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MOMS: MICHIGAN'S OWN MATHEMATICAL SYSTEM

Robert W. Taylor, Editor

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PREFACE

This report describes an interactive mathematical system with graphical input and output capabilities. The system was programmed during the winter of 1968 by the members of the advanced systems programming course, Computer and Communication Sciences 673, under the direction of Professors B. Arden, B. Galler, and L. Flanigan. It runs on an IBM 360/67 computer with 2250 display operating under MTS, the Michigan Terminal System.

Shortly after completion of the project, the 2250 display was removed from the Computing Center. This accounts both for the lack of photographs and the delay in publication.

The members of the class wish to thank the Department of Computer and Communication Sciences and the University of Michigan Computing Center for the support necessary to carry out this project.

Persons wishing further details should contact Professor Bernard Galler at the University of Michigan Computing Center.

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TABLE OF CONTENTS

Table of Contents, continued

1. INTRODUCTION

During the past several years, online mathematical analysis has received increasing interest [1,3]. These systems have been interpretive in nature, allowing a highly conversational approach to problem solving, and their usefulness in attacking complex mathematical problems has been demonstrated [2]. As stated in [1], these systems are generally characterized by a keyboard or pushbutton form of input and a graphical form of output. The output is sometimes also available in printed form. More significant is the fact that all systems allow a variety of data types, often including matrices, allowing a wide range of problems to be attacked. Finally, the languages employed by users of the systems are simple to learn but have a definitional facility which enhances flexibility.

During the 1968 winter term, the Computer and Communication Sciences 673 course, in order to understand more fully the internal workings of such a system, decided to build one of these systems as a class term-project. Michigan's Own Mathematical System—MOMS—is the result. It runs under the Michigan Terminal System, MTS, on an IBM 360/67, using an IBM model 2250 display console for both input and output. Because the project was to be completed in approximately fifteen weeks, it was necessary to restrict somewhat the allowable data types and certain other special

features. Nevertheless, a large variety of problems may still be attacked using MOMS.

2. HOW TO USE MOMS

A user at a 2250 console may use the MOMS system by issuing the MTS command

$RUN *MOMS

The MTS temporary file -MESSFILE will be created, and the user may examine this file to obtain a history of all error messages provided during his run.

When execution begins, the 2250 screen will appear as shown in Figure 1.1. Various words--the light buttons-- appear along the vertical edges of the screen. These light buttons define the various commands that the user may issue to the MOMS system, and are analogous to the "function keyboard" of various other systems [3]. At the bottom of the screen is the so-called Virtual Keyboard. This contains the buttons A through Z, which may be used to store data, as well as the predefined buttons 0 through 9, and various other commonly used system buttons. Just above the Virtual Keyboard is the Echo Line. A recent history of various light buttons that the user has pushed will appear here. The rest of the 2250 screen is used to display the results of computations, both in graphical and

alphanumeric form. Messages to the user are displayed in
the lower portion of this area.

```
              -1.0                          1.0
   SCREENA                                        DIMENSHN
   SCREENB                                        SETID
   SCREENC                                        DEFCONST
   ABS                                            BAKSPACE
   ARCCOS                                         DEQUEUE
   ARCSIN                                         LITNEXT
   ARCTAN                                         DEFBUTON
   ARCTAN2                                        DELBUTON
   COS                                            SKTPLTMD
   COSH                                           ID
   COTAN                                          PLOT1
   ERF                                            PLOT2
   ERFC                                           SCALE
   EXP                                            DISVALUE
   GAMMA                                          SCROLLUP
   LOG10                                          SCROLLDN
   LOGE                                           CLEAR
   LOGGAMMA                                         +
   SIN                                             -
   SINH                                            *
   SQRT                                            /
   TAN      -1.0                          1.0     **
   TANH
   DIFF                                           DEFMACRO
   DIFF2                                          ALPHA
   INTEG
   INTEG2


              MESSAGE:
                ECHO:   ID  ID  PLOT2


         A  B  C  D  E  F  G  H  I  J  K  L  M  N  O  P  Q

           R  S  T  U  V  W  X  Y  Z  +  -  *  /  **

                  0  1  2  3  4  5  6  7  8  9
```
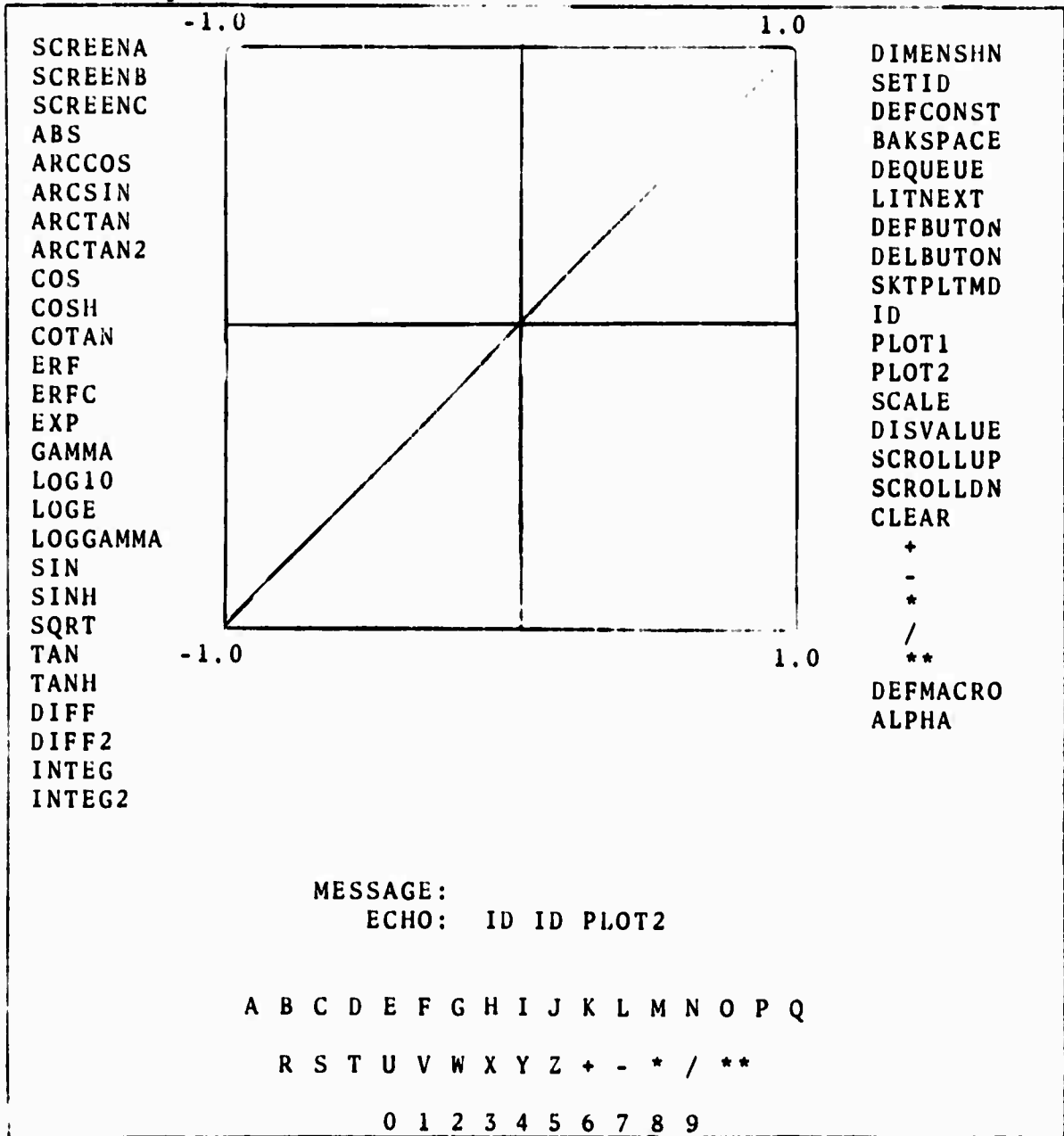
```
PROG.
FUNC.          2250 KEYBOARD
KBD.
```

Figure 1.1

The user makes input statements to the MOMS system by pointing at various light buttons with the light pen. A result of a pointing sequence will appear on the Echo Line. The syntax of the input statements is operator postfix notation. Nesting is allowed. Thus, for example,

$$A \ B \ +$$
$$A \ B \ C \ + \ +$$
$$B \ B \ * \ 4 \ A \ C \ * \ * \ - \ D \ =$$

will add A to B ; add A,B, and C ; compute B^2-4AC and store it under button D , respectively. The user may edit his input statement using system operators and eventually request interpretation of the statement and display of results, either in graphical or alphanumeric form. Various declarative and definitional capabilities are provided to enchance the flexibility of the system. These are discussed in detail in Section 2.2.

2.1 DATA TYPES IN MOMS

The current version of the MOMS system has four data types: scalars (real*4), vectors (real*4, dimension=101), vector-pairs (two vectors concatenated), and macros. Provision was made in the design of the system for complex scalars, complex vectors, and complex vector-pairs (as well as real*8 and integer modes), but they are not yet

legal data types. The dimension of 101 for vectors is a
default case and may be changed by the user using the
DIMENSHN button as in Section 2.2.1.

There are currently several restrictions concerning
the mode combinations acceptable to the various mathematical
and arithmetic operators. In general, the user will not
have to be concerned with mode incompatibilities, since
almost all commonly used mode combinations are acceptable.
However, should the default data types prove unacceptable
for certain problems, care should be taken or unacceptable
mode combinations will produce error messages.

The following facts summarize the default mode type
conditions for operands.

1. All defined constants are scalar, real*4.

2. Vector pairs may only be created by using a
   displayed graph as an operand.

3. Vector pairs are acceptable to any operator which
   accepts vectors. Only the "range" part of the vec-
   tor pair will be used. (This facility allows dis-
   played results to be used in further calculations,
   and has been found extremely useful.)

4. The arithmetic operators + , - , * , / , and
   ** take two arguments, of which either both are
   vector, real*4 (or vector—pair), or one only may
   be scalar—real or scalar—integer. The result of
   these operations will be vector real*4.

5. All other operators, except = , accept only
   vectors or vector-pair.

6. = will accept any mode combination. The following
   conventions are observed:

   a. vector substituted into vector: clear;
      the dimensions of the two vectors must agree.

   b. vector substituted into scalar: the first
      element of the vector is copied to the scalar.

   c. scalar copied into vector: produces a constant
      vector as the result.

   d. scalar substituted into scalar: clear.

2.2 THE PREDEFINED BUTTONS

A more systematic description of the system buttons
will now be given.

2.2.1 The Declaration Buttons

There are two major declarations which the
user should make immediately after execution begins, if
the default case is not acceptable. The first of these
concerns the dimension of the vector data type. The
default case for vectors is 101 entries. If the user
wishes to change this standard dimension, he should point
at the desired dimension (which may involve the definition
of the constant, see Section 2.2.3) and then point at the
DIMENSHN button. For example, the following sequence
sets the standard dimension to 201 entries:

DFCONST 2 0 1 DEFCONST DIMENSHN

The only predefined operand in the MOMS system is the
so-called ID vector. Stored under this button is the
useful vector which ranges from -1 to +1 in 100 steps
(i.e., 101 entries). If the user does not wish the
default case, he may change the ID vector by using the
SETID operator. This operation should be performed
before any other operation is undertaken, even before
changing of the standard dimension. The new definition
of the ID vector is made as follows:

        MIN   MAX   NUMBER OF ENTRIES   SETID .

Thus an ID vector from -1 to +1 with 200 steps (201
entries) would be established by the sequence
  DEFCONST - 1 DFCONST DEFCONST 1 DEFCONST DEFCONST
  2 0 1 DEFCONST SETID

2.2.2 Editing and Control Buttons

Editing of the input line is accomplished by
using the BAKSPACE button. This button will delete the
previous button pushed. Its effect is immediate. The user
may also erase all button pushes back to the last inter-
preted equal sign by pressing the DEQUEUE button. The user
is not allowed to use the BAKSPACE button or the DEQUEUE
button past the last interpreted = because interpretation
of that = will in general have changed data values.

-7-

In order that operator buttons may be used as data in special cases, the LITNEXT button is provided. Pushing this button causes the system to interpret the following button push as a data button unconditionally (See Sections 3.3 and 3.4 for examples.)

The START button may be invoked whenever the user wishes interpretation of its input sequence to start. Usually, however, the implicit starting of interpretation contained in the display operators (Section 2.2.4) will keep the use of this button to a minimum.

The RETURN button should be pointed at when the user wishes to terminate execution of MOMS and return to MTS. If for any reason he wishes to produce an error return to MTS, he may do so by depressing button Number 31 on the Programmed Function Keyboard of the 2250.

2.2.3 <u>Definition</u> <u>of</u> <u>New</u> <u>Buttons</u> <u>and</u> <u>Constants</u>

One uses the DEFCONST button to define a constant. For example, to define the constant 10.4 one would push

DEFCONST 1 0 . 4 DEFCONST

The user may define a new button using the DEFBUTON operation. For example, to define the button ALPHA, the user would push

DEFBUTON A L P H A DEFBUTON

Such a series of button pushes would cause the ALPHA button to appear in the vertical margin of the 2250.

Conversely, any user-defined button may be deleted using the DELBUTON button. Thus a user could press

ALPHA DELBUTON

to delete his button ALPHA. Only user-defined buttons may be deleted. If a user tries to delete a system button, for example A...Z , he will merely give it an undefined data type.

2.2.4 The Display Operators: PLOT1, PLOT2, SETPLTMD, SCALE, DISVALUE, SCROLLUP, SCROLDN.

A user may observe the results of a computation sequence defined by button pushes by using the various display operators. Graphical output may be in two forms. The first of these is a plot of the data on a coordinate grid. The second is a display of the numeric values of the data. Most often, a user will wish a plot of vector data types. The buttons PLOT1 and PLOT2 provide two means of obtaining such a display. PLOT1 plots the specified vector versus the system ID vector. This is the most common type of plotting. However, the button PLOT2 is available so that the user may plot two arbitrary vectors against each other. For example, suppose the user had pressed

$$ID \ ID \ * \ Y \ =$$
$$Y = X^2 \ , \ -1 < X \leq + 1$$

thus the function is stored under the Y button and the button pushes

Y PLOT1

and

Y ID PLOT2

will produce exactly the same result.

A user also has control over the scaling of the grid, and the mode of the grid lines. To set the scale of the grid, the user should press the four operands which are the coordinates of the lower-left and upper-right corners of the grid. He should then press the SCALE button. If no scale is specified by the user, the system will use the domain and range of the first plot to determine default scale values. If a subsequent plot falls outside of this scale, the user will be notified via the message line.

The SETPLTMD button controls the type of grids on which graphs are plotted. The default case is Linear-Linear, but the user may specify other types of plots using the statement

TYPENUMBER   SETPLTMD

The various options for TYPENUMBER are as follows:

Rectangular	0	Linear-Linear
	1	Linear-Log
	2	Log-Linear
	3	Log-Log
Polar	4	Angular-Linear
	5	Angular-Log

Thus for a Log-Log grid for his output, the user would make the statement

3   SETPLTMD

Normally, plots on a given screen (see Section 2.2.5) are cumulative. If a user wishes to have a replacement type of plotting, he may define a macro which first CLEARS the screen and then PLOTs the desired graph.

Numeric display of data may be obtained through use of the DISVALUE button. Thus, in our example, one might wish to determine how close to zero the approximation to X^2 is. Pointing at the buttons

Y DISVALUE

would display the first ten values of the vector Y . Since the vectors are usually 101 REAL*4 entries long, it is clear that we must examine more than the first ten locations to determine our answer. The SCROLLUP and SCROLLDN buttons are thus provided. By pointing at the numeric display and then pointing at the SCROLLUP button we successively scroll through the vector until we reach the desired entry. Up to three vectors may be displayed numerically on a single screen   (see below).

2.2.5 Screen Viewing Operators

The MOMS system provides the user with three "working areas." Only one of these can be viewed at any one time by the user. He may switch views by pointing at

the SCREENA, SCREENB, or SCREENC button. The three views
are independent of each other. Typically, therefore, a user
will display vectors, etc., as plots on one screen, then
change to another screen to examine numeric values, and
perhaps return to the first screen for further inspection.
Entities displayed on a screen may be selectively erased
by pointing at the displayed entity and then pointing at
the ERASE button. To erase all three screens the user
need point only at the CLEAR button.

3. THE MACRO PACKAGE

The ability to group together a collection of
"button pushes," and henceforth to treat that collection
as a single unit, is a facility which is vital in serious
computational problems. Other online mathematical analysis
systems have this facility in varying degrees [1], and it was
clear from the outset that the lack of such a facility in our
system would seriously limit its capabilities. Thus,
a definitional facility, called the Macro Processor,
was implemented. This package gives the user the ability
to define a string of button pushes and store this string
with an associated name. Certain button pushes in the
definition may be designated as formal parameters. When
the user points at the macro name, the definition will be
expanded with substitution of calling parameters in place
of the formal parameters. Thus, a true macro facility
exists in the MOMS system.

3.1 DEFINING A MACRO

A macro definition is a sequence of button pushes
delimited by the DEFMACRO button. The general form is:

$$\text{DEFMACRO NAME } (D_1 \ M_1 \ T_1 \ \ldots \ D_m \ M_m \ T_m \ ) \ B_1 \ B_2 \ \ldots$$
$$B_r \quad \text{DEFMACRO}$$

where NAME is the macro name, i.e., the button "under" which
the macro is to be stored; D_i is the i-th formal parameter
name; M_i is the (optional) mode of formal parameter D_i;
and T_i is the (optional) type of the formal parameter D_i .
B_i is the i-th button push for the macro body. The mode
of each formal parameter should be indicated by pointing at
one of the four light buttons SCALAR (default), VECTOR,
MACRO, OPERATOR; the type of each formal parameter should
be chosen from the light button set REAL (default), and
INTEGER. There may be at most 254 formal parameters within
a macro definition.

The following rules must be observed in defining
macros:

    a.   if m=0 , the form of the definition is DEFMACRO
         NAME (DUM) B_1 ... B_r DEFMACRO where DUM is used as
         place-holder but is never used in the macro body.

    b.   a macro definition must not appear within another
         macro definition.

    c.   a macro may call upon another macro, but it may
         not call upon itself (either directly of indirectly).

3.2 DELETING A MACRO

To delete a macro, press

NAME DELBUTON

where NAME is the name of the macro to be deleted.

3.3 CALLING A MACRO

A macro call can be one of the following forms:

$$(C_1 \; C_2 \; \ldots \; C_v) \; \text{NAME}$$
$$C_1 \; C_2 \; \ldots \; C_n \quad \text{NAME}$$

where NAME is the name of the macro being called, C_i is
the i-th calling parameter, n is the number of formal para-
meters for NAME, and $v \leqslant m$. The second form may be used
only when the number of calling parameters equals the
number of formal parameters. The first form allows for
a variable number of calling parameters (v) . If a macro
has no formal parameters, then it may be called by pressing
the button NAME.   This should be distinguished from
the case where no calling parameters are supplied, but
formal parameters do exist in the macro definition. The
following form should be used in the latter case:

( ) NAME

The following rules should be observed:

a.   The number of calling parameters should not exceed
     the number of formal parameters. If this happens,

-14-

the extras are ignored and a warning message is displayed.

b. The number of calling parameters may be less than the number of formal parameters only if the undefined formal values were given actual values by a previous call. If this is not the case and such a call occurs, a fatal error will result.

c. Nesting of macro calls is allowed to a maximum level of 500. If this limit is exceeded, a fatal error occurs.

d. If a call upon a macro involved another macro or operator name as a calling parameter, the LITNEXT button must immediately precede that parameter. For example, if MAC is a macro name, a call upon another macro MAK with MAC as a calling parameter might look like:

        (TI LITNEXT MAC ALPHA) MAK

The corresponding dummy parameter for MAC would have been given mode MACRO when MAK was defined.

3.4 DISPLAYING A MACRO

A macro definition may be displayed in the working area of the screen by the button sequence

        LITNEXT NAME DISVALUE

where NAME is the button under which the macro definition

is stored. The macro definition will appear on the screen
at a fixed position, and the formal parameters of the de-
finition will appear within parentheses. However, the
declared mode and type of the formal parameters are not
displayed. Once on the screen, the display of the macro
is treated as any other displayed entity and may be ERASEed
and CLEARed in the normal fashion. Up to three macros may
be displayed at one time, one on each of the three screens.

3.5 EXAMPLES

The following are permissible definitions of macros:

            DEFMACRQ A (D VECTOR INTEGER E SCALAR REAL)

                     D E = DEFMACRO

            DEFMACRO DEFBUTON A L P H A DEFBUTON ALPHA

                     (D E) D E = DEFMACRO

                     default modes and types for formal

                     parameters

            DEFMACRO QED (DUMY) DEFCONST 3 . 1

                     4 DEFCONST ARDVARK = DEFMACRO

                     no formal parameters in the definition

            DEFMACRO F (M N MACRO O OPERATOR)

                     M LITNEXT N O DEFMACRO

                     illustrates a call upon a macro definition

            DEFMACRO SUM (M MACRO N MACRO)

                      LITNEXT M LITNEXT M N DEFMACRO

                     The following would be an illegal call,

                     since it generates an infinite nesting

of the macro SUM.

(LITNEXT SUM LITNEXT SUM) SUM

4.   THE MATHEMATICAL OPERATORS

Various standard mathematical operations are
provided in the MOMS system. These include the standard
arithmetic operations of +, -, *, /, **, and = , where
** is the exponentiation operator. In addition, those parts
of the FORTRAN function library which accept REAL*4 argu-
ments have been included, as well as facilities for integra-
tion and differentation. It is believed that these predefined
operators will from a useful base from which more complicated
operations may be constructed using the macro facility in
MOMS.

4.1   THE ARITHMETIC OPERATORS

The arithmetic operators include those standard
operations enumerated above. They will operate on all mode
combinations (scalars, vectors, vector-pairs) and all type
combinations (integer, real*4). User statements must, of
course, be in the operator postfix notation, described
in Section 2. The following table shows the equivalence
between a FORTRAN-like notation and operator postfix notation:

FORTRAN	OPERATOR POSTFIX
A + B	A B +
A - B	A B -
A * B	A B *
A ** B	A B **

```
A / B                A B /

B = A                A B =
```

4.2   THE FORTRAN LIBRARY SUBPROGRAM OPERATORS

Table 4.1 lists those entries from the FORTRAN
function library which were adapted for the MOMS system.
Note, that when the argument type is listed as Real*4, the
mode of the argument may be either scalar, vector, or
vector-pair. If the mode is vector, the appropriate
function will be applied to each entry in the vector.
If the mode is vector-pair, the so-called "range" part
of the vector-pair will be treated as if it were a vector,
and the rest of the vector-pair will be ignored.

In general, an illegal argument to one of these
functions will cause a value of zero to be returned.
Thus, for example, X/0=0.

NAME	DEFINITION	ASSIGNMENTS		FUNCTION VALUE TYPE
		Number	Type	
ABS	$\lvert x \rvert$	1	real*4	real*4
ARCCOS	$\cos^{-1}(x)$	1	real*4	real*4
ARCSIN	$\sin^{-1}(x)$	1	real*4	real*4
ARCTAN	$\tan^{-1}(x)$	1	real*4	real*4
ARCTAN2	$\tan^{-1}\left(\dfrac{x_1}{x_2}\right)$	2	real*4	real*4
COS	$\cos(x)$	1	real*4	real*4
COSH	$\dfrac{e^x + e^{-x}}{2}$	1	real*4	real*4
COTAN	$\cotan(x)$	1	real*4	real*4
ERF	$\dfrac{2}{\sqrt{\pi}} \int_0^x e^{-u^2} du$	1	real*4	real*4
ERFC	$1 - ERF(X)$	1	real*4	real*4
EXP	e^x	1	real*4	real*4
GAMMA	$\int_0^{\infty} u^{x-1} e^{-u} du$	1	real*4	real*4
LOG 10	$\log_{10} x$	1	real*4	real*4
LOGE	$\log_e x$	1	real*4	real*4
LOGGAMMA	$\log_e \int_0^{\infty} u^{x-1} e^{-u} du$	1	real*4	real*4
SIN	$\sin(x)$	1	real*4	real*4
SINH	$\dfrac{e^x - e^x}{2}$	1	real*4	real*4
SQRT	$+\sqrt{x}$	1	real*4	real*4
TAN	$\tan(x)$	1	real*4	real*4
TANH	$\dfrac{e^x - e^{-x}}{e^x + e^{-x}}$	1	real*4	real*4

Table 4.1   FORTRAN Function Library Entries Adapted for MOMS

4.3 THE INTEGRATION AND DIFFERENTIATION OPERATORS

Four operators are provided for various cases of integration and differentiation. The light buttons INTEG and DIFF integrate and differentiate the one vector argument versus the standard domain, that is versus the ID vector. INTEG2 and DIFF2 use an explicitly provided domain, which is the second argument to the function. Both differentiation operators use the divided difference method to approximate the derivative. No attempt at smoothing is made; the last element of a vector is set equal to the second last element. INTEG uses trapezoidal integration to approximate the integral.

4.4 ADDITIONAL EXAMPLES

X Y ARCTAN2

In this function, the X argument is taken to be the abscissa, and the Y argument is taken to be the ordinate.

D V DIFF2

D V INTEG2

V is the vector (or vector-pair) being differentiated (integrated) versus the domain D.

5. A DETAILED EXAMPLE

Consider the problem of approximating $y(\Theta) = \sin(\Theta)$, $-\frac{\pi}{2} \leq \Theta \leq \frac{\pi}{2}$, with an nth degree polynomial $P_n(x)$ written in

terms of Chebyshev polynomials, i.e.,

$$P_n(x) = a_0 + a_1 T_1(x) + \ldots + a_n T_n(x).$$

In the interval (-1,1) the coefficients can be expressed by

$$a_0 = \frac{1}{\pi} \int_{-1}^{1} \frac{y(x)}{1-x^2} \, dx$$

$$\vdots$$

$$a_i = \frac{2}{\pi} \int_{-1}^{1} \frac{y(x) T_i(x) \, dx}{1-x^2}$$

and the Chebyshev polynomials are recursively defined by

$$T_0(x) = 1$$

$$T_1(x) = x$$

$$\vdots$$

$$T_{i+1}(x) = 2x T_i(x) - T_{i-1}(x)$$

The problem is to construct a sequence of error fucntions
$g_i(x) = y(x) - P_i(x)$ until a $g_i(x)$ is found which satisfies
a predetermined maximum error criterion. A sample solution
with comments follows.

Button Pushes	Comments
DEFBUTON N E X T T E R M DEFBUTON	Define a button called NEXTTERM
DEFBUTON P I DEFBUTON	and a button called PI
DEFMACRO NEXTTERM (X)	Define a macro NEXTTERM

Button Pushes	Comments
2 ID U * * V - T =	with 1 formal parameter (not used) which computes the next term in the approximation and adds it to the polynomial which is stored under button P.
U V =	
T U =	
Y D * INTEG PI *	
T * P + P = DEFMACRO	

T_i from above is stored under button U. T_{i-1} is stored under button V. The macro also updates these values when T_{i-1} is computed.

DEFMACRO DEFBUTON D I F F	Define a macro to compute the next term and take the difference between Y and the polynomial.
DEFBUTON DIFF (X)	
NEXTTERM Y P -	
DEFMACRO	
DEFCONST 3 . 1 4 1 5 9 DEFCONST	
B = 2 B / PI =	Store $\frac{2}{\pi}$ under button PI
1 PI / ID * SIN Y =	Construct vector Y=sin Θ, $-\frac{\pi}{2} \le \Theta \le \frac{\pi}{2}$ let up T_0 in V set up T_2 in U.
1 V =	
ID U =	
1 ID * - SQRT A =	Compute $\dfrac{y(x)}{1-x^2}$
Y A / D =	

where $-1 \le x \le 1$ and store under D.

Button Pushes	Comments
D INTEG PI 2 / * P =	Compute a_0 and store under P
D U * INTEG PI * U * P + P =	Compute a_1T_1 and add to P; store under P.
DIFF PLOT1 . . .	Compute successive approximations and display error function.
DIFF PLOT1	

Note that this would display an
approximation to any function
stored under the button Y.

6. DESIGN CONSIDERATIONS

MOMS runs under the MTS system, which in turn is under
the control of the UMMPS (University of Michigan Multi-
programming System) supervisor. From the outset, it was
decided that this total dependence on system I/O support
was the only reasonable way to proceed, since bugs in the
MOMS system could not be allowed to disrupt other users.
Moreover, the time and effort necessary to write the low-
level I/O code would have made the project difficult to
complete in one semester. However, idiosyncrasies of the
IBM 2250 display made some special adjustments necessary.
Specifically, it was necessary to process attention inter-
rupts from the 2250 in something approximating real-time,

in order to keep the screen lit and capable of accepting button pushes. (An attention interrupt is caused by a light pen, or by pushing a function keyboard button; in the former case, the display stops.)

Since the IBM Graphics package GRAPHLIB, described in IBM Document No. C27-6909 was available in MTS, it was decided to use the routines with slight modifications by Computing Center staff programmers. The routine ANALS, which previously polled for an attention interrupt, was changed to call a user-specified subroutine in "real-time" when an attention interrupt arrived. The display would be restarted and the user task resumed when the subroutine returned. It should be stated that

a. the user-specified subroutine and any subroutine it called had to be written to handle recursive calls, or had to be mutually exclusive from any code which could possibly be executing at the time of the attention interrupt.

b. "Real-Time" does not mean at the time of the actual attention interrupt, while all other tasks in the system are stopped. Instead, the interrupt causes the status of the task running MOMS to be saved, and that task is initial-ized to run the attention interrupt "real-time" routine. When the attention routine returns, the original status of the task is restored, and it continues. This can be thought of as a push-pop situation where the status of the task is saved on a push-down stack, and the interrupt is transparent

to it, except for any desired effect of the interrupt routine, such as building queues or setting status bits.

7. THE HIERARCHY OF THE SYSTEM

The 2250 display hardware is controlled by the 2840 display controller through standard I/O operations. Thus, via channel control word commands it is possible to

    a.   write the display buffer,

    b.   read the display buffer,

    c.   read information such as function button pushed, and coordinates of a light-pen detect,

    d.   control display starting location, etc.

The supervisor, UMMPS, is ultimately in charge of all operations concerning I/O devices. For example, I/O devices are allocated to tasks by the supervisor, I/O devices are "started" by a supervisor call whose operands resemble the start I/O operation, and asynchronous attention interrupts from a device are fielded by the supervisor, which either ignores them, or passes them to a "real-time" attention routine designated by the user.

MTS provides system subroutines which interface with the supervisor, and

    a.   acquire devices from the supervisor when requested by a program or command, and to release devices acquired by a user when he is finished with them, or when he signs off.

b. provide a general interface to the appropriate
    device support routine which can operate the
    device as a standard terminal.

GRAPHLlB is an lBM package for controlling the 2250.
lt has been modified to run under MTS.

a. lt contains subroutines for generating 2250
    order programs to display graphs, functions, etc.,

b. lt contains subroutines to perform 1/0 operations
    on the display. lt does this via supervisor calls.

c. It contains a subroutine to handle attention exits.
    This has been modified to call user-specified sub-
    routines in "real time."

The MOMS code may therefore be considered as being
devided into two sections. Part of MOMS consists of code
for interfacing with GRAPHLIB; the other part of MOMS is
completely independent of the 2250. The code which inter-
faces with GRAPHLIB does the following:

a. Allocates space within the 2250 buffer,

b. Uses GRAPHLIB to build order programs, which are
    subsequently displayed.

c. Uses GRAPHLIB to write the order programs to the
    allocated space in the 2250 buffer.

d. Uses GRAPHLIB to start the display.

e. Uses GRAPHLlB to call a subroutine which builds
    the queue of button pushes in real time.

8. THE INTERNAL ORGANIZATION OF MOMS

This section contains detailed documentation concerning the various parts of the MOMS system. In general, it will not be of interest to the MOMS user, but is included for completeness and future reference.

The major subparts of the MOMS system are as follows: initialization, interpretation, 2250 buffer management, light pen management, function display, numeric and keyboard display, the macro processor, symbol table management, the mathematical operators, and numeric conversion. The major connections between the various subparts are shown in Figure 8.1.

MTS enters the MOMS system at the initializer. This in turn calls other parts of the system in order that they might initialize themselves. The major portion of all initialization consists of building the system entries in the symbol table and the corresponding display representation of the system operations in the 2250 buffer. Clearly, each section must access the symbol table during this time. In fact, the symbol table, which may be considered the ultimate store of knowledge in the system, is accessed constantly by all sections, although this is not shown in Figure 8.1. When initialization is complete and the initial 2250 image is displayed on the screen, control is transferred to the interpreter, which retains ultimate control throughout the remaining execution. When a user points at
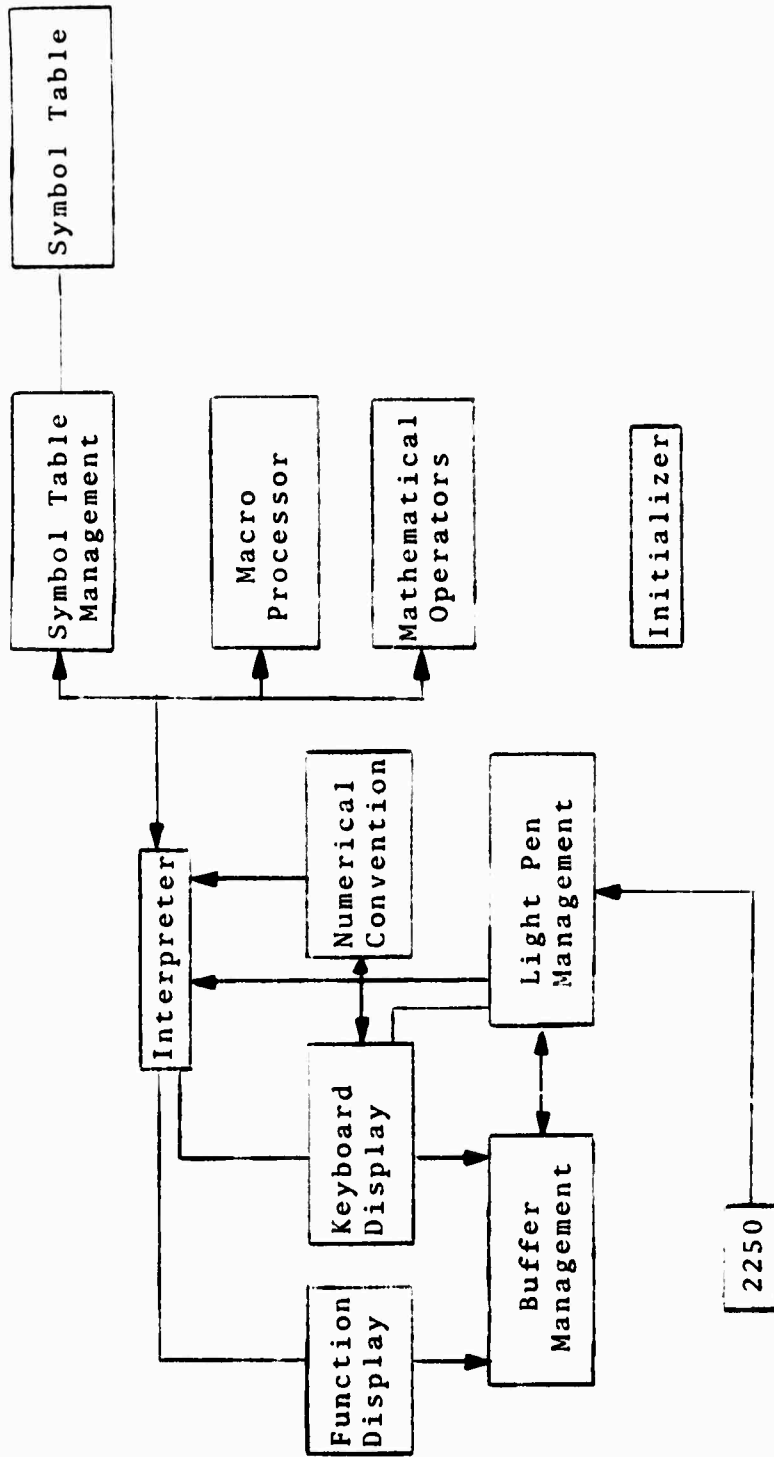
Figure 8.1 Major Connections between Subparts of MOMS.

a "light-button," the corresponding interrupt is fielded
by the light pen management routines. They determine which
light button was pointed at and communicate this fact both
to the keyboard display section, so that it may be displayed
on the echo line, and also to the interpreter. The inter-
preter handles all editing and definitional operations,
except macros. It records the various button pushes in a
queue, also called the stack. When a button push requiring
the start of interpretation is encountered, the interpreter
starts calling the various operators in this queue, collap-
sing the stack where appropriate. The system ultimately
returns to the idling state when all interpretation is
complete. The function of the various other parts may be
briefly summarized as follows:

a. function display is responsible for constructing
2250 graphic order programs from the various vectors and
vector-pairs supplied it. It is also responsible for hand-
ling the plotting mode and scaling operators for the grid.

b. keyboard display constructs 2250 graphic order
programs which contain alphanumeric and other character
information only. Thus it is responsible for the 2250
graphic order programs of all light buttons, the display
of all numeric values, the upkeep of the echo line, the
output of messages, and the display of macros.

c. the 2250 buffer management section is responsible

for actually writing the 2250 buffer and linking graphic order programs into the display regeneration loop. It also keeps track of the SCREENA, SCREENB, and SCREENC operations.

d. symbol table management controls all accesses and all editing of the symbol table.

e. the macro processor is responsible for the storage of all macro definitions and interacts closely with the interpreter when a stored macro is called.

f. the mathematical operators section and the numerical conversion section are self-explanatory.

8.1   INITIALIZATION   R.W. Taylor

Name: STINIT

Purpose: To initialize MOMS

Calling Sequence: OS(I) R type

Entry: No parameters

Return: Calls ERROR indicating a system error
                   if the Interpreter ever returns control
                   to it.

Functional Description:

The initialization section serves as the principal subroutine with respect to MTS.

1. Call initialization sections of

    Symbol Table Management   SYMINIT1

    Buffer Management   BUFINIT1

    Interpreter   INTINIT

Light Pen Management   LPMINIT

Function Display   FDINIT

Macro Processor   MACROFIX

in the above order (STLOOP1)

2. Use the SYMODEFS macro to put the buttons SCALAR, VECTOR, REAL, INTEGER onto the screen.

3. Enter A...Z,.,(,) into the symbol table with default parameters (see Section 8.3, Symbol Table Management Routines) and save their STEPS* in a list to be passed to the display virtual keyboard routine (STSYMLP)

4. Create the symbols +, -, *, /, = and save their STEPS for display on the virtual keyboard. (The actual operators +; -, *, /, = are initialized into the symbol table by U1N1T using the SYMODEFS macro.) (STSYMLP2)

5. Create the symbol table entries 0...9 and give them the attributes OPERAND, SCALAR, REAL, SYSTEM, CONSTANT (STSYMLP1)

6. Move the real values 0...9 into the appropriate place in the symbol table (that place pointed to by the VALUE pointer)

7. Call UINIT to define the mathematical operators and put them on the screen.

(Note: UINIT is called near the end so that

*STEPS = Symbol Table Entry Pointers

the mathematical operators will be at the
bottom of the function button list.)

8. Call BUFINIT2

    Buffer Management has two entries so that light
    pen interrupts will not be accepted until
    initialization is complete.

9. Transfer control to the Interpreter.

8.2 THE INTERPRETER   R. Srodawa, K. Moore, and J. Tripp

The Interpreter within the MOMS system is broken physi-
cally and logically into six sections, each of which is de-
scribed briefly below:

Initialization

The initialization section of the interpreter is broken
into two ports. The first port is called during the initial-
ization of MOMS at the entry point INTINIT. It presets the
global dimension to 1Q1, the global mode to VECTOR, REAL*4,
and creates and presets symbol table entries for the buttons
DIMENSHN, ID, LITNEXT, BAKSPACE, DEFCONST, DEFBUTON, DEFMACRO,
SETID, DELBUTON, DEQUEUE, and START. The second port of
initialization is called at the entry point INTERP when all
of MOMS has been initialized. This section initializes the
three stacks kept within the interpreter (STACK, MSTACK,
and BUTQ) and then transfers to the section of the inter-
preter which interprets button pushes (the Button Queue
Processor).

Interpretable Operators

The interpretable operators section of the inter-
preter contains the operator definitions for several of
the buttons.

START   The START operator is an immediate operator
           which requires no operands and returns no
           results.   Its only effect is to cause inter-
           pretation of the contents of the button queue
           to begin.   Normally interpretation begins only
           when a button is pushed whose interpretation
           causes new information to be displayed.   START
           is normally used to start interpretation because
           macros have been invoked which contain buttons
           that change the display.

SETID   The SETID operator is used to specify the standard
           domain.   It computes new values for the scalar
           button DIMENSHN and the vector button ID.   The
           SETID operator must be the first operator to
           ever be interpreted.

RETURN   The RETURN operator simply returns to MTS.   It
           is the standard exit from MOMS back into MTS.

DELBUTON   The DELBUTON operator accepts one operand and
           causes something to be deleted for it.   If the
           operand currently has something displayed (a
           macro definition, graph, numeric value), that

is erased.   Otherwise, if the operand currently
has a macro definition, that is deleted. Other-
wise, the button name is deleted from the screen
and its STE removed, unless it is a system symbol,
in which case the STE is changed back to undefined
status.   These deletions are performed by calling
the subroutine appropriate for deleting the type
of display represented by the operand (DSPDELNM
for a button name, DSPERSPR for a macro definition
display, DSPERSEV for a numeric vector display,
FDERASE for a graph, and MACDELET for a macro de-
finition).   These routines are each called for
the operand until one of them succeeds in removing
it.   The order of the calls is determined by the
mode and structure of the operand, and is such
that appropriate display deletes are attempted
before the macro definition or button name is
deleted.

DEQUEUE   The DEQUEUE operator clears the three interpreter
              queues   (BUTQ, STACK, and MSTACK) so that all
              past interpretive history, except items which
              have been stored in symbol tables entries , is
              forgotten.

Operator Call Processor

The operator call processor is called at the entry point INTKIP by the stack manipulation section of the interpreter. The operator call processor then searches for the appropriate definition of the operator, depending upon the modes of the operands, builds a parameter list for the operator, calls the operator definition, reduces the operand stack by the number of operands used, releases any temporaries that were used, and returns a result to the stack. The operator call processor is the interface between the operator definitions and the interpreter.

SYMOPDEF Subroutine

The SYMOPDEF subroutine is called by every occurrence of the SYMODEFS and SYMODEFD macros. This subroutine creates a new symbol table entry or instance for the new operator definition.

Button Queue Processor

This processor is called at the end of initialization by port two of the interpreter initialization. It processes the buttons which have been pressed by the operator and interprets the BAKSPACE, DEFCONST, DEFBUTON, and DEFMACRO buttons. Usually the symbol table entry pointer for a button is simply placed on the button queue (BUTQ). Whenever a button which requires immediate interpretation (DISPLAY, START, etc.) is encountered the stack manipulation section of the interpreter is called to interpret

all the button pushes since the last interpretation. The
BAKSPACE, DEFCONST, DEFBUTON, and DEFMACRO buttons require
more involved processing.

Stack Manipulation Processor

The stack manipulation processor is called at its
entry point, INTJOIN, whenever the button queue processor
receives a button which forces interpretation. The stack
manipulation processor processes the STEPs from the button
queue (BUTQ) and maintains the two stacks STACK and MSTACK.
It calls the operator call processor every time it processes
a button which is an operator or macro. The stack manipu-
lation processor also obtains the buttons comprising a macro
definition from the macro interpretation when appropriate.

8.2.1 Operator Call and External Specifications

This part of the documentation describes the function
of the operator call part of the interpreter in just enough
detail to allow those writing operators to set up appro-
priately the operator symbol table entry and know what to
expect (and what is expected of them) when the operator is
actually called.

The document is in three parts: the first indicates
what information may be passed to operators if requested;
the second gives something about the structure of operator
symbol table entries; and the third describes two macros
useful for putting operators into the symbol table.

*What Can Be Passed To Operators

Operators are called with a standard OS type I(S) calling sequence. If the operator wishes to return something to the stack, it can return only a single thing (which may be an operand or an operator), and it is expected to leave the STEP for that operand in GR0 on return. The parameter list for an operator may contain several different things, depending on the operator symbol table entry, including all or some of the following:

(1) A fixed, or variable, number of stack operands. These are always passed as a pair of parameters, one being the STEP, and the other being the VALUE (from the STE).

(2) Any fixed number of temporaries needed by this operator. These are passed as pairs of parameters, as in (1), and may be of any specified mode and structure, as needed by the operator. Temporaries are given the global dimension if they are vectors.

(3) The number of stack operands passed. Obviously of use only to operators which accept a variable number of operands, it is passed as a 4-byte integer.

(4) The standard dimension. This too is passed, if requested, as a 4-byte integer.

(5) The standard domain, or ID vector. This will always be passed as a REAL*4 vector if requested, and is passed as a pair of parameters as in (1) and (2).

(6) The operator STEP. This is passed directly in the
     parameter list (i.e., the STEP is in the list itself.)

     As mentioned above, what subset of the above is passed
to the operator, and in what order, depends on the STE for
the operators whose description follows.

*What Operator Symbol Table Entries Look Like

     An operator symbol table entry is really a rather
empty (or at least devoid of much information) STE, coupled
with a string of dope vectors, each of which describes an
instance of the operator. 'Instances' of operators are differ-
ent versions of the operator for operating on different kinds
of operands. For instance, one version of the COS operator
might operate on vectors, and another might operate on
vector pairs. Each version would be described by a dope
vector linked to the STE for the COS operator.

     Some parts of the operator symbol table entry are
relevant to the operator; these are given below.
The symbol table entry itself (the relevant parts):

(1) Name - gives 8-character name of this operator, as
     displayed on the screen.

(2) Dope Vector Pointer - points to first link in chain
     of dope vectors which describe instances of this oper-
     ator.

(3) Display Buffer ID - gives the buffer ID for the oper-
     ator (i.e., where it is displayed on the screen).

(4) Symbol Class - Will indicate macro or operator, depending on which it is (macros are treated nearly like operators by this section of the interpreter).

The rest of the STE for an operator is not used by anyone for anything of interest, so far as we know.

The dope vector contains all sorts of good information about this instance of the operator. Part of this information is fixed (in location within the dope vector), and that is given below. Figure 8.2.1 shows where and how this information appears in the dope vector.

(1) A full-word link to the next dope vector (if there is one, otherwise it is =0).

(2) Address of the routine which 'is' this instance of the operator (i.e., subroutine address).

(3) Flags indicating (A) if the operator returns a result, and (B) if the operator will accept a variable number of operands.

(4) The length of the dope vector, in words (as a half-word).

(5) A flag indicating if this operator is special, meaning it must be either interpreted immediately or changes a symbol table entry. (Which of these is the case is also indicated if the operator is really special.)

The skeleton part of the dope vector, which follows the fixed information described above, is used to specify

Figure 8.2.1   Form of Parameter Vector for Macro: SYMODEFD

```
0   ┌─────────────────────────────────────────────────┐
    │                                                 │
    │         LENGTH OF PARAMETER VECTOR,             │
    │               AS A FULL WORD                    │
    │      (GIVES NUMBER OF WORDS, NOT BYTES)         │
4   ├─────────────────────────────────────────────────┤
    │                                                 │
    │          8-CHARACTER EBCDIC NAME                │
    │           OF OPERATOR, AS IT IS                 │
    │         DISPLAYED ON THE SCREEN                 │
12  ├─────────────────────────────────────────────────┤
    │                                                 │
    │            ADDRESS OF ROUTINE                   │
    │          THAT IS THIS OPERATOR                  │
16  ├─────────┬─────────┬─────────┬───────────────────┤
    │ VARPAR  │ RETURN  │ MACRO   │ DISPLAY           │
    │ 1=TRUE  │ 1=TRUE  │ 1=TRUE  │ 1=TRUE            │
20  ├─────────┼─────────┼─────────┼───────────────────┤
    │ SPECIAL │  SEE    │  NOT    │  NOT              │
    │ 1=TRUE  │  RON    │  USED   │  USED             │
24  ├─────────┴─────────┴─────────┴───────────────────┤
    │         FIRST WORD OF SKELETON                  │
    │          (FORMER DOPE VECTOR)                   │
28  ├─────────────────────────────────────────────────┤
    │         SECOND WORD OF SKELETON                 │
    ├─────────────────────────────────────────────────┤
    │                                                 │
    │                    ──                           │
    │                    ──                           │
    │                    ──                           │
NN  ├─────────────────────────────────────────────────┤
    │          LAST WORD OF SKELETON                  │
    └─────────────────────────────────────────────────┘
```

just what parameters should be passed to this instance of
this operator when it is invoked, and also specifies what
mode of operand is acceptable to it for each operand it
takes. The length of the dope vector is determined when
the instance of the operator is placed in the symbol table.
The skeleton itself consists of some number of full words,
each word specifying a parameter (or sometimes, a pair of
parameters), to be passed to the operator. The first byte

of each word indicates the kind of parameter to be passed,
and the rest of the word is used to specify subsidiary
information. The possible values for byte 0 (the first
byte in the word) and the meaning of each value follow:

0   Means pass next stack operand, as a pair of parameters,
     checking the mode of the operand (on the basis of
     bytes 1 and 2) to see that it is suitable for this
     operator. In this case, the actual parameters (words
     in the parameter list) generated are STEP and VALUE
     (from the STEP), in that order, for the stack operand.

1   Means pass a temporary. In this case, a temporary of
     the mode indicated by bytes 1 and 2 is created and
     passed as a pair of parameters (STEP and VALUE as
     in (1)) to the operator. The temporary will be de-
     stroyed when the operator returns unless (1) the
     operator returns the particular temporary to the stack,
     or (2) the operator increments the use count   for
     the temporary. In case (2) the operator is responsible

for seeing that the temporary gets destroyed eventually.

2   Means pass the standard domain vector (always REAL*4) as a pair of parameters. Bytes 1 and 2 are ignored.

3   The number of stack operands passed (total) will be generated as a 4-byte integer and passed.

4   The standard dimension is passed as a 4-byte integer. Bytes 1 and 2 ignored.

5   The operator STEP is passed as a 4-byte integer. Bytes 1 and 2 ignored.

6   Indicates end of dope vector (and end of parameter list, in a sense). Bytes 1 and 2 are ignored.

Byte 1 is used to specify what mode(s) of operand are suitable for this operator (if byte 0 = 0) or to specify what mode of temporary should be generated (if byte 0 = 1). Otherwise, it is ignored. The meanings of the bits are as follows:

Bit 0 - X'80' - scalar (if bit is ON)

Bit 1 - X'40' - vector

Bit 2 - X'20' - complex (when implemented)

Bit 3 - X'10' - vector-pair

Bit 4 - X'08' - operator

Bit 5 - X'04' - macro (console program)

Bit 6 - X'02' - undefined (i.e., operand may be of class undefined)

In the case where byte 0 = 0, byte 1 is used as a mask to see what is acceptable as an operand, e.g., both bits 0 and 1 could be ON indicating that the operator will accept a scalar or a vector in this operand position.

Vector-pair here is taken to mean a pair of vectors, stored one after the other in memory.

If an operator will accept operands of undefined class, they are simply passed to it "as is." If an undefined operand appears elsewhere, it will be given the global mode before being passed to the operator (if it will accept that mode).

Note that the operand specifications in the skeleton are listed in the order of things coming off the top of the stack. That is, the first specification in the dope vector applies to the operand on the top of the stack.

Operators may accept operands that are of the class OPERATOR or MACRO, and buttons of this class can be placed on the stack for use as operands by the LITNEXT button. The operator DELBUTON is an example of an operator using this feature.

Byte 2 is used in the same way as byte 1, but specifies the structure of operands allowed (or to be generated), as follows:

```
Bit 0 - X'80' - INTEGER*2 (not implemented within system)
Bit 1 - X'40' - INTEGER*4
Bit 2 - X'20' - REAL*4
Bit 3 - X'10' - REAL*8 (not implemented within system).
```

*A Simple Example

Consider the SIN operator. It might, as mentioned above, have several instances. Suppose we have a FORTRAN subroutine called RSIN which computes the trignometric sine of a scalar, and is smart enough to do it for arguments which are INTEGER*4 or REAL*4. The dope vector entry for this instance of the SIN operator would probably look something like this:

Flags would be present to indicate that the operator would accept only a fixed number of operands, and did return a result to the stack. But the operator is not "special" as it does not require immediate interpretation, or change the symbol table.

The skeleton part of the dope vector would contain

    Word 0 - XL4'04000000'

    Word 1 - XL4'00803000'

    Word 2 - XL4'01802000'

    Word 3 - XL4'06000000'

Word 0 indicates that the standard dimension should be passed as the first parameter to RSIN (it doesn't really need it, but then this is just an example).

Word 1 requests that the operand on the top of the stack be passed, and that it must be scalar, but may be REAL*4 or INTEGER*4.

Word 2 requests that a temporary scalar, REAL*4, be created

and passed as the next pair of parameters. Presumably, this is what will be returned to the stack.

Word 3 indicates end of dope vector, and puts nothing in the parameter list.

The subroutine RSIN could now be written something like this:

Subroutine RSIN (IVDIM,INSTEP,WRDIN,OUTSTE,WRDOUT)

...Where IVDIM will have the integer value equal to the standard dimension. INSTEP could be used as an array name to address the STE for the input operand (similarly for OUTSTE, and the output operand). WRDIN is the name of the variable whose sine is to be taken, and WRDOUT is where the result should be stored.

There would have to be a special function written to place the STEP for the temporary directly into GR0 on return, so that it could be placed on the stack.

*What Do the (Operator) STE Macros Look Like?

There are two macros, SYMODEFS and SYMODEFD, available to make putting operators into the symbol table a little easier. One, SYMODEFS, is a "static" macro, in that it assumes you know what you are doing when you write the macro instruction. The other one, figuratively speaking, assumes you don't know what you are doing, but have acquired information about the operator you wish to enter in the symbol table dynamically (such as from a table). Both

macros make all and exactly the assumptions made by the
other symbol table management macros.

*SYMODEFS

Has several positional and keyword parameters with the
following descriptions:

Positional Parameters

(1) The name of the operator, as a CL8 character constant.

(2) An ADCON giving the address of the subroutine which
     is this instance of the operator. May be A or V
     type ADCON.

(3) An operand sublist-type parameter, giving the dope
     vector for the entry, as a series of constants suit-
     able for use in a DC-type statement.

Keyword Parameters

(1) RETURN=0   Operator does not return anything to the stack.
     RETURN=1   Operator returns something to stack (default).

(2) VARPAR=0   Operator takes fixed number of operands
               (default).

     VARPAR=1   Operator takes variable number of operands.

(3) DISPLAY=0 Don't try to display operator on screen.

     DISPLAY=1 Display operator on screen (default). (If
               operator is already on screen, it will not
               be displayed again.)

(4) MACRO=0   Operator is really a hard code operator
               (default).

     MACRO=1   Operator is really a macro (in which case
               the subroutine MACROINT is called, instead

of the macro itself, when the macro is
invoked).

(5) SPECIAL=0 Operator need not be executed immediately.
(It does not change screen, nor does it
change the symbol table or anything in
it.) (Default.)

SPECIAL=1 Operator does do one of the above.

If operator is SPECIAL=1 type, the keyword RONHEX
must be present, and be =04 if the operator should
be interpreted immediately and =02 if it modifies
the symbol table.

Example. A macro-instruction which would make the appro-
priate symbol table entry for the subroutine RSIN
described in the previous example follows:

SYMODEFS CL8'SIN',A(RSIN),(XL4'04000000',XL4'00806000',
XL4'0180200',XL4'06000000'),RETURN=1

*SYMODEFD

This macro assumes you have built a table in memory
providing the information to build a dope vector for an
instance of the operator. The information is essentially
the same as given in the SYMODEFS macro-instruction. The
exact format is given in Figure 8.2.2.

The macro instruction takes one optional positional
parameter which is the name of a general register con-
taining a pointer to a parameter vector of the form given
in Figure 8.2.2 (which must be on a full-word boundary).
GR1 is assumed if no parameter is given on the macro-
instruction.

Figure 8.2.2 Form of Dope Vector for Instance
of an Operator (for Purposes of Documentation)

0	
	LINK TO NEXT INSTANCE (IF = 1, THERE IS NONE)
4	
	ADDRESS OF ROUTINE THAT IS THIS OPERATOR (INSTANCE)
8	

FLAGS FOR RETURN, MACRO, ETC.	LENGTH OF THE DOPE VECTOR (WORDS)

USED BY RON IF SPECIAL	UNUSED

FIRST WORD OF SKELETON

——
——
——
——

LAST WORD OF SKELETON
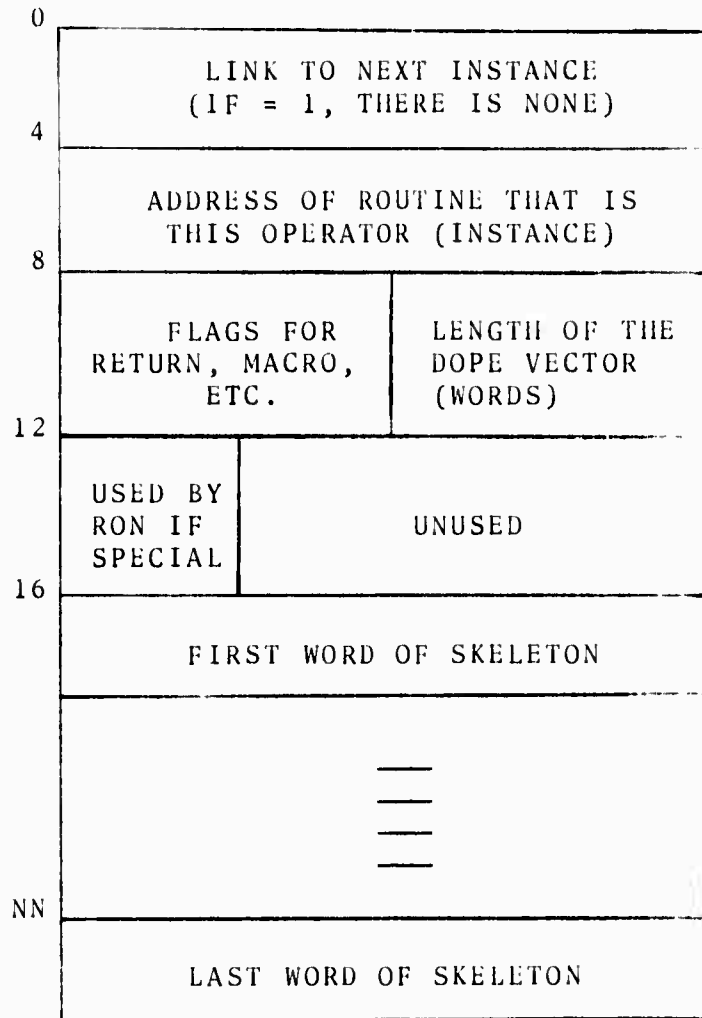
8.2.2   Internal Specifications and Operator Calls

This section of the interpreter (CSECT name - INTKIP) is executed whenever an operator in the button queue is to be invoked. It performs the following functions:

1   Searches for a suitable instance of the operator. (See external specifications for what this means.)

2   Builds a parameter list for the operator (or the macro processor, if the operator is really a macro), as specified by the operator's dope vector.

3   Calls the operator or macro with an OS type I(S) calling sequence.

4   Reduces the operand stack by the number of operands used by this operator, releases temporaries that were on the stack and used, and returns a result to the stack (if the operator produces one).

The above processing is performed in three logical "passes" over the operator dope vectors and/or operand stack: the search for the suitable instance of the invoked operator; the building of the parameter list for the selected instance; the release of used temporaries and return of result to stack.

*The Suitability Search

The linked list of dope vectors attached to the operator STE is searched, looking for the first suitable instance

of the operator. The instances are linked in such
a way that the last instance placed in the symbol table
will be the first one checked for suitability. This
allows you to replace a macro definition by simply defining
a new one -- the "latest" one will always be called.

Suitability is checked by matching each request for
an operand (type 00 entry in the skeleton) against succes-
sive operands from the top of the stack. An instance will
be found unsuitable in any of the following cases:

1   The operator (instance of it) will not accept some
     operand on the stack, e.g., the operator requires
     a real vector as its operand, and there is an in-
     teger scalar on top of the stack.

2   Some operand is of undefined mode and the operator
     will not accept the current default mode at this
     operand position.

3   There are not enough operands on the stack to satisfy
     this operator, e.g., it requires two operands and the
     stack is empty.

4   This operator will not accept a variable number of
     operands. The operator was preceded (on the button
     queue) by a parenthesized list explicitly defining
     the number of operands to be passed, and the numbers
     do not match.

5   The operator will accept a variable number of para-
     meters, but there are not enough operands to meet its

minimum demands, e.g., the mode-defining operator
will accept a parenthesized list of operands, but
must always have at least one operand.

*Building the Parameter List

When a suitable instance of an operator is by some
unlikely chance found, a parameter list for the operator
is built, according to the specifications given in the
skeleton of the dope vector for that instance. This
process is described in the external specifications,
except for one special case.

If the operator has said it would accept something
of the global mode in a particular operand position, but
that operand is at present of undefined class, the operand
is given the global mode by the interpreter before it is
passed to the operator. If the operator has said it will
accept something of undefined class at this operand posi-
tion, then the operand is untouched and is simply passed
as undefined.

When the parameter list has been built, the operator
is simply called with a standard OS calling sequence. It
is expected to return (the only exception to this being,
surprisingly enough, the operator RETURN, which gets you
back to MTS).

*Reducing the Stack

When an operator has returned to the interpreter,

the operands it used are removed from the stack. This
also involves checking to see if any of the operands are
temporaries. If they are, their use-count is reduced by
1 (and the temporary will be destroyed if the count has
gone to zero).

If the operator returned a result, the result is
placed on the top of the stack, and its use-count is in-
cremented by 1. A return is then made to the stack manage-
ment part (1NTJOHN) of the interpreter.

If the thing returned to the stack was an operator,
it will be interpreted immediately at this point.

8.2.3 Button Queue Processor (1NTRON)

The button queue processor requests buttons from
light pen management via the entry LPMDEQLP and takes
the appropriate action. This action can be

1) Stack the button on the button queue (BUTQ).

2) Edit the current contents of the button queue.

3) Gather together the buttons comprising a macro
    definition and call MACRODEF to define the macro.

4) Gather together the buttons comprising a new
    button name and then create a symbol table entry
    for this new button and have it displayed (by
    calling DSPNEWNM).

5) Gather together the buttons comprising a con-
    stant definition and then create a symbol table

entry for this constant and place it into the

button queue as an operand.

The button queue processor actually is written as a

finite state machine with four states and nine classes

of input symbols.   The four states are:

    0.   Normal state, not in any definition.

    1.   Inside of a DEFMACRO...DEFMACRO construction.

    2.   Inside of a DEFBUTON...DEFBUTON construction.

    3.   Inside of a DEFCONST...DEFCONST construction.

The nine input symbol classes are:

    0   Button of operand class

    1   Button of macro name class

    2   Button of undefined class

    3   Button of operator class (does not force inter-

        pretation)

    4   DEFMACRO

    5   DEFBUTON

    6   DEFCONST

    7   BAKSPACE

    8   Button of operator class (does force interpretation)

Besides this information, the index into the button queue

at the start of a macro, button, or constant definition is

saved while inside a definition to aid in the processing of

these definitions.

The button queue processor, when it receives a new

button, references the appropriate entry in a state transition

matrix which tells what state to go to next and gives the address of a routine to take any necessary action with the current button. This state transition diagram is given in Figure 8.2.3.

Besides the actions noted in Figure 8.2.3, any BAKSPACE while in state zero causes a bit to be set which causes the stack manipulation processor to update the working stack from the master stack and begin interpretation from the beginning of the button queue. This is necessary because the backspaces could have deleted operators which have already been interpreted and have left results in the stack. Every unstacking of items from the button queue, either because of a macro, button, or constant definition or because of a BAKSPACE, causes DSPECHOZ to be called to correct the echo line. Use counts are also incremented on every symbol placed on the button queue and decremented on every symbol removed from the button queue.

8.2.4 Brief Description of Stack Manipulation Processor (INTJOHN)

No parameters in calling sequence.

INTJOHN is called by INTRON whenever an operator which forces interpretation is placed on the Button Queue-BUTQ. INTJOHN places each Button Push —BP— from BUTQ onto STACK, determines whether the BP is a macro or operator, and if so calls INTKIP for execution of that operator. Otherwise, BPs

Figure 8.2.3 State Transition Diagram

Current State

Current Button Class	0 Normal State	1 Inside DEFMACRO	2 Inside DEFBUTON	3 Inside DEFCONST
0 Operand	0 Stack the button	1 Stack the button	2 Stack the button	3 Stack the button
1 Macro Name	0 Stack the button	1 Stack the button	2 Stack the button	3 Stack the button
2 Undefined	0 Stack the button	1 Stack the button	2 Stack the button	3 Stack the button
3 Normal Operator	0 Stack the button	1 Stack the button	2 Stack the button	3 Stack the button
4 DEFMACRO	1 Stack & note location	0 Unstack defn and send to MACRODEF	1 Error, ignore button	1 Error, ignore button
5 DEFBUTON	2 Stack & note location	2 Error, ignore button	0 Unstack defn, create symbol, display it	2 Error, ignore button
6 DEFCONST	3 Stack & note location	3 Error, ignore button	3 Error, ignore button	0 Unstack defn, create symbol, convert constant, stack it

Figure 8.2.3, continued

7 BAKSPACE	0 Remove previous button	1 or 0 Remove previous button, If DEFMACRO go to state 0 instead of 1	2 or 0 Remove previous button, If DEFBUTON go to state 0 instead of 2	3 or 0 Remove previous button, If DEFCONST go to state 0 instead of 3
8 Operator which forces interpretation	0 Stack the button Call INTJOHN	1 Stack the button	2 Stack the button	3 Stack the button

continue to accumulate on STACK from BUTQ until an operator or macro is finally encountered. When BUTQ is empty, INTJOHN returns to INTRON.

INTJOHN maintains two stacks: a working stack, STACK, and a master stack MSTACK. Normal interpretation is handled via STACK. However, when any operator is called which modifies symbol table entries, STACK is copied into MSTACK. In turn, whenever editing takes place in BUTQ, MSTACK is copied into STACK before interpretation begins! This feature permits the user to edit a string of input BPs back to the last symbol table changing operator (such as =). After an operator of this type has been executed, the echo display and BUTQ are collapsed. That is, the next element of BUTQ above the operator becomes the bottom of a new BUTQ and echo line. The displaced part of BUTQ is sent to the history queue.

INTJOHN increments the use-count of every STEP which is placed on STACK, and decrements the use-count of every step which is sent to the history queue. Whenever STACK is copied into MSTACK, the use-count of each BP in STACK is incremented, and the use-count of each BP in the old version of MSTACK is decremented. Use-counts are modified similarly when MSTACK is copied into STACK.

When the LITNEXT operator occurs, the BP following it is placed on STACK as an operand without regard to its class; the LITNEXT operator thus allows the user to use an an operator as an operand.

When macros are expanded, the BPs comprising the macro definition are obtained from MACROGET routine and treated in exactly the same fashion as BPs obtained from BUTQ. The initial call on a macro expansion is accomplished by INTKIP. Subsequent calls to obtain BPs are done within INTJOHN; once a macro expansion has begun, all BPs are obtained from MACROGET until it returns a 0 in GR1, signaling the end of the macro definition. Nesting of macros is monitored by the macro processor, and INTJOHN does no pushdown on macro calls.

INTJOHN does no checking for syntax except for the use of parentheses. It is assumed that parentheses will be used only to delimit the operand stream for an operator, and hence every right parenthesis, ")" must be followed by an operator. Furthermore, a count is maintained of the number of left parentheses minus the number of right parentheses. This count may never go negative. If either condition is violated, interpretation is halted, and an error comment is presented to the user. Additional checking for proper use of parentheses is done within INTKIP. Note that parentheses may not be used to delimit compound operands, unless followed immediately by an operator.

Examples of illegal syntax:

   (A) B+

   (AB-)C+

)AB*

Examples of legal syntax:

    A (B)+

    C(AB-)+

    (AB*

INTJOHN

HAS EDIT
OCCURRED OR
IS THIS IN
INITIAL CALL?
i.e.,RBTEDIT=1?

TF11

TCOPMTW

YES

INCREMENT USE
COUNTS IN MSTACK
DECREMENT USE
COUNTS IN STACK
COPY MSTACK INTO
STACK
RESET BUTQ
POINTER (TPBUTQ)

NO

RESET PAREN LATCH   TPRNSW ← 0
RESET LITNEXT LATCH   TLTNSW ← 0
RESET MACRO LATCH   TMSW   ← 0
COMPUTER POINTER TO TOP OF BUTQ;
i.e., TOPBQ ← BUTQ(0)·4+(=A(BUTQ))

TF1

RESET SPECIAL OPERATOR LATCH TOPSW ← 0

TF3

TPBUTQ > TPBQ
?

YES

RETURN TO
INTRON

TRET

NO

TPBUTQ ← TPBUTQ+4
GR1 ← BUTC(TPBUTQ)

TF5

INCREMENT USE COUNT OF STOP IN GR1
TPSTACK ← TPSTACK+4
STACK(0) ← STACK(0)+1

1

1

STACK(0) > 6000 ? — YES → ERROR COMMENT STACK OVERFLOW → ERROR

TQ1

NO

STACK(TPSTACK ← GR1

TLTNSW = 0 ? — NO → TLTNSW ← 0 → TF7

TQ2

TF9 → YES

SYMDCD CLASS

MACRO — TEST CLASS — OPERAND UNDEFINED → TF71

TF4

SET MACRO LATCH i.e., TMSW ← 1

TF6

OPERATOR

OPERATOR = LITNEXT ? — YES → TLTNSW ←1 TPSTACK ←TPSTACK-4 STACK(0)←STACK(0)-1

TF40

NO

TF7

SYMCHK IS OPERATOR SPECIAL ? — YES → SET SPECIAL OPERATOR LATCH; i.e.,TOPSW ← 1

NO

TFKIP

RESET PAREN LATCH, TPRNSW ← 0 CALL INTKIP

2

```
                          ( 3 )
                            │
                            ▼
┌──────────────────────────────────────────────┐
│ 1.   Portion of BUTQ below and including      │
│      current BP will be added to history stack│
│                                               │
│ 2.   Portion of BUTQ  having current BP will  │
│      become new BUTQ                          │
│                                               │
│ 3.   DISPECHO2 is notified about 1 + 2        │
└──────────────────────────────────────────────┘
       ⟨ TFC2 ⟩          │
                         ▼
      ┌───────────────────────────────────────┐
      │ Decrement use-counts in portion of    │
      │     BUTQ sent to history stack        │
      └───────────────────────────────────────┘
        ⟨ TFC1 ⟩          │
                          ▼
      ┌───────────────────────────────────────┐
      │  Form updated BUTQ by copying BP's     │
      │  above current BP into bottom of       │
      │            BUTQ Stack                   │
      │  Reset BUTQ pointer (TPBUTQ)            │
      └───────────────────────────────────────┘
       ⟨ TCOPWTM ⟩         │
                           ▼
      ┌───────────────────────────────────────┐
      │   Increment use-counts in STACK        │
      │   Decrement use-counts in MSTACK       │
      │   Copy STACK into MSTACK               │
      └───────────────────────────────────────┘
                           │
                           ▼
                    (     TF1      )
```
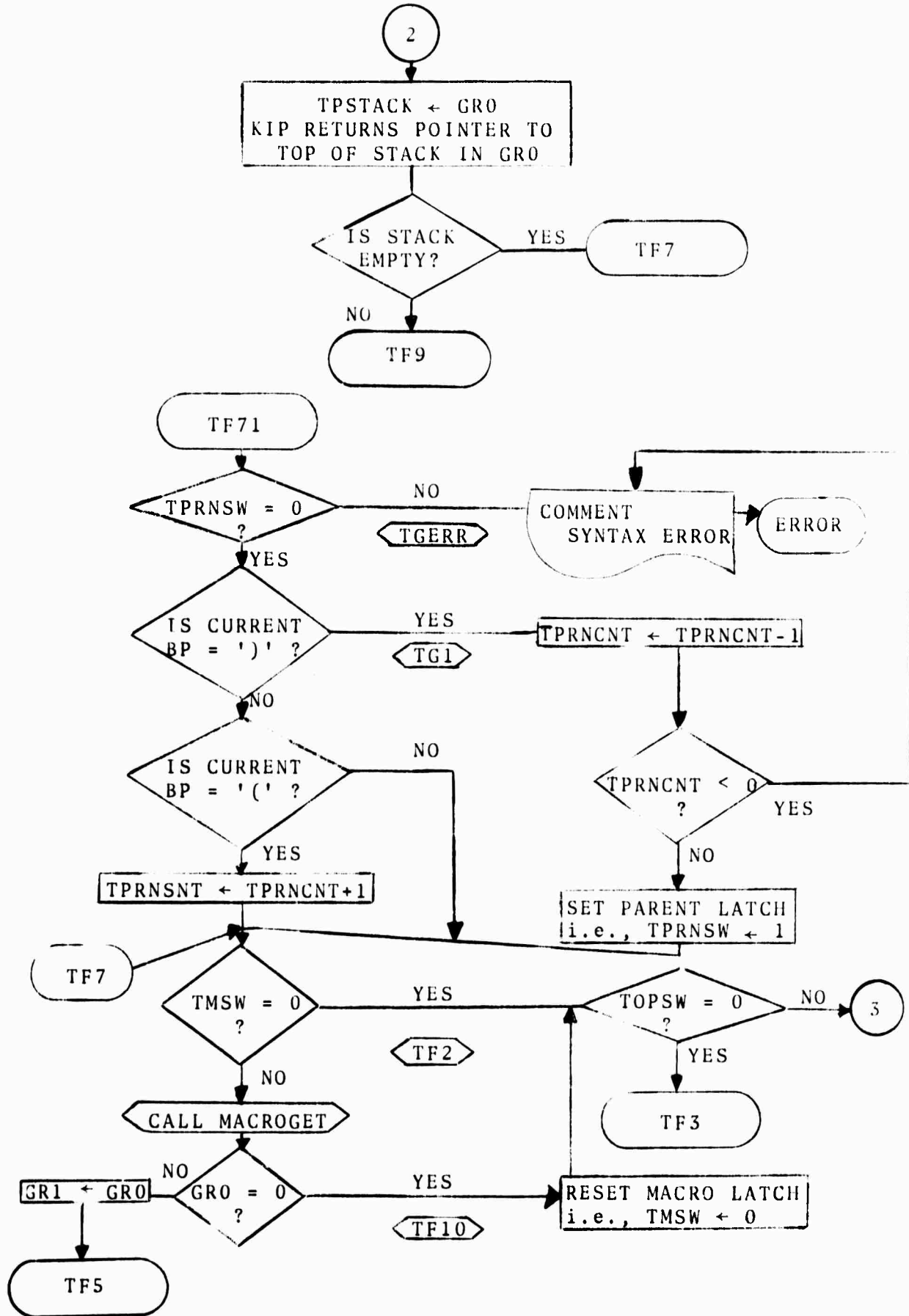
8.3   SYMBOL TABLE MANAGEMENT ROUTINES   P.Wilcox   J.Jonekait

    8.3.1   <u>Symbol Table Entries</u>

       Each symbol has one symbol table entry which con-
tains various pieces of information about the symbol.
The following is a description of the fields contained
in a symbol table entry and their uses.

NAME (SYMNAM - 8 bytes):   contains the 8-character EBCDIC
    name of the symbol.

VALUE (SYMVAL - 4 bytes):   full-word pointer to the "value"
    of the symbol.   It may be used for various purposes.

DOPE VECTOR (SYMDV - 4 bytes):   full-word pointer to sym-
    bol's "dope vector" or "extended attributes."   May
    be used for various purposes.

BUFFER ID (SYMBFRID - 4 bytes):   full-word pointer reserved
    for the display buffer ID for the symbol.

USE COUNT (SYMUSC - 2 bytes):   half-word "use count" for
    the symbol.   This will be used to determine when and
    if a symbol should or may be removed from the symbol
    table.

DISPLAY LINK (SYMDLNK - 2 bytes):   contains a half-word
    Symbol Table Index (STEI) which may be used to link
    symbol table entries together in a chain.   When this
    field is referred to in a macro call, a full-word
    STEP must be given since the macro will convert it
    to or from the STEI.   This field was originally re-
    quested by display people but they have since dis-
    owned it so it may be used for various purposes.

DIMENSION (SYMDIM - 2 bytes): half-word dimension of
operands. Number of elements in a vector; number
of elements in each of the two vectors of a vector-
pair. Not used by scalars.

MODE (SYMMOD - 1 byte): The bits in the mode byte are
used in conjunction with operands to indicate the
form of the data associated with the symbol. The
bits in this byte may be divided into three groups.
The first group shows the mode of the symbol:

SYMREAL   symbol is real

SYMINT   symbol is integer

SYMCPX   symbol is complex

The second group gives the structure of the data:

SYMSCALR   scalar

SYMVEC   vector

SYMVPAIR   vector-pair

The third group is a single bit which gives the length
or form of the individual elements:

SYMLNG   1=long, 0=short form

In each group, at most one bit may be set at any
time. It is possible for none of the bits to be
set; this is the undefined condition and is used
when the symbol is first created.

CLASS (SYMCLAS - 1 byte): The bits in the class byte are
switches which determine the basic nature of the sym-
bol table entry. The following bits are defined:

SYMOPND	symbol is an operand
SYMOPR	symbol is an operator
SYMMAC	symbol is a macro definition
SYMUDEF	class of symbol is undefined
SYMUNU	this symbol table entry is not in use
SYMSPC	special attention

The first five bits listed are mutually exclusive, so
only one (exactly) may be set at any time. SYMUNU
is internal to the symbol table management routines
and is not available to others through macros. The
last bit is used by the interpreter.

TYPE (SYMTYP - 1 byte): The bits in the type byte indicate
if a symbol may be changed or destroyed. The bits are:

SYMSYS	system symbol
SYMUD	user-defined symbol
SYMTMP	temporary symbol
SYMRDO	read-only symbol

ONE AND ONLY ONE of the first three bits should be
set for each symbol in the symbol table. System sym-
bols are never destroyed. If an attempt is made to
do so, nothing is done unless the symbol is an oper-
and, in which case it is reset to undefined class
and mode. User-defined symbols are destroyed only
when a request is made to do so. Temporary symbols
are destroyed automatically when they are no longer
being referred to anywhere. Read-only symbols should
not be changed, but the symbol table routines do not
do any checking for this.

EXTRA ROOM: At present, there are 32 bytes in a symbol

   table entry, of which all but three are being used.

   Currently the symbol table is aligned so that each

   symbol table entry pointer points to a 32-byte bound-

   ary and therefore has zeros for its five low-order

   bits.

8.3.2 Macro Descriptions

Parameters

   Many of the symbol table management macros accept

parameters which correspond to items in a symbol table

entry (STE).   These parameters may be divided into two

classes:

   Class I parameters refer to particular fields in a

symbol table entry.   For example, DOPE refers to the full-

word pointer to the dope vector.   When one of these para-

meters is used in a macro call, either the entire field

is replaced (from GR0) or else the entire field is returned

(in GR15), depending on the macro used.   If the field is

less than a full word long, it is right-adjusted in the

register and high-order bits are either ignored or set

to zero.   Only one Class I parameter may be given in a

macro call.

   Class II parameters refer to particular bits in the

TYPE, MODE, or CLASS bytes of the symbol table entry.

When one of these parameters is used, only the individual

bit associated with the parameter and possibly directly

conflicting bits are affected.   For example, if the para-

meter SYS is given with the SYMSET macro, then the system symbol bit will be set while the user and temporary symbol bits will be cleared, but no other bits in the TYPE byte will be changed. Any number of non-conflicting Class II parameters may be given in a macro call. Class I and Class II parameters referring to the same byte should not be used in the same call.

Class I Parameters

PARAMETER	FIELD	LENGTH
VALUE	value pointer	full word
DOPE, EXTATR	dope vector pointer	full word
DBUF#	display buffer ID	full word
TYPE	type bits	one byte
MODE	mode bits	one byte
CLASS	class bits	one byte
DLINK	STE link pointer	full word (STEP only)
DIM	dimension	half word
NAME	EBCDIC name	full-word pointer to 8-character name
USCNT	use count	half word

Class II Parameters

PARAMETER	BYTE	ATTRIBUTE*
OPER,OPERATOR	CLASS	operator
OPND,OPERAND	CLASS	operand
MACRO	CLASS	macro definition
UND	CLASS	undefined class
SPEC	CLASS	special attention
-SPEC	CLASS	not special
SCALAR	MODE	scalar operand
VECTOR	MODE	vector operand
VPAIR	MODE	vector-pair
INTEGER	MODE	integer
REAL	NODE	real

COMPLEX,CMPX	MODE	complex
SYS,SYSTEM	TYPE	system (permanent) symbol
USER	TYPE	user-defined
TEMP	TYPE	temporary symbol
CONST	TYPE	read-only
VRBL	TYPE	may be changed

*Vertical bars join mutually exclusive attributes.

8.3.3 List of Macros

SYMCRE

SYMCRE is used to create a symbol table entry and assign to it initial attributes. GR1 is assumed to point to an 8-byte region containing the name of the symbol to be created. If the symbol is to be temporary, the name may begin with the characters "#SYM". The last four characters of the name will then be supplied by the symbol table routines so that other programs will not have to worry about creating unique names for temporary symbols they use. If a name is given which is already in the symbol table, a return code of 4 will be given in GR15. Normally, the return code is zero. In either case, the STEP of the new or old symbol is returned in GR1. If there is no more room in the symbol table, a return code of 8 is used and GR1 is zero.

Initial attributes may be set by giving parameters acceptable to the SYMSET macro. Any fields not specified in this manner will be set to the value of the corresponding field in the global default entry, except for the mode byte which is set to zero (undefined).

```
PROTOTYPE:        label     SYMCRE  [par1.] [,par2,...]
EXAMPLE:                    LA      1,NAMEREG
                           SYMCRE SYS,OPND;REAL, VECTOR
```

SYMDES

SYMDES is used to destroy a symbol table entry. It
calls upon the symbol table management routine SYMDS.
If the S.EP in GR1 refers to a system symbol, the symbol
is reinitialized (in the same manner as when a symbol
is created). If the STEP refers to a user or temporary
symbol, the symbol is removed from the symbol table.
Note that the symbol is not removed from the screen by
the symbol table management routines; this must be done
by the routine which wishes to destroy the symbol before
SYMDES is called.

If the STEP in GR1 does not point to a valid STE,
a return code of 4 is given; otherwise a return code of
0 is provided.

```
PROTOTYPE:        label     SYMDES
EXAMPLE:                    CALL BUFBOD remove from screen
                           L   1,STEP
                           SYMDES
```

SYMFIND

SYMFIND is used to search the symbol table for an
STE with a known name. It calls upon the symbol table
management routine SYMFS. GR1 is assumed to point to
an 8-byte region containing the name of the symbol. If

it is found a STEP is returned in GR1 and the return code
is 0. Otherwise a return code of 4 is given.

PROTOTYPE: label   SYMFIND

EXAMPLE: LA   1,PLUS

                             SYMFIND

SYMDCD

SYMDCD decodes the CLASS, MODE, or TYPE byte of a
symbol table entry and returns it in GR15 in a form
suitable for use as a branch table index. The following
are legal parameters only one of which may be given in
one call: CLASS, MODE, TYPE, STRUCTURE (each may be
abbreviated to its first letter). If more than one para-
meter is given in the call to this macro, all after the
first are assumed to be statement labels to be used in
a branch table which the macro will construct. If some
of these labels are omitted, then the corresponding branch
table entry will point to the first location after the
macro expansion. If all the labels are missing, no
branch table is constructed.

The branch indices generated are as follows:

GR15	TYPE	CLASS	MODE	STRUCTURE
0	system	operand	real	scalar
4	user	operator	integer	vector
8	temp	macro	cmplx	vector-pair
12		undefined	undefined	undefined

```
PROTOTYPE:    label    SYMDCD    parl [,loc...]
EXAMPLE:               SYMDCD    MODE,REALLOC,,ERLOC
```

produces the same code as

```
               SYMDCD    MODE
          B    *+4(15)
          B    REALLOC
          B    *+8
          B    ERLOC
```

Use Count Management

All symbols of user-defined or temporary types have associated with them a use count. This should be incremented by one at the beginning of each usage of the symbol and decremented at the termination of said usage.

SYMREF

SYMREF is used to increment the use count by one. No action is taken if the symbol is a system symbol.

SYMDLE

SYMDLE is used to decrement the use count. If the use count is found to be zero after decrementing the macro, SYMDES is called to destroy the symbol. As before, no action is taken for system symbols.

Attribute Manipulation

SYMSET

SYMSET is used to set an attribute(s) of a symbol table entry. Any Class 1 parameter and any combination of Class 2 parameters are legal. There is no error-

checking to see if contradictory parameters are specified.
Parameters are processed left to right. If a symbol is
an operand (or is changed to an operand in the same SYMSET
call) and the mode byte is to be changed, the symbol
table manipulation routine SYMSMU or SYMSMS is called
and appropriate manipulations are performed to allocate
space for the value of the symbol.

PROTOTYPE: label   SYMSET par1[,par2][,par3...]

EXAMPLE: SYMSET OPER,DLINK

SYMGET

SYMGET is used to get the value of any symbol table
entry item. Any Class 1 parameter may be specified.
The value of the item is returned in GR15.

PROTOTYPE: label   SYMGET par

EXAMPLE: SYMGET DIM

SYMCHK

SYMCHK is used to determine if a symbol table entry
has certain specified attributes. Any Class 2 parameters
may be specified. The last parameter must be the address
to which a branch will be taken if any one of the attri-
butes is not associated with the symbol table entry, i.e.,
if multiple attributes are specified success will be
achieved if all of the attributes specified are present.

PROTOTYPE: label   SYMCHK par1[,par2][,par3...],LABEL

EXAMPLE: SYMCHK OPND,VECTOR,READ,BADPAR

SYMGINDX

    SYMGINDX converts a half-word symbol table entry index (STEI) into a STEP. A parameter is accepted which specifies the register in which the STEI exists. The STEP is returned in the same register. GR1 is assumed if no register is explicitly specified.

SYMGPTR

    SYMGPTR converts a full-word STEP to a STEI. Register conventions are as in SYMGINDX.

SYMERR	These macros are NOPS as anticipated de-
SYMDIAG	mand for them did not materialize.
SYMTRACE	
SYMTRAC	
SYMSETG	These macros perform the functions of the
SYMGETG	macros SYMSET, SYMGET, and SYMCHK on the
SYMCHKG	global symbol table entry which contains
	current defaults.

8.3.4 Symbol Table Management Routines

    The symbol table management routines which are normally used during execution are contained in two assemblies, each containing one control section. The first CSECT is named "SYMSTM1" and has the following entries:

SYMCS	create symbol
SYMDS	destroy symbol
SYMFS	find symbol

```
SYMINIT1        initialization

SYMTABLE        PSECT and symbol table
```

The second CSECT is named "SYMSTM3" and has the following entries:

```
SYMSMU          set mode to user byte

SYMSMS          set mode to macro-formed byte
```

Also, there is a CSECT which contains entries to print-out symbol table entries or dump the whole symbol table. This will be described below. There is also a program to test the symbol table macros and programs, but it is not described here.

SYMCS

The entry SYMCS in SYMSTM1 is used to create a symbol table entry given the name of the symbol. GR1 must contain a full-word pointer to the first byte of the 8-character name. GRS 13,14, and 15 are used in the normal manner. On return, GR1 will contain a STEP, and GR15 will have a return code of 0 or 4. RC=0 indicates that a new symbol table entry (STE) has been created and the symbol table entry pointer (STEP) is in GR1. If RC=4, then a symbol with the same name already exists and the STEP in GR1 points to that old symbol.

The operation of the routine is as follows: If the name of the symbol indicates that it is not to be a temporary, that is, its first four characters are not the same as the four characters in location "SYMTPFX" (which is addressable relative to "SYMTABLE"), then a search

of the entire symbol table is made to see if the name
is already used on an existing symbol. This search is
made starting at the end of the symbol table and going
toward the beginning. (The end of the symbol table means
the last STE in use, not the end of the storage reserved
for the table.) During the search, a check of each STE
is made to see if it is used. If it is not, then its
STEP is saved so that the STE may be used for this sym-
bol if necessary. If a symbol with same name is found,
its STEP is put in GR1 and a return with RC=4 is made.
Otherwise an STE is formed for the symbol either at the
end of the table or else in a previously unused STE
found during the search (if one was found). This new
STE is initialized by filling all fields from the global
symbol table entry except the name, which gets the new
name, and the mode and dimension which are set to zero.

If a temporary symbol is to be created, no check
is made to see if it already exists, since this is im-
possible (hopefully) because this routine creates a
unique name. A search is made starting from the begin-
ning of the symbol table to find the first unused STE,
which may be at the end of the table. In order that
room for TEMPS may be found quickly, the first few sym-
bol table entries are reserved exclusively for TEMPS.
The exact number reserved is an assembly parameter and
is the value of the symbol "SYMSTERT" which currently

is 5. When an unused STE is found, it is initialized
just as other STEs except that its type is set to TEMP
and the second four characters of its name are an index
which is incremented each time a TEMP symbol is created.
This index starts at 0001 and goes to 9999, at which
point it returns to 0001. The index 0000 is reserved
for the global entry which has the name "#SYM0000".
This routine is called from the macro "SYMCRE".

SYMDS

The entry SYMDS in SYMSTM1 is used to remove a sym-
bol table entry from the symbol table. GR1 must contain
the STEI for the symbol, and GRS 13, 14, and 15 are used
in the normal manner. First, a check is made to see if
the STE pointed to is in use and if it is not, a return
with RC=4 is given. If the symbol is a system (permanent)
symbol that is not an operand, then nothing is done and
a normal return is made. If the symbol is a system sym-
bol that is an operand, then it is reinitialized (in the
same manner as when a symbol is created) with its type
set to system. Any other symbol has its class set to
unused so that it may be reused later. Reinitialized
symbols and destroyed symbols have their mode byte set
to zero, thereby releasing storage assigned to their
value pointer (see SYMSMU write-up).

If a symbol was removed from the table, a check is
made and the pointer to the end of the symbol table is

set to point to the last STE actually currently in use.
(If the number of TEMPS defined is small enough so that
they all fit in the room reserved for them, and if no
other symbols are defined, then the end pointer points
to the first block available to non-TEMP symbols.)

This routine is called by "SYMDES" macro expansions.

SYMFS

The entry "SYMFS" in SYMSTM1 is used to search the
symbol table for a symbol with a given name. GR1 must
contain a full-word pointer to the first byte of the 8-
character name of the symbol to be found. The search is
straightforward, starting at the beginning of the symbol
table and including the reserved TEMP region but not the
global entry. If the symbol is found, a return is made
with its STEP in GR1 and RC=0 in GR15. If the symbol
is not found, GR1 is set to zero and RC=4.

This routine is called by the "SYMFIND" macro.

SYMINIT1 and SYMTABLE

The entry, "SYMINIT1" in SYMSTM1 is the initializ-
ation entry for the symbol table management routines.
It must be called during initialization before any
attempt is made to create symbols. The entry "SYMTABLE"
is the PSECT name for all the symbol table routines.
It contains pointers to the beginning of the symbol
table, the end of the table, the global entry, and the
symbol table management error exit routine (which does

not exist and is not used). There is also the temporary
symbol prefix, some scratch storage,and two save areas.
Following all this is the symbol table itself. The
entries in the symbol table are forced to a 32-byte align-
ment. The calculation of the first such address avail-
able to the symbol table is done during initialization
when the various pointers are also initialized. The
global STE is physically the first entry in the symbol
table although logically (to the various search routines)
it is not contained in it. The global entry is initial-
ized when it is created but it may be changed later,
during or after initialization by other routines. All
the STE's used exclusively for TEMPS as well as the first
non-TEMP STE have their class set to unused during initial-
ization.

SYMPTO

The CSECT "SYMPTO" contains two entry points:
"SYMTPO" (which is the same address as SYMPTO) and
"SYMSPO". The latter requires an STEP in GR1 and prints
out on SPRINT the state of that STE in a readable form.
The first entry dumps the whole symbol table by repeat-
edly calling on the second. Both entries establish their
own addressability and require only GR14 to be set to
the return address. A normal return preserves all regis-
ters except GR15.

Assembly Parameters

The following constants appear in SYMSTM1 and are used to establish various characteristics of the symbol table entries and programs.

The location "TPFX" contains the four characters which are initially used to denote that a TEMP symbol is to be created. During initialization, these four characters are moved into the location "SYMTPFX" in the PSECT which may be changed at any time.

The location "INIB" contains the initial values which are loaded into the global STE when it is created.

The symbol "SYMSTETL" has a value which is the total length of a symbol table entry (in bytes) and is currently 32. Changing this value implies that the symbol table DSECT and STE alignment calculation has been or should be changed.

The symbol "SYMSTEIL" has a value which is the initialization length for STE's. This is the number of bytes which are moved from the global entry to the other entries when they are initialized. Currently this is 24 bytes, since the name is not moved. If this symbol value is changed, probably other codes in SYMSTM1 will have to be changed to indicate which bytes are to be moved.

The symbol "SYMSTERT" has a value which is the number of STEs reserved exclusively for TEMP symbols at the beginning of the symbol table. Since TEMP symbols are

created and destroyed quite often during processing, this reserved room at the beginning makes it more likely that the CREATE routine can find space for a TEMP easily without looking through the whole symbol table for an unused STE. If this reserved room is filled up, then TEMP symbols will be placed in the first unused STE in the rest of the symbol table just as any other symbol. Currently, the value of SYMSTERT is 5, but experience may show a larger figure to be appropriate.

Currently, 16 pages of core are assigned for the symbol table and PSECT. This allows room for over 2000 symbols and is probably far more than will ever be needed. Contrary to what other write-ups may say, the CREATE routine (SYMCS) at this time does not check to see if there is room to add another symbol to the end of the symbol table.

SYMSMU and SYMSMS

The entries "SYMSMU" and "SYMSMS" in CSECT "SYMSTM3" are called by the SYMSET macro to set the mode byte of a symbol. GR1 must contain a STEP for the symbol to be changed and GRS 13, 14, and 15 are used in the normal manner. GR1 is not changed. The entry "SYMSMS" is used if the mode byte to be entered was generated by the macro as the result of the use of Class II parameters referring to the mode byte. "SYMSMU" is called if the Class I parameter "MODE" is used. The only difference between the

two entries is that SYMSMU checks the class of the symbol. If it is not an operand, then the given mode byte is stored and nothing else is done. If the class is operand or if "SYMSMS" is called, then the routine releases old storage associated with the symbol (value) and gets new storage in accordance with the new mode byte.

The operation of the routine is as follows. If the new mode byte is the same as the old, nothing is done. If the old value pointer is zero or if it points to the dope vector pointer field of the symbol, then no storage is released. Otherwise the storage pointed to by the value pointer is released using "FREESPAC". If the new mode byte is zero, the dimension, the value pointer, and the mode byte are set to zero and a normal return is made (RC=0). In order to assign storage, both the true mode (integer, real, or complex) and the structure (scalar, vector, or vector-pair) must be known. If the new mode byte indicates both of these, then that is used. If either field of the new mode byte is zero (undefined) then the corresponding field from the old mode byte is used. If this also is zero, then the field from the global entry is used. When this has been settled, the space needed for the symbol value is computed. The dimension field from the global symbol is always used if the symbol is vector of vector-pair and is stored in

the dimension field of the symbol. If the symbol is
a scalar, the dimension is set to 1. If four bytes or
less are needed, then the value pointer is set to point
to the dope vector pointer field of the symbol. If
more room is needed, GETSPACE is called to obtain it.
The return code for this routine is the same as the re-
turn code from GETSPACE or zero if GETSPACE was not called.
Note that there is no checking for validity of the new
mode byte, and if too many bits are set, the room allo-
cated depends on the particular sequence in which the
program checks the bits, and may well not be the largest
amount indicated.

8.4   LIGHT-PEN MANAGEMENT ROUTINES   F. Stephenson   R. Brender
      Relationship to Graphic Support Routines

These asynchronous attention routines are required
to be able to queue light-pen hits to be later processed
on a first-in first-out basis. This is not possible with
the graphic system as described in the MTS literature.

A new routine, SETANLZ, has been added to the
graphics support. This routine is very like that de-
scribed in IBM literature except that it is an initial-
ization call only. Return is to the calling routine
immediately after making interrupt connections with the
supervisor. When an attention occurs, control passes
to the device-handling routines (LPDETECT, KBFNCDET,
ENDORSEQ, and ASYNCER) on a true interrupt basis with

respect to the main program. These routines must return
to SETANLZ in normal fashion. By convention SETANLZ will
start buffer regeneration (redundantly perhaps) before
expiring.

This leaves only the problem of "task time—inter-
rupt time" coordination via the queue. When the queue
is empty on entry to routine LPMDEQLP a flag called FLAG
is set non-zero and WAYT state (via a SVC) is entered.
The last task of the interrupt routines when a STEP has
been added to the queue is to post that FLAG (set FLAG
to zero) and hence awaken the task-time routine.

Addressability

Common addressability is set up at all entry points
with

REG 10 = address of graphic DCB

REG 11 = address of fake PSECT (also known as LPMPSECT)

REG 12 = current CSECT (named LPMCSECT)

Note on Documentation

A name in parentheses after a STEP number in the
functional description of these routines gives the pro-
gram label roughly corresponding to the STEP description.

LPM INITIALIZATION

Name: LPMINIT

Purpose: To initialize internal tables and
                 data structure of the light-pen
                 management routines.

Calling Sequence: OS (I) R type

Entry: No parameters.

Return: No parameters.   RC = 0.

Functional Description:

1. SETANLZ is called to initialize the graphic sup-
    port software for handling asynchronous interrupts.

2. Various error counts are zeroed.

3. The initial values of the queue of STEPs are
    set to zero.

4. The light pattern in the function keys is set up.

5. The names 'FUNC00 ',...,'FUNC29 ' for the func-
    tion buttons are defined to the symbol table
    and the corresponding STEPs entered in the
    FUNCKEY table.

PROCESS LIGHT PEN DETECT

Name: LPDETECT

Purpose: To obtain STEI of an item identified
                      by light pen and place the corres-
                      ponding STEP into the light-pen queue.

Calling Sequence: OS (I) R type

Entry: Parameters in 8-byte region establish-
                      ed by previous call on SETANLZ

Return: RC = 0 All okay.

                      RC = 4 Something wrong, e.g., could not
                      find an STEI.

Functional Description: LPDETECT

1. (LPDETGRF) Read into core 2000 bytes from 2250
    buffer starting at the next lower even buffer
    address location as given in OUTPUT+2.

2. (LPSCAN2) Scan looking for two-byte sequence =
    X'2ACO' which is a "GNOP4"

3. If not found, return to SETANLZ without further
    action. SETANLZ will start regeneration of dis-
    play and total effect to user will be null.

4. (GOTNAME) If found, then interpret the next two
    bytes as the STEI of an entity. Convert to STEP
    to store into queue.

5. (GOTNAME2) If queue is full, then exit. Other-
    wise, place STEP in queue. Then POST the FLAG
    for the LPMDEQLP entry, and exit to SETANLZ.

PROCESS END-ORDER-SEQUENCE

Name:	ENDORSEQ
Purpose:	To process end-order-sequence con- dition from 2250 display.
Calling Sequence:	OS (I) R type
Entry:	Parameters in 8-byte region estab- lished by previous call on SETANLZ
Return:	RC = 0 All okay.

Functional Description: ENDORSEQ

1. Increment the counter EOSCOUNT by 1.

2. When EOSCOUNT exceeds = F'256' call ERROR, else
    return to SETANLZ.

This action is intended for diagnostic purposes.
An end-or-sequence command should never occur. If it
does, regeneration will be forced 256 times allowing the
user at least 10 seconds to examine the partial image.

PROCESS ASYNCHRONOUS ERRORS

Name: ASYNCER

Purpose: To process asynchronous error condi-
                    tions in 2250 display.

Calling Sequence: OS (I) R type

Entry: Parameters in 8-byte region establish-
                    ed by previous call on SETANLZ

Return: RC = 0 All okay.

Functional Description: ASYNCER

   1. Record the buffer location where the error occur-
      ed in DATACHK. Return to SETANLZ.

Comments: An error message via SERCOM will also be
        implemented.

PROCESS FUNCTION KEYBOARD DETECTS

Name: KBFNCDET

Purpose: To process keyboard detects from
                    either function or (real) manual key-
                    board.

Calling Sequence: OS (I) R type

Entry: Parameters in 8-byte region establish-
                    ed by previous call on SETANLZ.

Return: RC = 0 All okay.
                    RC = 4 Something wrong, i.e., END
                    or CANCEL from keyboard.

Functional Description:

   1. The keyboard sense data is read to determine
      cause of interrupt.

2. If interrupt from manual (real) keyboard, simply ignore and return to SETANLZ.

3. (FNCDET) Else from function keyboard so the keynumber is extracted and used to index into both FUNCKEY and KEYCODE tables.

4. If KEYCODE entry is zero, then FUNCKEY contains the STEP for the function depressed. Load this and go step 5 of LPDETECT description.

5. (PRECALL) If KEYCODE entry is = X'80000000', then FUNCKEY contains the address of an _immediate_ routine. This routine is called. It must return before the display regeneration is set up since all 2250 interrupt-handling is suspended.

GET 'STEP' FROM LIGHT PEN ROUTINES

Name: LPMDEQLP

Purpose: To obtain STEP of item pointed to
                   by user from a queue of such in FIFO
                   order.

Calling Sequence: OS (I) R type

Entry: No parameters

Return: GRO contains STEP
                   RC = 0   All okay.
                   RC = 4   Something wrong somewhere.

Routines Required: ANALYZ & SETANLZ from *GPAKLIB

      DSPECHO1 (Echo line entry) from display section

EXTERNAL SYMBOL - DCBADDR = DCB and STRTADDR from buffer

management.

Functional Descriptions:

(Note: ECH is pointer to next entry not in echo, BEGIN is pointer to next entry not on interpreter stack.)

1. On ENTRY, compare ECH to END. If equal, the echo line is up-to-date, so branch to (ALLECH).

2. To update echo, branch to (FILLTAIL) to get linear vector of queue. Call DSPECHO1 with address of parameter list in GR1. (Parameter list is two full-words: first is address of full-word length of the vector; second the address of the first word of the vector.)

3. (ALLECH) Compare BEGIN and END. If equal, the queue is empty so the program goes into wait state until another interrupt occurs which makes a queue entry. The echo line is updated after this entry.

4. (NTINT) The STEP of the next queue entry is put in GR0, BEGIN is incremented, and the routine returns with RC = 0.

5. (FILLTAIL) Given the pointer of where to start in the queue, entries are moved into a linear vector. A full-word count is computed and stored, as required for the parameter list. The value of ECH is updated and control returned. Also used by LPMNEWEC.

GET ECHO LINE NOT YET PASSED TO INTERP AFTER AN EDIT

Name: LPMNEWEC

Purpose: To obtain linear vector of that part
                    of the button queue not already passed
                    to the interpreter.

Calling Sequence: OS (I) R type

Entry: No Parameters

Return: GRl contains pointer to PARLIST
                     PARLIST = A (LENGTH OF VECTOR)
                                     A (VECTOR)
                     GRC = 0   All okay.
                     GRC = 4   ERROR

Routines Required: None

Function Description:

1. Picks up BEGIN and branches to (LIST).

2. (LIST) If queue is empty, returns with zero
    put in vector length. If queue is not empty,
    branches to (FILLTAIL) as in LPMDEQLP to get
    linear vector, and returns.

3. RETURN to calling program with address of para-
    meter list in GRl, GRC = 0.

8.5 KEYBOARD AND NUMERIC DISPLAY ROUTINES
M.Feldberg   R.Taylor   R.Nicholls

The mandate for this group was to translate alphanumeric
information derived from various parts of the system into
order programs to be passed to the screen management routines
for display on the screen and to 'manage' the order programs
thereafter; that is to say, the particular order programs were
to be cataloged.   These order programs were written in a
standard manner and were identifiable via an index subscripted
to each program.

DSPKBRD

This provides the keyboard display and the initial-
ization call to the echo line. It also provides the func-

tion definition (via SYMODEFS) for the scrolling, numeric display, and screen-clearing routines. At the time of the call to this module, a temporary file,-MESSFILE, is created and is used to keep all messages which are displayed on the screen and the entire button queue history.

DSPMESS

This contains both the message display routines and the message erasing routines. Figure 8.5.1 is a flow chart of the subroutine DSPMESS.

DSPNUMV

This module contains a large number of entries but we will describe only two in detail as the rest manipulate data in a simple way after it has been set up by the two routines to be described. The two to be described are:

            DSPNUMV
            DSPORDER

Each numeric display comes under the control of a control block (with the dummy structure VECTATT). This has the structure:

            STEP of variable displayed

            Starting address of value vector

            Address in value vector of start of present display

            Last address in vector

            Buffer ID of display

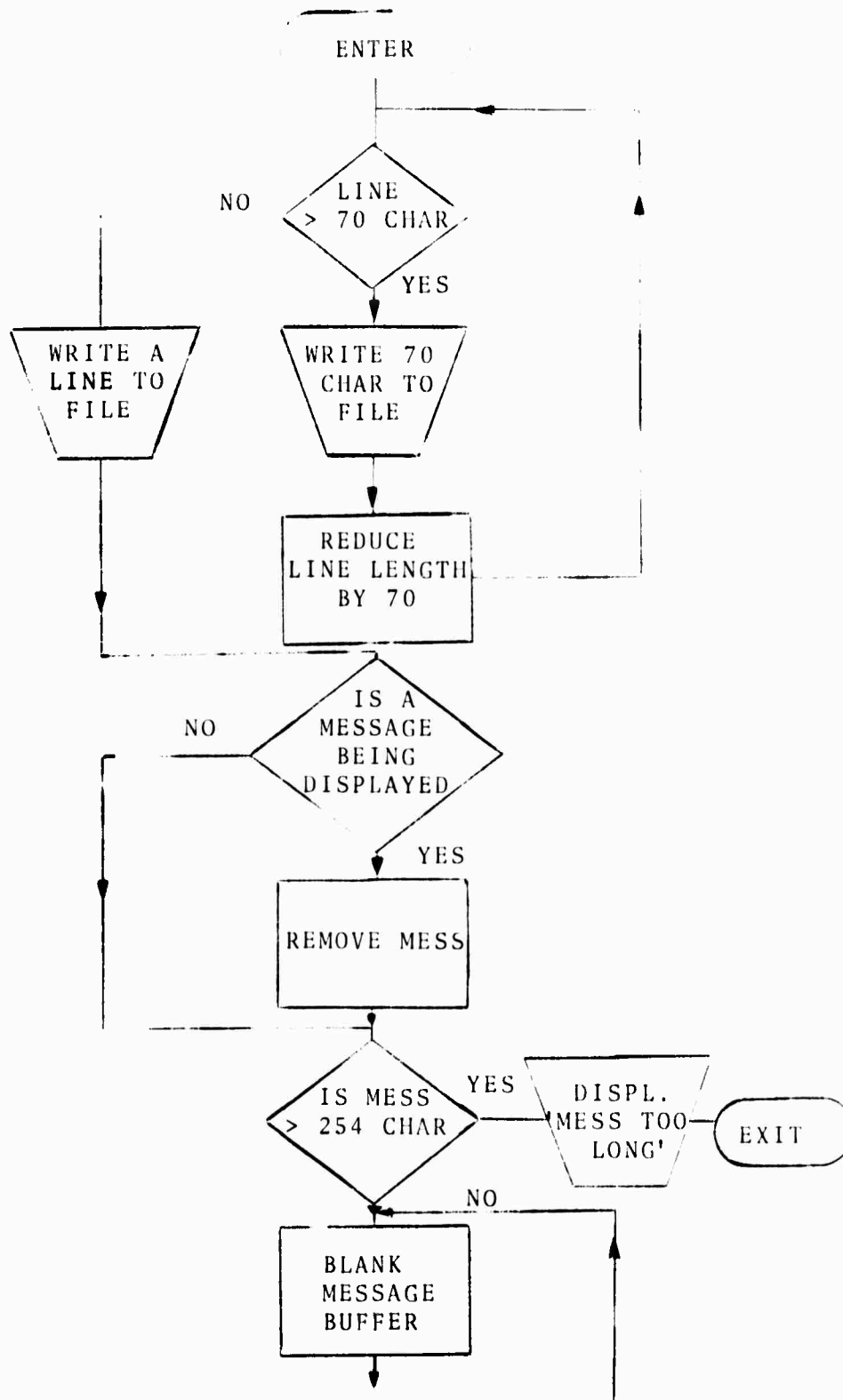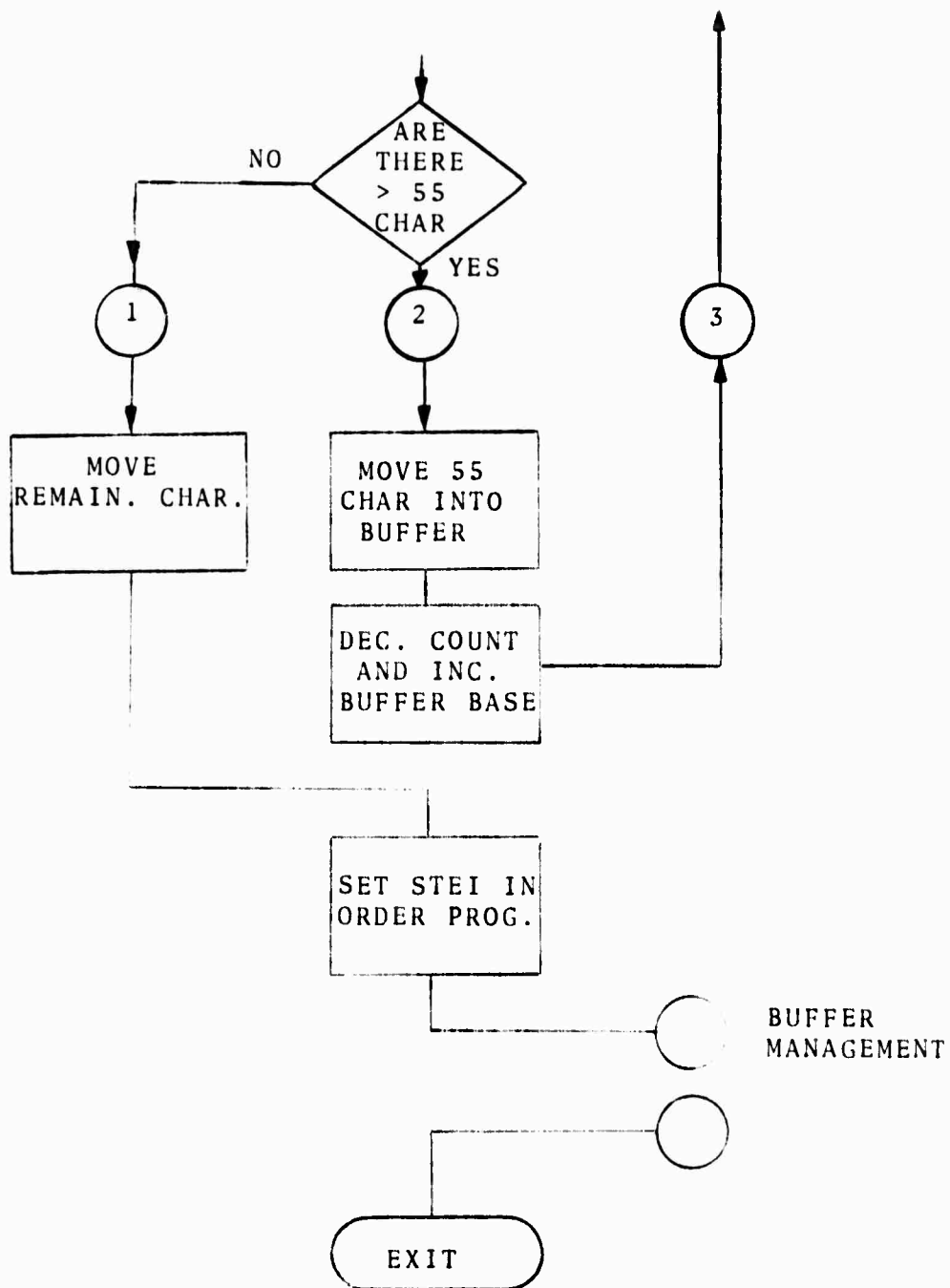Figure 8.5.1   Flow Chart of Subroutine DSPMESS

Figure 8.5.1, continued

> Dimension of vector (1 if a scalar)
>
> Pointer to head of list of a control block
>
> Eight bytes of positioning orders for start
> of order program.

This structure is used for both vector and scalar displays. Three blocks are provided each kind of display; they are queued and used sequentially until all are in use. If at any time the display corresponding to a given block is erased, the block is placed on the back of the queue for later use. The queue structure is:

> Byte index of first available pointer
>
> Pointer to control block
>
>   "
>
>   "
>
>   F'-1'

The -1 limits the length of the list.

In order to obtain an order program corresponding to a given set of values (or more properly, to display the values corresponding to a given STEP), a control block is acquired, the relevant data are put into the block, and the block is passed to DSPORDER. To scroll a vector display, only the address of the head of the display in the control block need be changed before passing the address of the block to DSPORDER.

System Sub-button Description

Name: DSPLPROC (part of the DISVALUE button)

Purpose: To display a macro definition in
                      the working area of the screen.

Calling Sequence: OS(I) S type

Entry: GR1 contains location of a list of
                      2 adcons
                              1.   A(STE of the procedure)
                              2.   A(Value of the procedure)

Return: RC=0   Procedure is displayed
                      RC=4   Procedure is not displayed

Instructions for use:

                      To display the definition of

                      MACRONAME, the user should point at

                      LITNEXT MACRONAME DISVALUE

                      in that order with the light pen.

                      The macro definition will be dis-

                      played in the current working area

                      of the screen.   The formal parameters

                      of the definition will appear in

                      parentheses.

Functional Description:

   1.   Pick up parameters using pointer in GR1.

   2.   Get the length   (number of STEPs) from the type
        entry in the symbol table.

   3.   Go through the double entry table which contains
        the macro definition starting at A(Value+#dummy
        args*4) to get the STEPs of the definition.
        (See macro write-up for details.)

   4.   Place these STEPs in a local list.   Record the
        number of STEP in the list.

5. Use a STEP to obtain an 8-byte EBCDIC name and build up a 2250 order program using these characters. (Trim all but one trailing blank and insert NEWLINE and spacing characters where appropriate.)

6. Loop on 5 until all STEPs processed.

7. Compute the length of the 2250 order program in bytes and call BUFBINGO.

8. Increase the use count of the macro.

9. Enter the STEP and Buffer ID of the displayed macro into the local table of macro definitions displayed.

10. Exit with RC=0.

Name:	DSPERSPR (part of the ERASE button)
Purpose:	To delete the display of a procedure from the working area.
Calling Sequence:	OS(I) S type
Entry:	GR1 contains the location of a list of 2 adcons

       1. A(STE of the procedure)

       2. A(Value of the procedure)

Return:	RC=0 Procedure erased
	RC=4 Parameter given was not a macro

Instructions for use:

    The user should point at MACRODEFINITION ERASE in that order with the light pen. The displayed macro definition will disappear from the screen working area.

Functional Description:

1. Pick up arguments using pointer in GR1.

2. Use SYMDCD to see if operand is a macro. If not, exit with RC=4. If so, go to 3.

3. Find the entry pair for this macro in the table being kept of macro definitions displayed. Remove this entry pair (i.e., Buffer ID and STEP) and close up the rest of the table.

4. Call BUFBOD to remove the order program.

5. Decrease the use count of the macro.

6. Exit with RC=0.

Name: DSPCLRPR   (part of the CLEAR button)

Purpose: To clear the "working area" of the screen of all macro definitions displayed there.

Calling Sequence: OS(I) R type

Entry: No parameters

Return: RC=0   Done
                   DSPCLRPR calls BUFBOD with a Buffer ID. If this ID is not legal, a system error is indicated by BUFBOD.

Instructions for Use:

When the user points at the clear button, the various sections which display information in the working section —graphs, numeric display of vectors, macro definitions-- are called and each deletes the order programs that it set up.

Functional Description:

1. Sequentially extract entries from the double
    entry table of Buffer IDs and STEPs.

2. Call BUFBOD with each ID.

3. Decrease the use count of each macro display
    deleted by one.

4. Exit when all entries processed.

The following constitutes a list and definition of the
present set of entry points into the package provided
by keyboard and function display. Given are the external
symbols and the calling sequence required at each entry.
In some cases, a return or return code is provided and
in these cases it is noted.

Name: DSPKBRD

Purpose: To display the predefined virtual
                    keyboard symbols on the screen.

Calling Sequence: OS (I) S type

Entry: GR1 contains the location of a list
                    of full word entries. The first
                    entry is a full word count of the
                    number of following entries. The
                    rest are STEPs of the predefined
                    symbols.

Return: RC=0 Screen displayed
                    RC=4 Screen not displayed

Notes: The format of the screen will be
                    entirely determined by the order of
                    the list of STEPs. The symbols will

be displayed in large characters
across the top of the screen, double-
spaced and staggered line-by-line.

Name: DSPNUMV

Purpose: To display a vector in numeric form.

Calling Sequence: OS (I) S type

Entry: GR1 will contain the location of a
                     list of adcons which will be prepared
                     in the standard function call format.
                     The list of adcons will be:
                     1. A(STE of vector to be displayed)
                     2. A(Vector)
                     3. A(Temporary STE)
                     4. A(Temporary vector)

Exit: RC=0 Vector displayed
                     RC=4 Vector not displayed

Notes: The value of the vector at the time
                     of the call will be copied into the
                     temporary vector, and the original STE
                     will be linked to the temporary by
                     the DLINK of the temporary. This
                     will allow for the use of the EBCDIC
                     name. The use count of both STEs
                     will be increased and both will be
                     decreased when the temporary is
                     erased. A maximum of 4 vectors may
                     be displayed at any one time with
                     maximum display length of 20 values.

Name: DSPORDER

Purpose: To construct an order program corres-
                     ponding to a given control block.
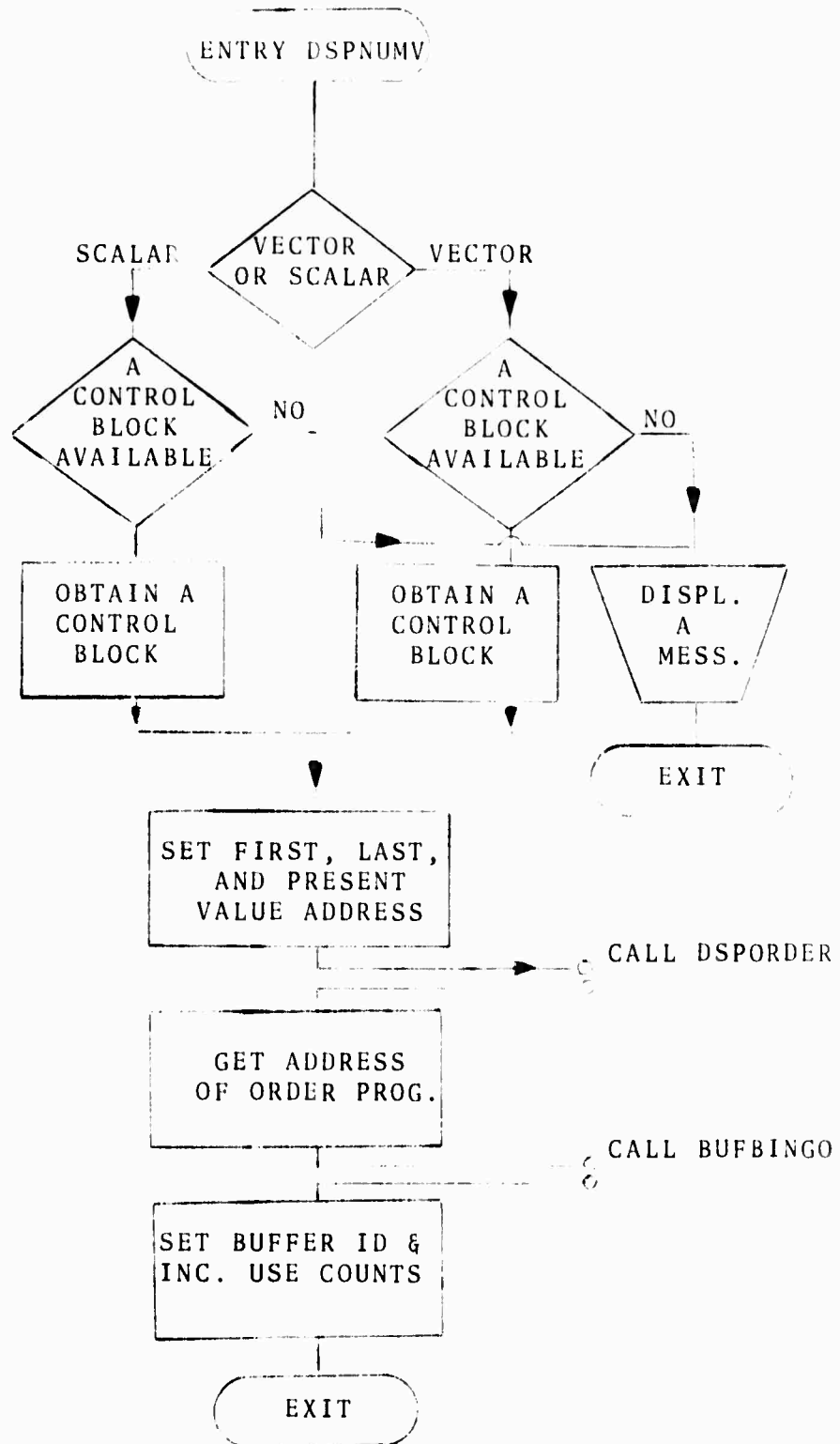
Figure 8.5.2   Flow Chart of Subroutine DSPNUMV

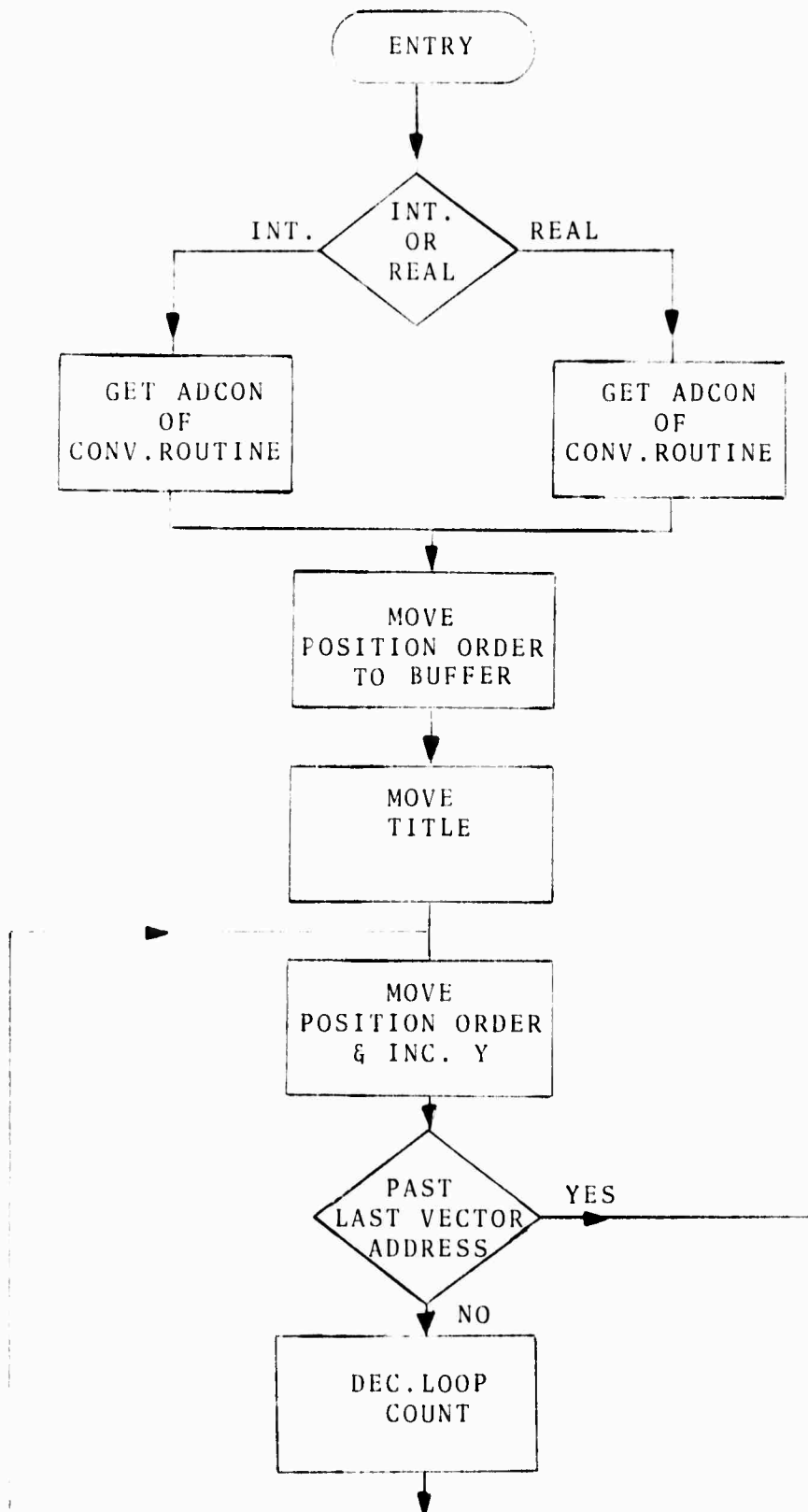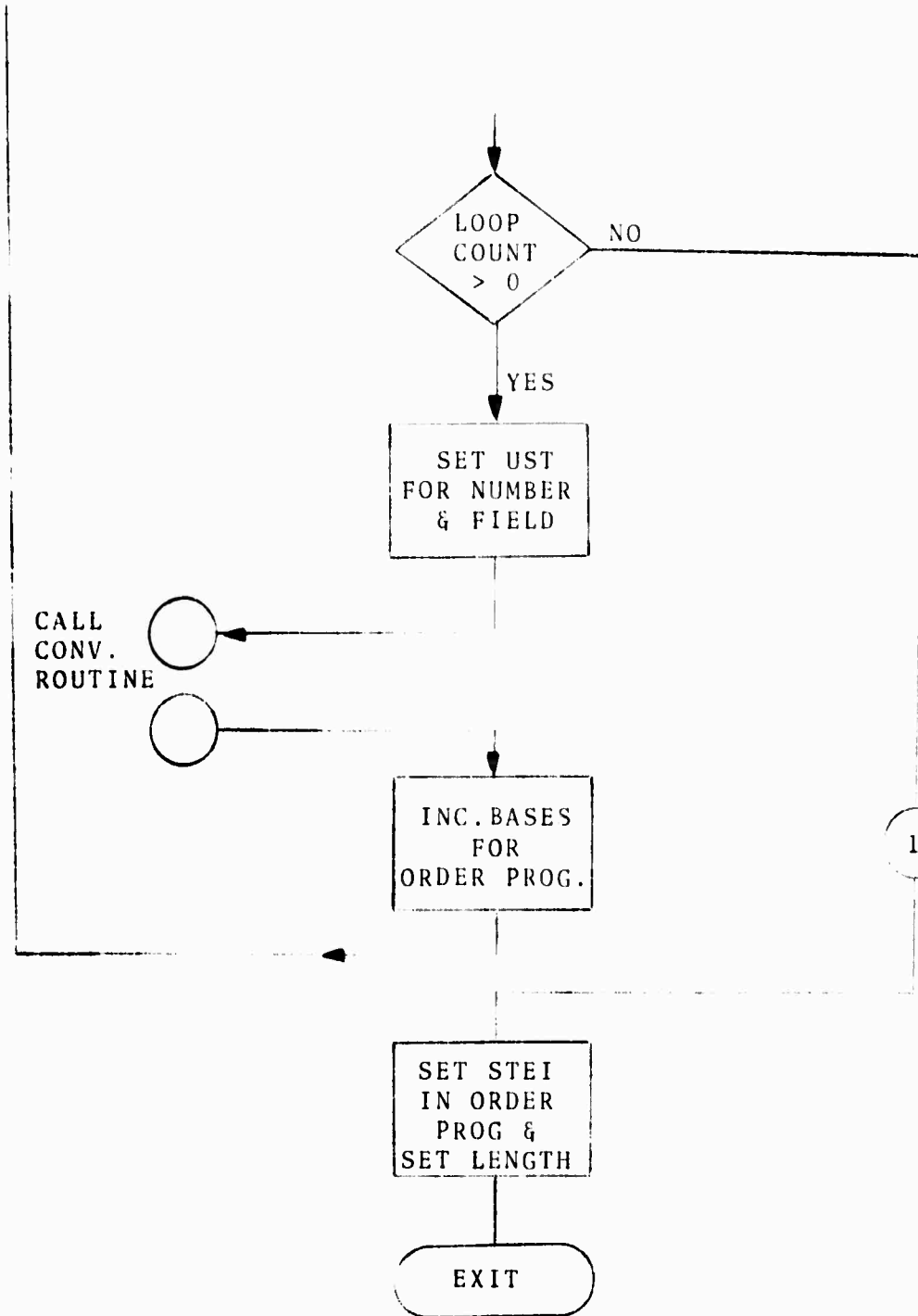Figure 8.5.3   Flow Chart of Subroutine DSPORDER

Figure 8.5.3, continued

Calling Sequence: OS(I) S type

Entry: GR1 contains the location of the
control block.

Exit: RC=0

Notes: An order program is left in the PSECT
with the count at the address COUNT
It is not an External Symbol.

Name: DSPSCRLU

Purpose: To scroll a displayed vector upwards.

Calling Sequence: OS (I) S type

Entry: GR1 contains the location of a list
of 2 full word adcons:
1. A(STE of vector)
2. A(Value of vector)

Exit: No return

Notes: The vector will be scrolled upwards
by 10 places for each call on the
routine until the last 10 are display-
ed. No more scrolling may then be
done.

Name: DSPSCRLD

Purpose: To scroll a vector downwards

Calling Sequence: OS (I) S type

Entry: GR1 contains the location of a 2 ad-
con list:
1. A(STE of vector)
2. A(Value of vector)

Exit: No return

Notes: The vector will be scrolled upwards

by 10 places on each call until the first 20 values are displayed.

Name:	DSPERSEV
Purpose:	To erase a vector which has been displayed on the screen.
Calling Sequence:	OS (I) S type
Entry:	GR1 contains the location of a list of adcons:
	1. A(STE of vector)
	2. A(Value of vector)
Exit:	No return
Notes:	The display will be erased, the temporary entry will be destroyed, and the use count of the original STE will be reduced.
Name:	DSPNEWNM
Purpose:	To display a name on the function keyboard.
Calling Sequence:	OS(I) R type
Entry:	GR1 contains the STEP of the required STE.
Exit:	RC=0 Name displayed
	RC=4 Name not displayed
Notes:	The new name will be added to the list of names. This list will first cover the right-hand side of the screen and then the left-hand side.

Name:	DSPDELNM
Purpose:	To delete the name of a function from the function keyboard.
Calling Sequence:	OS (I) R type
Entry:	GR 1 contains the STEP of the function to be deleted.
Exit:	RC=0 Name has been deleted
	RC=4 Name has not been deleted
Notes:	The name will be deleted and the whole keyboard moved up to remove the space left by the deletion.
Name:	DSPMESS
Purpose:	To display a message on the screen.
Calling Sequence:	OS (I) R type.
Entry:	GR 1 contains the location of a half word count of an immediately following character string.
Exit:	RC=0 Message displayed
	RC=4 Message not displayed
Notes:	The message is displayed on the screen below the virtual keyboard. A limit of 254 characters may be displayed. The message will also be written in the file -MESSFILE, which is created during the initialization. Any previous message which is on the screen at the time of a call on this routine will be erased.

Name: DSPERSMS

Purpose: To erase a message from the screen.

Calling Sequence: No parameters are required.

Notes: This is used internally but it may
                  be called by anyone who wants to.

Name: DSPECHO1

Purpose: To get those parts of the button queue
                  which are kept by Light Pen manage-
                  ment.

Calling Sequence: OS (I) S type

Entry: GR 1 contains the location of a list
                  of 2 adcons:
                  1. A(Count of queue)
                  2. A(Queue)

Exit: No return

Name: DSPECHO2

Purpose: To pass those parts of the button queue
                  which are kept by the Interpreter.

Calling Sequence: OS (I) S type

Entry: GR1 contains the location of a list
                  of 4 adcons:
                  1. A(Count of button queue)
                  2. A(Button queue)
                  3. A(Count of history queue)
                  4. A(History queue)

Exit: No return

Name: DSPLPROC

Purpose: To display a procedure on the screen.

Calling Sequence: OS (I) S type.

Entry: GR1 contains the location of a list
                   of 2 adcons:
                   1. A(STE of the precedure)
                   2. A('Value' of the procedure)

Exit: RC=0 Procedure is displayed
                   RC=4 Procedure is not displayed.

Notes: The call is a standard function call.

Name: DSPERSPR

Purpose: To delete the display of a procedure.

Calling Sequence: OS (I) S type

Entry: GR1 contains the location of a list
                   of 2 adcons:
                   1. A(STE of the procedure)
                   2. A('Value' of the procedure)

Exit: RC=0 Procedure erased
                   RC=4 Something not quite right.

Name: DSPINC

Purpose: To increase the time count on a mess-
                   age.

Calling Sequence: None

Notes: A display is kept on the screen un-
                   til one of the following has occurred:
                       a. A new message is displayed
                       b. Three additions are made to
                           the echo line.
                   This routine is used to update the
                   count from the echo line.

Name: DSPFLDFN

Purpose: To acquire a temporary MTS file called
                    -MESSFILE.

Calling Sequence: None

Exit: RC=0   File acquired

                    RC=4   File not acquired

Notes: A temporary file called -MESSFILE
                    is acquired and is used in order to
                    store a record of the user's compu-
                    tations. The echo line is placed
                    into the file whenever it is placed
                    in the history stack. All messages
                    that are displayed on the screen are
                    also placed in the file. The FDUB
                    of the file is kept under the external
                    symbol of DSPFDUB and this may be
                    used by anyone who wishes to place
                    anything in the file.

8.6 FUNCTION DISPLAY ROUTINES

General Description

All calls to display graphs in the shared area of
the 2250 screen come to Function Display as operator calls
from the interpreter. Operators are currently available
to display and erase graphs (PLOT1, PLOT2, ERASE, and
CLEAR) and to control the mode and scaling of displays
(SCALE and SETPLTMD).

Buffer programs for the IBM 2250 are generated using
the subroutines in *GRAPHLIB which are described in the

IBM Systems Reference Library manual, IBM System /360
Operating System Graphic Programming Services for the
IBM 2250 Display Unit, Model I (Form C27-6921-0 file
S360-30). These subroutines were used extensively, and
the IBM manual must be used to understand the parameter
tables that are set up to display graphs.

Four function display subroutines form the primitive
basis for other function display programming. They are:

1. FDADDDS which adds a graph to the screen given
    two vectors, and the Symbol Table Entry Pointer
    (STEP) of a temporary vector-pair.

2. FDGRIDDS which puts a grid and labels on the
    screen after the appropriate parameters are set
    up.

3. FDMAXMIN which chooses corner points (scale
    values) for a grid given the x and y vectors
    to be displayed.

4. FDSETVAR which chooses increments between grid
    lines and sets up the vectors to be used as labels.

The following few pages describe the operator entries
to handle PLOT1, PLOT2, and SCALE and the internal sub-
routines FDADDDS and FDGRIDDS.

Function Display: Operator Description

Name:

PLOT1 and PLOT2

Function:

display graphs that are composed of a vector-pair or
a pair of vectors.

Operands:

PLOT1 takes one operand from the stack. It may be either a vector or a vector-pair. A vector-pair operand is displayed using its own domain and range. A vector operand is used as the y-vector of a graph and is displayed against the standard domain (the ID vector).

PLOT 2 takes two operands. If they are both vectors, the vector first entered onto the stack is used as the y-vector in the graph displayed versus the second vector entered.

If the first entered operand is a vector-pair, its y-vector is used as the y-vector in a display versus the second operand entered.

Results:

Neither PLOT1 nor PLOT2 returns an operand to the stack.

Notes:

1. In all cases the scaling used will be determined by the first graph displayed. If this is unacceptable, the SCALE operator may be used to set the scale.

2. The displayed graph is a floating-point vector-pair operand and may be placed on the operand stack with a light-pen hit on it. It may be used with any operator that accepts vector-pair mode operands.

3. The grid is displayed with the first use of PLOT1, PLOT2, or SCALE.

4. Transformations are performed on the x and/or
   y vectors if the current plotmode specifies that
   either one or both of the ordinates is to be
   of log mode.

Possible Messages:

1. DIMENSIONS OF PAIR OF VECTORS FOR DISP DISAGREE
   The two vectors which are to be displayed with
   PLOT2 must have the same number of elements.
   No action is taken if this error occurs, but
   the operands are removed from the stack.

2. SOME PTS OF LAST GRAPH OFF THE SCREEN
   One or more points of the last graph fell out-
   side of the grid. All points within the grid
   boundaries are displayed.

3. INTEGERS IN LAST FP VECTOR FOR DISPLAY
   This means that there were some numbers that
   looked like integers that were supposed to have
   been floating point. Probably a programming
   error.

4. DISPLAY BUFFER OVERFLOW ERASE SOMETHING
   Too much is being displayed. Last display is
   ignored; operands are removed from stack.

Example:

Button pushes starting from the left

ID   ID   PLOT2

displays a straight line from (-1,-1) to (1,1).

Name:

SCALE

Function:

Sets the scale values to be used for the lower-left
and upper-right corners of the grid and then displays

an empty grid. PLOT1 and PLOT2 will use these scale

values for all subsequent displays.

Operands:

SCALE accepts four scalar floating point operands

that describe the lower-left and upper-right corners of

the grid to be displayed. The order which the operands

are to be placed on the stack is:

1. x value of the lower-left corner.

2. y value of the lower-left corner.

3. x value of the upper-right corner.

4. y value of the upper-right corner.

Results:

No results are returned to the stack.

Notes:

1. Use of SCALE overrides any automatic scaling
    by PLOT1 or PLOT2.

2. If some graphs are already displayed they will
    not be rescaled. The grid will be changed under
    them. They may be rescaled by getting two light-
    pen hits, i.e., placing the graph on the stack
    twice, and then erasing and plotting again.

3. SCALE does not alter the plotting mode. The
    grid displayed will be of the current mode.

4. No messages are displayed by SCALE.

Function Display: Subroutine Description

Name:

    FDDSVCPR

Function:

The entry point for all PLOT2 operator instances and the PLOT1 instance to display a vector against the standard domain.

Calling Sequence:

    OS(I) S-type

There are six parameters, the STEP and VALUE of the x vector to be displayed, of the y vector to be displayed, and of the vector-pair temporary for the displayed graph.

Subroutines used:

1. FDMAXMIN: routine to set up the scale values for the corner points of the grid.

2. FDSETVAR: routine to set up grid and label increments and the label vectors.

3. FDGRIDDS: routine to display grid, labels, and the scale messages.

4. FDADDDS: routine to construct the buffer program for the graph to be displayed.

Description:

1. The dimensions of the x and y vector are checked for agreements.

2. The y and then the x vectors are moved to the vector-pair temporary.

3. If either or both of the vectors are integer they are converted to floating point.

4. If no grid is currently being displayed, FDMAXMIN, FDSETVAR, and FDGRIDDS are called to display the grid.

5. Return to caller.

Name:

FDDSFN

Function:

Entry point of PLOT1 when it operates on a vector-pair operand.

Calling Sequence:

OS(I) S type.

There are four parameters, the STEP and VALUE of the vector-pair to be displayed and of the vector-pair temporary used for the displayed graph.

Subroutines Called:

None; however code in FDDSVCPR is entered after initial setup.

Description:

1. The vector pair is moved to the temporary.

2. Variables are set up and FDDSVCPR is entered at REALY.

Name:

FDSCALE

Function:

Entry point for the SCALE operator.

Calling Sequence:

OS(I) S-type

There are eight parameters: the STEP and VALUE of the following four floating point scalars.

1. y value of the upper-right corner.

2. x value of the upper-right corner.

3. y value of the lower-left corner.

4. x value of the lower-left corner.

Subroutines Used:

1. BUFBOD: to erase a grid if there is one already up.

2. FDSETVAR: to set up the grid and labels parameters.

3. FDGRIDDS: to display a new grid.

Description:

1. If a grid is already up, it is erased.

2. The upper-right and lower-left corner scale values are set into the parameter tables.

3. FDSETVAR is called to set the grid and label increments and the label vectors.

4. The buffer program for the grid and labels is constructed with FDGRIDDS.

5. Return to caller.

Name:

FDADDDS

Function:

Adds one graph to the 2250 display buffer.

Calling Sequence:

OS(I) S-type

GR1 contains an address that points to a vector of four other addresses:

1. The address of the first element of the x-vector to be displayed.

2. The address of the first element of the y-vector to be displayed.

3. The address of a full word containing the number of points to be plotted.

4. The address of a full word containing the Symbol Table Entry Pointer for the temporary space used for the displayed graph.

Exit:

GR15 is set to zero.

Subroutines Used:

1. GETSPACE: used to get space for graphs to be displayed in one of the log modes.

2. ALOG10: used to transform functions displayed in one of the log modes.

3. DSPMESS: to display messages on the screen.

4. GSTOR: ·GRAPHLIB routine used to add 2250 commands to the buffer program.

5. GSVPLOT: *GRAPHLIB routine used to construct the 2250 buffer programs for the graph itself.

6. BUFBINGO: used to write the buffer program into the 2250 buffer.

Format of the 2250 buffer program for graphs:

1. A 2-byte NOP (may be changed to "Defer Light Pen Detects" when used on 2250 model 3)

2. The buffer program for the graph. Absolute

vector mode plotting is used.

3. A 2-byte NOP (may be replaced by "Enable Deferred Detects" on the model 3).

4. ` 4-byte NOP containing the Symbol Table Entry Index (STEI).

Subroutine Description:

1. The parameter tables for the *GRAPHLIB routines are initialized and set up for the vectors to be displayed.

2. If either or both of the vectors is to be displayed in log mode, space is obtained from GETSPACE and the $\log_{10}$ of the appropriate vectors is moved into this space.

3. Three calls are made on *GRAPHLIB to build the first three parts of the buffer program.

4. The STEI is obtained, entered into the 4-byte NOP and the two are added to the buffer program.

5. The buffer program is written to the 2250 with BUFBINGO.

6. The buffer ID is entered into the symbol table.

7. The STEP is entered into the table of displayed graphs.

8. The use count of the temporary is incremented.

9. Return to caller.

Name:

FDGRIDDS

Function:

Constructs the buffer program for the grid, labels, and scale messages.

Calling Sequence:

    OS(I) R-type

    No parameters.

Subroutines used:

1. GSTOR: *GRAPHLIB routine to add 2250 commands to the buffer program.

2. GCGRID: *GRAPHLIB routine to construct the buffer program for the grid.

3. GLABEL: *GRAPHLIB routine to label the axes.

4. GCPRNT: *GRAPHLIB routine used to add the scale messages to the buffer program.

5. BUFBINGO: routine to write the buffer program to the 2250.

Description:

1. The 2250 command to disable light-pen detects is placed in the buffer program.

2. Plot mode is checked and parameters for GCGRID are set up to give the correct mode display.

3. Parameters set up previously by FDSETVAR are used to set up two calls to GLABEL to label the x and y axes.

4. The scale messages are added to the buffer program.

5. The 2250 command to enable switch detects is added to the buffer program.

6. The buffer program is sent to the 2250 using BUFBINGO.

7. The buffer ID of the grid is saved locally.

8. Return to caller.

Function Display: General Organization

The routines previously described are contained in one assembly with two CSECTs (FDADDDS and FDGLOB). FDGLOB is the CSECT to be used as a PSECT and contains the function display global variables.

Entries to the Function Display Routines

The following pages describe the entries FDINIT, FDINTFLT, FDSETVAR, FDFLTBCD, FDMAXMIN, FDERASE, FDCLEAR, and FDSETMOD to the display section of the mathematical analysis package. Thsse routines perform data conversion, set plotting parameters, erase displays, and initialize the function display section.

FDINIT

This routine is called during initialization to enter four operators--PLOT1, PLOT2, SCALE, and SETPLTMD-- into the symbol table (and onto the screen). In addition it calls the initialization point DSPECHO of the numeric and keyboard display section

The characteristics of the four operators initial- ized by FDINIT are as follows:

PLOT1: Has two possible mode combinations:

1. A vector (or the first half of a vector pair) is plotted against the ID vector.

2. A function is plotted (i.e., the first half of the vector pair is plotted against the second half).

PLOT2:   Has two possible mode-combinations:

1. A vector is plotted against another

2. The first half of a vector-pair is plotted against a vector.

SCALE: Requires four operands. These are the REAL*4 coordinates of the lower left and upper right corners of the graph (i.e., the values represented by these corners, which are positioned at fixed points relative to the screen).

SETPLTMD: Requires one REAL*4 or INTEGER*4 operand. This operand is the desired plotting mode number. The routine FDSETMOD, which interprets SETPLTMD, determines from the operand itself without reference to the symbol table whether it is of REAL*4 or INTEGER*4 mode.

The name of the PSECT for FDINIT is (predictably) FDINITPS. This PSECT contains the save area and all ad-cons for FDINIT.

FDSETVAR

This entry initializes or resets various parameters used by the *GRAPHLIB routines for displaying graphs. It examines U1, U2, V1, and V2, which are the scale values of the lower left (U1, V1) and upper right (U2, V2) scale values on the screen and sets the following variables:

ULABAX: the relative position in the V direction of the labels on the U-axis (=V1)

VLABAX: the relative position in the U direction of the labels on the V-axis (=U1)

UGRID:	the scale increment between the grid lines in the V direction (= (U2 - U1)/8)
VGRID:	the scale increment between the grid lines in the U direction (= (V2 - V1)/8)
ULABINC:	the scale increment between successive labels on the U-axis (= UGRID)
VLABINC:	the scale increment between successive labels on the V-axis (= VGRID)
USTRING:	the EBCDIC characters comprising the U-axis labels (c.f., FDFLTBCD)
VSTRING:	the EBCDIC characters comprising the V-axis labels (c.f., FDFLTBCD)

FDSETVAR is called without parameters, since all
necessary information is contained in the control section
FDGLOB. Note that the routine FDFLTBCD may reset ULABINC
and VLABINC to a multiple of their values upon entry.

The PSECT for FDSETVAR is FDSVPSCT. It contains
the save area and a four-fullword area used as a para-
meter list for the two calls to FDFLTBCD.

FDINTFLT

This is a "utility" routine which can be called to
convert a vector of integers (INTEGER*4) to a vector of
floating-point numbers. The REAL*4 results replace the
integers. The calling sequence is

CALL FDINTFLT,(N,X), where

N is the INTEGER*4 number of elements in

X, the INTEGER*4 vector to be converted.

The PSECT for FDINTFLT is FDINTFPS; it contains only the save area.

FDFLTBCD

This routine is called by FDSETVAR to set up the strings of EBCDIC characters which comprise the labels for the function display.

The calling sequence for FDFLTBCD is

CALL FDFLTBCD,(X1,X2,DX,STRING,DIGITS),

where:

X1 is a "starting value" (i.e., the most negative or the least scale value in the U or V direction)

X2 is the "terminal value" (i.e., the most positive or the greatest scale value in the U or V direction)

DX is an increment (i.e., either ULABINC or VLABINC)

STRING is the location of the region into which conversation is to take place

DIGITS is the location of a three-byte region into which the exponent part of a scale-factor is to be placed (c.f., below).

The routine first checks to see whether the values X1, X2, and DX are consistent. If either

       1. $X1 < X2$ and $DX \le 0$

or   2. $X1 > X2$ and $DX \ge 0$

immediate return is made with RC=4. Then DX is reset to $\underline{n} * DX$, where $\underline{n}$ is the least integer such that

$$\frac{56}{\left[\left|\dfrac{X1 - XTOP}{DX}\right| + 1\right]} \geq 6$$

Where $XTOP = X1 + DX[|X1 - X2|/DX]$ and the brackets denote "integer part."

The routine then converts the floating-point numbers $X1$, $X1 + DX$, ..., $XTOP$ to EBCDIC character strings of six characters each, with one of the following edit-patterns:

$$b\pm.ddd$$
$$b\pm d.dd$$
$$b\pm dd.d$$
$$b\pm ddd.,$$

where "b" denotes a blank, and "d" denotes a digit. The successive six-character groups are placed contiguously in STRING. In the field DIGITS the routine places three characters of the form $\pm dd$. These will appear on the screen in the form

$$VERT\ SCALE:*10**(\pm dd)$$
$$HORZ\ SCALE:*10**(\pm dd)$$

to indicate that internal range and domain values are $10**(\pm dd)$ times the values appearing externally in the labels.

FDFLTBCD also returns with a return-code of 4 if it encounters floating-point values below 10^{-74} or above 10^{75}.

The PSECT for FDFLTBCD is FDFLBCPS. It contains the save area and all constants generated by literals.

FDMAXMIN

This routine examines two REAL*4 vectors and assigns values to the plot variables U1, U2, V1, V2 corresponding to the values of the maxima and minima of the vectors X and Y of the calling sequence, which is:

CALL FDMAXMIN,(N,X,Y),

where N is the INTEGER*4 number of elements in (each of) X and Y, and X and Y are the REAL*4 vectors to be examined. FDMAXMIN then sets

$$U1 = \min(X) - 1/4 \, |\max(X) - \min(X)|$$
$$U2 = \max(X) + 1/4 \, |\max(X) - \min(X)|$$
$$V1 = \min(Y) - 1/4 \, |\max(Y) - \min(Y)|$$
$$V2 = \max(Y) + 1/4 \, |\max(Y) - \min(Y)|$$

FDMAXMIN then calls FDSETVAR to reset various global parameters in accordance with the new scale values for the screen corners.

The PSECT for FDMAXMIN is FDMXMNPS. It contains the save area as well as the four-word adcon area for the call to FDSETVAR.

FDCLEAR

This routine is called by the routine which inter-
prets the operator CLEAR, with no arguments. FDCLEAR
inspects the list DSPTAB containing the STEPs of all cur-
rent function-displays. For each non-zero entry, FDCLEAR:

1. Obtains the buffer ID of the display via
    SYMGET DBUF#

2. Deletes the display with a call to BUFBOD

3. Decrements the use-count of the temporary
    symbol via SYMDLE

4. Sets to zero the DSPTAB entry for the deleted
    display.

After all function displays have been deleted, FDCLEAR
deletes the grid display by a call to BUFBOD and zeroes
the contents of GRIDID in the control section FDGLOB.

The PSECT for this routine is FDCLPSCT. It contains
the save area and all adcons.

FDERASE

The routine FDERASE is called by the routine which
interprets the operator ERASE. General Register One must
contain the STEP for the display to be erased. FDERASE
then searches DSPTAB in the control section FDGLOB for
the same STEP. If it finds the STEP of the ERASE oper-
and, this entry in DSPTAB is zeroed, the macro SYMDLE
is executed to decrement the use count, the graph is
erased by a call to BUFBOD, and return is made with RC=0.

If the STEP of the operand cannot be found in DSPTAB, return is made with RC=4.

The PSECT for FDERASE is FDRSPSCT. It contains the save area and all adcons.

FDSETMOD

The chief function of this routine is to store a mode number for the current mode of plotting which is passed by the interpreter as a consequence of the SETPLTMD button-push. The call is

CALL FDSETMOD,(Z)

where Z is the REAL*4 or INTEGER*4 plot mode. FDSETMOD checks to see whether Z is integer or floating-point, and stores it as an integer in the location PLTMODE of the control section FDGLOB.

After storing the plot mode, FDSETMOD calls BUFBOD to erase the current grid, and FDGRIDDS to create a new one.

The PSECT for FDSETMOD is FDSMPSCT. It contains the save area and all adcons.

8.7 BUFFER MANAGEMENT ROUTINES   B.J. Bolas   R.W. McHard

General Layout of Buffer

The initial buffer has a start regeneration timer (GSRT) followed by a transfer (GTRU) to the first order program in the regeneration loop. This generally branches around the "buffer full" message, which is next in the

in the buffer; however, when a call on BUFBINGO or BUFBORE
fails due to insufficient space, this message is linked
into the regeneration loop. Following this message are
three initial GTRUs, one for each type of order program.
Type 0 order programs are those buttons on the periphery
of the screen which are always displayed; Type 1a order
programs are those displays in the central region of the
first screen given to the user; Type 1b order programs
are those displays in the central volatile region of the
screen given to the user when he hits the FLIP

button for the first time. The initial GTRUs point to
the first order program of the corresponding type.
The last Type 0 order program points to the initial 1a
or 1b GTRU, depending upon which screen is the currently
active screen. The last Type 1a and 1b order programs
both point to the GSRT. As indicated shortly, the buffer
is always "packed"; i.e., there are no unused buffer
locations between order programs in the buffer at any
time. To establish properly the linkage within types
of order programs, a GTRU to the next order program of
the same type is tacked onto the end of the order program
when BUFBINGO and BUFBORE are called. The address of
this GTRU is updated by buffer management whenever it
changes (due to a call on BUFBOD or BUFBORE).

Corresponding to each order program in the buffer is a control block with five full-word entries. The control blocks are linked with backward and forward pointers within each type, the linkage corresponding to the linkage of the corresponding order programs in the buffer. The format of these control blocks is as follows:

```
**************************************************
* 1 POINTER TO ITSELF FOR ERROR CHECKING,        *
**************************************************
* 2 BACKWARD POINTER TO PREVIOUS CONTROL BLOCK, *
**************************************************
* 3 FORWARD POINTER TO NEXT CONTROL BLOCK,       *
**************************************************
* 4 ABSOLUTE BUFFER ADDRESS OF ORDER PROGRAM,    *
**************************************************
* 5 BYTE-LENGTH OF ORDER PROGRAM.                *
**************************************************
```

Following is a general description of the internal procedures used in the subroutines in the buffer management package.

BUFINIT

Purpose:

To initialize the image of the buffer during initialization of the system.

Description.

The image of the buffer is a region of storage of length 8K = 8192 bytes. the length of the 2250 buffer. At initialization, certain necessities, such as a start regeneration timer, a message indicating that the buffer is full (which is displayed only when appropriate), and

transfers to order programs to eventually be inserted, are put into the image.

Entry:

No parameters are passed.

Exit:

GR1 has the storage address of the buffer image.

GR15 has return code 0.

Note:

BUFINIT is called by BUFINIT1.

BUFBINGO

Since the buffer is always packed (see below), the decision as to whether or not the buffer has sufficient space for the order program reduces to a comparison of its length against the difference between 8192 and the next available buffer address. If there is sufficient room in the buffer, the order program is moved into the buffer at the next available buffer location, and is linked into the regeneration loop for order programs of its type. If there is not sufficient room in the buffer, then a message to that effect is displayed to the user. To guarantee that there is always room for this message, it is resident in the buffer after initialization, but is normally not linked into the buffer display-regeneration loop.

BUFBOD

When an order program is deleted, the buffer is "packed" by moving all order programs (if any) following the deleted order program in the buffer (with higher absolute buffer addresses) into the region vacated by the deletion of the order program. This was designed to alleviate the problem of deciding whether an order program passed by BUFBINGO or BUFBORE can be inserted into the buffer. See the section on recommendations for the future for an argument against using this scheme.

Note: One obvious implication of this buffer-packing scheme is that linkage of order programs within their respective types is monotonic with respect to absolute buffer addresses. In other words, each order program branches to an order program with a higher absolute buffer address (except the ones at the end of the loops, which branch to appropriate locations in the initial buffer).

BUFBORE

The new order program is inserted at the same absolute buffer address as the old order program, if there is room. If not, the message that the buffer is full is linked into the regeneration loop. To insert the new order program, first all order programs with higher buffer addresses are moved to leave a hole just the right size for the inserted order program. Thus the buffer remains packed.

Note: BUFBORE inserts the new program into the
loop for the same type as the old program. Thus BUFBORE
implicitly assumes that the new order program will be
of the same type as the old order program. (It is specu-
lated that all such calls will involve only Type 0 order
programs, since BUFBORE is strictly a system-generated
call; however, BUFBORE will work for any type, as long
as both the inserted order program and the deleted order
program are the same type.)

BUFFLIP

The last Type 0 GTRU (transfer instruction) points
always to either the initial Type 1a GTRU or the initial
Type 1b GTRU. A call on BUFFLIP (i.e., a light-pen hit
of the FLIP button by the user) merely switches this
last Type 0 GTRU to point to the Type 1b loop instead
of the Type 1a loop, or vice versa.

It is now felt that the scheme of always packing
the buffer is inefficient and wasteful of CPU time, and
that instead the buffer should be packed only when there
is no space in the buffer big enough for insertion of
the order program. Then extra information is needed by
buffer management in order to keep track of the portions
of the buffer currently available. Given this informa-
tion, the most efficient method of buffer management is
to search the list (in whatever form kept) for the small-
est space large enough for the order program, while

accumulating the total available space in the same pass.
Then, if a space is found, the order program is moved
into that space. If no space is found, the accumulated
length is compared against the length of the order pro-
gram (allowing, of course, for the 4-byte GTRU which
buffer management tacks onto the end). If the order
program is no larger than this accumulated length, then
the buffer is packed (entirely) and the order program
is inserted. If the total space is not large enough for
the order program, then no packing takes place and the
user is notified that the buffer is full. This scheme
can obviously be extended to keep (again in a one-pass
search) a record of partial cumulative space-lengths
for spaces which are consecutive (no other space regions
in between) in the buffer. Then, for example, even if
no one free buffer region is sufficiently large for the
insertion of the order program, there may be two regions
separated by order programs which together may be large
enough for the order program. Then only this block of
order programs needs to be packed, combining the two small
free regions into one larger free region. This eliminates
the need to pack the entire buffer, and can easily
be extended to three or more consecutive regions.

The new information needed could easily be incorpor-
ated into the current control-block structure. Restruct-
ure the control blocks as follows:

```
* * * * * * * * * *
*     1       *
* * * * * * * * * *
*     2       *
* * * * * * * * * *
*     3       *
* * * * * * * * * *
*     4       *
* * * * * * * * * *
* 5a * 5b *
* * * * * * * * * *
```

Here 1 points to itself if the control block repre-
sents an order program, and is 0 if it represents a re-
gion of space; 2 is a backward pointer as before; 3 is
a forward pointer as before; 4 is a forward pointer to
the control block to the next region (allocated or not,
running through all types); 5a is the absolute buffer
address; and 5b is the length of the region.

Then there are four linked lists--one for each type
of order program, and one for blocks of available space.
The linkage is accomplished by the backward and forward
pointers in words 2 and 3 of the control block. For
control blocks representing order programs, the linkage
corresponds to the linkage of the corresponding order
programs in the buffer; for control blocks representing
unallocated regions in the buffer, any convenient scheme
(such as monotonicity with respect to absolute buffer
addresses) can be used. The main utility of the thread
linking all control blocks in word 4 is that the linkage
of order programs within their respective types is

not necessarily monotonic under this scheme, and up-
dating the linkage in the buffer after packing is greatly
facilitated by such information.

One last recommendation for future work on buffer
management is that the FLIP concept can be generalized
with very little difficulty. Allow any convenient number
of screens to the user, acquiring each by GETSPACE as
the user defines it (the first is by necessity defined
by the system during initialization). When defined, the
initial buffer is established. Only Type 0 programs are
in any image besides the volatile type peculiar to the
screen. This has the immediate advantage of not wasting
buffer space with order programs which often lie dormant
in the buffer, not being linked in the regeneration loop.
A table is maintained which indicates the storage address
of each defined image. To save the need for updating
the Type 0 order programs in every image as they change,
an "image" of Type 0 order programs only could be main-
tained. Then, when a user switches to a different screen,
see if the new Type 0 order programs will fit in with
the old Type 1 order programs. If not, link in the
message to the user that this particular screen is full;
otherwise, proceed as usual.

The user could specify a new screen by a hit of a
parameter followed by a hit of the FLIP button, for
example:

3 FLIP

If 3 was specified for the first time, this defines a
new screen. If 3 was previously specified, switch to
it as usual. If the user wishes to create several
screens, it would be wise for him to be able to create
a catalog of screens and their uses, and put that on a
separate screen. (It is not clear that he can do this
with the system as it now stands.)

Buffer Management

Name:	BUFINIT1
	BUFINIT2
Purpose:	To initialize Buffer Management.
Calling Sequence:	OS type I.
Entries:	Neither entry takes parameters.
Exits:	RC=0 only.
Subroutines called:	BUFINIT, SYMOPDEF, GOPEN.
Other external symbols:	BUFDCB, BUFPOLST. The locations of the graphic DCB and poll list; for use by Light Pen Management.

Usage:

BUFINIT1 must be called before calling any other
Buffer Management entry (which implies that it must come
early in the initialization sequence). It does not re-
quire that any other section be initialized. BUFINIT2
assumes that SYMOPDEF and the routines it calls are

already initialized, and that Light Pen Management is
ready to receive interrupts.

Description:

BUFINIT1 turns off Light Pen Management's interrupt
switch (LPMISW), calls GOPEN to open the 2250 display
and initialize the data control block (DCB), and calls
BUFINIT to initialize the rest of Buffer Management.
BUFINIT returns the address of the main storage graphic
output area (an "image" of the device buffer); this is
saved for use by BUFWR.

BUFINIT2 calls SYMOPDEF to enter the FLIP operator,
turns LPMISW on, and returns.

Name:	BUFBINGO
Purpose:	To insert an order program into the buffer to be displayed on the 2250.
Description:	The order program is linked into the buffer display-regeneration loop if there is sufficient room. If not, an error message resident in the buffer is linked into the regeneration loop. The linkage is in terms of the type of the order program to be inserted. System entities such as the virtual keyboard, the echo line, and system-defined buttons are

always displayed, as are all
user-defined buttons. All other
user-defined displays are displayed
on the current screen, but disappear
when the FLIP button is hit (and re-
appear when the FLIP button is hit
again).

Entry: GR0 = 0 if the order program is sys-
tem-defined or a user-defined button.
GR0 is nonzero otherwise.
GR1 has the storage location of the
order program to be inserted, the
first halfword of which contains the
byte-length of the remainder ("body")
of the order program.

Exit: GR15 = 4 if there is insufficient
room in the buffer for the order pro-
gram. In this case, the user is noti-
fied that the buffer is full.
GR15 = 0 if the order program was
inserted into the buffer.
GR0 contains the buffer ID for the
order program if it was successfully
inserted into the buffer.

Note: BUFBINGO calls BUFWR to write the buffer
from the image.

Name: BUFBOD

Purpose: To remove an order program from the buffer
                display-regeneration loop.

Entry: GR0 contains the buffer ID returned from the
                BUFBINGO call which inserted the order program
                into the buffer.

Exit: GR15 = 0 normally.

                GR15 = 4 if the buffer ID does not turn out
                to be one. This indicates a snark in our
                system. In this case, nothing is done.

Note: BUFBOD calls BUFWR to write the buffer from
                the image.

Name: BUFBORE

Purpose: To replace an order program in the buffer
                with another order program.

Description: This is strictly a system-generated call.
                Since the new order program is likely to
                be longer than the old order program, it is
                important to know that the new order program
                will fit into the buffer before deleting the
                old order program. This is not done if con-
                secutive calls on BUFBOD and BUFBINGO are
                used.

Entry: GR0 has the buffer ID returned from the
                BUFBINGO call which inserted the original

order program into the buffer.

GR1 has the storage address of the order
program which is to replace the old order
program. This order program has the same
format as for the call on BUFBINGO.

Exit: GR15 = 4 if there is insufficient room in
the buffer for the new order program. In
this case, the original order program is
not deleted, and the user is notified the
the buffer is full.

GR15 = 0 if there was sufficient room in
the buffer for the new order program.

GR0 contains the same buffer ID passed to
it, which serves as the buffer ID of the
new order program, if the operation was
successful.

Note: BUFBORE calls BUFWR to write the buffer
from the image.

Name: BUFFLIP

Purpose: To switch between the volatile graphic portion
of the three screens available to the user.

Description: BUFFLIP supports the immediate operators
SCREENA, SCREENB, SCREENC which are system-
defined buttons on the screen. All system
entities and user-defined buttons are always

displayed.

Entry: GR1 contains pointer to SCREENA, SCREENB, or
             SCREENC identifier.

Exit: GR15 = 0 always.

Note: BUFFLIP calls BUFWR to write the buffer
             from the image.

Name: BUFWR

Purpose: To write a composite order program to the
             2250 display and start regeneration.

Calling Sequence: OS (I) R type.

Entry: GR0 contains the length of the order program
             to be written from the output area.

Exit: RC = 0 only.

Subroutines called: GIOCR.

Description: BUFWR uses the length given in GR0 unless
             this is zero, in which case it uses the
             last nonzero length given. BUFWR puts the
             necessary information into a data event
             control block (DECB), calls GIOCR to write
             the specified length from the output area
             to the display buffer, and returns.

Note: If the Mathematical Analysis Program is
             re-entered after an interlude in MTS, the
             "restart" sequence should call BUFWR with
             Length=zero. This will re-establish the
             correct order program in the display buffer,
             and start it.

Additional Notes

All Buffer Management initialization is completely dynamic. Therefore, a "restart" package could re-initialize Buffer Management by calling BUFINIT1 and BUFINIT2.

MTS support for the 2250 (*GRAPHLIB) uses modified routines from IBM OS Graphic Access Method (GAM). These routines have been further modified especially for this Communication Sciences 673 project. In particular, the SETANLZ routine has been added, primarily for Light Pen Management. One feature has been added for Buffer Management: When SETANLZ restarts the display after an interrupt, it takes the buffer restart address (BRSA) from the DCB, for use in the Set Buffer Address Register and Start channel command. This address is placed in the DCB by GIOCR for each Read & Start or Write & Start operation. This ensures that display regeneration will always begin where Buffer Management last specified.

8.8 THE MACRO PROCESSOR

The Macro Processor handles the definition and calling of macros. Its entry points are as follows:

Entry Point	Purpose	External symbols or macros referenced
MACDINIT	part of initialization, called internally by MACROFIX	SYMCRE
MACDSCT	simulated PSECT	

MACRODEF	define a new macro	GETSPACE, SYMREF, DSPMESS,SYMODEFD
MACDELET	delete a macro	FREESPAC
MACROGET	returns the next STEP in a macro expansion	DSPMESS, SYMGET
MACROFIX	initializes the Macro Processor	SYMCRE, DISPNEWNM, MACDINIT
MACROINT	initializes a call upon the MP	DSPMESS, SYMGET
MAC2PSCT	simulated PSECT	
MDEF	simulated PSECT	

Internal specifications

1. The interpreter calls MACRODEF with GR1 pointing to the beginning of the definition and GR0 containing its length (i.e., the number of button pushes, exclusive of the DEFMACROs):
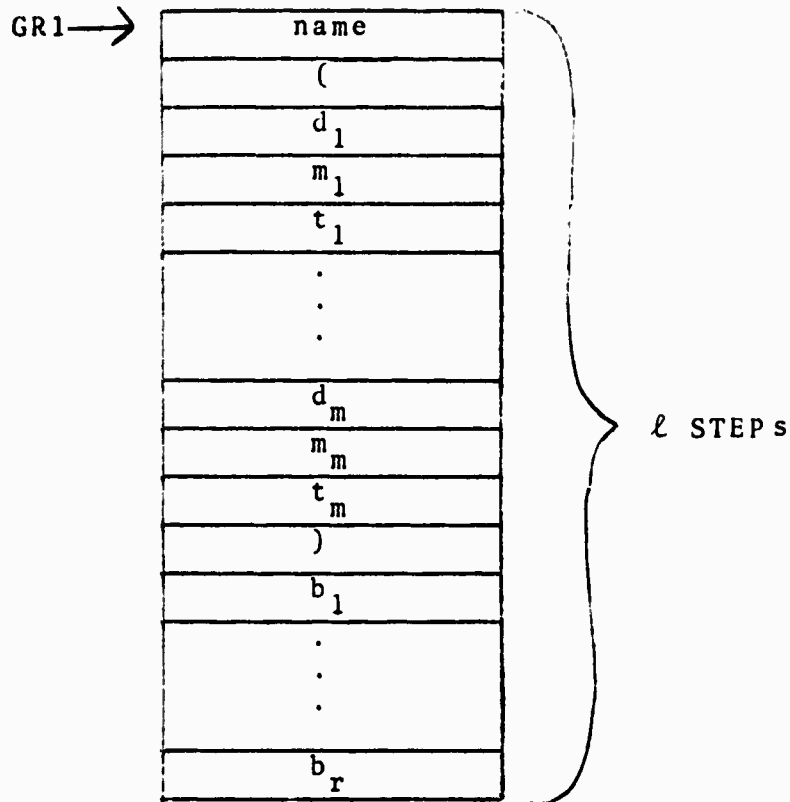
Figure 8.8.1 Storage of a Macro Definition by Interpreter
,GR0 contains the number of STEPs (ℓ)

All editing is done prior to this call by the inter-
preter.

2. The Macro Processor will create the DOPE vector for
"name" in the same format as that for operators (see
Section 8.2). The first parameter in the "skeleton"
will indicate the number of calling parameters,
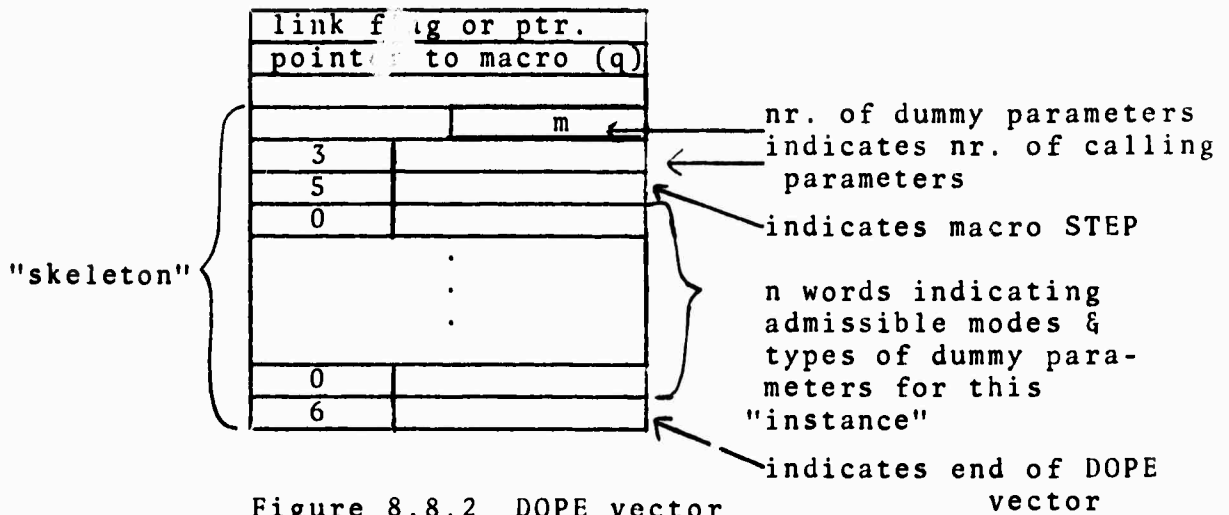then the macro STEP, then the operands:

Figure 8.8.2   DOPE vector

3.   The Macro Processor will increase the use count for each distinct dummy parameter STE and for the macro STE.
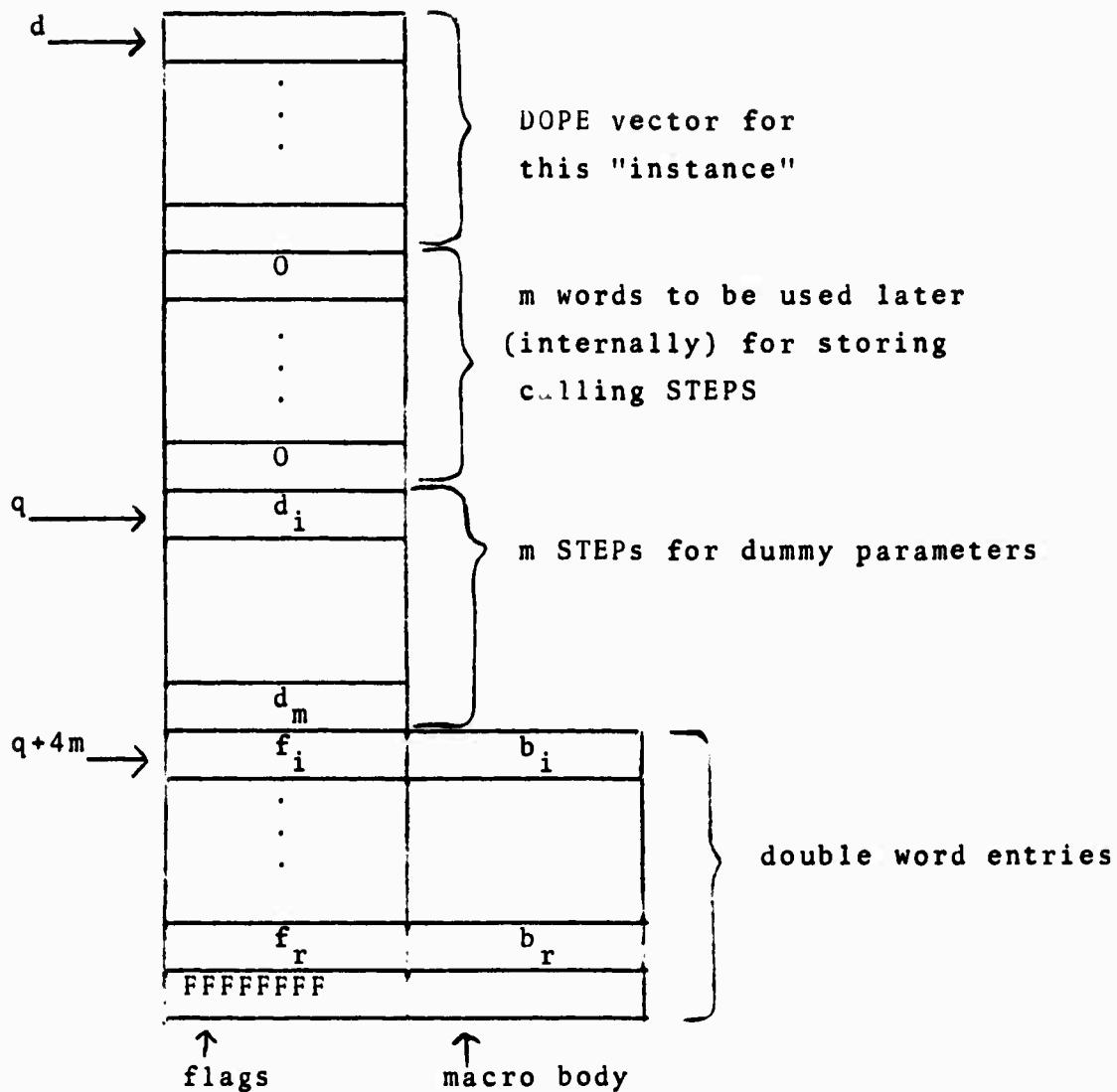
4.   Using GETSPACE, the MP stores a macro as follows:

Figure 8.8.3   Final Storage of a Macro Definition.

where

b_i is the STEP corresponding to the button push
b_i.

f_i is a flag for the ith STEP b_i:

when b_i is not a dummy STEP, $f_i = 1$

when b_i is a dummy STEP, for d_k, then
   $f_i = 4(k-1)$

the last entry is signaled by a flag of
hexadecimal FFFFFFFF, as shown, and has
no corresponding STEP.

5.   Return Codes (in GR15)

If there is any error in the definition, an error
message is displayed, and control is returned to
the interpreter with a return code of 4.   In this
case, it is just as if the macro had never been
defined.   The user may then redefine the macro.

Displaying a Macro

Figure 8.3.3 indicates how a macro is stored.   The m
dummy STEPs start at location q.   Both m and q can be
obtained from the DOPE vector for the macro by noting
that the second word of the dope vector contains q and
the 12th and 13th bytes (i.e., one half-word) contain
the number of dummy parameters plus 7, i.e., (m+7) (see
Section 8.2, Interpreter).   Thus, if GR15 had the pointer
to the DOPE vector,

              L   GR,4(GR15)
              LH GS,10(GR15)

would load GR and GS with q and M+7, respectively.

The macro body then starts at location q+4m as double word entries. The first word of each entry is a flag, the second a STEP. The only flag the display need consider is hexadecimal FFFFFFFF, which signals the end of the macro body (and which has no STEP).

Deleting a Macro

A.   External specifications

A macro is deleted as follows:

name DELBUTON

where name is the name of the macro to be deleted. All "instances" of the macro will be deleted.

B.   Internal specifications

1.   The interpreter calls upon the MP via entry MACDELET. The MP then FREEs all SPACs associated with storage of the macro, including DOPE vectors. It also decreases the use count for the macro and for each distinct dummy parameter.

2.   The interpreter will see to it that the macro button is no longer displayed.

Initializing the MP

The MP is initialized via entry MACROFIX, which requires no parameters (except a save area pointer in GR13). In addition to internal initialization, the MP creates the buttons MACRO and OPERATOR and indicates that they are to be displayed.

Calling a Macro

Internal specifications

1. The calling mechanism for a macro is very similar
    to that for an operator. After doing any necessary
    editing, the interpreter calls upon the operator
    processor indicating an operator or macro has been
    encountered. If the operator processor determines
    that it is a macro, it calls MACROINT to initialize
    the call, giving it a pointer in GR1 to a parameter
    list (specified in the DOPE vector skeleton), as
    follows:

GR1 ⟶
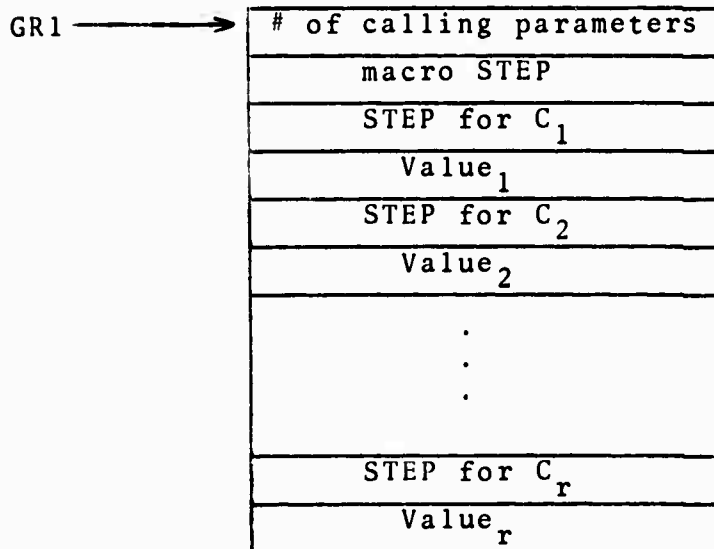| # of calling parameters |
|-------------------------|
| macro STEP |
| STEP for C_1 |
| $Value_1$ |
| STEP for C_2 |
| $Value_2$ |
| . |
| . |
| . |
| STEP for C_r |
| $Value_r$ |

Figure 8.8.4   Parameter List to MACROINT

2. After the MP returns to the operator processor, the
    OP indicates to the interpreter that subsequent
    "button pushes" are to come from the MP, and returns
    control to the interpreter.

3. The interpreter calls entry MACROGET for subsequent STEPs, which are returned one per call in GR0. When the MP has no more STEPs to return, it returns a 0 in GR0. If MACROINT is called before a 0 has been returned by MACROGET, the MP will handle the appropriate nesting. A 0 is not returned until all nesting has been "popped" and the last macro has been returned.

4. Return codes (in GR15)

   a. 0 - normal return from MACROINT or MACROGET

   b. 4 - too few calling parameters, with undefined values (in MACROINT); fatal error. The MP displays the error message

   c. 8 - nesting level exceeds 500 in MACROINT; fatal error. The MP displays the error message

   d. 12 - debugging error for MACROINT or MACROGET: in the former, a negative number of dummy or calling parameters was encountered; in the latter, MACROGET was called when it had not STEPs to return; in either case, an appropriate message is displayed.

8.9   MATHEMATICAL OPERATORS   Ross H. Hieber

   8.9.1   Program Logic

   The assembly code CSECTs are:

UINIT - The math operator's initialization section, con-
        taining the SYMODEFS.   Completely reentrant-
        compatible, and uses OS macros.

UINIT# - The "PSECT" for UINIT.

UINIT2 - This is called by UINIT and is logically equivalent
        to a subset of UINIT, but is a separate CSECT to
        allow assembly of new SYMODEFS without reassembling
        everything; currently contains the scalar-vector
        mode combinations for the arithmetic operations.
        It uses UINIT# PSECT.

USTEP - Used as a function by FORTRAN functions to return
        in GR0 a STEP from the parameter list, needed to
        tell the operator call section of the interpreter
        what operand to put on the stack.   No PSECT is
        needed.

   The FORTRAN functions (subroutine for = since it needn't
return a STEP in GR0) are intermediaries between the inter-
preter and FORTRAN library functions in most cases.   Most
of the intermediary FORTRAN functions are multiple entry,
and there are several separate functions to allow addition
of features without recompiling everything.   These inter-
mediate functions are needed to loop over the dimension,
sometimes to check for arguments out of range with IF state-
ments, and to return a STEP in GR0.

8.9.2 Nonfatal Handling of Arithmetic Errors

FORTRAN IF statements are used where appropriate to check for arguments illegal (too large, etc.) to FORTRAN library functions. A true zero is returned for any element of a vector which can't be calculated. Zero is used because i) this is most obvious on the graph, ii) it can never cause trouble in later operations. A few possible arithmetic errors not checked are exponent overflow and underflow, and $|argument| > 2^{50} \cdot \pi \sim 10^{15}$ to SIN & COS. The overhead for this approach of checking with IF statements would be intolerable in a batch FORTRAN program doing massive calculations, but it is quite practical where the arithmetic calculations are a minor part of the total time and storage.

8.9.3 Allowable Mode Combinations and Automatic Mode Conversion

Here we come to the weak point of the current implementation. Handling all possible mode combinations requires massive numbers of SYMODEFS and entries (e.g., 16 combinations each for +,-,*,/,** to handle vector-scalar and real*4-integer*4; and it goes up exponentially if we add vector-pair, complex, real*8, etc.). I have extended my original set to accept what now seems to be the vast majority of common needs, as described below.

1. Vector-pairs: Any vector input argument can also be vector-pair, with only the range used. No additional SYMODEFS or instances are needed. This allows using a graph as an operand.

2. In the rare cases where the other operators can't handle the modes, = can always be used first to convert since it will handle all 16. This takes 16 SYMODEFS, i.e., 16 instances, but fewer entries since (real real =) can be combined with (int int =), and (vec vec =) with (vec scalar =).

3. +,-,*,/,**: These take two arguments, of which either both are vector-real*4 (or vector-pair, of course), or else one only may be scalar-real or scalar-integer. I added the scalars by request since such operations as (3 ID *) are very common.

4. All other operators: Will accept vector(-pair) only.

5. **: FORTRAN's ** library functions will not accept (negative base) ** ($\neq$0 real power) even though a real power of integer value is well-defined. Since DEFCONST produces a real scalar to use as exponent, and present vector exponents are all real, I've glitched the two applicable FORTRAN function entries. If the exponent is integer value within 1 part in 10^6 I use (negative real base) ** (integer exponent).

8.9.4 Meaning of Vector-Scalar Combinations

For +,-,*,/,**: Modes are for the 2 input arguments.

1. Vector vector: The calculations are done and stored in the temporary element by element (as scalars for

each element).

2. Vector scalar: The scalar is used as if it were a constant vector, with vector temporary output.

3. Scalar scalar: This could produce a scalar temporary output, but a constant vector output was preferred to avoid later mode problems with vector-only operators that use this temporary as an input argument.

For =:

Equals is unique in not producing a temporary; it gets its output operand from the stack with predefined mode.

1. Vector-vector: Obvious, just copied over.

2. Vector in, scalar out: The first element of the vector is copied into the output.

3. Scalar in, vector out: Produces a constant vector out, currently necessary as the only way to get constants to some operators.

4. Scalar in, scalar out: Obvious to the meanest intelligence.

In summary, the most commonly needed mode combinations are provided. A policy of always producing vector-real temporaries as output is followed to avoid mode problems with subsequent operators.

8.9.5 Notes on Other Operators (Not Calling FORTRAN Library)

1. INTEG, INTEG2, DIFF, DIFF2:

INTEG and DIFF integrate and differentiate the one vector argument versus the standard domain; INTEG2 and DIFF2 use the same routines but take the domain from the stack. DIFF uses divided differences between adjacent elements of the vectors, i.e., a 2-point formula, with no attempt at smoothing. Since this produces one less output element than the dimension, the last element is set equal to the second last; the expected jiggle on the last n points after $\dfrac{d^n}{dx^n}$ is no worse than the noise over the whole domain due to this crude method. Attempted division by ~0 gives 0 out for that elt. INGET uses trapezoidal integration, i.e., a 2-point formula; for the additive constant I set the first element = 0. The trapezoidal integration, though crude, works nicely within our resolution and has the advantage of being compatible with the differentiation.

8.10 UTILITIES   Daniel R. Frantz

General Description

The basic idea behind the numeric conversion sub-group is to provide a limited subset of the IOH360 input/output operations so that the large core requirements of IOH360 can be reduced. To this end, three subroutines were written: floating point input, floating point output, and integer output. The input routine accepts a number in standard FORTRAN format E-type notation and coverts to a

REAL*4 internal representation. The output routines produce either an I14 or EO.6.14 formatted character string from an internal form of INTEGER*4 or REAL*4, respectively.

All routines use OS (I) S type calling sequences and do their best to simulate CSECT/PSECT reentrancy requirements to facilitate future conversion to TSS.

The current design of the system states that the input routine is called only by the interpreter and that the output routines are called only by numeric display, although this is not a limitation. These routines do not call any lower level subroutines.

Limitations and Future Work

The mathematical analysis system as designed by the Communication Sciences 673 class provides the option of expanding the type of numbers used to include REAL*8 and INTEGER*2. The current routines don't handle these formats explicitly in themselves, but obvious simple manipulations by the calling programs should be able to provide at least usable results (i.e., converting short integers to long before output, and zeroing the low-order word on short input to simulate long input).

If the decision is made to go ahead on the alternate number form, the calling sequences for output should probably be expanded to include a parameter indicating long or short forms. To make things neater, this parameter could

also be extended to be a four-way switch (simulating the interpretive abilities of IOH360) on the form of the output so that there would be only one output routine name rather than the two currently used. The output routines would have to be changed very little to provide this extra capability. The input routine currently converts numbers to the long form and then truncates before returning so that the changeover for this routine would be even simpler.

Mode and Structure Operators

The Numeric Conversion subgroup also programmed the operators VECTOR, SCALAR, REAL, and INTEGER. These operators enable the user to declare the mode (REAL or INTEGER) and structure (VECTOR or SCALAR) of a variable-length list of symbols. Additional operators of this sort for future expansion (e.g., COMPLEX or VCTRPAIR) can be added to the routine very simply by inserting a call to an internally defined macro. The label field or the call should contain the subroutine entry name, and the single macro parameter is the name of the symbol table mode bit to be set. The symbol table macro calls to set up the light buttons, operator definitions, and parameter list structures are made in the initialization section.

CONVERT A FULL-WORD INTEGER TO EBCDIC

Name: NCINT

Purpose: To convert a long-form integer (INTEGER*4)
                    to an EBCDIC string of characters in format
                    I14.

Calling Sequence: OS (I) S type.

Entry: GR1 contains the address of a list of
                    adcons:
                    1. A(full-word integer to be con-
                        verted)
                    2. A(14-byte region for I14 EBCDIC
                        string output)

Exit: No return code.

Note: No other subroutines are called.

Algorithm: The number is divided by successively
                    smaller powers of 10 (decimal). The
                    quotient is used as the next lower digit
                    and the remainder is used in the next
                    step. Leading zeros are converted to
                    blanks.

CONVERT SHORT FLOATING-POINT NUMBER TO EBCDIC

Name: NCFPT

Purpose: To convert a short-form floating-point
                    number (REAL*4) to a string of characters
                    in format E0.6.14.

Calling Sequence: OS (I) S type

Entry: GR1 contains the address of a list of
                    adcons:

                    1. A(short-form floating-point number
                       to be converted)
                    2. A(14-byte region for E0.6.14 EBCDIC
                       string output)

Exit: No return code.

Note: No other subroutines are called.

Algorithm: Reduce the number to one of form (hexa-
                    decimal exponent=0) (mantissa normalized)
                    by multiplying by 10 or 0.1 if the hexa-
                    decimal exponent is less than or greater
                    than zero, respectively, keeping track
                    of the number of multiplications and the
                    sign generated (negative and positive,
                    respectively). This number is the tenta-
                    tive decimal exponent. The mantissa, M,
                    is then of the form $1/16 \leq M < 1.0$. This
                    number is converted to a decimal fraction
                    by successive multiplications by 10(decimal)
                    and taking the overflow past the decimal
                    (rather, hexadecimal) point as the base ten
                    number to the right of the point, in
                    successively lower positions. If the
                    first digit so generated is zero, decrease
                    the decimal exponent by one.

CONVERT SHORT FLOATING-POINT NUMBER TO EBCDIC

Name: NCFPT

Purpose: To convert a short-form floating-point
                     number (REAL*4) to a string of characters
                     in format E0.6.14.

Calling Sequence: OS (I) S type

Entry: GR1 contains the address of a list of
                     adcons:

  1. A(short-form floating-point number
     to be converted)
  2. A(14-byte region for E0.6.14 EBCDIC
     string output)

Exit: No return code.

Note: No other subroutines are called.

Algorithm: Reduce the number to one of form (hexa-
                     decimal exponent=0) (mantissa normalized)
                     by multiplying by 10 or 0.1 if the hexa-
                     decimal exponent is less than or greater
                     than zero, respectively, keeping track
                     of the number of multiplications and the
                     sign generated (negative and positive,
                     respectively). This number is the tenta-
                     tive decimal exponent. The mantissa, M,
                     is then of the form $1/16 \leq M < 1.0$. This
                     number is converted to a decimal fraction
                     by successive multiplications by 10(decimal)
                     and taking the overflow past the decimal
                     (rather, hexadecimal) point as the base ten
                     number to the right of the point, in
                     successively lower positions. If the
                     first digit so generated is zero, decrease
                     the decimal exponent by one.

DECLARE MODE OR STRUCTURE OF SYMBOLS

Name: NCREAL
                        NCINTGER
                        NCSCALAR
                        NCVECTOR

Purpose: To call symbol table management for the
                        purpose of setting mode bits in the de-
                        finition of a variable length list of
                        symbols.

Calling Sequence: OS (I) S type.

Entry: GR1 contains the address of a list of
                        adcons:

             1.   A(number of pairs of words in follow-
                     ing list=n)
             2.   STEP (Symbol Table Entry Pointer) of
                     the first symbol.
             3.   Value of the first symbol (from STE)
             4.   STEP of the second symbol
             5.   Value of second symbol
             . . .
             2n.   STEP of last symbol in list
             2n+1.   Value of last symbol in list

Exit: No return code.

Notes: 1. The form of the user call on these oper-
                       ators during a run is to "push" the
                       following succession of buttons (e.g.,
                       for SCALAR):
                       (VAR1 VAR2 VAR3 ... VARn) SCALAR
                   2. The value words in the parameter list
                       are not used or needed, but are provided
                       as part of the generalized operator
                       calling sequence.
                   3. The symbol table macro calls to set up
                       the light buttons, operator definitions
                       and paramater list structure are made in
                       the initialization section.
                   4. Subroutine called: SYMSMS.

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
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13. ABSTRACT

MOMS--Michigan's Own Mathematical System--provides a facility for interactive, computer-aided mathematical investigations. The system runs on an IBM 360/67 under the Michigan Terminal System (MTS). An IBM 2250 Graphic Display is used for input and output. This report contains a user's manual as well as detailed documentation of the system organization and resulting modules. Sections on the relation between MOMS and the operating system are also included.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
computer-aided mathematics computer graphics IBM 360/67 IBM 2250						