
         SELECT row(2)
         SORT DESCENDING col USING var2
         SELECT row*
         WRITE var2

                                    A 2-Dimensional Array

                                    COL(1)   COL(2)   COL(3)   COL(4)   COL(5)
                   ROW(1)                24        5       56       34       21
                   ROW(2)                98       76       34       27       14
                   ROW(3)                11       23       41       17       32
                   ROW(4)                54       10       99        2       20
                   ROW(5)                 1       22        3        4       35
                   ROW(6)                51       49       48       47       46
                   ROW(7)                11       31       33       22       11
                   ROW(8)                33       15       67       22       44
                   ROW(9)                79       21       59       85       69
                   ROW(10)               33       99        1       98       49
```

3.7.98 STOP

Purpose:

Returns control to the calling program after a **RUN** statement.

Syntax:

```
      STOP
```

Remarks:

PROMULA's run statements: **RUN file**, **RUN COMMAND**, and **RUN SOURCE**, allow you to run programs while in command mode or from within procedures.

The **STOP** statement returns control to the program that executed the last **RUN** statement. Execution resumes at the statement following the run statement. See example in the discussion of the **RUN COMMAND** statement.

The PROMULA Main Menu is at the top of every run chain.

3.7.99 STOP PROMULA

Purpose:

Stops PROMULA execution and returns control to the operating system.

Syntax:

```
STOP PROMULA
```

Remarks:

Sometimes it is useful to stop execution of the PROMULA system altogether and return to the operating system; the **STOP PROMULA** statement enables you to do this.

3.7.100 TIME

Purpose:

Initializes the values of the four time parameters used in controlling dynamic simulations.

Syntax:

```
TIME(dt,beginning,ending) [[SIZE](w,d)]
```

Remarks:

`dt`	is a real number that will be used to set the value of **DT**, the integration interval for time integrals.
`beginning`	is a real number that will be used to set the value of **BEGINNING**, the beginning time point or lower limit of time integrals. The time parameter **TIME** is also set to the value of `beginning` by the **TIME** statement.
`ending`	is a real number that will be used to set the value of **ENDING**, the ending time point or upper limit of time integrals.
`w`	is an integer that specifies the width in characters of time parameter values when they are displayed in reports produced by the report generator.
`d`	is an integer that specifies the number of decimal digits for time parameter values when they are displayed in reports produced by the report generator.

Before executing any dynamic simulation models, the control parameters must have been assigned a definite value via the **TIME** statement. Note that once they have been defined, the values of the individual parameters may be displayed via the **BROWSE** and **WRITE** statements, and may be changed via equations introduced by the verb **COMPUTE**. They may also be referenced on the right-hand side of equations and within conditional expressions.

The current value for the independent variable **TIME** is initially set equal to the value of **BEGINNING**. In a program that has a value of **TIME** defined, all tabular displays generated by the report generator statements whose columns are not classified by a time series set will have the current value of time added to the title.

See also **Time Parameters** in Chapter 1 and the discussion of **Dynamic Procedures** in the **DEFINE PROCEDURE** section of Chapter 3.

3.7.101 WRITE COMMENT

Purpose:

Displays text in the Comment Screen.

Syntax:

```
WRITE COMMENT
  text
  ...
END
```

Remarks:

`text` is any text that you wish to display in the Comment Screen. The amount of text displayed is limited by the size of the Comment Screen.

The keyword **END** must be entered starting in column 1 and must be capitalized.

Upon execution, the text will be shown in the Comment Screen of the display.

For more details, see the sections on Windowing in the beginning of this chapter.

3.7.102 WRITE DISK

Purpose:

Transfers data from a local variable to a disk variable in an array file in the dynamic access method.

Syntax:

```
WRITE DISK(vars)
```

Remarks:

`vars` is a list of dynamic variables.

A dynamic variable is a scratch or fixed variable (also called a local variable) that has a dynamic relationship to a disk variable. Local variables may be related to disk variables through the **DISK** option of the **DEFINE VARIABLE** statement. See chapter 4 for a detailed description of disk access methods.

Examples:

The following code

```
DEFINE FILE
  filea
END FILE

OPEN filea "test.dba" STATUS=NEW
DEFINE SET
 rec(1000)  "Record"
END SET

DEFINE VARIABLE filea
  dsk(pnt), "A Disk Variable on 'filea'"
END VARIABLE filea

DEFINE VARIABLE
  pp  "Record Pointer"
  scr "A dynamic variable for accessing single elements of dsk",DISK(filea,dsk(pp)
END VARIABLE
```

defines two variables: `dsk` and `scr`. The disk variable, `dsk`, is a vector of 1000 elements on the disk file named `test.dba`. The variable `scr` is a dynamic local variable that is related to `dsk`. The **READ DISK** and **WRITE DISK** statements transfer a specific value from and to disk as illustrated in the dialog below.

```
scr = 0
dsk(i) = i
pp = 4
READ DISK(scr)

WRITE scr
A Scratch Variable in Memory 4
scr = 6
WRITE DISK(scr)

WRITE (dsk:L," ",dsk(pp))
A Disk Variable on 'filea' 6
```

3.7.103 WRITE file

Purpose:

Write data to a text file or a random file.

Syntax 1: Write a record of data to a random file

```
WRITE file
```

Syntax 2: Write to a text file

```
WRITE file(var1[,fmt1] [,var2[,fmt2]] [,...]
```

Remarks:

`file` is the identifier of the file you are writing to.

`var1` is the identifier of the variable whose data is first on each data record.

`fmt1` is the format specification for `var1` and has the following syntax:

`\p:w:d`

`p` is an integer indicating the starting column on each data line where the value for `var1` begins. The backslash means: "start writing in column `p`". If omitted, the value begins in column 1.

`w` is an integer indicating the width of the value and it means "write the next `w` columns." A negative width parameter left justifies the value of `var`.

`d` is an integer indicating the number of decimal places to be displayed. If `d` is an "E", the values will be displayed in exponential notation.

If `w` and `d` are 0, no trailing blanks will be written.

`var2`	is the identifier of the variable whose data is second on each data record.
`fmt2`	is the format specification for `var2` and may have the same form as `fmt1` above. If `p` is omitted in `fmt2`, the starting column for `var2` is immediately to the right of `var1`.

Examples:

The examples in this section are based on the following definitions:

```
DEFINE FILE
  txt1 TYPE=TEXT
  ran1 TYPE=RANDOM
  arr1 TYPE=ARRAY
END FILE

OPEN ran1 "b:ran1.ran", STATUS=NEW
DEFINE VARIABLE ran1
  item1 "Item 1"   TYPE=REAL(8,0)
  item2 "Item 2"   TYPE=STRING(8)
  item3 "Item 3"   TYPE=DATE(8)
END VARIABLE ran1
```

1. Read from a text file and write to a random file.

```
OPEN txt1 "b:txt1.txt", STATUS=OLD
DO txt1
  READ txt1(item1:8,item2:8,item3:8)
  WRITE ran1
END txt1
```

2. Read from a text file and write to an array file.

```
DEFINE SET
  rec(100)  "Records"
END SET

OPEN arr1 "b:arr1.arr", STATUS=NEW
DEFINE VARIABLE arr1
  var1(rec) "Variable 1"         TYPE=REAL(8,0)
  var2(rec) "Variable 2"         TYPE=STRING(8)
  var3(rec) "Variable 3"         TYPE=DATE(8)
END VARIABLE arr1

DEFINE VARIABLE
  rn        "Record Number"
END VARIABLE

rn = 1
DO txt1
  READ txt1(var1(rn):8,var2(rn):8,var3(rn):8)
  rn = rn+1
END txt1
```

3. Read from a random file and write to a text file.

```
DO ran1
   WRITE txt1(item1:8,item2:8,item3:8)
END ran1
```

4. Read from a random file and write to an array file.

```
rn = 1
DO ran1
  var1(rn) = item1
  var2(rn) = item2
  var3(rn) = item3
  rn = rn+1
END ran1
```

3.7.104 WRITE function

Purpose:

Writes the values of a function in tabular form.

Syntax:

```
WRITE func[fmt] [TITLE(text)]
```

Remarks:

`func` is the logical identifier of a function defined by the **DEFINE FUNCTION** or **DEFINE LOOKUP** statement.

`fmt` is a format specification of the form `\p:w:d` to indicate the position of the display, the width of the values displayed, and the number of decimals in real values, where

`p` is an integer indicating the width in characters of the row descriptors for the display.

`w` is an integer indicating the width, in characters, of the columns of the display. A negative width parameter left justifies the values displayed.

`d` is an integer indicating the number of decimal places to be displayed. If `d` is an "E", the values will be displayed in exponential notation.

For functions defined by the **DEFINE LOOKUP** statement, the default format is `p=10`, `w=8` and `d=2`.

For functions defined by the **DEFINE FUNCTION** statement, `w` and `d` have the values specified in the **DEFINE VARIABLE** statement for the function variables, and `p` is the value specified in the definition of the row descriptors of the set subscripting the function variables.

`text` is a title for the display and can contain text, variables, and other formatting characters as described in the **WRITE text** statement.

Examples:

The **WRITE function** statement is illustrated below:

```
DEFINE SET
  pnt(6)
END SET

DEFINE VARIABLE
  x(pnt) "The X values"
  y(pnt) "The Y values"
  p(pnt) "PNT Names"   TYPE=STRING(6)
END VARIABLE
```

```
       x(i) = i
       y(i) = i**2
       p(i) = "PNT# "+i
       SELECT ROW(pnt,p)

       DEFINE FUNCTION
         fx(x,y)
       END FUNCTION

       DEFINE LOOKUP
         gx(6) X(1,2,3,4,5,6) Y(2,8,18,32,50,72)
       END LOOKUP
```

Given the above definitions, the statements

```
       WRITE fx\10:10:4 TITLE(/"Y=f(x)=x**2")
       WRITE gx\3:6:1 TITLE(/"Y=g(x)=2x**2")
```

produce the output below.

```
          Y=f(x)=x**2

                                               (1)       (2)
                           PNT# 1           1.0000    1.0000
                           PNT# 2           2.0000    4.0000
                           PNT# 3           3.0000    9.0000
                           PNT# 4           4.0000   16.0000
                           PNT# 5           5.0000   25.0000
                           PNT# 6           6.0000   36.0000
                                    Y=g(x)=2x**2

                                           (1)   (2)
                                  (1)      1.0   2.0
                                  (2)      2.0   8.0
                                  (3)      3.0  18.0
                                  (4)      4.0  32.0
                                  (5)      5.0  50.0
                                  (6)      6.0  72.0
```

3.7.105 WRITE menu

Purpose:

Displays a "data" menu including the values of its data fields. This statement is useful for displaying output results in menu form.

Syntax:

```
       WRITE menu(vars)
```

Remarks:

`menu`	is the identifier of a "data" menu.
`vars`	is a list of variable identifiers that contain the values of the data fields to be displayed. The variables in the list must be arranged in the same order as the data fields in the menu to which they correspond.

A data menu is a template which is designed to help its user edit and display data. The fields in a data menu are previously defined in a **DEFINE MENU** statement.

Data menus contain a number of **data fields** to be displayed by the user. In the **DEFINE MENU** statement, each data field is denoted by a series of contiguous "at signs", @, or "tilde signs", ~, equal in number to the desired number of digits in the data field. The data fields are ordered from left to right and from top to bottom of the menu template.

Upon execution, the data menu is displayed on the screen. The values of the data fields are displayed in the places marked by @ or ~ characters.

Remarks:

The use of the **WRITE menu** statement is especially helpful if you want to display output data in menu format. You can send the results of a **WRITE menu** statement to the printer or to a file using a **SELECT OUTPUT** and **SELECT PRINTER=ON** statement. The default length of the output is 25 lines, this may be modified by a **SELECT lines** statement.

3.7.106 WRITE set

Purpose:

Shows the element codes and element descriptors for a set.

Syntax:

```
WRITE set
```

Remarks:

`set` is the identifier of the set being shown.

Examples:

```
DEFINE SET
  month(12)
END SET

DEFINE VARIABLE
  mc(month) "Month Codes" TYPE=STRING(3)
END VARIABLE

DEFINE RELATION
 ROW(month,mc)
END RELATION

READ mc
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
```

Given the above definitions, the statement

```
WRITE month
```

lists the members (or elements or entries) of the set `month` as shown below

```
Identifier Description
1          JAN
2          FEB
3          MAR
4          APR
5          MAY
```

```
             6          JUN
             7          JUL
             8          AUG
             9          SEP
             10         OCT
             11         NOV
             12         DEC
```

3.7.107 WRITE TABLE

Purpose:

Writes a table of several variables on an output device.

Syntax:

```
      WRITE TABLE(sets), [TITLE(title)] [,FORMAT(rw,cw)],
      BODY(["text1",] var1[fmt1] [,"text2",] var2[fmt2],...)
```

Remarks:

`sets` is a list of the identifiers of the sets classifying columns and pages of the variables in the table. The first set will classify the columns of the table; the other sets, if any, will classify the pages of the table. Sets dimensioning table variables which are missing from the list will classify the rows of the table. The `sets` list `sets` must contain at least one set (or the number 1 for writing a group of scalar variables) and must be missing those set identifiers which will classify the rows of the multidimensional table variables.

`title` is any text you wish to show as a title for the table. The title may include variables and other format characters according to the rules defined in the **WRITE variables** statement.

`text1` is any text that you wish to precede the values of `var1` as a left-justified subtitle. This text may not contain variables.

`var1` is the identifier of the first variable in the table.

`fmt1` is the desired format for the values of `var1`. Usually, this is used to specify the number of decimal digits for `var1`.

`text2` is any text that you wish to precede the values of `var2` as a left-justified subtitle. This text may not contain variables.

`var2` is the identifier of the second variable in the table.

`fmt2` is the desired format for the values of `var2`.

`rw` is the number of spaces allocated for row descriptors.

`cw` is the number of spaces allocated for table columns.

A table is a display or report of several variables whose values are classified by a common set (or sets). The common sets classify the columns and pages of the table.

A table has a body and an optional title and format. The body of the table contains the names of the variables whose values will be displayed as the 'body' of the table. The format specifies the width of the rows and columns of the table.

You may include as many variables as you wish in the body of a table.

A table may be 'browsed' interactively by using the **BROWSE TABLE** statement.

Examples:

The following program demonstrates the **WRITE TABLE** statement:

```
DEFINE SET
  row(3)
  col(6)
END SET

DEFINE VARIABLE
  a(row,col) "A Data Set"
  b(row,col) "B data set"
  tot(col)   "The Total of A and B"
END VARIABLE

DEFINE PROCEDURE wrttab
  SELECT LINES=60
  WRITE TABLE(col), TITLE("The Table Title"),
                    FORMAT(20,10),
                    BODY(tot::1/"The A Values"/,a::2,/"The B Values"/,b)
END PROCEDURE wrttab

a = 1
b = 2
tot(c) = SUM(r)( a(r,c) + b(r,c) )
```

Given the above definitions, the statement

```
DO wrttab
```

produces the following output.

```
                                The Table Title
                        COL(1)    COL(2)    COL(3)    COL(4)    COL(5)    COL(6)
The Total of A and B       9.0       9.0       9.0       9.0       9.0       9.0

The A Values

ROW(1)                    1.00      1.00      1.00      1.00      1.00      1.00
ROW(2)                    1.00      1.00      1.00      1.00      1.00      1.00
ROW(3)                    1.00      1.00      1.00      1.00      1.00      1.00

The B Values

ROW(1)                       2         2         2         2         2         2
ROW(2)                       2         2         2         2         2         2
ROW(3)                       2         2         2         2         2         2
```

3.7.108 WRITE text

Purpose:

Writes text in the Main Screen.

Syntax:

```
WRITE [param] [(text)]
```

Remarks:

`text` is a specification for the text being written and may contain any of the following:

`text`	write text enclosed in quotes as is. You can use single quotes within double quotes, or vice versa, if you want to write quotation marks.
`$`	begin a new page.
`/`	begin a new line.
`+`	suppress automatic carriage return (must be the last character of `text`). This allows you to concatenate the output of several **WRITE text** statements.
`var[\p:w:d]`	write value of a variable `var` starting in column `p`. Allow `w` spaces for the width of the value and `d` spaces for decimals. A negative `w` left justifies the value of `var`. If `w` and `d` are both zero, no trailing blanks will be displayed. This is especially useful for writing string type variables that may contain unknown numbers of trailing blanks.
`set`	write the value of the current primary descriptor of `set`.
`variable:I`	write the identifier of a variable.
`variable:L`	write the descriptor of a variable.
`variable:D`	write the identifier of a variable, followed by a colon, a space, and the descriptor for the variable

`param` is any (or all) of the following:

LEFT	to left justify the output (default).
RIGHT	to right justify the output.
CENTER	to center the output.
CLEAR(`s`**)**	to pause `s` seconds, clear the screen, then continue. A negative `s` causes a pause until the user strikes any key, and then clears the screen.
CURSOR=type	to specify the type of the cursor. Three cursor types are possible:
GOTOXY(`x,y`**)**	to specify `x` and `y` screen coordinates for the next write. The visible part of the screen contains values for `x` between 0 at the left and 79 at the right, and values for `y` between 0 at the top and 24 at the bottom.

Cursor types:

OFF	no cursor
STANDARD	blinking dash (default)
BLOCK	blinking block

You may intermix several `text` and `param` specifications in the same **WRITE text** statement.

Examples:

PROMULA's **WRITE** statement generates an automatic line-feed after the write. If you want to suppress this action, you may include a **+** character as the last character of output. The example below demonstrates this feature and **:0:0** formatting.

```
DEFINE SET
  tst(5)
END

DEFINE VARIABLE
  x
  tstn(tst) TYPE=STRING(10)
END

SELECT ROW(tst,tstn)

tstn(i)="# "+i


DEFINE PROCEDURE wrt
DO tst
  x = tst:S
  WRITE (tst" x ="x"--fills 8 characters by default. "+)
  x = x**2
  WRITE ("x**2 = "x:0:0" No trailing blanks with :0:0.")
END tst
END PROCEDURE wrt
```

Execution of procedure `wrt` produces the following output.

```
  # 1 x =       1--fills 8 characters by default. x**2 = 1 No trailing blanks with :0:0.
  # 2 x =       2--fills 8 characters by default. x**2 = 4 No trailing blanks with :0:0.
  # 3 x =       3--fills 8 characters by default. x**2 = 9 No trailing blanks with :0:0.
  # 4 x =       4--fills 8 characters by default. x**2 = 16 No trailing blanks with
:0:0.
  # 5 x =       5--fills 8 characters by default. x**2 = 25 No trailing blanks with
:0:0.
```

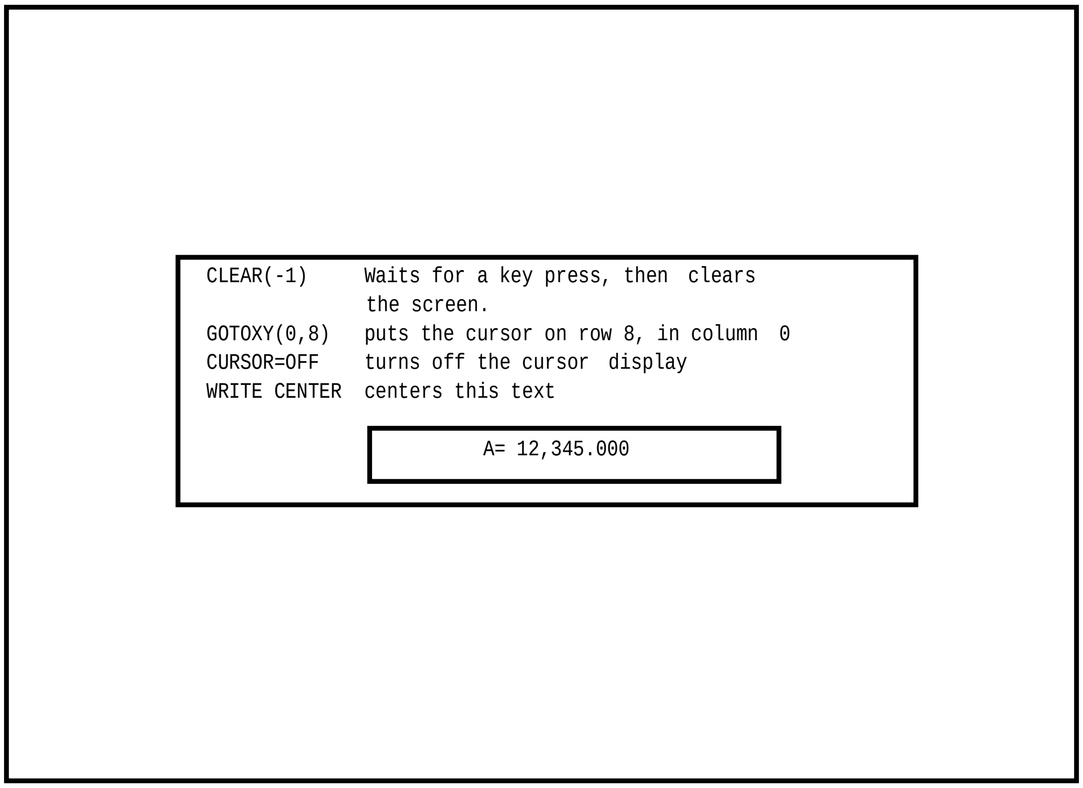
This example demonstrates the `justify` parameter, variable formatting, and several other **WRITE text** options.

```
DEFINE PROCEDURE writxt
a=12345
WRITE LEFT ("A=" a) CENTER ("A=" a) RIGHT  ("A=" a),
      CENTER ("---------------------------------------------------------"),
      ("A=" a:-15:3 "A=" a /,
       "A=" a:-25:3 "A=" a /,
       "A=" a:-35:3 "A=" a),
      CLEAR(-1),GOTOXY(0,8),CURSOR=OFF, CENTER(,
"        CLEAR(-1)    Waits for a key press, then        "/,
"        clears                                          "/,
                      the screen
"        GOTOXY(0,8)   puts the cursor on row 8,         "/,
         in column 0
"        CURSOR=OFF       turns   off   the   cursor     "/,
         display
"        WRITE CENTER centers this text                  "/,
"                     A= ",a:-12.3, "                    "/,
"                                                        ")
END PROCEDURE writxt
```

The procedure `writxt` writes the lines below, then pauses (because of the **CLEAR(-1)** option.)

```
          A=  12,345
                                         A=  12,345
                                                                       A=  12,345
               -------------------------------------------------------------
          A=12,345.000     A=  12,345
          A=12,345.000          A=  12,345
          A=12,345.000               A=  12,345
```

If the user presses a key, PROMULA clears the Main Screen and writes the display below.



```
CLEAR(-1)     Waits for a key press, then  clears
              the screen.
GOTOXY(0,8)   puts the cursor on row 8, in column  0
CURSOR=OFF    turns off the cursor  display
WRITE CENTER  centers this text

                         A= 12,345.000
```

3.7.109 WRITE TEXT

Purpose:

Displays free form text in the Main Screen.

Syntax:

```
WRITE TEXT
  text
  ...
END
```

Remarks:

`text`   is any text that you want to display in the Main Screen.

The keyword **END** must be entered starting in column 1 and must be capitalized in order to distinguish it from other occurrences of the word "end" in the text.

Upon execution, the text will be shown in the Main Screen (Action Window) of the display.

For more details, see the discussion of PROMULA's Basic Windowing capabilities.

3.7.110 WRITE VALUE segment

Purpose:

Writes the information of a program or program segment to disk. Only the values of the segment variables are written. To write both code and data values, use the **END SEGMENT** or **END PROGRAM** statement.

Syntax:

```
WRITE VALUE seg
```

Remarks:

`seg` is the identifier of the segment whose values are being written to disk.

Use the **OPEN SEGMENT** statement before using the **WRITE VALUE segment** statement.

Examples:

The code below opens a segment file on disk called `wrvalseg.xeq`. This segment is given the default name **MAIN** since it is a top-level segment. Segment **MAIN** contains the single variable, `a`.

```
OPEN SEGMENT "wrvalseg.xeq" STATUS=NEW

DEFINE PROGRAM
  DEFINE VARIABLE
    a "The value of variable A ="
  END VARIABLE
END PROGRAM
```

The effect of the **WRITE VALUE segment** and **READ VALUE segment** are illustrated in the dialogs below.

```
a=10
WRITE a
The value of variable A = 10
```

The statement, **WRITE VALUE MAIN**, writes the values of segment **MAIN** variables (in this case only variable `a`) in the segment file on disk called `wrvalseg.xeq`.

```
WRITE VALUE MAIN
```

The value of a variable can be changed by an expression.

```
a=20
WRITE a
The value of variable A = 20
```

The **READ VALUE MAIN** statement will read in the values of the segment **MAIN**'s variables that were stored by the last **WRITE VALUE MAIN** statement.

```
            READ VALUE MAIN
            WRITE a
            The value of variable A = 10
```

3.7.111 WRITE variable

Purpose:

Shows the information in a variable.

Syntax:

```
      WRITE var[fmt][ORDER(sets)][TITLE(title)][DISPLAY(dvar)][option]
```

Remarks:

`var` is the identifier of a variable.

`fmt` is a format specification to indicate the position of the display, the width of the values displayed, and the number of decimals in real values, as follows:

`\p:w:d`

where

`p` is an integer specifying the width in characters for row descriptors. The default width is the width specifications of the row descriptors related to the set subscripting the rows of the display.

`w` is an integer specifying the width in characters for each column of values. The default is the width specification in the definition of `var`. A negative width parameter left justifies the values of `var` in each column**.**

`d` is an integer specifying the number of decimals to display for real numeric values. The default is the decimal specification (if applicable) in the definition of `var`. If `d` is an "E", the values of `var` will be displayed in exponential notation (base-10), and will show seven digits and six decimal places.

If omitted, `w` and `d` are the parameters specified in the **TYPE** specification for `var`, and `p` is the width specifications of the row descriptors related to the set subscripting the rows of the display.

`sets` is a list of the sets classifying the values of `var`. The order of the sets in this list specifies the structure of the display: the first set classifies the rows of the display, the second set the columns, and the third to last sets classify the pages of the display. The keyword **ORDER** is optional; if it is omitted, `sets` must follow immediately after the optional format specification.

`title` is any text you wish to show as a title for the table. The title may include variables, and other format characters according to the rules defined in the **WRITE text** statement.

`dvar` is a variable used to control the display of variable `var`. `dvar` should be subscripted by the set that defines the rows of the display. PROMULA will display values of `var` only for those rows corresponding to elements of `dvar` that contain nonzero values. See Example in the section on the **BROWSE variable** statement.

`option` is one of the following **WRITE variable** options:

TOTAL[(`sets`**)]** displays totals over the selected sets along with values of `var`. If `sets` is omitted, all the marginal and grand totals for `var` will be displayed.

PERCENT(`set`**)** displays the percent distribution of the total over `set` of `var`.

CHANGE(n**)** The **CHANGE** option allows the user to show a table of percent change in time series data for a previously defined time series dataset or array.

The percent change for time `t` is computed from values for time `t` and `t-1`, where `t` and `t-1` are two consecutive selections of the time set. The selections depend on the current local setting of the set. They may or may not be consecutive time points. There may be more than one time unit between them.

Following the keyword, **CHANGE**, a real number within parentheses is required. It represents the number of time units to be used in computing percent change. Internally it is divided by the difference in time values for selections `t` and `t-1`.

Suppose values for 1970 and 1975 are used in computing the percent change. That is, the user has selected these years for computation and output generation. Also s/he wants to compute an annual percent change, so one time unit (a year) is designated on the **CHANGE** option **(CHANGE(1))**. The change for 1975 is computed as the difference in values for 1970 and 1975, divided by the 1970 value, and multiplied by .2 (for annual change). A factor of 100 gives the final result as a percent change from 1970 to 1975 in one year increments.

In the tabular display the words, **Percent Change in**, are placed in front of the original title (from the variable definition). If the **TITLE** option is used with the **CHANGE** option no words are prefixed.

GROWTH(n**)** The **GROWTH** option allows the user to show a table of growth rates in time series data for a previously defined time series dataset or array. A time series dataset or array is one which is defined by a time series set. The growth rate for time `t` is computed from values for time `t` and `t-1`, where `t` and `t-1` are defined as above.

Following the keyword, **GROWTH**, a real number within parentheses is required and stands for the number of time units between growth rates. Internally it is divided by the difference in time values for selected `t` and `t-1`.

Suppose the user has selected 1970 and 1975 and wishes to show annual growth rates **(GROWTH(1))**. The growth rate for 1975 is computed as a quotient — value for 1975 divided by value for 1970 — raised to the power .2 (1.0/(1975-1970)). One is subtracted from this quantity to get a growth rate and a factor of 100 gives the final result as a percent rate from 1970 to 1975 in one year increments.

In the tabular display, the words, **Growth Rate in**, are placed in front of the original title unless the **TITLE** option is specified.

MOVING(n**)** The **MOVING** option allows the user to show a table of moving averages in time series data for a previously defined time series array. Following the keyword **MOVING**, an integer, n, within parentheses, gives the number of single unit time increments over which the moving average is computed. The moving average for time t is computed from values for time t,...,t-(n-1), where the t's are consecutive time points. They are not consecutive time set selections, based on a local setting of the time set. Rather, they are time points as defined initially by the time values related to the set subscripting var.

Suppose the user has selected a five year moving average **(MOVING(5))** based on an annual time series from 1970 to 1990, and he wishes to show only 1975, 1980, 1985, 1990 moving averages. The average for 1990 is computed as the sum of values from 1986 to 1990 divided by the number of time points as defined initially by the **TIME** option on the set definition.

In the tabular display the words, **Moving Average for**, are placed in front of the original title unless the **TITLE** option is specified.

Example:

```
DEFINE SET
  row(3)
  col(2)
  pag(2)
END SET

DEFINE VARIABLE
  a(row,col,pag) "A 3-Dimensional Array"
END VARIABLE
a(i,j,k)=i*j*k
```

Given the defintions above, the statements

```
WRITE a TITLE ("Unformatted Display of variable A")
WRITE a\6:10:2(pag,col,row) TOTAL(col) TITLE(//"Formatted Display of variable A")
```

produce the following output.

```
                Unformatted Display of variable A

                             PAG(1)

                                 COL(1)  COL(2)
                 ROW(1)               1       2
                 ROW(2)               2       4
                 ROW(3)               3       6

                             PAG(2)

                                 COL(1)  COL(2)
                 ROW(1)               2       4
                 ROW(2)               4       8
                 ROW(3)               6      12

                 Formatted Display of variable A

                             ROW(1)

                         Total    COL(1)    COL(2)
               PAG(1)     3.00      1.00      2.00
               PAG(2)     6.00      2.00      4.00
```

```
                          ROW(2)

                  Total    COL(1)    COL(2)
       PAG(1)      6.00      2.00      4.00
       PAG(2)     12.00      4.00      8.00

                          ROW(3)

                  Total    COL(1)    COL(2)
       PAG(1)      9.00      3.00      6.00
       PAG(2)     18.00      6.00     12.00
```

Examples of the other **WRITE VARIABLE** options are presented with the discussion of the **BROWSE VARIABLE** statement.

4. PROGRAM AND DATA MANAGEMENT

A program that has too much data or too much code will not fit in your working space and will not run. Fortunately, in addition to its extensive interface design and modeling features, PROMULA has considerable database management and program management capabilities. Since these capabilities are required for large scale application development they are given special attention in this chapter. This chapter is divided into two sections: the first discusses the construction and use of PROMULA's array database files; the second discusses PROMULA's program segment manager.

4.1 Database Management in PROMULA

In PROMULA, a database is a file containing information. The file's type may be **TEXT**, **ARRAY**, or **RANDOM**. Databases allow your applications to use disk memory to permanently store a copy of program information. Databases may be shared by several applications, extended, read from, written to, and manipulated by your computer operating system like other files.

Text files are the least structured type of database, they are simply a collection of variable length text records. The records of a text file must be accessed sequentially, so they may be difficult or inefficient to access and update. Furthermore, unless the information in the text file is carefully structured into a predictable pattern, it will be very difficult to work with. The lack of internal structure in text files is an advantage for some applications since the file may be easily extended by simply appending text at its end.

Random files are more structured than text files. Random files are composed of fixed length binary records. Each record in the random file is composed of a collection of variables; the variables may be scalars or arrays. The information in a random file is accessed one record at a time. The records may be accessed at random – by record number, or through selection keys – by using an inverted file. Random files may be updated by adding records to the end of the random file, or by re-writing existing records.

Array files are the most structured type of database. Array files are composed of variables, usually arrays, although scalars may also be present. An array file can also contain sets and relations. The information in an array file is accessed using sets and variables. Array files are ideally suited for the science and engineering applications that PROMULA is typically used for. Because of this, text and random files are rarely used for database management in PROMULA. This chapter focuses on using array files. Readers interested in the other files should refer to Chapter 3 of this Manual. For the remainder of this chapter, the terms database and array file will be used interchangeably.

Before discussing the actual syntax of PROMULA's data management language, we should review PROMULA's variable storage types. Here, the phrase "variable storage type" refers to where PROMULA stores each variable's values.

There are three storage types for PROMULA variables:

Fixed Fixed variables are accessed from a fixed space in primary memory (RAM). They are defined with a **DEFINE VARIABLE** statement. The values of fixed variables may be saved in a segment file on disk by the **END SEGMENT, END PROGRAM,** and **WRITE VALUE segment** statements. Computations run fastest when they use fixed variables.

Scratch Scratch variables are accessed from a scratch space in primary memory. They are defined with a **DEFINE VARIABLE SCRATCH** statement. Their values can be cleared from memory with a **CLEAR** statement to make room for other scratch variables. The values of scratch variables cannot be saved in a segment file on disk. Computations using scratch variables will be slower than using fixed variables because PROMULA must do more internal calculations to access their values.

Disk Disk variables are stored on disk in an array file. They are defined with a **DEFINE VARIABLE file** statement. Disk variables are also referred to as database variables. The values of disk variables may be accessed directly on disk and they may be accessed dynamically or virtually in memory via scratch or fixed variables which are related to them.

There are three methods of accessing the values of disk variables:

Direct In direct access, the file containing the disk variable is opened and the variable is used like a fixed variable. This is the slowest and least flexible method of accessing disk variables, but it requires no special programming. With the direct access method, disk variable values are addressed on disk as needed; any changes made to the disk variable are saved in the array file. In order to use direct access, the *definition* of the disk variable must be in memory.

Virtual In virtual access, an appropriate fixed or scratch variable (called a *local variable*) is associated with a disk variable. This local variable is used to access the values of the disk variable *on disk*. PROMULA manages transferring the data between the disk and local variable automatically. Virtual access allows programmers to access disk variables through local variables which are defined in programs that are physically separate from the ones which defined the disk variables. It also allows programmers to access different disk variables through a single local variable.

Dynamic In dynamic access, an appropriate local variable is associated with a disk variable. This local variable is used to access the values of the disk variable *in scratch memory*. This method offers the same advantages as virtual access, but it requires the programmer to transfer values between disk and memory via explicit **READ DISK** and **WRITE DISK** statements. Dynamic access also allows programmers to transfer dimensional sections and subsets of multi-dimensional disk variables between disk and memory. For example, two-dimensional pages of a three-dimensional disk variable can be accessed through a two-dimensional local variable. Dynamic access is also faster than either direct or virtual access because a large number of disk variable values may be quickly transferred between disk and core memory for processing. Local variables used for dynamic access are like scratch variables in that their values may be cleared from memory via the **CLEAR** statement.

4.1.1 Program 1 – Create a 'New' Database

The first step in building a PROMULA database is to define an array file, and open it physically on disk. Since we plan to build a new database, the array file is opened with **STATUS=NEW.**

```
DEFINE FILE
  af  "Array file for database 'filea.dba'" TYPE=ARRAY
END FILE
*
* Open af; its physical name is filea.dba
*
OPEN af  "filea.dba" STATUS=NEW
```

The next step in building the database is to define the logical structure of the file. Here, the sets, variables, and relations of the file are physically laid out on disk. To do this, simply use the **DEFINE SET file**, **DEFINE VARIABLE file** and **DEFINE RELATION file** statements as described in Chapter 3 .

```
DEFINE SET af
  drow(3)
  dcol(4)
  dpag(2)
END SET

DEFINE VARIABLE af
  dat1(drow,dcol,dpag) "A 3-dimensional Array on af"
  dat2(drow,dcol)      "A 2-dimensional Array on af"
  datb(drow,dcol,dpag) "A 3-dimensional Array on af"
END VARIABLE
```

When a database is first created, PROMULA initializes its variables: numeric variables are given the value zero, and non-numeric variables are initialized with "empty strings". Once the database variables are defined, they may be initialized with your data. We will do so here by using the disk variables themselves (i.e., by direct access).

```
READ dat1
111 121 131 141
211 221 231 241
311 321 331 341
112 122 132 142
212 222 232 242
312 322 332 342

dat2(r,c) = dat1(r,c,1) * 10

datb = dat1 * 100
```

The database structure and data can be physically saved, and its file closed with a **CLEAR file** statement.

```
CLEAR af
```

That's all there is to it. The database is defined and ready to use. Of course this is a very simplistic database; it only contains three small, numeric, array variables. The methodology for constructing larger, more complex databases containing all types of PROMULA variables is the same.

1. Define an array file and open it physically on disk.

2. Use the **DEFINE SET**, **DEFINE VARIABLE**, and **DEFINE RELATION** statements to define the structure of the database.

3. Initialize the variables as desired.

4. Close the file.

Note, you may add new sets, variables, and relations to an existing database by opening it with **STATUS=OLD** then following steps 2 through 4 as desired.

4.1.2 Program 2 – Access an 'Old' Database

After building, the database file is on disk and it may be used by other programs. Using a database makes it possible for your application to manipulate very large array variables even if they are too large to fit in primary memory. Another advantage is that database files store a permanent copy of program information separate from the program's segment file, and this copy may be shared by other applications (including programs written in other languages such as C or FORTRAN) or even accessed from PROMULA's command mode.

Although it is not required, the program used to build and initialize a database is usually kept in its own file. This "database build" program need be run only once. Programs that use the database variables are defined in independent source files and the database variables are accessed virtually or dynamically using local variables.

The first step in creating a program to use an array database on disk is to define an array file to access the database using the **DEFINE FILE** statement.

```
DEFINE FILE
  filea  "Array file for database 'filea.dba'" TYPE=ARRAY
END FILE
```

Next, define program variables and relate them to the database variables by including a **DISK** option in their definitions.

The **DISK** option of the **DEFINE VARIABLE** statement is used to relate local variables to disk variables. The syntax for this option is described below:

Syntax:

```
DEFINE VARIABLE [SCRATCH]
  var[(sets)][,"desc"][,TYPE=type],DISK(file,dvar[(dsets)])
END VARIABLE
```

Remarks:

`var`	is the identifier of a local variable. It is through `var` that your application will virtually or dynamically access the disk variable, `dvar`.
`sets`	is the list of set identifiers specifying the dimensions of the variable `var`.
`desc`	is a descriptor for the variable `var`.
`type`	is the format type of `var`. This type (**REAL**, **INTEGER**, **STRING**), etc. must match the type of `dvar`. For **REAL** type variables, the width and decimal specifications of `var` are not required to match those of `dvar`. For all other types, the width specifications of `var` and `dvar` must match.
`file`	is the identifier of an array file. In order to access `dvar` through `var`, the physical file specified when `file` is opened must contain `dvar`.
`dvar`	is the identifier of the actual disk variable that you want to access through `var`.
`dsets`	is an optional list of set identifiers, scalar variables or integer constants — one for each dimension of `dvar`. These define the local sets and/or pointers which correspond to the disk sets subscripting `dvar`.

The access method is defined by the specifications of `dsets`. There are two different ways to specify `dsets`:

1. For virtual access, omit the specification of `dsets`. For example

   ```
   DEFINE VARIABLE
     var(sets) "desc" DISK(file, dvar)
   END
   ```

   PROMULA will handle transferring information between the disk and local variable for you. This is the simplest approach, but since it may require a great deal of disk access, it may be too slow for computationally intensive applications. In virtual access, `var` must have the same shape and size as `dvar`; an exception to this is overlap mapping which we will describe in a later section.

2. For dynamic access, `dsets` is a subscript list — one subscript for each dimension of `dvar`. The subscripts may be numeric scalar variables (pointers), numeric constants, or local set identifiers. You may access specific values of `dvar` by assigning values to the subscripts and then executing **READ DISK** or **WRITE DISK** statements.

   In dynamic access, `sets` defines the size and shape of the subset of `dvar` that may be dynamically transferred to and from disk. The dimensions of `var` may be any subset of the dimensions of `dvar`. However, the sizes of `sets` must not be larger than their corresponding `dsets`. The rules of correspondence between `sets` and `dsets` here are very much like the rules of correspondence that govern subscripting multidimensional equations — row to row, column to column, etc.

The code below uses a variety of **DISK** options to relate local variables to the disk variables in the database `filea.dba` which was built in the last section.

```
DEFINE SET
  row(3)
  col(4)
  pag(2)
END SET

* Define fixed variables to use as pointers to disk variable dimensions.
DEFINE VARIABLE
  rr     "A Row Pointer"
  cc     "A Column Pointer"
  pp     "A Page Pointer"
END VARIABLE

* Define fixed variables that will access disk variables virtually
DEFINE VARIABLE
  ldat1(row,col,pag) "A 3-dimensional Array" DISK(filea,dat1)
  ldatb(row,col,pag) "A 3-dimensional Array" DISK(filea,datb)
  ldat2(row,col)     "A 2-dimensional Array" DISK(filea,dat2)
END VARIABLE

* Define fixed variables that will access disk variables dynamically
DEFINE VARIABLE
  dsv              "Dynamic Scalar"                 DISK(filea,dat1(rr,cc,pp))
  drv(row)         "Dynamic Vector by row"          DISK(filea,dat1(row,cc,pp))
  dcv(col)         "Dynamic Vector by col"          DISK(filea,dat1(rr,col,pp))
  dpv(pag)         "Dynamic Vector by pag"          DISK(filea,dat1(rr,cc,pag))
  drc(row,col)     "Dynamic Array by row and col"   DISK(filea,dat1(row,col,pp))
  dpc(pag,col)     "Dynamic Array by pag and col"   DISK(filea,dat1(rr,col,pag))
  dpr(pag,row)     "Dynamic Array by pag and row"   DISK(filea,dat1(row,cc,pag))
END VARIABLE

* Define scratch variables that will access disk variables dynamically
DEFINE VARIABLE SCRATCH
  sdat1(row,col,pag)     "Dynamic     Array     by     row,     col     and     pag"
DISK(filea,dat1(row,col,pag))
  sdatb(row,col,pag)     "Dynamic     Array     by     row,     col     and     pag"
DISK(filea,datb(row,col,pag))
END VARIABLE
```

Let's look at these examples of how local variables are related to disk variables starting with the local variables `ldat1`, `ldatb` and `ldat2`.

```
ldat1(row,col,pag) "A 3-dimensional Array" DISK(filea,dat1)
ldatb(row,col,pag) "A 3-dimensional Array" DISK(filea,datb)
ldat2(row,col)     "A 2-dimensional Array" DISK(filea,dat2)
```

The above definitions create three array variables. Variable `ldat1` is a three-dimensional array for virtually accessing the disk variable `dat1`. Variable `ldatb` is similar to `ldat1` except that it is for virtually accessing the disk variable `datb`. Variable `ldat2` is a two-dimensional array variable for virtually accessing the disk variable `dat2`.

Notice that each local variable has the same size, shape, and type as the disk variables to which it is related. This is required for correct virtual access. We will discuss how to access subsets and dimensional sections of disk variables shortly.

The values of the three local arrays do not occupy any value storage because the **DISK** option in their definition tells PROMULA that they should be accessed virtually from disk. The virtual access method is indicated because the variables named in their **DISK** options are not subscripted. Local variables which are used to access disk variables virtually are sometimes referred to as *virtual variables*.

Any changes in the virtual variables are automatically and immediately reflected in the values of the corresponding disk variables, and vice versa. It is this automatic passing of data to and from disk that makes virtual access slower than accessing local variables in memory. Virtual access is acceptable for operations which do not require fast execution, but in order to use disk variables efficiently, the dynamic access method should be employed.

Now let's look at some examples of dynamic access starting with variable `dsv`.

```
       dsv   "Dynamic Scalar"  DISK(filea,dat1(rr,cc,pp))
```

Variable `dsv` is a local scalar variable related to the disk variable `dat1` on disk. It may be used for dynamic access of the disk variable `dat1`. Here, dynamic access means explicitly transferring data between disk and memory. Dynamic access is indicated because the reference to `dat1` in the **DISK** option is subscripted by three items — one for each dimension of the actual disk variable. Local variables which are used to access disk variables dynamically are sometimes referred to as *dynamic variables.*

A value of `dat1` on disk may be transferred to `dsv` by specifying the values of the pointer variables `rr`, `cc`, and `pp` to indicate which `drow`, `dcol`, and `dpag` element to read; then executing a **READ DISK** statement. Similarly, the current value of `dsv` may be written to a specific cell in array `dat1` by specifying the values of the pointer variables `rr`, `cc`, and `pp` to indicate which `drow`, `dcol`, and `dpag` element to write then executing a **WRITE DISK** statement. The memory used by `dsv` may be cleared for use by other dynamic or scratch variables by a **CLEAR** statement.

The programmer must make sure that the value of each pointer variable (`rr`, `cc`, and `pp`) is within the range of the disk set to which it corresponds whenever a **READ DISK** or **WRITE DISK** statement is executed.

Notice that the local scalar `dsv` and the disk array `dat1` do not have the same structure. This is allowed in dynamic access. It is required, however, that the structure (i.e., scalar, vector, two-dimensional array, etc.) of the local variable matches the structure of the disk variable as referenced in **DISK** option. We see in the above example that this is true: `dsv` is a scalar; and the reference to `dat1` in the **DISK** option, `dat1(rr,cc,pp)`, is also a scalar. `dat1(rr,cc,pp)` may look like an array definition to some readers, but since `rr`, `cc`, and `pp` are scalars, instead of sets, it is indeed a scalar — similar to a reference to a single cell of a three-dimensional array. The programmer indicates that the actual disk variable is three dimensional by including three subscripts.

Now let's look at the three variables `drv`, `dcv`, and `dpv`.

```
       drv(row)  "Dynamic Vector by row"  DISK(filea,dat1(row,cc,pp))
       dcv(col)  "Dynamic Vector by col"  DISK(filea,dat1(rr,col,pp))
       dpv(pag)  "Dynamic Vector by pag"  DISK(filea,dat1(rr,cc,pag))
```

The above definitions create three dynamic vector variables. Variable `drv` may be used to access an arbitrary `row`-vector of the disk variable `dat1`; variable `dcv` may be used to access an arbitrary `col`-vector of `dat1`; and variable `dpv` may be used to access an arbitrary `pag`-vector of `dat1`. Recall from Chapter 2 that a vector is simply a one-dimensional, or list-structured variable.

Dynamic access is indicated because the reference to `dat1` in the **DISK** option is subscripted — one set or pointer variable for each dimension of the actual disk variable.

The correspondence between the local sets and the sets dimensioning the actual disk variable is indicated by the placement of pointers and set identifiers in the reference to `dat1` in the **DISK** option. Thus, for the variable `dpv(pag)`, `dat1` is referred to as `dat1(rr,cc,pag)` indicating that the `pag` dimension of `dpv` corresponds to the third dimension of the actual disk variable. Similarly, for the variable `dcv(col)`, `dat1` is referred to as `dat1(rr,col,pp)` indicating that the `col` dimension of `dcv` corresponds to the second dimension of `dat1` on disk. The dimensions of the disk variable which do not correspond to a dimension of the local variable are basepointed (i.e., assumed to take on an arbitrary single value) as indicated by the use of scalar variables in the reference to the disk variable.

A `row`-vector of `dat1` may be read into `drv` by specifying the values of the pointer variables `cc` and `pp` to indicate which `dcol` and `dpag` to read, then executing a **READ DISK** statement. Similarly, the current values of `drv` may be written to a specific `row`-vector in `dat1` by specifying the values of the pointer variables `cc` and `pp` to indicate the `dcol` and `dpag` to write, then executing a **WRITE DISK** statement. The memory used by drv may be cleared for use by other dynamic or scratch variables by a **CLEAR** statement. Completely analogous techniques may be applied to transfer values for the other dynamic vector variables.

Notice that the structures of the local vectors drv, dcv, and dpv match the structures of the disk variable referred to in their respective **DISK** options. For example, the structure of the disk variable referred to in the **DISK** option for the col-vector dcv, dat1(rr,col,pp), is also a vector by col. dat1(rr,col,pp) may look like the definition of a three dimensional array, but since rr and pp are scalars, and col is a set, it is indeed a vector by col. Analogous relationships hold for the other local vectors drv and dpv.

The definitions for variables drc, dpr, and dpc are shown below:

```
      drc(row,col)  "Dynamic Array by row and col"  DISK(filea,dat1(row,col,pp))
      dpc(pag,col)  "Dynamic Array by pag and col"  DISK(filea,dat1(rr,col,pag))
      dpr(pag,row)  "Dynamic Array by pag and row"  DISK(filea,dat1(row,cc,pag))
```

These variables are dynamic two-dimensional arrays. The variable drc may be used to access a row-by-col array of values for an arbitrary dpag; the variable dpc may be used to access a pag-by-col array of values for an arbitrary drow; and the variable dpr may be used to access a pag-by-row array of values for an arbitrary dcol.

As before, dynamic access is indicated because the specification of dat1 in the **DISK** option is subscripted — one pointer or set for each dimension of the actual disk variable.

The correspondence between the local sets and the sets dimensioning the disk variable is indicated by the placement of pointers and set identifiers in the reference to dat1 in the **DISK** option. Thus for variable dpc(pag,col), dat1 is referred to as dat1(rr,col,pag) indicating that the pag and col dimensions of dpc correspond to the third and second dimensions of dat1 respectively. Similarly, for variable dpr(pag,row), dat1 is referred to as dat1(row,cc,pag) indicating that the pag and row dimensions of dpr correspond to the third and first dimensions of dat1 respectively. The dimensions of the disk variable which do not correspond to a dimension of the local variable are base-pointed (i.e., assumed to take on an arbitrary single value) as indicated by the use of scalar variables in the **DISK** option.

A row-by-col array of dat1 on disk may be read into drc from disk by specifying a value for the pointer variable pp to indicate which dpag of the array to read then executing a **READ DISK** statement. Similarly, the current values of drc may be written to a specific dpag of dat1 by specifying a value for the pointer variable pp to indicate which dpag of the array to write then executing a **WRITE DISK** statement. The memory used by drc may be cleared for use by other dynamic or scratch variables by a **CLEAR** statement. Completely analogous techniques may be applied to transfer values for the other dynamic array variables. Again, the programmer must make sure that the value of each pointer variable is kept within the range of the disk set to which it corresponds.

Finally, let's take a look at definitions of variables sdat1 and sdatb.

```
      DEFINE VARIABLE SCRATCH
        sdat1(row,col,pag) "Dynamic Array by row, col and pag"
      DISK(filea,dat1(row,col,pag))
        sdatb(row,col,pag) "Dynamic Array by row, col and pag"
      DISK(filea,datb(row,col,pag))
      END VARIABLE
```

These variables are dynamic three-dimensional arrays. Variable sdat1 may be used to access the entire three-dimensional array of values in the disk variable dat1, and variable sdatb may be used to access the entire three-dimensional array of values in the disk variable datb.

The values are transferred to and from disk by **WRITE DISK** and **READ DISK** statements. The variables may be cleared from memory by a **CLEAR** statement.

It is up to the programmer to be sure that there is sufficient memory to bring a dynamic variable into memory either explicitly with a **READ DISK** statement or implicitly by using it in an expression. This is especially true when dealing with large dynamic variables.

Note that even though these variables are defined as memory type **SCRATCH**, they are not truly scratch variables because their values are stored on disk. In fact, using the **DISK** option makes the classification of local variables as fixed or scratch artificial. It is much more meaningful to classify local variables which have a **DISK** option in their definition as being either virtual or dynamic.

Before accessing a disk variable, it is necessary to open the file containing it with an **OPEN file** statement. Be sure not to use **STATUS=NEW** when you open an existing datafile or PROMULA will erase the file's contents.

```
OPEN filea "filea.dba" STATUS=OLD
```

Once the file specified in the **DISK** option is physically opened, the disk variables may be accessed. The dialog below illustrates that the virtual variables do indeed contain the values of the disk variables to which they are related.

```
WRITE ldat1
                             A 3-dimensional Array

                                     PAG(1)

                                 COL(1)  COL(2)  COL(3)  COL(4)
                ROW(1)              111     121     131     141
                ROW(2)              211     221     231     241
                ROW(3)              311     321     331     341

                                     PAG(2)

                                 COL(1)  COL(2)  COL(3)  COL(4)
                ROW(1)              112     122     132     142
                ROW(2)              212     222     232     242
                ROW(3)              312     322     332     342

WRITE ldat2
                             A 2-dimensional Array

                                 COL(1)  COL(2)  COL(3)  COL(4)
                ROW(1)            1,110   1,210   1,310   1,410
                ROW(2)            2,110   2,210   2,310   2,410
                ROW(3)            3,110   3,210   3,310   3,410

WRITE ldatb
                             A 3-dimensional Array

                                     PAG(1)

                                 COL(1)  COL(2)  COL(3)  COL(4)
                ROW(1)           11,100  12,100  13,100  14,100
                ROW(2)           21,100  22,100  23,100  24,100
                ROW(3)           31,100  32,100  33,100  34,100

                                     PAG(2)

                                 COL(1)  COL(2)  COL(3)  COL(4)
                ROW(1)           11,200  12,200  13,200  14,200
                ROW(2)           21,200  22,200  23,200  24,200
                ROW(3)           31,200  32,200  33,200  34,200
```

In order to use a dynamic variable which is a dimensional section of a disk variable, it is necessary to assign values to each pointer variable that corresponds to a disk set. Each pointer value must be greater than or equal to 1 and less than or equal to the size of the disk sets to which it corresponds. **REAL** type pointer variables are rounded to the nearest integer.

For example, variable `rr` is used as a pointer to the set `drow(3)` on disk; `rr` may only take on the values 1, 2, or 3; variable `cc` is used as a pointer to the set `dcol(4)`; `cc` may only take on the values 1, 2, 3, or 4; and variable `pp` is used as a pointer to `dpag(2)`; `pp` may only take on the values 1 or 2.

The statements below set the `drow`-pointer to 2, the `dcol`-pointer to 3, and the `dpag`-pointer to 2.

```
rr = 2
cc = 3
pp = 2
```

Once the pointers contain the desired values, the selected data may be transferred from disk into the associated local variables via a **READ DISK** statement.

```
READ DISK dsv drv dcv dpv drc dpc dpr sdat1
```

After the **READ DISK** statement, the local variables' values have the values of their associated disk variables. The local variables may be used like other fixed or scratch variables as illustrated in the dialog below.

```
*** dsv equals dat1(2,3,2)
WRITE dsv
Dynamic Scalar 232

*** drv(rec) equals dat1(rec,3,2)
WRITE drv
                             Dynamic Vector by row

  ROW(1)              132   ROW(2)              232   ROW(3)              332

*** dcv(col) equals dat1(2,col,2)
WRITE dcv
                             Dynamic Vector by col

  COL(1)              212   COL(2)              222   COL(3)              232
  COL(4)              242

*** dpv(pag) equals dat1(2,3,pag)
WRITE dpv
                             Dynamic Vector by pag

  PAG(1)              231   PAG(2)              232

*** drc(row,col) equals dat1(row,col,3)
WRITE drc

                          Dynamic Array by row and col

                                 COL(1)  COL(2)  COL(3)  COL(4)
                ROW(1)              112     122     132     142
                ROW(2)              212     222     232     242
                ROW(3)              312     322     332     342

*** dpc(pag,col) equals dat1(2,col,pag)
WRITE dpc
                          Dynamic Array by pag and col

                                 COL(1)  COL(2)  COL(3)  COL(4)
                PAG(1)                  211      221      231      241
                PAG(2)                  212      222      232      242

*** dpr(pag,row) equals dat1(row,3,pag)
WRITE dpr
                          Dynamic Array by pag and row

                                     ROW(1)   ROW(2)   ROW(3)
                    PAG(1)                131      231      331
                    PAG(2)                132      232      332
```

The values of `dat1` on disk may be modified by changing the values of the associated dynamic local variables then performing a **WRITE DISK** statement. For example, the statements

```
          drc(r,c) = r*c
          WRITE DISK drc
```

will replace page two `(pp = 2)` of `dat1` with an `r*c` product matrix, and the statements

```
          dsv = 1000
          WRITE DISK dsv
```

will assign the value 1000 to the page two `(pp = 2)`, column three `(cc = 3)`, row two `(rr = 2)` cell of `dat1`. Notice that the values of the local variable `ldat1` are also modified, since it is virtually related to `dat1`, as illustrated in the dialog below.

```
          WRITE ldat1
                                              A 3-dimensional Array

                                                      PAG(1)

                                              COL(1)   COL(2)   COL(3)   COL(4)
                          ROW(1)                 111      121      131      141
                          ROW(2)                 211      221      231      241
                          ROW(3)                 311      321      331      341

                                                      PAG(2)

                                              COL(1)   COL(2)   COL(3)   COL(4)
                          ROW(1)                   1        2        3        4
                          ROW(2)                   2        4    1,000        8
                          ROW(3)                   3        6        9       12
```

The dynamic variable `sdat1` is not automatically modified, since it is not virtually related to `dat1`. As illustrated below, `sdat1` still has the values of `dat1` that were read in by the previous **READ DISK** statement.

```
          WRITE sdat1
                                        Dynamic Array by row, col and pag

                                                      PAG(1)

                                              COL(1)   COL(2)   COL(3)   COL(4)
                          ROW(1)                 111      121      131      141
                          ROW(2)                 211      221      231      241
                          ROW(3)                 311      321      331      341
```

```
                                   PAG(2)

                               COL(1)  COL(2)  COL(3)  COL(4)
                ROW(1)            112     122     132     142
                ROW(2)            212     222     232     242
                ROW(3)            312     322     332     342
```

In fact, the values of the disk variable `dat1` may be "restored" to their "original" state by transferring the values of `sdat1` back to disk with a **WRITE DISK** statement.

```
WRITE DISK sdat1
```

Notice that the values of the local variable `ldat1` are also "restored", since it is virtually related to `dat1` as illustrated in the dialog below.

```
WRITE ldat1
                           A 3-dimensional Array

                                   PAG(1)

                               COL(1)  COL(2)  COL(3)  COL(4)
                ROW(1)            111     121     131     141
                ROW(2)            211     221     231     241
                ROW(3)            311     321     331     341

                                   PAG(2)

                               COL(1)  COL(2)  COL(3)  COL(4)
                ROW(1)            112     122     132     142
                ROW(2)            212     222     232     242
                ROW(3)            312     322     332     342
```

The dynamic variables associated with `dat1` are not changed unless an explicit **READ DISK** or **CLEAR variable** statement is executed. As illustrated in the dialog below.

```
WRITE dsv
Dynamic Scalar 1,000

WRITE drc
                         Dynamic Array by row and col

                               COL(1)  COL(2)  COL(3)  COL(4)
                ROW(1)              1       2       3       4
                ROW(2)              2       4       6       8
                ROW(3)              3       6       9      12
```

The **READ DISK** statement transfers values from disk to memory.

```
READ DISK dsv drc

WRITE dsv
Dynamic Scalar 232

WRITE drc
```

```
                              Dynamic Array by row and col

                                     COL(1)  COL(2)  COL(3)  COL(4)
                ROW(1)                  112     122     132     142
                ROW(2)                  212     222     232     242
                ROW(3)                  312     322     332     342
```

4.1.2.1 Accessing Subsets of Disk Variables

The dynamic method for accessing array files described above allows a programmer to access dimensional sections of array variables on disk and to have different orderings for the dimensions of the local and disk variables. For example, the local variable `dpr` defined above is a `pag`-by-`row` section of the `drow`-by-`dcol`-by-`dpag` disk variable, `dat1`.

Sometimes, in addition to accessing dimensional sections and reordering the structure of related disk and local variables, the programmer wants the local variable to be smaller than the disk variable. In other words, the programmer wants to bring in a subrange of values from one or more dimensions of the disk variable. The syntax of the **DISK** option described in the previous section is not flexible enough to support a ***floating subrange*** within a dimension. Consider for example the disk variable defined below:

```
DEFINE SET af
  dsub(500)   "Survey Subject"
  dqst(100)   "Survey Question"
  dyer(10)    "Survey Year"
END SET

DEFINE VARIABLE af
  data(dsub,dqst,dyer) "Survey Responses by Subject, Question, and Year"
END VARIABLE
```

Suppose the programmer wants to be able to dynamically access the data for all `dsub` elements, a single arbitrary `dyer` element, and a range, say 20, of the `dqst` elements. In addition, the programmer wants to access the data through a local question-by-subject array. With the notation discussed thus far, he/she might try to define the local array as follows:

```
DEFINE SET
  sub(500)   "Survey Subject"
  qst(20)    "Survey Question"
END SET

DEFINE VARIABLE
  yp              "Year Pointer"
  ldata(qst,sub)   "Survey Responses"  DISK(af,data(sub,qst,yp))
END VARIABLE
```

The problem with this notation is that it will only allow the programmer to access *the first 20* elements of set `dqst`. The data for `dqst` elements 21-100 cannot be accessed. Of course, the programmer could try increasing the size of set `qst` to 100, but that would define a local variable with 500 x 100 = 50,000 values = 200 Kbytes — too large to fit in memory on most platforms. The programmer might also try using virtual access, but that is slow and does not allow reordering of local sets. Finally, the programmer might try basepointing the `qst` dimension of the local array but then he/she could only access one `dqst` element at a time. None of these approaches is satisfactory. What is required is a means of having a basepoint *and* a local set corresponding to the same disk set. In order to provide for this, an extended **DISK** option syntax is available. The extended syntax for defining a dynamic variable that can access a floating subrange of values from a disk variable is described below.

Syntax:

```
DEFINE VARIABLE [SCRATCH]
```

```
  var[(sets)][,"desc"][,TYPE=type,] DISK(file,dvar[, BASE(dsets1)][, ORDER(dsets2)])
END VARIABLE
```

Remarks:

`var`	is the identifier of a fixed or scratch variable. It is through `var` that your application will dynamically access the disk variable, `dvar`.
`sets`	is the list of local set identifiers specifying the dimensions of the variable `var`.
`desc`	is an optional descriptor for the variable `var`.
`type`	is the format type of `var`. This type, **REAL**, **INTEGER**, **STRING**, etc. must match the type of `dvar`. For **REAL** type variables, the width and decimal specifications of `var` are not required to match those of `dvar`. For all other types, the width specifications of `var` and `dvar` must match.
`file`	is the identifier of an array file. In order to access `dvar` through `var`, the disk file specified when `file` is physically opened must contain `dvar`.
`dvar`	is the identifier of the actual disk variable that you want to access through `var`.
`dsets1`	is an optional list of set identifiers, scalar variables or integer constants — one for each dimension of `dvar`. These define the local sets and pointers which correspond to the disk sets subscripting the `dvar`.
`dsets2`	is an optional list of set identifiers and asterisks (*) — one for each dimension of `dvar`. These define the correspondence between the local sets and the disk sets which actually subscript `dvar`. Asterisks are used to indicate which dimensions of the disk variable are basepointed.

Let's take a look at how to apply this extended syntax to our example.

The database definition is the same:

```
DEFINE SET af
  dsub(500)   "Survey Subject"
  dqst(100)   "Survey Question"
  dyer(10)    "Survey Year"
END SET

DEFINE VARIABLE af
  data(dsub,dqst,dyer) "Survey Responses by Subject, Question, and Year"
END VARIABLE
```

The programmer wants to be able to dynamically access the data for all `dsub` elements, a single arbitrary `dyer` element, and a range, say 20, of the `dqst` elements. In addition, the programmer wants to reorder the dimensions of the local variable as a `qst`-by-`sub` array. The syntax required for our example is

```
DEFINE SET
  sub(500)   "Survey Subject"
  qst(20)    "Survey Question"
END SET

DEFINE VARIABLE
  yp               "Year Pointer"
  qp               "Question Pointer"
  ldata(qst,sub)   "Survey Responses"  DISK(af,data, BASE(sub,qp,yp),
ORDER(sub,qst,*))
END VARIABLE
```

The **BASE** parameter of the **DISK** option tells PROMULA that the variables `qp` and `yp` are basepoints for the second and third dimensions of the disk variable, and that the set `sub` corresponds to its first dimension. The **ORDER** parameter of the **DISK** option tells PROMULA that the local sets `sub` and `qst` correspond to the first and second dimensions of the disk variable, and that ranges of values should be accessed from these dimensions. The third subscript of the **ORDER** parameter is an asterisk (*) indicating that a single element of the third dimension of the disk variable should be accessed.

Given the above definition, any 20 consecutive `dqst` elements may be accessed by assigning the basepoint (first-element) value to variable `qp` and then executing a **READ DISK** statement. The programmer must be careful that the value of `qp` is at least 1 and no greater than 80 whenever a **READ DISK** or **WRITE DISK** is executed. For example, to read in the data for `dqst` elements 41 through 60, assign the value 41 to `qp` and execute a **READ DISK** statement.

4.1.3 More About Database Management

4.1.3.1 COPY file IMAGE

It is possible to access a database without having to relate local variables to disk variables. The easiest way to do this is with the **COPY file IMAGE** statement. This variation of the **COPY** statement reads the definition of a database into memory and makes its sets, variables, and relations available for *direct* access. For example, if `filea.dba` is an array file on disk, the following code would load its definition into memory.

```
DEFINE FILE
  af TYPE=ARRAY
END
OPEN af "filea.dba" STATUS=OLD
COPY af IMAGE
```

4.1.3.2 The file:variable and file:set notations

It is possible to *directly* access disk variables using the notation `file:var`. Where `file` is the identifier of a file which has been opened to an array file on disk, and `var` is the identifier of the database variable you wish to access. Similarly, the notation `file:set` may be used to reference sets in an array file.

4.1.3.3 PAGED VIRTUAL and AUTOMATIC DYNAMIC Access

Programs that manipulate database variables through virtual or direct access are easier to write than those that use dynamic access because explicit **READ DISK**, **WRITE DISK**, and **CLEAR variables** statements are not required. Unfortunately, virtual and direct access methods can be much slower than dynamic access. It seems the programmer must trade off ease of programming for execution speed. There is, however, a way to have the best of both worlds.

As described in Chapter 3, the **OPEN file** statement can open array files as **STATUS=VIRTUAL** or **STATUS=DYNAMIC**. Files opened **STATUS=VIRTUAL** use *paged virtual access*. In this mode, large pieces of the database are transferred from disk to memory automatically by PROMULA. The efficiency of paged virtual access depends on the structure of the database variables and the way in which the virtual or disk variables are defined and used by the program. Files opened **STATUS=DYNAMIC** use *automatic dynamic access***.** In this mode, the database is read into memory once — when the file is opened, and then it is written back out once — when the file is cleared.

Of course, these methods do not provide the same degree of control that is possible when data access is described via the **READ DISK** and **WRITE DISK** statements. Furthermore, paged virtual and automatic dynamic access can require a great deal of memory and can only be used with small databases or with machines that have a large or virtual memory.

4.1.3.4 Increasing PROMULA's Scratch Storage Area.

Paged virtual and automatic dynamic access can only be used with small databases or with machines that have a large memory. There is, however, a way to increase the *paging space* (also called scratch storage) used for manipulating dynamic variables. This is done by including a -**PS**=`xx` -**DS**=`yy` -**VS**=`zz` switch on the PROMULA command line.

As mentioned in Chapter 3 (see discussion of **SELECT MAP**), PROMULA divides your working space into three partitions, each of which can accommodate about 32 Kbytes of storage. The three partitions are entitled **Value Storage**, **Definition Storage**, and **Procedure Storage**. The Value partition accommodates data values — the contents of variables. The Definition partition accommodates the definitions of data structures, sets, variables, menus, etc. The Procedure partition accommodates executable code — the statements of procedures. Your program is too large whenever any one of these three storage areas is filled. PROMULA's default memory allocation map is shown in Figure 4-2 below. This diagram indicates that PROMULA creates a 32K partition for each storage area, and that a scratch storage area whose size is hardware dependent is available at the "top" of memory.

TOTAL AVAILABLE WORKING SPACE			
DEFINITION	PROCEDURE	VALUE	SCRATCH
32K	32K	32K	Hardware dependent

The -**PS**=`xx` -**DS**=`yy` -**VS**=`zz` switch allows you to change the allocation of memory. The switch values (`xx`, `yy`, and `zz`) are integers between 1 and 32. The switches have no effect on machines that employ a virtual memory system.

The amount of storage required by your application can be determined by compiling it with **SELECT MAP=ON** and finding the maximum value attained by the storage counters. For example, the listing shown in Figure 4-2 indicates that the application requires a minimum of 10,011 bytes of value storage, 668 bytes of definition storage, and 92 bytes of procedure storage. A safe set of allocation switches for this program would be -**VS**=`11` -**DS**=`1` -**PS**=`1`. For example, entering the command line

```
        PROMULA -VS=11 -DS=1 -PS=1 RUN PROGRAM segment.xeq
```

will start PROMULA and load the application stored in the file `segment.xeq`. PROMULA will allocate a total of 13 Kbytes for the standard memory partitions and at least 83 Kbytes for scratch storage as diagrammed below.

TOTAL AVAILABLE WORKING SPACE			
DEF	PROC	VAL	SCRATCH
1K	1K	11K	Hardware dependent

4.1.3.5 Automatic READ DISK

PROMULA performs an automatic **READ DISK** operation whenever a dynamic variable is encountered on the right side of an equation or displayed with a **WRITE** or **BROWSE** statement — unless the variable has already been read into memory. The automatic **READ DISK** does not automatically move pointer variables, but it does ensure that dynamic variables have default values. The default for the basepointed dimensions of dynamic variables is the element indexed by the value of the pointer related to the disk set.

PROMULA never performs an automatic **WRITE DISK** of a dynamic variable.

4.1.3.6 Overlap Mapping

It is possible to use a single n-dimensional local variable to *virtually* access several n-1 dimensional disk variables. The local and disk variables must all be of the same type, and the disk variables must be contiguous in a single database. The

DISK option should specify the identifier of the first of the contiguous variables to be accessed. For example, the two-dimensional local variable `data` may be mapped across the disk vectors `name`, `adr1`, `adr2`, and `phon` as shown below:

Database Definition:	**Fixed Variable Definitions**
`DEFINE FILE`	`DEFINE FILE`
`  af TYPE=ARRAY "ARRAY FILE"`	`  af TYPE=ARRAY "ARRAY FILE"`
`END FILE`	`END FILE`
`OPEN af "test.dba" STATUS=NEW`	
`DEFINE SET`	`DEFINE SET`
`  rec(100)`	`  rec(100)`
`END SET`	`  var(4)`
`DEFINE VARIABLE af`	`END SET`
`  name(rec) TYPE=STRING(30) "NAME"`	
`  adr1(rec) TYPE=STRING(30) "Address 1"`	`DEFINE VARIABLE`
`  adr2(rec) TYPE=STRING(30) "Address 2"`	`data(rec,var) TYPE=STRING(30) "Data"`
`  phon(rec) TYPE=STRING(30) "PHONE"`	`DISK(af,name)`
`END VARIABLE af`	`END VARIABLE`
`CLEAR AF`	

4.2 Program Management in PROMULA

In addition to helping you manage data with array variables and database files, PROMULA can help you manage large programs with segments and segment files. If your program code or data becomes too large to fit in your working space, you may divide it into segments that can be transferred to and from disk on an as needed basis. A segment is a program unit. When a segment is defined, it is explicitly given a name and is implicitly given a place in a program hierarchy. Program segmentation and segment files allow you to create very large, structured applications that run in environments with limited memory. Segment files also allow you to keep large program source codes in separate files so they can be edited, compiled, and debugged separately.

Figure 4-1 is a schematic of how PROMULA organizes a segmented program; the segments could be kept in separate files on disk or grouped together in a single file. The resultant program has a hierarchical tree structure in which the lower segments of the tree inherit the structures and procedures of their parent segments.

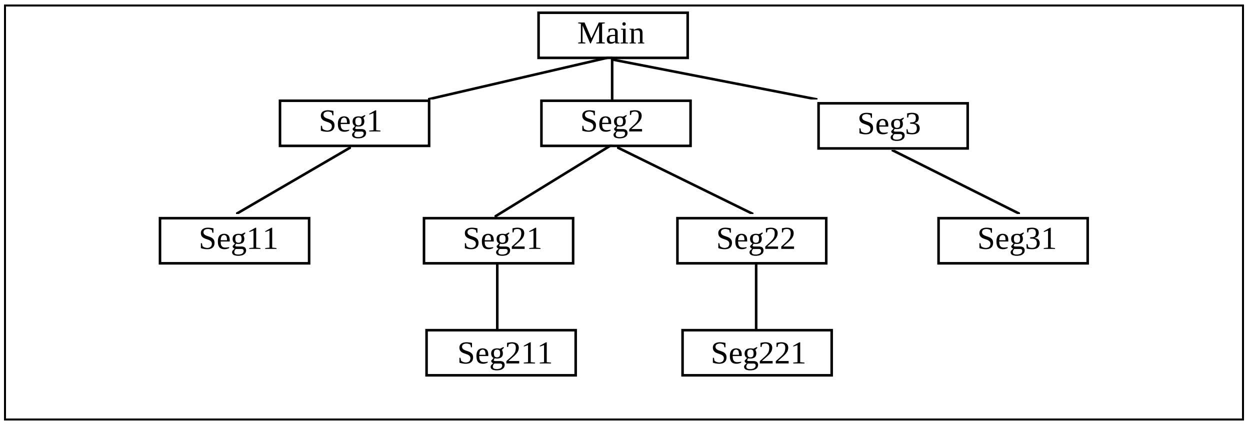


Figure 4-1: Hierarchy of a Segmented Program

4.2.1 A Segmented Program with a Database

Figure 4-2 is the listing of an artificially large program that has been "segmented" and "databased" in order to fit in a small working space.

The program in Figure 4-2 has five variables: `var`, `var1`, `var11`, `var2`, and `var3`. Together they require 70,000 words or 280 Kilobytes of storage:

Variable	Storage Words	Storage Bytes
var	50,000	200K
var1	5,000	20K
var11	5,000	20K
var2	5,000	20K
var3	5,000	20K
Total	70,000	280K

How do you fit them in a space of, say, 64 Kilobytes? Easy, break the oversized program into smaller pieces and only bring in the necessary pieces one at a time. This is analogous to using a set of encyclopedias: you work with the one volume that you are interested in while the rest of them sit on the shelf until they are needed. A mapped compilation listing of the source code that produced `SEGMENT.XEQ` is shown below.

Figure 4-2: A Segmented Program with a Database

```
Storage Allocation
Value   Def  Proc Line#   PROMULA Source Statement
   11    24    20     1   OPEN SEGMENT 'segment.xeq', STATUS=NEW
   11    24    20     2   DEFINE PROGRAM "************ Begin Segment MAIN
**************"
   11    24    30     3   DEFINE FILE
   11    24    30     4     Filex
   11    39    30     5   END
   11    39    30     6     OPEN Filex "segment.dba", STATUS=NEW
   11    39    30     7   DEFINE SET
   11    39    30     8     row(500)
   11   551    30     9     col(10)
   11   573    30    10     page(10)
   11   595    30    11   END
   11   595    30    12   DEFINE VARIABLE  Filex
   11   595    30    13     var(row,col,page), 'Data for Segment MAIN'
   11   613    30    14   END
   11   616    30    15   DEFINE PROCEDURE proc
   11   622    30    16     OPEN Filex "segment.dba", STATUS=OLD
   11   622    37    17     WRITE( 'You are in Segment MAIN')
   11   622    49    18     READ SEGMENT  Seg1, DO(proc1)
   11   622    53    19     READ SEGMENT  Seg2, DO(proc2)
   11   622    57    20     READ SEGMENT  Seg3, DO(proc3)
   11   622    61    21   END proc
   11   622    62    22   DEFINE SEGMENT Seg1 "********** Begin Seg1 ******************"
   11   622    62    23      DEFINE VARIABLE
   11   622    62    24        var1(row,col), 'Data for Segment Seg1'
 5011   639    62    25      END
 5011   639    62    26      DEFINE PROCEDURE proc1
 5011   645    62    27        WRITE('You are in Segment Seg1')
 5011   645    74    28        READ SEGMENT  Seg11, DO(proc11)
 5011   645    78    29      END proc1
 5011   645    79    30      DEFINE SEGMENT Seg11 "****** Begin Seg11 *****************"
 5011   645    79    31         DEFINE VARIABLE
 5011   645    79    32            var11(row,page), 'Data for Segment Seg11'
10011   662    79    33         END
10011   662    79    34         DEFINE PROCEDURE proc11
10011   668    79    35            WRITE('You are in Segment Seg11')
10011   668    91    36         END proc11
10011   668    92    37       END SEGMENT Seg11
 5011   645    79    38   END SEGMENT Seg1
   11   622    62    39   DEFINE SEGMENT Seg2 "********** Begin Seg2
*****************"
   11   622    62    40      DEFINE VARIABLE
```

Figure 4-2: A Segmented Program with a Database

```
  11   622    62    41        var2(row,page), 'Data for Segment Seg2'
5011   639    62    42      END
5011   639    62    43      DEFINE PROCEDURE proc2
5011   645    62    44        WRITE('You are in Segment Seg2')
5011   645    74    45      END proc2
5011   645    75    46    END SEGMENT Seg2
  11   622    62    47    DEFINE SEGMENT Seg3 "********** Begin Seg3
******************"
  11   622    62    48      DEFINE VARIABLE
  11   622    62    49        var3(row,col), 'Data for Segment Seg3'
5011   639    62    50      END
5011   639    62    51      DEFINE PROCEDURE proc3
5011   645    62    52        WRITE('You are in Segment Seg3')
5011   645    74    53      END proc3
5011   645    75    54    END SEGMENT Seg3
  11   622    62    55    END PROGRAM
  11   622    62    56    ************************* End Segment MAIN ******************
```

The program in Figure 4-2 combines *program segmentation* and *database management* to give you what is sometimes called *dynamic memory management*. Dynamic memory management means being able to develop and use large programs. The memory management is achieved in two ways: using database files to store program variables, and using program segmentation to store program code. When the program is compiled, PROMULA creates two files: the program segments are physically stored on the disk file named `SEGMENT.XEQ`. The array file `Filex` is physically stored on the disk file named `SEGMENT.DBA`.

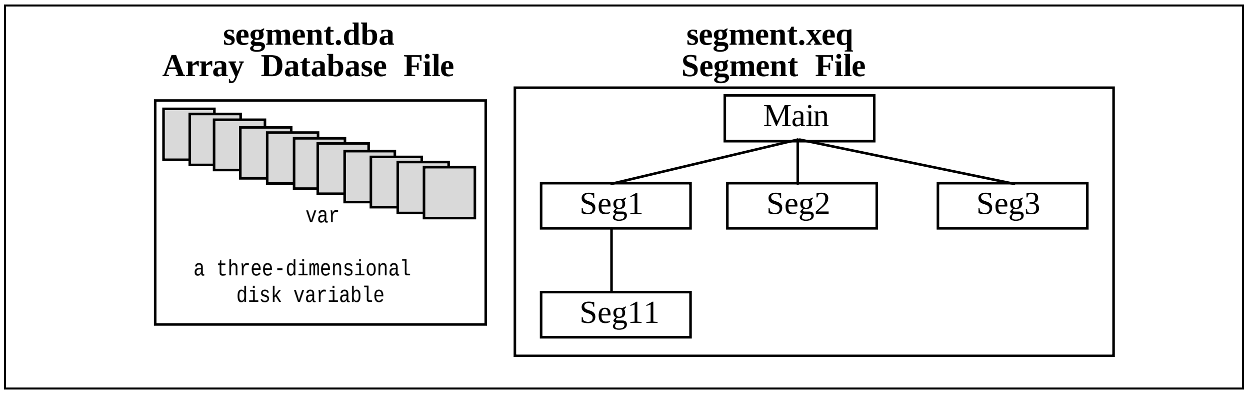


Figure 4-3: Hierarchical Structure of `SEGMENT.XEQ` and the database `SEGMENT.DBA`

This diagram is the organizational chart of the program in Figure 4-2 and its supporting database. The database is stored in a disk file referred to as `Filex` in the program. The five segments are linked into a hierarchy of three levels of inheritance. The level of inheritance is increasing from top to bottom in the diagram. For example, the segment **MAIN** inherits no information from other program segments; it is at inheritance level 0. Segments `Seg1`, `Seg2`, and `Seg3` inherit information from segment **MAIN**; they are at inheritance level 1. Segment `Seg11` inherits information from segments `Seg1` and **MAIN**; it is at inheritance level 2.

Segment inheritance in the context of the diagram means the following: to access information in a segment of inheritance level **n** you must first gain access to the information in the segment at inheritance **n-1** that is directly linked to the segment at level **n**. In addition, segments at the same level of inheritance cannot share information directly, i.e., they cannot be in memory simultaneously. Parallel segments can share information only through a common parent segment and/or through shared databases. In the program of Figure 4-2, segment inheritance is manifested in terms of the following possible working space configurations:

1. Segment **MAIN** may exist in working space alone.
2. Segment `Seg1` can exist in working space with segment **MAIN** alone or with **MAIN** and `Seg11`.
3. Segment `Seg11` can exist in working space only with **MAIN** and `Seg1`.
4. Segment `Seg2` can exist in working space only with segment **MAIN**.
5. Segment `Seg3` can exist in working space only with segment **MAIN**.
6. Segments `Seg1`, `Seg2` and `Seg3` cannot be in your working space simultaneously.
7. All segments share the information in the master segment **MAIN**; thus, all segments have access to the information in the database `Filex`, which is defined in the **MAIN** segment.

The storage allocation for the segments is summarized below:

Segment	Begins at			Ends at		
	Value	Definition	Procedure	Value	Definition	Procedure
MAIN	11	24	20	11	622	62
`Seg1`	11	622	62	5011	645	79
`Seg11`	5011	645	78	10011	668	92
`Seg2`	11	622	62	5011	645	75
`Seg3`	11	622	62	5011	645	75

Figure 4-4: Storage Allocation Statistics for `SEGMENT.XEQ`

Notice that the level n segments begin where their parent (level n-1) segments end. The segment **MAIN** starts with the **DEFINE PROGRAM** statement and ends with the **END PROGRAM** statement. Each of the other segments starts with a **DEFINE SEGMENT** statement and ends with an **END SEGMENT** statement.

Variable `var` is a **disk variable**: its values are stored on the array file `Filex` and, thus, *do not take up any RAM space!* This saves you 200 Kilobytes of working space without compromising your ability to access the values of `var` in your program. The other four variables — `var1`, `var11`, `var2`, and `var3` — occupy fixed spaces in your working space and are called fixed variables. Each of these variables requires 20 Kilobytes of RAM and is available to you only if you are working in the program segment where the variable is defined. For example, `var1` is available in segments `Seg1` and `Seg11`; `var11` is available only in `Seg11`; `var2` is available only in `Seg2`; and `var3` is available only in `Seg3`. If all four fixed variables were in RAM simultaneously they would require 80 Kilobytes of memory. Separately, however, they each require 20 Kilobytes only, for a maximum requirement of 40 Kilobytes (when both `var1` and `var11` are in RAM). This segmentation saves you 40 Kilobytes of RAM space.

Thus, in this example you only require 40 Kilobytes of RAM to use 280 Kilobytes of data values.

Figure 4-5 below contains a sample interaction with the program `SEGMENT.XEQ`.

Figure 4-5: An Interactive Run with a Segmented Program

```
PROMULA? RUN PROGRAM segment.xeq

PROMULA? DO proc
You are in Segment MAIN
You are in Segment Seg1
You are in Segment Seg11
You are in Segment Seg2
You are in Segment Seg3

PROMULA? AUDIT SET
Identifier Description
ROW
COL
PAGE
```

Figure 4-5: An Interactive Run with a Segmented Program

```
PROMULA? AUDIT VARIABLE
Identifier Description
VAR        Data for Segment MAIN
VAR3       Data for Segment Seg3

var = 10

PROMULA? SELECT row(450-455), col(4-8), page(1)
PROMULA? WRITE var

                             A Segmented Program with a Database Page 1

                             Data for Segment MAIN

                                    PAGE(1)

                             COL(4)  COL(5)  COL(6)  COL(7)  COL(8)
            ROW(450)             10      10      10      10      10
            ROW(451)             10      10      10      10      10
            ROW(452)             10      10      10      10      10
            ROW(453)             10      10      10      10      10
            ROW(454)             10      10      10      10      10
            ROW(455)             10      10      10      10      10
```

4.2.2 Multi-Segment Programs in Separate Disk Files

If the segments of your program become very large, or if you just want the convenience of being able to edit and debug them independently, you can store each segment in a separate file.

If you choose to do this, there are several important rules you must follow.

1. In order to use any structures defined in a segment, you must first physically open the disk file that contains the segment then read in the segment by executing **OPEN SEGMENT** and **READ SEGMENT** statements.

2. If you change and recompile a parent segment, you must also recompile all the segments "under" it. Lower level segments and parallel segments, however, can be recompiled without having to recompile their parent segments.

3. After returning from a lower level segment, you must reopen the parent segment before you can write to it with a **WRITE VALUE segment** statement.

Example:

The following example shows how the source code of `SEGMENT.XEQ` would have to be modified in order for each segment to reside in a separate disk file.

The file containing segment MAIN is shown below. Notice that it contains a **DEFINE PROGRAM** statement but no **DEFINE SEGMENT** statement.

Procedure `proc` in this multi-file version of `SEGMENT.XEQ` has been modified by adding the appropriate **OPEN SEGMENT** statements before the **READ SEGMENT** statements that execute the lower level segments.

MAIN

```
OPEN SEGMENT "segment.xeq"  STATUS=NEW
****************** Begin Main Segment *************
DEFINE PROGRAM "A Segmented Program with a Database"
DEFINE FILE
  Filex
END
OPEN Filex "segment.dba", STATUS=NEW
DEFINE SET
  row(500)
  col(10)
  page(10)
END
DEFINE VARIABLE  Filex
  var(row,col,page), 'Data for Segment MAIN'
END
DEFINE PROCEDURE proc
  OPEN Filex "segment.dba"
  WRITE( 'You are in Segment MAIN')
  OPEN SEGMENT "seg1.xeq"
  READ SEGMENT  Seg1, DO(proc1)
  OPEN SEGMENT "seg2.xeq"
  READ SEGMENT  Seg2, DO(proc2)
  OPEN SEGMENT "seg3.xeq"
  READ SEGMENT  Seg3, DO(proc3)
  CLEAR filex
END proc
**************** End Main Segment ***********************
END PROGRAM
STOP
```

The files containing the segments `seg1`, `seg2`, and `seg3` are shown below. Notice that the file containing segment **MAIN** is opened and read at the top of each of these files so that the definitions in segment **MAIN** can be used. This implicitly puts `seg1`, `seg2`, `and seg3` at inheritance level 1 under segment **MAIN** .

seg1

```
OPEN SEGMENT "segment.xeq" STATUS=OLD
READ SEGMENT MAIN
OPEN SEGMENT "seg1.xeq" STATUS=NEW

DEFINE SEGMENT Seg1
**************** Begin Segment 1 *******************
   DEFINE VARIABLE
     var1(row,col), 'Data for Segment Seg1'
   END
   DEFINE PROCEDURE proc1
     WRITE('You are in Segment Seg1')
     OPEN SEGMENT "seg11.xeq"
     READ SEGMENT  Seg11, DO(proc11)
   END proc1
**************** End Segment Seg1 ******************
END SEGMENT Seg1
STOP
```

seg2

```
OPEN SEGMENT "segment.xeq" STATUS=OLD
READ SEGMENT MAIN
OPEN SEGMENT "seg2.xeq" STATUS=NEW

DEFINE SEGMENT Seg2
**************** Begin Segment Seg2 ****************
   DEFINE VARIABLE
     var2(row,page), 'Data for Segment Seg2'
   END
   DEFINE PROCEDURE proc2
     WRITE('You are in Segment Seg2')
   END proc2
***************** End Segment Seg2 *****************
END SEGMENT Seg2
STOP
```

seg3

```
OPEN SEGMENT "segment.xeq" STATUS=OLD
READ SEGMENT MAIN
OPEN SEGMENT "seg3.xeq" STATUS=NEW

DEFINE SEGMENT Seg3
***************** Begin Segment Seg3 ***************
   DEFINE VARIABLE
     var3(row,col), 'Data for Segment Seg3'
   END
   DEFINE PROCEDURE proc3
     WRITE('You are in Segment Seg3')
   END proc3
**************** End Segment Seg3 ******************
END SEGMENT Seg3
STOP
```

The file containing `seg11` is shown below. Notice that both parent segments: `seg1` and **MAIN** are opened and read at the top of this file. This implicitly puts `seg11` at inheritance level 2 under segments **MAIN** and `seg1`.

seg11

```
OPEN SEGMENT "segment.xeq" STATUS=OLD
READ SEGMENT MAIN
OPEN SEGMENT "seg1.xeq" STATUS=OLD
READ SEGMENT seg1
OPEN SEGMENT "seg11.xeq" STATUS=NEW

DEFINE SEGMENT Seg11
*************** Begin Segment Seg11 *************
  DEFINE VARIABLE
     var11(row,page), 'Data for Segment Seg11'
  END
  DEFINE PROCEDURE proc11
      WRITE('You are in Segment Seg11')
  END proc11
**************** End Segment Seg11 **************
END SEGMENT Seg11
STOP
```

The **STOP** statements at the end of all the files are used during multi-file compilations; they return control to a "job file" that contains a series of **RUN** statements that compile the segments of the program in the right order. A job file can be a convenient way to automatically compile all segments after you have changed segment **MAIN**.

A simple sequential job file is shown below. Your own job files can be more elaborate allowing you to select individual segment files for compilation. The important thing to remember is that if you compile a parent segment, all segments "under" it must also be compiled in order to insure that the beginnings and endings of Value, Definition, and Procedure storage for each segment are correct and consistent.

```
WRITE("RUNNING segment.prm")
RUN segment.prm
WRITE("RUNNING seg1.prm")
RUN seg1.prm
WRITE("RUNNING seg11.prm")
RUN seg11.prm
WRITE("RUNNING seg2.prm")
```

```
RUN seg2.prm
WRITE("RUNNING seg3.prm")
RUN seg3.prm
STOP PROMULA
```

5. CONFIGURING PROMULA

Most of PROMULA's system options may be configured by each application through the **SELECT option** statement. However, the physical configuration of PROMULA's graphics modes may only be controlled through PROMULA's graphics configuration program **PCONFIG.XEQ**. This program is a PROMULA application that provides a menu-driven interface for configuring each of PROMULA's graphics modes to your hardware's capabilities and your preferences so that you can produce plots on your screen and printer. The program provides the means to select predefined graphics configurations and to create and manage custom graphics configurations for hardware that does not work under one of the predefined configurations. Typically, you will only have to configure PROMULA's graphics once — when you first install PROMULA on your system.

Currently, PROMULA supports graphics configurations for the following types of devices:

1. CGA medium resolution 3-color graphics adapter
2. CGA high resolution black & white graphics adapter
3. EGA 16 color high resolution graphics adapter
4. VGA 16 color high resolution graphics adapter
5. IBM/Epson printer, high resolution, landscape
6. IBM/Epson printer, high resolution, portrait
7. IBM/Epson printer, medium resolution, landscape
8. IBM/Epson printer, medium resolution, portrait
9, IBM/Epson printer, CGA high resolution screen dump
10. IBM/Epson printer, CGA medium resolution screen dump
11. HP LaserJet II printer, high resolution, landscape
12. HP LaserJet II printer, medium resolution, landscape
13. HP LaserJet II printer, high resolution, portrait
14. HP LaserJet II printer, medium resolution, portrait
15. VT 330 SIXEL graphics
16. VT 240 REGIS graphics
17. IBM/Epson printer, VGA high resolution screen dump
18. LN03 Plus Printer, landscape

PROMULA's default graphics configuration is as follows:

MEDIUM mode	CGA medium resolution 3-color graphics adapter
HIGH mode	CGA high resolution black & white graphics adapter
PLOTTER mode	IBM/Epson printer, high resolution, landscape

5.1 Using the Graphics Configuration Program

There are two primary functions of the graphics configuration program:

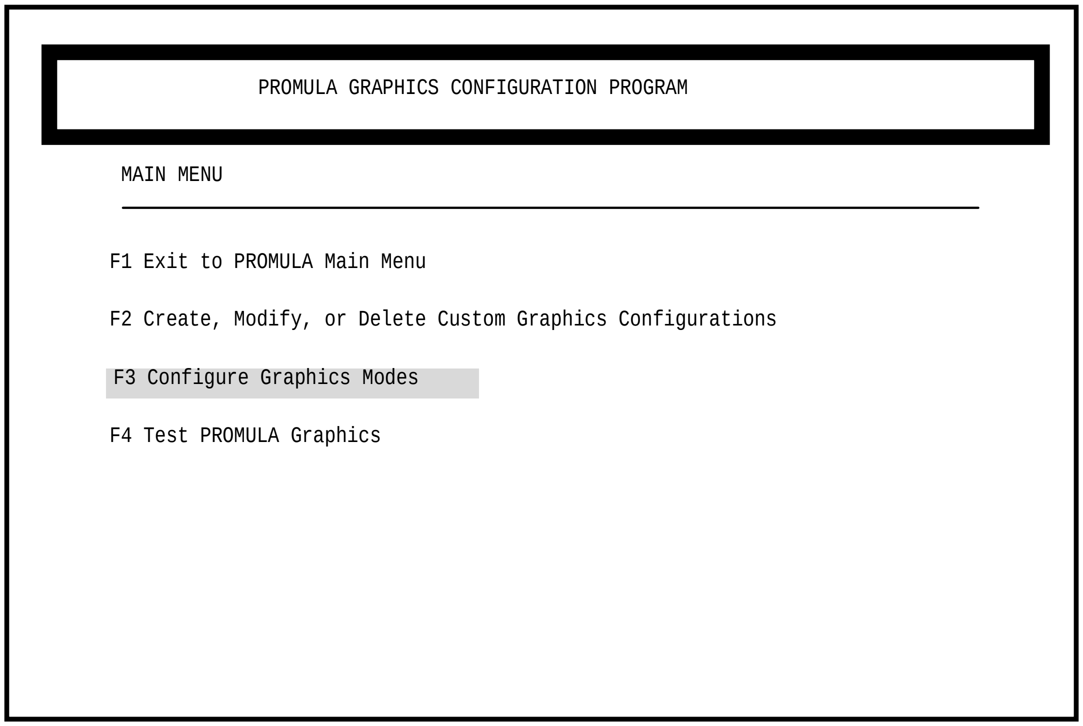
1. Selecting a graphics configuration to be used by one of PROMULA's graphics modes.
2. Managing custom graphics configurations.

5.1.1 Selecting Graphics Configurations

Configuring PROMULA's graphics is a simple two-step process. First, you select the graphics mode you wish to configure. Then you select the graphics configuration you want to assign to the selected mode.

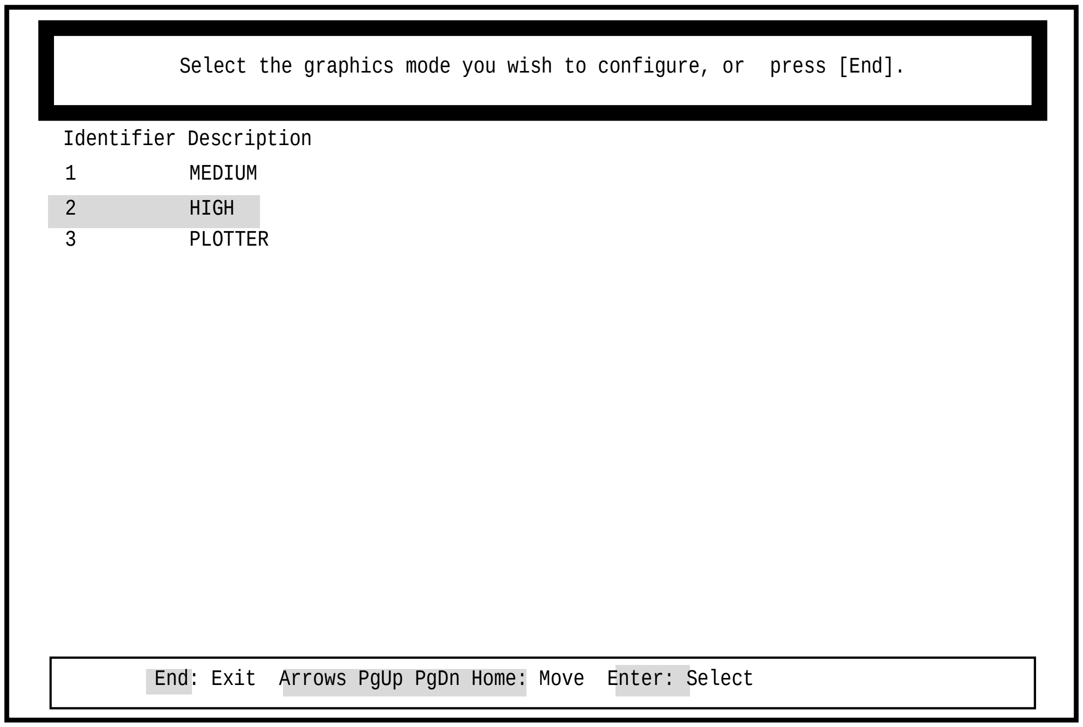
Although it is possible to assign any device to any graphics mode, only configurations supported by your hardware will perform properly. If you misconfigure PROMULA's graphics, it is likely that plots on screen or on the printer will not look right, or your computer may lock up when PROMULA tries to produce a plot. If either of these events occurs, first try pressing the **Esc** key; if that does not help, reboot your computer and reconfigure PROMULA's graphics for a device that is supported by your hardware.

The following screens illustrate this sequence of steps. First, you run the program **PCONFIG.XEQ**. The screen below shows the main menu of the graphics configuration program.



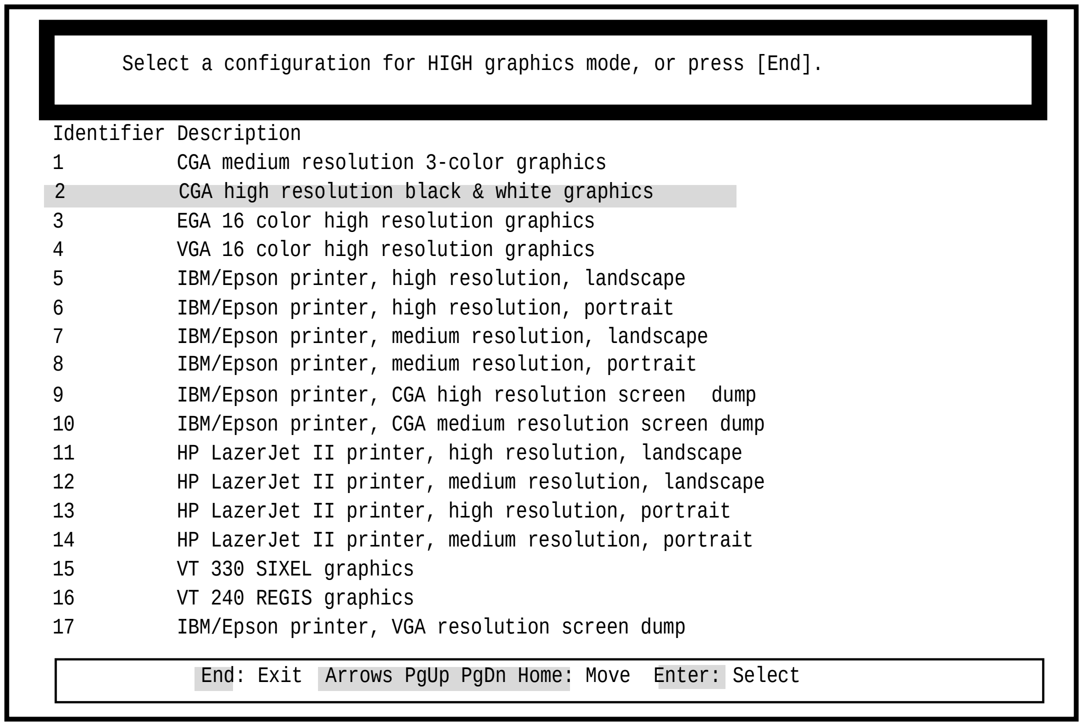
```
PROMULA GRAPHICS CONFIGURATION PROGRAM

MAIN MENU

F1 Exit to PROMULA Main Menu

F2 Create, Modify, or Delete Custom Graphics Configurations

F3 Configure Graphics Modes

F4 Test PROMULA Graphics
```

Choosing the third option off the main menu will bring up the graphics mode selection screen shown below. Use the arrow keys to highlight the graphics mode you wish to configure and press **Enter** to select it.



```
           Select the graphics mode you wish to configure, or  press [End].

Identifier Description
1          MEDIUM
2          HIGH
3          PLOTTER

        End: Exit  Arrows PgUp PgDn Home: Move  Enter: Select
```

After selecting a graphics mode to configure, the graphics configuration selection screen is displayed. Use the arrow keys to highlight the graphics configuration you want to assign to the selected graphics mode and press **Enter** to select it.



```
      Select a configuration for HIGH graphics mode, or press [End].

Identifier Description
1          CGA medium resolution 3-color graphics
2          CGA high resolution black & white graphics
3          EGA 16 color high resolution graphics
4          VGA 16 color high resolution graphics
5          IBM/Epson printer, high resolution, landscape
6          IBM/Epson printer, high resolution, portrait
7          IBM/Epson printer, medium resolution, landscape
8          IBM/Epson printer, medium resolution, portrait
9          IBM/Epson printer, CGA high resolution screen  dump
10         IBM/Epson printer, CGA medium resolution screen dump
11         HP LazerJet II printer, high resolution, landscape
12         HP LazerJet II printer, medium resolution, landscape
13         HP LazerJet II printer, high resolution, portrait
14         HP LazerJet II printer, medium resolution, portrait
15         VT 330 SIXEL graphics
16         VT 240 REGIS graphics
17         IBM/Epson printer, VGA resolution screen dump

             End: Exit  Arrows PgUp PgDn Home: Move  Enter: Select
```

After making these two selections, your new graphics configuration will be written permanently in the PROMULA configuration file, **PROMULA.PAK**, and you will be returned to the graphics configuration program main menu where you may exit the program and use PROMULA.

5.1.2 Managing Custom Graphics Configurations

You can use the graphics configuration program to create new graphics configurations that satisfy the requirements of your hardware and/or your preferences. Changing the line colors and patterns requires no technical knowledge, but changing plot sizes, especially for printers, requires detailed technical information about your printer's data transfer protocol.

Currently, the following items are used to define a PROMULA graphics configuration:

1. **Device Descriptor**

   This is a string of up to sixty characters that describes the configuration definition. It is used only for descriptive purposes, and its value does not affect the behavior of graphics in any way.

2. **Device type**

   This is a code describing the type of output device that will be used for plots.

   0 = video
   1 = raster-printer, e.g., HP LaserJet
   2 = vector-video, e.g., VT 240 Regis Graphics
   3 = raster-video, e.g., VT 330 Sixel Graphics
   4 = vector-printer, e.g., a Pen Plotter

3. **Horizontal text pixel width**

   This is the width in pixels of each character of horizontal text that may appear with a plot. Text on plots uses an internally defined fixed-width font.

4. **Horizontal text pixel height**

   This is the height in pixels of each character of horizontal text that may appear with a plot.

5. **Vertical text pixel width**

   This is the width in pixels of each character of vertical text that appears with the plot.

6. **Vertical text pixel height**

   This is the height in pixels of each character of vertical text that appears with the plot.

7. **Total width in pixels**

   This is the total width of the plot area in pixels.

8. **Total height in pixels**

   This is the total height of the plot area in pixels.

9. **Total width in standard units**

   This is the total width of the plot, including accompanying text, in standard units, typically inches.

10. **Total height in standard units**

This is the total height of the plot, including accompanying text, in standard units, typically inches.

11. **Border color code**

In LINE and VALUES plots, this is the color to be used for the border around the plot and all text displayed with the plot. In all other plot styles (i.e., PIE-CHARTS, MARKED-POINT PLOTS, and BAR PLOTS), the entire image will be drawn in this color.

12. **Line color codes**

These six values specify the colors to be used for the plotted curves in LINE and VALUES plots. The colors available depend on your hardware. The color codes used by PROMULA are listed below.

SIXTEEN-COLOR GRAPHICS CONFIGURATIONS.

```
  0 = BLACK       1 = BLUE          2 = GREEN         3 = CYAN
  4 = RED         5 = PURPLE        6 = YELLOW        7 = WHITE
  8 = GREY        9 = LT BLUE      10 = LT GREEN     11    =    LT
                                                     CYAN
 12 = LT RED     13 = LT PURPLE    14 = LT YELLOW    15    =    LT
                                                     WHITE
```

THREE-COLOR GRAPHICS CONFIGURATIONS.

```
1=CYAN          2=MAGENTA          3=WHITE
```

For monochrome monitors and printers the only valid color code is 1.

13. **Line patterns**

These six strings of twenty-character values specify the patterns to be used for the plotted curves in LINE and VALUES plots. The default line patterns are shown below:

```
SIXTEEN-COLOR        THREE-COLOR          MONOCHROME MONITORS
MONITORS             MONITORS             AND PRINTERS

XXXXXXXXXXXXXXXX     XXXXXXXXXXXXXXXX     XXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXX     XXXXXXXXXXXXXXXX     XXXXXXX
XXXXXXXXXXXXXXXX     XXXXXXXXXXXXXXXX     X X X X X X X X
XXXXXXXXXXXXXXXX     XXXX    XXXX         XXXX    XXXX
XXXXXXXXXXXXXXXX     XXXX    XXXX         XX  XX  XX  XX
XXXXXXXXXXXXXXXX     XXXX    XXXX         XXXX  X  XXXX  X
```

14. **Video BIOS type code**

This decimal number is used to tell PROMULA the appropriate settings to use for your graphics monitor. For example, the video BIOS type codes for PROMULA's four video configurations are listed below:

Configuration	Code
1. CGA medium resolution 3-color graphics	4
2. CGA high resolution black & white graphics	6
3. EGA 16 color high resolution graphics	16
4. VGA 16 color high resolution graphics	18

For additional information on the **Video BIOS type code** consult Milton, R. *Programmers Guide to PC and PS/2 Video Systems* Microsoft Press; Redmond, Washington (1987)

15. **Raster Orientation: 0=portrait, 1=landscape**

    For raster devices such as printers, this code specifies the orientation of the image.

16. **Raster bandwidth**
17. **Raster horizontal bit multiplier**
18. **Raster vertical bit multiplier**
19. **Raster initialization string**
20. **Raster start-of-line string**
21. **Raster end-of-line string**
22. **Raster end-of-plot string**

Items 16 through 22 are used to control raster devices (e.g., printers). See your printer manual for the values of these parameters.

23. **Vector Draw line string**
24. **Vector Write Horizontal Text String**
25. **Vector Write Vertical Text String**
26. **Vector draw Circle String**

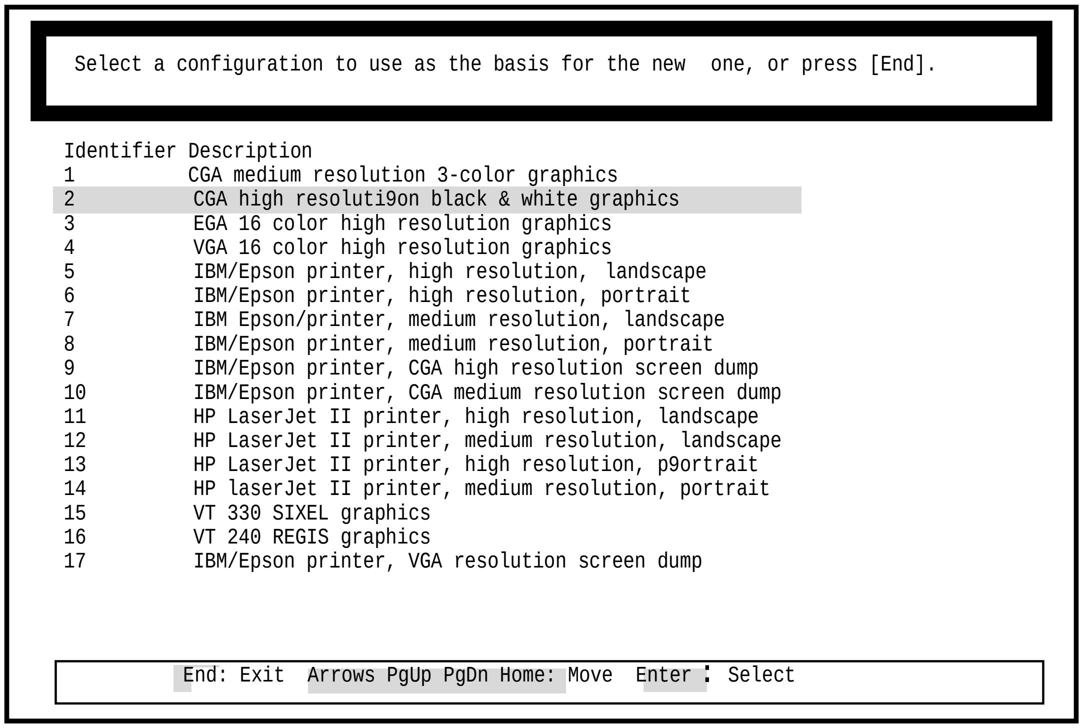
Items 23 through 26 are used to control vector devices (e.g., pen plotters). See your plotter manual for the values of these parameters.

After determining the values of the items to include in a custom graphics definition, you may use the graphics configuration program to create a configuration that matches these specifications.

First load the program and select option 2 off the main menu. This brings up the custom graphics management menu shown below.

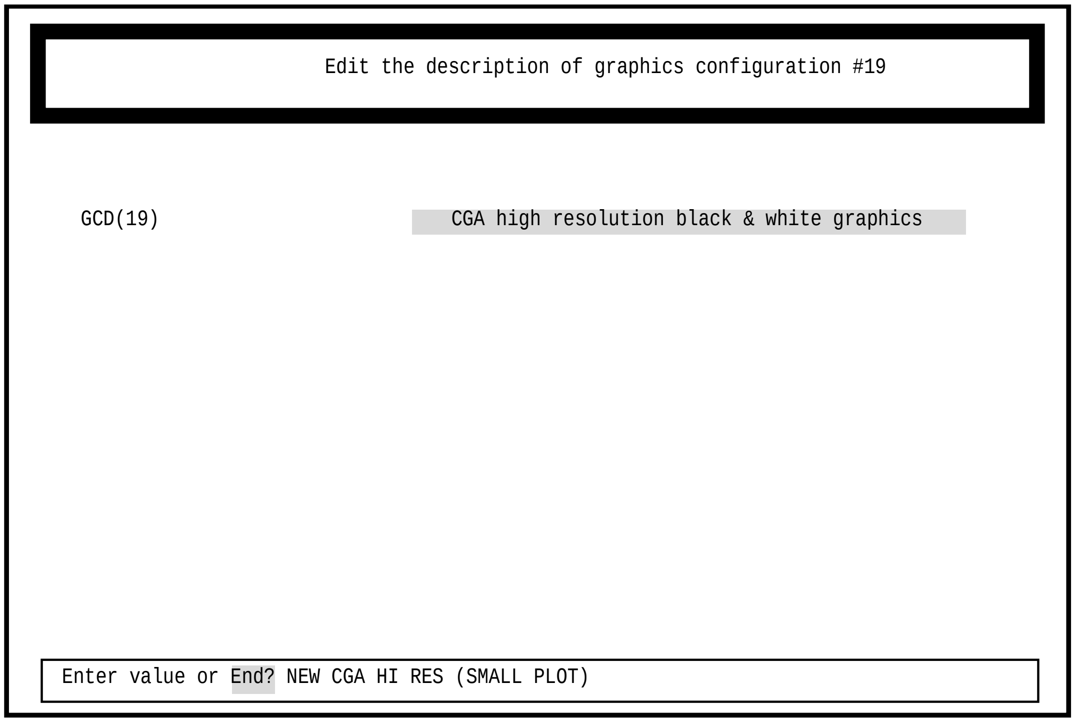
From this menu, you can create a new custom graphics configuration, or modify or delete an existing one. To create a new configuration, select option 2 from this menu. This will bring up the configuration selection screen.

Next, select a configuration to use as the basis for the new one.



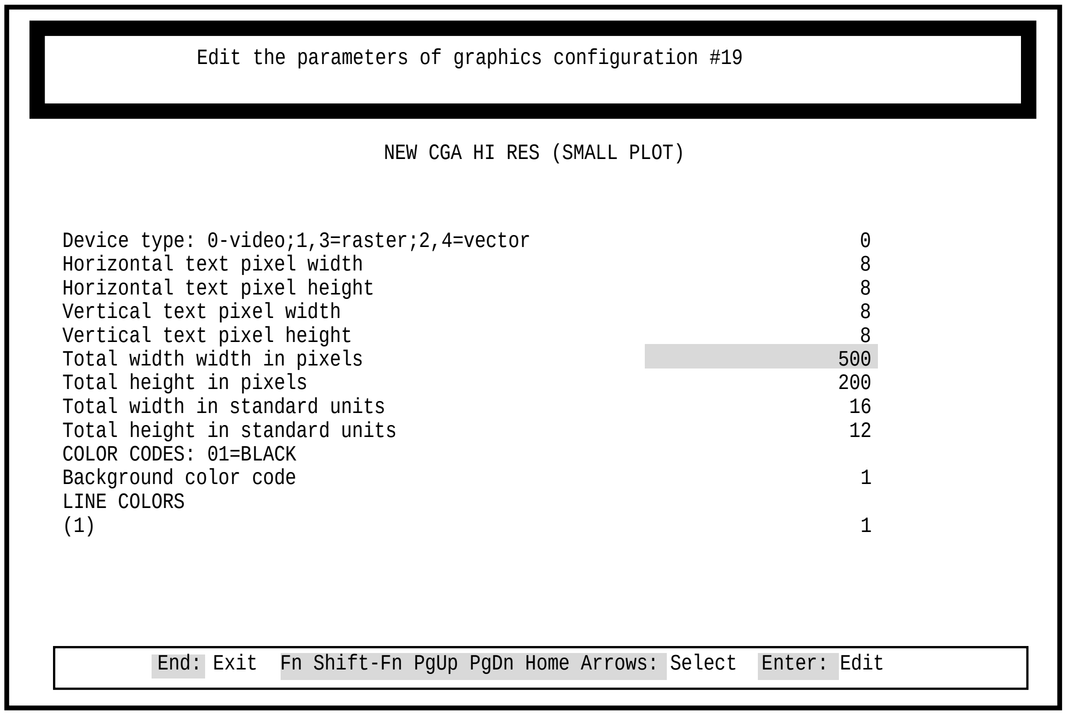
```
Select a configuration to use as the basis for the new  one, or press [End].

Identifier Description
1          CGA medium resolution 3-color graphics
2           CGA high resoluti9on black & white graphics
3           EGA 16 color high resolution graphics
4           VGA 16 color high resolution graphics
5           IBM/Epson printer, high resolution,  landscape
6           IBM/Epson printer, high resolution, portrait
7           IBM Epson/printer, medium resolution, landscape
8           IBM/Epson printer, medium resolution, portrait
9           IBM/Epson printer, CGA high resolution screen dump
10          IBM/Epson printer, CGA medium resolution screen dump
11          HP LaserJet II printer, high resolution, landscape
12          HP LaserJet II printer, medium resolution, landscape
13          HP LaserJet II printer, high resolution, p9ortrait
14          HP laserJet II printer, medium resolution, portrait
15          VT 330 SIXEL graphics
16          VT 240 REGIS graphics
17          IBM/Epson printer, VGA resolution screen dump

          End: Exit  Arrows PgUp PgDn Home: Move  Enter : Select
```

After selecting a template configuration, you can edit its descriptor to give it a unique name.



```
                         Edit the description of graphics configuration #19

GCD(19)                              CGA high resolution black & white graphics

Enter value or End? NEW CGA HI RES (SMALL PLOT)
```

Last, enter the parameters associated with the new configuration using PROMULA's interactive data editor on the screen below.

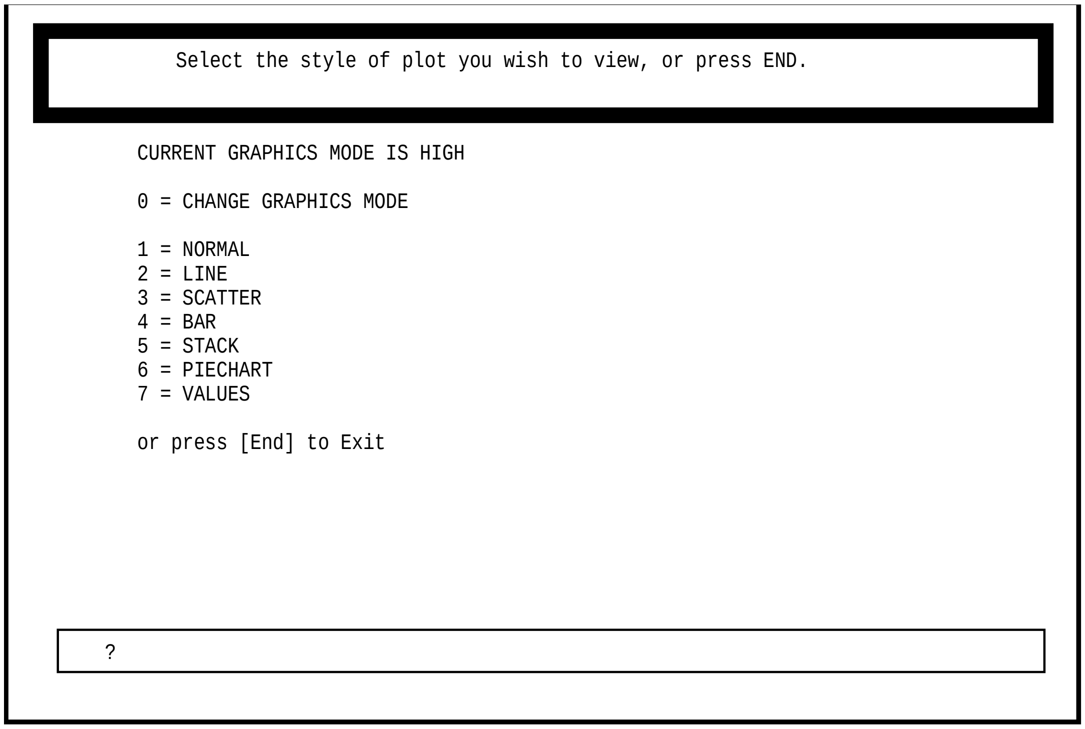


```
              Edit the parameters of graphics configuration #19

                           NEW CGA HI RES (SMALL PLOT)


   Device type: 0-video;1,3=raster;2,4=vector                          0
   Horizontal text pixel width                                         8
   Horizontal text pixel height                                        8
   Vertical text pixel width                                           8
   Vertical text pixel height                                          8
   Total width width in pixels                                       500
   Total height in pixels                                            200
   Total width in standard units                                      16
   Total height in standard units                                     12
   COLOR CODES: 01=BLACK
   Background color code                                               1
   LINE COLORS
   (1)                                                                 1



         End: Exit  Fn Shift-Fn PgUp PgDn Home Arrows: Select  Enter: Edit
```

The custom configuration management menu also offers the options of modifying or deleting existing custom graphics configurations. If you choose to modify an existing configuration, the list of existing custom graphics configurations will be displayed and you may select one for editing. If you choose to delete an existing configuration, the list of existing custom graphics configurations will be displayed and you may select one to be deleted.

5.1.3 Testing PROMULA Graphics

The graphics configuration program also offers the opportunity to test graphics configurations. Selecting the fourth option from the configuration program's main menu brings up the plot testing control screen. From this screen, you may change the graphics modes or generate the various types of PROMULA plots.



```
Select the style of plot you wish to view, or press END.

CURRENT GRAPHICS MODE IS HIGH

0 = CHANGE GRAPHICS MODE

1 = NORMAL
2 = LINE
3 = SCATTER
4 = BAR
5 = STACK
6 = PIECHART
7 = VALUES

or press [End] to Exit

?
```