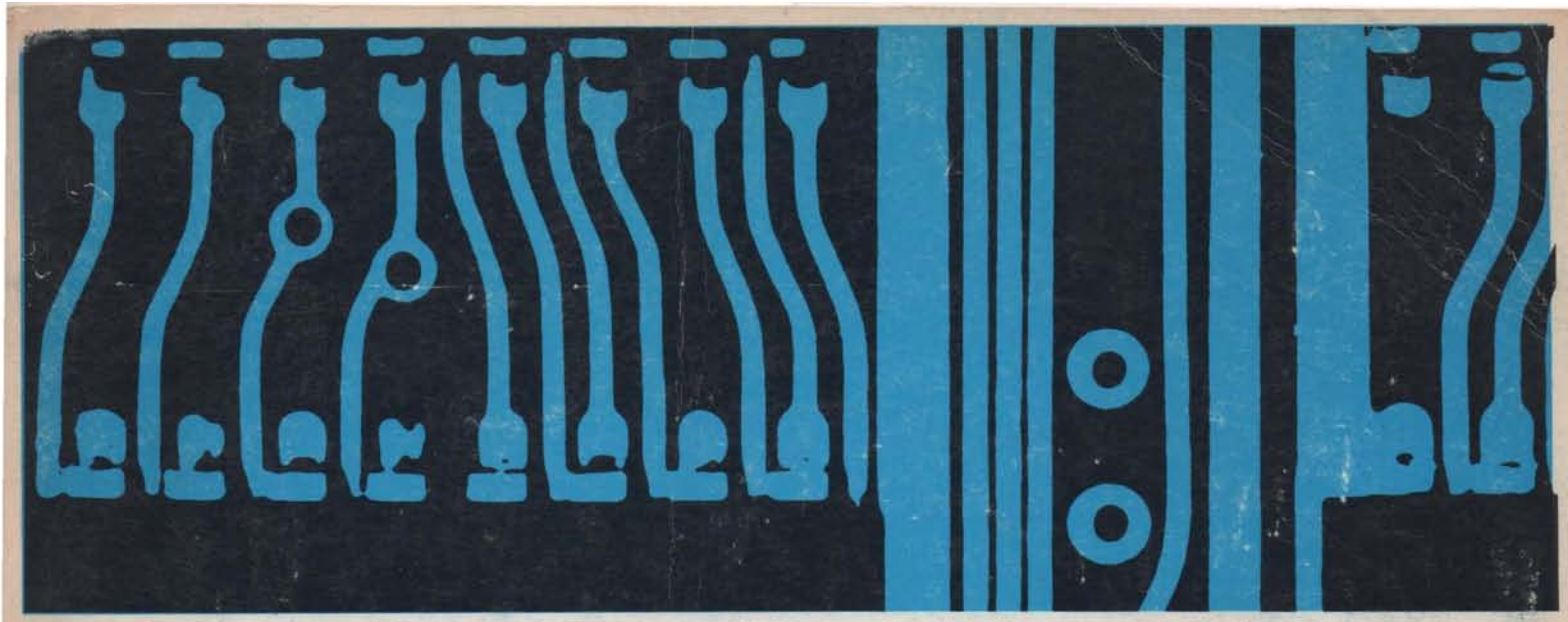
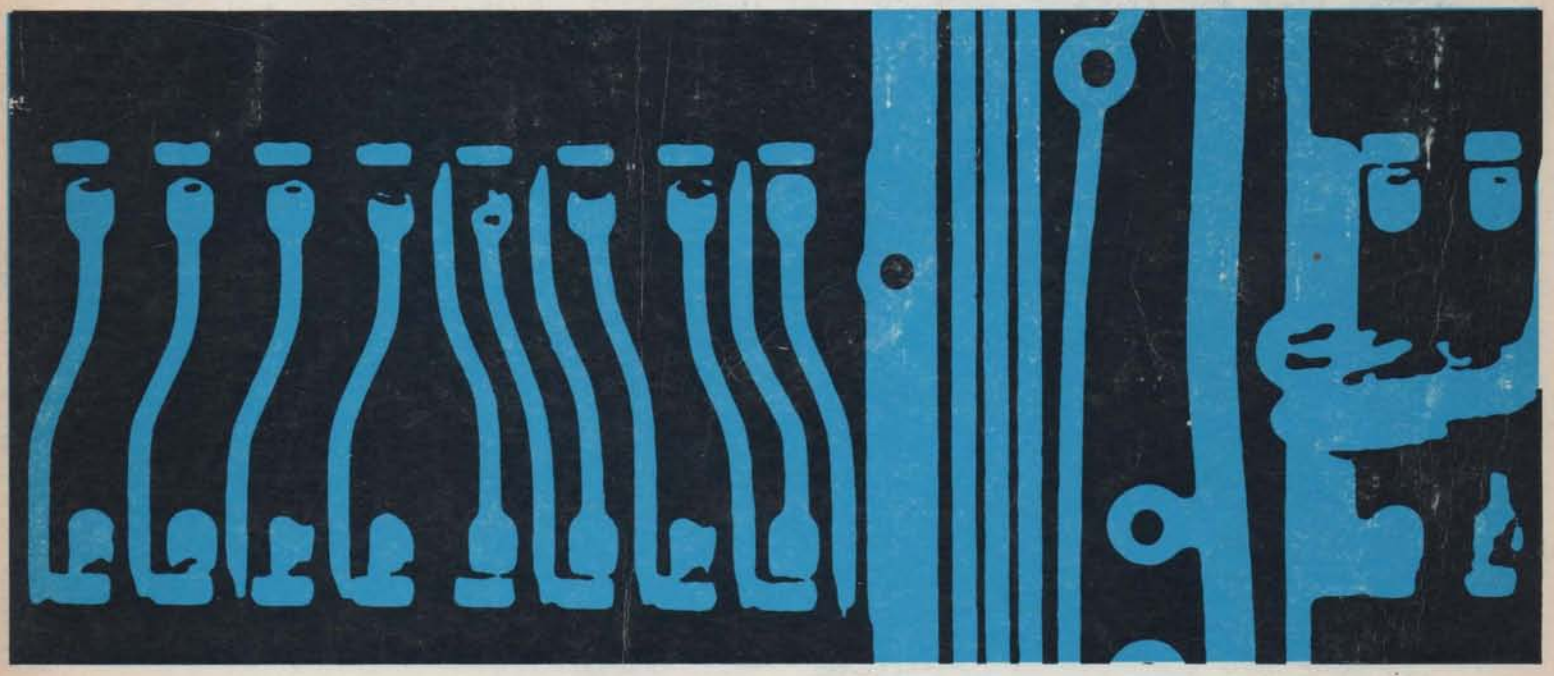


# SCELBAL



## A HIGHER LEVEL LANGUAGE FOR 8008/8080 SYSTEMS

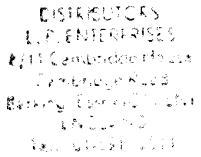
SCELBI COMPUTER CONSULTING INC.

# SCELBAL - A HIGHER LEVEL LANGUAGE FOR 8008/8080 SYSTEMS

BY

Mark Arnold
and
Nat Wadsworth





IMPORTANT NOTICE

The authors wish to thank the following members of the staff at Scelbi Computer Consulting, Inc., for their dedicated assistance in the preparation of this publication:

Robert Findley
Raymond Edwards
Ms. Gabrielle Tingley

SCELBAL - A HIGHER LEVEL LANGUAGE FOR 8008/8080 SYSTEMS

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TABLE OF CONTENTS

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## NOTES

In the assembled listings the contents of address locations 01 272 through 01 303 as presented on page 4 in chapters 12 and 13 should be changed to contain the following data.

| | | |
|---|---|---|
| 01 272 | 004 | (cc) for SAVE |
| 01 273 | 323 | S |
| 01 274 | 301 | A |
| 01 275 | 326 | V |
| 01 276 | 305 | E |
| 01 277 | 004 | (cc) for LOAD |
| 01 300 | 314 | L |
| 01 301 | 317 | O |
| 01 302 | 301 | A |
| 01 303 | 304 | D |

These locations were incorrectly identified in the listing as being part of the Arithmetic Stack and a temporary storage location for the FPACC. Failure to make the above corrections in the listings will result in the program being unable to correctly respond to a SAVE or LOAD executive command directive.

## PATCH NR. 1

The following patch is recommended to correct a condition in the floating point addition subroutine. If the patch is not installed, small mathematical errors may be introduced into calculations (in the order of 10 to the minus seventh power) under certain conditions. These errors are caused by residue left in the FPOP (Floating Point OPerand) extension byte. The patch clears the FPOP extension byte when it is used by the portion of the FPADD subroutine labeled SHACOP.

To correct the source listing make a note in chapter ten on page 6 that two instructions:

```
LLI 133
LMI 000
```

should be inserted between the second and third lines of the subroutine labeled SHACOP.

To implement the correction for the assembled listings of the program provided, it is recommended that the first two instructions of the subroutine labeled SHACOP be changed to read:

```
SHACOP,  CAL PATCH1
         LAA
```

PATCH1 may be inserted starting at location 000 on page 30 in the assembled versions. Making this change to direct the program to the patch would result in the 8008 listing shown on page 48 of chapter 12 in the vicinity of the label SHACOP to appear as:

```
20 341  106 000 030   SHACOP,  CAL PATCH1
20 344  300                    LAA
```

Similarly, the 8080 version listing on page 48 of chapter 13 would appear as:

```
20 341  315 000 030   SHACOP,  CAL PATCH1
20 344  177                    LAA
```

The actual PATCH1 subroutine would need to contain the two instructions replaced by the calling sequence as well as the two instructions being added. The unused bytes starting at location 000 on page 30 (in the program listing) as shown for the 8008 version on page 68 of chapter 12 would appear as:

```
30 000  066 123       PATCH1,  LLI 123
30 002  076 000                LMI 000
30 004  066 133                LLI 133
30 006  076 000                LMI 000
30 010  007                    RET
```

While the 8080 version (page 68 of chapter 13) would appear as:

```
30 000  056 123       PATCH1,  LLI 123
30 002  066 000                LMI 000
30 004  056 133                LLI 133
30 006  066 000                LMI 000
30 010  311                    RET
```

# NOTES

## PATCH NR. 2 - Revised

The implementation of PATCH NR. 1 will cause a problem to occur in the square root function subroutine if the following PATCH NR. 2 is not also installed. This is because the square root routine initially only tested for convergence by examining the size of the exponent involved. The increased accuracy that results when PATCH NR. 1 is implemented can cause certain values to converge to zero as the square root is calculated. PATCH NR. 2 inserts an additional test for the zero condition in that subroutine. Failure to implement this patch when the first patch has been implemented can result in the square root function subroutine "hanging up" in an endless loop when an attempt is made to take the square root of a number such as 1.0 or 4.0! The following patch corrects for this possibility.

To correct the source listing make a note in chapter nine on page 11 that the following instructions:

```
DCL
LAM
NDA
JTZ SQRCNV
```

should be inserted between the 16th and 17th lines from the top of that page between the instructions:

```
JTS SQRCNV
```

and

```
LLI 034
```

To implement the correction for the assembled listings of the program provided, it is recommended that a patch be made by changing the JTS SQRCNV instruction which starts at address 32 163 to the instruction JMP PATCH2 and adding a label SQR1 to the LLI 034 instruction which is at location 32 166. The actual patching instructions may be placed starting at address 32 364 and would consist of the sequence:

```
PATCH2,  JTS SQRCNV
         DCL
         LAM
         NDA
         JTZ SQRCNV
         JMP SQR1
```

Implementing the patch in this recommended fashion would result in the 8008 version (chapter 12 page 75) being altered at the following addresses to appear as:

```
32 163  104 364 032          JMP PATCH2
32 166  066 034      SQR1,   LLI 034
```

at the patch to appear as:

```
32 364  160 203 032 PATCH2,  JTS SQRCNV
32 367  061                  DCL
32 370  307                  LAM
32 371  240                  NDA
32 372  150 203 032          JTZ SQRCNV
32 375  104 166 032          JMP SQR1
```

Similarly, for the 8080 version (chapter 13 on page 75) the patch would result in the following locations being changed to:

```
32 163  303 364 032          JMP PATCH2
32 166  056 034      SQR1,   LLI 034
```

and the patch locations to appear as:

```
32 364  372 203 032 PATCH2,  JTS SQRCNV
32 367  055                  DCL
32 370  176                  LAM
32 371  247                  NDA
32 372  312 203 032          JTZ SQRCNV
32 375  303 166 032          JMP SQR1
```

---

In the source listing, on page 13 of chapter 10, change the first three instructions in the routine labeled DVEXIT to appear as follows:

```
DVEXIT,  LLI 143
         LEI 123
         LBI 004
```

Change the corresponding section of the assembled listing for the 8008 version on page 52 of chapter 12 to read:

```
22 070   066 143          DVEXIT,  LLI 143
22 072   046 123                   LEI 123
22 074   016 004                   LBI 004
```

And the 8080 version on page 52 of chapter 13 to read:

```
22 070   056 143          DVEXIT,  LLI 143
22 072   036 123                   LEI 123
22 074   006 004                   LBI 004
```

This revision will correct a residue problem which can cause incorrect results to occur when a number with a negative exponent is divided into the value zero.

NOTES

patch3

PATCH #3

```
011_307 066 201          PATCH3: LLI 201
011_311 056 027                  LHI 027
011_313 076 000                  LMI 000
011_315 104 266 010              JMP EXEC

012_354 104 307 011              JMP PATCH3

026_360 033                      _DB 033

011_027 076 000                  LMI 000
```

# INTRODUCTION

In the early 1970's technology produced the integrated circuit microprocessor. The advent of this device offered the promise of making low cost computing elements available to the general public at large and raised the hopes of many citizens that the power of the computer could finally be accessed by individuals of limited means. This promise was most exciting for in the past the use of computers had been fairly limited, for economic reasons, to institutions that could afford the use of their incredible power.

For the first several years after their introduction, microprocessors remained primarily in the domain of highly educated scientist and engineers who were backed by organizations equipped to exploit the device's capabilities in a variety of fields. Gradually, however, as knowledge spread, their capabilities became known to the general public. People, many of them electronic enthusiasts and hobbyists, wanting to harness the power of these devices for personal use began to clamor for low cost computing systems. The old laws of supply and demand came into effect. Within a short time span, a number of small corporations began to offer the hardware for small personalized systems. Initially, only individuals with appropriate technical backgrounds were able to capitalize on the availability of these low cost systems and put them to effective use. Some people, enthralled by the exciting potential of such systems, had some rude awakenings. For, while the microprocessor is touted as being able to do any and everything, it turns out that these little devices are virtually worthless without SOFTWARE or PROGRAMS that can direct their activities. The development of useful software using early machine language techniques is no trivial task. It takes a considerable amount of individual effort to get to the point where one can program a computer using the most fundamental programming method, which is machine or assembly language programming. These programming methods require an intimate knowledge of the detailed operation of a computer on a step-by-step basis. The development of even seemingly simple tasks using these programming methods can take an inordinate amount of time. This is particularly so if one is not skilled in the art and practice.

The limitations of machine language programming have been known for many years since the beginnings of computer technology some 30 years ago. Over the years a number of HIGHER LEVEL LANGUAGES have been developed so that people other than computer experts could work effectively with computers. Higher level language programs are actually programs written in machine or assembler language by skilled personnel that will in turn allow other people to communicate with the computer using simple commands and statements. The degree of programming efficiency that may be achieved using a higher level language is many orders of magnitude over that required to perform the same tasks using the fundamental machine language programming methods. For instance, a simple directive such as:

```
LET X = (Y + 145*Z) ↑ (2*N - M)
```

might require several THOUSAND individual machine language instructions to achieve a general solution capability. A person who had many such equations to solve would soon opt to forget the use of a computer if such a task had to be performed for each variation of similar problems. It may be apparent, however, that such equations, while individually different in detail, consist of similar operations (such as multiply, add, raise to a power and so forth). A higher level language is designed to take advantage of such similarities in a generalized fashion.

On the other hand, while a higher level language yields such tremendous increases in programming efficiency, this increase is not achieved without sacrifice! It takes many

thousands of man hours to develop such a generalized higher level language, and this investment in labor must be made each time such a language is created. It is not always easy to get a group of people together and make the type of investment necessary to initially develop such a language. Additionally, the individual user who desires to install such a language on a computer, must pay for the increased programming efficiency by budgeting a significant amount of the available memory in the computer for the exclusive use of the operating portion of the higher level language program. What is left over may then be used to hold the user's program (in the higher level language form) along with any data that is to be manipulated or processed. For the small system user, the "significant" amount of memory set aside for the operating portion of the higher level language, for the program described herein, will be some six to seven thousand bytes of memory. This is indeed a good chunk of memory for the system owner who has but 8 K of that precious commodity!

The individual user must also sacrifice certain aspects of a computer's capability when utilizing a higher level language. For instance, it is virtually impossible to program real-time routines whose precise execution times can be controlled when using the higher level syntax. This is because the higher level syntax does not give the programmer access to individual machine language instructions. Additionally, many types of instructions available in machine language (for instance, rotating a register to the right or to the left) have no direct counter-part in the higher level language. (However, the student of this publication will be in a position to incorporate subroutines that can be accessed by higher level language programs and can thus enjoy the benefits of both types of programming!)

Despite the relatively large memory requirements of a high level language, and the other types of limitations mentioned, it is felt that the time has arrived when such a language would be welcomed by small systems owners when presented in the detailed manner of this publication.

The higher level language to be presented in this publication has been given the acronym SCELBAL. This stands for SCientific ELementary BAsic Language. It has been patterned after a commonly used higher level language referred to as BASIC.

SCELBAL was specifically developed to be able to run on systems using the ubiquitous 8008 CPU. This CPU is generally acknowledged as being the first true 8-bit CPU to be manufactured on an integrated circuit. It was first developed by a California based firm, Intel Corporation. SCELBAL is believed to be the first such higher level language to be specifically developed to run on the 8008 CPU and be made generally available to the public. The program described herein can also be run on systems using the more powerful 8080 CPU though it is not as memory efficient as it could have been if the program had forsaken 8008 capability.

While this publication was specifically prepared to demonstrate the details of the language as developed for 8008/8080 machines, the publication should be of considerable interest to users of other types of similar computing devices. Indeed, the experienced programmer, armed with the knowledge presented in this book, should be in a pretty good position to implement a similar language on just about any other microprocessor by simply translating the machine code instructions to those of the machine of particular interest to the user. (While such a project might seem monumental to some, the information in this book would make the task considerably less difficult than approaching such a task without the practical, detailed information which is presented herein!)

The major objectives of this publication are to:

1.) Present a higher level language that can

be implemented on 8008/8080 microprocessor systems with the user having the freedom to adapt the package to various individual I/O configurations.

2.) Present the intimate details of its operation so that it may be readily modified and adapted to individual user's applications and requirements.

3.) Serve as an educational and stimulative tool for the future development of similar languages, possibly of a more advanced nature.

Much thought in the preparation of the overall program went into just what capabilities to provide given the various technical trade-offs that one must consider. It was known at the start that the program could not be developed to satisfy every potential user. Nobody has a system with that much memory available! Care was taken to provide a good fundamental selection of syntax statements and functions in the language. From that point, backed by the descriptions of the program's organization, general flow charts, and highly commented listings provided in this publication, it is felt that the user will be equipped to add extended capabilites depending on memory available, or willingness to sacrifice described functions. For many users, it is felt that the program as presented, will be entirely satisfactory. The extra measure of providing the information so that the user may go further if desired, is the fundamental premise behind this publication.

## INTERPRETER VERSUS COMPILER

SCELBAL was developed as an INTERPRETIVE language, not a compiler. Some readers might be asking, "What's the difference?"

There is a lot of difference. An interpretive language is one that essentially processes each line or statement in the source code of the higher level syntax and then executes the directive before going on to the next line or statement. It does this by calling on machine language routines that perform the various functions as soon as it has been determined which job is to be accomplished. A compiler operates quite differently. Each time it processes a statement in the higher level language syntax it PRODUCES some machine language coding that can later be executed to perform the desired task.

From this brief introduction it may be apparent that there are some major organizational differences between the two types of higher level language processors. The key ingredient is that the INTERPRETER immediately interprets and executes. The compiler COMPILES, that is it produces machine code, and the machine code it produces is executed at a later stage.

What does this mean from an organizational and systems view point? Perhaps the best way to obtain the overall view is to present the typical practical operation of both types of systems.

## COMPILER OPERATION

The general sequence of operations to get a program written in a higher level language into actual operation using a compiler oriented language is as follows.

First, a program written in the higher level language syntax is prepared. This might be done using an Editor program on the computer. Note that if such is the case, that first an Editor program must be loaded into the computer's memory and the computer system used for editing purposes. When the high level language source listing has been prepared, it must usually be saved or stored on some external medium such as punched paper tape or magnetic tape.

Next the COMPILE portion of the higher level compiler program would be loaded into the system's memory and the original source listing of the high level language program processed. Generally this procedure requires several passes or readings of the source listing. The final result of this operation is the production of machine language code, which once again would usually have to be stored on some sort of external medium.

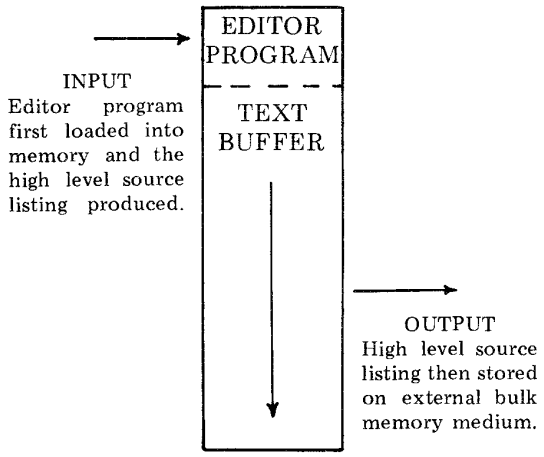
Finally, the RUN or EXECUTE portion of the compiler program would be loaded into the system's memory along with the machine language code that was produced previously by the COMPILE portion of the compiler. At this point, the user's program, originally written in the higher level syntax, would be ready to operate, having been converted to machine code.

The first two stages of a compiler oriented language can be considered as analogous to the sequence of operations necessary to create a program using an Editor and Assembler. The only difference being that the source listing when using an assembler would consist of the machine language mnemonics, while when using a compiler it would consist of the higher level language syntax.

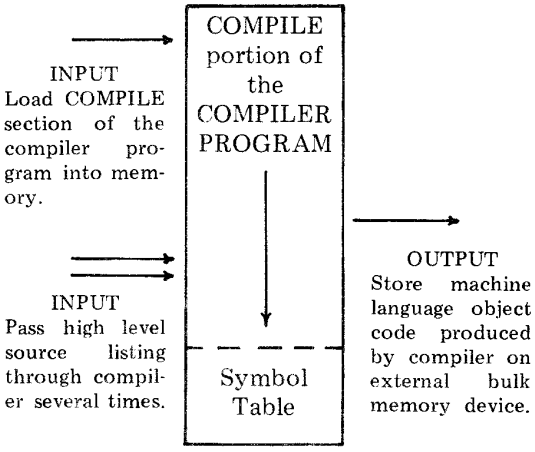
The final stage of a compiler oriented language is generally not quite the same as would be the case if machine code was produced by an assembler. This is because

the run or execute portion of the compiler typically provides some control over the compiled program by the operator. Additionally, this portion of the compiler program has a number of routines that the program that has been compiled is able to utilize, such as, a floating point arithmetic package. At this point, when the RUN portion of the compiler along with the machine code produced by the COMPILE portion are both residing in memory, the user is finally able to execute the original program that was written using the higher level syntax.

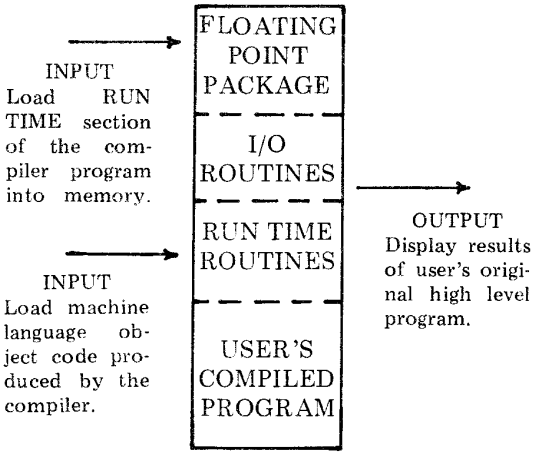
It may now be apparent that a compiler oriented language is highly dependent on the host system having fast and reliable I/O capability with an external bulk memory device. This is because of the constant need to input the various sections of the compiler program and output the intermediate information during the program development process. This requirement for the constant use of an external memory medium may be observed more clearly by reviewing the development process for a higher level language, going from the creation of the high level source listing to final execution of the high level program, as illustrated in the following diagrams.




COMPILER OPERATION - STEP 1




COMPILER OPERATION - STEP 2




COMPILER OPERATION - STEP 3

The fact that a compiler oriented version of a high level language is so dependent on I/O operations with an external bulk device is the primary reason that SCELBAL was not developed as a compiler. Most small system owners must be satisfied with either paper tape or audio cassette magnetic tape bulk storage devices. Both of these types of

peripherals are relatively slow in operation and not as reliable as commercially oriented magnetic tape systems. For convenient compiler operations a system really needs a disc peripheral unit that will allow the rapid loading of programs and storage of intermediate data (such as the object code produced during the second step of compiler operations discussed above). It could take as much time as an hour or more to attempt to compile a higher level language program on a small system equipped with slow peripherals. The task of operating a compiler would quickly become quite frustrating if the programmer was a novice and frequently made programming errors in the source syntax. Remember, for the system just described, that if a program error was not detected until compiler RUN TIME, the user would have to go all the way back to the first step of loading an Editor program back into the computer and correcting the source listing of the high level language program!

As a matter of interest, if a compiler is so much trouble to use, what good is a higher level language that utilizes the method? Well, first of all, a compiler is not so difficult to use if one has a computer system equipped with a disc or other high speed memory peripherals. With such equipment it takes just a few seconds to load in a program or save the results of intermediate operations. Remember, the choice was made to not use the compiler method for SCELBAL based on the consideration that most small system owners could not afford the luxery of such speedy peripherals. There are, of course, institutions and organizations that do have such capabilities. For them, a compiler oriented system can have advantages.

A few advantages of using a compiler are as follows.

As a general rule of thumb, a compiler program can be created to operate in less actual read and write memory in the computer than an interpretive version. This is almost self-evident from the presentation of the information that a compiler is generally split into several portions, the COMPILE part, and the RUN or EXECUTE portion. Thus, had SCELBAL been developed as a compiler it might have been possible to provide the same capabilities (from the final results view point of having a program executed that was originally written in a higher level syntax) with a program that only required, say, 4 K of RAM memory in the computer at any one time.

Second, the final operating version of the higher level program will generally function at a considerably faster speed than the same program executed in an interpretive fashion. This too is easy to see since one now knows that the interpreter must examine and interpret each statement as it goes along, whereas the compiled version had already accomplished that task when it produced the machine code that will result in the desired functions being performed at program execution time. This final speed of the program may be important when massive amounts of calculations are being performed, or in real-time situations. It is not likely to be that critical when a small system (that is probably severely restricted by I/O timing considerations) is being utilized.

Third, in line with what has already been mentioned about a compiler oriented program requiring less actual memory in the computer, the final machine code version of the program that has been compiled will generally be much more efficient memory usage-wise. This again is pretty much self-evident when one considers that the compiled program will only have machine language routines that perform the specific functions asked for in the actual program that was compiled. The interpretive package, on the other hand, must have all the possible functions for the language available in memory, since it is not known which functions may be utilized by a particular program.

In summary, it might be stated that a compiler becomes much more attractive when viewed in the context of larger computing systems with high speed peripherals available.

From the microprocessor view point, compiler oriented higher level languages, implemented on larger machines, are quite valuable if one is interested in developing a relatively large number of programs that will operate in microprocessor systems when they are part of a product. For instance, a manufacturer that desired to produce a line of test instruments, each of which would utilize a microprocessor, but with a special software package for each type of instrument, would be well off to use a compiler to create the programs. Compilers operating on microprocessor systems themselves, however, for the reasons indicated, are simply not practical for most small system users.

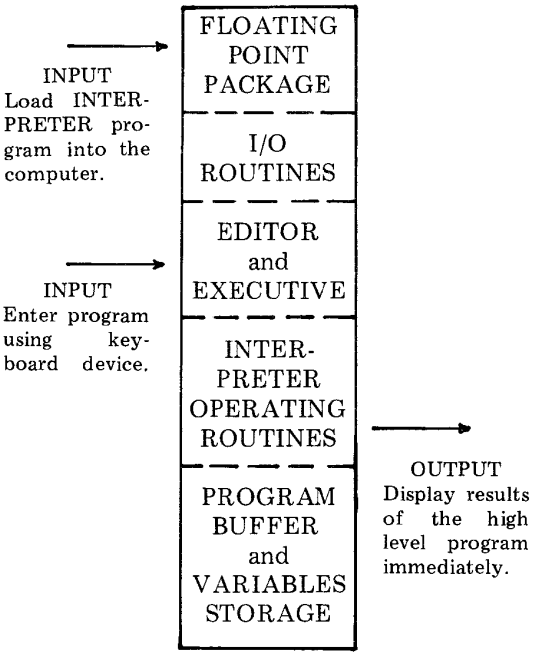
## INTERPRETER OPERATION

An interpretive version of a higher level language, while not as memory efficient as a compiler, is much convenient for the small systems user. In the context of being able to prepare and execute many different kinds of programs in a short time span, it is much more efficient in terms of overall program development to execution time. This is particularly true for inexperienced programmers as they can almost instantaneously be notified of syntax errors and immediately make corrections to the program being created on an on-line, real-time basis.

An interpreter differs from a compiler, as mentioned previously, in the fact that each line of the source syntax is interpreted and then executed before going on to the next line. The execution is performed by calling on various routines provided as part of the interpreter package. There is no production of intermediate machine code as in the sense of the compiler (though there may be the production of intermediate data, symbols, etc.).

An interpreter such as SCELBAL has everything required to create and execute a program residing in memory at one time. Thus, once the interpreter program itself has been loaded into memory, there is no need to use external bulk memory devices (unless one wants to save a higher level program, or restore one previously saved on such an external memory storage device). This eliminates all the critical bulk memory operations necessary for the successful development of such programs when using a compiler.

The following diagram illustrates a memory map view of a typical interpreter program.




INTERPRETER OPERATION

The diagram above illustrates that the interpretive oriented program really consists of an Editor program (to enter and edit the high level syntax into a program buffer), an Executive (to direct the operation of the various portions of the package as directed by the user), and an Interpretive/Operating section that is able to analyze the contents of the program buffer and call on the desired routines as indicated by the statements it interprets.

With this type of arrangement one can typi-

cally create and execute higher level language programs in seconds or minutes versus an hour or two.

Thus, SCELBAL was developed to operate as an INTERPRETER. The details of its operation will be presented in this manual. To find out the fundamental capabilites of SCELBAL just continue reading into the next chapter.

# THE FUNDAMENTAL CAPABILITIES OF SCELBAL

As explained in Chapter One, SCELBAL was developed to operate in an INTERPRETIVE mode. This means that the entire program resides in memory at one time along with the program written in the higher level language that is to be executed. When the INTERPRETER is given the RUN command it immediately proceeds to INTERPRET each line of the higher level language program and perform the necessary calculations and functions.

SCELBAL has actually been designed so that it may operate in a "calculator" mode or operate in a stored program mode. In the calculator mode, each statement is executed immediately after it is entered on the input device. In this mode, the program is ideal for solving simple formulas when the user only needs to obtain a few values.

For instance, if one typed in the statement:

```
PRINT 2*2 + 3*3 +4*4
```

the value:

```
29
```

would be displayed as soon as the end of line code (carriage-return) was issued at the end of the PRINT statement.

One may use the calculator mode to solve more complex problems. For instance, if one entered a series of statements such as:

```
LET A = 2
LET B = 3
LET C = 4
```

and then entered:

```
PRINT A*A + B*B + C*C
```

the answer:

```
29
```

would immediately be displayed. This is because, in the calculator mode, the values assigned to A, B and C would be immediately assigned and available for use in solving the formula given in the PRINT statement above.

When it is not desired to operate in the calculator mode, but rather in a stored program mode, the user simply inserts a line number in front of each statement. A whole series of statements may then be arranged to form a program. When it is desired to execute the steps in the program, a special executive RUN command is issued. This command will cause the INTERPRETER to proceed to execute the program one statement at a time.

SCELBAL is able to handle actual numeric values using a floating point package which is an integral part of the interpreter. While a floating point package is used to perform all calculations, inputs and outputs to the program may be in fixed format within certain ranges.

When inputting information or specifying values within a program, the user may use fixed point notation for numbers in the range plus or minus 0.999999 to 999999. Numbers smaller or greater than this must be stated in floating point format, such as:

```
+0.123456E-10
```

or

```
-654321E+12
```

The minimum and maximum powers that

the floating point package used in SCELBAL can handle is ten to the plus or minus thirty-eighth.

SCELBAL automatically outputs numbers in the range plus or minus 1.0 to approximately 999999 in fixed point format. Outside this range, output automatically switches to floating point notation.

The floating point package itself provides SCELBAL with the four most fundamental arithmetic capabilities. They are addition, subtraction, multiplication and division. All calculations in the floating point package are maintained to twenty-three significant binary bits in the mantissa, with the multiplication and division routines providing binary rounding when calculations yield numbers that exceed twenty-three binary bits.

While the floating point package provides the essential capability to handle the operators: +, -, * (multiply) and / (divide), the language, using supplementary routines, can also recognize the operators ↑ (raise to a power), and parenthesis "(" and ")" which may be used to group or nest mathematical statements.

Up to twenty user defined variables are permitted at one time when using the language. However, in order to conserve memory space, variables must be limited to a maximum of two characters. Variables must begin with a letter of the alphabet.

The Executive portion of SCELBAL allows the user to control the overall operation of the program from an I/O device such as a keyboard and teleprinter. The user can create a program in the higher level language and have it executed using the features of the Executive portion of the program. A portion of the Executive is actually a small Editor program that allows the user to "edit" the information (program) in the program buffer at any time. Lines may be deleted and new lines entered. Clerical errors on a line may be corrected. Furthermore, a portion of the Executive checks for various types of syntax errors as each line is entered. If an error is detected, an error code message is presented to the operator. This feature is extremely valuable for novice programmers, (and though some of them might not admit it, is quite comforting to the old professionals as well).

The Exective portion of SCELBAL has five major commands available to the operator which are defined and explained breifly below.

SCR is used to indicate the SCRATCH command. This command effectively clears out any previous program stored in the program buffer along with any previous user defined variables. It is used in preparation for entering a new high level program into the program storage area.

The LIST command does just that! It causes the contents of the program buffer to be displayed or "listed" on the system's output device so that it may be reviewed by the operator.

RUN directs the interpreter to begin operations and execute the program stored in the program buffer.

SAVE. This command may be used to direct the program to save a copy of the program stored in the program buffer on the system's external bulk storage device. A program saved using this command can later be restored for further use by using the command presented next.

LOAD. This command directs the program to read in a copy of a program from an external bulk storage device (previously written thereon using the above SAVE command) into the program buffer so that it may be executed by the interpreter.

The higher level language SCELBAL consists of STATEMENTS that are interpreted by the program resulting in selected operations being performed. SCELBAL recognizes the

following types of statements.

The REM for REMarks statement indicates a comment which is to be ignored as far as the interpreter is concerned. Information on a line prefaced by a REM statement is intended only for the use of programmers and may be used to document a program.

The LET statement is used to set a variable equal to a numerical value, another variable, or an expression. For instance, the statement:

```
LET X = (Y*Y + 2*Y - 5)*(Z + 3)
```

would mean that the variable X was to be given the value of the expression on the right hand side of the equal sign.

Since the LET statement is such a frequently used directive, SCELBAL also recognizes an implied LET statement. Thus, the simple statement:

```
X = (Y*Y + 2*Y - 5)*(Z + 3)
```

would be interpreted as though the LET directive had been stated.

The IF combined with the THEN statement allows the higher level program to make decisions. SCELBAL will allow one or two conditions to be expressed in an IF....THEN statement. Thus, the statement:

```
IF X = Y THEN LL
```

would be interpreted to mean that if, and only if, X is equal to Y, then the program would branch to line number LL in the program.

While the directive:

```
IF X <= Y THEN LL
```

would mean that if X was less than OR equal to Y (two conditions), that the program was to go to line number LL.

Similarly, the statement:

```
IF X <> Y THEN LL
```

would mean that if X was less than OR greater than Y that the program was to branch (again two conditions).

If the condition(s) in an IF...THEN statement are not met, then the program continues by going directly to the next sequential statement in the program and does not execute the branch directive.

The GOTO statement directs the program to effectively JUMP to a specified line number in a program. The GOTO statement may be used to skip over a block of instructions in a multiple segment or subroutined program.

The FOR, NEXT and STEP statements provide capability for the programmer to form program loops. For example, the series of statements:

```
FOR X = 1 TO 10
LET Z = X*X + 2*X + 5
NEXT X
```

would result in Z being calculated for all the integer values of X from 1 to 10. While SCELBAL does not require the insertion of a STEP directive in a FOR - NEXT loop, a STEP value may be defined if desired. The implied STEP value if not specifically stated is always 1. However, it may be set to a value other than 1 by following the FOR range statement by a STEP directive that dictates the desired STEP size. Thus, the statement line:

```
FOR X = 1 TO 10 STEP 2
```

would result in X assuming values of 1, 3, 5, 7 and 9 as the FOR - NEXT loop was traversed.

GOSUB is a statement that is used to direct the program to perform another statement or group of statements as a subroutine. The statement is used in conjunction with a line number which desig-

nates where subroutine execution is to begin.

A RETURN statement is used to indicate the end of a subroutine. When a RETURN statement is encountered, the program will return to the next statement immediately following the GOSUB directive which was used to call the subroutine.

SCELBAL permits multiple nesting of subroutines (up to eight levels) within a program.

INPUT is used to direct the interpreter to wait for an operator to INPUT information to the program. After the information has been received operation of the program automatically continues.

The PRINT statement is used to output information from a program. By using the PRINT statement the user may direct the program to display the values of variables, expressions, or other types of information such as messages. The PRINT statement in SCELBAL permits mixed types of output on the same line (numerical values and alphanumeric messages), and the option of providing a carriage-return and line-feed after outputting information or the suppression of that function. For instance, the statement:

```
PRINT 'X IS EQUAL TO: ';X
```

would result in the program first printing the text message "X IS EQUAL TO: " and then the value of the variable X on the same line. After the value of the variable X had been displayed a carriage-return and line-feed combination would be issued. To suppress the issuing of the CR & LF function in the above example, the programmer would only need to include another semicolon at the end of the statement!

The PRINT statement is augmented by several functions and features. For instance, a comma sign in a PRINT statement may be used to cause the display device to space over to the next TAB position before continuing to output more data. A special TAB function that will be discussed later may also be used with the PRINT statement to format the outputting of data. And, another special function which will be presented shortly will provide capability for SCELBAL to convert decimal numbers (representing ASCII codes) into alphanumeric characters for display.

The END statement is used to designate the conclusion of a higher level program in the program buffer. When this statement is interpreted control will return to the Executive portion of SCELBAL.

There is an optional statement available in SCELBAL that may be added to the package if the user desires to utilize the capability and has sufficient memory to adequately support the statement. This is the DIM for DIMension statement. It is used to specify the formation of a one dimensional array in a program. Up to four such arrays having a total of up to 64 entries are permitted in a program when the optional feature is included in the user's version of SCELBAL. Thus, when a user elects to provide the capability, the statement:

```
DIM K(20)
```

would set up space for an array containing 20 entries. (The array size must be specified using a numerical value, not a variable.)

The power of SCELBAL is further enhanced by the addition of seven functions that may be used within statements. These functions are discussed below.

INT returns the INTeger value of the expression, variable or number requested as the argument. The integer value is defined as the greatest integer number less than or equal to the argument. Thus, a statement which contained:

```
INT(X)
```

would result in the value, for instance, 5.0 being returned if X at the time the func-

tion was encountered was greater than or equal to 5.0 but less than 6.0 (such as 5.0001, 5.54321, 5.99999).

SGN returns the SiGN of the variable, number, or expression. If the value is greater than zero, the value +1.0 is returned. If the value is less than zero the value -1.0 is returned. The value 0 is returned when the expression or variable is zero.

ABS returns the ABSolute value (magnitude without regard to sign) of the variable or expression identified as the argument of the function.

SQR returns the SQuare Root of the expression, variable, or number.

RND produces a semi-psuedo-RaNDom number in the range of 0 to 0.99. This function is particularly useful to have available for games programs or when it is desired to have random values when doing statistical analysis problems. The random number generated may be operated on to produce random numbers within a desired range. For instance, the statement:

```
LET X = RND(0)*10
```

would result in X being assigned values in the range of 0 to 9.99.

CHR is a special CHaRacter function. It may be used in a PRINT statement and will cause the ASCII character corresponding to the decimal value of the argument to be displayed. Thus, if:

```
CHR(193)
```

was contained in a PRINT statement, the letter A would be displayed. The argument portion of the CHR function may be a user defined variable so that different characters would be displayed depending on the value of the variable at the time the PRINT statement was executed.

A reverse function is available for use in an INPUT statement. This function is specified by placing a dollar sign ($) immediately after a variable in an INPUT statement. This function will cause the decimal value for the ASCII code of the letter that is inputted to be returned to the program. Thus, if an INPUT statement contained the directive:

```
INPUT A$
```

and the operator entered the letter Y as an input to the program, the value 217 would be returned as the value for the variable A. This function is valuable in a number of applications. For instance, if the programmer desired to have a user answer a question in a program with a yes or no response, the function enables the higher level program to ascertain which response was entered by testing the decimal value received.

A TAB function is available for use in a PRINT statement. This function allows the programmer to direct the display device to space over to the column number specified as the argument of the function. This function thus allows the programmer to format the output into neat columns. Thus, the statement:

```
PRINT X; TAB(10);Y;TAB(20);Z
```

would result in the value for X being displayed starting at column 1, the value Y starting at column 10, and the value of Z starting at column 20.

SCELBAL is designed to run in a system having a minimum of 8 K of read and write memory. In an 8 K system, the program, leaving out the optional DIMension (single dimension array) capability, provides about 1,250 bytes of memory for storage of the users higher level language program. While it is possible to include the DIMension capability in an 8 K system, doing so would reduce the program storage area in about half. One nice feature about SCELBAL is that the user with more than 8 K of memory can use the additional memory for higher level pro-

gram storage. A user with, for instance, a 12 K system, may configure the package so that there are about 5,000 bytes of memory available for storage of a program. It is recomended that those desiring to include the DIMension capability of SCELBAL have 9 or 10 K of memory in the system so that the program storage area will not be prohibitively small. The package has been arranged so that those that desire the DIMension option can install this section in the upper portion of available memory. Those that do not desire this feature, may leave it out to provide additional program storage room.

Even with just an 8 K system, surprisingly complex programs can be executed. A game such as Lunar Landing is easily accomodated if one reduces the number and lengths of the messages issued to the player. An 8 K system will be adequate for many users who are primarily interested in using the package as a sophisticated programmable calculator.

A 12 K system will support quite sophisticated programs with plenty of alphanumeric messages. With approximately 5 K bytes of memory available for program storage in such a system, the user would have the capability to execute programs that contained several hundred statements.

While most 8008 based systems are limited to a maximum of 16 K of memory, those utilizing the 8080 version of SCELBAL could conceivably have a program storage area (in a 64 K system) in excess of 56 thousand bytes. The kinds of programs one could run in that amount of memory could fill books alone!

The execution speed of SCELBAL, while slow compared to higher level languages that are designed to run on large computers, is surprisingly good. The 8008 version is, of course, about an order of magnitude slower than the 8080 version due to the relative speeds of the two types of CPUs. The execution speed of an 8008 version can be almost doubled if one installs an 8008-1 CPU in their system. Some users may want to consider that option. However, even on an 8008 based unit, the execution speed of SCELBAL is quite tolerable. For instance, the typical response time between the displaying of a new set of parameters when running a Lunar Landing game is in the order of six to seven seconds. A program that calculates the mortgage payments on a house on a monthly basis and displays such data as the payment number and current balance after each payment requires but a few seconds between the displaying of each new line of data. A dice playing game responds with new throws of the dice in the order of a second or so when using a formula that includes the use of the random number generating function. These times are by no means fast but they are in the general range that one might obtain when solving formulas of similar complexity on commonly used programmable hand held calculators. Remember, these times are for the slowest 8008 version. They are lowered by an order of magnitude on an 8080 based system.

The information presented in this chapter is merely to whet the reader's appetite and present an overall picture of the fundamental capabilities of SCELBAL. The detailed use of the language will be presented in a later chapter along with numerous actual programming examples. It is now time to start learning how SCELBAL is organized as an overall package and then proceed to discuss the various portions of the program in detail. This coverage starts with the next chapter.

# FUNDAMENTAL OPERATION OF SCELBAL

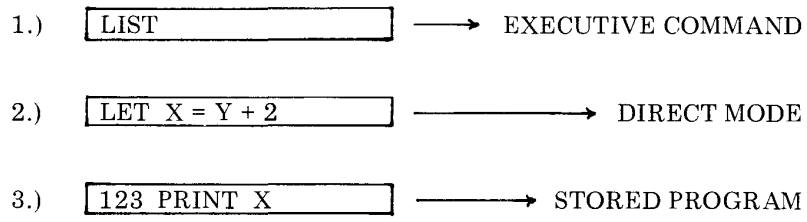
The following brief description provides a summary of the manner in which SCELBAL proceeds to process a higher level program. It should help the reader who needs some confidence building before digging into a software package that may initially seem complex due to the large number of individual machine language instructions that make up the overall package. The reader will hopefully soon see that all the individual machine language instructions are organized into relatively small routines and these in turn are carefully organized into a surprisingly simple scheme. The essential concepts of this simple scheme are presented in this section.

SCELBAL, as discussed in the opening chapter, is an interpretive language. The program simply operates by analyzing each line of source coding which the operator inputs in the defined higher level language format using the defined syntax. As the program analyzes each portion of a line, it performs the operations indicated.

Virtually all of the analyzation of a line of source coding is accomplished when the information is residing in a temporary storage buffer in memory called the LINE INPUT BUFFER. This LINE INPUT BUFFER is used to initially store data as it is inputted to the program from the operator's console, which would typically be an input device such as an ASCII encoded electronic keyboard. As will be illustrated shortly, information stored in the LINE INPUT BUFFER can be transferred to a USER PROGRAM BUFFER. Or, information in the LINE INPUT BUFFER can be analyzed and interpreted. Finally, a line of information in the USER PROGRAM BUFFER can be transferred back to the LINE INPUT BUFFER.

A LINE of information is simply a string of allowable ASCII encoded characters which may consist of COMMANDS, NUMBERS, STATEMENTS, FUNCTIONS, user defined VARIABLES and mathematical OPERATORS. A LINE is always terminated (during operator input) when a line ending terminator, the ASCII code for a carriage-return (CR) is detected.

The pictorial below illustrates three general formats for lines of information. These three general formats essentially provide a means of controlling the overall operation of SCELBAL.




The first line format illustrated above has an EXECUTIVE COMMAND as the first word in the line. Each time a line of information is entered into the LINE INPUT BUFFER from the system's input device, the EXECUTIVE portion of SCELBAL checks to see if the first word in the line represents any one of the valid SCELBAL commands such as LIST, RUN, SCRatch, SAVE or LOAD. If so, appropriate action is taken such as LISTing the contents of the USER PROGRAM BUFFER or SCRatching (clearing out the USER PRO-

GRAM BUFFER).

If the first word in a line is not an EXECUTIVE COMMAND, SCELBAL checks to see if the first string of characters represents a LINE NUMBER such as shown in example number three on the previous page. If such is the case it means that the line of information is to be stored in the USER PROGRAM BUFFER as part of a high level stored program being created by the user. Appropriate steps are then taken by the program to append, insert, change or delete information in the USER PROGRAM BUFFER.

If a LINE NUMBER is not detected at the start of a line, the program assumes that the information in the line represents a higher level program STATEMENT which is to be DIRECTly interpreted. This would be the situation when the user desired to use SCELBAL in the "calculator" mode.

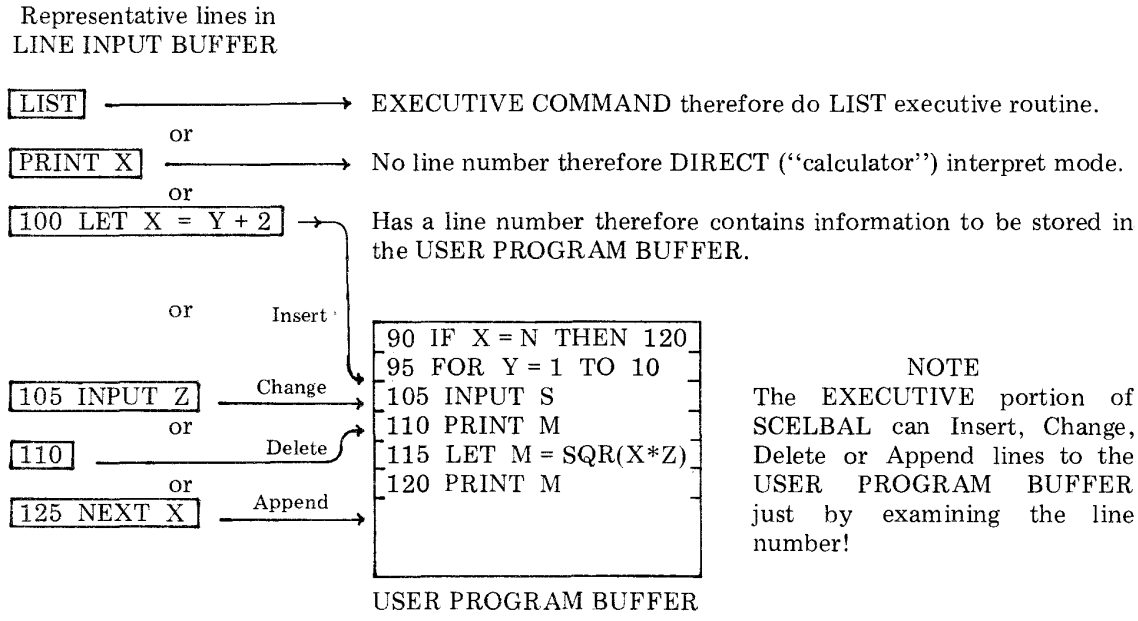
In this case, the program would proceed to EVALuate the information by SCANning the information in the LINE INPUT BUFFER. This is done by examining the SYNTAX of the line and initially testing to see if the first word in the line represents a statement KEYWORD such as LET, FOR, IF, GOSUB etc. Upon ascertaining the type of STATEMENT that is to be processed, the program is directed to an appropriate routine that will further evaluate and process the information on the line. This is accomplished by calling on routines that SCAN the line and decode the information, then performing the indicated operations. To do this, other routines such as a PARSER (routine to detect and decode mathematical operators), FUNCTION subroutines (such as SQR, TAB, INT), and FLOATING POINT mathematical routines may be called on to perform the operations specified by the higher level syntax. This process is accomplished on a step-by-step basis following logical rules that establish a HEIRarchy for performing the various types of operations that will be explained in detail in the appropriate sections of this publication.

O.K. The reader now knows how three basic line formats direct SCELBAL to perform an executive function, or place a line of information into the USER PROGRAM BUFFER, or DIRECTly execute a line of information being held in the INPUT LINE BUFFER. What happens when it is desired to execute a higher level program that has been stored in the USER PROGRAM BUFFER?

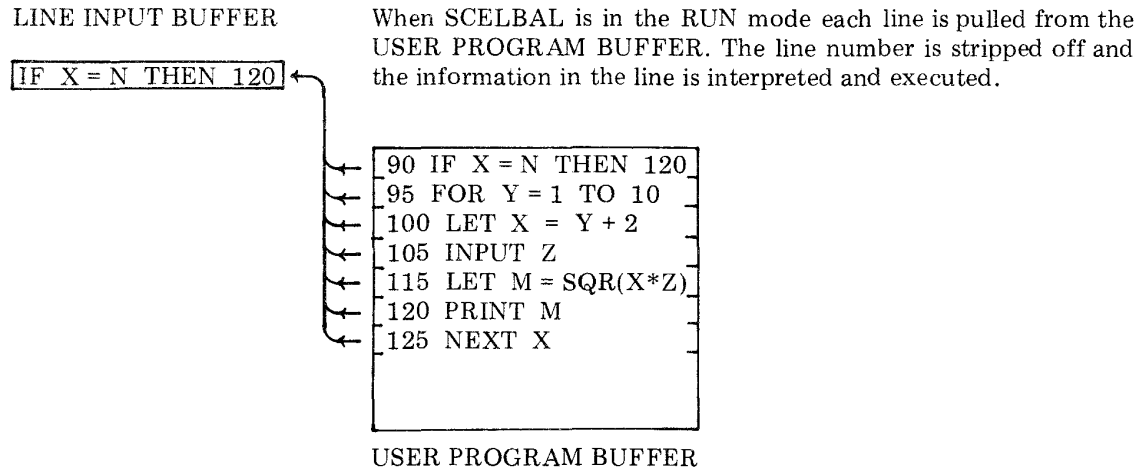
The scheme is still very simple. When the executive portion of SCELBAL detects a line containing the executive RUN command the program simply does the following. It goes to the start of the USER PROGRAM BUFFER and pulls a copy of the first line of information from that storage area back into the INPUT LINE BUFFER. As it does this it strips off the LINE NUMBER. The information in the LINE INPUT BUFFER is then simply processed in the same manner in which a DIRECT type of line would be handled. When the directives contained in that line have been performed, the program proceeds to get the next line in the USER PROGRAM BUFFER (unless directed otherwise by such statements as IF, GOSUB and so forth), strip off the line number, and DIRECTly execute that statement. This process continues until the end of the USER PROGRAM BUFFER has been reached, or an END statement is encountered!

These operational concepts, the reader may now agree, are indeed quite straightforward. True, it does take thousands of machine language instructions to accomplish the tasks, the concepts of which are so easily conveyed in just a few paragraphs. However, the essential point being made is that the overall plan is quite simple. The reader should keep this simple picture in mind as the various sections are discussed in detail. A similar pattern of simplicity will hopefully emerge as the various levels of detail are presented in the following chapters. Readers should refer to this section whenever they feel they are becoming too immersed in the details of individual routines to review where the particular

process being discussed fits in to the basically simple scheme of SCELBAL. The pictorials provided below serve as a summary of what has just been presented as a quick and easy review when desired.




SUMMARY OF FUNDAMENTAL OPERATION OF SCELBAL AS CONTROLLED BY THE THREE DIFFERENT TYPES OF LINES IN THE LINE INPUT BUFFER




OPERATION OF SCELBAL WHEN IN THE PROGRAM RUN MODE

# THE EXECUTIVE

The EXECUTIVE portion of SCELBAL is the part that essentially enables the operator to control the primary operations of the program from a keyboard device. This part of the program actually performs two types of operations. It can decode and direct the program to execute any of the defined executive COMMANDS which are SCRatch, LIST, RUN, SAVE and LOAD. It also serves as an Editor to enable information to be arranged in the USER PROGRAM BUFFER. This buffer is an area in memory used to hold a user created program in the high level syntax of SCELBAL. The executive RUN command causes a program stored in this area to be executed as a stored program.

Before beginning to present the routines that make up SCELBAL it will be beneficial to explain some aspects of the presentation techniques to be used in this publication.

As each section of the program is discussed the actual source listings for that section of the program will be presented with highly detailed comments. These source listings will refer to the assembled version of the program for an 8008 machine that will be presented later in this publication. (An assembled version for an 8080 machine will also be presented.) That is, the values of pointers, counters, temporary storage locations, and buffers used in the source listings will be those values used in the actual assembled example listing.

SCELBAL uses three PAGES of memory for the storage of pointers, counters, temporary data areas and look up tables. In the assembled program presented in this publication these areas were assigned to pages 01, 26 and 27 in memory. A considerable number of machine language instructions in the program are devoted to establishing pointers to these areas through the use of LLI XXX and LHI YYY instructions. It is likely that some users may desire to assemble the package to reside in areas of memory other than those used by the version provided. In such an event, if the storage locations assigned to pages 01, 26 and 27 were altered, the user would have to alter the values used when setting up pointers to those areas. As an aid to those that might undertake this task, those LHI YYY instructions that point to those areas in memory have been "flagged" with a double asterisk (**) at the beginning of the associated comments lines. (It is assumed that the locations of storage areas within a page would not be altered.) Thus, a person desiring to create a new assembly of the program would be able to easily spot those instructions to which particular attention would have to be paid.

While discussing the subject of pointers, counters, temporary storage locations, etc., it will be pointed out that the actual locations of all these storage locations will be presented in the final assembled listing of SCELBAL. During the discussion and presentation of the various routines that make up the program during the next several chapters, the reader does not have to be concerned with where each and every such storage location resides. Indeed, there are too many of them for a person to even attempt to keep close tabs on. The actual locations of such storage areas is not important during the description process as it is only necessary for the reader to realize that such locations do exist and to understand the functions that they perform when required.

During the course of the following chapters, virtually each and every routine used in SCELBAL will be presented in its source listing format. However, due to the general complexity of the program (in the microscopic view point of individual instructions, remember, the fundamental concepts are quite simple), some routines may not be explained or presented in detail the first time they are utilized in the source listing. In these cases the user need only understand that there is a routine or subroutine that

will perform a particular function, the details of which will eventually be presented. This is particularly true in the next several chapters as the beginning sections of the program are discussed.

## LINE FORMAT

In the preceeding chapter, the general format of a line of information as it came from the system's input device was presented. The precise format will now be shown.

Whenever the operator enters information on the system's input device an input routine (labeled STRIN) will arrange a line of information in an INPUT BUFFER in the following format which is illustrated for the example input:

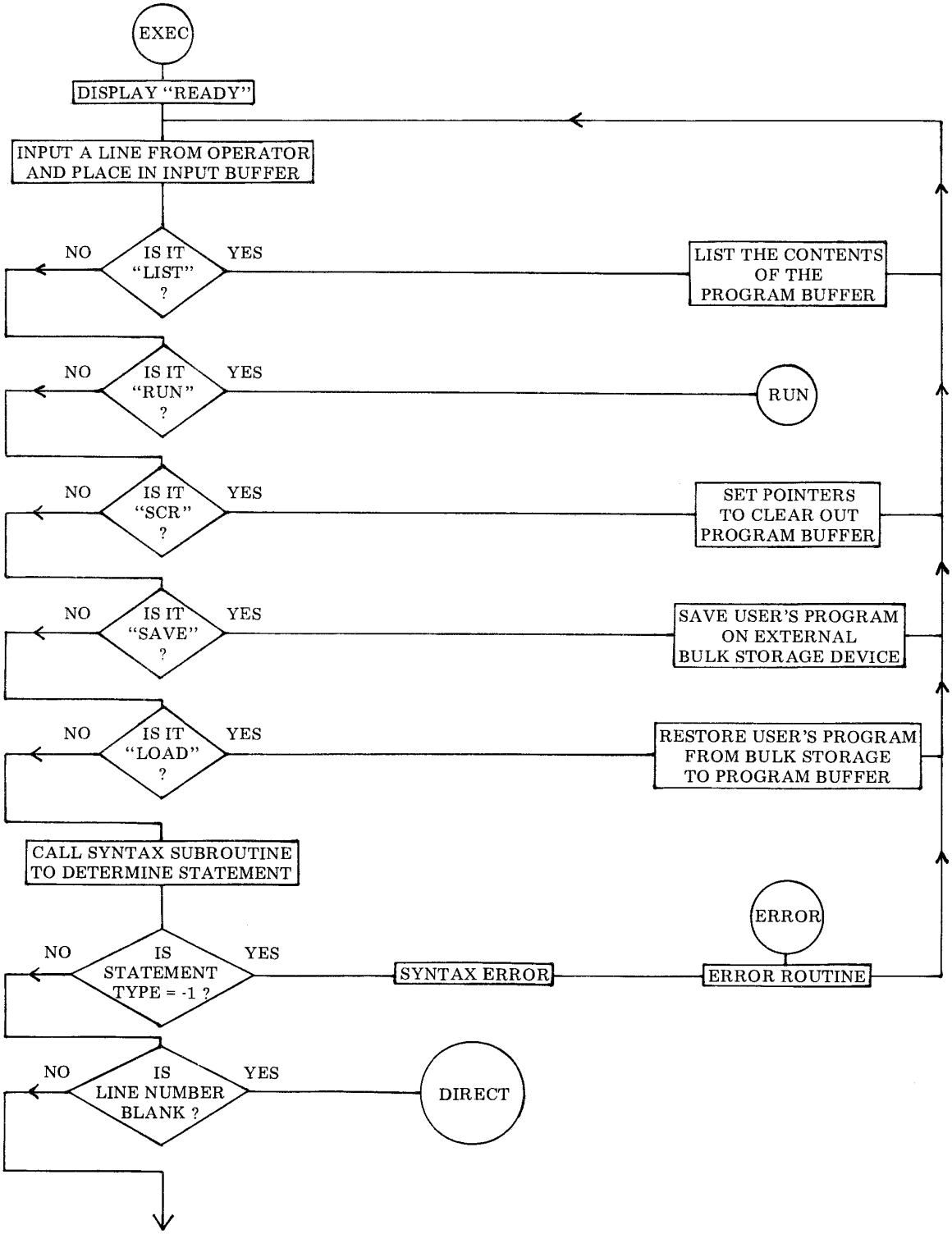
```
100 LET X = Y + 2
```

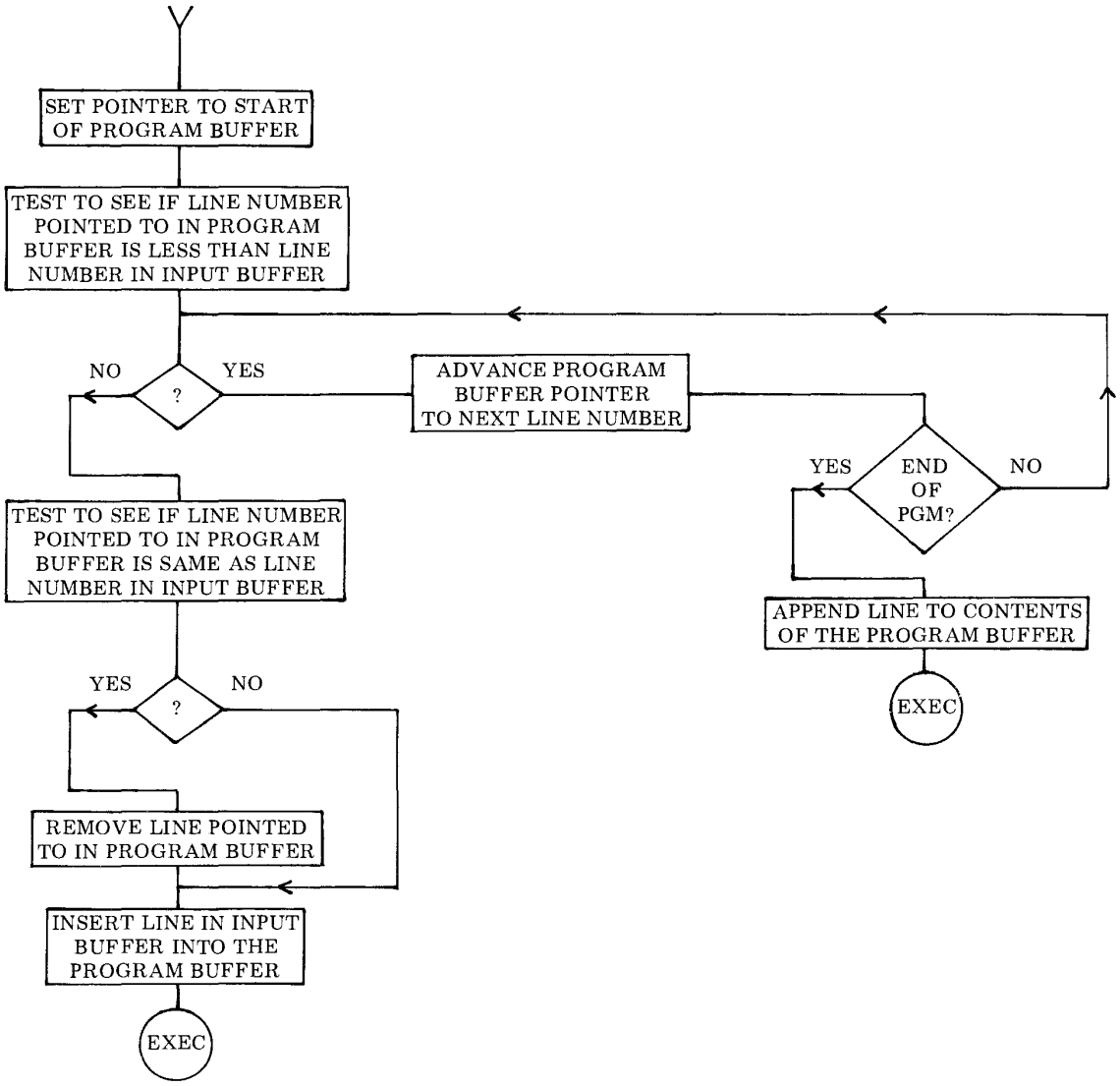
```
021 261 260 260 240 314 305 324 240 330 240 275 240 331 240 253 240 262
cc   1   0   0  sp   L   E   T  sp   X  sp   =  sp   Y  sp   +  sp   2
```

The first line in the above illustration shows the actual machine code that would be stored in successive locations in the INPUT LINE BUFFER. The line beneath it gives the data the code represents in the example. The reader should note that the first entry in the string represents a CHARACTER COUNT. That is a binary count of the number of bytes that the character string consumes. This CHARACTER COUNT (cc) will always be the first byte of data in a character string that is processed by the program. The remaining bytes in a character string are occupied by the ASCII code for the characters being represented shown in eight-bit octal format with the parity bit always being defined in this program as being in a marking (logic one) state. The CHARACTER COUNT for a line of information is calculated by simply reserving the first location in a character string buffer for that information, counting the number of characters inputted until a line terminating character (carriage-return) is received, and then storing the value of that count in the first byte of the character string buffer. The character count for a line of information is an important piece of data that is utilized by many parts of the program package. The reader will soon see how this information is utilized when manipulating lines of data in the Executive/Editor portion of SCELBAL.

With the precise manner in which character strings are stored now explained, one can proceed to present the first major section of SCELBAL. The section to be presented is illustrated by the flow chart shown on the next two pages. The commented source listing begins below.

```
                        SCELBAL and EXECUTIVE start here. This first part
                        sets a pointer to a buffer containing the message
                        READY and calls on a subroutine to display this to the
                        operator indicating program is in the EXECUTIVE
                        COMMAND mode.

EXEC,   LLI 352         Load L with address of READY message
        LHI 001         ** Load H with page of READY message
        CAL TEXTC       Call subroutine to display the READY message
```


EXEC
DISPLAY "READY"
INPUT A LINE FROM OPERATOR AND PLACE IN INPUT BUFFER
IS IT "LIST" ?
NO
YES
LIST THE CONTENTS OF THE PROGRAM BUFFER
IS IT "RUN" ?
NO
YES
RUN
IS IT "SCR" ?
NO
YES
SET POINTERS TO CLEAR OUT PROGRAM BUFFER
IS IT "SAVE" ?
NO
YES
SAVE USER'S PROGRAM ON EXTERNAL BULK STORAGE DEVICE
IS IT "LOAD" ?
NO
YES
RESTORE USER'S PROGRAM FROM BULK STORAGE TO PROGRAM BUFFER
CALL SYNTAX SUBROUTINE TO DETERMINE STATEMENT
ERROR
IS STATEMENT TYPE = -1 ?
NO
YES
SYNTAX ERROR
ERROR ROUTINE
IS LINE NUMBER BLANK ?
NO
YES
DIRECT




---

This next section fetches a line from the operator's input device into the INPUT LINE BUFFER. After making sure that the line contains data it tests to see if the first word in the line is the command LIST. If so, it sets up to perform the LIST directive.

```
EXEC1,  LLI 000     Load L with starting address of INPUT LINE BUFFER
        LHI 026     ** Load H with page of INPUT LINE BUFFER
        CAL STRIN   Call subroutine to input a line into the buffer
        LAM         The STRIN subroutine will exit with pointer set to the
        NDA         CHARACTER COUNT for the line inputted. Fetch the
        JTZ EXEC1   Value of the counter, if it is zero then line was blank.
```

```
        LLI 335     Load L with address of LIST in look up table
        LHI 001     ** Load H with address of LIST in look up table
        LDI 026     ** Load D with page of line input buffer
        LEI 000     Load E with start of line input buffer
        CAL STRCP   Call string compare subroutine to see if first word in
        JFZ NOLIST  Input buffer is LIST. Jump ahead if not LIST.
        LLI 000     If LIST, set up pointers to start of USER PROGRAM
        LHI 033     †† BUFFER. (Note user could alter this starting addr)

                    Next portion of program will LIST the contents of the
                    USER PROGRAM BUFFER until an end of buffer
                    (zero byte) indicator is detected.

LIST,   LAM         Fetch the first byte of a line in the USER PROGRAM
        NDA         BUFFER and see if it is zero. If so, have finished LIST
        JTZ EXEC    So go back to start of Executive and display READY.
        CAL TEXTC   Else call subroutine to display a line of information
        CAL ADV     Now call subroutine to advance buffer pointer to
        CAL CRLF    Character count in next line. Also display a CR & LF.
        JMP LIST    Continue LISTing process

                    If line inputted by operator did not contain a LIST
                    command, continue program to see if RUN or SCRatch
                    command.

NOLIST, LLI 342     Load L with address of RUN in look up table
        LHI 001     ** Load H with address of RUN in look up table
        LEI 000     Load E with start of line input buffer
        LDI 026     ** Load D with page of line input buffer
        LEI 000     (Reserve 2 locs in case of patching by duplicating above)
        CAL STRCP   Call string compare subroutine to see if first word in
        JTZ RUN     Input buffer is RUN. Go to RUN routine if match.
        LDI 026     ** If not RUN command, reset address pointers back
        LEI 000     To the start of the line input buffer
        LLI 346     Load L with address of SCR in look up table
        LHI 001     ** Load H with page of SCR in look up table
        CAL STRCP   Call string compare subroutine to see if first word in
        JFZ NOSCR   Input buffer is SCR. If not then jump ahead.
        LHI 026     ** If found SCR command then load memory pointer
        LLI 364     With address of a pointer storage location. Set that
        LMI 033     †† Storage location to page of start of USER PRO-
        INL         GRAM BUFFER. (Buffer start loc may be altered).
        LMI 000     Then adv pntr and do same for low addr portion of pntr
        LLI 077     Now set pointer to address of VARIABLES counter
        LHI 027     ** Storage location. Initialize this counter by placing
        LMI 001     The count of one into it. Now change the memory pntr
        LLI 075     To storage location for number of dimensioned arrays
        LMI 000     @@ And initialize to zero. (@@ = Substitute NOPs if
        LLI 120     @@ DIMension capability not used in package.) Also
        LMI 000     @@ Initialize 1'st byte of array name table to zero.
        LLI 210     Set pointer to storage location for the first byte of the
```

```
        LMI 000     VARIABLES symbol table. Initialize it to zero too.
        INL         Advance the pointer and zero the second location
        LMI 000     In the Variables table also.
        LHI 033     †† Load H with page of start of USER PROGRAM
        LLI 000     BUFFER. (Buffer start location could be altered.)
        LMI 000     Clear first location to indicate end of user program.
        LHI 057     @@ Load H with page of ARRAYS storage

SCRLOP, LMI 000     @@ And form a loop to clear out all the locations
        INL         @@ On the ARRAYS storage page. (@@ These become
        JFZ SCRLOP  @@ NOPs if DIMension capability deleted fm package.)
        JMP EXEC    SCRatch operations completed, go back to EXEC.

                    If line inputted did not contain RUN or SCRatch com-
                    mand, program continues by testing for SAVE or LOAD
                    commands. If it does not find either of these com-
                    mands, then operator did not input an executive com-
                    mand. Program then sets up to see if the first entry in
                    the line inputted is a LINE NUMBER.

NOSCR,  LEI 272     Load E with address of SAVE in look up table
        LDI 001     ** Load D with page of look up table
        LHI 026     ** Load H with page of input line buffer
        LLI 000     Set L to start of input line buffer
        CAL STRCP   Call string compare subroutine to see if first word in
        JTZ SAVE    †† Input buffer is SAVE. If so, go to user's SAVE rtn
        LLI 277     If not SAVE then load L with address of LOAD in look
        LHI 001     ** Up table and load H with page of look up table
        LDI 026     ** Load D with page of input line buffer
        LEI 000     And L to start of input line buffer
        CAL STRCP   Call string compare subroutine to see if first word in
        JTZ LOAD    †† Input buffer is LOAD. If so, go to user's LOAD rtn
        LLI 360     If not LOAD then set pointer to address of storage loc
        LHI 026     ** For USER PROGRAM BUFFER pointer. Initialize this
        LMI 033     †† Pointer to the starting address of the program buffer.
        INL         Advance memory pntr. Since pointer storage requires
        LMI 000     Two locations, initialize the low addr portion also.
        CAL SYNTAX  Call the SYNTAX subroutine to obtain a TOKEN indi-
        LLI 203     Cator which will be stored in this location. Upon return
        LHI 026     ** From SYNTAX subroutine set memory pointer to
        LAM         The TOKEN indicator storage location and fetch the
        NDA         Value of the TOKEN. If the value of the syntax TOKEN
        JFS SYNTOK  Is positive then have a valid entry.

SYNERR, LAI 323     However, if SYNTAX returns a negative value TOKEN
        LCI 331     Then have an error condition. Set up the letters SY in
        JMP ERROR   ASCII code and go to display error message to operator.

SYNTOK, LLI 340     Set pointer to start of LINE NUMBER storage area
        LAM         First byte there will contain the length of the line
        NDA         Number character string. Fetch that value (cc).
```

```
        JTZ DIRECT      If line number blank, have a DIRECT statement!
        LLI 360         If have a line number must get line in input buffer into
        LMI 033         †† User program buffer. Initialize pointer to user buffer.
        INL             This is a two byte pointer so after initializing page addr
        LMI 000         Advance pointer and initialize location on page address
```

If the line in the LINE INPUT BUFFER has a line number then the line is to be placed in the USER PROGRAM BUFFER. It is now necessary to determine where the new line is to be placed in the USER PROGRAM BUFFER. This is dictated by the value of the new line number in relation to the line numbers currently in the program buffer. The next portion of the program goes through the contents of the USER PROGRAM BUFFER comparing the values of the line numbers already stored against the value of the line number currently being held in the LINE INPUT BUFFER. Appropriate action is then taken to Insert or Append, Change, or Delete a line in the program buffer.

```
GETAUX, LLI 201         Set memory pointer to line character pointer storage
        LHI 026         ** Location and then initialize that storage location
        LMI 001         To point to the 1'st character in a line
        LLI 350         Set memory pointer to addr of start of auxiliary line
        LMI 000         Number storage area and initialize first byte to zero
GETAU0, LLI 201         Set memory pointer to line character pointer storage loc
        CAL GETCHP      Fetch a char in line pointed to by line pointer
        JTZ GETAU1      If character is a space, skip it by going to advance pntrs
        CPI 260         If not a space check to see if character represents a
        JTS GETAU2      Valid decimal digit in the range 0 to 9 by testing the
        CPI 272         ASCII code value obtained. If not a decimal digit then
        JFS GETAU2      Assume have obtained the line number. Go process.
        LLI 350         If valid decimal digit want to append the digit to the
        LHI 026         ** Current string being built up in the auxiliary line
        CAL CONCT1      Number storage area so call sub to concat a character.

GETAU1, LLI 201         Reset memory pointer to line character pntr storage loc
        LHI 026         ** On the appropriate page.
        LBM
        INB             Fetch the pointer, increment it, and restore new value
        LMB
        LLI 360         Set memory pointer to pgm buff line pntr storage loc
        LHI 026         **
        LCM             Bring the high order byte of this double byte pointer
        INL             Into CPU register C. Then advance the memory pntr
        LLM             And bring the low order byte into register L. Now trans-
        LHC             Fer the higher order portion into memory pointer H.
        LAM             Obtain the char cntr (cc) which indicates the length of
        DCB             The line being pointed to by the user program line pntr
        CPB             Compare this with the value of the chars processed so
        JFZ GETAU0      Far in current line. If not equal, continue getting line nr.
```

```
GETAU2,  LLI 360      Reset mem pntr to pgm buffer line pntr storage
         LHI 026      ** On this page and place the high order byte
         LDM          Of this pointer into CPU register D
         INL          Advance the memory pointer, fetch the second
         LLM          Byte of the pgm buffer line pointer into register L
         LHD          Now make the memory pointer equal to this value
         LAM          Fetch the first byte of a line in the program buffer
         NDA          Test to see if end of contents of pgm buff (zero byte)
         JFZ NOTEND   If not zero continue processing. If zero have reached
         JMP NOSAME   End of buffer contents so go APPEND line to buffer.

NOTEND,  LLI 350      Load L with addr of auxiliary line number storage loc
         LHI 026      ** Load H with addr of aux line number storage loc
         LDI 026      ** Load D with addr of line number buffer location
         LEI 340      Load E with address of line number buffer location
         CAL STRCP    Compare line nr in input buffer with line number in
         JTS CONTIN   User program buffer. If lesser in value keep looking.
         JFZ NOSAME   If greater in value then go to Insert line in pgm buffer
         LLI 360      If same values then must remove the line with the same
         LHI 026      ** Line number from the user program buffer. Set up
         LCM          The CPU memory pointer to point to the current
         INL          Position in the user program buffer by retrieving that
         LLM          Pointer from its storage location. Then obtain the first
         LHC          Byte of data pointed to which will be the character
         LBM          Count for that line (cc). Add one to the cc value to take
         INB          Account of the (cc) byte itself and then remove that
         CAL REMOVE   Many bytes to effectively delete the line fm the user
         LLI 203      Program buffer. Now see if line in input buffer consists
         LHI 026      ** Only of a line number by checking SYNTAX
         LAM          TOKEN value. Fetch the TOKEN value from its
         NDA          Storage location. If it is zero then input buffer only
         JTZ EXEC     Contains a line number. Action is a pure Delete.
NOSAME,  LLI 360      Reset memory pointer to program buffer
         LHI 026      ** Line pointer storage location
         LDM          Load high order byte into CPU register D
         INL          Advance memory pointer
         LEM          Load low order byte into CPU register E
         LLI 000      Load L with address of start of line input buffer
         LHI 026      ** Do same for CPU register H
         LBM          Get length of line input buffer
         INB          Advance length by one to include (cc) byte
         CAL INSERT   Go make room to insert line into user program buffer
         LLI 360      Reset memory pointer to program buffer
         LHI 026      ** Line pointer storage location
         LDM          Load higher byte into CPU register D
         INL          Advance memory pointer
         LEM          Load low order byte into CPU register E
         LLI 000      Load L with address of start of line input buffer
         LHI 026      ** Do same for CPU register H
         CAL MOVEC    Call subroutine to Insert line in input buffer into the
         JMP EXEC1    User program buffer then go back to start of EXEC.
```

```
MOVEC,   LBM          Fetch length of string in line input buffer
         INB          Increment that value to provide for (cc)
MOVEPG,  LAM          Fetch character from line input buffer
         CAL ADV      Advance pointer for line input buffer
         CAL SWITCH   Switch memory pointer to point to user pgm buffer
         LMA          Deposit character fm input buff into user pgm buff
         CAL ADV      Advance pointer for user program buffer
         CAL SWITCH   Switch memory pntr back to point to input buffer
         DCB          Decrement character counter stored in CPU register B
         JFZ MOVEPG   If counter does not go to zero continue transfer ops
         RET          When counter equals zero return to calling routine

CONTIN,  LLI 360      Reset memory pointer to program buffer
         LHI 026      ** Line pointer storage location
         LDM          Load high order byte into CPU register D
         INL          Advance memory pointer
         LEM          Load low order byte into CPU register E
         LHD          Now set CPU register H to high part of address
         LLE          And set CPU register L to low part of address
         LBM          Fetch the character counter (cc) byte fm line in
         INB          Program buffer and add one to compensate for (cc)
         CAL ADBDE    Add length of line value to old value to get new pointer
         LLI 360      Reset memory pointer to program buffer
         LHI 026      ** Line pointer storage location
         LMD          Restore new high portion
         INL          Advance memory pointer
         LME          And restore new low portion
         JMP GETAUX   Continue til find point at which to enter new line

GETCHP,  LHI 026      ** Load H with pointer page (low portion set upon
         LBM          Entry). Now fetch pointer into CPU register B.
         LLI 360      Reset pntr to pgm buffer line pointer storage location
         LDM          Load high order byte into CPU register D
         INL          Advance memory pointer
         LEM          Load low order byte into CPU register E
         CAL ADBDE    Add pointer to pgm buffer pointer to obtain address of
         LHD          Desired character. Place high part of new addr in H.
         LLE          And low part of new address in E.
         LAM          Fetch character from position in line in user pgm buffer
         CPI 240      See if it is the ASCII code for space
         RET          Return to caller with flags set to indicate result

REMOVE,  CAL INDEXB   Add (cc) plus one to addr of start of line
         LCM          Obtain byte from indexed location and
         CAL SUBHL    Subtract character count to obtain old location
         LMC          Put new byte in old location
         LAC          As well as in the Accumulator
         NDA          Test to see if zero byte to indicate end of user pgm buff
         JTZ REMOV1   If it is end of user pgm buffer, go complete process
         CAL ADV      Otherwise add one to the present pointer value
         JMP REMOVE   And continue removing characters from the user pgm bf
```

```
REMOV1,  LLI 364      Load L with end of user pgm buffer pointer storage loc
         LHI 026      ** Load H with page of that pointer storage location
         LDM          Get page portion of end of pgm buffer address
         INL          Advance memory pointer
         LAM          And get low portion of end of pgm buffer address into
         SUB          Accumulator then subtract displacement value in B
         LMA          Restore new low portion of end of pgm buffer address
         RFC          If subtract did not cause carry can return now
         DCL          Otherwise decrement memory pointer back to page
         DCD          Storage location, decrement page value to give new page
         LMD          And store new page value back in buffer pntr storage loc
         RET          Then return to calling routine

INSERT,  LLI 364      Load L with end of user pgm buffer pointer storage loc
         LHI 026      ** Load H with page of that pointer storage location
         LAM          Get page portion of end of program buffer address
         INL          Advance memory pointer
         LLM          Load low portion of end of program buffer address
         LHA          Into L and finish setting up memory pointer
         CAL INDEXB   Add (cc) of line in input buffer to form new end of
         LAH          Program buffer address. Fetch new end of buffer page
         CPI 054      †† Address and see if this value would exceed user's
         JFS BIGERR   System capability. Go display error message if so!
         CAL SUBHL    Else restore original value of end of buffer address

INSER1,  LCM          Bring byte pointed to by H & L into CPU register C
         CAL INDEXB   Add displacement value to current memory pointer
         LMC          Store the byte in the new location
         CAL SUBHL    Now subtract displacement value from H & L
         CAL CPHLDE   Compare this with the address stored in D & E
         JTZ INSER3   If same then go finish up Insert operation
         CAL DEC      Else set pointer to the byte before the byte just
         JMP INSER1   Processed and continue the Insert operation

INSER3, INCLIN,  LLI 000      Load L with start of line input buffer
         LHI 026      ** Load H with page of start of line input buffer
         LBM          Fetch length of the line in line input buffer
         INB          Increment value by one to include (cc) byte
         LLI 364      Set memory pointer to end of user pgm buffer pointer
         LDM          Storage location on same page and fetch page address
         INL          Of this pointer into D. Then advance memory pointer
         LEM          And get low part of this pointer into CPU register E.
         CAL ADBDE    Now add displacement (cc) of line in input buffer to
         LME          The end of program buffer pointer. Replace the updated
         DCL          Low portion of the new pointer value back in storage
         LMD          And restore the new page value back into storage
         RET          Then return to calling routine
```

```
                        The following are small subroutines used by the
                        EXECutive and other parts of SCELBAL.

CPHLDE,  LAH            Subroutine to compare if the contents of CPU registers
         CPD            H & L are equal to registers D & E. First compare
         RFZ            Register H to D. Return with flags set if not equal. If
         LAL            Equal continue by comparing register L to E.
         CPE            IF L equals E then H & L equal to D & E so return to
         RET            Calling routines with flags set to equality status

ADBDE,   LAE            Subroutine to add the contents of CPU register B (single
         ADB            Byte value) to the double byte value in registers D & E.
         LEA            First add B to E to form new least significant byte
         RFC            Restore new value to E and exit if no carry resulted.
         IND            If had a carry then must increment most significant byte
         RET            In register D before returning to calling routine

CTRLC,   LAI 336        Set up ASCII code for ↑ (up arrow) in Accumulator.
         LCI 303        Set up ASCII code for letter 'C' in CPU register C.
         JMP ERROR      Go display the 'Control C' condition message.

FINERR,  LLI 340        Load L with starting address of line number storage area
         LHI 026        ** Load H with page of line number storage area
         LAM            Get (cc) for line number string. If length is zero meaning
         NDA            There is no line number stored in the buffer then jump
         JTZ FINER1     Ahead to avoid displaying "AT LINE" message
         LLI 366        Else load L with address of start of "AT LINE" message
         LHI 001        ** Stored on this page
         CAL TEXTC      Call subroutine to display the "AT LINE" message
         LLI 340        Now reset L to starting address of line number storage
         LHI 026        ** Area and do same for CPU register H
         CAL TEXTC      Call subroutine to display the line number
FINER1,  CAL CRLF       Call subroutine to provide a carriage-return and line-feed
         JMP EXEC       To the display device then return to EXEC UTIVE.

DVERR,   LAI 304        Set up ASCII code for letter 'D' in Accumulator
         LCI 332        Set up ASCII code for letter 'Z' in CPU register C
         JMP ERROR      Go display the 'DZ' (divide by zero) error message

FIXERR,  LAI 306        Set up ASCII code for letter 'F' in Accumulator
         LCI 330        Set up ASCII code for letter 'X' in CPU register C
         JMP ERROR      Go display the 'FX' (FiX) error message

NUMERR,  LAI 311        Set up ASCII code for letter 'I' in Accumulator
         LCI 316        Set up ASCII code for letter 'N' in CPU register C
         LLI 220        Load L with address of pointer used by DINPUT
         LHI 001        ** Routine. Do same for register H.
         LMI 000        Clear the location
         JMP ERROR      Go display the 'IN' (Illegal Number) error message
```

```
                        The following subroutine, used by various sections of
                        SCELBAL, will search the LINE INPUT BUFFER for
                        a character string which is contained in a buffer starting
                        at the address pointed to by CPU registers H & L when
                        the subroutine is entered.

INSTR,  LDI 026         ** Set D to starting page of LINE INPUT BUFFER
        LEI 000         Load E with starting location of LINE INPUT BUFFER

INSTR1, CAL ADVDE       Advance D & E pointer to the next location (input
        CAL SAVEHL      Buffer). Now save contents of D, E, H & L before the
        LBM             Compare operations. Get length of TEST buffer in B.
        CAL ADV         Advance H & L pointer to first char in TEST buffer
        CAL STRCPC      Compare contents of TEST buffer against input buffer
        JTZ RESTHL      For length B. If match, restore pntrs and exit to caller.
        CAL RESTHL      If no match, restore pointers for loop test.
        LLI 000         Load L with start of input buffer (to get the char cntr)
        LHI 026         ** Load H with page of input buffer.
        LAM             Get length of buffer (cc) into the accumulator.
        CPE             Compare with current input buffer pointer value.
        JTZ INSTR2      If at end of input buffer, jump ahead.
        CAL RESTHL      Else restore test string address (H&L) and input buffer
        JMP INSTR1      Address (D&E). Look for occurence of test string in ln.
        HLT             Safety halt. If program reaches here have system failure.

INSTR2, LEI 000         If reach end of input buffer without finding a match
        RET             Load E with 000 as an indicator and return to caller.

ADVDE,  INE             Subroutine to advance the pointer stored in the register
        RFZ             Pair D & E. Advance contents of E. Return if not zero.
        IND             If register E goes to zero when advanced, then advance
        RET             Register D too. Exit to calling routine.
```

# THE MAIN SYNTAX ROUTINE

In order to avoid confusing the reader with the title of this chapter, it will be pointed out that the word SYNTAX generally refers to the complete set of rules or grammar associated with a language such as SCELBAL. The above title implies more than this single chapter will cover. The preceeding chapter actually began explaining the complete syntax of SCELBAL by showing how Executive commands were processed and defining the use of line numbers. Other rules of the syntax defined for SCELBAL will become apparent as other chapters are presented. The section of SCELBAL to be discussed in this chapter is limited to the first major subset of the language which consists of the statement classifications. Statements are the major types of higher level directives which the language can interpret and execute such as LET, GOTO, IF, FOR etc. When SCELBAL finds one of these statements in a line of higher level coding, it will know what major type of operation it is to perform. The portion of the program that makes this initial syntax determination has been labeled SYNTAX, hence the title name of this chapter.

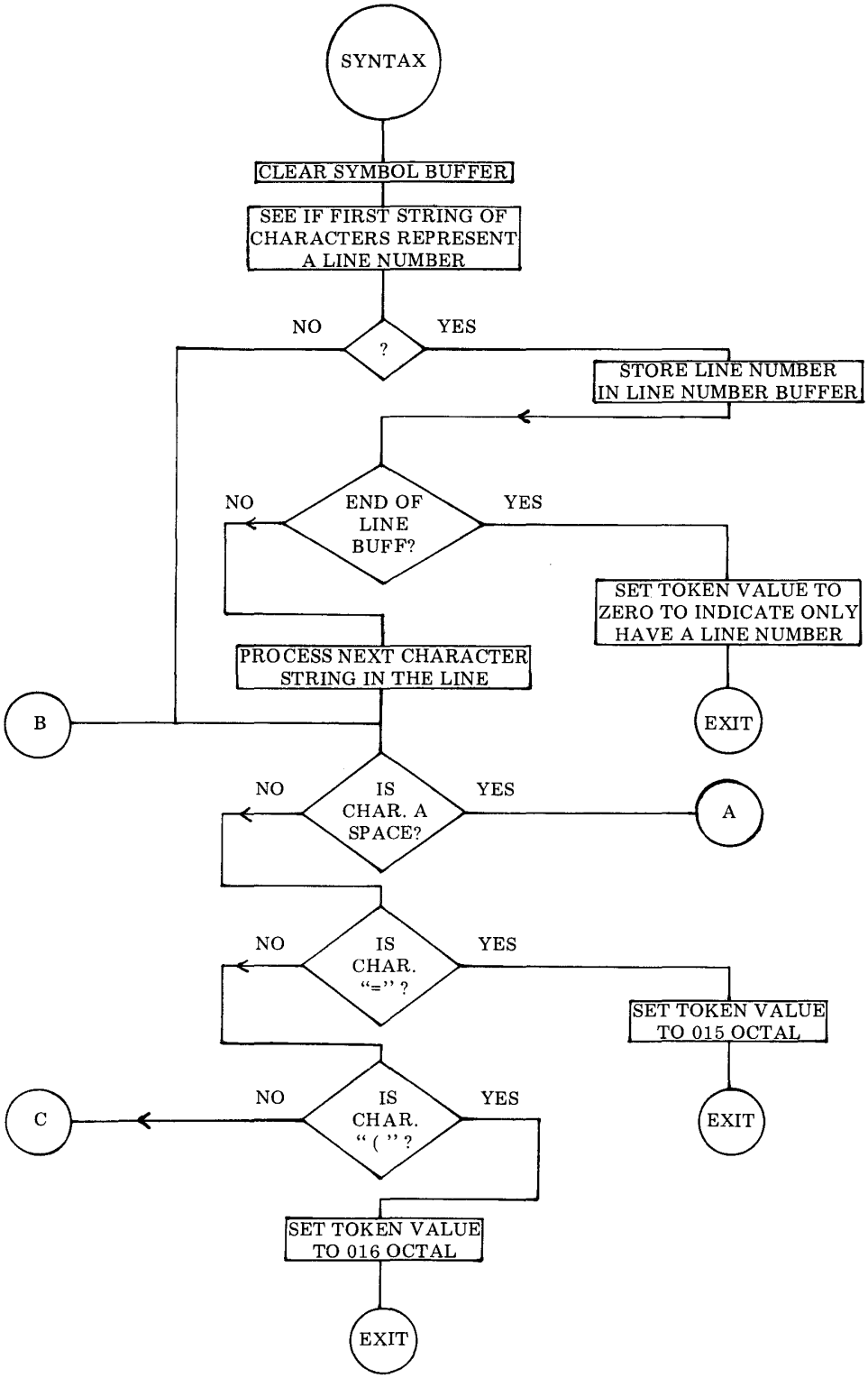
The SYNTAX subroutine to be presented in this chapter is not difficult to understand once the reader gets an overall view of the process. Referring to the flow chart for the routine illustrated on the next several pages will help the reader get the essential concepts involved.

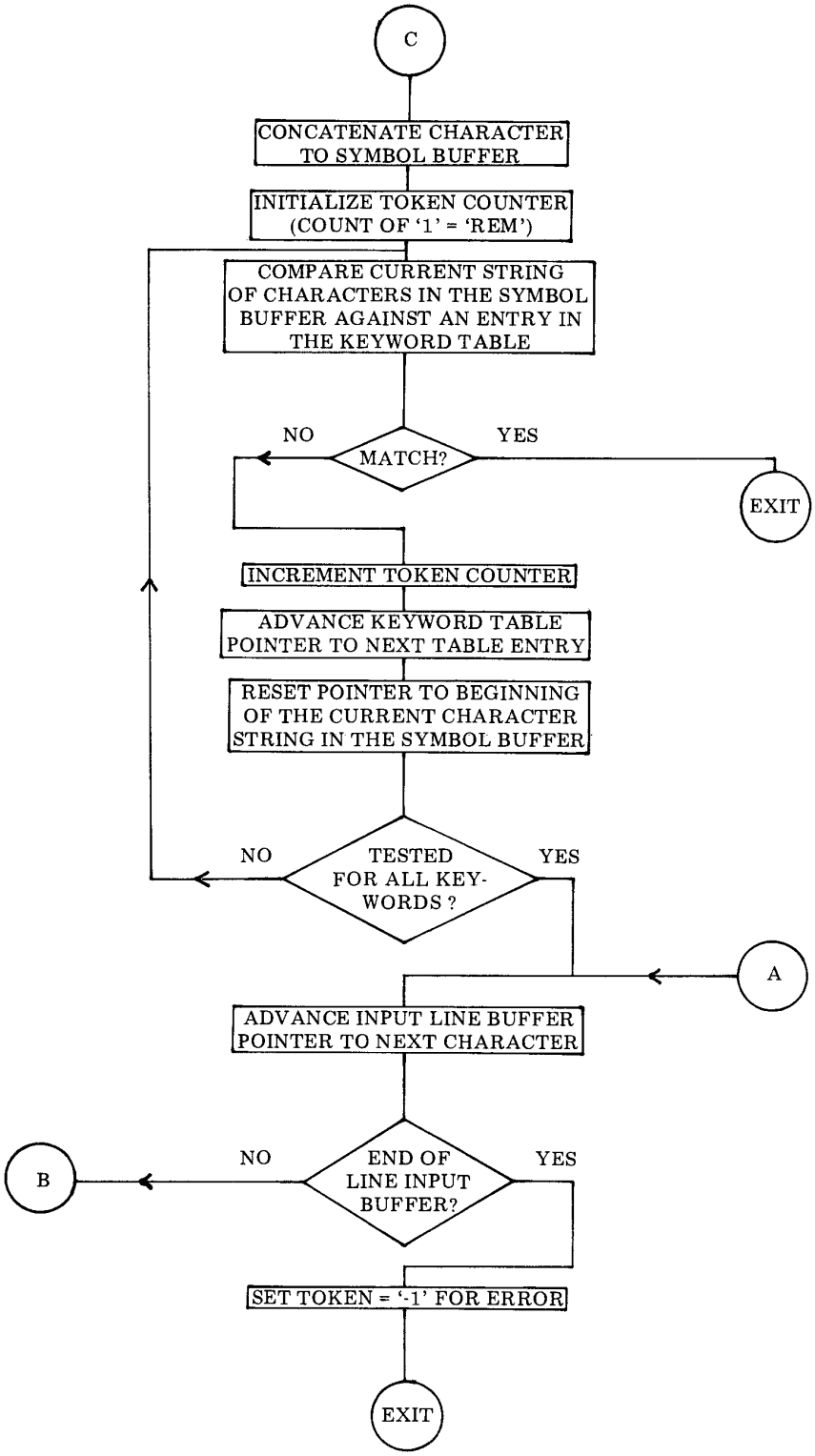
The purpose of the routine is simply to determine whether a group of characters (taken from the contents of the LINE INPUT BUFFER) represent a program line number, and a valid statement KEYWORD. A KEYWORD in this context is simply a group of characters that form the name of a valid statement such as LET, GOSUB, FOR, NEXT and so forth. If a line number is found, and/or a valid KEYWORD is found, the routine will place a TOKEN value in a special TOKEN BUFFER to indicate what the SYNTAX subroutine processed. A TOKEN value in this context is simply a numerical value used to symbolize the finding of a particular type of character string. It is a sort of shorthand notation that serves to reduce the amount of data that must be processed by the computer in the future.

Thus, for instance, if during the operation of the SYNTAX routine, the keyword REM is detected, a token value of 001 (octal) will be established. The finding of the keyword GOTO would result in a token value of 004 being set up. Each valid keyword has a token value associated with it. The token value established is then used later by other portions of SCELBAL to signify a particular type of operation using much less storage space than would be required if one had to refer to an entire string of ASCII characters that make up a keyword. The technique of establishing a token value to represent a particular string of characters is thus a powerful method in the process of converting higher level English language directives which are convenient for human programmers, down to the simple numerical directives that the computer needs for sustenance!

The process by which keywords are converted to token values is shown quite clearly in the flow chart provided. Essentially the routine seeks to find a match between a group of characters (taken from the line input buffer and examined while in a working register) to determine if they match any entry in a keyword look-up table. The keyword look-up table utilized by this routine is formatted as follows:

| | |
|---|---|
| CCC | Number of characters in keyword. |
| AAA | ASCII code for 1'st letter of keyword |
| BBB | ASCII code for 2'nd letter of keyword |
| . | |
| NNN | ASCII code for N'th letter of keyword |
| CCC | Number of characters in next keyword |
| AAA | ASCII code for 1'st letter of the next |
| . | entry in the keyword table, etc. |


SYNTAX
CLEAR SYMBOL BUFFER
SEE IF FIRST STRING OF CHARACTERS REPRESENT A LINE NUMBER
NO
?
YES
STORE LINE NUMBER IN LINE NUMBER BUFFER
NO
END OF LINE BUFF?
YES
SET TOKEN VALUE TO ZERO TO INDICATE ONLY HAVE A LINE NUMBER
PROCESS NEXT CHARACTER STRING IN THE LINE
EXIT
B
NO
IS CHAR. A SPACE?
YES
A
NO
IS CHAR. "=" ?
YES
SET TOKEN VALUE TO 015 OCTAL
EXIT
C
NO
IS CHAR. " ( " ?
YES
SET TOKEN VALUE TO 016 OCTAL
EXIT


C
CONCATENATE CHARACTER TO SYMBOL BUFFER
INITIALIZE TOKEN COUNTER (COUNT OF '1' = 'REM')
COMPARE CURRENT STRING OF CHARACTERS IN THE SYMBOL BUFFER AGAINST AN ENTRY IN THE KEYWORD TABLE
NO
MATCH?
YES
EXIT
INCREMENT TOKEN COUNTER
ADVANCE KEYWORD TABLE POINTER TO NEXT TABLE ENTRY
RESET POINTER TO BEGINNING OF THE CURRENT CHARACTER STRING IN THE SYMBOL BUFFER
NO
TESTED FOR ALL KEY-WORDS ?
YES
A
ADVANCE INPUT LINE BUFFER POINTER TO NEXT CHARACTER
B
NO
END OF LINE INPUT BUFFER?
YES
SET TOKEN = '-1' FOR ERROR
EXIT

The table contains all the valid keywords defined for statement types used in the high level language SCELBAL. These are: REM, IF, LET, GOTO, PRINT, INPUT, FOR, NEXT, GOSUB, RETURN, DIM and END. They appear in the table in the order just presented.

Since the number of characters making up a keyword can vary, the technique used to look for a match between a group of characters in the line input buffer and the look-up table is as follows.

Characters are taken one at a time from the line input buffer and placed in a special buffer (referred to as the SYMBOL buffer). Each time a character is added to the symbol buffer, a search is made through the keyword look-up table. At the start of the search a TOKEN value of 001 (octal) is set in the TOKEN VALUE storage register. Now, as each entry in the look-up table is compared against the character string currently in the symbol buffer and fails to match, the token value is incremented. This technique results, if a match IS found, in the token value already being set to the proper token value. For instance, if a match was found for the keyword PRINT, the token value would be at 005. (Print is the fifth entry in the look-up table.) If a match is not found during the search of the table, the routine goes back and appends another character from the input buffer onto the symbol buffer. It then reinitializes the token value back to 001 and tries searching the table again. This process continues until either a match is found or an end of character string terminator is detected. Notice that if a keyword is not found, once the table look-up process is started, that an error condition (SYntax error) is assumed to exist. For such an error condition, a negative value (377 octal) is placed in the token value register so that the routine calling SYNTAX will be able to detect the error condition.

The reader should note that the flow chart illustrates two special syntax conditions. One is when an equal (=) sign is detected. Finding an equal sign before a keyword has been established can occur for a special situation called the IMPLIED LET. The IMPLIED LET statement enables SCELBAL to interpret a statement such as:

$$X = Y$$

without having to put in the actual LET keyword. An IMPLIED LET statement signified by an equal sign at the point in a line where the SYNTAX routine would be processing the information is handled as a special keyword and given the token value of 015.

A second special case is defined for handling array (subscripted) variables in an IMPLIED LET situation. The use of a left hand parenthesis "(" at this point in a line is assigned a token value of 016.

One of the principal functions of the SYNTAX subroutine, which is shown at the beginning of the flow chart, is to see if the line being processed contains a line number and to store the line number in a special line number buffer. This is because the SYNTAX routine is the first routine to be called when SCELBAL is in the RUN mode each time a new line is processed. Lines stored in the program buffer start with a line number, and then the keyword statement. Naturally, the SYNTAX subroutine must get beyond the line number before it can look for the keyword in the line. However, there are certain cases, such as when SYNTAX is called by the EXECutive routine (described in the previous chapter) where a line in the input buffer may contain just a line number and no keyword. (This is the situation when an operator wishes to delete a specific line number from the user's program buffer.) For this special case, the SYNTAX subroutine assigns a token value of 000.

The converse case can occur when a DIRECT (calculator mode) statement is being processed. In that case there would be no line number. The flow chart illustrates that if the first group of characters in a line is not num-

erical the routine proceeds to just look for a keyword.

The reader should now be prepared to follow the detailed source listing for this section of the program as presented next starting at the instruction labeled SYNTAX. The reader may review from the flow chart as desired.

```
SYNTAX,  CAL CLESYM   Clear the SYMBOL BUFFER area
         LLI 340      Set L to start of LINE NUMBER BUFFER
         LHI 026      ** Set H to page of LINE NUMBER BUFFER
         LMI 000      Initialize line number buff by placing zero as (cc)
         LLI 201      Change pointer to syntax counter/pointer storage loc.
         LMI 001      Set pointer to first character (after cc) in line buffer

SYNTX1,  LLI 201      Set pointer to syntax cntr/pntr storage location
         CAL GETCHR   Fetch the character pointed to by contents of syntax
         JTZ SYNTX2   Cntr/pntr from the line input buffer. If character was
         CPI 260      A space, ignore. Else, test to see if character was ASCII
         JTS SYNTX3   Code for a decimal digit. If not a decimal digit, consider
         CPI 272      Line number to have been processed by jumping
         JFS SYNTX3   Over the remainder of this SYNTX1 section.
         LLI 340      If have decimal digit, set pointer to start of LINE
         CAL CONCT1   NUMBER BUFFER and append incoming digit there.

SYNTX2,  LLI 201      Reset L to syntax cntr/pntr storage location. Call sub-
         CAL LOOP     Routine to advance pntr and test for end of input buffer
         JFZ SYNTX1   If not end of input buffer, go back for next digit
         LLI 203      If end of buffer, only had a line number in the line.
         LMI 000      Set pntr to TOKEN storage location. Set TOKEN = 000.
         RET          Return to caller.

SYNTX3,  LLI 201      Reset pointer to syntax cntr/pntr and fetch
         LBM          Position of next character after the line number
         LLI 202      Change pntr to SCAN pntr storage location
         LMB          Store address when SCAN takes up after line number

SYNTX4,  LLI 202      Set pntr to SCAN pntr storage location
         CAL GETCHR   Fetch the character pointed to by contents of the SCAN
         JTZ SYNTX6   Pointer storage location. If character was ASCII code
         CPI 275      For space, ignore. Else, compare character with "=" sign
         JTZ SYNTX7   If is an equal sign, go set TOKEN for IMPLIED LET.
         CPI 250      Else, compare character with left parenthesis " ( "
         JTZ SYNTX8   If left parenthesis, go set TOKEN for implied array LET
         CAL CONCTS   Otherwise, concatenate the character onto the string
         LLI 203      Being constructed in the SYMBOL BUFFER. Now set
         LMI 001      Up TOKEN storage location to an initial value of 001.
         LHI 027      ** Set H to point to start of KEYWORD TABLE.
         LLI 000      Set L to point to start of KEYWORD TABLE.
```

```
SYNTX5,  LDI 026      ** Set D to page of SYMBOL BUFFER
         LEI 120      Set E to start of SYMBOL BUFFER
         CAL STRCP    Compare char string presently in SYMBOL BUFFER
         RTZ          With entry in KEYWORD TABLE. Exit if match.
         CAL SWITCH   TOKEN will be set to keyword found. Else, switch

SYNTXL,  INL          Pointers to get table address back and advance pntr to
         LAM          KEYWORD TABLE. Now look for start of next entry
         NDI 300      In KEYWORD TABLE by looking for (cc) byte which
         JFZ SYNTXL   Will NOT have a one in the two most sig. bits. Advance
         CAL SWITCH   Pntr til next entry found. Then switch pointers again so
         LLI 203      Table pointer is in D&E. Put addr of TOKEN in L.
         LHI 026      ** And page of TOKEN in H. Fetch the value currently
         LBM          In TOKEN and advance it to account for going on to
         INB          The next entry in the KEYWORD TABLE.
         LMB          Restore the updated TOKEN value back to storage.
         CAL SWITCH   Restore the keyword table pointer back to H&L.
         LAB          Put TOKEN count in ACC.
         CPI 015      See if have tested all entries in the keyword table.
         JFZ SYNTX5   If not, continue checking the keyword table.

SYNTX6,  LLI 202      Set L to SCAN pointer storage location
         LHI 026      ** Set H to page of SCAN pointer storage location
         CAL LOOP     Call routine to advance pntr & test for end of ln buffer
         JFZ SYNTX4   Go back and add another character to SYMBOL BUFF
         LLI 203      And search table for KEYWORD again. Unless reach
         LMI 377      End of line input buffer. In which case set TOKEN=377
         RET          As an error indicator and exit to calling routine.

SYNTX7,  LLI 203      Set pointer to TOKEN storage register. Set TOKEN
         LMI 015      Equal to 015 when "=" sign found for IMPLIED LET.
         RET          Exit to calling routine.

SYNTX8,  LLI 203      Set pointer to TOKEN storage register. Set TOKEN
         LMI 016      Equal to 016 when "(" found for IMPLIED array LET.
         RET          Exit to calling routine.

                      The following are subroutines used by SYNTAX and
                      other routines in SCELBAL.

BIGERR,  LAI 302      Load ASCII code for letters B and G to indicate BIG
         LCI 307      ERROR (For when buffer, stack, etc., overflows.)

ERROR,   CAL ECHO     Call user provided display routine to print ASCII code
         LAC          In accumulator. Transfer ASCII code from C to ACC
         CAL ECHO     And repeat to display error codes.
         JMP FINERR   Go complete error message (AT LINE) as required.

GETCHR,  LAM          Get pointer from memory location pointed to by H&L
         CPI 120      See if within range of line input buffer
         JFS BIGERR   If not then have an overflow condition = error.
```

```
        LLA         Else can use it as addr of character to fetch from the
        LHI 026     ** LINE INPUT BUFFER by setting up H too.
        LAM         Fetch the character from the line input buffer.
        CPI 240     See if it is ASCII code for space.
        RET         Return to caller with flags set according to comparison.

CLESYM, LLI 120     Set L to start of SYMBOL BUFFER.
        LHI 026     ** Set H to page of SYMBOL BUFFER.
        LMI 000     Place a zero byte at start of SYMBOL BUFFER.
        RET         To effectively clear the buffer. Then exit to caller.

                    Subroutine to concatenate (append) a character to the
                    SYMBOL BUFFER. Character must be alphanumeric.

CONCTA, CPI 301     See if character code less than that for letter A.
        JTS CONCTN  If so, go see if it is numeric.
        CPI 333     See if character code greater than that for letter Z.
        JTS CONCTS  If not, have valid alphabetical character.

CONCTN, CPI 260     Else, see if character in valid numeric range.
        JTS CONCTE  If not, have an error condition.
        CPI 272     Continue to check for valid number.
        JFS CONCTE  If not, have an error condition.

CONCTS, LLI 120     If character alphanumeric, can concatenate. Set pointer
        LHI 026     ** To starting address of SYMBOL BUFFER.

CONCT1, LCM         Fetch old character count in SYMBOL BUFFER.
        INC         Increment the value to account for adding new
        LMC         Character to the buffer. Restore updated (cc).
        LBA         Save character to be appended in register B.
        CAL INDEXC  Add (cc) to address in H & L to get new end of buffer
        LMB         Address and append the new character to buffer
        LAI 000     Clear the accumulator
        RET         Exit to caller

CONCTE, JMP SYNERR  If character to be appended not alphanumeric, ERROR!

                    Subroutine to compare character strings pointed to by
                    register pairs D & E and H & L.

  STRCP, LAM        Fetch (cc) of first string.
        CAL SWITCH  Switch pointers and fetch length of second string (cc)
        LBM         Into register B. Compare the lengths of the two strings.
        CPB         If they are not the same
        RFZ         Return to caller with flags set to non-zero condition
        CAL SWITCH  Else, exchange the pointers back to first string.

STRCPL, CAL ADV     Advance the pointer to string number 1 and fetch a
        LAM         Character from that string into the accumulator.
        CAL SWITCH  Now switch the pointers to string number 2.
```

```
        CAL ADV         Advance the pointer in line number 2.

STRCPE, CPM             Compare char in string 1 (ACC) to string 2 (memory)
        RFZ             If not equal, return to caller with flags set to non-zero
        CAL SWITCH      Else, exchange pointers to restore pntr to string 1
        DCB             Decrement the string length counter in register B
        JFZ STRCPL      If not finished, continue testing entire string
        RET             If complete match, return with flag in zero condition

STRCPC, LAM             Fetch character pointed to by pointer to string 1
        CAL SWITCH      Exchange pointer to examine string 2
        JMP STRCPE      Continue the string comparison loop

                        Subroutine to advance the two byte value in CPU regi-
                        sters H and L.

   ADV, INL             Advance value in register L.
        RFZ             If new value not zero, return to caller.
        INH             Else must increment value in H
        RET             Before returning to caller

                        Subroutine to advance a buffer pointer and test to see
                        if the end of the buffer has been reached.

  LOOP, LBM             Fetch memory location pointed to by H & L into B.
        INB             Increment the value.
        LMB             Restore it back to memory.
        LLI 000         Change pointer to start of INPUT LINE BUFFER
        LAM             Fetch buffer length (cc) value into the accumulator
        DCB             Make value in B original value
        CPB             See if buffer length same as that in B
                        Return with flags yielding results of the comparison

                        The following subroutine is used to input characters
                        from the system's input device (such as a keyboard)
                        into the LINE INPUT BUFFER. Routine has limited
                        editing capability included. (Rubout = delete previous
                        character(s) entered.)

  STRIN, LCI 000        Initialize register C to zero.

 STRIN1, CAL CINPUT     Call user provided device input subroutine to fetch one
        CPI 377         Character from the input device. Is it ASCII code for
        JFZ NOTDEL      Rubout? Skip to next section if not rubout.
        LAI 334         Else, load ASCII code for backslash into ACC.
        CAL ECHO        Call user display driver to present backslash as a delete
        DCC             Indicator. Now decrement the input character counter.
        JTS STRIN       If at beginning of line do NOT decrement H and L.
        CAL DEC         Else, decrement H & L line pointer to erase previous
        JMP STRIN1      Entry, then go back for a new input.
```

```
NOTDEL,  CPI 203      See if character inputted was 'CONTROL C'
         JTZ CTRLC    If so, stop inputting and go back to the EXECutive
         CPI 215      If not, see if character was carriage-return
         JTZ STRINF   If so, have end of line of input
         CPI 212      If not, see if character was line-feed
         JTZ STRIN1   If so, ignore the input, get another character
         CAL ADV      If none of the above, advance contents of H & L
         INC          Increment the character counter
         LMA          Store the new character in the line input buffer
         LAC          Put new character count in the accumulator
         CPI 120      Make sure maximum buffer size not exceeded
         JFS BIGERR   If buffer size exceeded, go display BG error message
         JMP STRIN1   Else can go back to look for next input

STRINF,  LBC          Transfer character count from C to B
         CAL SUBHL    Subtract B from H & L to get starting address of
         LMC          The string and place the character count (cc) there
         CAL CRLF     Provide a line ending CR & LF combination on the
         RET          Display device. Then exit to caller.

                      Subroutine to subtract contents of CPU register B from
                      the two byte value in CPU registers H & L.

SUBHL,   LAL          Load contents of register L into the accumulator
         SUB          Subtract the contents of register B
         LLA          Restore the new value back to L
         RFC          If no carry, then no underflow. Exit to caller.
         DCH          Else must also decrement contents of H.
         RET          Before returning to caller.

                      Subroutine to display a character string on the system's
                      display device.

TEXTC,   LCM          Fetch (cc) from the first location in the buffer (H & L
         LAM          Pointing there upon entry) into register B and ACC.
         NDA          Test the character count value.
         RTZ          No display if (cc) is zero.

TEXTCL,  CAL ADV      Advance pointer to next location in buffer
         LAM          Fetch a character from the buffer into ACC
         CAL ECHO     Call the user's display driver subroutine
         DCC          Decrement the (cc)
         JFZ TEXTCL   If character counter not zero, continue display
         RET          Exit to caller when (cc) is zero.

                      Subroutine to provide carriage-return and line-feed
                      combination to system's display device. Routine also
                      initializes a column counter to zero. Column counter
                      is used by selected output routines to count the num-
                      ber of characters that have been displayed on a line.
```

```
CRLF,   LAI 215      Load ASCII code for carriage-return into ACC
        CAL ECHO     Call user provided display driver subroutine
        LAI 212      Load ASCII code for line-feed into ACC
        CAL ECHO     Call user provided display driver subroutine
        LLI 043      Set L to point to COLUMN COUNTER storage location
        LHI 001      ** Set H to page of COLUMN COUNTER
        LMI 001      Initialize COLUMN COUNTER to a value of one
        LHD          Restore H from D (saved by ECHO subroutine)
        LLE          Restore L from E (saved by ECHO subroutine)
        RET          Then exit to calling routine
```

Subroutine to decrement double-byte value in CPU registers H and L.

```
DEC,    DCL          Decrement contents of L
        INL          Now increment to exercise CPU flags
        JFZ DECN0    If L not presently zero, skip decrementing H
        DCH          Else decrement H
DECN0,  DCL          Do the actual decrement of L
        RET          Return to caller
```

Subroutine to index the value in CPU registers H and L by the contents of CPU register B.

```
INDEXB, LAL          Load L into the accumulator
        ADB          Add B to that value
        LLA          Restore the new value to L
        RFC          If no carry, return to caller
        INH          Else, increment value in H
        RET          Before returning to caller
```

The following subroutine is used to display the ASCII encoded character in the ACC on the system's display device. This routine calls a routine labeled CINPUT which must be provided by the user to actually drive the system's output device. The subroutine below also increments an output column counter each time it is used.

```
ECHO,   LDH          Save entry value of H in register D
        LEL          And save entry value of L in register E
        LLI 043      Set L to point to COLUMN COUNTER storage location
        LHI 001      ** Set H to page of COLUMN COUNTER
        LBM          Fetch the value in the COLUMN COUNTER
        INB          And increment it for each character displayed
        LMB          Restore the updated count in memory
        CAL ††† †††  †† Call the user's device driver subroutine
        LHD          Restore entry value of H from D
        LLE          Restore entry value of L from E
        RET          Return to calling routine

CINPUT, JMP ††† ††† †† Reference to user defined input subroutine
```

# STATEMENT INTERPRETATION

The reader has now been presented with the knowledge of how SCELBAL utilizes an Executive routine to store a user created high level language program in memory. Additionally, the reader has been shown how the SYNTAX routine is used to analyze the first portion of a line in order to obtain the line number and to set up a token value representing the finding of a particular type of statement in the beginning portion of a line. (A line referring to a line of the source coding in the higher level language.) The reader should now be prepared to learn how a program stored in the user program buffer (or a single line "calculator mode" directive residing in the line input buffer) is further processed.

The flow chart on the next page will once again illustrate how the program continues to operate in a straightforward, conceptually simple manner. It illustrates that when the Executive interprets a RUN command, the program proceeds to perform operations in the following fashion.

The first line stored in the user program buffer is pulled into the line input buffer. Then the SYNTAX subroutine is used to find out what type of statement is contained in the line. A TOKEN value representing the type of statement found is returned by the SYNTAX subroutine. This token value is then used to direct the program to go to a particular routine that will perform the type of operation dictated by the statement type. It is as simple as that!

There is then a whole series of routines, one for each type of statement used in the language, that processes the remaining data on a line after the statement keyword. This chapter will present the details for each of these routines.

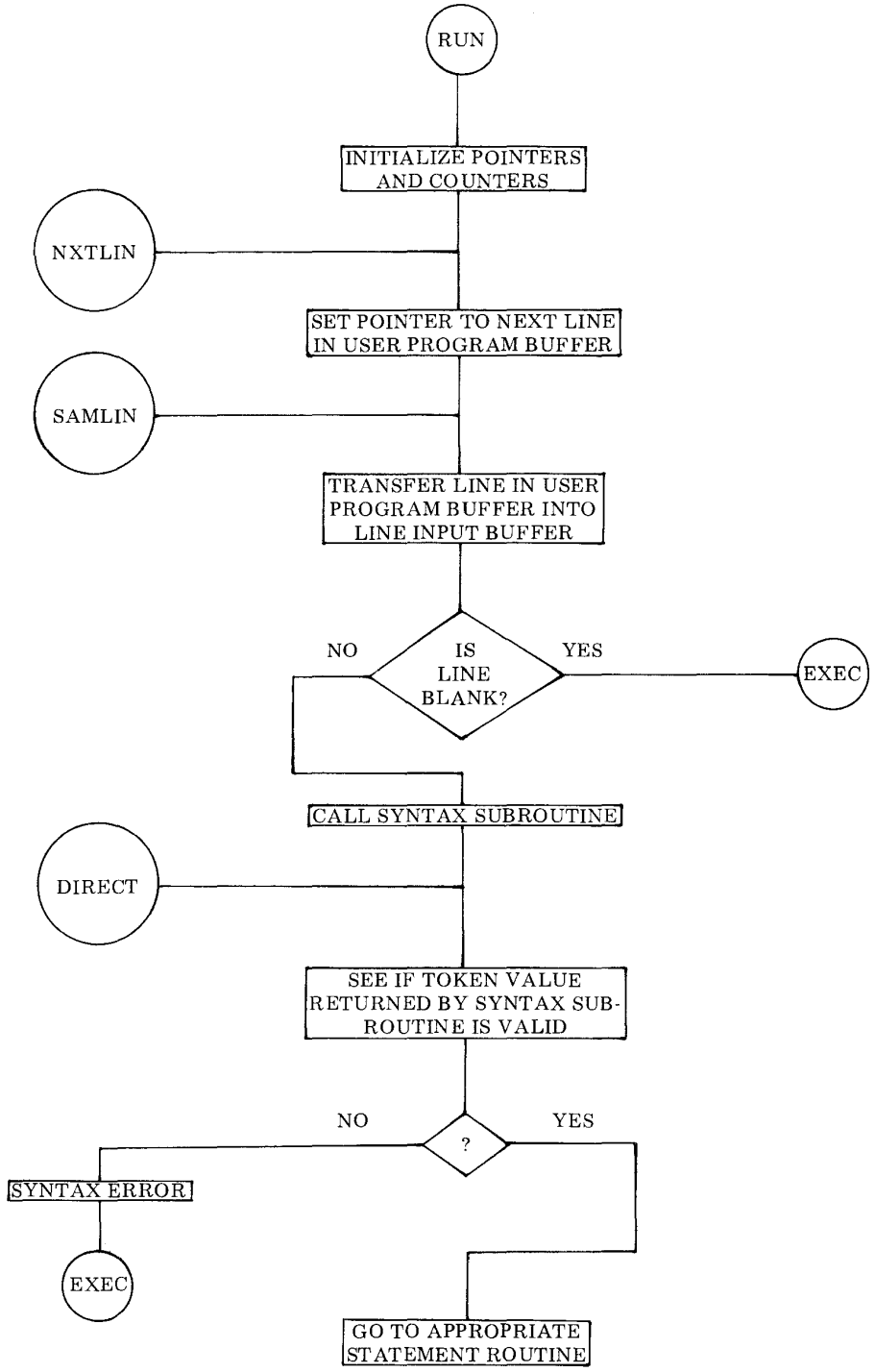
When the execution of a statement routine has been completed, the program continues by simply extracting the next line of information stored in the user program buffer and repeating the process.

In the DIRECT, or "calculator" mode, the program simply restricts its operation to processing the line of information stored in the input line buffer, instead of extracting lines from the user program buffer. The reader may observe that the RUN flow chart shows several entry points to various subsections of the program. The reader can see that there is a DIRECT entry to the routine which is used when the program is interpreting a single line statement in the "calculator" mode.

The reader might also note that there are two special entry points in the RUN routine named NXTLIN and SAMLIN. The first entry point is used when the program has finished the execution of a statement and is to proceed to interpret the next line of information in the user program buffer. The second entry point is used in special situations which will be explained more fully later in this chapter. One such case is when the program has executed a GOTO statement. This is because, the routine that processes a GOTO statement will search for the line number in the user program buffer that was specified in the GOTO directive. When it finds that line number, the program will already have the user program buffer pointer set up to point to the line that should be processed next!

The various statement routines presented in this chapter will call on subroutines whose functions will be described in detail in following chapters. However, the reader should be able to discern the essential operations of each type of statement as they are presented. The supplementary subroutines will fall into logical order once the information in this chapter has been digested and is understood.

The source listing for the RUN routine and associated subsections of that routine are presented immediately following the flow chart.


RUN
INITIALIZE POINTERS AND COUNTERS
NXTLIN
SET POINTER TO NEXT LINE IN USER PROGRAM BUFFER
SAMLIN
TRANSFER LINE IN USER PROGRAM BUFFER INTO LINE INPUT BUFFER
NO
IS LINE BLANK?
YES
EXEC
CALL SYNTAX SUBROUTINE
DIRECT
SEE IF TOKEN VALUE RETURNED BY SYNTAX SUB-ROUTINE IS VALID
NO
?
YES
SYNTAX ERROR
EXEC
GO TO APPROPRIATE STATEMENT ROUTINE

```
RUN,    LLI 073     Load L with addr of GOSUB/RETURN stack pointer
        LHI 027     ** Load H with page of same pointer
        LMI 000     Initialize the GOSUB/RETURN stack pointer to zero
        LLI 205     Load L with addr of FOR/NEXT stack pointer
        LMI 000     Initialize the FOR/NEXT stack pointer to zero
        LLI 360     Load L with addr of user pgm buffer line pointer
        LHI 026     ** Load H with page of user pgm buffer line pointer
        LMI 033     †† Initialize pointer (may be altered by user)
        INL         Advance memory pointer to low portion of user pgm
        LMI 000     Buffer pointer and initialize to start of buffer
        JMP SAMLIN  Start executing user program with first line in buffer

NXTLIN, LLI 360     Load L with addr of user program buffer line pointer
        LHI 026     ** Load H with page of user pgm buffer line pointer
        LDM         Place page addr of pgm buffer line pointer in D
        INL         Advance the memory pointer
        LEM         Place low addr of pgm buffer line pointer in E
        LHD         Also put page addr of pgm buffer line pointer in H
        LLE         And low addr of pgm buffer line pointer in L
        LBM         Now fetch the (cc) of current line into register B
        INB         Add one to account for (cc) byte itself
        CAL ADBDE   Add value in B to D&E to point to next line in
        LLI 360     User program buffer. Reset L to addr of user pgm
        LHI 026     ** Buffer pointer storage location. Store the new
        LMD         Updated user pgm line pointer in pointer storage
        INL         Location. Store both the high portion
        LME         And low portion. (Now points to next line to be
        LLI 340     Processed from user program buffer.) Change pointer
        LHI 026     ** To address of line number buffer. Fetch the last
        LAM         Line number (length) processed. Test to see if it was
        NDA         Blank. If it was blank
        JTZ EXEC    Then stop processing and return to the Executive
        LAA         Insert two effective NOPs here
        LAA         In case of patching

SAMLIN, LLI 360     Load L with addr of user program buffer line pointer
        LHI 026     ** Load H with page of same pointer
        LCM         Fetch the high portion of the pointer into register C
        INL         Advance the memory pointer
        LLM         Fetch the low portion of the pointer into register L
        LHC         Now move the high portion into register H
        LDI 026     ** Set D to page of line input buffer
        LEI 000     Set E to address of start of line input buffer
        CAL MOVEC   Move the line from the user program buffer into the
        LLI 000     Line input buffer. Now reset the pointer to the start
        LHI 026     ** Of the line input buffer.
        LAM         Fetch the first byte of the line input buffer (cc)
        NDA         Test (cc) value to see if fetched a blank line
        JTZ EXEC    If fetched a blank line, return to the Executive
        CAL SYNTAX  Else call subrtn to strip off line nr & set statement token
```

```
DIRECT,  LLI 203      Load L with address of syntax TOKEN storage location
         LHI 026      ** Load H with page of syntax TOKEN location
         LAM          Fetch the TOKEN value into the accumulator
         CPI 001      Is it token value for REM statement? If so, ignore the
         JTZ NXTLIN   Current line and go on to the next line in pgm buffer.
         CPI 002      Is it token value for IF statement?
         JTZ IF       If yes, then go to the IF statement routine.
         CPI 003      Is it token value for LET statement? (Using keyword)
         JTZ LET      If yes, then go to the LET statement routine.
         CPI 004      Is it token value for GOTO statement?
         JTZ GOTO     If yes, then go to the GOTO statement routine.
         CPI 005      Is it token value for PRINT statement?
         JTZ PRINT    If yes, then go to the PRINT statement routine.
         CPI 006      Is it token value for INPUT statement?
         JTZ INPUT    If yes, then go to the INPUT statement routine.
         CPI 007      Is it token value for FOR statement?
         JTZ FOR      If yes, then go to the FOR statement routine.
         CPI 010      Is it token value for NEXT statement?
         JTZ NEXT     If yes, then go to the NEXT statement routine.
         CPI 011      Is it token value for GOSUB statement?
         JTZ GOSUB    If yes, then go to the GOSUB statement routine.
         CPI 012      Is it token value for RETURN statement?
         JTZ RETURN   If yes, then go to the RETURN statement routine.
         CPI 013      Is it token value for DIM statement?
         JTZ DIM      If yes, then go to the DIM statement routine.
         CPI 014      Is it token value for END statement?
         JTZ EXEC     If yes, then go back to the Executive, user pgm finished!
         CPI 015      Is it token value for IMPLIED LET statement?
         JTZ LET0     If yes, then go to special LET entry point.
         CPI 016      @@ Is it token value for ARRAY IMPLIED LET?
         JFZ SYNERR   If not, then assume a syntax error condition.
         CAL ARRAY1   @@ Else, perform array storage set up subroutine.
         LLI 206      @@ Set L to array pointer storage location.
         LHI 026      @@ ** Set H to array pointer storage location.
         LBM          @@ Fetch array pointer to register B.
         LLI 202      @@ Change memory pointer to syntax pntr storage loc.
         LMB          @@ Save array pointer value there.
         CAL SAVSYM   @@ Save array name in auxiliary symbol buffer
         JMP LET1     @@ Go to special array implied LET entry point.
```

## THE PRINT STATEMENT ROUTINE

The PRINT statement routine is used to output data as directed by the creator of a SCELBAL program. There are several types of information that the PRINT statement can display. It can display text messages that have been enclosed by single ('.....') or double (".....") quotation marks on the line containing the PRINT statement. It is also used to display the numerical values of variables or expressions referred to in the line containing the PRINT directive. Finally, the PRINT statement may be used to

TAB (space over) to a TABBING POSITION (every sixteenth column) and control the occurrence of a line-feed and carriage-return combination after the displaying of information. (The PRINT statement may also be used to perform two special functions that will be explained in a later chapter. These relate to the capability to TAB to a specific column position specified by the user, and the capability to display a certain range of numbers as an alphanumeric character through the use of the CHR function.)

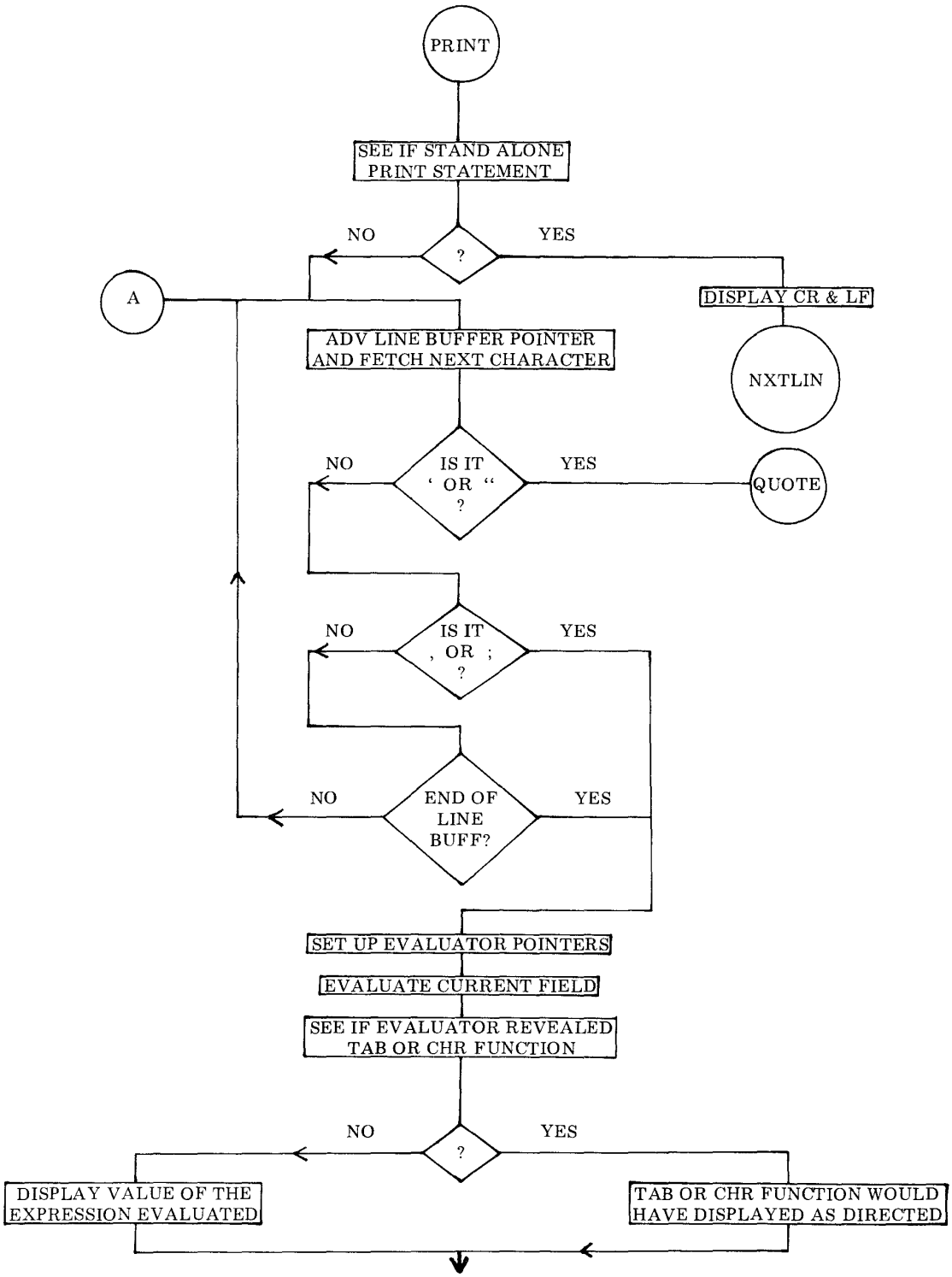
The PRINT routine is split into two major sections. The first section is primarily concerned with determining whether the statement line requires the outputting of text information (enclosed in single or double quotation marks) or the displaying of the value of an expression. If the value of an expression is to be displayed, the program calls on relevant portions of SCELBAL to obtain the value to be outputted and then displays the value. The second section of the PRINT routine starts with the label QUOTE. It is used to display text information enclosed by quotation marks in the PRINT statement line.

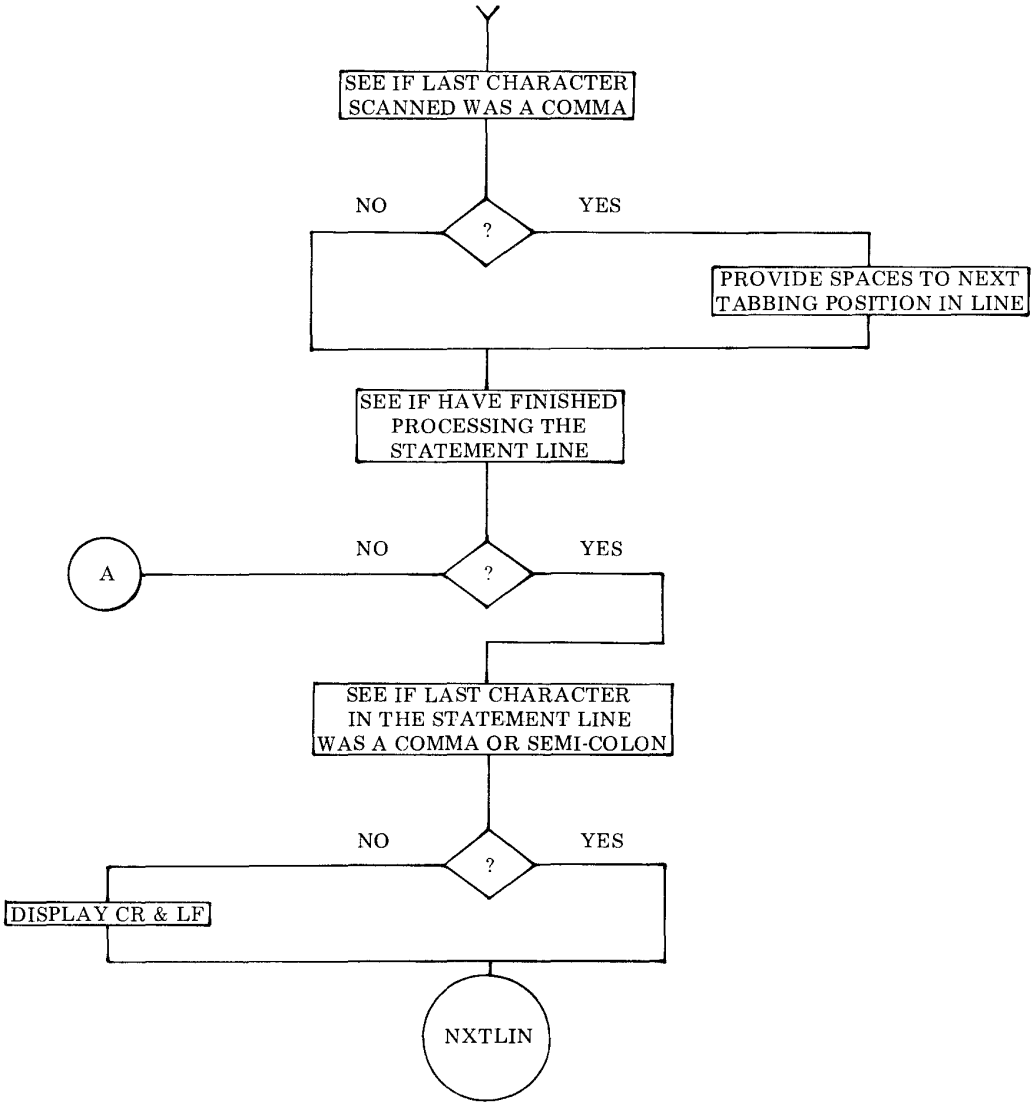
Since a PRINT statement line can contain both expressions and text strings, the routine essentially operates by splitting the line into appropriate fields and processing each field independently, either outputting the value of an expression, or a text string as required.

The flow chart on the next two pages illustrates the key portions of the first section of the PRINT routine. The source listing for this section starts below. The QUOTE portion of the routine is then presented along with it flow chart. The reader may note that the QUOTE portion of the routine may direct program operation back to the first section when it is finished processing a text field. This is indicated in the QUOTE flow chart by the exit point marked A which refers to the A entry point in the PRINT flow chart.

The PRINT routine may at first appear somewhat complicated because a good deal of pointer manipulation is required by the routine as it analyzes fields within a line. Reference to the flow charts will show, though, that its operation is really quite straightforward in concept.

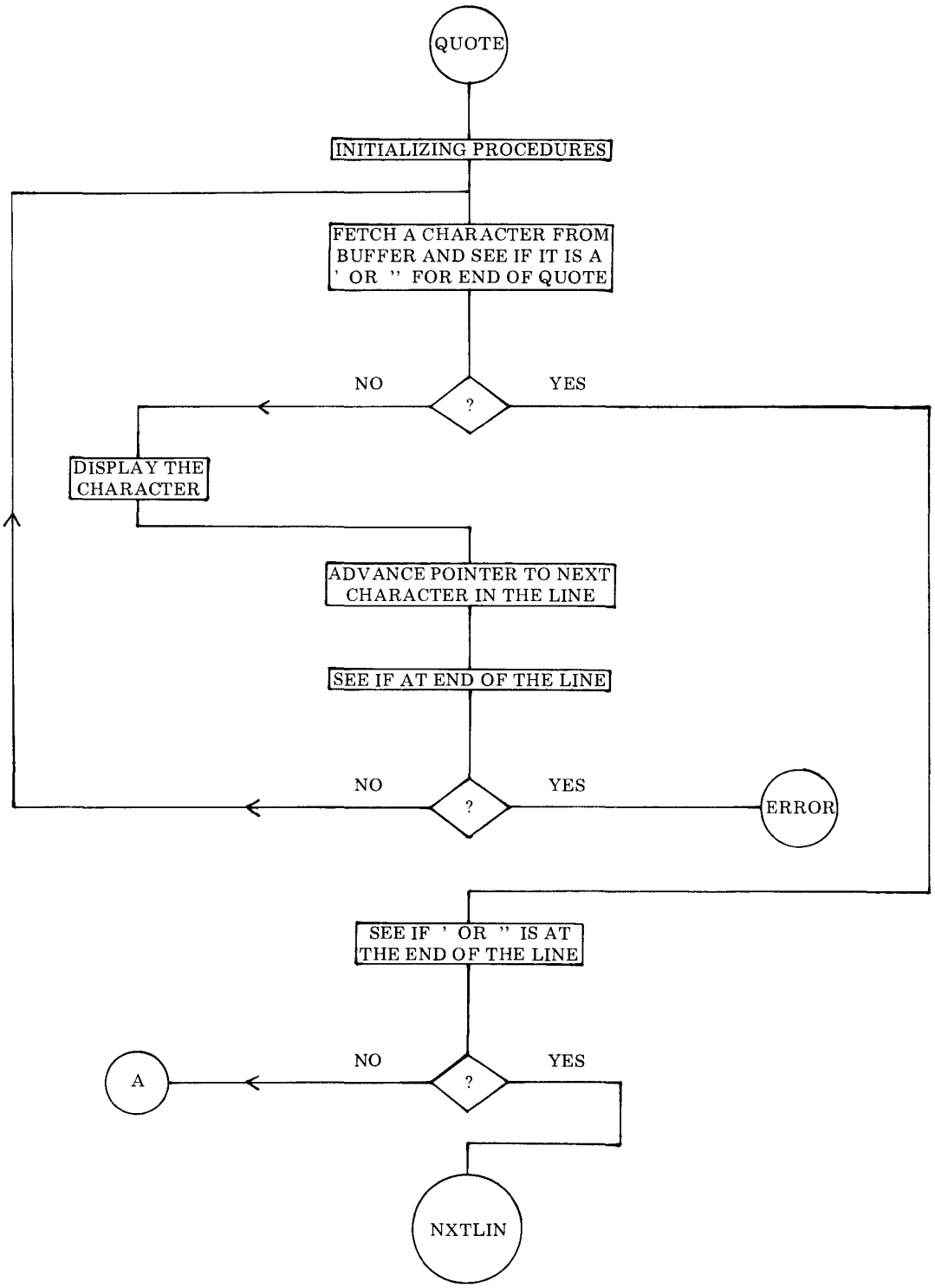
```
PRINT,  LLI 202     Load L with address of SCAN pointer storage location
        LHI 026     ** Load H with page of SCAN pointer
        LAM         Fetch the pointer value (last character scanned by the
        LLI 000     SYNTAX routine). Change pointer to line buffer (cc).
        CPM         Compare pointer value to buffer length. If not equal
        JTS PRINT1  Then line contains more than stand alone PRINT state-
        CAL CRLF    Ment. However, if just have PRINT statement then issue
        JMP NXTLIN  A carriage-return & line-feed combination, then exit.

PRINT1, CAL CLESYM  Initialize the SYMBOL buffer for new entry.
        LLI 202     Load L with address of SCAN buffer pointer
        LHI 026     ** Load H with page of SCAN pointer
        LBM         Pointer points to last char scanned by SYNTAX. Need
        INB         To increment it to point to next char in statement line.
        LLI 203     Load L with address of former TOKEN value. Use it as
        LMB         Storage location for a PRINT statement pointer.

PRINT2, LLI 203     Set memory pointer to PRINT pointer storage location
        CAL GETCHR  Fetch character in input buffer pointed to by PRINT
        CPI 247'    Pointer. See if it is ASCII code for single quote mark.
```


PRINT
SEE IF STAND ALONE PRINT STATEMENT
NO
?
YES
A
DISPLAY CR & LF
ADV LINE BUFFER POINTER AND FETCH NEXT CHARACTER
NXTLIN
NO
IS IT ' OR " ?
YES
QUOTE
NO
IS IT , OR ; ?
YES
NO
END OF LINE BUFF?
YES
SET UP EVALUATOR POINTERS
EVALUATE CURRENT FIELD
SEE IF EVALUATOR REVEALED TAB OR CHR FUNCTION
NO
?
YES
DISPLAY VALUE OF THE EXPRESSION EVALUATED
TAB OR CHR FUNCTION WOULD HAVE DISPLAYED AS DIRECTED




| | |
|---|---|
| JTZ QUOTE | If so, go to QUOTE section to process text string. |
| CPI 242 | If not, see if it is ASCII code for double quote mark. |
| JTZ QUOTE | If so, go to QUOTE section to process text string. |
| CPI 254 | If not, see if it is ASCII code for comma sign. |
| JTZ PRINT3 | If so, go evaluate expression. |
| CPI 273 | If not, see if it is ASCII code for semi-colon sign. |
| JTZ PRINT3 | If so, go evaluate expression. |
| LLI 203 | Load L with address of PRINT pointer storage location. |
| CAL LOOP | Increment pointer and test for end of line. |
| JFZ PRINT2 | If not end of line, fetch the next character. |

```
PRINT3,  LLI 202      Load L with address of SCAN pointer storage location
         LBM          Fetch value of the pointer (last letter of KEYWORD)
         INB          Add one to point to first character of expression
         LLI 276      Load L with addr of EVAL pointer storage location
         LMB          Store addr at which EVAL should start scanning
         LLI 203      Load L with address of PRINT pointer
         LBM          Which points to field terminator
         DCB          Decrement pointer value to last character of expression
         LLI 277      Load L with address of EVAL FINISH pntr storage loc.
         LMB          Place address value of last char in PRINT field there
         LLI 367      Load L with address of QUOTE flag
         LAM          Fetch the value of the QUOTE flag into the ACC
         NDA          Test the QUOTE flag status
         JTZ PRINT4   If field not quoted, proceed to evaluate expression
         LMI 000      If field quoted, then clear the QUOTE flag for next field
         JMP PRINT6   And skip the evaluation procedure

PRINT4,  CAL EVAL     Evaluate the current PRINT field
         LLI 177      Then load L with address of the TAB flag
         LHI 026      ** Load H with the page of the TAB flag
         LAM          Fetch the value of the TAB flag into the accumulator
         NDA          Test the TAB flag
         LLI 110      Change L to the FIXED/FLOAT flag location
         LHI 001      ** Change H to the FIXED/FLOAT flag page
         LMI 377      Set FIXED/FLOAT flag to fixed point
PRINT5,  CTZ PFPOUT   If TAB flag not set, display value of expression
         LLI 177      Load L with address of TAB flag
         LHI 026      ** Load H with page of TAB flag
         LMI 000      Reset TAB flag for next PRINT field

PRINT6,  LLI 203      Load L with address of PRINT pointer storage location
         CAL GETCHR   Fetch the character pointed to by the PRINT pointer
         CPI 254      See if the last character scanned was a comma sign
         CTZ PCOMMA   If so, then display spaces to next TAB location
         LLI 203      Reset L to address of PRINT pointer storage location
         LHI 026      ** Reset H to page of PRINT pointer storage location
         LBM          Fetch the value of the pointer into register B
         LLI 202      Change L to SCAN pointer storage location
         LMB          Place end of last field processed into SCAN pointer
         LLI 000      Change pointer to start of line input buffer
         LAB          Place pntr to last char scanned into the accumulator
         CPM          Compare this value to the (cc) for the line buffer
         JTS PRINT1   If not end of line, continue to process next field
         LLI 000      If end of line, fetch the last character in the line
         CAL GETCHR   And check to see if it
         CPI 254      Was a comma. If it was, go on to the next line in the
         JTZ NXTLIN   User program buffer without displaying a CR & LF.
         CPI 273      If not a comma, check to see if it was a semi-colon.
         JTZ NXTLIN   If so, do not provide a CR & LF combination.
         CAL CRLF     If not comma or semi-colon, provide CR & LF at end
         JMP NXTLIN   Of a PRINT statement. Go process next line of pgm.
```


QUOTE
INITIALIZING PROCEDURES
FETCH A CHARACTER FROM BUFFER AND SEE IF IT IS A ' OR " FOR END OF QUOTE
NO
?
YES
DISPLAY THE CHARACTER
ADVANCE POINTER TO NEXT CHARACTER IN THE LINE
SEE IF AT END OF THE LINE
NO
?
YES
ERROR
SEE IF ' OR " IS AT THE END OF THE LINE
NO
?
YES
A
NXTLIN

```
QUOTE,  LLI 367      Load L with address of QUOTE flag
        LMA          Store type of quote in flag storage location
        CAL CLESYM   Initialize the SYMBOL buffer for new entry
        LLI 203      Load L with address of PRINT pointer
        LBM          Fetch the PRINT pointer into register B
        INB          Add one to advance over quote character
        LLI 204      Load L with address of QUOTE pointer
        LMB          Store the beginning of the QUOTE field pointer

QUOTE1, LLI 204      Load L with address of QUOTE pointer
        CAL GETCHR   Fetch the next character in the TEXT field
        LLI 367      Load L with the QUOTE flag (type of quote)
        CPM          Compare to see if latest character this quote mark
        JTZ QUOTE2   If so, finish up this quote field
        CAL ECHO     If not, display the character as part of TEXT
        LLI 204      Reset L to QUOTE pointer storage location
        CAL LOOP     Increment QUOTE pointer and test for end of line
        JFZ QUOTE1   If not end of line, continue processing TEXT field

QUOTER, LAI 311      If end of line before closing quote mark have an error
        LCI 321      So load ACC with I and register C with Q
        LLI 367      Load L with the address of the QUOTE flag
        LHI 026      ** Load H with the page of the QUOTE flag
        LMI 000      Clear the QUOTE flag for future use
        JMP ERROR    Go display the IQ (Illegal Quote) error message

QUOTE2, LLI 204      Load L with address of QUOTE pointer
        LBM          Fetch the QUOTE pointer into register B
        LLI 202      Load L with address of SCAN pointer storage location
        LMB          Store former QUOTE pointer as start of next field
        LAB          Place QUOTE pointer into the accumulator
        LLI 000      Change L to point to start of the input line buffer
        CPM          Compare QUOTE pointer value with (cc) value
        JFZ PRINT1   If not end of line, process next PRINT field
        CAL CRLF     Else display a CR & LF combination at end of line
        LLI 367      Load L with the address of the TAB flag
        LHI 026      ** Load H with the page of the TAB flag
        LMI 000      Clear the TAB flag for future use
        JMP NXTLIN   Go process next line of the program.
```

The following subroutines are utilized by the PRINT routine.

```
PFPOUT, LLI 126      Load L with the address of the FPACC MSW (Floating
        LHI 001      ** Point ACC). Load H with page of the FPACC MSW.
        LAM          Fetch the FPACC MSW into the accumulator. Test to
        NDA          See if the FPACC MSW is zero. If so, then simply go and
        JTZ ZERO     Display the value "0"
        INL          Else advance the pointer to the FPACC Exponent
```

```
        LAM         Fetch the FPACC Exponent into the accumulator
        NDA         See if any exponent value. If not, mantissa is in range
        JTZ FRAC    0.5 to 1.0. Treat number as a fraction.
        JMP FPOUT   Else perform regular numerical output routine.

ZERO,   LAI 240     Load ASCII code for space into the ACC
        CAL ECHO    Display the space
        LAI 260     Load ASCII code for 0 into the ACC
        JMP ECHO    Display 0 and exit to calling routine

FRAC,   LLI 110     Load L with address of FIXED/FLOAT flag
        LMI 000     Reset it to indicate floating point mode
        JMP FPOUT   Display floating point number and return to caller

PCOMMA, LLI 000     Load L with address of (cc) in line input buffer
        LAM         Fetch the (cc) for the line into the ACC
        LLI 203     Change pointer to PRINT pointer storage location
        SUM         Subtract value of PRINT pointer from line (cc)
        RTS         If at end of buffer, do not TAB
        LLI 043     If not end, load L with address of COLUMN COUNTER
        LHI 001     ** Set H to page of COLUMN COUNTER
        LAM         Fetch COLUMN COUNTER into the accumulator
        NDI 360     Find the last TAB position (multiple of 16 decimal)
        ADI 020     Add 16 (decimal) to get new TAB position
        SUM         Subtract current position from next TAB position
        LCA         Store this value in register C as a counter
        LAI 240     Load the ACC with the ASCII code for space

PCOM1,  CAL ECHO    Display the space
        DCC         Decrement the loop counter
        JFZ PCOM1   Continue displaying spaces until loop counter is zero
        RET         Then return to calling routine
```

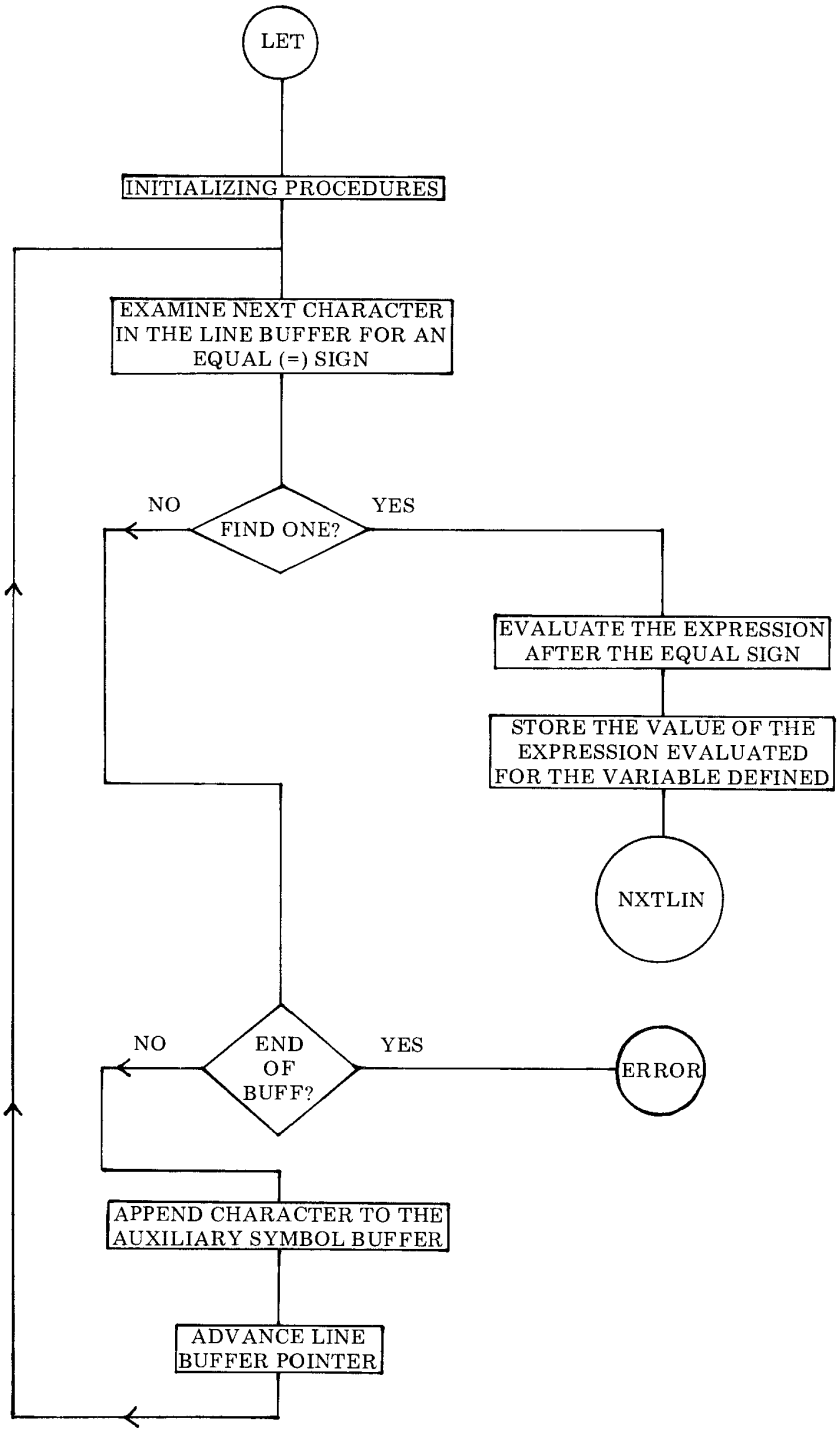
## THE LET STATEMENT ROUTINE

The LET statement is used to set a variable equal to the value of another variable, an expression, or a specific number. This is illustrated by the following examples.

```
LET  X = Y
or
LET  X = (Y*2 + 3*Y + 4)*(N - M)
or
LET  X = 3.14159
```

The operation of the LET routine simply consists of defining the variable on the left hand side of the equal sign in a statement line (by defining, it is meant determining what character(s) are being used to represent the variable) and then calculating the value of the expression contained on the right hand side of the equal sign. This value is then stored along with the variable in a variables symbol table.

The operation of the LET statement routine is summarized in the flow chart shown on the next page. The source listing for the routine is then presented.


LET
INITIALIZING PROCEDURES
EXAMINE NEXT CHARACTER IN THE LINE BUFFER FOR AN EQUAL (=) SIGN
NO
FIND ONE?
YES
EVALUATE THE EXPRESSION AFTER THE EQUAL SIGN
STORE THE VALUE OF THE EXPRESSION EVALUATED FOR THE VARIABLE DEFINED
NXTLIN
NO
END OF BUFF?
YES
ERROR
APPEND CHARACTER TO THE AUXILIARY SYMBOL BUFFER
ADVANCE LINE BUFFER POINTER

```
LET0,   CAL SAVSYM   Entry point for IMPLIED LET statement. Save the
        LLI 202      Variable (to left of the equal sign). Set L to the SCAN
        LHI 026      ** Pointer. Set H to the page of the SCAN pointer.
        LBM          Fetch value of SCAN pointer. (Points to = sign in ln bf)
        LLI 203      Change pointer to LET pointer (was TOKEN value)
        LMB          Place the SCAN pointer value into the LET pointer
        JMP LET5     Continue processing the LET statement line

 LET,   CAL CLESYM   Initialize the SYMBOL BUFFER for new entry
        LLI 144      Load L with address of start of AUX SYMBOL BUFF
        LHI 026      ** Load H with page of AUX SYMBOL BUFFER
        LMI 000      Initialize AUX SYMBOL BUFFER

 LET1,  LLI 202      Entry point for ARRAY IMPLIED LET statement.
        LHI 026      ** Set pointer to SCAN pointer storage location
        LBM          Fetch the SCAN pointer value (last letter scanned by
        INB          SYNTAX subroutine) and add one to next character
        LLI 203      Change L to LET pointer storage location
        LMB          Store former SCAN value (updated) in LET pointer

 LET2,  LLI 203      Set L to storage location of LET pointer
        CAL GETCHR   Fetch the character pointed to by the LET pointer
        JTZ LET4     If character is a space, ignore it
        CPI 275      See if character is the equal (=) sign
        JTZ LET5     If so, go process other side of the statement (after =)
        CPI 250      @@ If not, see if character is a right parenthesis "("
        JFZ LET3     If not, continue looking for equal sign
        CAL ARRAY    @@ If so, have subscript. Call array set up subroutine.
        LLI 206      @@ Load L with address of ARRAY pointer
        LHI 026      @@ ** Load H with page of ARRAY pointer
        LBM          @@ Fetch value (points to ")" character of subscript)
        LLI 203      @@ Load L with address of LET pointer
        LMB          @@ Place ARRAY pointer value as new LET pointer
        JMP LET4     @@ Continue to look for = sign in statement line

 LET3,  LLI 144      Reset L to start of AUX SYMBOL BUFFER
        LHI 026      ** Load H with page of AUX SYMBOL BUFFER
        CAL CONCT1   Concatenate character to the AUX SYMBOL BUFFER

 LET4,  LLI 203      Load L with address of LET pointer storage location
        CAL LOOP     Add one to pointer and test for end of line input buffer
        JFZ LET2     If not end of line, continue looking for the equal sign

LETERR, LAI 314      If do not find an equal sign in the LET statement line
        LCI 305      Then have a LE (Let Error). Load the code for L and E
        JMP ERROR    Into registers ACC and C and go display the error msg.

 LET5,  LLI 203      When find the equal sign, reset L to point to the LET
        LHI 026      ** Pointer and H to the proper page. Fetch the pointer
        LBM          Value into register B and add one to advance pointer
        INB          Over the equal sign to first char in the expression.
```

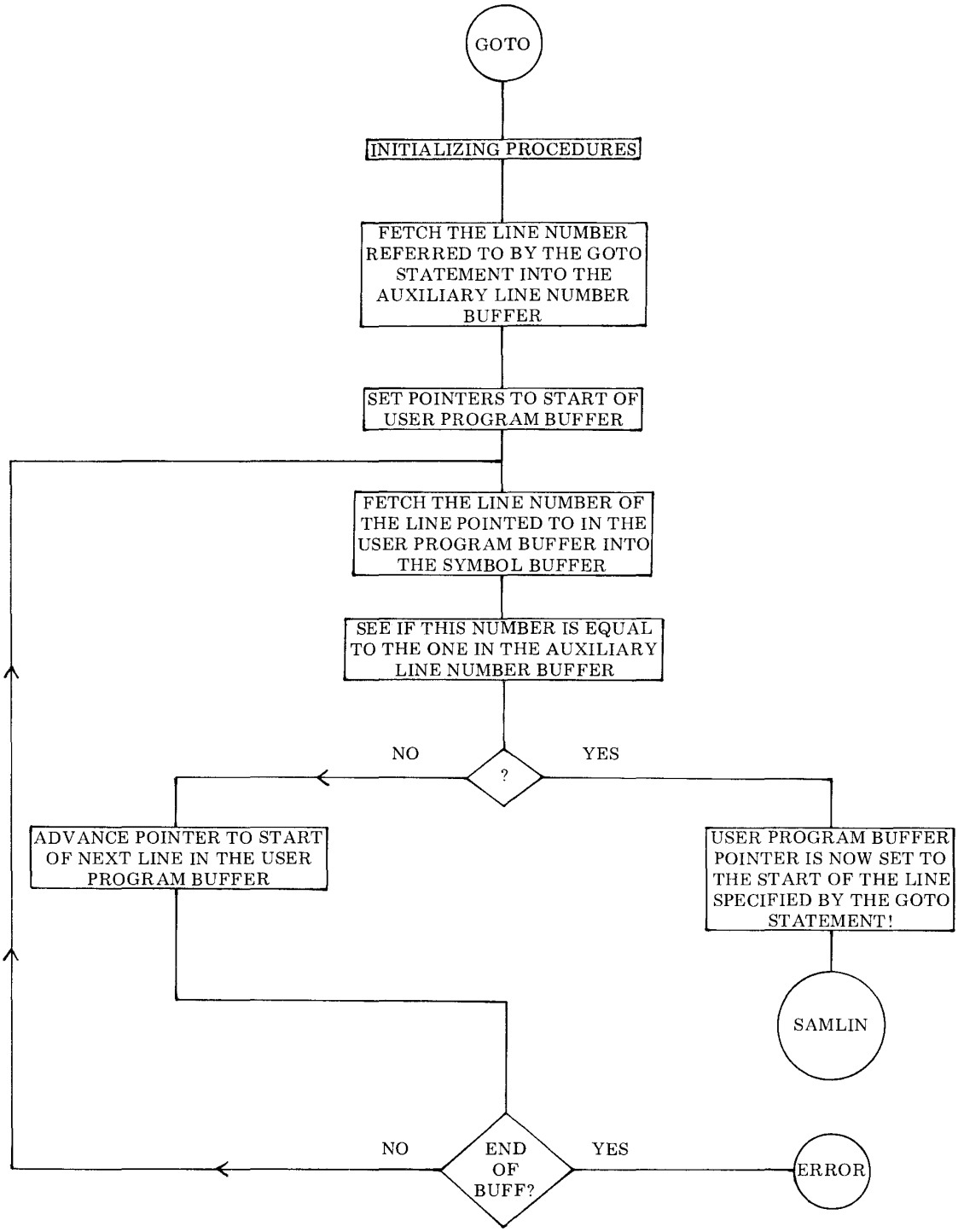
```
LLI 276     Set L to point to the address of the EVAL pointer
LMB         Set EVAL pointer to start evaluating right after the
LLI 000     Equal sign. Now change L to start of line input buffer.
LBM         Fetch the (cc) value into register B. (Length of line.)
LLI 277     Load L with EVAL FINISH pointer storage location.
LMB         Set it to stop evaluating at end of the line.
CAL EVAL    Call the subroutine to evaluate the expression.
CAL RESTSY  Restore the name of the variable to receive new value.
CAL STOSYM  Store the new value for the variable in variables table.
JMP NXTLIN  Go process next line of the program.
```

## THE GOTO STATEMENT ROUTINE

The GOTO statement is one of the easiest statements to process even though the source listing is somewhat longer than the LET routine just described. The reason for the relatively lengthy source listing is because a lot of pointer manipulation is required. Conceptually, the process involves nothing more than searching the user program buffer for the line containing the line number specified as part of the GOTO statement. Once it is located, the program simply continues executing the high level program with that line!

The source listing for the GOTO statement is presented below. The reader may correlate it with the flow chart on the next page.

```
GOTO,   LLI 350     Load L with start of AUX LINE NR BUFFER
        LHI 026     ** Load H with page of AUX LINE NR BUFFER
        LMI 000     Initialize the AUX LINE NR BUFFER to zero
        LLI 202     Load L with address of SCAN pointer storage location
        LBM         Fetch pointer value (last char scanned by SYNTAX)
        INB         Add one to skip over the last O in GOTO keyword
        LLI 203     Change pointer to GOTO pointer (formerly TOKEN)
        LMB         Store the updated SCAN pointer as the GOTO pointer

GOTO1,  LLI 203     Load L with address of GOTO pointer
        CAL GETCHR  Fetch the character pointed to by the GOTO pointer
        JTZ GOTO2   If character was a space, ignore it
        CPI 260     See if character is in the range of a decimal digit
        JTS GOTO3   If not, must have end of the line number digit string
        CPI 272     Continue to test for decimal digit
        JFS GOTO3   If not, must have end of the line number digit string
        LLI 350     If valid decimal digit, load L with addr of AUX LINE
        CAL CONCT1  NR BUFFER and concatenate digit to the buffer.

GOTO2,  LLI 203     Reset pointer to GOTO pointer storage location
        CAL LOOP    Advance the pointer value and test for end of line
        JFZ GOTO1   If not end of line, fetch next digit in GOTO line number
```


GOTO
INITIALIZING PROCEDURES
FETCH THE LINE NUMBER REFERRED TO BY THE GOTO STATEMENT INTO THE AUXILIARY LINE NUMBER BUFFER
SET POINTERS TO START OF USER PROGRAM BUFFER
FETCH THE LINE NUMBER OF THE LINE POINTED TO IN THE USER PROGRAM BUFFER INTO THE SYMBOL BUFFER
SEE IF THIS NUMBER IS EQUAL TO THE ONE IN THE AUXILIARY LINE NUMBER BUFFER
NO
?
YES
ADVANCE POINTER TO START OF NEXT LINE IN THE USER PROGRAM BUFFER
USER PROGRAM BUFFER POINTER IS NOW SET TO THE START OF THE LINE SPECIFIED BY THE GOTO STATEMENT!
SAMLIN
NO
END OF BUFF?
YES
ERROR

```
GOTO3,  LLI 360      Set L to user program buffer pointer storage location
        LHI 026      ** Set H to page of program buffer pointer
        LMI 033      †† Initialize high part of pointer to start of pgm buffer
        INL          Advance the memory pointer
        LMI 000      Initialize the low part of pointer to start of pgm buffer

GOTO4,  CAL CLESYM   Clear the SYMBOL BUFFER
        LLI 204      Load L with address of GOTO SEARCH pointer
        LMI 001      Initialize to one for first char of line

GOTO5,  LLI 204      Load L with address of GOTO SEARCH pointer
        CAL GETCHP   Fetch character pointed to by GOTO SEARCH pointer
        JTZ GOTO6    From line pointed to in user program buffer. Ignore
        CPI 260      Spaces. Check to see if character is a decimal digit.
        JTS GOTO7    If not, then have processed line number at the start of
        CPI 272      The current line. Continue the check for a valid decimal
        JFS GOTO7    Digit. If have a decimal digit then concatenate the digit
        CAL CONCTS   Onto the current string in the SYMBOL BUFFER.

GOTO6,  LLI 204      Change L to the address of the GOTO SEARCH pointer
        LHI 026      ** And H to the proper page of the pointer
        LBM          Fetch the GOTO SEARCH pointer value
        INB          Increment the GOTO SEARCH pointer
        LMB          And restore it back to memory
        LLI 360      Change L to address of user program buffer pointer
        LCM          Save the high part of this pointer value in register C
        INL          Advance L to the low part of the pgm buffer pointer
        LLM          Now load it into L
        LHC          And transfer C into H to point to start of the line
        LAM          Fetch the (cc) of the current line being pointed to in the
        DCB          User pgm buff. Decrement B to previous value. Compare
        CPB          GOTO SEARCH pointer value to length of current line.
        JFZ GOTO5    If not end of line then continue getting current line nr.

GOTO7,  LLI 120      Load L with address of start of the SYMBOL BUFFER
        LHI 026      ** Set H to the page of the SYMBOL BUFFER
        LDI 026      ** Set D to the page of the AUX LINE NR BUFFER
        LEI 350      Set E to the start of the AUX LINE NR BUFFER
        CAL STRCP    Compare GOTO line number against current line nr.
        JTZ SAMLIN   If they match, found GOTO line. Pick up ops there!
        LLI 360      Else, set L to user program buffer pntr storage location
        LHI 026      ** Set H to page of user program buffer pointer
        LDM          Fetch the high part of this pointer into register D
        INL          Advance the memory pointer
        LEM          Fetch the low part into register E
        LHD          Transfer the pointer to H
        LLE          And L. Fetch the (cc) of the current line into register
        LBM          B and then add one to account for the (cc) byte to get
        INB          Total length of the current line in the user pgm buffer
        CAL ADBDE    Add the total length to the pointer value in D & E
        LLI 360      To get the starting address of the next line in the user
```

```
            LHI 026     ** User program buffer. Place the new value for the user
            LMD         Program buffer pointer back into the user program
            INL         Buffer pointer storage locations so that it points to the
            LME         Next line to be processed in the user program buffer.
            LLI 364     Load L with address of end of user pgm buffer storage
            LAD         Location (page address) and fetch end of buffer page.
            CPM         Compare this with next line pointer (updated).
            JFZ GOTO4   If not end of buffer, keep looking for the specified line
            INL         If have same page addresses, check the low address
            LAE         Portions to see if
            CPM         Have reached end of user program buffer
            JFZ GOTO4   If not, continue looking. If end of buffer without

GOTOER,     LAI 325     Finding specified line, then have an error condition.
            LCI 316     Load ACC and register C with code for "UN" and go
            JMP ERROR   Display "Undefined Line" error message.
```

## THE IF STATEMENT ROUTINE

The IF statement routine is a little more complicated than most statement routines presented so far. This is because the statement line may take several forms. The typical forms the IF statement may appear in are illustrated here:

```
IF X = Y + 2 GOTO 120

or

IF X = Y + 2 THEN 120

or

IF X = Y + 2 THEN Z = 3.14159
```

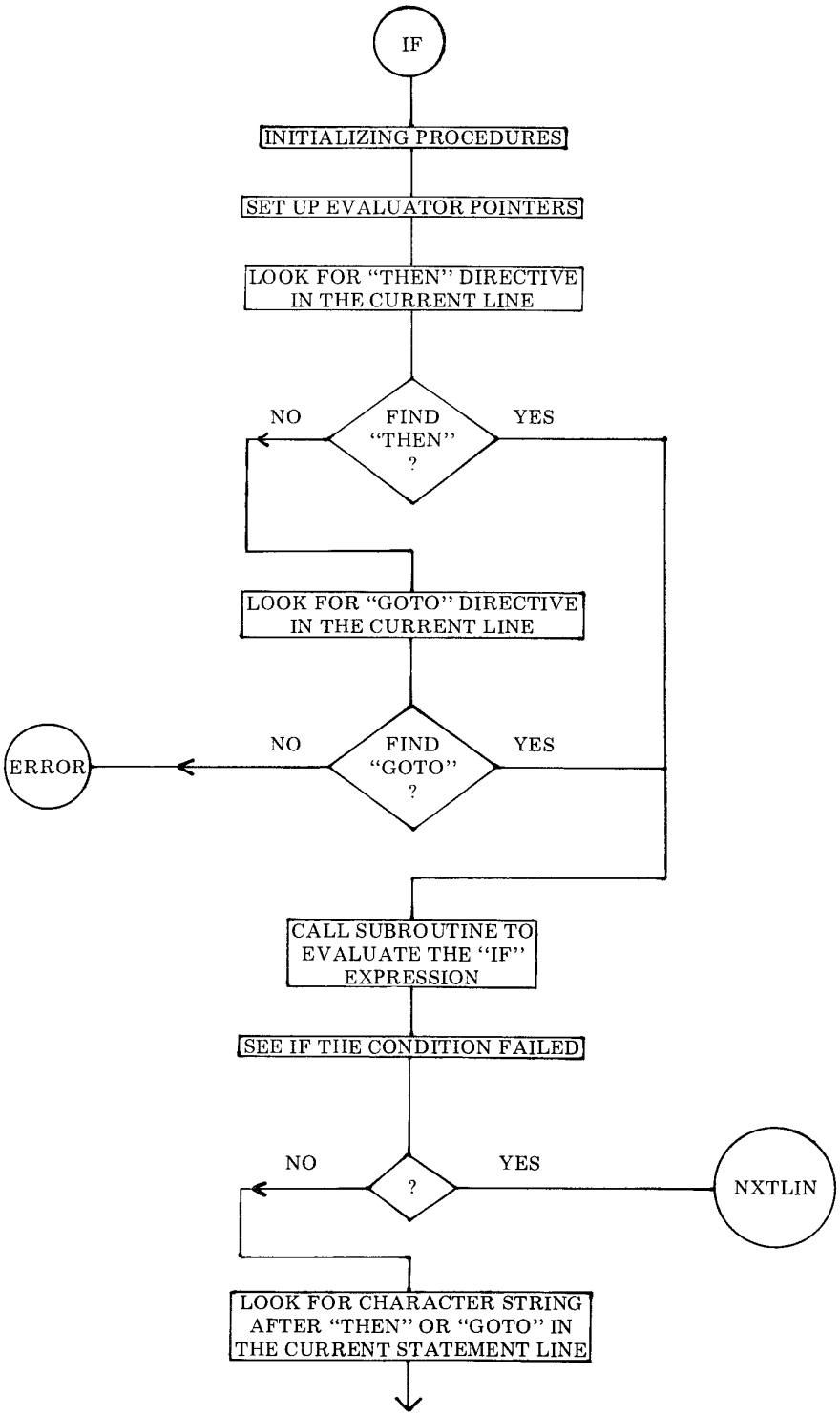
The first two examples of the IF statement format are relatively straightforward. If the specified condition is not met, the user program simply continues with the next high level statement in the program. If the condition is satisfied, the program simply proceeds directly to the line number specified after the GOTO or THEN directive.

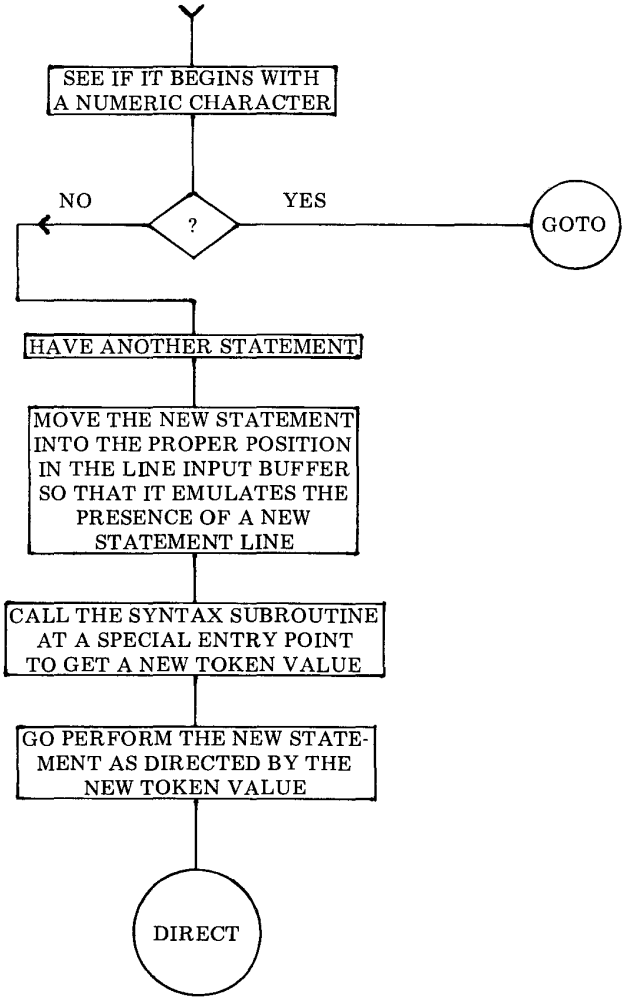
The third example effectively results in a line of the user's high level program containing two statements. The first statement in the example is the IF directive, the second is an IMPLIED LET provided that the IF condition is satisfied.

It should be noted that the IMPLIED LET part of the line in the example could be replaced by other types of SCELBAL statements.

The processing of an IF statement is outlined in the flow chart shown on the next several pages. The case where a line number follows the THEN or GOTO directive in the statement is handled effectively as a JUMP to the designated line number in the user program buffer. The case where another statement follows the THEN directive is handled as if the program actually was processing a new line of the higher level program except that the line number remains the same as that used for the originating IF statement!

The reader may refer to the flow chart when necessary to understand the operation of this portion of SCELBAL while studying the source listing of the IF statement routine.


IF
INITIALIZING PROCEDURES
SET UP EVALUATOR POINTERS
LOOK FOR "THEN" DIRECTIVE IN THE CURRENT LINE
NO
FIND "THEN" ?
YES
LOOK FOR "GOTO" DIRECTIVE IN THE CURRENT LINE
ERROR
NO
FIND "GOTO" ?
YES
CALL SUBROUTINE TO EVALUATE THE "IF" EXPRESSION
SEE IF THE CONDITION FAILED
NO
?
YES
NXTLIN
LOOK FOR CHARACTER STRING AFTER "THEN" OR "GOTO" IN THE CURRENT STATEMENT LINE




```
IF,  LLI 202      Set L to SCAN pointer storage location.
     LHI 026      ** Load H to page of SCAN pointer storage location.
     LBM          Fetch the SCAN pointer value to register B.
     INB          Add one to advance pointer over last char scanned.
     LLI 276      Change L to address of EVAL pointer. Set up EVAL
     LMB          Pointer to begin evaluation with next char in the line.
     CAL CLESYM   Clear the SYMBOL BUFFER.
     LLI 320      Set L to starting address of THEN in look-up table.
     LHI 001      ** Set H to page of the look-up table.
     CAL INSTR    Search for occurrence of THEN in the line input buffer.
     LAE          Transfer register E to ACC. If THEN not found
     NDA          The value in E will be zero.
     JFZ IF1      If THEN found, can evaluate the IF expression.
     LLI 013      If THEN not found, set L to starting address of GOTO
     LHI 027      ** In the KEYWORD look-up table. Set H to table
     CAL INSTR    Search for occurrence of GOTO in the line input buffer.
```

```
        LAE         Transfer E to ACC. If GOTO not found
        NDA         The value in E will be zero.
        JFZ IF1     If GOTO found, can evaluate the IF expression.

IFERR,  LAI 311     Set ASCII code for letter I in ACC
        LCI 306     And code for letter F in register C
        JMP ERROR   Go display the IF error message

  IF1,  LLI 277     Load L with addr of EVAL FINISH pointer storage loc
        LHI 026     ** Load H with page of storage location
        DCE         Subtract one from pointer in E and set the EVAL
        LME         FINISH pointer so that it will evaluate up to the THEN
        CAL EVAL    Or GOTO directive. Evaluate the expression.
        LLI 126     Load L with address of FPACC Most Significant Word
        LHI 001     ** Load H with page of FPACC MSW
        LAM         Fetch the FPACC MSW into the accumulator
        NDA         Test the value of the FPACC MSW
        JTZ NXTLIN  If it is zero, IF condition failed, ignore rest of line.
        LLI 277     If not, load L with addr of EVAL FINISH pointer
        LHI 026     ** Set H to the appropriate page
        LAM         Fetch the value in the EVAL FINISH pointer
        ADI 005     Add five to skip over THEN or GOTO directive
        LLI 202     Change L to SCAN pointer storage location
        LMA         Set up the SCAN pointer to location after THEN or
        LBA         GOTO directive. Also put this value in register B.
        INB         Add one to the value in B to point to next character
        LLI 204     After THEN or GOTO. Change L to addr of THEN pntr
        LMB         Storage location and store the pointer value.

  IF2,  LLI 204     Load L with the address of the THEN pointer
        CAL GETCHR  Fetch the character pointed to by the THEN pointer
        JFZ IF3     If character is not a space, exit this loop
        LLI 204     If fetch a space, ignore. Reset L to the THEN pointer
        CAL LOOP    Add one to the THEN pointer and test for end of line
        JFZ IF2     If not end of line, keep looking for a character other
        JMP IFERR   Than a space. If reach end of line first, then error

  IF3,  CPI 260     When find a character see if it is numeric.
        JTS IF4     If not numeric, then should have a new type of
        CPI 272     Statement. If numeric, then should have a line number.
        JTS GOTO    So process as though have a GOTO statement!

  IF4,  LLI 000     Load L with addr of start of line input buffer.
        LAM         Fetch the (cc) byte to get length of line value.
        LLI 204     Change L to current value of THEN pointer (where first
        SUM         Non-space char. found after THEN or GOTO). Subtract
        LBA         This value from length of line to get remainder. Now
        INB         Have length of second statement portion. Add one for
        LCM         (cc) count. Save THEN pointer value in register C.
        LLI 000     Reset L to start of line input buffer. Now put length of
        LMB         Second statement into (cc) position of input buffer.
```

```
LLC          Set L to where second statement starts.
LDI 026      ** Set D to page of line input buffer.
LEI 001      Set E to first character position of line input buffer.
CAL MOVEIT   Move the second statement up in line to become first!
LLI 202      Load L with address of new SCAN pointer. Load
LMI 001      It with starting position for SYNTAX scan.
CAL SYNTX4   Use special entry to SYNTAX to get new TOKEN value.
JMP DIRECT   Process the second statement in the original line.
```

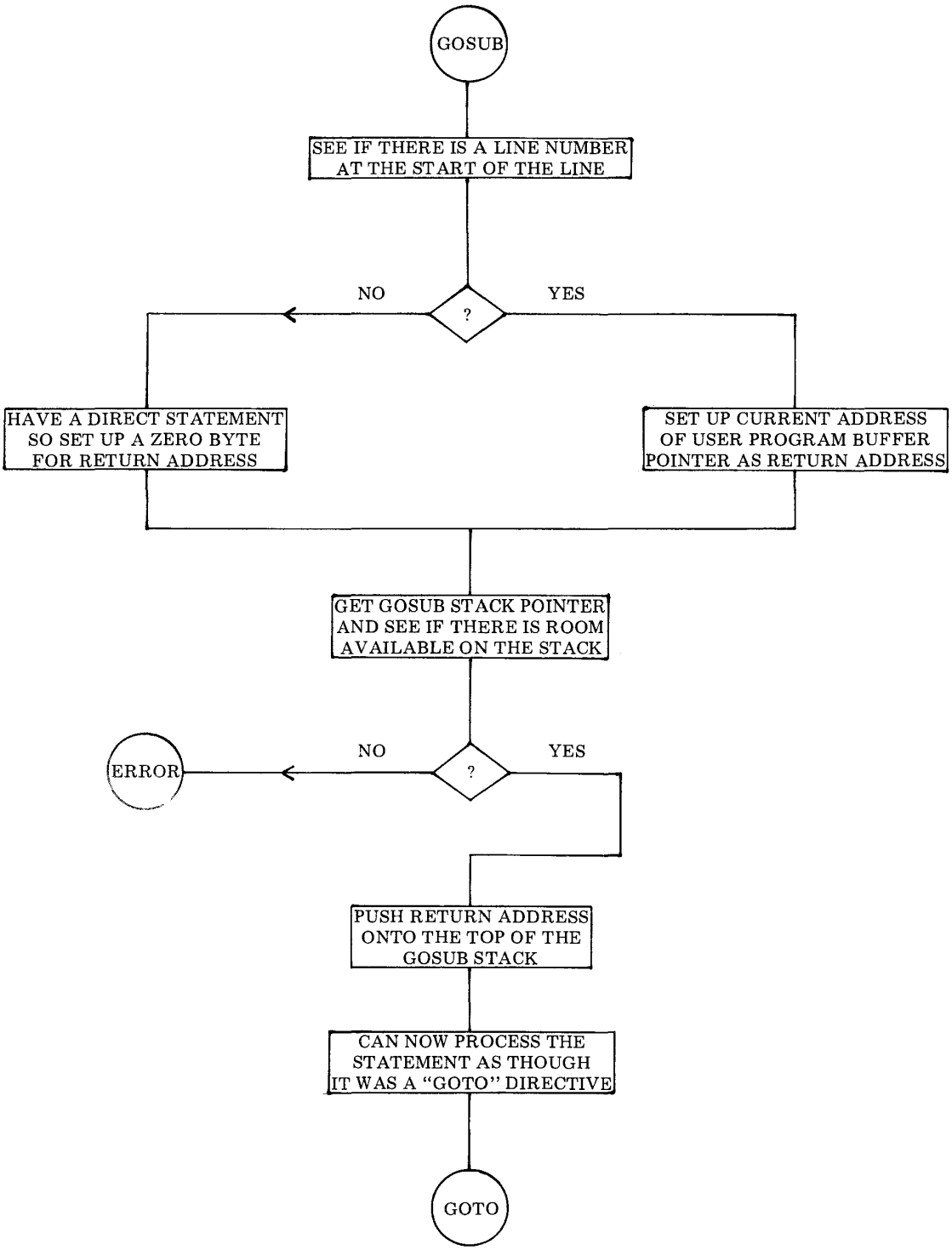
## THE GOSUB STATEMENT ROUTINE

The GOSUB statement routine creates a software STACK so that the high level program can return, after executing the subroutine, to the next line in the user program buffer following the GOSUB statement. The software stack created is merely a group of locations in memory where addresses are stored and a stack pointer system that indicates what position in the stack is in use. The software stack utilized for GOSUB statements has enough room reserved in it to nest GOSUB statements up to eight levels.

The GOSUB software stack operates in a push-down manner. Each time a GOSUB statement is encountered, the current address of the user program buffer line pointer is placed on the top of the stack, with any previous addresses on the stack being pushed down. The RETURN statement, to be discussed shortly, causes the reverse to occur. The address on the top of the stack is removed (as the returning address) and any remaining addresses on the stack are popped up.

The GOSUB flow chart on the following page illustrates the procedure followed when a GOSUB statement is encountered. Once the current user program buffer line pointer has been placed on the GOSUB stack, the GOSUB directive is handled as an effective GOTO statement. This use of the GOTO routine already presented, to complete the GOSUB process, makes the source listing for the GOSUB routine quite short as illustrated below.

```
GOSUB,   LLI 340      Load L with start of LINE NUMBER BUFFER
         LHI 026      ** Load H with page of LINE NUMBER BUFFER
         LDM          Fetch (cc) of current line number into register D
         IND          Test contents of register by first incrementing
         DCD          And then decrementing the value in the register
         JTZ GOSUB1   If no line number, then processing a DIRECT statement
         LLI 360      Else, load L with address of user pgm buff line pointer
         LDM          Fetch high value (page) of pgm line pointer to D
         INL          Advance the memory pointer
         LEM          Fetch the low part of pgm line pointer to E

GOSUB1,  LLI 073      Set L to address of GOSUB STACK POINTER
         LHI 027      ** Set H to page of GOSUB STACK POINTER
         LAM          Fetch value in GOSUB stack pointer to ACC
         ADI 002      Add two to current stack pointer for new data to be
         CPI 021      Placed on the stack and see if stack overflows
```


GOSUB
SEE IF THERE IS A LINE NUMBER AT THE START OF THE LINE
NO
?
YES
HAVE A DIRECT STATEMENT SO SET UP A ZERO BYTE FOR RETURN ADDRESS
SET UP CURRENT ADDRESS OF USER PROGRAM BUFFER POINTER AS RETURN ADDRESS
GET GOSUB STACK POINTER AND SEE IF THERE IS ROOM AVAILABLE ON THE STACK
NO
?
YES
ERROR
PUSH RETURN ADDRESS ONTO THE TOP OF THE GOSUB STACK
CAN NOW PROCESS THE STATEMENT AS THOUGH IT WAS A "GOTO" DIRECTIVE
GOTO

```
JFS GOSERR    If stack filled, have an error condition
LMA           Else, store updated stack pointer
LLI 076       Load L with address of start of stack less offset (2)
ADL           Add GOSUB stack pointer to base address
LLA           To get pointer to top of stack (page byte)
LMD           Store page part of pgm buffer line pointer in stack
INL           Advance pointer to next byte in stack
LME           Store low part of pgm buffer line pointer in stack
JMP GOTO      Proceed from here as though processing a GOTO
```

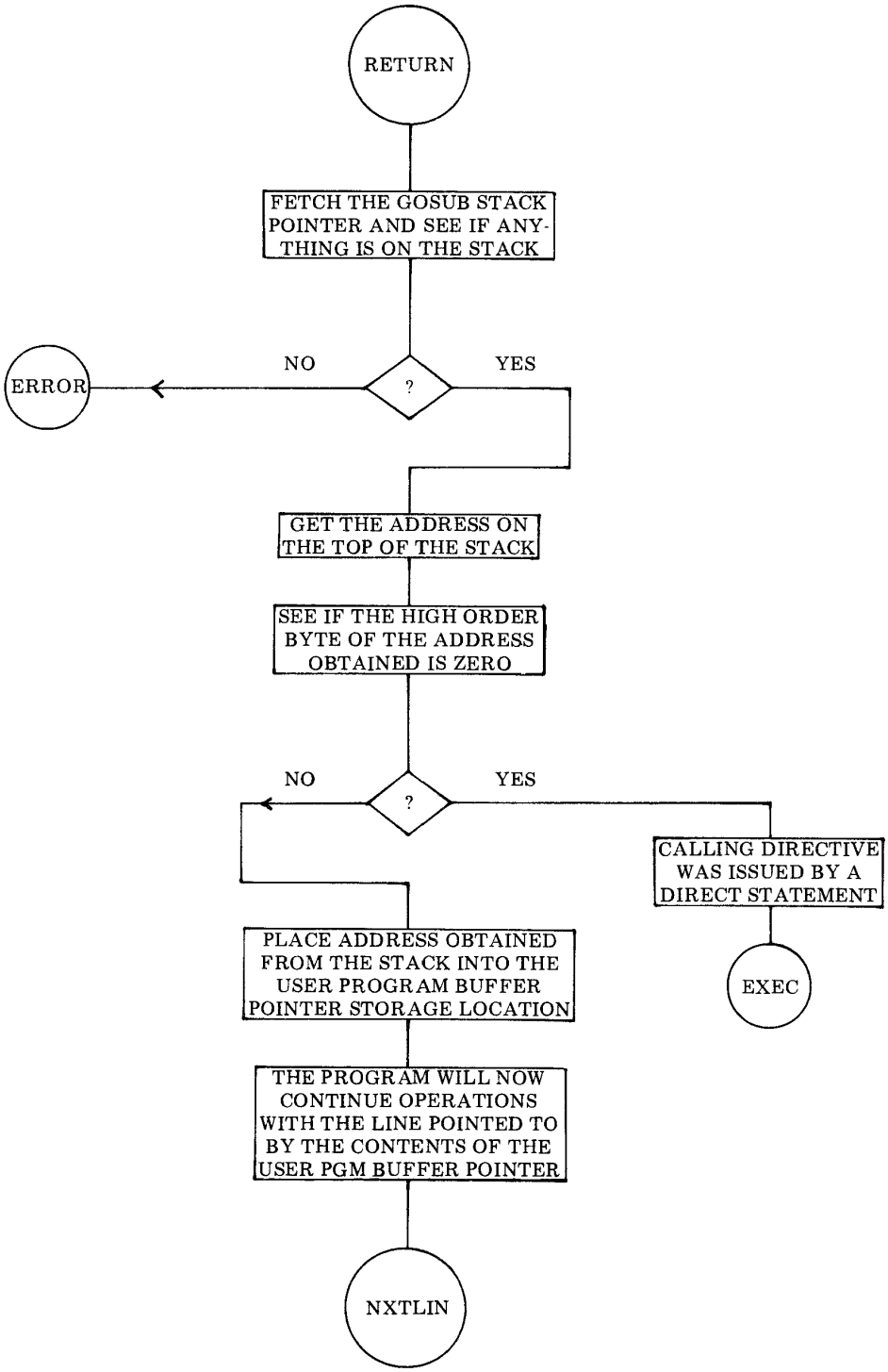
## THE RETURN STATEMENT ROUTINE

The RETURN statement routine takes the address residing on the top of the GOSUB stack just discussed and places it in the user program buffer line pointer. This operation will cause the high level program to continue with the next statement following the original GOSUB directive. Any remaining addresses on the GOSUB stack are popped up, as mentioned in the discussion of the GOSUB statement, so that nested subroutines may be properly handled.

The flow chart provided on the next page illustrates the RETURN statement execution process. The source listing for this short routine is presented below.

```
RETURN,  LLI 073      Set L to address of GOSUB STACK POINTER
         LHI 027      ** Set H to page of GOSUB STACK POINTER
         LAM          Fetch the value of GOSUB stack pointer to ACC
         SUI 002      Subtract two for data to be removed from stack
         JTS RETERR   If stack underflow, then have an error condition
         LMA          Restore new stack pointer to memory
         ADI 002      Add two to point to previous top of stack
         LLI 076      Load L with address of start of GOSUB stack less two
         ADL          Add address of previous top of stack to base value
         LLA          Set pointer to high address value in the stack
         LDM          Fetch the high address value from stack to register D
         IND          Exercise the register contents to see if high address
         DCD          Obtained is zero. If so, original GOSUB statement was
         JTZ EXEC     A DIRECT statement. Must return to Executive!
         INL          Else, advance pointer to get low address value from the
         LEM          Stack into CPU register E.
         LLI 360      Load L with address of user pgm line pointer storage
         LHI 026      ** Location. Load H with page of user pgm line pntr.
         LMD          Put high address from stack into pgm line pointer.
         INL          Advance the memory pointer
         LME          Put low address from stack into pgm line pointer.
         JMP NXTLIN   Execute the next line after originating GOSUB line!
```

(Two short error routines used by the GOSUB and RETURN routines are shown following the flow chart.)


RETURN
FETCH THE GOSUB STACK POINTER AND SEE IF ANY-THING IS ON THE STACK
NO
YES
?
ERROR
GET THE ADDRESS ON THE TOP OF THE STACK
SEE IF THE HIGH ORDER BYTE OF THE ADDRESS OBTAINED IS ZERO
NO
YES
?
CALLING DIRECTIVE WAS ISSUED BY A DIRECT STATEMENT
EXEC
PLACE ADDRESS OBTAINED FROM THE STACK INTO THE USER PROGRAM BUFFER POINTER STORAGE LOCATION
THE PROGRAM WILL NOW CONTINUE OPERATIONS WITH THE LINE POINTED TO BY THE CONTENTS OF THE USER PGM BUFFER POINTER
NXTLIN

```
GOSERR,  LAI 307      Load ASCII code for letter G into accumulator
         LCI 323      Load ASCII code for letter S into register C
         JMP ERROR    Go display GoSub (GS) error message.

RETERR,  LAI 322      Load ASCII code for letter R into accumulator
         LCI 324      Load ASCII code for letter T into register C
         JMP ERROR    Go display ReTurn (RT) error message.
```

## THE INPUT STATEMENT ROUTINE

The INPUT statement routine is used to input the values for user defined variables during the operation of a high level program from the system's input device such as a keyboard. The values that are inputted from the operator are then stored in the variables symbol table.

The flow chart on the following page illustrates the essential operation of the statement routine. However, not illustrated in the flow chart is the fact that the INPUT statement routine has a special capability that is essentially the reverse of the CHR function. The CHR function was mentioned in the discussion of the PRINT statement and will be detailed in a later chapter.

The reverse of the CHR function is the capability to accept a character from an input device and convert the character to a numerical value corresponding to its ASCII code (in decimal for SCELBAL).

When a programmer using SCELBAL wants to have the operator enter a character as an input for a variable value, a dollar sign ($) must be placed immediately after the variable in the statement directive. Thus:

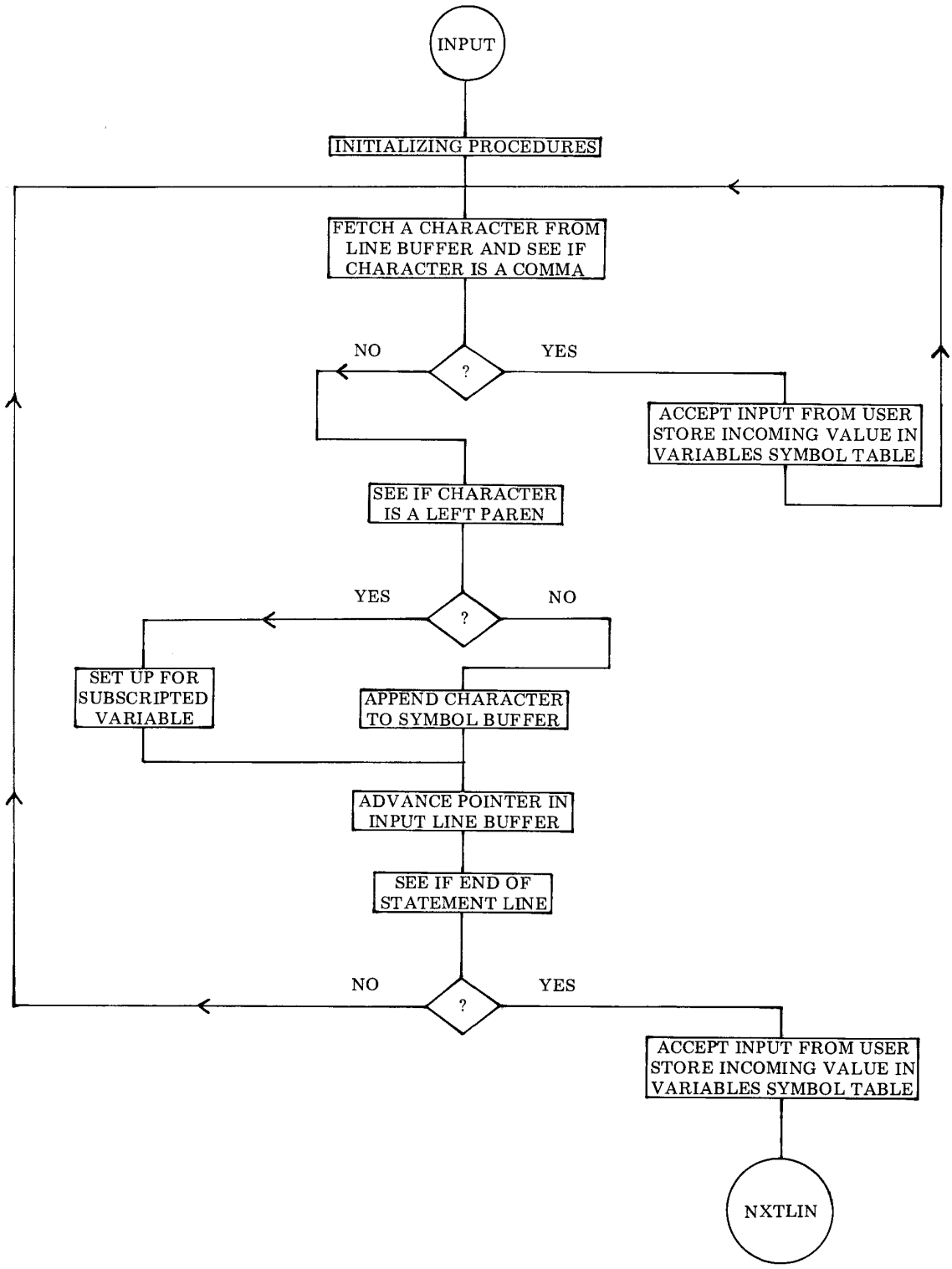
```
INPUT A$,B,C,D$
```

as an INPUT statement would mean that the variables B and C were to be entered as numerical values, while variables A and D were to entered as alphanumeric characters (which will then be converted to numerical values according to their ASCII code equivalents).

When the INPUT statement routine is processing the statement line, it checks to see if the last character of each variable is a dollar sign. If so, the routine converts the character inputted by the operator for the variable value to its decimal ASCII code numerical value. That numerical value thus becomes the value assigned to the variable. If the dollar sign is not present as the last character of a variable, then the operator input is assumed to represent the actual numerical value entered.

This special capability is provided in the portion of the INPUT statement routine labeled INPUTX. The source listing which follows illustrates that the capability is a small subset of the fundamental INPUT statement routine. Hence, it is not highlighted in the flow chart.

```
INPUT,   CAL CLESYM   Clear the SYMBOL BUFFER
         LLI 202      Load L with address of SCAN pointer storage location
         LBM          Fetch value of SCAN pointer to register B
         INB          Increment value to point to next character
         LLI 203      Change L to point to INPUT pointer (formerly TOKEN)
         LMB          Updated SCAN pointer becomes INPUT pointer
```


INPUT
INITIALIZING PROCEDURES
FETCH A CHARACTER FROM LINE BUFFER AND SEE IF CHARACTER IS A COMMA
NO
?
YES
ACCEPT INPUT FROM USER STORE INCOMING VALUE IN VARIABLES SYMBOL TABLE
SEE IF CHARACTER IS A LEFT PAREN
YES
?
NO
SET UP FOR SUBSCRIPTED VARIABLE
APPEND CHARACTER TO SYMBOL BUFFER
ADVANCE POINTER IN INPUT LINE BUFFER
SEE IF END OF STATEMENT LINE
NO
?
YES
ACCEPT INPUT FROM USER STORE INCOMING VALUE IN VARIABLES SYMBOL TABLE
NXTLIN

```
INPUT1,  LLI 203      Load L with address of INPUT pointer
         CAL GETCHR   Fetch a character from the line input buffer
         JTZ INPUT3   If character is a space, ignore it. Else,
         CPI 254      See if character is a comma. If so, process the
         JTZ INPUT4   Variable that preceeds the comma.
         CPI 250      If not, see if character is a left parenthesis.
         JFZ INPUT2   If not, continue processing to build up symbolic variable
         CAL ARRAY2   @@ If so, call array subscripting subroutine
         LLI 206      @@ Load L with address of array set up pointer
         LHI 026      @@ ** Load H with page of array set up pointer
         LBM          @@ Fetch pointer value (point to ")" of subscript)
         LLI 203      @@ Change pointer to address of INPUT pointer
         LMB          @@ Update INPUT pointer
         JMP INPUT3   @@ Jump over concatenate instruction below

INPUT2,  CAL CONCTS   Concatenate character to SYMBOL BUFFER

INPUT3,  LLI 203      Load L with address of INPUT pointer
         CAL LOOP     Increment INPUT pointer and test for end of line
         JFZ INPUT1   If not end of line, go get next character
         CAL INPUTX   If end of buffer, get input for variable in the SYMBOL
         CAL STOSYM   BUFFER and store the value in the VARIABLES table
         JMP NXTLIN   Then continue to interpret next statement line


INPUT4,  CAL INPUTX   Get input from user for variable in SYMBOL BUFFER
         CAL STOSYM   Store the inputted value in the VARIABLES table
         LHI 026      ** Set H to page of INPUT pointer
         LLI 203      Set L to location of INPUT pointer
         LBM          Fetch pointer value for last character examined
         LLI 202      Change L to point to SCAN pointer storage location
         LMB          Update the SCAN pointer
         JMP INPUT    Continue processing statement line for next variable


INPUTX,  LLI 120      Load L with start of SYMBOL BUFFER (contains cc)
         LAM          Fetch the (cc) (length of symbol in the buffer) to ACC
         ADL          Add (cc) to base address to set up
         LLA          Pointer to last character in the SYMBOL BUFFER
         LAM          Fetch the last character in the SYMBOL BUFFER
         CPI 244      See if the last character was a $ sign
         JFZ INPUTN   If not a $ sign, get variable value as a numerical entry
         LLI 120      If $ sign, reset L to start of the SYMBOL BUFFER
         LBM          Fetch the (cc) for the variable in the SYMBOL BUFF
         DCB          Subtract one from (cc) to chop off the $ sign
         LMB          Restore the new (cc) for the SYMBOL BUFFER
         CAL FP0      Call subroutine to zero the floating point accumulator
         CAL CINPUT   Input one character from system input device
         LLI 124      Load L with address of the LSW of the FPACC
         LMA          Place the ASCII code for the character inputted there
         JMP FPFLT    Convert value to floating point format in FPACC
```

```
INPUTN,  LLI 144      Load L with address of start of AUX SYMBOL BUFF
         LHI 026      ** Load H with page of AUX SYMBOL BUFFER
         LAI 277      Load accumulator with ASCII code for ? mark
         CAL ECHO     Call output subroutine to display the ? mark
         CAL STRIN    Input string of characters (number) fm input device
         JMP DINPUT   Convert decimal string into binary floating point nr.

FP0,     LHI 001      ** Load H with floating point working registers page
         JMP CFALSE   Zero the floating point accumulator & exit to caller
```

## THE FOR STATEMENT ROUTINE

The FOR statement routine actually only performs part of the tasks related to the statement. The NEXT statement routine, which will be described in the following section, performs the major portion of the operations using the data entered on the FOR statement line.

The use of the combination of the FOR and NEXT statements permits the high level language programmer to form iterative programming loops. These statements must always be used in pairs. The FOR statement initiates an iterative loop. The NEXT statement ends the loop. Statements in between a FOR and a NEXT statement may be used to perform desired operations.

FOR/NEXT loops may be nested one inside another provided that the nesting occurs in the following fashion.

```
FOR X = 1 TO 5
  .
  .
  FOR Y = 1 TO 3
    .
    .
    FOR Z = 1 TO 10
      .
      .
    NEXT Z
  NEXT Y
NEXT X
```

In other words, the deepest loop must be closed out by a NEXT statement first! Attempting to nest loops in the following manner:

```
FOR X = 1 TO 5
  .
  .
  FOR Y = 1 TO 3
    .
    .
NEXT X
NEXT Y
```

will result in an error condition.

In order to allow for the nesting of FOR/NEXT loops, a FOR/NEXT STACK implemented by software is maintained similar in operation (push-down, pop-up) to the software stack established for GOSUB/RETURN statements. However, the FOR/NEXT stack requires four bytes for each nested loop. Two bytes are used to store the address of the user program buffer line pointer when a FOR statement is encountered, and two are used to store the symbolic name of the variable which is iterated. (Remember, the GOSUB/RETURN stack just required two bytes per statement. These were used to store the address of the GOSUB statement that initiated the subroutine call operation.)

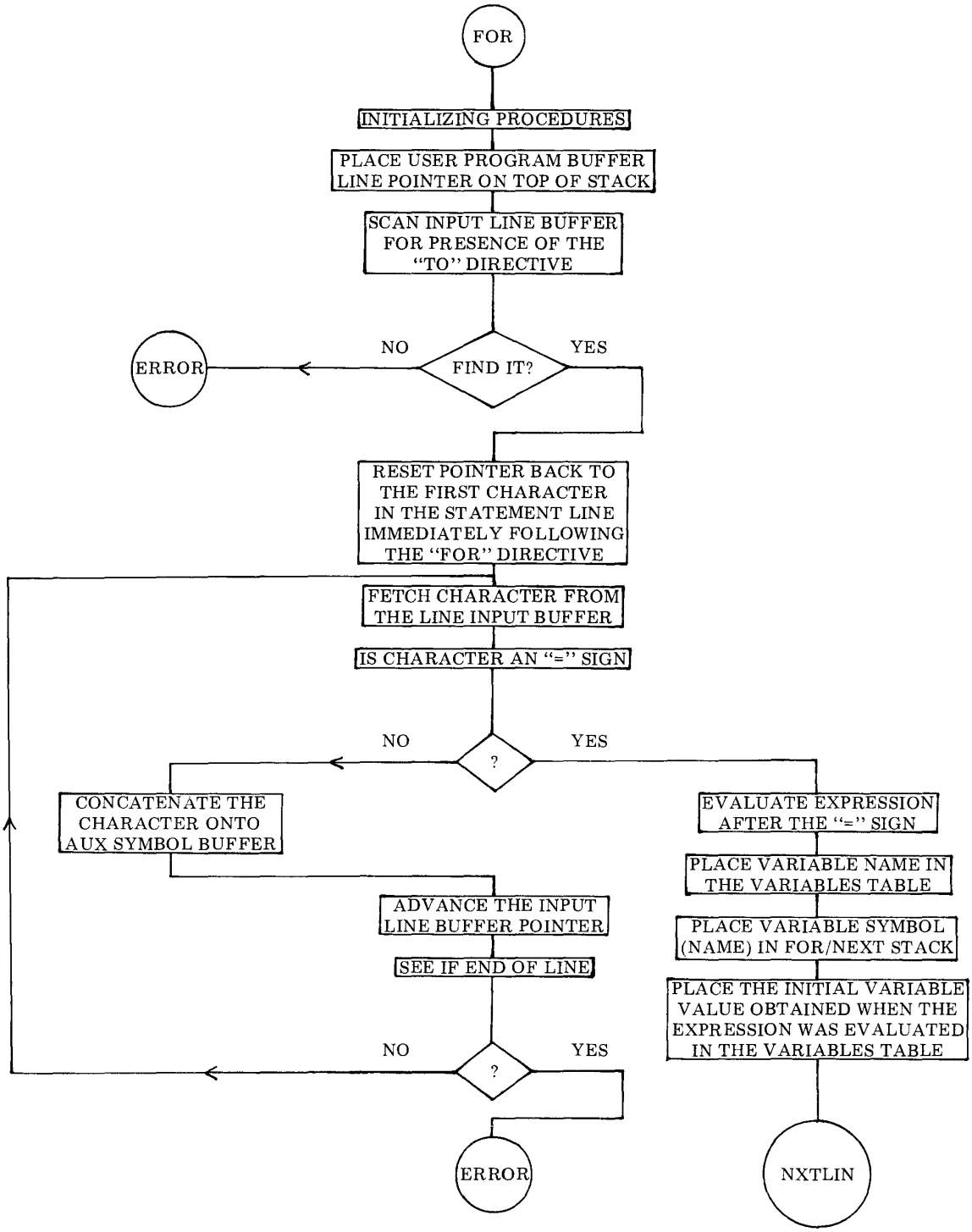
Room has been provided in one of the special pointer/counters/look-up table pages used in SCELBAL for a FOR/NEXT stack area that will allow nesting of FOR/NEXT

loops up to eight levels. A stack pointer is used to point to the proper locations in the stack area as a function of the nesting level at any given time.

The flow chart presented on the following page illustrates that the major function of the FOR statement routine is to place the appropriate information on the FOR/NEXT stack.

The source listing for the routine starts below.

```
FOR,    LLI 144     Load L with address of AUX SYMBOL BUFFER
        LHI 026     ** Load H with page of AUX SYMBOL BUFFER
        LMI 000     Initialize buffer by clearing first byte
        LLI 146     Load L with location of second character in buffer
        LMI 000     Clear that location in case of single character variable
        LLI 205     Load L with address of FOR/NEXT STACK pointer
        LHI 027     ** Load H with page of FOR/NEXT STACK pointer
        LBM         Fetch the FOR/NEXT STACK pointer
        INB         Increment it in preparation for pushing operation
        LMB         Restore it back to its storage location
        LLI 360     Load L with address of user pgm buffer line pointer
        LHI 026     ** Set H to page of line pointer
        LDM         Fetch page address of pgm buffer line pntr into D
        INL         Advance the memory pointer to pick up low part
        LEM         Fetch low address of pgm buffer line pntr into E
        LAB         Restore updated FOR/NEXT STACK pointer to ACC
        RLC         Rotate it left to multiply by two, then rotate it again to
        RLC         Multiply by four. Add this value to the base address of
        ADI 134     The FOR/NEXT STACK to point to the new top of
        LLA         The FOR/NEXT STACK and set up to point to stack
        LHI 027     ** Set H for page of the FOR/NEXT STACK
        LMD         Store the page portion of the user pgm buffer line pntr
        INL         In the FOR/NEXT STACK, advance register L, then
        LME         Store the low portion of the pgm line pntr on the stack
        LLI 325     Change L to point to start of TO string which is stored
        LHI 001     ** In a text strings storage area on this page
        CAL INSTR   Search the statement line for the occurrence of TO
        LAE         Register E will be zero if TO not found. Move E to ACC
        NDA         To make a test
        JFZ FOR1    If TO found then proceed with FOR statement

FORERR, LAI 306     Else have a For Error. Load ACC with ASCII code for
        LCI 305     Letter F and register C with code for letter E.
        JMP ERROR   Then go display the FE message.

FOR1,   LLI 202     Load L with address of SCAN pointer storage location
        LHI 026     ** Set H to page of the SCAN pointer
        LBM         Fetch pointer value to ACC (points to letter R in the
        INB         For directive). Increment it to point to next character
        LLI 204     In the line. Change register L and set this value up
        LMB         As an updated FOR pointer.
        LLI 203     Set L to address of TO pointer (formerly TOKEN)
        LME         Save pointer to TO in the TO pointer!
```


FOR
INITIALIZING PROCEDURES
PLACE USER PROGRAM BUFFER LINE POINTER ON TOP OF STACK
SCAN INPUT LINE BUFFER FOR PRESENCE OF THE "TO" DIRECTIVE
NO
FIND IT?
YES
ERROR
RESET POINTER BACK TO THE FIRST CHARACTER IN THE STATEMENT LINE IMMEDIATELY FOLLOWING THE "FOR" DIRECTIVE
FETCH CHARACTER FROM THE LINE INPUT BUFFER
IS CHARACTER AN "=" SIGN
NO
?
YES
CONCATENATE THE CHARACTER ONTO AUX SYMBOL BUFFER
EVALUATE EXPRESSION AFTER THE "=" SIGN
PLACE VARIABLE NAME IN THE VARIABLES TABLE
ADVANCE THE INPUT LINE BUFFER POINTER
PLACE VARIABLE SYMBOL (NAME) IN FOR/NEXT STACK
SEE IF END OF LINE
PLACE THE INITIAL VARIABLE VALUE OBTAINED WHEN THE EXPRESSION WAS EVALUATED IN THE VARIABLES TABLE
NO
?
YES
ERROR
NXTLIN

```
FOR2,   LLI 204       Load L with address of the FOR pointer
        CAL GETCHR    Fetch a character from the statement line
        JTZ FOR3      If it is a space, ignore it
        CPI 275       Test to see if character is the "=" sign
        JTZ FOR4      If so, variable name is in the AUX SYMBOL BUFFER
        LLI 144       If not, then set L to point to start of the AUX SYMBOL
        CAL CONCT1    BUFFER and concatenate the character onto the buffer

FOR3,   LLI 204       Reset L to address of the FOR pointer
        CAL LOOP      Increment the pointer and see if end of line
        JFZ FOR2      If not end of line, continue looking for the "=" sign
        JMP FORERR    If reach end of line before "=" sign, then have error

FOR4,   LLI 204       Set L with address of the FOR pointer
        LBM           Fetch pointer value to ACC (pointing to "=" sign)
        INB           Increment it to skip over the "=" sign
        LLI 276       Set L to address of the EVAL pointer
        LMB           Restore the updated pointer to storage
        LLI 203       Set L to the address of the TO pointer
        LBM           Fetch pointer value to ACC (pointing to letter T in TO)
        DCB           Decrement it to point to character before the T in TO
        LLI 277       Set L to EVAL FINISH pointer storage location
        LMB           Store the EVAL FINISH pointer value
        CAL EVAL      Evaluate the expression between the "=" sign and TO
        CAL RESTSY    Directive. Place the variable name in the variables table.
        LLI 144       Load L with starting address of the AUX SYMBOL BF
        LHI 026       ** Load H with the page of the AUX SYMBOL BUFF
        LAM           Fetch the (cc) for the name in the buffer
        CPI 001       See if the symbol (name) length is just one character
        JFZ FOR5      If not, go directly to place name in FOR/NEXT STACK
        LLI 146       If so, set L to point to second character location in the
        LMI 000       AUX SYMBOL BUFFER and set it equal to zero.
        JMP FOR5      This jump directs program over pntrs/cntrs/table area

FOR5,   LLI 205       Load L with address of the FOR/NEXT STACK pointer
        LHI 027       ** Load H with page of the FOR/NEXT STACK pntr
        LAM           Fetch the stack pointer to the ACC.
        RLC           Rotate it left to multiply by two, then rotate it again to
        RLC           Multiply by four. Add this value to the base address
        ADI 136       Plus two of the base address to point to the next part of
        LEA           The FOR/NEXT STACK. Place this value in register E.
        LDH           Set D to the FOR/NEXT STACK area page.
        LLI 145       Load L with the address of the first character in the
        LHI 026       ** AUX SYMBOL BUFFER and set up H to this page.
        LBI 002       Set up register B as a number of bytes to move counter.
        CAL MOVEIT    Move the variable name into the FOR/NEXT STACK.
        CAL STOSYM    Store initial variable value in the VARIABLES TABLE.
        JMP NXTLIN    Continue with next line in user program buffer.
```

## THE NEXT STATEMENT ROUTINE

The NEXT statement routine is the work horse portion of the FOR/NEXT combination. As indicated in the preceeding section, the statement types must always appear in pairs in a high level program. When a NEXT statement is used it must be followed (in the statement line) by the identifying variable that associates it with an originating FOR statement.

The flow chart on the next several pages illustrates the essential operations of the NEXT statement. This flow chart is amplified by the following discussion.

The first thing the NEXT statement routine accomplishes is to go to the FOR/NEXT stack to obtain the starting address of the associated FOR statement line in the user program buffer. As a check for proper FOR/NEXT nesting, a test is made to see if the variable in the FOR statement line pointed to by the entry in the FOR/NEXT stack is the same as that specified in the NEXT statement being processed. If not, improper FOR/NEXT nesting has been attempted.

The NEXT statement routine then proceeds to process the information on the originating FOR statement line. Remember, the originating FOR statement line contains the the variable range (limit) and step size for the FOR/NEXT loop being processed.

A FOR statement may be formatted in one of two possible ways. The statement:

```
FOR X = 1 TO 5
```

represents an IMPLIED STEP SIZE. That is, since no STEP size is specified, the statement is to be interpreted as having an implied value of 1.0.

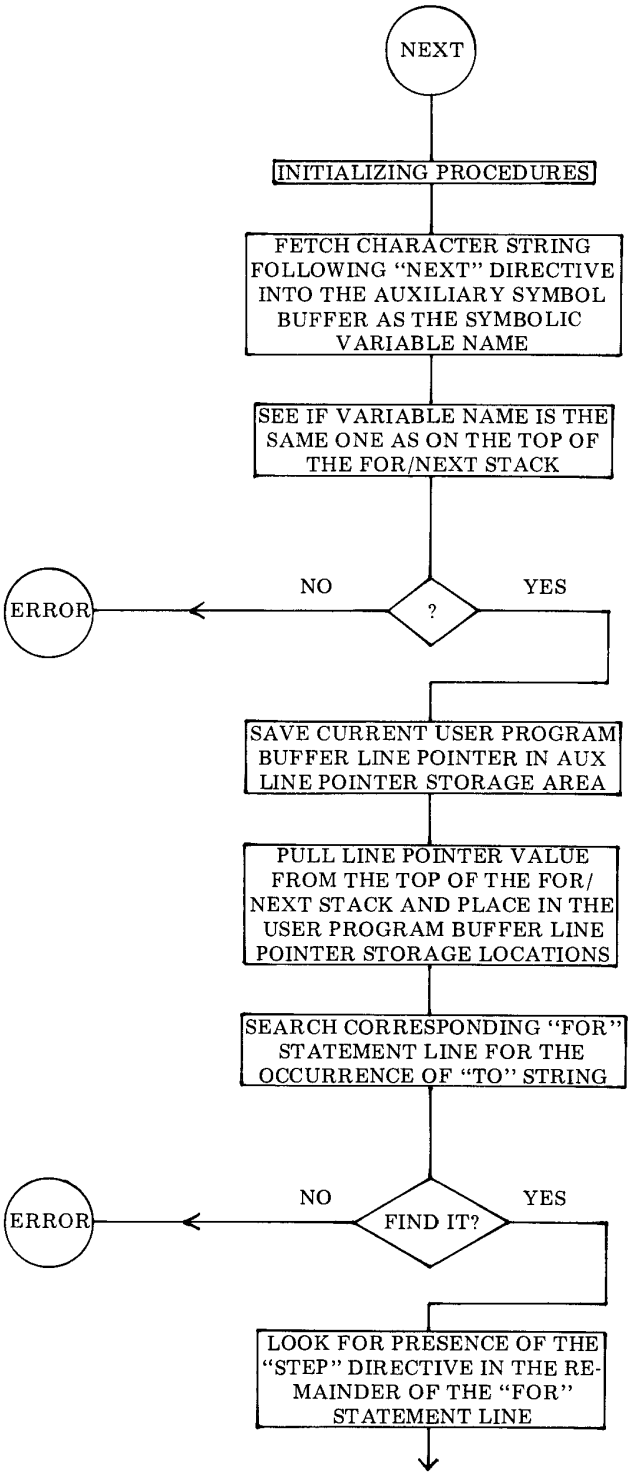
If desired, the high level language programmer may specify a STEP size in a FOR statement such as in the example:

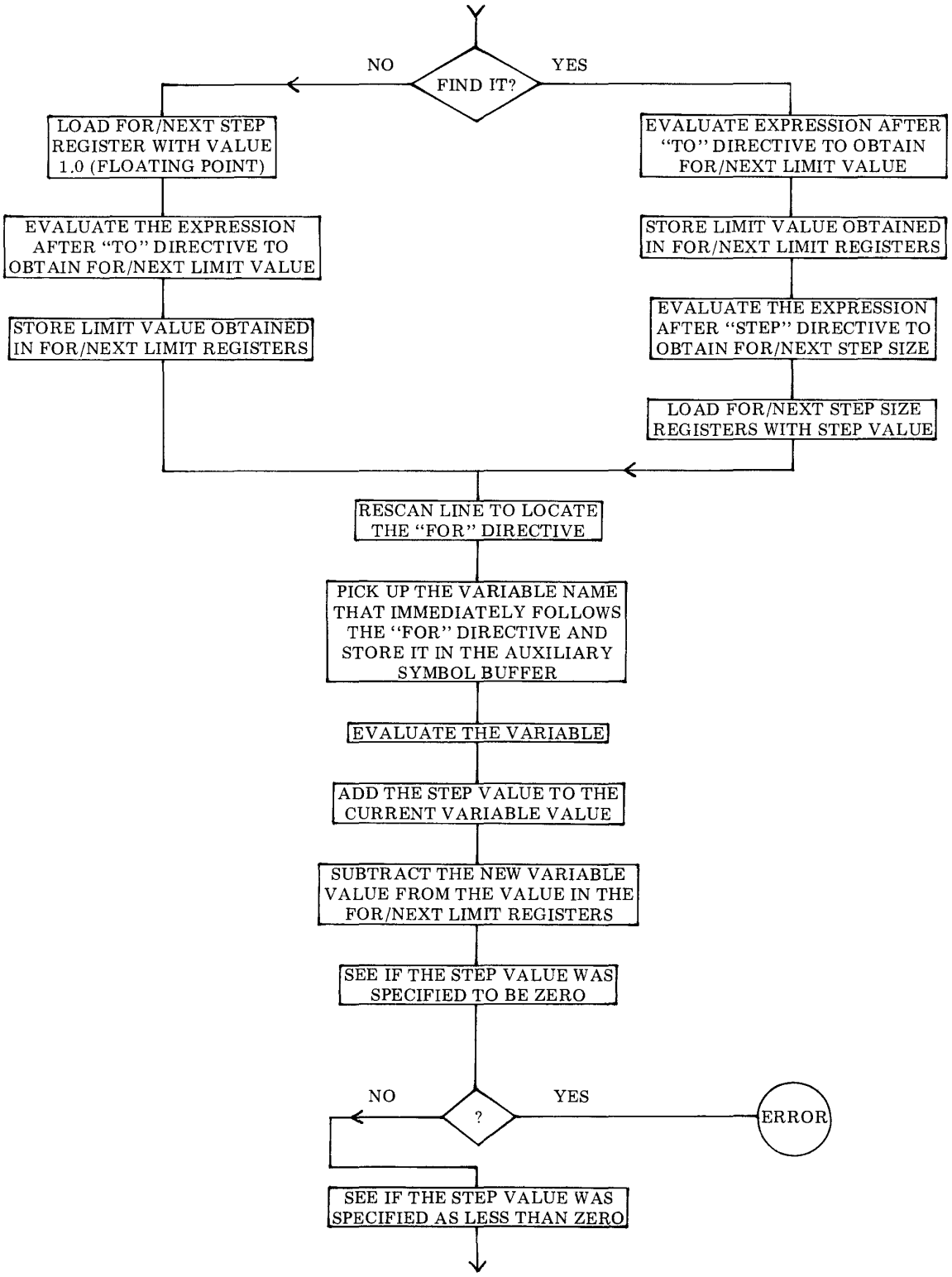
```
FOR X = 1 TO 5 STEP (2)
```

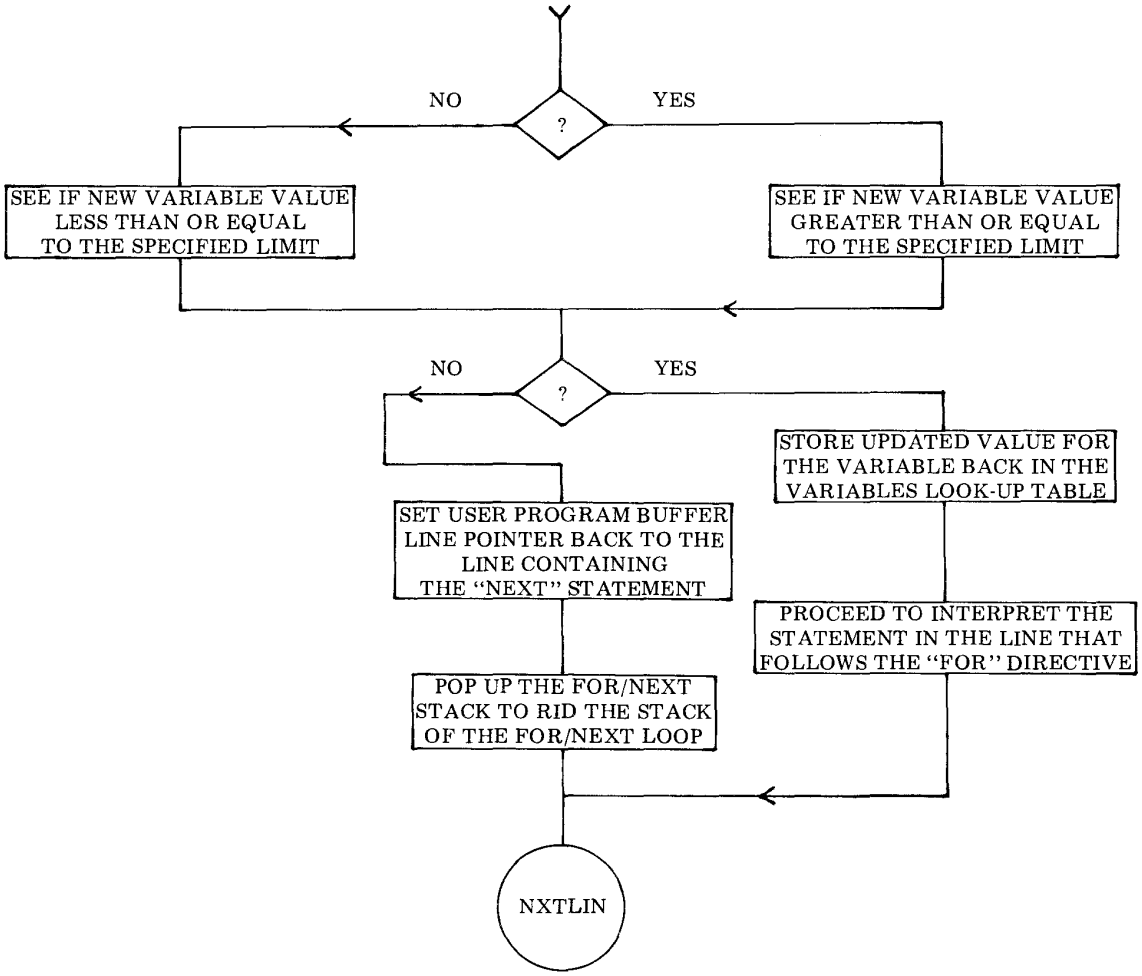
In this case, the STEP size will be whatever value is dictated by the programmer in the term that follows the STEP directive.

Thus, the NEXT statement routine must determine whether an implied or specific STEP size is involved. When this has been accomplished, the STEP size is added to the current value of the associated variable specified in the FOR/NEXT loop. A test is made to see if the new variable value thus obtained is within the range limit specified in the FOR statement line. If the new value causes the variable to exceed the limit value, then the FOR/NEXT loop must be terminated. This is accomplished by removing the associated data from the top of the FOR/NEXT stack and then directing program operation to continue with the statement that follows the NEXT statement. (And NOT the statement following the FOR statement line!) If, on the other hand, the new variable value is still within the specified limit range, then the FOR/NEXT loop must be executed again. In this case, the updated variable value is stored for future use and the statement following the FOR statement will be the next program line executed by the interpreter.

This flow of operations is apparent in the accompanying flow chart. The details of the routine's execution are presented in the source listing which follows the flow chart.


NEXT
INITIALIZING PROCEDURES
FETCH CHARACTER STRING FOLLOWING "NEXT" DIRECTIVE INTO THE AUXILIARY SYMBOL BUFFER AS THE SYMBOLIC VARIABLE NAME
SEE IF VARIABLE NAME IS THE SAME ONE AS ON THE TOP OF THE FOR/NEXT STACK
NO
?
YES
ERROR
SAVE CURRENT USER PROGRAM BUFFER LINE POINTER IN AUX LINE POINTER STORAGE AREA
PULL LINE POINTER VALUE FROM THE TOP OF THE FOR/ NEXT STACK AND PLACE IN THE USER PROGRAM BUFFER LINE POINTER STORAGE LOCATIONS
SEARCH CORRESPONDING "FOR" STATEMENT LINE FOR THE OCCURRENCE OF "TO" STRING
NO
FIND IT?
YES
ERROR
LOOK FOR PRESENCE OF THE "STEP" DIRECTIVE IN THE RE-MAINDER OF THE "FOR" STATEMENT LINE


NO
FIND IT?
YES
LOAD FOR/NEXT STEP REGISTER WITH VALUE 1.0 (FLOATING POINT)
EVALUATE EXPRESSION AFTER "TO" DIRECTIVE TO OBTAIN FOR/NEXT LIMIT VALUE
EVALUATE THE EXPRESSION AFTER "TO" DIRECTIVE TO OBTAIN FOR/NEXT LIMIT VALUE
STORE LIMIT VALUE OBTAINED IN FOR/NEXT LIMIT REGISTERS
STORE LIMIT VALUE OBTAINED IN FOR/NEXT LIMIT REGISTERS
EVALUATE THE EXPRESSION AFTER "STEP" DIRECTIVE TO OBTAIN FOR/NEXT STEP SIZE
LOAD FOR/NEXT STEP SIZE REGISTERS WITH STEP VALUE
RESCAN LINE TO LOCATE THE "FOR" DIRECTIVE
PICK UP THE VARIABLE NAME THAT IMMEDIATELY FOLLOWS THE "FOR" DIRECTIVE AND STORE IT IN THE AUXILIARY SYMBOL BUFFER
EVALUATE THE VARIABLE
ADD THE STEP VALUE TO THE CURRENT VARIABLE VALUE
SUBTRACT THE NEW VARIABLE VALUE FROM THE VALUE IN THE FOR/NEXT LIMIT REGISTERS
SEE IF THE STEP VALUE WAS SPECIFIED TO BE ZERO
NO
?
YES
ERROR
SEE IF THE STEP VALUE WAS SPECIFIED AS LESS THAN ZERO




```
NEXT,   LLI 144     Load L with start of AUX SYMBOL BUFFER
        LHI 026     ** Set H to page of AUX SYMBOL BUFFER
        LMI 000     Initialize AUX SYMBOL BUFFER by clearing first byte
        LLI 202     Change L to address of SCAN pointer
        LBM         Fetch pointer value to CPU register B
        INB         Add one to the current pointer value
        LLI 201     Load L with address of NEXT pointer storage location
        LMB         Place the updated SCAN pointer as the NEXT pointer

NEXT1,  LLI 201     Reset L to address of NEXT pointer storage location
        CAL GETCHR  Fetch the character pointed to by the NEXT pointer
        JTZ NEXT2   If the character is a space, ignore it
        LLI 144     Else, load L with start of AUX SYMBOL BUFFER
        CAL CONCT1  Concatenate the character onto the AUX SYMBOL BF
```

```
NEXT2,  LLI 201     Reset L to address of NEXT pointer storage location
        CAL LOOP    Advance the NEXT pointer and see if end of line
        JFZ NEXT1   Fetch next character in line if not end of line
        LLI 144     When reach end of line, should have variable name
        LAM         In the AUX SYMBOL BUFFER. Fetch the (cc) for
        CPI 001     The buffer and see if variable name is just one letter
        JFZ NEXT3   If more than one proceed directly to look for name
        LLI 146     In FOR/NEXT STACK. If have just a one letter name
        LMI 000     Then set second character in buffer to zero

NEXT3,  LLI 205     Load L with address of FOR/NEXT STACK pointer
        LHI 027     ** Set H to page of FOR/NEXT STACK pointer
        LAM         Fetch the FOR/NEXT STACK pointer value to ACC
        RLC         Rotate value left to multiply by two. Then rotate it
        RLC         Left again to multiply by four. Add base address plus
        ADI 136     Two to form pointer to variable name in top of stack
        LHI 027     ** Set H to page of FOR/NEXT STACK
        LLA         Move pointer value from ACC to CPU register L
        LDI 026     ** Set register D to page of AUX SYMBOL BUFFER
        LEI 145     Set register E to first character in the buffer
        LBI 002     Set B to serve as a character counter
        CAL STRCPC  See if variable name in the NEXT statement same as
        JTZ NEXT4   That stored in the top of the FOR/NEXT STACK

FORNXT, LAI 306     Load ACC with ASCII code for letter F
        LCI 316     Load register C with ASCII code for letter N
        JMP ERROR   Display For/Next (FN) error message if required

NEXT4,  LLI 360     Load L with address of user program line pointer
        LHI 026     ** Load H with page of user pgm line pntr storage loc.
        LDM         Fetch the page portion of the line pointer into D
        INL         Advance the memory pointer
        LEM         Fetch the low portion of the line pointer into E
        INL         Advance pntr to AUXILIARY LINE POINTER storage
        LMD         Location and store value of line pointer there too (page)
        INL         Advance pointer to second byte of AUXILIARY line
        LME         Pointer and store value of line pointer (low portion)
        LLI 205     Load L with address of FOR/NEXT STACK pointer
        LHI 027     ** Set H to page of FOR/NEXT STACK pointer
        LAM         Fetch the FOR/NEXT STACK pointer value to ACC
        RLC         Rotate value left to multiply by two. Then rotate it
        RLC         Left again to multiply by four. Add base address to
        ADI 134     Form pointer to top of FOR/NEXT STACK and place
        LLA         The pointer value into CPU register L. Fetch the page
        LDM         Address of the associated FOR statement line pointer
        INL         Into register D. Advance the pointer and fetch the low
        LEM         Address value into register E. Prepare to change user
        LLI 360     Program line pointer to the FOR statement line by
        LHI 026     ** Setting H & L to the user pgm line pntr storage loc.
        LMD         Place the page value in the pointer storage location
        INL         Advance the memory pointer
```

```
        LME         Place the low value in the pointer storage location
        LHD         Now set up H and L to point to the start of the
        LLE         Associated FOR statement line in the user pgm buffer
        LDI 026     ** Change D to point to the line input buffer
        LEI 000     And set L to the start of the line input buffer
        CAL MOVEC   Move the associated FOR statement line into the input
        LLI 325     Line buffer. Set L to point to start of TO string which is
        LHI 001     ** Stored in a text strings storage area on this page
        CAL INSTR   Search the statement line for the occurrence of TO
        LAE         Register E will be zero if TO not found. Move E to ACC
        NDA         To make a test. If TO found then proceed to set up for
        JTZ FORNXT  Evaluation. If TO not found, then have error condition.
        ADI 002     Advance the pointer over the characters in TO string
        LLI 276     Change L to point to EVAL pointer storage location
        LHI 026     ** Set H to page of EVAL pointer. Set up the starting
        LMA         Position for the EVAL subroutine (after TO string)
        LLI 330     Set L to point to start of STEP string which is stored
        LHI 001     ** In text strings storage area on this page. Search the
        CAL INSTR   Statement line for the occurrence of STEP
        LAE         Register E will be zero if STEP not found. Move E to
        NDA         The accumulator to make a test. If STEP found must
        JFZ NEXT5   Evaluate expression after STEP to get STEP SIZE.
        LLI 004     Else, have an IMPLIED STEP SIZE of 1.0. Set pointer
        LHI 001     ** To start of storage area for 1.0 in floating point
        CAL FLOAD   Format and call subroutine to load FPACC with 1.0
        LLI 304     Set L to start of FOR/NEXT STEP SIZE storage loc.
        CAL FSTORE  Store the value 1.0 in the F/N STEP SIZE registers
        LLI 000     Change L to the start of the input line buffer
        LHI 026     ** Set H to the page of the input line buffer
        LBM         Fetch the (cc) into CPU register B (length of FOR line)
        LLI 277     Change L to EVAL FINISH pointer storage location
        LMB         Set the EVAL FINISH pointer to the end of the line
        CAL EVAL    Evaluate the LIMIT expression to obtain FOR LIMIT
        LLI 310     Load L with address of start of F/N LIMIT registers
        LHI 001     ** Load H with page of FOR/NEXT LIMIT registers
        CAL FSTORE  Store the FOR/NEXT LIMIT value
        JMP NEXT6   Since have IMPLIED STEP jump ahead

NEXT5,  DCE         When have STEP directive, subtract one from pointer
        LLI 277     To get to character before S in STEP. Save this value in
        LHI 026     ** The EVAL FINISH pointer storage location to serve
        LME         As evaluation end location when obtaining TO limit
        CAL EVAL    Evaluate the LIMIT expression to obtain FOR LIMIT
        LLI 310     Load L with address of start of F/N LIMIT registers
        LHI 001     ** Load H with page of FOR/NEXT LIMIT registers
        CAL FSTORE  Store the FOR/NEXT LIMIT value
        LLI 277     Reset L to EVAL FINISH pointer storage location
        LHI 026     ** Set H to page of EVAL FINISH pointer storage loc.
        LAM         Fetch the pointer value (character before S in STEP)
        ADI 005     Add five to change pointer to character after P in STEP
        DCL         Decrement L to point to EVAL (start) pointer
```

```
        LMA         Set up the starting position for the EVAL subroutine
        LLI 000     Load L with starting address of the line input buffer
        LBM         Fetch the (cc) for the line input buffer (line length)
        LLI 277     Change L to the EVAL FINISH storage location
        LMB         Set the EVAL FINISH pointer
        CAL EVAL    Evaluate the STEP SIZE expression
        LLI 304     Load L with address of start of F/N STEP registers
        LHI 001     ** Set H to page of F/N STEP registers
        CAL FSTORE  Store the FOR/NEXT STEP SIZE value

NEXT6,  LLI 144     Load L with address of AUX SYMBOL BUFFER
        LHI 026     ** Set H to page of the AUX SYMBOL BUFFER
        LMI 000     Initialize AUX SUMBOL BUFFER with a zero byte
        LLI 034     Set L to start of FOR string which is stored in the
        LHI 027     ** KEYWORD look-up table on this page
        CAL INSTR   Search the statement line for the FOR directive
        LAE         Register E will be zero if FOR not found. Move E to
        NDA         ACC and make test to see if FOR directive located
        LLI 202     Load L with address of SCAN pointer
        LHI 026     ** Load H with page of SCAN pointer
        LMA         Set up pointer to occurrence of FOR directive in line
        JTZ FORNXT  If FOR not found, have an error condition
        ADI 003     If have FOR, add three to advance pointer over FOR
        LLI 203     Set L to point to F/N pointer storage location
        LMA         Set F/N pointer to character after FOR directive

NEXT7,  LLI 203     Set L to point to F/N pointer storage location
        CAL GETCHR  Fetch a character from position pointed to by F/N pntr
        JTZ NEXT8   If character is a space, ignore it
        CPI 275     Else, test to see if character is "=" sign
        JTZ NEXT9   If yes, have picked up variable name, jump ahead
        LLI 144     If not, set L to the start of the AUX SYMBOL BUFFER
        CAL CONCT1  And store the character in the AUX SYMBOL BUFFER

NEXT8,  LLI 203     Load L with address of the F/N pointer
        CAL LOOP    Increment the pointer and see if end of the line
        JFZ NEXT7   If not, continue fetching characters
        JMP FORNXT  If end of line before "=" sign then have error condx

NEXT9,  LLI 202     Load L with address of SCAN pointer
        LHI 026     ** Load H with page of SCAN pointer
        LAM         Fetch pointer value to ACC (points to start of FOR
        ADI 003     Directive) and add three to move pointer over FOR
        LLI 276     Directive. Change L to EVAL pointer storage location
        LMA         Set EVAL pointer to character after FOR in line
        LLI 203     Load L with address of F/N pointer storage location
        LBM         Fetch pointer to register B (points to "=" sign) and
        DCB         Decrement the pointer (to character before "=" sign)
        LLI 277     Load L with address of EVAL FINISH pointer
        LMB         Set EVAL FINISH pointer
        CAL EVAL    Call subroutine to obtain current value of the variable
```

```
        LLI 304     Load L with address of start of F/N STEP registers
        LHI 001     ** Set H to page of F/N STEP registers
        CAL FACXOP  Call subroutine to set up FP registers for addition
        CAL FPADD   Add F/N STEP size to current VARIABLE value
        LLI 314     Load L with address of F/N TEMP storage registers
        LHI 001     **Set H to page of F/N TEMP storage registers
        CAL FSTORE  Save the result of the addition in F/N TEMP registers
        LLI 310     Load L with starting address of F/N LIMIT registers
        CAL FACXOP  Call subroutine to set up FP registers for subtraction
        CAL FPSUB   Subtract F/N LIMIT value from VARIABLE value
        LLI 306     Set pointer to MSW of F/N STEP registers
        LAM         Fetch this value into the ACC
        NDA         Test to see if STEP value might be zero
        LLI 126     Load L with address of MSW of FPACC
        LAM         Fetch this value into the ACC
        JTZ FORNXT  If STEP size was zero, then endless loop, an error condx
        JTS NEXT11  If STEP size less than zero make alternate test on limit
        NDA         Test the contents of the MSW of the FPACC
        JTS NEXT12  Continue FOR/NEXT loop if current variable value is
        JTZ NEXT12  Less than or equal to the F/N LIMIT value

NEXT10, LLI 363     If out of LIMIT range, load L with address of the AUX
        LHI 026     ** PGM LINE pointer. (Contains pointer to the NEXT
        LEM         Statement line that initiated this routine.) Fetch the
        DCL         Low part of the address into E, decrement the memory
        LDM         And get the page part of the address into CPU register
        DCL         Decrement memory pointer to the low portion of the
        LME         User pgm buffer line pointer (regular pointer) and set it
        DCL         With the value from the AUX line pntr, decrement the
        LMD         Pointer and do the same for the page portion
        LLI 205     Set L to address of FOR/NEXT STACK pointer
        LHI 027     ** Set H to page of FOR/NEXT STACK pointer
        LBM         Fetch and decrement the
        DCB         FOR/NEXT STACK pointer value
        LMB         To perform effective popping operation
        JMP NXTLIN  Statement line after NEXT statement is done next

NEXT11, NDA         When F/N STEP is negative, reverse test so that if the
        JFS NEXT12  Variable value is greater than or equal to the F/N LIMIT
        JMP NEXT10  The FOR/NEXT loop continues. Else it is finished.

NEXT12, LLI 314     Load L with address of F/N TEMP storage registers
        LHI 001     ** Set H to F/N TEMP storage registers page
        CAL FLOAD   Transfer the updated variable value to the FPACC
        CAL RESTSY  Restore the variable name and value
        CAL STOSYM  In the VARIABLES table. Exit routine so that
        JMP NXTLIN  Statement line after FOR statement is done next
```

## THE OPTIONAL DIM STATEMENT ROUTINE

The DIM statement routine is an optional statement routine that may be included in SCELBAL depending on whether the user desires to utilize its capabilities and sacrifice the memory space that it and routines associated with it utilize.

The purpose of the DIM statement routine is to allow the defining of single character ARRAY VARIABLES and to reserve space in an ARRAY VALUES TABLE for the specified number of entries that the array will occupy.

The DIM statement capability in SCELBAL is restricted to single dimension arrays. To conserve memory space, the DIM routine to be presented restricts the total amount of memory used to store the values at points in an array to 256 bytes (one page). The storage of floating point numbers in the format used in SCELBAL requires four bytes of memory to store a value. Thus, the total number of array points that may be set aside in one program is 256 divided by 4 or 64 (decimal).

To keep the DIM capability in line with the storage space allotted for array values, the number of arrays that may be created in a program is restricted to four. However, regardless of whether one, two, three or four array variables are defined, the total number of array subscripts for all the variables must not exceed 64 because of the limitation discussed in the previous paragraph.

Thus, one could DIMension a single array to have 64 locations. One could specify two arrays, each using 32 entries. One could create four array variables and DIMension 16 locations for each. Or, any other combination may be specified as long as the total number of array variable names does not exceed four, and the total number of subscripted array points does not exceed 64!

The reader must remember that an array variable name may only consist of one letter followed by a subscript. Thus, a four element array having the symbolic variable name A would consist of the elements:

A(1)
A(2)
A(3)
A(4)

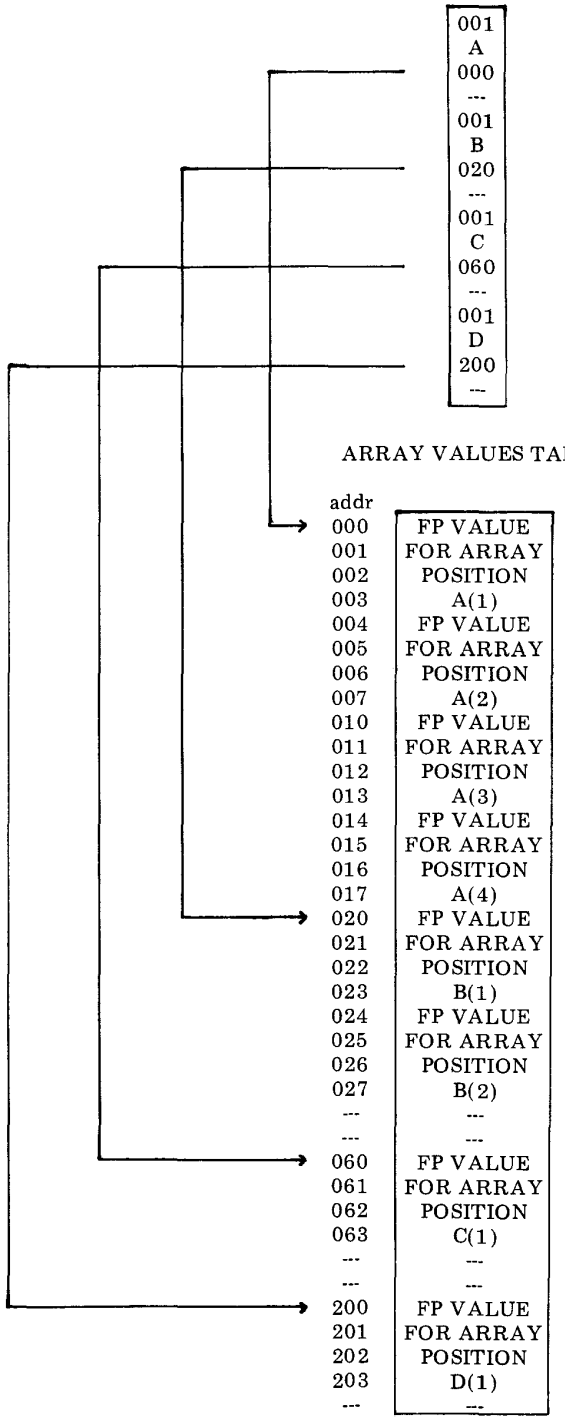
Since the above array would need to have four locations reserved for it in the ARRAY VALUES TABLE, the DIMension statement for it would appear as:

DIM A(4)

The reader must note too, that the array size in a DIMension statement must always be given in the form of an integer value (less than or equal to 64) and may not be another variable.

Associated with the ARRAY VALUES TABLE is another table called the ARRAY VARIABLES TABLE. This short table, having room for a maximum of four entries, contains the array name(s) and the starting location(s) in the ARRAY VALUES TABLE for the first array value associated with an array name. The ARRAY VARIABLES TABLE reserves four bytes for each array specified in a program. Two are used to store the array name. (This is done using string format, thus the first byte will always be 001 to indicate a one byte character string and the second byte will be the alphabetical character designated as the name of the array.) The third byte in an ARRAY VARIABLES TABLE entry is used to store the starting location for the first element in the associated ARRAY VALUES TABLE. The fourth byte is reserved for possible use by the user who might desire to modify and expand the array capability of SCELBAL. It could be used to store the page address value in the ARRAY VALUES TABLE if that table crossed page boundaries.

ARRAY VARIABLES TABLE




The ARRAY VARIABLES TABLE holds the array variable names and points to the starting location for each series of subscripted array entries associated with an array name. In this example the array named A has had room for four entries reserved for it. The array named B has had eight value locations reserved. C has 16 and D has 32.

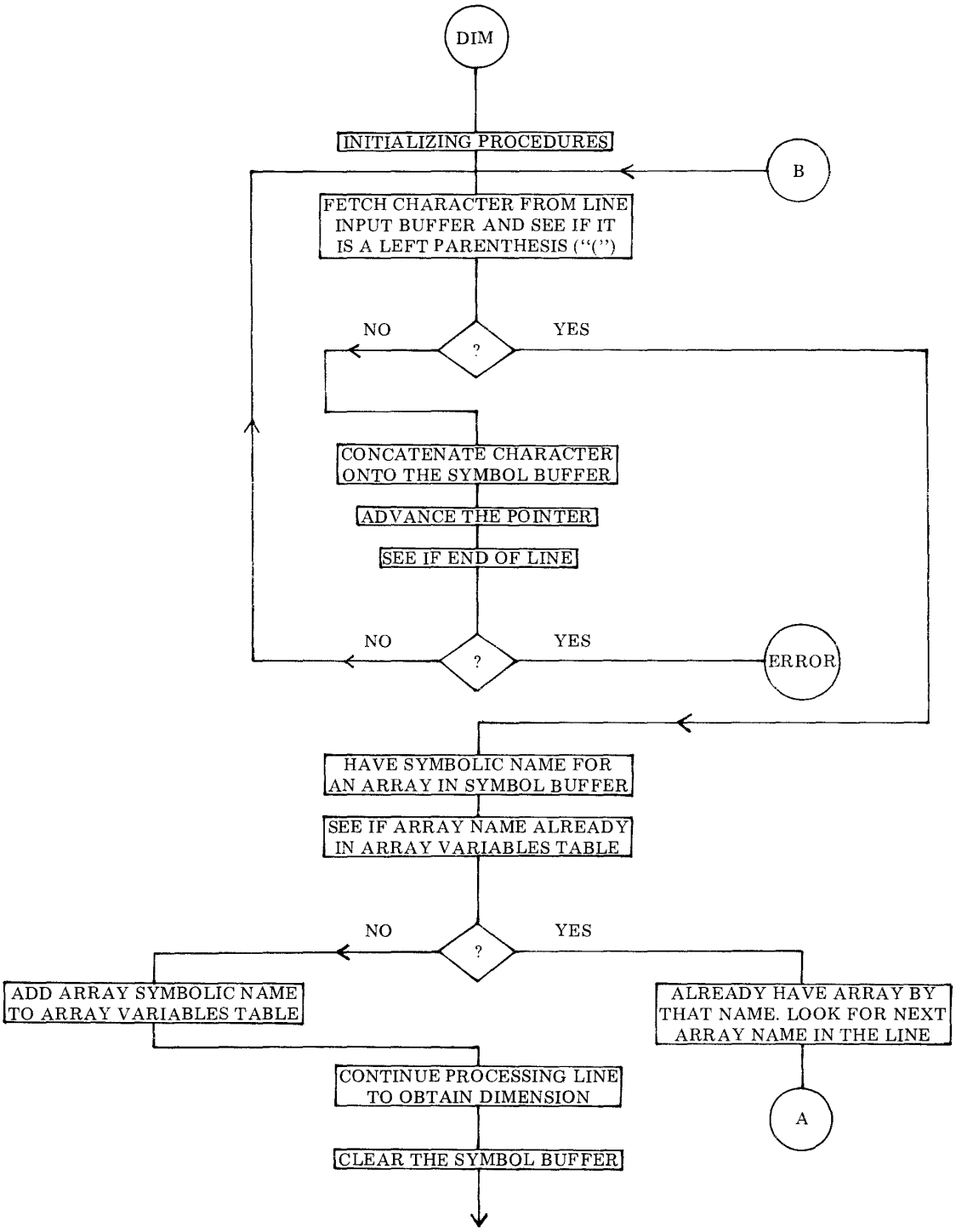
The ARRAY VALUES TABLE is used to hold the numerical value for each position in the array. Numerical values are stored in floating point format and require four bytes each. Note that the starting address for each series of values associated with an array name is that address pointed to in the ARRAY VARIABLES TABLE. The address for a particular point in an array is calculated as a function of the subscript specified.

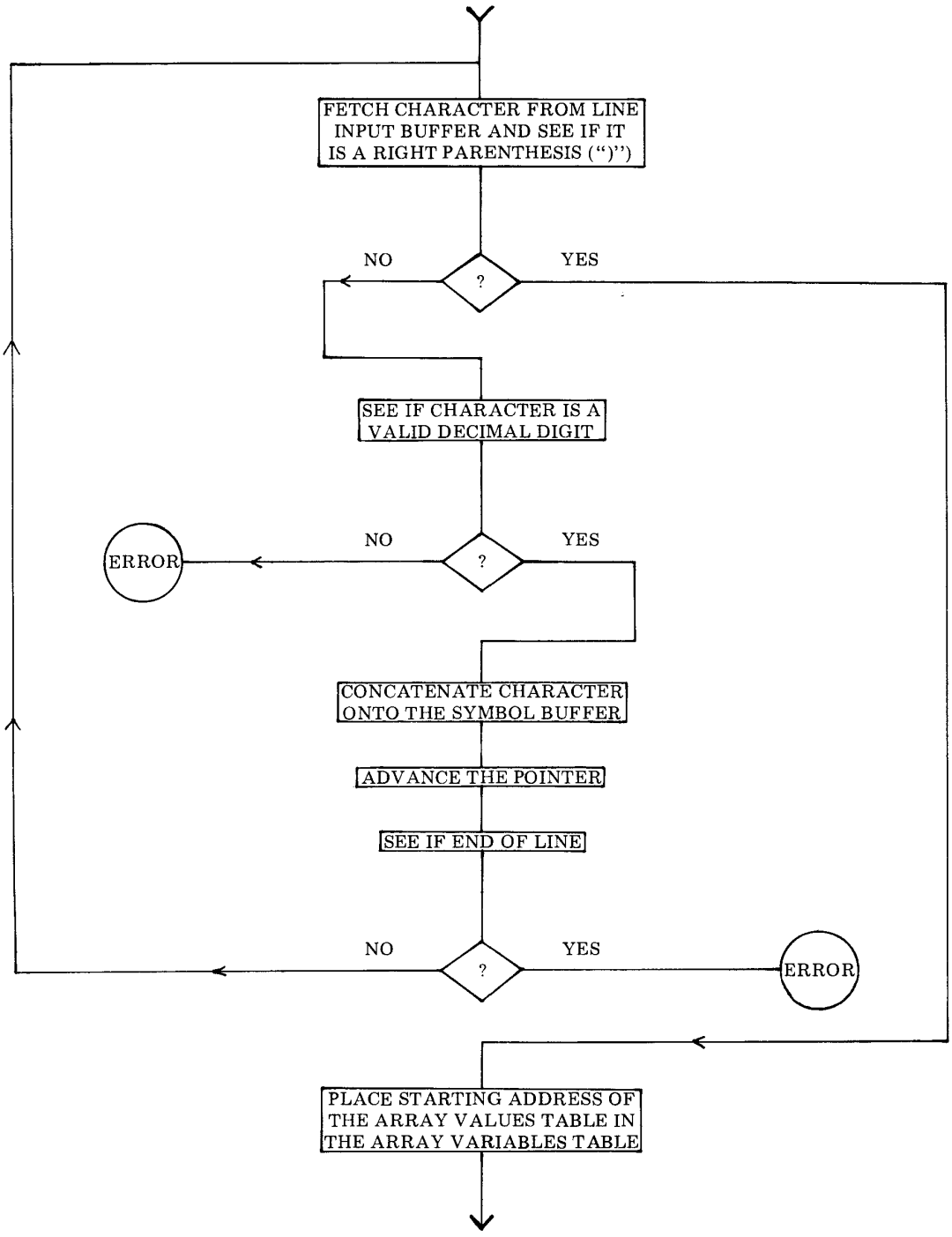
The relationship between the ARRAY VARIABLES TABLE and the ARRAY VALUES TABLE may be seen a little more clearly by examining the pictorial illustration presented on the preceeding page.

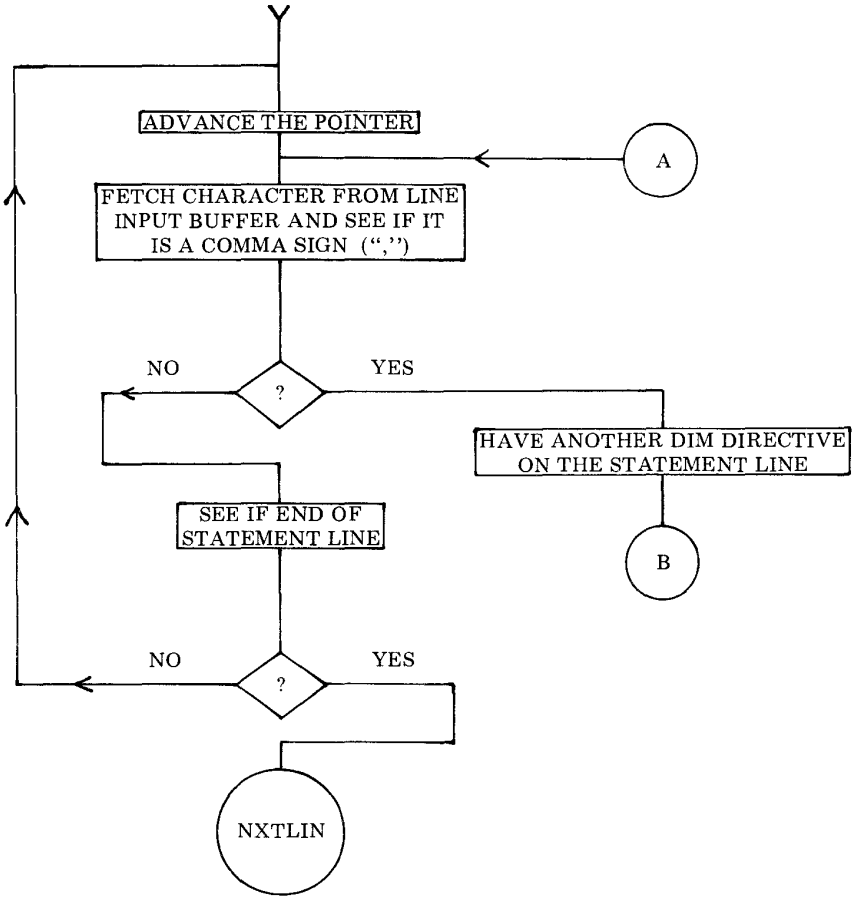
The flow chart on the next several pages summarizes the operation of the DIM routine as just discussed. The commented source listing for the routine starts below.

Remember, this routine is an optional routine. If array capability is not desired this routine may be left out of SCELBAL (along with related routines which will be presented later). If the routine is not incorporated in the reader's individual version of SCELBAL the various locations throughout the program identified by an @@ mark should be changed to effective no-operation instructions (such as LAA) as previously explained.

```
DIM,   CAL CLESYM   Initialize the SYMBOL BUFFER to cleared condition
       LLI 202      Load L with address of SCAN pointer
       LBM          Fetch SCAN pointer value into register B
       INB          Add one to the SCAN pointer value
       LLI 203      Change L to DIM pointer (formerly TOKEN) storage
       LMB          Store the updated SCAN pointer as the DIM pointer

DIM1,  LLI 203      Load L with the address of DIM pointer storage location
       CAL GETCHR   Fetch a character from the line input buffer
       JTZ DIM2     If character fetched is a space, ignore it
       CPI 250      Else see if character is "(" left parenthesis
       JTZ DIM3     If so, should have ARRAY VARIABLE name in buffer
       CAL CONCTS   If not, append the character to the SYMBOL BUFFER

DIM2,  LLI 203      Load L with the address of DIM pointer storage location
       CAL LOOP     Increment the pointer and see if end of line
       JFZ DIM1     If not end of line, fetch next character
       JMP DIMERR   Else have a DIMension error condition

DIM3,  LLI 206      Load L with address of ARRAY pointer storage loc
       LMI 000      Initialize ARRAY pointer to starting value of zero

DIM4,  LLI 206      Load L with address of ARRAY pointer storage loc
       LHI 026      ** Set H to page of ARRAY pointer storage location
       LAM          Fetch value in ARRAY pointer to ACC (effectively
       RLC          Represents number of arrays defined in pgm). Rotate
       RLC          Left twice to multiply by four (number of bytes per
       ADI 114      entry in ARRAY VARIABLES table). Add to base
       LHI 027      ** Address to form pointer to ARRAY VARIABLES
       LLA          Table and set up H & L as the memory pointer.
       LEI 120      Load E with starting address of the SYMBOL BUFFER
       LDI 026      ** Load D with the page address of the SYMBOL BUFF
       CAL STRCP    Compare contents of SYMBOL BF to entry in ARRAY
       JTZ DIM9     VARIABLES table. If same, have duplicate array name.
       LLI 206      Else, load L with address of ARRAY pointer storage
       LHI 026      ** Load H with page of ARRAY pointer storage
       LBM          Fetch the ARRAY pointer value to register B
```


DIM
INITIALIZING PROCEDURES
B
FETCH CHARACTER FROM LINE INPUT BUFFER AND SEE IF IT IS A LEFT PARENTHESIS ("(")
NO
?
YES
CONCATENATE CHARACTER ONTO THE SYMBOL BUFFER
ADVANCE THE POINTER
SEE IF END OF LINE
NO
?
YES
ERROR
HAVE SYMBOLIC NAME FOR AN ARRAY IN SYMBOL BUFFER
SEE IF ARRAY NAME ALREADY IN ARRAY VARIABLES TABLE
NO
?
YES
ADD ARRAY SYMBOLIC NAME TO ARRAY VARIABLES TABLE
ALREADY HAVE ARRAY BY THAT NAME. LOOK FOR NEXT ARRAY NAME IN THE LINE
CONTINUE PROCESSING LINE TO OBTAIN DIMENSION
A
CLEAR THE SYMBOL BUFFER


FETCH CHARACTER FROM LINE INPUT BUFFER AND SEE IF IT IS A RIGHT PARENTHESIS (")")
NO
?
YES
SEE IF CHARACTER IS A VALID DECIMAL DIGIT
ERROR
NO
?
YES
CONCATENATE CHARACTER ONTO THE SYMBOL BUFFER
ADVANCE THE POINTER
SEE IF END OF LINE
NO
?
YES
ERROR
PLACE STARTING ADDRESS OF THE ARRAY VALUES TABLE IN THE ARRAY VARIABLES TABLE




| | |
|---|---|
| INB | Increment the value |
| LMB | Restore it to ARRAY pointer storage location |
| LLI 075 | Change L to number of arrays storage location |
| LHI 027 | ** Set H to page of the number of arrays storage loc |
| LAM | Fetch the number of arrays value to the ACC |
| DCB | Restore B to previous count |
| CPB | Compare number of arrays tested against nr defined |
| JFZ DIM4 | If not equal, continue searching ARRAY VARIABLES |
| LLI 075 | Table. When table searched with no match, then must |
| LHI 027 | ** Append name to table. First set pointer to number |
| LBM | Of arrays storage location. Fetch that value and |
| INB | Add one to account for new name being added. |
| LMB | Restore the updated value back to memory. |
| LLI 076 | Change pointer to ARRAY TEMP pointer storage |
| LMB | Store pointer to current array in ARRAY TEMP too. |
| LLI 206 | Load L with address of ARRAY pointer storage loc. |
| LHI 026 | ** Set H to page of ARRAY pointer storage location |
| LMB | And update it also for new array being added. |

```
        LAM         Fetch the current ARRAY pointer value to the ACC
        RLC         Multiply it times four by performing two rotate left
        RLC         Operations and add it to base value to form address in
        ADI 114     The ARRAY VARIABLES table. Place the low part
        LEA         Of this calculated address value into register E.
        LDI 027     ** Set register D to the page of the table.
        LLI 120     Load L with the start of the SYMBOL BUFFER
        LHI 026     ** Load H with the page of the SYMBOL BUFFER
        CAL MOVEC   Move the array name from the SYMBOL BUFFER to
        CAL CLESYM  The ARRAY VARIABLES table. Then clear the
        LLI 203     SYMBOL BUFFER. Reset L to the DIM pointer storage
        LHI 026     ** Location. Set H to the DIM pointer page.
        LBM         Fetch the pointer value (points to "(" part of DIM
        INB         Statement). Increment the pointer to next character in
        LLI 204     The line input buffer. Change L to DIMEN pointer.
        LMB         Store the updated DIM pointer in DIMEN storage loc.

DIM5,   LLI 204     Set L to DIMEN pointer storage location
        CAL GETCHR  Fetch character in line input buffer
        JTZ DIM6    Ignore character for space
        CPI 251     If not space, see if character is right parenthesis (")").
        JTZ DIM7    If yes, process DIMension size (array length)
        CPI 260     If not, see if character is a valid decimal number
        JTS DIMERR  If not valid number, have DIMension error condition
        CPI 272     Continue testing for valid decimal number
        JFS DIMERR  If not valid number, then DIMension error condition
        CAL CONCTS  If valid decimal number, append digit to SYMBOL BF

DIM6,   LLI 204     Set L to DIMEN pointer storage location
        CAL LOOP    Advance the pointer value and check for end of the line
        JFZ DIM5    If not end of line, continue fetching DIMension size
        JMP DIMERR  If end of line before right parenthesis, have error condx.

DIM7,   LLI 120     Load L with address of start of SYMBOL BUFFER
        LHI 026     ** Load H with page of SYMBOL BUFFER. (Now
        CAL DINPUT  Contains DIMension size.) Convert buffer to floating
        CAL FPFIX   Point number and then reformat to fixed point.
        LLI 124     Load L with address of LSW of fixed point number
        LAM         And fetch the low order byte of the nr into the ACC
        RLC         Rotate it left two times to multiply it by four (the
        RLC         Number of bytes required to store a floating point nr).
        LCA         Store this value in CPU register C temporarily.
        LLI 076     Set L to ARRAY TEMP storage location.
        LHI 027     ** Set H to ARRAY TEMP pointer page.
        LAM         Fetch the value in ARRAY TEMP (points to ARRAY
        SUI 001     VARIABLES table). Subtract one from the pointer
        RLC         Value and multiply the result by four using rotate left
        RLC         Instructions. Add this value to a base address
        ADI 122     (Augmented by two) to point to ARRAY VALUES
        LLA         Pointer storage location in the ARRAY VARIABLES
        LHI 027     ** Table and set the pointer up in registers H & L.
```

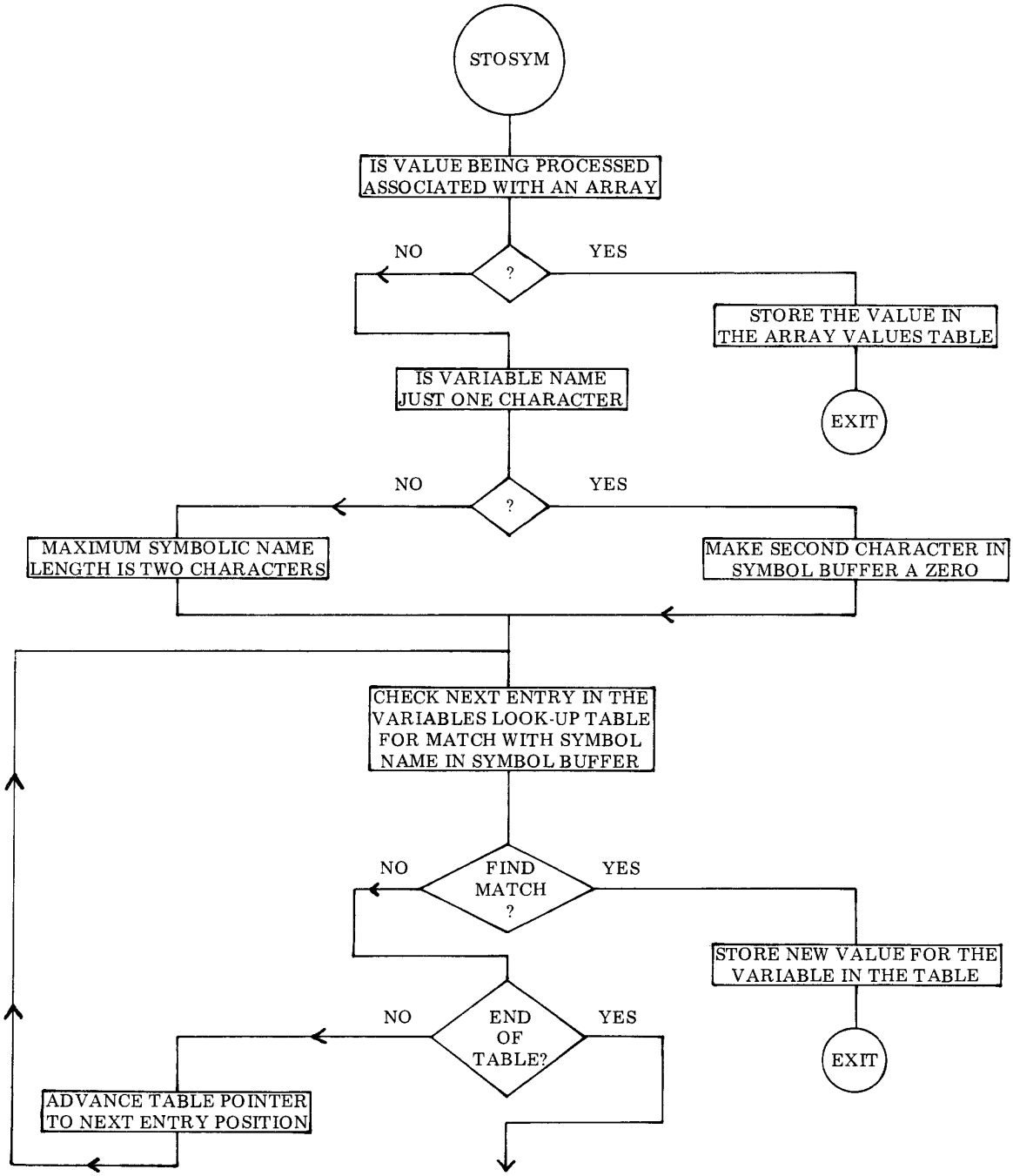
```
        LBM         Fetch the starting address in the ARRAY VALUES
        ADI 004     Table for the previous array into register B. Now add
        LLA         Four to the ARRAY VARIABLES table pointer to
        LAB         Point to current ARRAY VALUES starting address.
        ADC         Add the previous array starting address plus number of
        LMA         Bytes required and store as starting loc for next array

DIM8,   LLI 204     Set L to address of DIMEN pointer storage location
        LHI 026     ** Set H to page of DIMEN pointer
        LBM         Fetch pointer value (points to ")" in line)
        LLI 203     Change L to DIM pointer storage location
        LMB         Store former DIMEN value back in DIM pointer

DIM9,   LLI 203     Load L with address of DIM pointer storage location
        CAL GETCHR  Fetch a character from the line input buffer
        CPI 254     See if character is a comma (,) sign
        JTZ DIM10   If yes, have another array being defined on the line
        LLI 203     If not, reset L to the DIM pointer
        CAL LOOP    Increment the pointer and see if end of the line
        JFZ DIM9    If not end of the line, keep looking for a comma
        JMP NXTLIN  Else exit the DIM statement routine to continue pgm

DIM10,  LLI 203     Set L to DIM pointer storage location
        LBM         Fetch pointer value (points to comma sign just found)
        LLI 202     Load L with address of SCAN pointer storage location
        LMB         Place DIM pointer into the SCAN pointer
        JMP DIM     Continue processing DIM statement line for next array

DIMERR, LAI 304     On error condition, load ASCII code for letter D in ACC
        LCI 305     And ASCII code for letter E in CPU register C
        JMP ERROR   Go display the Dimension Error (DE) message.
```

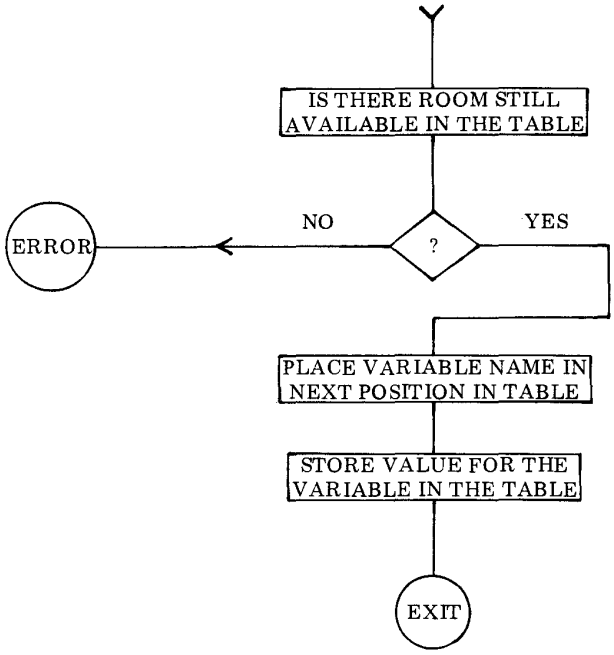
The final routine to be discussed in this chapter is used by several of the statement routines such as the LET and INPUT routines. This routine is used to store the name of a variable and its numerical value in a table called the VARIABLES LOOK-UP TABLE. (A portion of the routine is also used to handle the storing of values assigned to array variables (which are stored in a separate table) if the user elects to utilize the single DIMension array handling capability of SCELBAL. The array handling routines themselves are discussed in a later chapter.)

The VARIABLES LOOK-UP TABLE is organized to hold the variable names and the current values assigned to those names in the following format. The first two bytes of an entry are used to hold the one or two letter NAME for the variable. (If the variable name only consist of one letter, the second byte of the entry will be zero.) The next four bytes in an entry are used to store the current value of the variable in floating point format. (This format for storing mathematical values will be presented in a later chapter.) Thus, each entry in the table requires six bytes of storage. Sufficient room has been provided in the assembled version of SCELBAL presented in this book for storage of up to 20 variable names at one time during the execution of a higher level program.

The general operation of the routine is illustrated in the flow chart which starts below.

The source listing for the subroutine is presented following the flow chart.






```
STOSYM,  LLI 201      Load L with address of ARRAY FLAG
         LHI 027      ** Load H with page of ARRAY FLAG
         LAM          Fetch the value of the ARRAY FLAG into the ACC
         NDA          Check to see if the flag is set indicating processing an
         JTZ STOSY1   Array variable value. Jump ahead if flag not set.
         LMI 000      If ARRAY FLAG was set, clear it for next time.
         LLI 204      Then load L with address of array address storage loc
         LLM          Fetch the array storage address as new pointer
         LHI 057      †† Set H to ARRAY VALUES page
         JMP FSTORE   Store the array variable value and exit to caller.

STOSY1,  LLI 370      Load L with address of TEMP CNTR
         LHI 026      ** Load H with page of TEMP CNTR
         LMI 000      Initialize the TEMP CNTR by clearing it
         LLI 120      Load L with starting address of SYMBOL BUFFER
         LDI 027      ** Load D with page of VARIABLES LOOK-UP table
         LEI 210      Load E with starting addr of VARIABLES LOOK-UP
         LAM          Table. Fetch the (cc) for the SYMBOL BUFFER into
         CPI 001      The ACC and see if length of variable name is just one
         JFZ STOSY2   Character. If not, skip next couple of instructions.
         LLI 122      Else, set pointer to second character location in the
         LMI 000      SYMBOL BUFFER and set it to zero
```

```
STOSY2,  LLI 121      Load L with address of first character in the SYMBOL
         LHI 026      ** BUFFER. Load H with page of the buffer.
         CAL SWITCH   Exchange pointer to buffer for pointer to VARIABLES
         LAM          LOOK-UP table. Fetch first char in a name from the
         INL          Table. Advance the pointer to second char in a name.
         LBM          Fetch the second character into register B.
         INL          Advance the pointer to first byte of a value in the table.
         CAL SWITCH   Exchange table pointer for pointer to SYMBOL BUFF
         CPM          Compare first character in buffer against first character
         JFZ STOSY3   In table entry. If no match, try next entry in the table.
         INL          If match, advance pointer to second character in buffer.
         LAB          Move second character obtained from table into ACC.
         CPM          Compare second characters in table and buffer.
         JTZ STOSY5   If same, have found the variable name in the table.

STOSY3,  CAL AD4DE    Add four to pointer in registers D&E to skip over value
         LLI 370      Portion of entry in table. Load L with address of TEMP
         LHI 026      ** CNTR. Load H with page of TEMP CNTR.
         LBM          Fetch the counter
         INB          Increment the counter
         LMB          Restore it to storage
         LLI 077      Set L to address of VARIABLES CNTR (indicates
         LHI 027      ** Number of variables currently in table.) Set H too.
         LAB          Move the TEMP CNTR value into the ACC. (Number of
         CPM          Entries checked.) Compare with number of entries in
         JFZ STOSY2   The table. If have not checked all entries, try next one.
         LLI 077      If have checked all entries, load L with address of the
         LHI 027      ** VARIABLES CNTR. Set H too. Fetch the counter
         LBM          Value and increment it to account for
         INB          New variable name that will now be
         LMB          Added to the table. Save the new value.
         LAB          Place the new counter value into the accumulator
         CPI 025      And check to see that adding new variable name to the
         JFS BIGERR   Table will not cause table overflow. Big Error if it does!
         LLI 121      If room available in table, set L to address of first
         LHI 026      ** Character in the SYMBOL BUFFER. Set H too.
         LBI 002      Set a counter for number of characters to transfer.
         CAL MOVEIT   Move the variable name from buffer to table.

STOSY5,  CAL SWITCH   Exchange buffer pointer for table pointer.
         CAL FSTORE   Transfer new mathematical value into the table.
         JMP CLESYM   Clear the SYMBOL BUFFER and exit to calling routine.

                      The subroutines below are used by some of the routines
                      in this chapter as well as other parts of the program.

SAVESY,  LLI 120      Load L with the address of the start of the SYMBOL
         LHI 026      ** BUFFER. Load H with the page of the buffer.
         LDH          Load register D with the page of the AUX SYMBOL
         LEI 144      BUFFER and set register E to start of that buffer.
         JMP MOVECP   Transfer SYMBOL BF contents to AUX SYMBOL BF
```

```
RESTSY,  LLI 144      Load L with address of start of AUX SYMBOL BUFF
         LHI 026      ** Load H with page of AUX SYMBOL BUFFER
         LDH          Set D to page of SYMBOL BUFFER (same as H)
         LEI 120      Load E with start of SYMBOL BUFFER

MOVECP,  LBM          Load (cc) for source string (first byte in source buffer)
         INB          Add one to (cc) to include (cc) byte itself
         JMP MOVEIT   Move the source string to destination buffer
```

# EVALUATING MATHEMATICAL EXPRESSIONS

This and the next several chapters will present the routines associated with EVALUATING mathematical expressions. While it will take a considerable number of pages of text to present the details and source listings of the routines, the essential concepts of this process remain quite simple and straightforward.

The reader who has studied the preceeding chapter may recall that when a portion of a statement line contained a mathematical expression that needed to be evaluated, the routine would set up pointers to the starting and ending characters of the expression and then call a subroutine labeled EVAL. The EVAL routine, which is presented in this chapter, is able to process the string of characters making up a mathematical expression. In doing so, it calls on several other subroutines that will have separate chapters devoted to their details. However, the EVAL routine is the primary expression processing routine that ties the supportive subroutines for this process together.

Mathematical expressions that are to be evaluated by SCELBAL are assumed to consist of strings of characters that represent symbols joined by operators. Symbols in this context mean either actual numerical values such as 123.456 or 995 or 1.14159E+15; or they may be characters representing a variable name such as X. Operators are mathematical operating signs such as "+" (addition), "-" (subtraction or minus), "*" (multiplication), "/" (division), " ↑ " (exponentiation), and such signs as "=" (equal), "<" (less than) and " > " (greater than). Two special operator signs are the right and left parenthesis "()" which may be used to group or nest portions of mathematical expressions, denote the argument part of a function, or be used to indicate a subscripted variable.

A typical mathematical expression that might appear in a SCELBAL program is illustrated here:

```
X ↑ 2 + 4 * X - 16
```

In this expression, X is a symbol (name of a variable) as are 2, 4 and 16 (actual numerical values). Four mathematical operators are used in the above expression, ↑, *, + and - in that order.

The process of evaluating an expression to obtain a mathematical (numerical) value consists of scanning the expression to break it up into symbols and operators, and then performing the required operations in the proper order. The requirement of performing the operations IN THE PROPER ORDER is essential. The proper evaluation of mathematical expressions requires the following of precise rules for performing certain operations. For instance, the example expression just presented is meant to be read as, and evaluated in the following fashion.

"Raise the value represented by X to the second power. To this quantity add four times the quantity X. From this new total subtract the value 16."

A person who did not know the order in which operations were to be performed according to custom, or a computer that was not instructed otherwise, might just as easily interpret the example expression to mean.

"Raise X to the power of 2 plus four times X minus 16."

The order in which to perform various types of operations is defined by establishing a heirarchy for the various types of mathematical operators. The portion of SCELBAL that establishes the heirarchy and actually determines when various mathematical operations are to be performed has been given the label PARSER in accordance with the task it performs. This routine will be discussed and described in detail in the next chapter.

The EVALuating routine presented in this

chapter essentially serves to perform the following tasks. It breaks the mathematical expression being processed up into component parts consisting of symbols (whether a variable name or a numerical value) and mathematical operators. Characters making up a symbol are stored in the SYMBOL BUFFER. Whenever a mathematical operator is detected, a TOKEN VALUE is assigned to represent the operator similar to the manner in which a token value was assigned when the SYNTAX subroutine identified a STATEMENT KEYWORD. This TOKEN VALUE assigned for the mathematical operator is passed on to another subroutine called the PARSER (to be described in the next chapter) which will either store the symbol and operator for future use or perform the indicated operations depending on the precedence of the operator being processed. This process of obtaining symbols and operators continues until the entire expression has been scanned.

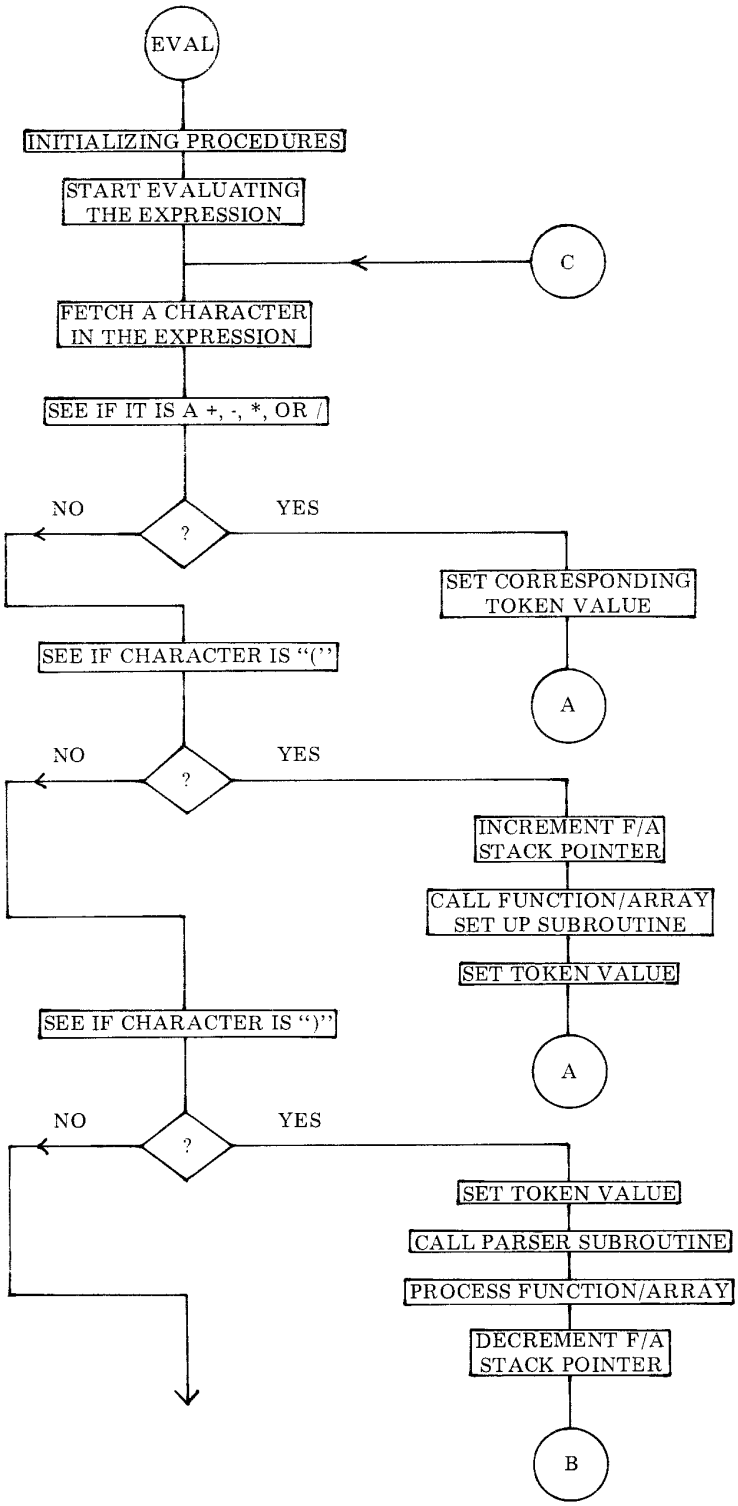
For reference purposes, a list of the TOKEN VALUES assigned to the various mathematical operators is presented below. Note that the first part of the table assigns a TOKEN VALUE to single operators. The latter part of the table assigns values to some special combinations of operators which may occur in IF statements. Later chapters will illustrate how these TOKEN VALUES are used to direct the operations of other SCELBAL expression handling routines.

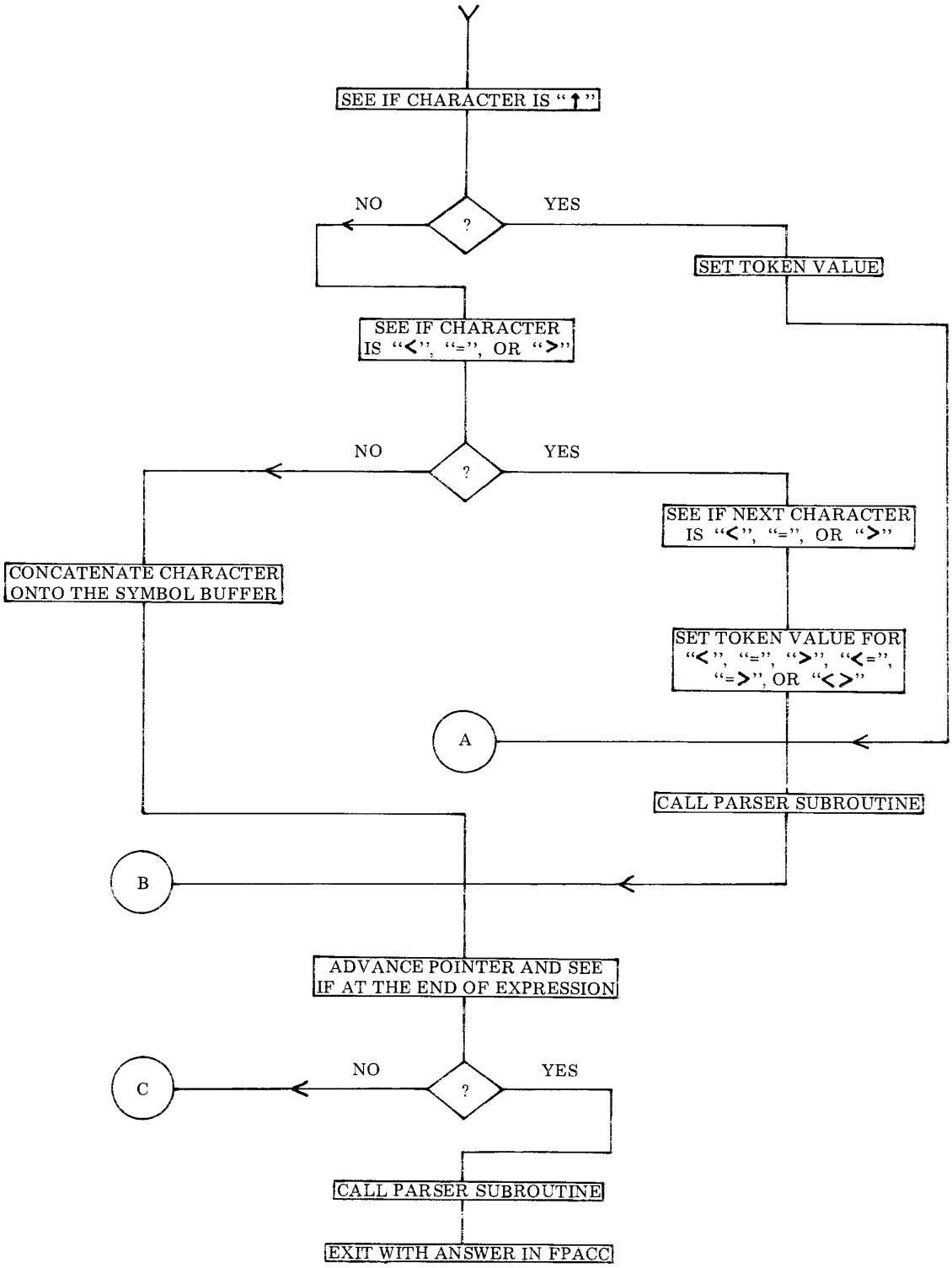
| OPERATOR | TOKEN VALUE |
|---|---|
| EOS | 000 |
| + | 001 |
| - | 002 |
| * | 003 |
| / | 004 |
| ↑ | 005 |
| ( | 006 |
| ) | 007 |
| < | 011 |
| = | 012 |
| > | 013 |
| <= | 014 |
| => | 015 |
| <> | 016 |

The presence of a parenthesis in a mathematical expression requires special consideration. As will be detailed in following chapters, a parenthesis may indicate grouping of terms, or the argument portion of a function, or the subscripted part of an array variable. When a parenthesis is detected by the EVAL subroutine, it will call on appropriate subroutines to determine what action is to be taken as a function of where the parenthesis occurs in an expression.

The overall operation of the EVAL routine is summarized in the flow chart shown on the next several pages. The source listing starts below.

```
EVAL,   LLI 227     Load L with address of ARITHMETIC STACK pointer
        LHI 001     ** Set H to page of ARITHMETIC STACK pointer
        LMI 224     Initialize ARITH STACK pointer value to addr minus 4
        INL         Advance memory pointer to FUN/ARRAY STACK pntr
        LHI 026     ** Set H to page of FUN/ARRAY STACK pointer
        LMI 000     Initialize FUN/ARRAY STACK pointer to start of stack
        CAL CLESYM  Initialize the SYMBOL BUFFER to empty condition
        LLI 210     Load L with address of OPERATOR STACK pointer
        LMI 000     Initialize OPERATOR STACK pointer value
        LLI 276     Set L to address of EVAL pointer (start of expression)
        LBM         Fetch the EVAL pointer value into register B
        LLI 200     Set up a working pointer register in this location
        LMB         And initialize EVAL CURRENT pointer
```


EVAL
INITIALIZING PROCEDURES
START EVALUATING THE EXPRESSION
C
FETCH A CHARACTER IN THE EXPRESSION
SEE IF IT IS A +, -, *, OR /
NO
?
YES
SET CORRESPONDING TOKEN VALUE
A
SEE IF CHARACTER IS "("
NO
?
YES
INCREMENT F/A STACK POINTER
CALL FUNCTION/ARRAY SET UP SUBROUTINE
SET TOKEN VALUE
A
SEE IF CHARACTER IS ")"
NO
?
YES
SET TOKEN VALUE
CALL PARSER SUBROUTINE
PROCESS FUNCTION/ARRAY
DECREMENT F/A STACK POINTER
B


SEE IF CHARACTER IS "↑"
NO
?
YES
SET TOKEN VALUE
SEE IF CHARACTER IS "<", "=", OR ">"
NO
?
YES
SEE IF NEXT CHARACTER IS "<", "=", OR ">"
CONCATENATE CHARACTER ONTO THE SYMBOL BUFFER
SET TOKEN VALUE FOR "<", "=", ">", "<=", "=>", OR "<>"
A
CALL PARSER SUBROUTINE
B
ADVANCE POINTER AND SEE IF AT THE END OF EXPRESSION
C
NO
?
YES
CALL PARSER SUBROUTINE
EXIT WITH ANSWER IN FPACC

```
SCAN1,  LLI 200      Load L with address of EVAL CURRENT pointer
        CAL GETCHR   Fetch a character in the expression being evaluated
        JTZ SCAN10   If character is a space, jump out of this section
        CPI 253      See if character is a "+" sign
        JFZ SCAN2    If not, continue checking for an operator
        LLI 176      If yes, set pointer to PARSER TOKEN storage location
        LMI 001      Place TOKEN value for "+" sign in PARSER TOKEN
        JMP SCANFN   Go to PARSER subroutine entry point

SCAN2,  CPI 255      See if character is a minus ("-") sign
        JFZ SCAN4    If not, continue checking for an operator
        LLI 120      If yes, check the length of the symbol stored in the
        LAM          SYMBOL BUFFER by fetching the (cc) byte
        NDA          And testing to see if (cc) is zero
        JFZ SCAN3    If length not zero, then not a unary minus indicator
        LLI 176      Else, check to see if last operator was a right parenthesis
        LAM          By fetching the value in the PARSER TOKEN storage
        CPI 007      Location and seeing if it is token value for ")"
        JTZ SCAN3    If last operator was ")" then do not have a unary minus
        CPI 003      Check to see if last operator was "*"
        JTZ SYNERR   If yes, then have a syntax error
        CPI 005      Check to see if last operator was exponentiation
        JTZ SYNERR   If yes, then have a syntax error
        LLI 120      If none of the above, then minus sign is unary, put
        LMI 001      Character string representing the
        INL          Value zero in the SYMBOL BUFFER in string format
        LMI 260      (Character count (cc) followed by ASCII code for zero)

SCAN3,  LLI 176      Set L to address of PARSER TOKEN storage location
        LMI 002      Set PARSER TOKEN value for minus operator

SCANFN, CAL PARSER   Call the PARSER subroutine to process current symbol
        JMP SCAN10   And operator. Then jump to continue processing.

SCAN4,  CPI 252      See if character fetched from expression is "*"
        JFZ SCAN5    If not, continue checking for an operator
        LLI 176      If yes, set pointer to PARSER TOKEN storage location
        LMI 003      Place TOKEN value for "*" (multiplication) operator in
        JMP SCANFN   PARSER TOKEN and go to PARSER subroutine entry

SCAN5,  CPI 257      See if character fetched from expression is "/"
        JFZ SCAN6    If not, continue checking for an operator
        LLI 176      If yes, set pointer to PARSER TOKEN storage location
        LMI 004      Place TOKEN value for "/" (division) operator in
        JMP SCANFN   PARSER TOKEN and go to PARSER subroutine entry

SCAN6,  CPI 250      See if character fetched from expression is "("
        JFZ SCAN7    If not, continue checking for an operator
        LLI 230      If yes, load L with address of FUN/ARRAY STACK
        LBM          Pointer. Fetch the value in the stack pointer. Increment
        INB          It to indicate number of "(" operators encountered.
```

```
        LMB         Restore the updated stack pointer back to memory
        CAL FUNARR  Call subroutine to process possible FUNCTION or
        LLI 176     ARRAY variable subscript. Then set pointer to
        LMI 006     PARSER TOKEN storage and set value for "(" operator
        JMP SCANFN  Go to PARSER subroutine entry point.

SCAN7,  CPI 251     See if character fetched from expression is ")"
        JFZ SCAN8   If not, continue checking for an operator
        LLI 176     If yes, load L with address of PARSER TOKEN
        LMI 007     Set PARSER TOKEN value to reflect ")"
        CAL PARSER  Call the PARSER subroutine to process current symbol
        CAL PRIGHT  Call subroutine to handle FUNCTION or ARRAY
        LLI 230     Load L with address of FUN/ARRAY STACK pointer
        LHI 026     ** Set H to page of FUN/ARRAY STACK pointer
        LBM         Fetch the value in the stack pointer. Decrement it
        DCB         To account for left parenthesis just processed.
        LMB         Restore the updated value back to memory.
        JMP SCAN10  Jump to continue processing expression.

SCAN8,  CPI 336     See if character fetched from expression is "↑"
        JFZ SCAN9   If not, continue checking for an operator
        LLI 176     If yes, load L with address of PARSER TOKEN
        LMI 005     Put in value for exponentiation
        JMP SCANFN  Go to PARSER subroutine entry point.

SCAN9,  CPI 274     See if character fetched is the "less than" sign
        JFZ SCAN11  If not, continue checking for an operator
        LLI 200     If yes, set L to the EVAL CURRENT pointer
        LBM         Fetch the pointer
        INB         Increment it to point to the next character
        LMB         Restore the updated pointer value
        CAL GETCHR  Fetch the next character in the expression
        CPI 275     Is the character the "=" sign?
        JTZ SCAN13  If so, have "less than or equal" combination
        CPI 276     Is the character the "greater than" sign?
        JTZ SCAN15  If so, have "less than or greater than" combination
        LLI 200     Else character is not part of the operator. Set L back
        LBM         To the EVAL CURRENT pointer. Fetch the pointer
        DCB         Value and decrement it back one character in the
        LMB         Expression. Restore the original pointer value.
        LLI 176     Have just the "less than" operator. Set L to the
        LMI 011     PARSER TOKEN storage location and set the value for
        JMP SCANFN  The "less than" sign then go to PARSER entry point.

SCAN11, CPI 275     See if character fetched is the "=" sign
        JFZ SCAN12  If not, continue checking for an operator
        LLI 200     If yes, set L to the EVAL CURRENT pointer
        LBM         Fetch the pointer
        INB         Increment it to point to the next character
        LMB         Restore the updated pointer value
        CAL GETCHR  Fetch the next character in the expression
```

```
        CPI 274     Is the character the "less than" sign?
        JTZ SCAN13  If so, have "less than or equal" combination
        CPI 276     Is the character the "greater than" sign?
        JTZ SCAN14  If so, have "equal or greater than" combination
        LLI 200     Else character is not part of the operator. Set L back
        LBM         To the EVAL CURRENT pointer. Fetch the pointer
        DCB         Value and decrement it back one character in the
        LMB         Expression. Restore the original pointer value.
        LLI 176     Just have "=" operator. Set L to the PARSER TOKEN
        LMI 012     Storage location and set the value for the "=" sign.
        JMP SCANFN  Go to the PARSER entry point.

SCAN12, CPI 276     See if character fetched is the "greater than" sign
        JFZ SCAN16  If not, go append the character to the SYMBOL BUFF
        LLI 200     If so, set L to the EVAL CURRENT pointer
        LBM         Fetch the pointer
        INB         Increment it to point to the next character
        LMB         Restore the updated pointer value
        CAL GETCHR  Fetch the next character in the expression
        CPI 274     Is the character the "less than" sign?
        JTZ SCAN15  If so, have "less than or greater than" combination
        CPI 275     Is the character the "=" sign?
        JTZ SCAN14  If so, have the "equal to or greater than" combination
        LLI 200     Else character is not part of the operator. Set L back
        LBM         To the EVAL CURRENT pointer. Fetch the pointer
        DCB         Value and decrement it back one character in the
        LMB         Expression. Restore the original pointer value.
        LLI 176     Have just the "greater than" operator. Set L to the
        LMI 013     PARSER TOKEN storage location and set the value for
        JMP SCANFN  The "greater than" sign then go to PARSER entry

SCAN13, LLI 176     When have "less than or equal" combination set L to
        LMI 014     PARSER TOKEN storage location and set the value.
        JMP SCANFN  Then go to the PARSER entry point.

SCAN14, LLI 176     When have "equal to or greater than" combination set L
        LMI 015     To PARSER TOKEN storage location and set the value.
        JMP SCANFN  Then go to the PARSER entry point.

SCAN15, LLI 176     When have "less than or greater than" combination set
        LMI 016     L to PARSER TOKEN storage location and set value.
        JMP SCANFN  Then go to the PARSER entry point.

SCAN16, CAL CONCTS  Concatenate the character to the SYMBOL BUFFER

SCAN10, LLI 200     Set L to the EVAL CURRENT pointer storage location
        LHI 026     ** Set H to page of EVAL CURRENT pointer
        LBM         Fetch the EVAL CURRENT pointer value into B
        INB         Increment the pointer value to point to next character
        LMB         In the expression and restore the updated value.
        LLI 277     Set L to EVAL FINISH storage location.
```

```
        LAM         Fetch the EVAL FINISH value into the accumulator.
        DCB         Set B to last character processed in the expression.
        CPB         See if last character was at EVAL FINISH location.
        JFZ SCAN1   If not, continue processing the expression. Else, jump
        JMP PARSEP  To final evaluation procedure and test. (Directs routine
        HLT         To a dislocated section.) Safety Halt in unused byte.

PARSEP, LLI 176     Load L with PARSER TOKEN storage location. Set
        LMI 000     The value indicating end of expression. Call the
        CAL PARSER  PARSER subroutine for final time for the expression.
        LLI 227     Change L to point to the ARITH STACK pointer.
        LHI 001     ** Set H to the page of the ARITH STACK pointer.
        LAM         Fetch the ARITH STACK pointer value.
        CPI 230     Should indicate only one value (answer) in stack.
        RTZ         Exit with answer in FPACC if ARITH STACK is O.K.
        JMP SYNERR  Else have a syntax error!
```

# THE PARSER ROUTINE

The PARSER routine is a most important part of the mathematical expression evaluating process. The primary purpose of the routine is to arrange numbers and operators in an expression so that they may be performed in the proper order according to a set of rules. At appropriate times, the routine will call on other subroutines to perform mathematical operations.

The rules used to evaluate an expression are established according to standard mathematical practices by establishing a heirarchy among the various mathematical operators and following a consistant left to right pattern for evaluating expressions. In SCELBAL, the operating sign precedence is defined as follows.

Parenthesis, when used to enclose a group of operators and symbols (versus being used to separate the argument of a function or to indicate a subscripted variable), have the highest precedence. That is, whenever a right hand parenthesis is encountered, all of the operations signified by operators between it and the initiating left hand parenthesis, must be performed before any further processing is attempted.

Individual operators are assigned precedence according to the following heirarchy. Exponentiation has highest precedence. Next are the multiplication and division operators (having equal precedence to each other). Then comes the plus or minus operator. The lowest operator precedence is assigned to the equal, less than, or greater than operators (or combinations).

How do the rules of precedence enable the PARSER routine to correctly analyze mathematical expressions? They enable the program to determine whether to perform an operation between two symbols (numbers) joined by an operator, or whether to hold the values until more data is obtained! The process involves the use of stacking operations as will be explained now.

The reader may recall from the previous chapter that each time the PARSER subroutine is called by EVAL, the routine will have placed a symbol (either a variable name or a number) in the SYMBOL BUFFER (unless the end of the expression had been reached which is a special case). Additionally, an operator TOKEN VALUE will have been set up for use by the PARSER routine.

The contents of the SYMBOL BUFFER are converted to a number in floating point format (using subroutines that will be presented in a later chapter). This number (which will reside in a special set of registers called the FPACC ) will be considered as the topmost entry in an ARITHMETIC STACK for the purposes of the following discussion. The primary task of the PARSER is to obtain the precedence value of the operator currently being processed and determine whether or not an actual mathematical operation should be performed. This simple decision of whether or not to perform an operation is made by comparing the precedence of the current operator against any previous operator(s) it has received. If the precedence of the current operator is greater than the previous operator, then the operator is saved on an OPERATOR STACK. Remember, the numerical value of the symbol being processed has already been placed on the top of an ARITHMETIC STACK. Both of these stacks are configured as push-down, pop-up stacks (first in, last out). If the precedence of the operator just received is equal to or less than the previous operator (on the top of the OPERATOR STACK), then the operation indicated by the operator sign on the top of the OPERATOR STACK is performed between the two top-most numbers in the ARITHMETIC STACK. After this is done, the operator is removed from the OPERATOR STACK. The two values in the top of the ARITHMETIC STACK are replaced by the answer just obtained by per-

forming the operation. (It is important to note that the number in the top of the arithmetic stack operates on the number beneath it in the stack. For instance, for division the number in the top of the stack will be the divisor, the next number down will be the dividend. At the end of the operation, both the divisor and dividend will be removed from the arithmetic stack. The quotient obtained from the division process will be on the top of the arithmetic stack.) After cases where a precedence test results in an operation being performed, the precedence test is repeated against the next entry in the OPERATOR STACK (unless the stack is empty). Remember, since the operator for the operation just performed will be removed from the stack, any previous operator(s) stored in the stack will be popped-up to place a new operator in the top position. When a point is reached where the precedence fails (that is, the precedence of the current operator is greater than the sign at the top of the OPERATOR STACK), then the current operator sign is placed on the top of the stack. The routine then returns to the EVAL routine which will get the next symbol/operator pair!

The above explanation of the primary purpose of the PARSER routine may seem a bit complicated when first read. Indeed, the PARSER routine is perhaps the most complicated portion of SCELBAL. The actual operation of the major portion of the routine just described may be made somewhat clearer by following the evaluation of an example expression on a step-by-step basis.

Suppose the program is evaluating the mathematical expression:

X ↑ 2 + 4 * X - 16

When the EVAL routine (presented in the preceeding chapter) starts processing the expression from left to right it will first pick up the symbol X and the operator " ↑ " which it will pass to the PARSER routine. Since the expression is just starting to be processed, both the ARITHMETIC STACK and the OPERATOR STACK will be empty.

When the PARSER routine receives the symbol X it will determine that it is a variable name. It will call on a routine to ascertain the current value of X from a VARIABLES TABLE. This value will be placed (using floating point format) in the top of the ARITHMETIC STACK.

The TOKEN VALUE for the operator sign passed to the PARSER routine will be used to assign a precedence value to the operator using a precedence look-up table. The precedence of the operator will then be compared to the precedence of the operator currently at the top of the OPERATOR STACK. Since, at this point, the OPERATOR STACK will be empty, the current operator sign will be placed on the top of the OPERATOR STACK. Thus, at this point, the ARITHMETIC STACK and the OPERATOR STACK would have the following contents:

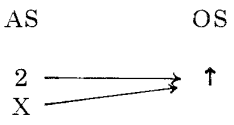
| AS | OS |
|---|---|
| X | ↑ |

(Remember, the value shown as being the top-most entry on the ARITHMETIC STACK in this discussion will actually be stored in the floating point accumulator (FPACC). This view simplifies the concept being explained.)

The PARSER routine at this point would return control back to the EVAL routine which would proceed to bring the next symbol and operator in the expression into appropriate buffers. For the example being presented this would mean the number 2 would be placed in the SYMBOL BUFFER. The token value for the operator "+" would be placed in the TOKEN VALUE register.

When the PARSER routine was again called upon, it would proceed to convert the number 2 into floating point format and store it as the top-most entry in the ARITHMETIC

STACK. The precedence for the "+" operator would be obtained and compared against that of the top-most entry in the OPERATOR STACK. At this point the two stacks would appear as:



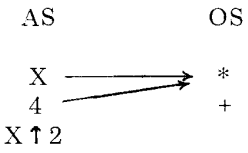

The precedence of the current operator (plus sign) would be lower than that of the exponentiation sign on the top of the OPERATOR STACK. At this point, the operation dictated by the operator in the top of the OPERATOR STACK is performed on the top two numbers in the ARITHMETIC STACK (as indicated by the arrows in the above diagram). At the completion of this operation, the numerical result of the operation will be stored on the top of the ARITHMETIC STACK in place of the two original values that were operated on. The OPERATOR STACK will now be empty because the operator is removed from the stack once the operation has been performed. Since there are no more operators on the stack to compare against, the current "+" operator will be placed on the top of the OPERATOR STACK. The two stacks will now appear as shown here:

| AS | OS |
|---|---|
| X↑2 | + |

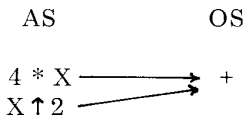
The program will then return back to the EVAL routine to obtain the next symbol and operator in the expression being processed. The next time the PARSER subroutine is entered the number 4 will be in the SYMBOL BUFFER and the token for the operator "*" (multiplication) will be in the TOKEN VALUE register. Since the precedence of the "*" sign is higher than the "+" sign on the top of the OPERATOR STACK, the new sign will be placed on the top of the stack. The two stacks will now contain:

| AS | OS |
|---|---|
| 4 | * |
| X↑2 | + |

The program will return back to the EVAL routine which will proceed to obtain the symbol X and the operator "-" from the expression. The value for X will be placed on the top of the ARITHMETIC STACK by the PARSER. The two stacks will now contain:




Since the minus sign operator obtained by the routine has a lower precedence than the multiplication sign in the top of the OPERATOR STACK, the multiplication operation is performed between the two top entries in the ARITHMETIC STACK as indicated in the above diagram. At the completion of this operation, the two stacks will contain:




At this point the current operator is compared with the sign which has just been popped-up to the top of the OPERATOR STACK. The current operator, being the minus sign, has the same precedence as the plus sign. This means the operation at the top of the operator stack must be performed. (Remember, if the precedence test results in the current operator being less

than OR EQUAL to the precedence of the operator in the top of the stack, that the operation is performed!) This operation is signified by the arrows in the diagram just presented. At the conclusion of this operation, the two stacks will hold:

| AS | OS |
|---|---|
| X↑2 + 4 * X | - |

Once again the program will return to the EVAL routine which will proceed to pick up the final symbol in the expression (16) and then find the end of the expression. When the end of the expression is found, a special token value of zero is set up in place of an operator sign. This special zero token value has a precedence lower than any operator. When the symbol value is placed on the ARITHMETIC STACK by the PARSER routine the two stacks will register:

| AS | OS |
|---|---|
| 16 ⟶ | - |
| X↑2 + 4 * X ↗ | |

Since the zero token value has a lower precedence than any operator, it means that any operators on the OPERATOR STACK will have to be performed to complete the evaluation of the expression. In the example there is only one operator left on the stack. This operation is performed. The OPERATOR STACK will then be empty. The ARITHMETIC STACK will contain the final value of the complete expression:

| AS | OS |
|---|---|
| X↑2 + 4 * X - 16 | empty |

The PARSER has performed its primary task!

In performing its primary task as just explained in detail, the PARSER routine has several subsections that perform related tasks. One such section is able to look-up the values of variable names in the VARIABLES TABLE and obtain the current value for the variable if the name is already present in the table. If it is not found in the table, the symbolic name is entered in the table and the initial value of zero is assigned to the variable.

Another subsection of the PARSER routine is a subsection that directs the program to perform specific mathematical operations when the PARSER has determined that they should be executed. This portion of the program uses the TOKEN VALUE assigned to the operator sign to determine which mathematical subroutines to call in order to execute the operation. The operation is performed using the top two entries in the ARITHMETIC STACK. Some of these operations, such as addition, subtraction, multiplication and division are performed by simply calling on appropriate parts of a floating point arithmetic package which is an integral part of SCELBAL. (This package is discussed in a separate chapter.)

However, a special group of operations involving the equal, less than, and greater than operators, are slightly more complex and are processed by individual routines that are presented as subsections in this chapter. These special operators have a very low precedence in the precedence heirarchy. These operators are used to actually perform comparison operations between the two top values in the ARITHMETIC STACK. If the comparison condition specified (such as less than, greater than etc., or combinations of these conditions) is found to be TRUE, then the result left in the ARITHMETIC STACK will be the value one. If the condition is not satisfied, the value zero will be left in the ARITHMETIC STACK. Thus, the PARSER is able to process conditional expressions such as those made in IF statements!

The handling of the unary minus sign by the EVAL and PARSER is a special case that should be understood by the reader. The unary minus sign is considered to be simply the case when a number is being negated (instead of subtracted). The EVAL and PARSER handle the unary minus sign by subtracting the value to be negated from zero. For instance, the evaluation of an expression such as:

A + -B

will actually be processed as:

A + (0 - B)

The reader may review the preceeding chapter to see that whenever the EVAL routine picks up a unary minus sign in an expression, it will load the SYMBOL BUFFER with the value zero so that the PARSER will perform the negation on the next symbol that is passed to it. Because of the method used to handle the unary minus case, expressions are prohibited from containing double operators such as:

A * -B or A ↑ -B

because they would be processed as:

A * 0 - B or A ↑ 0 - B

(A times zero minus B or A raised to the zero power, with B subtracted from the result.)

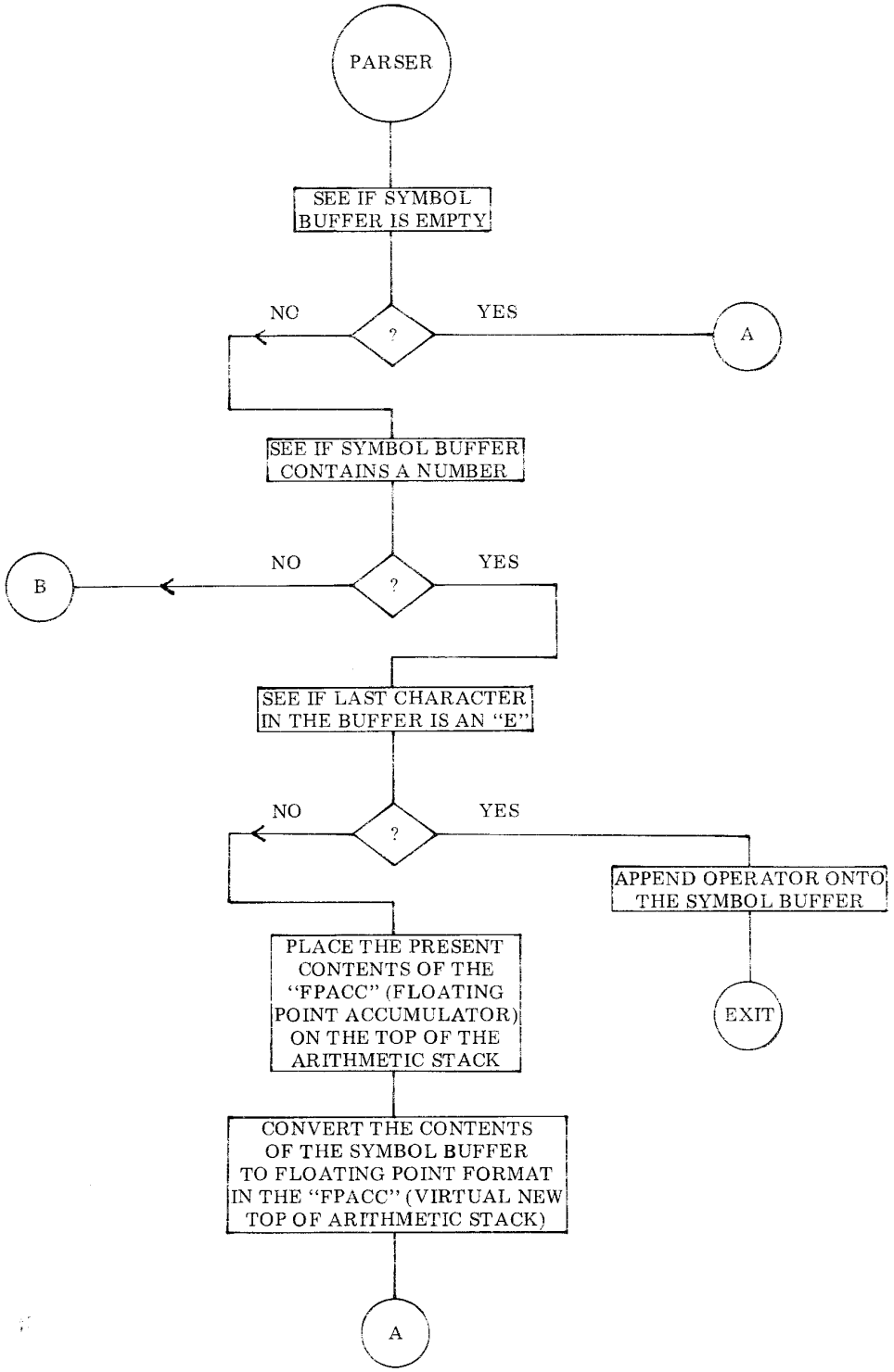
Thus, when using the unary minus sign with such operators, it is necessary to enclose the value to be negated in parenthesis thus:

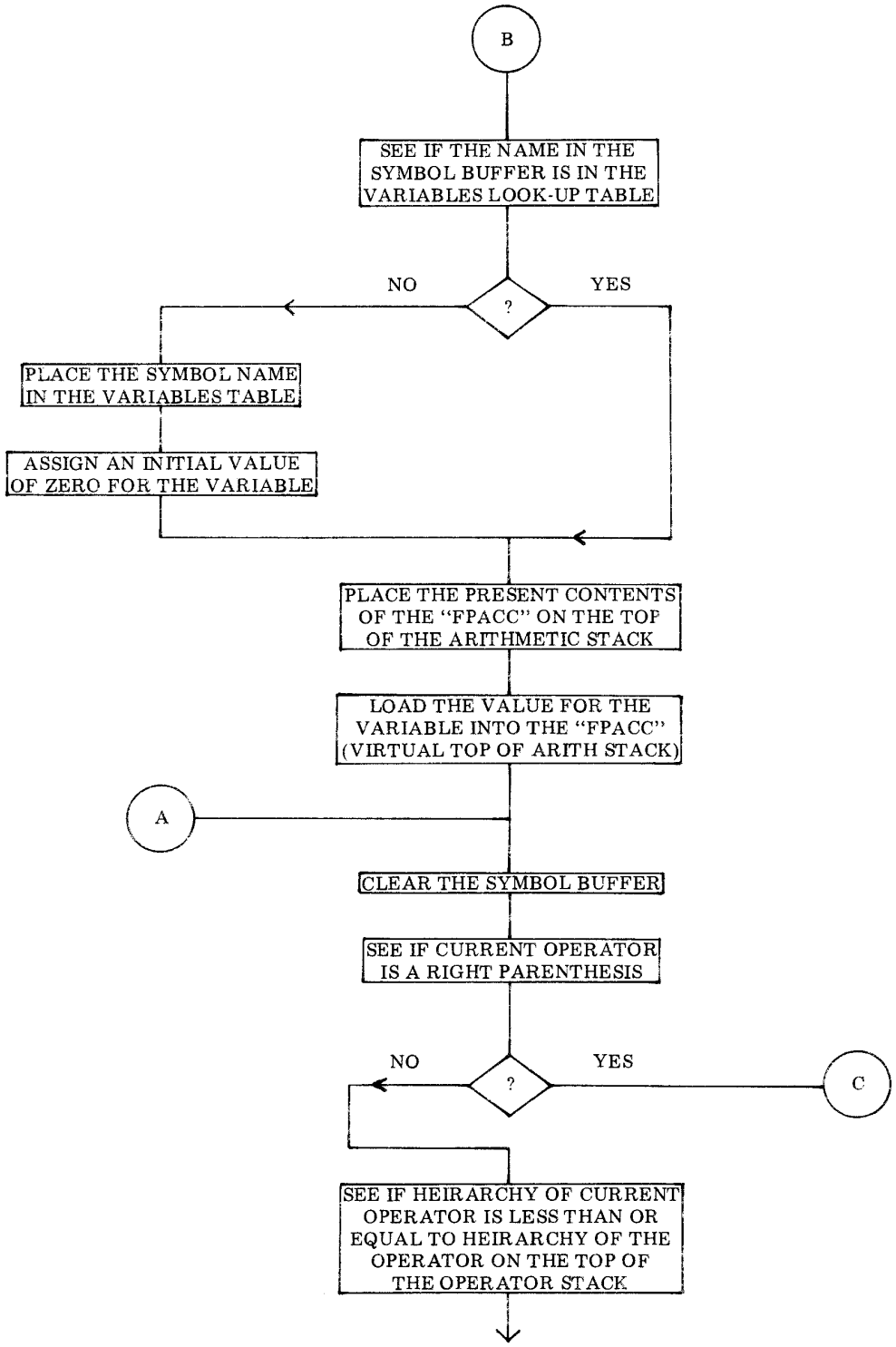
A * (-B) or A ↑ (-B)

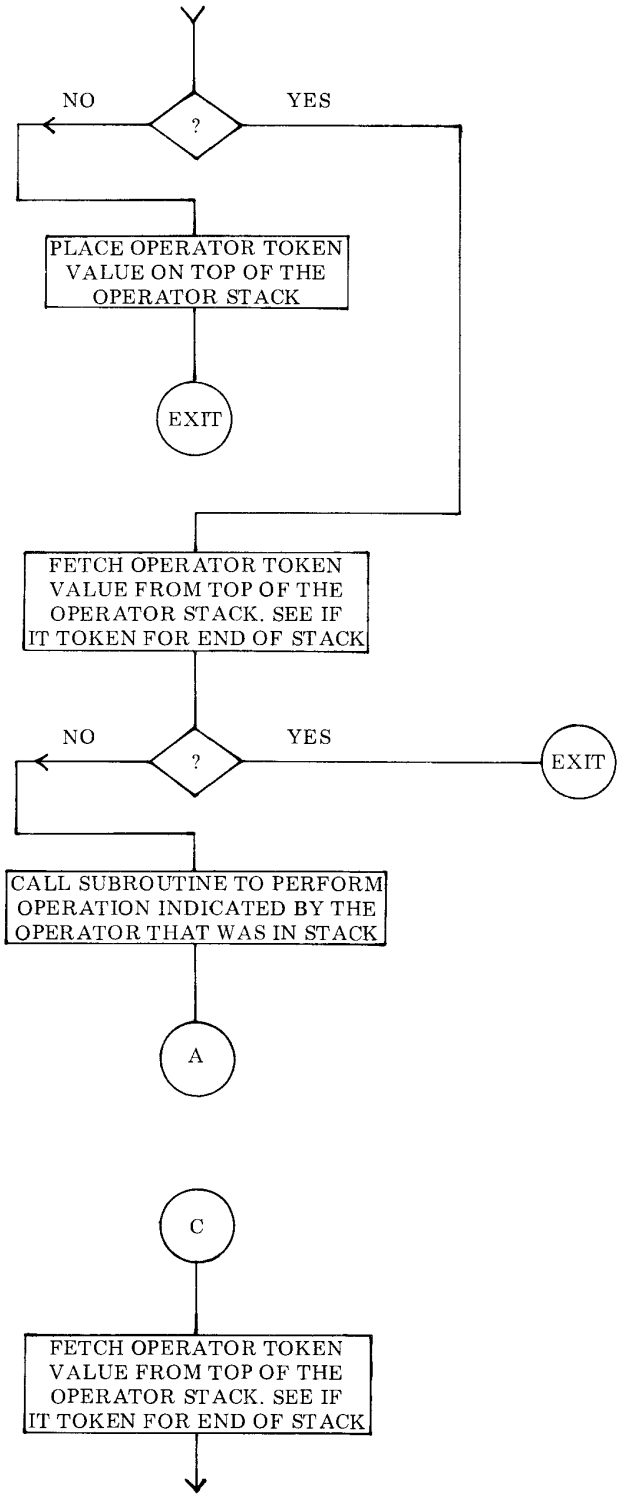
Expressions so stated can then be handled correctly by the EVAL and PARSER subroutines. (The reader may review the EVAL routine to see that incorrect use of the unary minus sign in expressions will result in a syntax error message being generated.)

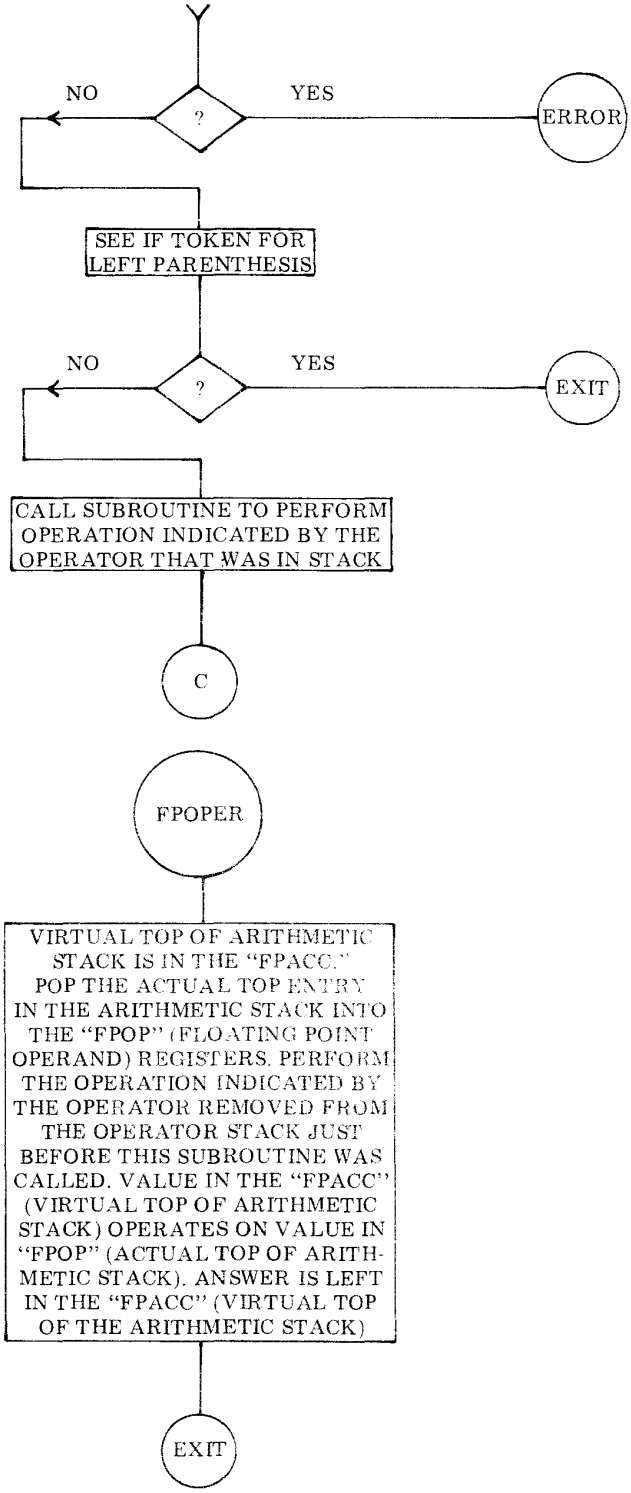
The flow of operations handled by the PARSER is illustrated by the flow chart presented on the next several pages. The source listing starts below.

```
PARSER,  LLI 120      Load L with starting address of SYMBOL BUFFER
         LHI 026      ** Load H with page of SYMBOL BUFFER
         LAM          Fetch the (cc) for contents of SYMBOL BUFFER
         NDA          Into the ACC and see if buffer is empty
         JTZ PARSE    If empty then no need to convert contents
         INL          If not empty, advance buffer pointer
         LAM          Fetch the first character in the buffer
         CPI 256      See if it is ASCII code for decimal sign
         JTZ PARNUM   If yes, consider contents of buffer to be a number
         CPI 260      If not decimal sign, see if first character represents
         JTS LOOKUP   A decimal digit, if not, should have a variable
         CPI 272      Continue to test for a decimal digit
         JFS LOOKUP   If not, go look up the variable name

PARNUM,  DCL          If SYMBOL BUFFER contains number, decrement
         LAM          Buffer pointer back to (cc) and fetch it to ACC
         CPI 001      See if length of string in buffer is just one
         JTZ NOEXPO   If so, cannot have number with scientific notation
         ADL          If not, add length to buffer pointer to
         LLA          Point to last character in the buffer
         LAM          Fetch the last character in buffer and see if it
         CPI 305      Represents letter E for Exponent
```


PARSER
SEE IF SYMBOL BUFFER IS EMPTY
NO
?
YES
A
SEE IF SYMBOL BUFFER CONTAINS A NUMBER
B
NO
?
YES
SEE IF LAST CHARACTER IN THE BUFFER IS AN "E"
NO
?
YES
APPEND OPERATOR ONTO THE SYMBOL BUFFER
EXIT
PLACE THE PRESENT CONTENTS OF THE "FPACC" (FLOATING POINT ACCUMULATOR) ON THE TOP OF THE ARITHMETIC STACK
CONVERT THE CONTENTS OF THE SYMBOL BUFFER TO FLOATING POINT FORMAT IN THE "FPACC" (VIRTUAL NEW TOP OF ARITHMETIC STACK)
A


B
SEE IF THE NAME IN THE SYMBOL BUFFER IS IN THE VARIABLES LOOK-UP TABLE
NO
?
YES
PLACE THE SYMBOL NAME IN THE VARIABLES TABLE
ASSIGN AN INITIAL VALUE OF ZERO FOR THE VARIABLE
PLACE THE PRESENT CONTENTS OF THE "FPACC" ON THE TOP OF THE ARITHMETIC STACK
LOAD THE VALUE FOR THE VARIABLE INTO THE "FPACC" (VIRTUAL TOP OF ARITH STACK)
A
CLEAR THE SYMBOL BUFFER
SEE IF CURRENT OPERATOR IS A RIGHT PARENTHESIS
NO
?
YES
C
SEE IF HEIRARCHY OF CURRENT OPERATOR IS LESS THAN OR EQUAL TO HEIRARCHY OF THE OPERATOR ON THE TOP OF THE OPERATOR STACK


NO
?
YES
PLACE OPERATOR TOKEN VALUE ON TOP OF THE OPERATOR STACK
EXIT
FETCH OPERATOR TOKEN VALUE FROM TOP OF THE OPERATOR STACK. SEE IF IT TOKEN FOR END OF STACK
NO
?
YES
EXIT
CALL SUBROUTINE TO PERFORM OPERATION INDICATED BY THE OPERATOR THAT WAS IN STACK
A
C
FETCH OPERATOR TOKEN VALUE FROM TOP OF THE OPERATOR STACK. SEE IF IT TOKEN FOR END OF STACK


NO
?
YES
ERROR
SEE IF TOKEN FOR LEFT PARENTHESIS
NO
?
YES
EXIT
CALL SUBROUTINE TO PERFORM OPERATION INDICATED BY THE OPERATOR THAT WAS IN STACK
C
FPOPER
VIRTUAL TOP OF ARITHMETIC STACK IS IN THE "FPACC." POP THE ACTUAL TOP ENTRY IN THE ARITHMETIC STACK INTO THE "FPOP" (FLOATING POINT OPERAND) REGISTERS. PERFORM THE OPERATION INDICATED BY THE OPERATOR REMOVED FROM THE OPERATOR STACK JUST BEFORE THIS SUBROUTINE WAS CALLED. VALUE IN THE "FPACC" (VIRTUAL TOP OF ARITHMETIC STACK) OPERATES ON VALUE IN "FPOP" (ACTUAL TOP OF ARITHMETIC STACK). ANSWER IS LEFT IN THE "FPACC" (VIRTUAL TOP OF THE ARITHMETIC STACK)
EXIT

```
        JFZ NOEXPO      If not, cannot have number with scientific notation
        LLI 200         If yes, have part of a scientific number, set pointer to
        CAL GETCHR      Get the operator that follows the E and append it to
        JMP CONCTS      The SYMBOL BUFFER and return to EVAL routine

NOEXPO, LLI 227         Load L with address of ARITHMETIC STACK pointer
        LHI 001         ** Load H with page of ARITHMETIC STACK pointer
        LAM             Fetch AS pointer value to ACC and add four to account
        ADI 004         For the number of bytes required to store a number in
        LMA             Floating point format. Restore pointer to memory.
        LLA             Then, change L to point to entry position in the AS
        CAL FSTORE      Place contents of the FPACC onto top of the AS
        LLI 120         Change L to point to start of the SYMBOL BUFFER
        LHI 026         ** Set H to page of the SYMBOL BUFFER
        CAL DINPUT      Convert number in the buffer to floating point format
        JMP PARSE       In the FPACC then jump to check operator sign.

LOOKUP, LLI 370         Load L with address of LOOK-UP COUNTER
        LHI 026         ** Load H with page of the counter
        LMI 000         Initialize the counter to zero
        LLI 120         Load L with starting address of the SYMBOL BUFFER
        LDI 027         ** Load D with page of the VARIABLES TABLE
        LEI 210         Load E with start of the VARIABLES TABLE
        LAM             Fetch the (cc) for the string in the SYMBOL BUFFER
        CPI 001         See if the name length is just one character. If not,
        JFZ LOOKU1      Should be two so proceed to look-up routine. Else,
        LLI 122         Change L to second character byte in the buffer and set
        LMI 000         It to zero to provide compatibility with entries in table

LOOKU1, LLI 121         Load L with addr of first character in the SYMBOL
        LHI 026         ** BUFFER. Set H to page of the SYMBOL BUFFER.
        CAL SWITCH      Exchange contents of D&E with H&L so that can
        LAM             Fetch the first character of a name in the VARIABLES
        INL             TABLE. Advance the table pointer and save the
        LBM             Second byte of name in B. Then advance the pointer
        INL             Again to reach first byte of floating point formatted
        CAL SWITCH      Number in table. Now exchange D&E with H&L and
        CPM             Compare first byte in table against first char in buffer
        JFZ LOOKU2      If not the same, go try next entry in table. If same,
        INL             Advance pointer to next char in buffer. Transfer the
        LAB             Character in B (second byte in table entry) to the ACC
        CPM             Compare it against second character in the buffer.
        JTZ LOOKU4      If match, have found the name in the VARIABLES tbl.

LOOKU2, CAL AD4DE       Call subroutine to add four to the pointer in D&E to
        LLI 370         Advance the table pointer over value bytes. Then set
        LHI 026         ** Up H and L to point to LOOK-UP COUNTER.
        LBM             Fetch counter value (counts number of entries tested
        INB             In the VARIABLES TABLE), increment it
        LMB             And restore it back to memory
        LLI 077         Load L with address of SYMBOL VARIABLES counter
```

```
        LHI 027     ** Do same for H. (Counts number of names in table.)
        LAB         Place LOOK-UP COUNTER value in the accumulator.
        CPM         Compare it with number of entries in the table.
        JFZ LOOKU1  If have not reached end of table, keep looking for name.
        LLI 077     If reach end of table without match, need to add name
        LHI 027     ** To table. First set H & L to the SYMBOL
        LBM         VARIABLES counter. Fetch the counter value and
        INB         Increment to account for new name being added to the
        LMB         Table. Restore the updated count to memory. Also,
        LAB         Move the new counter value to the accumulator and
        CPI 025     Check to see that table size is not exceeded. If try to
        JFS BIGERR  Go over 20 (decimal) entries then have BiG error.
        LLI 121     Else, set L to point to first character in the SYMBOL
        LHI 026     ** BUFFER and set H to proper page. Set the number
        LBI 002     Of bytes to be transferred into register B as a counter.
        CAL MOVEIT  Move the symbol name from the buffer to the
        LLE         VARIABLES TABLE. Now set up H & L with value
        LHD         Contained in D & E after moving ops (points to first
        XRA         Byte of the value to be associated with the symbol
        LMA         Name.) Clear the accumulator and place zero in all four
        INL         Bytes associated with the variable name entered
        LMA         In the VARIABLES TABLE
        INL         In order to
        LMA         Assign an
        INL         Initial value
        LMA         To the variable name
        LAL         Then transfer the address in L to the accumulator
        SUI 004     Subtract four to reset the pointer to start of zeroing ops
        LEA         Restore the address in D & E to be in same state as if
        LDH         Name was found in the table in the LOOKUP routine

LOOKU4, CAL SAVEHL  Save current address to VARIABLES TABLE
        LLI 227     Load L with address of ARITHMETIC STACK pointer
        LHI 001     ** Load H with page of the pointer
        LAM         Fetch the AS pointer value to the accumulator
        ADI 004     Add four to account for next floating point formatted
        LMA         Number to be stored in the stack. Restore the stack
        LLA         Pointer to memory and set it up in register L too.
        CAL FSTORE  Place the value in the FPACC on the top of the
        CAL RESTHL  ARITHMETIC STACK. Restore the VARIABLES
        CAL SWITCH  TABLE pointer to H&L and move it to D&E. Now load
        CAL FLOAD   The VARIABLE value from the table to the FPACC.

PARSE,  CAL CLESYM  Clear the SYMBOL BUFFER
        LLI 176     Load L with address of PARSER TOKEN VALUE
        LAM         And fetch the token value into the accumulator
        CPI 007     Is it token value for right parenthesis ")" ? If so, have
        JTZ PARSE2  Special case where must perform ops til find a "(" !
        ADI 240     Else, form address to HEIRARCHY IN table and
        LLA         Set L to point to HEIRARCHY IN VALUE in the table
        LBM         Fetch the heirarchy value from the table to register B
```

```
        LLI 210     Set L to OPERATOR STACK pointer storage location
        LCM         Fetch the OS pointer into CPU register C
        CAL INDEXC  Add OS pointer to address of OS pointer storage loc
        LAM         Fetch the token value for the operator at top of the OS
        ADI 257     And form address to HEIRARCHY OUT table
        LLA         Set L to point to HEIRARCHY OUT VALUE in the
        LAB         Table. Move the HEIRARCHY IN value to the ACC.
        CPM         Compare the HEIRARCHY IN with the HEIRARCHY
        JTZ PARSE1  OUT value. If heirarchy of current operator equal to or
        JTS PARSE1  Less than operator on top of OS stack, perform
        LLI 176     Operation indicated in top of OS stack. Else, fetch the
        LBM         Current operator token value into register B.
        LLI 210     Load L with address of the OPERATOR STACK pntr
        LCM         Fetch the stack pointer value
        INC         Increment it to account for new entry on the stack
        LMC         Restore the stack pointer value to memory
        CAL INDEXC  Form pointer to next entry in OPERATOR STACK
        LMB         Place the current operator token value on top of the OS
        RET         Exit back to the EVAL routine.

PARSE1, LLI 210     Load L with address of the OPERATOR STACK pntr
        LAM         Fetch the stack pointer value to the accumulator
        ADL         Add in the value of the stack pointer address to form
        LLA         Address that points to top entry in the OS
        LAM         Fetch the token value at the top of the OS to the ACC
        NDA         Check to see if the token value is zero for end of stack
        RTZ         Exit back to the EVAL routine if stack empty
        LLI 210     Else, reset L to the OS pointer storage location
        LCM         Fetch the pointer value
        DCC         Decrement it to account for operator removed from
        LMC         The OPERATOR STACK and restore the pointer value
        CAL FPOPER  Perform the operation obtained from the top of the OS
        JMP PARSE   Continue to compare current operator against top of OS

PARSE2, LLI 210     Load L with address of the OPERATOR STACK pntr
        LHI 026     ** Load H with page of the pointer
        LAM         Fetch the stack pointer value to the accumulator
        ADL         Add in the value of the stack pointer address to form
        LLA         Address that points to top entry in the OS
        LAM         Fetch the token value at the top of the OS to the ACC
        NDA         Check to see if the token value is zero for end of stack
        JTZ PARNER  If end of stack, then have a parenthesis error condx
        LLI 210     Else, reset L to the OS pointer storage location
        LCM         Fetch the pointer value
        DCC         Decrement it to account for operator removed from
        LMC         The OPERATOR STACK and restore the pointer value
        CPI 006     Check to see if token value is "(" to close parenthesis
        RTZ         If so, exit back to EVAL routine.
        CAL FPOPER  Else, perform the op obtained from the top of the OS
        JMP PARSE2  Continue to process data in parenthesis
```

```
FPOPER,  LLI 371      Load L with address of TEMP OP storage location
         LHI 026      ** Load H with page of TEMP OP storage location
         LMA          Store OP (from top of OPERATOR STACK)
         LLI 227      Change L to address of ARITHMETIC STACK pointer
         LHI 001      ** Load H with page of AS pointer
         LAM          Fetch AS pointer value into ACC
         LLA          Set L to top of ARITHMETIC STACK
         CAL OPLOAD   Transfer number from ARITHMETIC STACK to FPOP
         LLI 227      Restore pointer to AS pointer
         LAM          Fetch the pointer value to the ACC and subtract four
         SUI 004      To remove top value from the ARITHMETIC STACK
         LMA          Restore the updated AS pointer to memory
         LLI 371      Set L to address of TEMP OP storage location
         LHI 026      ** Set H to page of TEMP OP storage location
         LAM          Fetch the operator token value to the ACC
         CPI 001      Find out which kind of operation indicated
         JTZ FPADD    Perform addition if have plus operator
         CPI 002      If not plus, see if minus
         JTZ FPSUB    Perform subtraction if have minus operator
         CPI 003      If not minus, see if multiplication
         JTZ FPMULT   Perform multiplication if have multiplication operator
         CPI 004      If not multiplication, see if division
         JTZ FPDIV    Perform division if have division operator
         CPI 005      If not division, see if exponentiation
         JTZ INTEXP   Perform exponentiation if have exponentiation operator
         CPI 011      If not exponentiation, see if "less than" operator
         JTZ LT       Perform comparison for "less than" op if indicated
         CPI 012      If not "less than" see if have "equal" operator
         JTZ EQ       Perform comparison for "equal" op if indicated
         CPI 013      If not "equal" see if have "greater than" operator
         JTZ GT       Perform comparison for "greater than" op if indicated
         CPI 014      If not "greater than" see if have "less than or equal" op
         JTZ LE       Perform comparison for the combination op if indicated
         CPI 015      See if have "equal to or greater than" operator
         JTZ GE       Perform comparison for the combination op if indicated
         CPI 016      See if have "less than or greater than" operator
         JTZ NE       Perform comparison for the combination op if indicated

PARNER,  LLI 230      If cannot find operator, expression is not balanced
         LHI 026      ** Set H and L to address of F/A STACK pointer
         LMI 000      Clear the F/A STACK pointer to re-initialize
         LAI 311      Load ASCII code for letter I into the accumulator
         LCI 250      And code for "(" character into register C
         JMP ERROR    Go display I( for "Imbalanced Parenthesis) error msg

     LT, CAL FPSUB    Subtract contents of FPACC from FPOP to compare
         LLI 126      Set L to point to the MSW of the FPACC (Contains
         LAM          Result of the subtraction.) Fetch the MSW of the
         NDA          FPACC to the accumulator and test to see if result is
         JTS CTRUE    Positive or negative. Set up the FPACC as a function
         JMP CFALSE   Of the result obtained.
```

```
EQ,   CAL FPSUB   Subtract contents of FPACC from FPOP to compare
      LLI 126     Set L to point to the MSW of the FPACC (Contains
      LAM         Result of the subtraction.) Fetch the MSW of the
      NDA         FPACC to the accumulator and test to see if result is
      JTZ CTRUE   Equal. Set up the FPACC as a function
      JMP CFALSE  Of the result obtained.

GT,   CAL FPSUB   Subtract contents of FPACC from FPOP to compare
      LLI 126     Set L to point to the MSW of the FPACC (Contains
      LAM         Result of the subtraction.) Fetch the MSW of the
      NDA         FPACC to the accumulator and test to see if result is
      JTZ CFALSE  Positive, Negative, or Equal. Set up the FPACC
      JFS CTRUE   As a function
      JMP CFALSE  Of the result obtained.

LE,   CAL FPSUB   Subtract contents of FPACC from FPOP to compare
      LLI 126     Set L to point to the MSW of the FPACC (Contains
      LAM         Result of the subtraction.) Fetch the MSW of the
      NDA         FPACC to the accumulator and test to see if result is
      JTZ CTRUE   Positive, Negative, or Equal. Set up the FPACC
      JTS CTRUE   As a function
      JMP CFALSE  Of the result obtained

GE,   CAL FPSUB   Subtract contents of FPACC from FPOP to compare
      LLI 126     Set L to point to the MSW of the FPACC (Contains
      LAM         Result of the subtraction.) Fetch the MSW of the
      NDA         FPACC to the accumulator and test to see if result is
      JFS CTRUE   Positive or Negative. Set up the FPACC
      JMP CFALSE  As a function of the result obtained

NE,   CAL FPSUB   Subtract contents of FPACC from FPOP to compare
      LLI 126     Set L to point to the MSW of the FPACC (Contains
      LAM         Result of the subtraction.) Fetch the MSW of the
      NDA         FPACC to the accumulator and test to see if result is
      JTZ CFALSE  Equal. Set up the FPACC as a function of the result.


CTRUE, FPONE,  LLI 004   Load L with address of floating point value +1.0
               JMP FLOAD Load FPACC with value +1.0 and exit to caller


CFALSE,  LLI 127   Load L with address of FPACC Exponent register
         LMI 000   Set the FPACC Exponent to zero and then set the
         JMP FPZERO Mantissa portion of the FPACC to zero. Exit to caller.


AD4DE,  LAE    Subroutine to add four to the value in register E.
        ADI 004 Move contents of E to the ACC and add four.
        LEA    Restore the updated value back to register E.
        RET    Return to the calling routine.
```

```
INTEXP,  LLI 126      Load L with address of MSW of FPACC (Floating Point
         LHI 001      ** ACCumulator). Load H with page of FPACC.
         LAM          Fetch MSW of the FPACC into the accumulator.
         LLI 003      Load L with address of EXP TEMP storage location
         LMA          Store the FPACC MSW value in EXP TEMP location
         NDA          Test contents of the MSW of the FPACC. If zero, then
         JTZ FPONE    Set FPACC equal to +1.0 (any nr to zero power = 1.0!)
         CTS FPCOMP   If MSW indicates negative number, complement
         CAL FPFIX    The FPACC. Then convert floating point number to
         LLI 124      Fixed point. Load L with address of LSW of fixed nr
         LBM          Fetch the LSW into CPU register B.
         LLI 013      Set L to address of EXPONENT COUNTER
         LMB          Place the fixed value in the EXP CNTR to indicate
         LLI 134      Number of multiplications needed (power). Now set L
         LEI 014      To LSW of FPOP and E to address of FP TEMP (LSW)
         LHI 001      ** Set H to floating point working area page.
         LDH          Set D to same page address.
         LBI 004      Set transfer (precision) counter. Call subroutine to move
         CAL MOVEIT   Contents of FPOP into FP TEMP registers to save
         CAL FPONE    Original value of FPOP. Now set FPACC to +1.0.
         LLI 003      Load L with pointer to original value of FPACC
         LAM          (Stored in FP TEMP) MSW and fetch contents to ACC.
         NDA          Test to see if raising to a negative power. If so, divide
         JTS DVLOOP   Instead of multiply!

MULOOP,  LLI 014      Load L with address of LSW of FP TEMP (original
         CAL FACXOP   Value in FPOP). Move FP TEMP into FPOP.
         CAL FPMULT   Multiply FPACC by FPOP. Result left in FPACC.
         LLI 013      Load L with address of EXPONENT COUNTER.
         LBM          Fetch the counter value
         DCB          Decrement it
         LMB          Restore it to memory
         JFZ MULOOP   If counter not zero, continue exponentiation process
         RET          When have raised to proper power, return to caller.

DVLOOP,  LLI 014      Load L with address of LSW of FP TEMP (original
         CAL FACXOP   Value in FPOP). Move FP TEMP into FPOP.
         CAL FPDIV    Divide FPACC by FPOP. Result left in FPACC.
         LLI 013      Load L with address of EXPONENT COUNTER
         LBM          Fetch the counter value
         DCB          Decrement it
         LMB          Restore to memory
         JFZ DVLOOP   If counter not zero, continue exponentiation process
         RET          When have raised to proper power, return to caller.
```

# FUNCTION AND OPTIONAL ARRAY HANDLING ROUTINES

When a mathematical expression is being evaluated by SCELBAL the presence of a parenthesis sign can indicate one of three possible conditions. The parenthesis may simply be used to group parts of a mathematical formula such as in the example:

$$((X + 2) * (X - 3))/(X + 4)$$

When parentheses are used in this manner, they are processed by the appropriate portions of the EVAL and PARSER routines previously described.

A second way in which parentheses may be used is when they isolate the argument portion of a function, such as in the examples illustrated here:

INT(X)

or

RND(0)

or

TAB(12)

The third case in which a parenthesis may be used is to indicate the subscripted part of an array variable:

A(1), A(2),.....A(8)

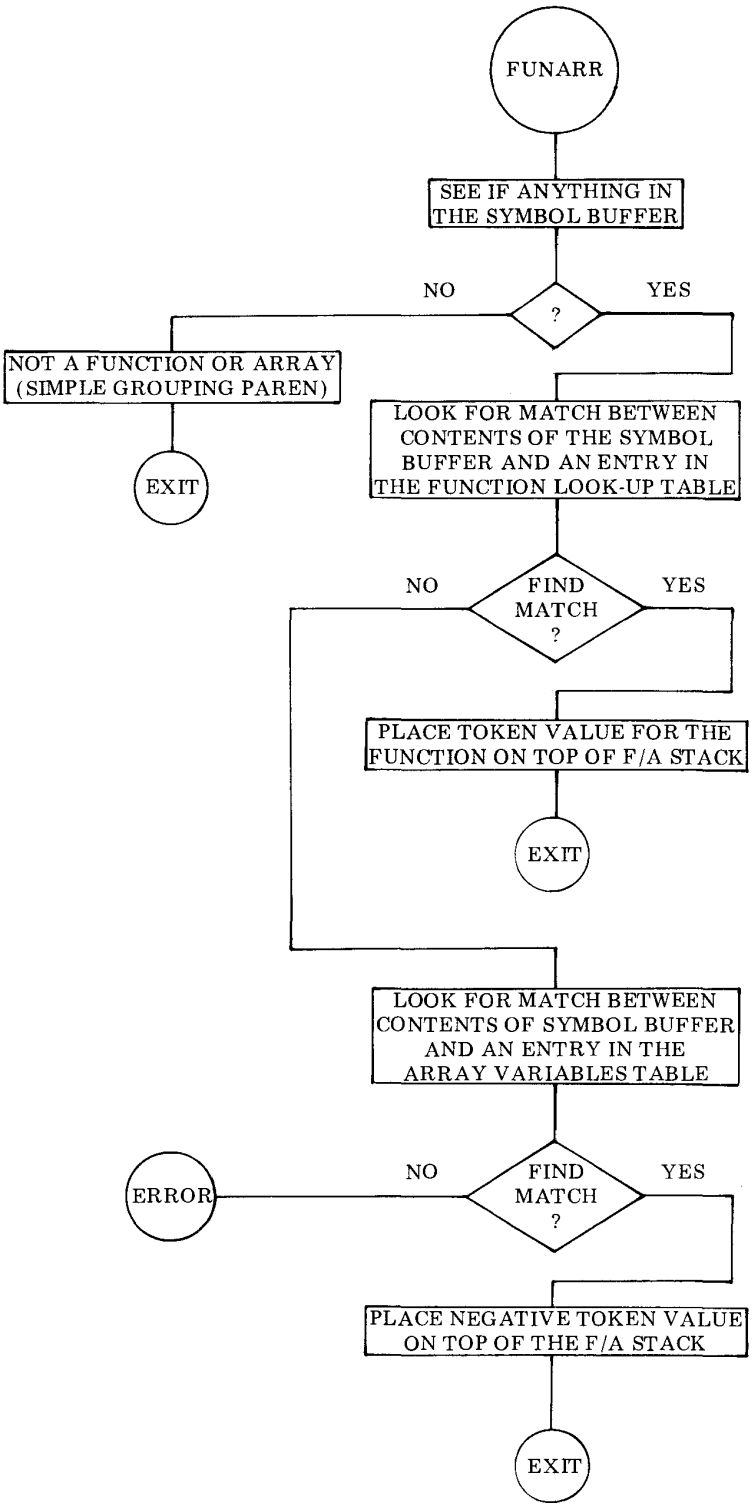
such as would occur for an array that had a DIMension of eight.

SCELBAL must be capable of distinguishing the purpose of a parenthesis whenever one is encountered and taking appropriate action once that purpose has been ascertained.

The process of determining the purpose of a parenthesis is handled by a subroutine to be presented shortly referred to by the label FUNARR (FUNction or ARRay handler). This subroutine is called by the EVAL routine presented previously whenever it encounters a left hand ("(") parenthesis sign while processing an expression. The flow chart on the next page illustrates the basic operation of the FUNARR subroutine.

Essentially, the subroutine first determines whether the parenthesis is simply being used to group mathematical terms by checking to see if there is anything in the SYMBOL BUFFER. If there is anything in the symbol buffer it should either be the name of a function or the symbolic name for an array variable. A check for a function name is made by scanning a FUNCTION LOOK-UP table for a match between an entry in it and the character string in the SYMBOL BUFFER. Upon finding a match, a FUNCTION TOKEN VALUE is set up in a stack called the F/A STACK. This token value for a function will always be positive in value. (It is simply the position of the function name in the name table!) If the data in the SYMBOL BUFFER does not represent a function name, and if the user desires to utilize the optional array handling capability of SCELBAL, another subroutine (labeled FUNAR2) is called upon to see if the character in the SYMBOL BUFFER is an array variable by looking for a match with it in the ARRAY VARIABLES TABLE (discussed previously in the chapter describing the optional DIM statement). If the name is found in the table, a negative token value (corresponding to the position of the array name in the table) is established and placed in the F/A STACK.

The routine that handles the processing of subscripted array names is left out of the program if the user does not desire to incorporate the optional DIM statement and associated capability in SCELBAL. If it is left out, the reference instruction to it is changed to a no-operation instruction (indicated in the listing by the @@ notation) so that the routine will issue an error message if the program user attempts to subscript a variable when array capability is not implemented.


FUNARR
SEE IF ANYTHING IN THE SYMBOL BUFFER
NO
?
YES
NOT A FUNCTION OR ARRAY (SIMPLE GROUPING PAREN)
EXIT
LOOK FOR MATCH BETWEEN CONTENTS OF THE SYMBOL BUFFER AND AN ENTRY IN THE FUNCTION LOOK-UP TABLE
NO
FIND MATCH ?
YES
PLACE TOKEN VALUE FOR THE FUNCTION ON TOP OF F/A STACK
EXIT
LOOK FOR MATCH BETWEEN CONTENTS OF SYMBOL BUFFER AND AN ENTRY IN THE ARRAY VARIABLES TABLE
ERROR
NO
FIND MATCH ?
YES
PLACE NEGATIVE TOKEN VALUE ON TOP OF THE F/A STACK
EXIT

```
FUNARR,  LLI 120      Load L with starting address of SYMBOL BUFFER
         LHI 026      ** Load H with page of SYMBOL BUFFER
         LAM          Fetch the (cc) for contents of buffer to the ACC
         NDA          See if (cc) is zero, if so buffer is empty, return to
         RTZ          Caller as have simple grouping parenthesis sign
         LLI 202      Else set L to TEMP COUNTER location
         LHI 027      ** Set H to TEMP COUNTER page
         LMI 000      Initialize TEMP COUNTER to zero

FUNAR1,  LLI 202      Load L with address of TEMP COUNTER
         LHI 027      ** Load H with page of TEMP COUNTER
         LBM          Fetch the counter value to register B
         INB          Increment the counter
         LMB          Restore the updated value to memory
         LCI 002      Initialize C to a value of two for future ops
         LLI 274      Load L with starting address (less four) of FUNCTION
         LHI 026      ** LOOK-UP TABLE. Set H to table page.
         CAL TABADR   Find address of next entry in the table
         LDI 026      ** Load D with page of SYMBOL BUFFER
         LEI 120      Load E with starting address of SYMBOL BUFFER
         CAL STRCP    Compare entry in FUNCTION LOOK-UP TABLE with
         JTZ FUNAR4   Contents of SYMBOL BUFFER. If find match, go set
         LLI 202      Up the function token value. Else, set L to the TEMP
         LHI 027      ** COUNTER and set H to the proper page. Fetch the
         LAM          Current counter value and see if have tried all eight
         CPI 010      Possible functions in the table.
         JFZ FUNAR1   If not, go back and check the next entry.
         LLI 202      If have tried all of the entries in the table, set L
         LHI 027      ** As well as H to the address of the TEMP COUNTER
         LMI 000      And reset it to zero. Now go see if have subscripted
         JMP FUNAR2   @@ Array (unless array capability not in program).

FAERR,   LLI 230      Load L with address of F/A STACK pointer
         LHI 026      ** Load H with page of F/A STACK pointer
         LMI 000      Clear the F/A STACK pointer to reset on an error
         LAI 306      Load the ASCII code for letter F into the ACC
         LCI 301      Load the ASCII code for letter A into register C
         JMP ERROR    Go display the FA error message

FUNAR4,  LLI 202      Load L with address of TEMP COUNTER
         LHI 027      ** Set H to page of TEMP COUNTER
         LBM          Load value in counter to register B. This is FUNCTION
         LLI 230      TOKEN VALUE. Change L to F/A STACK pointer.
         LHI 026      ** Load H with page of F/A STACK pointer.
         LCM          Fetch the F/A STACK pointer value into register C.
         CAL INDEXC   Form the address to the top of the F/A STACK.
         LMB          Store the FUNCTION TOKEN VALUE in the F/A
         JMP CLESYM   STACK. Then exit by clearing the SYMBOL BUFFER.
```

```
TABADR,  LAB          Move the TEMP COUNTER value from B to ACC
TABAD1,  RLC          Multiply by four using this loop to form value equal
         DCC          To number of bytes per entry (4) times current entry
         JFZ TABAD1   In the FUNCTION LOOK-UP TABLE.
         ADL          Add this value to the starting address of the table.
         LLA          Form pointer to next entry in table
         RFC          If no carry return to caller
         INH          Else, increment H before
         RET          Returning to caller

                      The following routine is only installed if the user
                      desires to utilize single dimension array capability.
                      This and associated array routines, if installed, will
                      be in a separate area in memory apart from the
                      standard SCELBAL routines.

FUNAR2,  LLI 202      Load L with address of TEMP COUNTER
         LHI 027      ** Load H with page of counter
         LBM          Fetch the counter value
         INB          Increment the value
         LMB          Restore the value to memory
         LCI 002      Initialize register C to a value of two for future ops
         LLI 114      Load L with address of start of ARRAY VARIABLES
         LHI 027      ** TABLE (less four). Set H to page of the table.
         CAL TABADR   Calculate address of start of next name in table.
         LDI 026      ** Load D with page of the SYMBOL BUFFER
         LEI 120      Set E to starting address of the SYMBOL BUFFER
         CAL STRCP    Compare name in ARRAY VARIABLES table to the
         JTZ FUNAR3   Contents of the SYMBOL BUFFER. If match, go set up
         LLI 202      Array token value. Else, reset L to address of TEMP
         LHI 027      ** COUNTER. Set H to page of TEMP COUNTER.
         LAM          Fetch the counter value into the accumulator.
         LLI 075      Change L to number of arrays storage location.
         CPM          Compare number of entries checked against number
         JFZ FUNAR2   Possible. Keep searching table if not finished.
         JMP FAERR    If finished and no match than have F/A error condx.

FUNAR3,  LLI 202      Load L with address of TEMP COUNTER
         LHI 027      ** Load H with page of counter.
         XRA          Clear the accumulator. Subtract the value in the TEMP
         SBM          COUNTER from zero to obtain two's complement.
         LMA          Place this back in counter location as ARRAY TOKEN
         JMP FUNAR4   VALUE (negative). Go place the value on F/A STACK.
```

The routines just presented take care of determining what type of purpose a parenthesis is being used for when the left hand parenthesis sign is encountered in an expression. There is, of course, still more to do! The information enclosed in a set of parenthesis will either be argument portion of a function, the subscript of an array variable, or the terms that make up a mathematical expression when the parenthesis is used

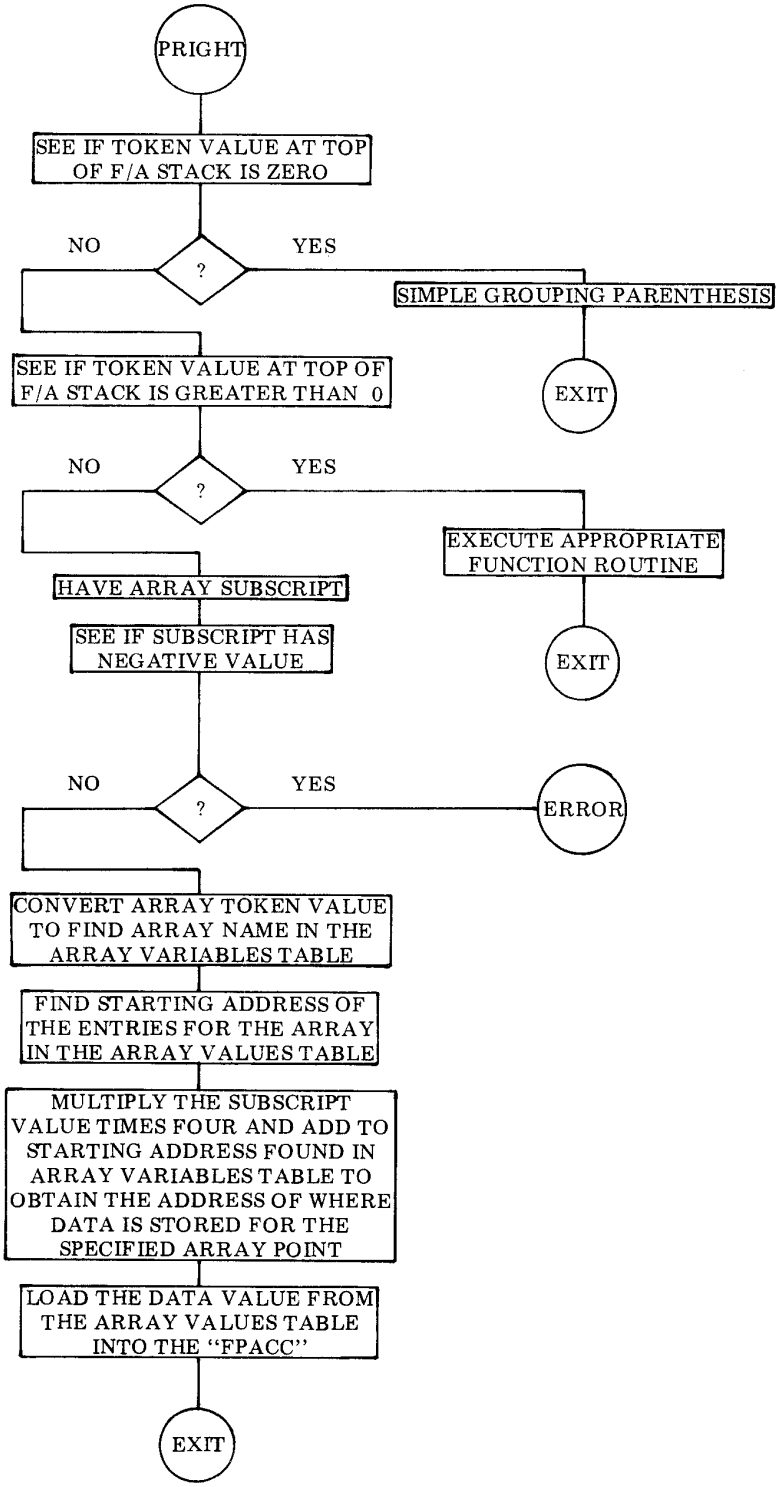
for grouping purposes. The latter case is taken care of between the EVAL and PARSER routines previously described as they simply proceed to evaluate all the terms enclosed by the current parenthesis before proceeding any further with the process of scanning the expression. Handling the cases involving functions or array variables is initiated when the EVAL routine detects a right hand (")") parenthesis sign and calls on the subroutine to be described next labeled PRIGHT.

The flow chart on the following page illustrates the key tasks of the PRIGHT subroutine and a supporting (optional) subroutine labeled PRIGH1. The routine portion starting with the label PRIGH1 is only used if array capability is implemented in a version of SCELBAL.

The source listings for these routines start here:

```
PRIGHT,  LLI 230      Load L with address of F/A STACK pointer
         LHI 026      ** Load H with page of F/A STACK pointer
         LAM          Fetch the pointer value into the ACC
         ADL          Form pointer to top of the F/A STACK
         LLA          Set L to point to top of the F/A STACK
         LAM          Fetch the contents of the top of the F/A STACK into
         LMI 000      The ACC then clear the top of the F/A STACK
         LLI 203      Load L with address of F/A STACK TEMP storage
         LHI 027      ** Location. Set H to page of F/A STACK TEMP
         LMA          Store value from top of F/A STACK into temp loc.
         NDA          Test to see if token value in top of stack was zero
         RTZ          If so, just had simple grouping parenthesis!
         JTS PRIGH1   @@ If token value minus, indicates array subscript
         CPI 001      For positive token value, look for appropriate function
         JTZ INTX     If token value for INTeger function, go do it.
         CPI 002      Else, see if token value for SiGN function.
         JTZ SGNX     If so, go do it.
         CPI 003      Else, see if token value for ABSolute function
         JTZ ABSX     If so, go do it.
         CPI 004      If not, see if token value for SQuare Root function
         JTZ SQRX     If so, go do it.
         CPI 005      If not, see if token value for TAB function
         JTZ TABX     If so, go do it.
         CPI 006      If not, see if token value for RaNDom function
         JTZ RNDX     If so, go find a random number.
         CPI 007      If not, see if token value for CHaRacter function
         JTZ CHRX     If so, go perform the function.
         CPI 010      Else, see if token for user defined machine language
         JTZ UDEFX    †† Function. If so, perform the User DEfined Function
         HLT          Safety halt. Program should not reach this location!
```

The following routine is only installed if the user desires to utilize single dimension array capability. This and associated array routines, if installed, will be in a separate area in memory apart from the standard SCELBAL routines. (Starts at top of page following the flow chart.)


PRIGHT
SEE IF TOKEN VALUE AT TOP OF F/A STACK IS ZERO
NO
?
YES
SIMPLE GROUPING PARENTHESIS
EXIT
SEE IF TOKEN VALUE AT TOP OF F/A STACK IS GREATER THAN 0
NO
?
YES
EXECUTE APPROPRIATE FUNCTION ROUTINE
EXIT
HAVE ARRAY SUBSCRIPT
SEE IF SUBSCRIPT HAS NEGATIVE VALUE
NO
?
YES
ERROR
CONVERT ARRAY TOKEN VALUE TO FIND ARRAY NAME IN THE ARRAY VARIABLES TABLE
FIND STARTING ADDRESS OF THE ENTRIES FOR THE ARRAY IN THE ARRAY VALUES TABLE
MULTIPLY THE SUBSCRIPT VALUE TIMES FOUR AND ADD TO STARTING ADDRESS FOUND IN ARRAY VARIABLES TABLE TO OBTAIN THE ADDRESS OF WHERE DATA IS STORED FOR THE SPECIFIED ARRAY POINT
LOAD THE DATA VALUE FROM THE ARRAY VALUES TABLE INTO THE "FPACC"
EXIT

```
PRIGH1,  LLI 126      Load L with address of the MSW in the FPACC
         LHI 001      ** Set H to page of FPACC
         LAM          Fetch MSW of FPACC into the ACC.
         NDA          Test to see if value in FPACC is positive.
         JTS OUTRNG   If not, go display error message.
         CAL FPFIX    If O.K. then convert floating point to fixed point
         LLI 124      Load L with address of LSW of converted value
         LAM          Fetch the LSW of the value into the ACC
         SUI 001      Subtract one from the value to establish proper
         RLC          Origin for future ops. Now rotate the value twice
         RLC          To effectively multiply by four. Save the
         LCA          Calculated result in CPU register C
         LLI 203      Load L with address of F/A STACK TEMP
         LHI 027      ** Load H with page of F/A STACK TEMP
         LAM          Fetch the value into the accumulator
         XRI 377      Complement the value
         RLC          Rotate the value twice to multiply by four (the number
         RLC          Of bytes per entry in the ARRAY VARIABLES table).
         ADI 120      Add the starting address of the ARRAY VARIABLES
         LHI 027      ** TABLE to form pointer. Set page address in H.
         LLA          Point to the name in the ARRAY VARIABLES
         INL          Increment the pointer value twice to move over the
         INL          Name in the table and point to starting address for the
         LAM          Array values in the ARRAY VALUES table. Fetch this
         ADC          Address to the ACC. Now add in the figure calculated
         LLA          To reach desired subscripted data storage location. Set
         LHI 057      †† The pointer to that location. Load the floating point
         JMP FLOAD    Value stored there into the FPACC and exit to caller.

OUTRNG,  LAI 317      Load the ASCII code for letter O into the accumulator
         LCI 322      Load the ASCII code for letter R into register C
         JMP ERROR    Go display Out of Range (OR) error message.
```

The reader has just observed how the PRIGHT subroutine is used to direct the program to a specific routine if a right parenthesis indicates that a FUNCTION is to be executed.

The capabilities of the various FUNCTION routines were described briefly in an early chapter. Their use will be described in more detail in a later use. The actual implementation of these FUNCTION subroutines are quite straightforward for the most part and their operation can be easily followed by studying the commented source listings that follow.

There is one special FUNCTION to which a name has been assigned in the FUNCTION LOOK-UP TABLE but which will not be presented. The name given this function (which the user may readily alter) is UDF for User Defined Function. The reason the routine is not presented is because the routine is precisely what it has been named. The user is free to create whatever type of machine language subroutine the user might desire to have available in the higher level language. (How about special I/O handling capability or a frequently used mathematical function?) This user created routine may be installed wherever there is available memory in the user's system. (Small routines may be

placed at the end of page 31 in the assembled version provided in this manual.) The user should make sure the address to the start of the user defined subroutine is substituted for the dummy address provided for the jump instruction to the label UDEFX shown in the listing. The user defined function routine should conclude with a RET instruction. Typical techniques that might be used in such a user created routine might be gleaned from studying the listings for the function routines that are provided as presented below.

```
INTX,   LLI 126     Load L with address of MSW of the FPACC
        LHI 001     ** Load H with the page of the FPACC
        LAM         Fetch the MSW of the FPACC into the accumulator
        NDA         Test the sign of the number in the FPACC. If
        JFS INT1    Positive jump ahead to integerize
        LLI 014     If negative, load L with address of FP TEMP registers
        CAL FSTORE  Store the value in the FPACC in FP TEMP
        CAL FPFIX   Convert the value in FPACC from floating point to
        LLI 123     Fixed point. Load L with address of FPACC
        LMI 000     Extension register and clear it.
        CAL FPFLT   Convert fixed binary back to FP to integerize
        LLI 014     Load L with address of FP TEMP registers
        CAL OPLOAD  Load the value in FP TEMP into FPOP
        CAL FPSUB   Subtract integerized value from original
        LLI 126     Set L to address of MSW of FPACC
        LAM         Fetch the MSW of the FPACC into the accumulator
        NDA         See if original value and integerized value the same
        JTZ INT2    If so, have integer value in FP TEMP
        LLI 014     Else, load L with address of FP TEMP registers
        CAL FLOAD   Restore FPACC to original (non-integerized) value
        LLI 024     Set L to register containing small value
        CAL FACXOP  Set up to add small value to original value in FPACC
        CAL FPADD   Perform the addition

INT1,   CAL FPFIX   Convert the number in FPACC from floating point
        LLI 123     To fixed point. Load L with address of FPACC
        LMI 000     Extension register and clear it. Now convert the number
        JMP FPFLT   Back to floating point to integerize it and exit to caller.

INT2,   LLI 014     Load L with address of FP TEMP registers. Transfer
        JMP FLOAD   Number from FP TEMP (orig) to FPACC and return.

ABSX,   LLI 126     Load L with address of MSW of the FPACC
        LHI 001     ** Set H to page of the FPACC
        LAM         Fetch the MSW of the FPACC into the accumulator
        NDA         Test the sign of the number to see if it is positive.
        JTS FPCOMP  If negative, complement the number before returning.
        RET         Else, just return with absolute value in the FPACC.
```

```
SGNX,   LLI 126     Load L with address of MSW of the FPACC
        LHI 001     ** Load H with the page of the FPACC
        LAM         Fetch the MSW of the FPACC into the accumulator
        NDA         Test to see if the FPACC is zero
        RTZ         Return to caller if FPACC is zero
        JFS FPONE   If FPACC is positive, load +1.0 into FPACC and exit
        LLI 024     If FPACC is negative, set up to load -1.0 into the
        JMP FLOAD   FPACC and exit to caller


CHRX,   CAL FPFIX   Convert contents of FPACC from floating point to
        LLI 124     Fixed point. Load L with address of LSW of fixed
        LAM         Value. Fetch this byte into the accumulator.
        CAL ECHO    Display the value.
        LLI 177     Set L to address of the TAB FLAG
        LHI 026     ** Set H to page of the TAB FLAG
        LMI 377     Set TAB FLAG (to inhibit display of FP value)
        RET         Exit to caller.


TABX,   CAL FPFIX   Convert contents of FPACC from floating point to
TAB1,   LLI 124     Fixed point. Load L with address of LSW of fixed
        LAM         Value. Fetch this byte into the accumulator.
        LLI 043     Load L with address of COLUMN COUNTER
        SUM         Subtract value in COLUMN COUNTER from desired
        LLI 177     TAB position. Load L with address of the TAB FLAG.
        LHI 026     ** Set H to page of the TAB FLAG.
        LMI 377     Set TAB FLAG (to inhibit display of FP value)
        JTS BACKSP  If beyond TAB point desired, simulate back spacing
        RTZ         Return to caller if at desired TAB location

TABC,   LCA         Else, put difference count in register C
        LAI 240     Place ASCII code for space in ACC

TABLOP, CAL ECHO    Display space on output device
        DCC         Decrement displacement counter
        JFZ TABLOP  If have not reached TAB position, continue to space
        RET         Else, return to calling routine.

BACKSP, LAI 215     Load ASCII code for carriage-return into the ACC
        CAL ECHO    Display the carriage-return
        CAL ECHO    Repeat to provide extra time if TTY
        LLI 043     Load L with address of COLUMN COUNTER
        LHI 001     ** Set H to page of COLUMN COUNTER
        LMI 001     Set COLUMN COUNTER to first column
        LLI 124     Set L to address containing desired TAB position
        LAM         Fetch the desired TAB position value
        NDA         Test to see if it is
        RTS         Negative or zero
        RTZ         In which case return to caller
        JMP TAB1    Else, proceed to perform the TAB operation.
```

```
SQRX,   LLI 014     Load L with address of FP TEMP registers
        LHI 001     ** Set H to page of FP TEMP. Move contents of FPACC
        CAL FSTORE  [Argument of SQR(X)] into FP TEMP for storage.
        LLI 126     Load L with MSW of FPACC
        LAM         Fetch the MSW into the accumulator
        NDA         Check the sign of the number in the FPACC
        JTS SQRERR  If number negative, cannot take square root
        JTZ CFALSE  If number is zero, return with zero value in FPACC
        LLI 017     Load L with address of FP TEMP Exponent register
        LAM         Fetch the Exponent value into the ACC
        NDA         Check sign of the Exponent
        JTS NEGEXP  If Exponent less than zero, process negative Exponent
        RAR         If Exponent positive, rotate right to divide by two
        LBA         And save the result in CPU register B
        LAI 000     Clear the accumulator without disturbing Carry bit
        RAL         Rotate Carry bit into the ACC to save remainder
        LMA         Store the remainder back in FP TEMP Exponent reg.
        JMP SQREXP  Jump to continue processing

NEGEXP, LBA         For negative Exponent, form two's complement by
        XRA         Placing the positive value in CPU register B, clearing
        SUB         The accumulator, and then subtracting B from the ACC
        NDA         Clear the Carry bit after the complementing operation
        RAR         Rotate the value right to divide by two
        LBA         Save the result in CPU register B
        LAI 000     Clear the accumulator without disturbing Carry bit
        ACA         Add Carry bit to the accumulator as remainder
        LMA         Store the remainder back in FP TEMP Exponent reg
        JTZ NOREMD  If remainder was zero skip ahead. If not, increment the
        INB         Result of the divide by two ops to compen for negative

NOREMD, XRA         Clear the accumulator
        SUB         Subtract the quotient of the divide by two op to
        LBA         Form two's complement and save the result in register B

SQREXP, LLI 013     Load L with address of TEMP register
        LMB         Store Exponent quotient from above ops in TEMP
        LLI 004     Load L with address of FP registers containing +1.0
        LEI 034     Load E with address of SQR APPROX working registers
        LDH         Set D to same page as H
        LBI 004     Set up register B as a number of bytes to move counter
        CAL MOVEIT  Transfer value +1.0 into SQR APPROX registers
        CAL CFALSE  Now clear the FPACC registers
        LLI 044     Load L with address of LAST SQR APPROX temp regs.
        CAL FSTORE  Initialize the LAST SQR APPROX regs to value of zero

SQRLOP, LLI 034     Load L with address of SQR APPROX working registers
        CAL FLOAD   Transfer SQR APPROX into the FPACC
        LLI 014     Load L with address of SQR ARG storage registers
        CAL OPLOAD  Transfer SQR ARG into the FPOP
        CAL FPDIV   Divde SQR ARG by SQR APPROX (Form X/A)
```

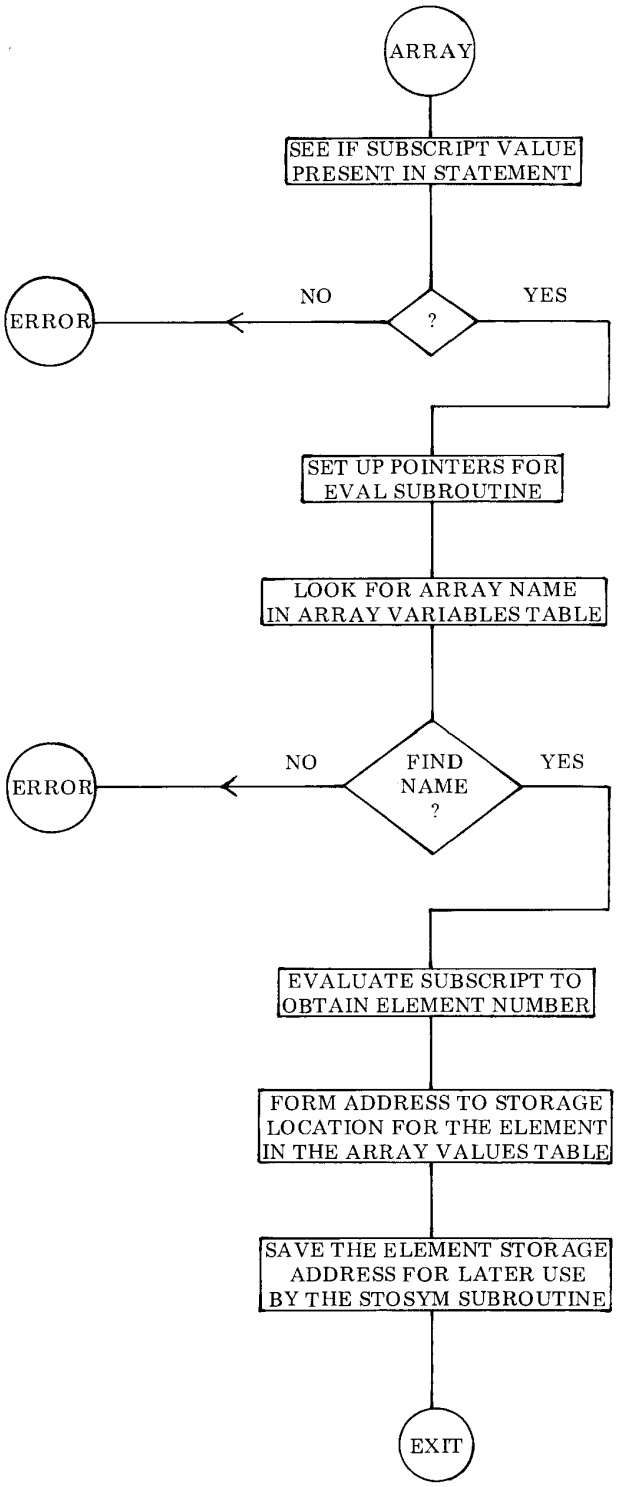
```
        LLI 034     Load L with address of SQR APPROX registers
        CAL OPLOAD  Transfer SQR APPROX into the FPOP
        CAL FPADD   Add to form value (X/A + A)
        LLI 127     Load L with address of FPACC Exponent register
        LBM         Fetch Exponent value into CPU register B
        DCB         Subtract one to effectively divide FPACC by two
        LMB         Restore to memory. (Now have ((X/A + A)/2)
        LLI 034     Load L with address of SQR APPROX registers
        CAL FSTORE  Store contents of FPACC as new SQR APPROX
        LLI 044     Load L with address of LAST SQR APPROX registers
        CAL OPLOAD  Transfer LAST SQR APPROX into the FPOP
        CAL FPSUB   Subtract (LAST SQR APPROX - SQR APPROX)
        LLI 127     Load L with address of FPACC Exponent
        LAM         Fetch the Exponent into the accumulator
        CPI 367     See if difference less than 2 to the minus ninth
        JTS SQRCNV  If so, approximation has converged
        LLI 034     Else, load L with address of SQR APPROX
        LDH         Set D to same page as H
        LEI 044     And E with address of LAST SQR APPROX
        LBI 004     Set up register B as a number of bytes to move counter
        CAL MOVEIT  Transfer SQR APPROX into LAST SQR APPROX
        JMP SQRLOP  Continue ops until approximation converges

SQRCNV, LLI 013     Load L with address of TEMP register. Fetch the
        LAM         Exponenent quotient store there into accumulator.
        LLI 037     Change L to point to SQR APPROX exponent.
        ADM         Add SQR APPROX exponent to quotient value.
        LMA         Store sum back in SQR APPROX Exponent register.
        LLI 034     Load L with address of SQR APPROX. Transfer the
        JMP FLOAD   SQR APPROX into FPACC as answer and exit.

SQRERR, LAI 323     Load ASCII code for letter S into the accumulator.
        LCI 321     Load ASCII code for letter Q into CPU register C.
        JMP ERROR   Display the SQuare root (SQ) error message.


  RNDX, LLI 064     Load L with address of SEED storage registers
        LHI 001     ** Set H to page for floating point working registers
        CAL FLOAD   Transfer SEED into the FPACC
        LLI 050     Load L with address of random constant A
        CAL OPLOAD  Transfer random constant A into the FPOP
        CAL FPMULT  Multiply to form (SEED * A)
        LLI 060     Load L with address of random constant C
        CAL OPLOAD  Transfer random constant C into the FPOP
        CAL FPADD   Add to form (SEED * A) + C
        LLI 064     Load L with address of SEED storage registers
        CAL FSTORE  Store [(SEED * A) + C] in former SEED registers
        LLI 127     Load L with address of FPACC Exponent register
        LAM         Fetch Exponent value into the accumulator
        SUI 020     Subtract 16 (decimal) to effectively divide by 65,536
        LMA         Now FPACC = [((SEED * A) + C)/65,536]
```

```
CAL FPFIX     Convert floating to fixed point to obtain integer part
LLI 123       Load L with address of FPACC Extension register
LMI 000       Clear the FPACC Extension register
LLI 127       Load L with address of FPACC Exponent
LMI 000       Clear the FPACC Exponent register
CAL FPFLT     Fetch INT(((SEED * A) + C)/65,536) into the FPACC
LLI 127       Load L with address of FPACC Exponent
LAM           Fetch FPACC Exponent into the accumulator
ADI 020       Add 16 (decimal) to effectively multiply by 65,536
LMA           (65,536 * INT[((SEED * A) + C)/65,536] ) in FPACC
LLI 064       Load L with address of [(SEED * A) + C]
CAL OPLOAD    Transfer it into FPOP. Subtract FPACC to form
CAL FPSUB     [(SEED * A) + C] MOD 65,536
LLI 064       Load L with address of former SEED registers
CAL FSTORE    Store SEED MOD 65,536 in place of [(SEED * A) + C]
LLI 127       Load L with address of FPACC Exponent
LAM           Fetch FPACC Exponent into the ACC and subtract
SUI 020       16 (decimal) to form (SEED MOD 65,536)/65,536
LMA           So that random number in FPACC is between
RET           0.0 and +1.0 and exit to calling routine
```

The final routine to be discussed in this chapter is labeled ARRAY. It is part of the optional group of routines that are included if SCELBAL is to be implemented with single dimension array handling capability. This routine is actually a special extension of the LET statement routine. It is used to locate the address in the ARRAY VALUES TABLE at which a value assigned to an element of an array is to be stored.

The key portions of the ARRAY routine are illustrated in the flow chart on the following page. The reader may wish to refer to the description of the optional DIMension statement routine in an earlier chapter. A discussion of the organization of the ARRAY VARIABLES and ARRAY VALUES tables is presented there which will be helpful in following the operation of the following routine.

```
ARRAY,    CAL RESTSY    Transfer contents of AUX SYMBOL BUFFER into the
          JMP ARRAY2    SYMBOL BUFFER. (Entry when have actual LET)

ARRAY1,   LLI 202       Load L with address of SCAN pointer
          JMP ARRAY3    Proceed to process. (Entry point for IMPLIED LET)

ARRAY2,   LLI 203       Load L with address of LET pointer

ARRAY3,   LHI 026       ** Set H to pointer page
          LBM           Fetch pointer to location where "(" found in statement
          INB           Line. Increment it to point to next character in the line.
          LLI 276       Load L with address of EVAL pointer and load it with
          LMB           The starting address for the EVAL routine
          LLI 206       Change L to address of ARRAY SETUP pointer
          LMB           And also store address in that location
```


ARRAY
SEE IF SUBSCRIPT VALUE PRESENT IN STATEMENT
NO
?
YES
ERROR
SET UP POINTERS FOR EVAL SUBROUTINE
LOOK FOR ARRAY NAME IN ARRAY VARIABLES TABLE
NO
FIND NAME ?
YES
ERROR
EVALUATE SUBSCRIPT TO OBTAIN ELEMENT NUMBER
FORM ADDRESS TO STORAGE LOCATION FOR THE ELEMENT IN THE ARRAY VALUES TABLE
SAVE THE ELEMENT STORAGE ADDRESS FOR LATER USE BY THE STOSYM SUBROUTINE
EXIT

```
ARRAY4,  LLI 206      Load L with address of ARRAY SETUP pointer
         CAL GETCHR   Fetch character pointed to by ARRAY SETUP pntr
         CPI 251      See if character is ")" ? If so, then have located
         JTZ ARRAY5   End of the subscript. If not, reset
         LLI 206      L to the ARRAY SETUP pointer. Increment the
         CAL LOOP     Pointer and test for the end of the statement line.
         JFZ ARRAY4   If not end of line, continue looking for right paren.
         LAI 301      If reach end of line before right parenthesis than load
         LCI 306      ASCII code for letters A and F and display message
         JMP ERROR    Indicating Array Format (AF) error condition

ARRAY5,  LLI 206      Load L with address of ARRAY SETUP pointer
         LBM          Fetch pointer (pointing to ")"sign) into register B
         DCB          Decrement it to move back to end of subscript number
         LLI 277      Load L with address of EVAL FINISH pointer location
         LMB          Place the pointer value in the EVAL FINISH pointer
         LLI 207      Load L with address of LOOP COUNTER
         LMI 000      Initialize LOOP COUNTER to value of zero

ARRAY6,  LLI 207      Load L with address of LOOP COUNTER
         LHI 026      ** Load H with page of LOOP COUNTER
         LBM          Fetch the counter value
         INB          Increment it
         LMB          Restore the counter value to memory
         LCI 002      Set up counter in register C for future ops
         LLI 114      Load L with address of start of ARRAY VARIABLES
         LHI 027      ** Table (less four). Set H to page of the table.
         CAL TABADR   Calculate the address of next entry in the table
         LEI 120      Load register E with starting address of SYMBOL BUFF
         LDI 026      ** Set D to page of SYMBOL BUFFER
         CAL STRCP    Compare entry in table against contents of SYMBOL BF
         JTZ ARRAY7   If match, have found array name in the table.
         LLI 207      Else, set L to address of the LOOP COUNTER
         LHI 026      ** Set H to page of the LOOP COUNTER
         LAM          Fetch the counter value to the ACC
         LLI 075      Change L to the counter containing number of arrays
         LHI 027      ** Set H to the proper page
         CPM          Compare number of arrays to count in LOOP CNTR
         JFZ ARRAY6   If more entries in the table, continue looking for match
         JMP FAERR    If no matching name in table then have an error condx.

ARRAY7,  CAL EVAL     Call subroutine to evaluate subscript expression
         CAL FPFIX    Convert the subscript value obtained to fixed format
         LLI 207      Load L with address of LOOP COUNTER
         LHI 026      ** Set H to page of the LOOP COUNTER
         LBM          Fetch the value in the LOOP COUNTER into the ACC
         LCI 002      Set up counter in register C for future ops
         LLI 114      Load L with address of ARRAY VARIABLES
         LHI 027      ** Table (less four). Set H to page of the table.
         CAL TABADR   Calculate the address of entry in the table
         INL          Advance the ARRAY VARIABLES table pointer twice
```

```
INL       To advance pointer over array name.
LCM       Fetch array base address in ARRAY VALUES table
LLI 124   Load L with address of subscript value
LHI 001   ** Set H to page of subscript value
LAM       Fetch the subscript value into the accumulator
SUI 001   Subtract one from subscript value to allow for zero
RLC       Origin. Now multiply by four
RLC       Using rotates (number of bytes required for each entry
ADC       In the ARRAY VALUES table). Add in base address to
LLI 204   The calculated value to form final address in the
LHI 027   ** ARRAY VALUES table. Now set H & L to TEMP
LMA       ARRAY ELEMENT storage location & store the addr.
LLI 201   Change L to point to ARRAY FLAG
LMI 377   Set the ARRAY FLAG for future use
RET       Exit to calling routine
```

Essentially all mathematical operations in SCELBAL are performed by a group of subroutines utilizing triple-precision binary floating point techniques. That is, the mantissa portion of a binary number is stored in three consecutive memory registers in order to provide 23 bits of magnitude plus a sign bit in which to represent the magnitude of the significant digits of a number. In order to allow for the raising of numbers to a power, a fourth byte is used to maintain the exponent of a number. That is, the power to which the mantissa is to be raised. The exponent portion of a number may thus have a magnitude of 7 bits. The eighth bit available in a register is used to maintain the sign of the exponent. Thus, each number stored in floating point format in SCELBAL requires four consecutive bytes in memory for storage. One byte for the exponent and three bytes for the significant digits or mantissa. The format is illustrated in the following diagram.

| ...EXPONENT... | ..... MSW ..... MANTISSA ..... | | ..... LSW ..... |
|---|---|---|---|
| S E E E E E E E | S.M M M M M M M | M M M M M M M M | M M M M M M M M |
| MEM LOC N+3 | MEM LOC N+2 | MEM LOC N+1 | MEM LOC N |

Twenty-three binary bits can represent decimal numbers from 0.0 to 8,388,847. This is thus the largest value that the mantissa portion may represent in SCELBAL. (While the floating point routines can manipulate numbers up to this size, the input routine for SCELBAL limits the maximum decimal number that may be inputted to about half this value. As a general rule, the operator should restrict decimal inputs to six significant digits for the mantissa portion of a number.)

The seven bits available for the exponent portion of a number in the floating point routines allow a decimal number to be raised to approximately the 38'th power of ten. (While the reader at first glance might think that seven bits would provide for an exponent range to 127 decimal, such is not the case. This is because raising a number by a power of ten decimal requires raising a binary number by between the third and fourth power when using the base 2 (remember, two to the third power is 8, which is less than 10). Thus, instead of 7 bits allowing for an exponent of up to 127 decimal, it can only represent about one third that amount.

The reader should note that if numbers being manipulated by SCELBAL should exceed the absolute magnitudes indicated above that the results of such calculations will be in error. This is because the binary exponent register would change sign on an overflow/underflow condition. This type of error is most likely to occur if a user should raise a large number to a relatively higher power, or multiply two large numbers such as 100E+22 times 50E+24. The range of powers (plus or minus 38 decimal) that SCELBAL can handle is quite adequate for most applications. Extending this range would require increasing the number of registers (precision) used to hold numbers and would significantly decrease the overall operating speed of the language. The triple-precision plus exponent format was chosen as a suitable compromise between other options.

Various portions of the floating point package to be described in this chapter are called upon by many of the routines described previously. Most of the mathematical operations are performed between two floating point multiple-byte registers named the FLOATING POINT ACCUMULATOR (abbreviated FPACC) and FLOATING POINT OPERAND (abbreviated FPOP).

The first section of the floating point section of SCELBAL consists of a group of subroutines that may be called upon separately to perform the following operations.

FLOATING POINT FIX (FPFIX). This subroutine will convert a number stored in floating point format back to binary fixed point format provided that the floating point number is in a range that can be converted to fixed point. (That is, will not require more than 23 decimal bits for storage.) Thus a number such as 5 decimal, which would appear in binary floating point format as:

0.101 E+11

would be converted to the fixed binary format:

101

The reader may note that converting floating point to fixed point is merely a matter of rotating the floating point value to the left until the binary exponent has a value of zero. Thus the above floating point number:

0.101 E+11

would be rotated to the left three places.

A floating point number such as:

0.101 E+10000

could not be properly positioned as a fixed point binary number in a triple-precision register (8 bits per register) format because it would have to be rotated to the left 32 decimal positions.

FLOATING POINT ZER0 (FPZERO). subroutine simply sets the FPACC to a value of zero. It is used to initialize or clear out the floating point accumulator.

FLOATING POINT NORMALIZE (FPNORM). This is the reverse procedure of for the case when a binary fixed point value is being changed to floating point notation. The fixed point value is simply rotated to the right while the binary exponent value is incremented until all significant digits are to the right of an implied decimal point. Thus, the fixed point value:

101

would be converted to:

0.101 E+11

Normalization is also used after other floating point operations to standardize the mantissa to be in the range greater than or equal to ONE HALF (1/2) but less than ONE. Thus, if a number such as 0.1 decimal which would appear as:

0.00011001100... E+0

in binary was normalized it would be shifted to the left while the binary exponent was decremented until it appeared as:

0.11001100... E+11

This normalization or standardization process is valuable primarily because the process aids in maintaining the maximum number of significant digits throughout a series of complex operations.

FLOATING POINT ADDITION (FPADD). This subroutine simply adds the floating point binary number in the FPACC to the floating point binary number in the FPOP and leaves the result of the addition in the FPACC.

FLOATING POINT SUBTRACTION (FPSUB). This subroutine subtracts the value in the FPACC from the value in the FPOP and

leaves the result in the FPACC.

The source listings for the five floating point operations just described (FPFIX, FPZERO, FPNORM, FPADD and FPSUB) are presented next.

```
                        Following subroutine converts number stored as float-
                        ing point in FPACC to fixed point.

FPFIX,  LLI 126         Set L to point to MSW of FPACC
        LHI 001         ** Set H to point to page of FPACC
        LAM             Fetch MSW of FPACC
        LLI 100         Change pointer to SIGN indicator on same page
        LMA             Place MSW of FPACC into SIGN indicator
        NDA             Now test sign bit of MSW of FPACC
        CTS FPCOMP      Two's complement value in FPACC if negative
        LLI 127         Change pointer to FPACC Exponent register
        LAI 027         Set accumulator to 23 (decimal) for number of bits
        LBM             Load FPACC Exponent into CPU register B
        INB             Exercise the value in register B
        DCB             To set CPU flags
        JTS FPZERO      If FPACC Exponent is negative set FPACC to zero
        SUB             Subtract value of FPACC Exponent from 23 decimal
        JTS FIXERR      If Exp larger than 23 decimal cannot convert
        LCA             Else place result in register C as counter for number
FPFIXL, LLI 126         Of rotate ops. Set pointer to MSW of FPACC
        LBI 003         Set precision counter (number of bytes in mantissa)
        CAL ROTATR      Rotate FPACC right the number of places indicated
        DCC             By count in register C to effectively rotate all the
        JFZ FPFIXL      Significant bits to the left of the floating point decimal
        JMP RESIGN      Point. Go check original sign & negate answer if req'd.

                        Following subroutine clears the FPACC to the zero
                        condition.

FPZERO, LLI 126         Set L to point to MSW of FPACC
        XRA             Clear the accumulator
        LMA             Set the MSW of FPACC to zero
        DCL             Decrement the pointer
        LMA             Set the next significant word of FPACC to zero
        DCL             Decrement the pointer
        LMA             Set the LSW of FPACC to zero
        DCL             Decrement the pointer
        LMA             Set the auxiliary FPACC byte to zero
        RET             Exit to calling routine

                        The next instruction is a special entry point to the
                        FPNORM subroutine that is used when a number is
                        converted from fixed to floating point. The FPNORM
                        label is the entry point when a number already in float-
                        ing point format is to be normalized.
```

```
FPFLT,  LBI 027         For fixed to float set CPU register B to 23 decimal

FPNORM, LAB             Get CPU register B into ACC to check for special case
        LHI 001         ** Set H to page of FPACC
        LLI 127         Set L to FPACC Exponent byte
        NDA             Set CPU flags to test what was in CPU register B
        JTZ NOEXCO      If B was zero then do standard normalization
        LMB             Else set Exponent of FPACC to 23 decimal

NOEXCO, DCL             Change pointer to MSW of FPACC
        LAM             Fetch MSW of FPACC into accumulator
        LLI 100         Change pointer to SIGN indicator storage location
        LMA             Place the MSW of FPACC there for future reference
        NDA             Set CPU flags to test MSW of FPACC
        JFS ACZERT      If sign bit not set then jump ahead to do next test
        LBI 004         If sign bit set, number in FPACC is negative. Set up
        LLI 123         For two's complement operation
        CAL COMPLM      And negate the value in the FPACC to make it positive

ACZERT, LLI 126         Reset pointer to MSW of FPACC
        LBI 004         Set precision counter to number of bytes in FPACC
LOOK0,  LAM             Plus one. Fetch a byte of the FPACC.
        NDA             Set CPU flags
        JFZ ACNONZ      If find anything then FPACC is not zero
        DCL             Else decrement pointer to NSW of FPACC
        DCB             Decrement precision counter
        JFZ LOOK0       Continue checking to see if FPACC contains anything
        LLI 127         Until precision counter is zero. If reach here then
        XRA             Reset pointer to FPACC Exponent. Clear the ACC and
        LMA             Clear out the FPACC Exponent. Value of FPACC is zip!
        RET             Exit to calling routine

ACNONZ, LLI 123         If FPACC has any value set pointer to LSW minus one
        LBI 004         Set precision counter to number of bytes in FPACC
        CAL ROTATL      Plus one for special cases. Rotate the contents of the
        LAM             FPACC to the LEFT. Pointer will be set to MSW after
        NDA             Rotate ops. Fetch MSW and see if have anything in
        JTS ACCSET      Most significant bit position. If so, have rotated enough
        INL             If not, advance pointer to FPACC Exponent. Fetch
        LBM             The value of the Exponent and decrement it by one
        DCB             To compensate for the rotate left of the mantissa
        LMB             Restore the new value of the Exponent
        JMP ACNONZ      Continue rotating ops to normalize the FPACC
ACCSET, LLI 126         Set pntr to FPACC MSW. Now must provide room for
        LBI 003         Sign bit in normalized FPACC. Set precision counter.
        CAL ROTATR      Rotate the FPACC once to the right now.

RESIGN, LLI 100         Set the pointer to SIGN indicator storage location
        LAM             Fetch the original sign of the FPACC
        NDA             Set CPU flags
        RFS             If original sign of FPACC was positive, can exit now.
```

```
FPCOMP,  LLI 124        However, if original sign was negative, must now restore
         LBI 003        The FPACC to negative by performing two's comple-
         JMP COMPLM     Ment on FPACC. Return to calling rtn via COMPLM.

                        Floating point ADDITION. Adds contents of FPACC to
                        FPOP and leaves result in FPACC. Routine first checks
                        to see if either register contains zero. If so addition
                        result is already present!

FPADD,   LLI 126        Set L to point to MSW of FPACC
         LHI 001        ** Do same for register H
         LAM            Fetch MSW of FPACC to accumulator
         NDA            Set CPU flags after loading op
         JFZ NONZAC     If accumulator non-zero then FPACC has some value

MOVOP,   LLI 124        But, if accumulator was zero then normalized FPACC
         LDH            Must also be zero. Thus answer to addition is simply the
         LEL            Value in FPOP. Set up pointers to transfer contents of
         LLI 134        FPOP to FPACC by pointing to the LSW of both
         LBI 004        Registers and perform the transfer. Then exit to calling
         JMP MOVEIT     Routine with answer in FPACC via MOVEIT.

NONZAC,  LLI 136        If FPACC was non-zero then check to see if FPOP has
         LAM            Some value by obtaining MSW of FPOP
         NDA            Set CPU flags after loading op. If MSW zero then
         RTZ            Normalized FPOP must be zero. Answer is in FPACC!

                        If neither FPACC or FPOP was zero then must perform
                        addition operation. Must first check to see if two num-
                        bers are within significant range. If not, largest number
                        is answer. If numbers within range, then must align ex-
                        ponents before performing the addition of the man-
                        tissa.

CKEQEX,  LLI 127        Set pointer to FPACC Exponent storage location.
         LAM            Fetch the Exponent value to the accumulator.
         LLI 137        Change the pointer to the FPOP Exponent
         CPM            Compare the values of the exponents. If they are the
         JTZ SHACOP     Same then can immediately proceed to add operations.
         LBA            If not the same, store FPACC Exponent size in regis B
         LAM            Fetch the FPOP Exponent size into the ACC
         SBB            Subtract the FPACC Exponent from the FPOP Exp.
         JFS SKPNEG     If result is positive jump over the next few instructions
         LBA            If result was negative, store the result in B
         XRA            Clear the accumulator
         SBB            Subtract register B to negate the original value

SKPNEG,  CPI 030        See if difference is less than 24 decimal.
         JTS LINEUP     If so, can align exponents. Go do it.
         LAM            If not, find out which number is largest. Fetch FPOP
         LLI 127        Exponent into ACC. Change pointer to FPACC Exp.
```

```
         SUM       Subtract FPACC from FPOP. If result is negative then
         RTS       FPACC was larger. Return with answer in FPACC.
         LLI 124   If result was positive, larger value in FPOP. Set pointers
         JMP MOVOP To transfer FPOP into FPACC and then exit to caller.

LINEUP,  LAM       Fetch FPOP Exponent into accumulator.
         LLI 127   Change pointer to FPACC Exponent.
         SUM       Subtract FPACC Exponent from FPOP Exponent. If
         JTS SHIFTO Result is negative FPACC is larger. Go shift FPOP.
         LCA       If result positive FPOP larger, must shift FPACC. Store
MORACC,  LLI 127   Difference count in C. Reset pointer to FPACC Exp
         CAL SHLOOP Call the SHift LOOP to rotate FPACC mantissa RIGHT
         DCC       And INCREMENT Exponent. Decr difference counter
         JFZ MORACC Continue rotate operations until diff counter is zero
         JMP SHACOP Go do final alignment and perform addition process

SHIFTO,  LCA       Routine to shift FPOP. Set difference count into reg. C

MOROP,   LLI 137   Set pointer to FPOP Exponent.
         CAL SHLOOP Call the SHift LOOP to rotate FPOP mantissa RIGHT
         INC       And INCREMENT Exponent. Then incr difference cntr
         JFZ MOROP Continue rotate operations until diff counter is zero

SHACOP,  LLI 123   Set pointer to FPACC LSW minus one to provide extra
         LMI 000   Byte for addition ops. Clear that location to zero.
         LLI 127   Change pointer to FPACC Exponent
         CAL SHLOOP Rotate FPACC mantissa RIGHT & Increment Exponent
         LLI 137   Change pointer to FPOP Exponent
         CAL SHLOOP Rotate FPOP mantissa RIGHT & Increment Exponent
         LDH       Rotate ops provide room for overflow. Now set up
         LEI 123   Pointers to LSW minus one for both FPACC & FPOP
         LBI 004   (FPOP already set after SHLOOP). Set precision counter
         CAL ADDER Call quad precision ADDITION subroutine.
         LBI 000   Set CPU register B to indicate standard normalization
         JMP FPNORM Go normalize the result and exit to caller.

SHLOOP,  LBM       Shifting loop. First fetch Exponent currently being
         INB       Pointed to and Increment the value by one.
         LMB       Return the updated Exponent value to memory.
         DCL       Decrement the pointer to mantissa portion MSW
         LBI 004   Set precision counter

FSHIFT,  LAM       Fetch MSW of mantissa
         NDA       Set CPU flags after load ops
         JFS ROTATR If MSB not a one can do normal rotate ops

BRING1,  RAL       If MSB is a one need to set up carry bit for the negative
         JMP ROTR  Number case. Then make special entry to ROTATR sub
```

The following subroutine moves the contents of a string of memory locations from the address pointed to by CPU registers H & L to the address specified by the contents of registers D & E when the routine is entered. The process continues until the counter in register B is zero.

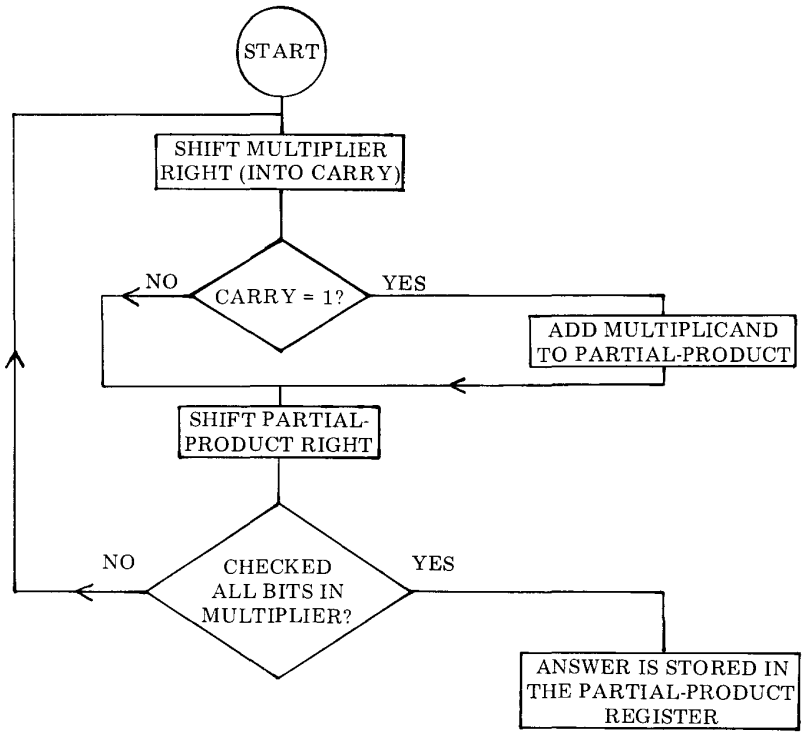
```
MOVEIT,  LAM          Fetch a word from memory string A
         INL          Advance A string pointer
         CAL SWITCH   Switch pointer to string B
         LMA          Put word from string A into string B
         INL          Advance B string pointer
         CAL SWITCH   Switch pointer back to string A
         DCB          Decrement loop counter
         RTZ          Return to calling routine when counter reaches zero
         JMP MOVEIT   Else continue transfer operations
```

The following subroutine SUBTRACTS the contents of the FLOATING POINT ACCUMULATOR from the contents of the PLOATING POINT OPERAND and leaves the result in the FPACC. The routine merely negates the value in the FPACC and then goes to the FPADD subroutine just presented.

```
FSUB,    LLI 124      Set L to address of LSW of FPACC
         LHI 001      ** Set H to page of FPACC
         LBI 003      Set precision counter
         CAL COMPLM   Two's complement the value in the FPACC
         JMP FPADD    Now go add the negated value to perform subtraction!
```

## FLOATING POINT MULTIPLICATION

The next section of the floating point package is a routine that performs floating point multiplication. A conventional floating point multiplication algorithm is utilized to perform this function. The essence of the algorithm is illustrated in the flow chart shown on the next page. Prior to implementing this algorithm the routine performs several initializing procedures. It checks the signs of the multiplier and multiplicand and negates the values if they are negative. If the signs of the two numbers to be multiplied are different, the final answer will be negated. The exponents of the two numbers are then added. Finally the two mantissas are multiplied using a double width (six byte) partial-product register. The final answer in this register is then rounded off to the 23 most significant binary bits as the final answer. This answer is left in the FPACC at the conclusion of the routine (after being negated if the signs of the original numbers were different). The listing for the floating point multiplication subroutine is presented next.




The first part of the FLOATING POINT MULTIPLICATION subroutine calls a subroutine to check the original signs of the numbers that are to be multiplied and perform working register clearing functions. Next the exponents of the numbers to be multiplied are added together.

```
FPMULT,  CAL CKSIGN   Call routine to set up registers & ck signs of numbers
ADDEXP,  LLI 137      Set pointer to FPOP Exponent
         LAM          Fetch FPOP Exponent into the accumulator
         LLI 127      Change pointer to FPACC Exponent
         ADM          Add FPACC Exponent to FPOP Exponent
         ADI 001      Add one more to total for algorithm compensation
         LMA          Store result in FPACC Exponent location

SETMCT,  LLI 102      Change pointer to bit counter storage location
         LMI 027      Initialize bit counter to 23 decimal
```

Next portion of the FPMULT routine is the implementation of the algorithm illustrated in the flow chart above. This portion multiplies the values of the two mantissas. The final value is rounded off to leave the 23 most significant bits as the answer that is stored back in the FPACC.

```
MULTIP,  LLI 126      Set pointer to MSW of FPACC mantissa
         LBI 003      Set precision counter
         CAL ROTATR   Rotate FPACC (multiplier) RIGHT into carry bit
         CTC ADOPPP   If carry is a one, add multiplicand to partial-product
         LLI 146      Set pointer to partial-product most significant byte
         LBI 006      Set precision counter (p-p register is double length)
         CAL ROTATR   Shift partial-product RIGHT
         LLI 102      Set pointer to bit counter storage location
         LCM          Fetch current value of bit counter
         DCC          Decrement the value of the bit counter
         LMC          Restore the updated bit counter to its storage location
         JFZ MULTIP   If have not multiplied for 23 (decimal) bits, keep going
         LLI 146      If have done 23 (decimal) bits, set pntr to p-p MSW
         LBI 006      Set precision counter (for double length)
         CAL ROTATR   Shift partial-product once more to the RIGHT
         LLI 143      Set pointer to access 24'th bit in partial-product
         LAM          Fetch the byte containing the 24'th bit
         RAL          Position the 24'th bit to be MSB in the accumulator
         NDA          Set the CPU flags after to rotate operation and test to
         CTS MROUND   See if 24'th bit of p-p is a ONE. If so, must round-off
         LLI 123      Now set up pointers
         LEL          To perform transfer
         LDH          Of the multiplication results
         LLI 143      From the partial-product location
         LBI 004      To the FPACC

EXMLDV,  CAL MOVEIT   Perform the transfer from p-p to FPACC
         LBI 000      Set up CPU register B to indicate regular normalization
         CAL FPNORM   Normalize the result of multiplication
         LLI 101      Now set the pointer to the original SIGNS indicator
         LAM          Fetch the indicator
         NDA          Exercise the CPU flags
         RFZ          If indicator is non-zero, answer is positive, can exit here.
         JMP FPCOMP   If not, answer must be negated, exit via 2's complement.
```

The following portions of the FPMULT routine set up working locations in memory by clearing locations for an expanded FPOP area and the partial-product storage area. Next, the signs of the two numbers to be multiplied are examined. Negative numbers are negated in preparation for the multiplication algorithm. A SIGNS Indicator register is set up during this process to indicate whether the final result of the multiplication should be positive or negative. (Negative if original signs of the two numbers to be multiplied are different.)

```
CKSIGN,  LLI 140      Set pointer to start of partial-product working area
         LHI 001      ** Set H to proper page
         LBI 010      Set up a loop counter in CPU register B
         XRA          Clear the accumulator
```

```
CLRNEX,  LMA          Now clear out locations for the partial-product
         INL          Working registers
         DCB          Until the loop counter
         JFZ CLRNEX   Is zero

CLROPL,  LBI 004      Set a loop counter
         LLI 130      Set up pointer
CLRNX1,  LMA          Clear out some extra registers so that the
         INL          FPOP may be extended in length
         DCB          Perform clearing ops until loop counter
         JFZ CLRNX1   Is zero
         LLI 101      Set pointer to M/D SIGNS indicator storage location
         LMI 001      Set initial value of SIGNS indicator to plus one
         LLI 126      Change pointer to MSW of FPACC
         LAM          Fetch MSW of mantissa into accumulator
         NDA          Test flags
         JTS NEGFPA   If MSB in MSW of FPACC is a one, number is negative

OPSGNT,  LLI 136      Set pointer to MSW of FPOP
         LAM          Fetch MSW of mantissa into accumulator
         NDA          Test flags
         RFS          Return to caller if number in FPOP is positive
         LLI 101      Else change pointer to M/D SIGNS indicator
         LCM          Fetch the value in the SIGNS indicator
         DCC          Decrement the value by one
         LMC          Restore the new value back to storage location
         LLI 134      Set pointer to LSW of FPOP
         LBI 003      Set precision counter
         JMP COMPLM   Two's complement value of FPOP & return to caller

NEGFPA,  LLI 101      Set pointer to M/D SIGNS indicator
         LCM          Fetch the value in the SIGNS indicator
         DCC          Decrement the value by one
         LMC          Restore the new value back to storage location
         LLI 124      Set pointer to LSW of FPACC
         LBI 003      Set precision counter
         CAL COMPLM   Two's complement value of FPACC
         JMP OPSGNT   Proceed to check sign of FPOP

                      The following subroutine adds the double length (six
                      register) multiplicand in FPOP to the partial-product
                      register when called on by the multiplication algorithm.

ADOPPP,  LEI 141      Pointer to LSW of partial-product
         LDH          On same page as FPOP
         LLI 131      LSW of FPOP which contains extended multiplicand
         LBI 006      Set precision counter (double length working registers)
         JMP ADDER    Add multiplicand to partial-product & return to caller
```

```
MROUND,  LBI 003        Set up precision counter
         LAI 100        Prepare to add one to 24'th bit of partial-product
         ADM            Add one to the 24'th bit of the partial-product
CROUND,  LMA            Restore the updated byte to memory
         INL            Advance the memory pointer to next most significant
         LAI 000        Byte of partial-product, then clear ACC without
         ACM            Disturbing carry bit. Now perform add with carry to
         DCB            Propagate any rounding in the partial-product registers.
         JFZ CROUND     If counter is not zero continue propagating any carry
         LMA            Restore final byte to memory
         RET            Exit to calling routine
```

## FLOATING POINT DIVISION

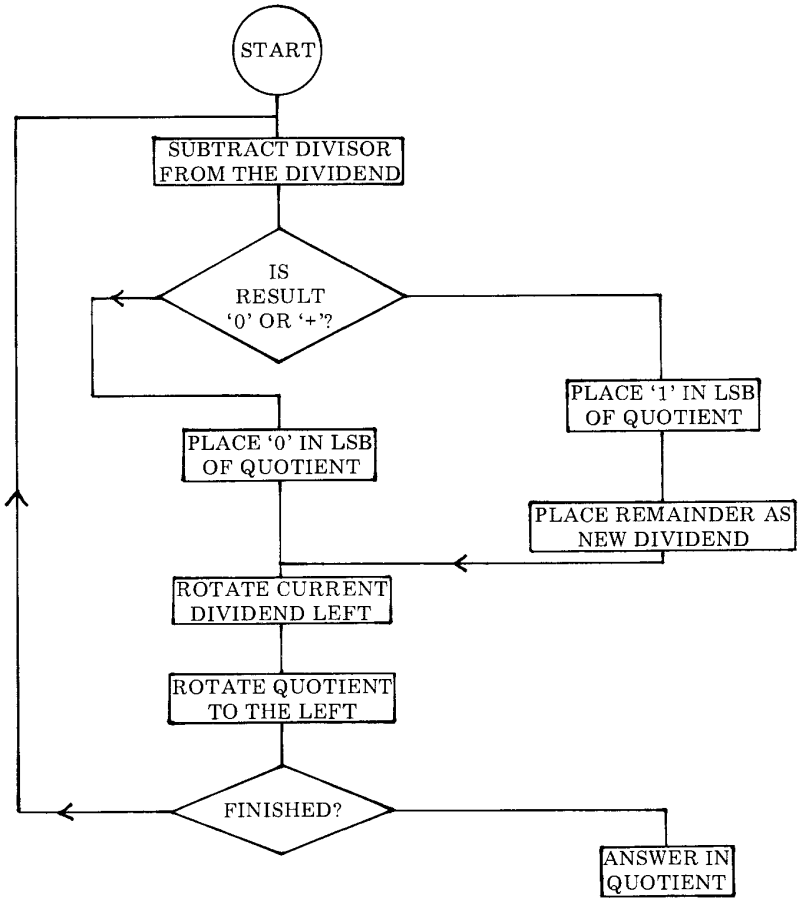
The next part of the floating point group of routines is that which performs floating point division. A flow chart on the next page illustrates the conventional algorithm that is the main portion of this routine.

The division subroutine begins in the same manner used for floating point multiplication. Working registers are initialized and the signs of the two numbers (dividend and divisor) are tested. Negative numbers are negated before performing the division. The final answer is negated if the signs of the original numbers are different. Prior to attempting division, a check is made to see if the divisor is zero. If so, an error message is displayed to the operator. If not, division is accomplished by first subtracting the exponent of the divisor from that of the dividend. The mantissas are then multiplied using the algorithm illustrated in the flow chart.

At the conclusion of the division process, a check is made to see if rounding-off is required. If so, this function is performed. The final answer is left in the FPACC at the conclusion of the routine (after being negated if the signs of the original numbers were different). The listing for the floating point division subroutine is presented next.

The first part of the FLOATING POINT DIVISION subroutine calls a subroutine to check the original signs of the numbers and perform initialization procedures. Next a test is made to see if the divisor is zero. An error message is displayed in such a case. Next the exponent of the divisor is subtracted from the dividend exponent.

```
FPDIV,   CAL CKSIGN     Call routine to set up registers & ck signs of numbers
         LLI 126        Set pointer to MSW of FPACC (divisor)
         LAM            Fetch MSW of FPACC to accumulator
         NDA            Exercise CPU flags
         JTZ DVERR      If MSW of FPACC is zero go display 'DZ' error message

SUBEXP,  LLI 137        Set pointer to FPOP (dividend) Exponent
         LAM            Get FPOP Exponent into accumulator
         LLI 127        Change pointer to FPACC (divisor) Exponent
```




```
        SUM         Subtract divisor exponent from dividend exponent
        ADI 001     Add one for algorithm compensation
        LMA         Place result in FPACC Exponent

SETDCT, LLI 102     Set pointer to bit counter storage location
        LMI 027     Initialize bit counter to 23 decimal

                    Main division algorithm for mantissas

DIVIDE, CAL SETSUB  Go subtract divisor from dividend
        JTS NOGO    If result is negative then place a zero bit in quotient
        LEI 134     If result zero or positive then move remainder after
        LLI 131     Subtraction from working area to become new dividend
        LBI 003     Set up moving pointers and initialize precision counter
        CAL MOVEIT  Perform the transfer
        LAI 001     Place a one into least significant bit of accumulator
        RAR         And rotate it out into the carry bit
```

```
        JMP QUOROT    Proceed to rotate the carry bit into the current quotient

NOGO,   XRA           When result is negative, put a zero in the carry bit, then:

QUOROT, LLI 144       Set up pointer to LSW of quotient register
        LBI 003       Set precision counter
        CAL ROTL      Rotate carry bit into quotient by using special entry to
        LLI 134       ROTATL subroutine. Now set up pointer to dividend
        LBI 003       LSW and set precision counter
        CAL ROTATL    Rotate the current dividend to the left
        LLI 102       Set pointer to bit counter storage location
        LCM           Fetch the value of the bit counter
        DCC           Decrement the value by one
        LMC           Restore the new counter value to storage
        JFZ DIVIDE    If bit counter is not zero, continue division process
        CAL SETSUB    After 23 (decimal) bits, do subtraction once more for
        JTS DVEXIT    Possible rounding. Jump ahead if no rounding required.
        LLI 144       If rounding required set pointer to LSW of quotient
        LAM           Fetch LSW of quotient to accumulator
        ADI 001       Add one to 23'rd bit of quotient
        LMA           Restore updated LSW of quotient
        LAI 000       Clear accumulator without disturbing carry bit
        INL           Advance pointer to next significant byte of quotient
        ACM           Propagate any carry as part of rounding process
        LMA           Restore the updated byte of quotient
        LAI 000       Clear ACC again without disturbing carry bit
        INL           Advance pointer to MSW of quotient
        ACM           Propagate any carry to finish rounding process
        LMA           Restore the updated byte of quotient
        JFS DVEXIT    If most significant bit of quotient is zero, go finish up
        LBI 003       If not, set precision counter
        CAL ROTATR    And rotate quotient to the right to clear the sign bit
        LLI 127       Set pointer to FPACC Exponent
        LBM           Fetch FPACC exponent
        INB           Increment the value to compensate for the rotate right
        LMB           Restore the updated exponent value

DVEXIT, LLI 144       Set up pointers
        LEI 124       To transfer the quotient into the FPACC
        LBI 003       Set precision counter
        JMP EXMLDV    And exit through FPMULT routine at EXMLDV

                      Subroutine to subtract divisor from dividend. Used by
                      main DIVIDE subroutine.

SETSUB, LEI 131       Set pointer to LSW of working area
        LDH           On same page as FPACC
        LLI 124       Set pointer to LSW of FPACC (divisor)
        LBI 003       Set precision counter
        CAL MOVEIT    Perform transfer
```

```
        LEI 131     Reset pointer to LSW of working area (now divisor)
        LLI 134     Reset pointer to LSW of FPOP (dividend)
        LBI 003     Set precision counter
        CAL SUBBER  Subtract divisor from dividend
        LAM         Get MSW of the result of the subtraction operations
        NDA         Exercise CPU flags
        RET         Return to caller with status
```

## FLOATING POINT UTILITY SUBROUTINES

The following section presents a group of so-called "utility" subroutines. These subroutines perform a variety of minor functions required by the floating point package. Many of these subroutines are also used by other portions of SCELBAL. The specific purpose of each routine will be explained in the comments portion of the source listing which is presented below.

```
                            N'th precision addition subroutine. Length of multi-
                            byte numbers specified by contents of CPU register
                            B upon entry. Number starting at location pointed to
                            by H & L (least significant byte) is added to number
                            starting at address specified by contents of D & E.

ADDER,  NDA         Initialize the carry bit to zero upon entry
ADDMOR, LAM         Fetch byte from register group A
        CAL SWITCH  Switch memory pointer to register group B
        ACM         Add byte from A to byte from B with carry
        LMA         Leave result in register group B
        DCB         Decrement number of bytes (precision) counter
        RTZ         Return to caller when all bytes in group processed
        INL         Else advance pointer for register group B
        CAL SWITCH  Switch memory pointer back to register group A
        INL         Advance the pointer for register group A
        JMP ADDMOR  Continue the multi-byte addition operation

                            N'th precision two's complement (negate) subroutine.
                            Performs a two's complement on the multi-byte register
                            starting at the address pointed to by H & L (least signifi-
                            cant byte) upon entry.

COMPLM, LAM         Fetch the least significant byte of the number to ACC
        XRI 377     Exclusive OR to complement the byte
        ADI 001     Add one to form two's complement of byte
MORCOM, LMA         Restore the negated byte to memory
        RAR         Save the carry bit
        LDA         In CPU register D
        DCB         Decrement number of bytes (precision) counter
```

```
        RTZ         Return to caller when all bytes in number processed
        INL         Else advance the pointer
        LAM         Fetch the next byte of the number to ACC
        XRI 377     Exclusive OR to complement the byte
        LEA         Save complemented value in register E temporarily
        LAD         Restore previous carry status to ACC
        RAL         And rotate it out to the carry bit
        LAI 000     Clear ACC without disturbing carry status
        ACE         Add in any carry to complemented value
        JMP MORCOM  Continue the two's complement procedure as req'd
```

N'th precision rotate left subroutine. Rotates a multi-byte number left starting at the address initially specified by the contents of CPU registers H & L upon subroutine entry (LSW). First entry point will clear the carry bit before beginning rotate operations. Second entry point does not clear the carry bit.

```
ROTATL, NDA         Clear the carry bit at this entry point
  ROTL, LAM         Fetch a byte from memory
        RAL         Rotate it left (bring carry into LSB, push MSB to carry)
        LMA         Restore rotated word to memory
        DCB         Decrement precision counter
        RTZ         Exit to caller when finished
        INL         Else advance pointer to next byte
        JMP ROTL    Continue rotate left operations
```

N'th precision rotate right subroutine. Opposite of above subroutine.

```
ROTATR, NDA         Clear the carry bit at this entry point
  ROTR, LAM         Fetch a byte from memory
        RAR         Rotate it right (carry into MSB, LSB to carry)
        LMA         Restore rotated word to memory
        DCB         Decrement precision counter
        RTZ         Exit to caller when finished
        DCL         Else decrement pointer to next byte
        JMP ROTR    Continue rotate right operations
```

N'th precision subtraction subroutine. Number starting at location pointed to by D & E (least significant byte) is subtracted from number starting at address specified by contents of H & L.

```
SUBBER, NDA         Initialize the carry bit to zero upon entry
SUBTRA, LAM         Feth byte from register group A
        CAL SWITCH  Switch memory pointer to register group B
        SBM         Subtract byte from group B from that in group A
        LMA         Leave result in register group B
        DCB         Decrement number of bytes (precision) counter
        RTZ         Return to caller when all bytes in group processed
```

```
        INL         Else advance pointer for register group B
        CAL SWITCH  Switch memory pointer back to register group A
        INL         Advance the pointer for register group A
        JMP SUBTRA  Continue the multi-byte subtraction operation
```

The next subroutine will transfer the four byte register string (generally a number in floating point format) from the starting address pointed to by CPU registers H & L when the subroutine is entered to the FPACC (floating point accumulator registers).

```
FLOAD,  LDI 001     ** Set page address of FPACC
        LEI 124     Set address of least signficant byte of FPACC
        LBI 004     Set precision counter to four bytes (mantissa bytes
        JMP MOVEIT  Plus Exponent) and exit via the transfer routine
```

The next several subroutines are used to perform floating pojnt register loading and transfer operations.

```
FSTORE, LEL         Transfer contents of register L to E
        LDH         Transfer contents of register H to D
        LLI 124     Set L to least significant byte of FPACC mantissa
        LHI 001     ** Set page to FPACC storage area
        JMP SETIT   Go transfer FPACC contents to area pointed to by D&E

OPLOAD, LDI 001     ** Set page to FPOP storage area
        LEI 134     Set pointer to least significant byte of FPOP
SETIT,  LBI 004     Set precision counter. Transfer from H & L area to
        JMP MOVEIT  Locations pointed to by D & E
```

The next subroutine performs a double transfer operation. It first transfers the contents of the FPACC into the FPOP. It then transfers new data (as pointed to by H & L upon entry to the subroutine) into the FPACC.

```
FACXOP, CAL SAVEHL  Save contents of H & L upon entry to subroutine
        LLI 124     Set pointer to FPACC LSW
        LHI 001     ** Set pointer to page of FPACC
        CAL OPLOAD  Transfer FPACC to FPOP
        CAL RESTHL  Recover original subroutine entry values for H & L
        JMP FLOAD   Transfer registers pointed to by H & L into the FPACC
```

Subroutine to save the contents of CPU registers D, E, H and L in a temporary storage area in memory.

```
SAVEHL, LAH         Transfer value in H to ACC
        LBL         And value in L to B
        LLI 200     Now set L to start of temporary storage locations
        LHI 001     ** And set H to storage area page
        LMA         Save A (entry value of H) in memory
        INL         Advance pointer
```

```
        LMB     Save B (entry value of L) in memory
        INL     Advance pointer
        LMD     Save D in memory
        INL     Advance pointer
        LME     Save E in memory
        LHA     Restore entry value of H
        LLB     Restore entry value of L
        RET     Exit to calling routine

                Subroutine to restore the contents of CPU registers D,
                E, H and L from temporary storage in memory.

RESTHL, LLI 200 Set L to start of temporary storage locations
        LHI 001 ** Set H to storage area page
        LAM     Fetch stored value for H in ACC
        INL     Advance pointer
        LBM     Fetch stored value for L into B
        INL     Advance pointer
        LDM     Fetch stored value for D
        INL     Advance pointer
        LEM     Fetch stored value for E
        LHA     Restore saved value for H
        LLB     Restore saved value for L
        LAM     Leave stored value for E in ACC
        RET     Exit to calling routine

                Subroutine to exchange the contents of H & L with
                D & E.

SWITCH, LCH     Transfer register H to C temporarily
        LHD     Place value of D into H
        LDC     Now put former H from C into D
        LCL     Transfer register L to C temporarily
        LLE     Place value of E into L
        LEC     Now put former L from C into E
        RET     Exit to calling routine
```

## CONVERSION OF FIXED AND FLOATING POINT DECIMAL TO FLOATING POINT BINARY

The next section of the floating point package is used to convert strings of ASCII characters representing fixed or floating point numbers to floating point binary numbers.

The ASCII character strings which are to be inputted to this portion of the floating point package will be residing in a buffer, such as the SYMBOL or TOKEN buffer, after having been evaluated by other portions of SCELBAL as representing numbers.

Such numbers may be in the form of fixed point decimal numbers such as:

1234.56

or floating point decimal numbers such as:

654.321 E-15

The next portion of the floating point program effectively inputs these character strings representing decimal numbers and converts them to a normalized floating point binary number for further processing by SCELBAL.

This is accomplished in a two part process. First the ASCII character string representing the mantissa portion of a decimal number is converted to a normalized binary floating point number. Next, any decimal exponent associated with the mantissa, as in the case when a floating point decimal number is being inputted, is processed. This conversion is accomplished by raising the binary floating point representation of the mantissa by a power of ten for each digit in the decimal exponent. (This is readily accomplished as will be observed shortly by calling on the subroutine FPMULT presented earlier in this chapter.) Or, by multiplying the floating point representation of the mantissa by one tenth (dividing by ten) for each digit in the decimal exponent when it represents a minus power.

The decimal to binary conversion routine must also examine the signs of the decimal numbers (mantissas and exponents) and take appropriate steps to negate the binary representations as necessary.

All of these tasks are handled by the next section of the package as may be observed by studying the following source listing.

The following subroutine is used to input decimal number strings (stored as ASCII characters in a buffer) to the floating point input routine. Each time the subroutine is called it fetches one ASCII character from the buffer location pointed to by the contents of D & E (upon entry) as augmented by an indexing register.

```
GETINP,  LHI 001      ** Set H to page of GETINP character counter
         LLI 220      Set L to address of GETINP character counter
         LCM          Load counter value into CPU register C
         INC          Exercise the counter in order
         DCC          To set CPU flags. If counter is non-zero, then indexing
         JFZ NOT0     Register (GETINP counter) is all set so jump ahead.
         LLE          But, if counter zero, then starting to process a new
         LHD          Character string. Transfer char string buffer pointer into
         LCM          H & L and fetch the string's character count value (cc)
         INC          Increment the (cc) by one to take account of (cc) byte
         CAL INDEXC   Add contents of regis C to H & L to point to end of the
         LMI 000      Character string in buffer and place a zero byte marker

NOT0,    LLI 220      Set L back to address of GETINP counter which is used
         LHI 001      ** As an indexing value. Set H to correct page.
         LCM          Fetch the value of GETINP counter into register C
         INC          Increment the value in C
         LMC          Restore the updated value for future use
         LLE          Bring the base address of the character string buffer into
         LHD          CPU registers H & L
         CAL INDEXC   Add contents of register C to form indexed address of
```

```
        LAM     Next character to be fetched as input. Fetch the next
        NDA     Character. Exercise the CPU flags.
        LHI 001 ** Restore page pointer to floating point working area
        RFZ     If character is non-zero, not end of string, exit to caller
        LLI 220 If zero character, must reset GETINP counter for next
        LMI 000 String. Reset pointer and clear GETINP counter to zero
        RET     Then exit to calling routine

                Following subroutine causes register C to be used as an
                indexing register. Value in C is added to address in H
                and L to form new address.

INDEXC, LAL     Place value from register L into accumulator
        ADC     Add quantity in register C
        LLA     Restore updated value back to L
        RFC     Exit to caller if no carry from addition
        INH     But, if have carry then must increment register H
        RET     Before returning to calling routine

                Main Decimal INPUT subroutine to convert strings of
                ASCII characters representing decimal fixed or floating
                point numbers to binary floating point numbers.

DINPUT, LEL     Save entry value of register L in E. (Pointer to buffer
        LDH     Containing ASCII character string.) Do same for H to D.
        LHI 001 ** Set H to page of floating point working registers
        LLI 150 Set L to start of decimal-to-binary working area
        XRA     Clear the accumulator
        LBI 010 Set up a loop counter

CLRNX2, LMA     Deposit zero in working area to initialize
        INL     Advance the memory pointer
        DCB     Decrement the loop counter
        JFZ CLRNX2 Clear working area until loop counter is zero
        LLI 103 Set pointer to floating point temporary registers and
        LBI 004 Indicators working area. Set up a loop counter.

CLRNX3, LMA     Deposit zero in working area to initialize
        INL     Advance the memory pointer
        DCB     Decrement the loop counter
        JFZ CLRNX3 Clear working area until loop counter is zero
        CAL GETINP Fetch a character from the ASCII char string buffer
        CPI 253 (Typically the SYMBOL/TOKEN buffer). See if it is
        JTZ NINPUT Code for + sign. Jump ahead if code for + sign.
        CPI 255 See if code for minus (-) sign.
        JFZ NOTPLM Jump ahead if not code for minus sign. If code for
        LLI 103 Minus sign, set pointer to MINUS flag storage location.
        LMA     Set the MINUS flag to indicate a minus number

NINPUT, CAL GETINP Fetch another character from the ASCII char string
```

```
NOTPLM,  CPI 256       See if character represents a period (decimal point) in
         JTZ PERIOD    Input string. Jump ahead if yes.
         CPI 305       If not period, see if code for E as in Exponent
         JTZ FNDEXP    Jump ahead if yes.
         CPI 240       Else see if code for space.
         JTZ NINPUT    Ignore space character, go fetch another character.
         NDA           If none of the above see if zero byte
         JTZ ENDINP    Indicating end of input char string. If yes, jump ahead.
         CPI 260       If not end of string, check to see
         JTS NUMERR    If character represents
         CPI 272       A valid decimal number (0 to 9)
         JFS NUMERR    Display error message if not a valid digit at this point!
         LLI 156       For valid digit, set pointer to MSW of temporary
         LCA           Decimal to binary holding registers. Save character in C.
         LAI 370       Form mask for sizing in accumulator. Now see if
         NDM           Holding register has enough room for the conversion of
         JFZ NINPUT    Another digit. Ignore the input if no more room.
         LLI 105       If have room in register then set pointer to input digit
         LBM           Counter location. Fetch the present value.
         INB           Increment it to account for incoming digit.
         LMB           Restore updated count to storage location.
         CAL DECBIN    Call the DECimal to BINary conversion routine to add
         JMP NINPUT    In the new digit in holding registers. Continue inputting.

PERIOD,  LBA           Save character code in register B
         LLI 106       Set pointer to PERIOD indicator storage location
         LAM           Fetch value in PERIOD indicator
         NDA           Exercise CPU flags
         JFZ NUMERR    If already have a period then display error message
         LLI 105       If not, change pointer to digit counter storage location
         LMA           Clear the digit counter back to zero
         INL           Advance pointer to PERIOD indicator
         LMB           Set the PERIOD indicator
         JMP NINPUT    Continue processing the input character string

FNDEXP,  CAL GETINP    Get next character in Exponent
         CPI 253       See if it is code for + sign
         JTZ EXPINP    Jump ahead if yes.
         CPI 255       If not + sign, see if minus sign
         JFZ NOEXPS    If not minus sign then jump ahead
         LLI 104       For minus sign, set pointer to EXP SIGN indicator
         LMA           Set the EXP SIGN indicator for a minus exponent

EXPINP,  CAL GETINP    Fetch the next character in the decimal exponent

NOEXPS,  NDA           Exercise the CPU flags
         JTZ ENDINP    If character inputted was zero, then end of input string
         CPI 260       If not end of string, check to see
         JTS NUMERR    If character represents
         CPI 272       A valid decimal number (0 to 9)
         JFS NUMERR    Display error message if not a valid digit at this point!
```

```
        NDI 017         Else trim the ASCII code to BCD
        LBA             And save in register B
        LLI 157         Set pointer to input exponent storage location
        LAI 003         Set accumulator equal to three
        CPM             See if any previous digit in exponent greater than three
        JTS NUMERR      Display error message if yes
        LCM             Else save any previous value in register C
        LAM             And also place any previous value in accumulator
        NDA             Clear the carry bit with this instruction
        RAL             Single precision multiply by ten algorithm
        RAL             Two rotate lefts equals times four
        ADC             Adding in the digit makes total times five
        RAL             Rotating left again equals times ten
        ADB             Now add in digit just inputted
        LMA             Restore the value to exponent storage location
        JMP EXPINP      Go get any additional exponent input

ENDINP, LLI 103         Set pointer to mantissa SIGN indicator
        LAM             Fetch the SIGN indicator to the accumulator
        NDA             Exercise the CPU flags
        JTZ FININP      If SIGN indicator is zero, go finish up as nr is positive
        LLI 154         But, if indicator is non-zero, number is negative
        LBI 003         Set pntr to LSW of storage registers, set precision cntr
        CAL COMPLM      Negate the triple-precision number in holding registers

FININP, LLI 153         Set pointer to input storage LSW minus one
        XRA             Clear the accumulator
        LMA             Clear the LSW minus one location
        LDH             Set register D to floating point working page
        LEI 123         Set E to address of FPACC LSW minus one
        LBI 004         Set precision counter
        CAL MOVEIT      Move number from input register to FPACC
        CAL FPFLT       Now convert the binary fixed point to floating point
        LLI 104         Set pointer to Exponent SIGN indicator location
        LAM             Fetch the value of the EXP SIGN indicator
        NDA             Exercise the CPU flags
        LLI 157         Reset pointer to input exponent storage location
        JTZ POSEXP      If EXP SIGN indicator zero, exponent is positive
        LAM             Else, exponent is negative so must negate
        XRI 377         The value in the input exponent storage location
        ADI 001         By performing this two's complement
        LMA             Restore the negated value to exponent storage location

POSEXP, LLI 106         Set pointer to PERIOD indicator storage location
        LAM             Fetch the contents of the PERIOD indicator
        NDA             Exercise the CPU flags
        JTZ EXPOK       If PERIOD indicator clear, no decimal point involved
        LLI 105         If have a decimal point, set pointer to digit counter
        XRA             Storage location. Clear the accumulator.
        SUM             And get a negated value of the digit counter in ACC
```

```
EXPOK,   LLI 157      Change pointer to input exponent storage location
         ADM          Add this value to negated digit counter value
         LMA          Restore new value to storage location
         JTS MINEXP   If new value is minus, skip over next subroutine
         RTZ          If new value is zero, no further processing required

                      Following subroutine will multiply the floating point
                      binary number stored in FPACC by ten times the
                      value stored in the decimal exponent storage location.

FPX10,   LLI 210      Set pointer to registers containing floating point
         LHI 001      ** Binary representation of 10 (decimal).
         CAL FACXOP   Transfer FPACC to FPOP and 10 (dec) to FPACC
         CAL FPMULT   Multiply FPOP (formerly FPACC) by 10 (decimal)
         LLI 157      Set pointer to decimal exponent storage location
         LCM          Fetch the exponent value
         DCC          Decrement
         LMC          Restore to storage
         JFZ FPX10    If exponent value is not zero, continue multiplication
         RET          When exponent is zero can exit. Conversion completed.

                      Following subroutine will multiply the floating point
                      binary number stored in FPACC by 0.1 times the value
                      (negative) stored in the decimal exponent storage
                      location.

MINEXP, FPD10, LLI 214  Set pointer to registers containing floating point
         LHI 001      ** Binary representation of 0.1 (decimal).
         CAL FACXOP   Transfer FPACC to FPOP and 0.1 (dec) to FPACC
         CAL FPMULT   Multiply FPOP (formerly FPACC) by 0.1 (decimal)
         LLI 157      Set pointer to decimal exponent storage location
         LBM          Fetch the exponent value
         INB          Increment
         LMB          Restore to storage
         JFZ FPD10    If exponent value is not zero, continue multiplication
         RET          When exponent is zero can exit. Conversion completed.

                      Following subroutine is used to convert decimal charac-
                      ters to binary fixed point format in a triple-precision
                      format.

DECBIN,  CAL SAVEHL   Save entry value of D, E, H and L in memory
         LLI 153      Set pointer to temporary storage location
         LAC          Restore character inputted to accumulator
         NDI 017      Trim ASCII code to BCD
         LMA          Store temporarily
         LEI 150      Set pointer to working area LSW of multi-byte register
         LLI 154      Set another pointer to LSW of conversion register
         LDH          Make sure D set to page of working area
         LBI 003      Set precision counter
         CAL MOVEIT   Move original value of conversion register to working
```

```
LLI 154      Register. Reset pointer to LSW of conversion register.
LBI 003      Set precision counter
CAL ROTATL   Rotate register left. (Multiplies value by two.)
LLI 154      Reset pointer to LSW.
LBI 003      Set precision counter
CAL ROTATL   Multiply by two again (total now times four).
LEI 154      Set pointer to LSW of conversion register.
LLI 150      Set pointer to LSW of working register (original value).
LBI 003      Set precision counter.
CAL ADDER    Add original value to rotated value (now times five).
LLI 154      Reset pointer to LSW
LBI 003      Set precision counter
CAL ROTATL   Multiply by two once more (total now times ten).
LLI 152      Set pointer to clear working register locations
XRA          Clear the accumulator
LMA          Clear MSW of working register
DCL          Decrement pointer
LMA          Clear next byte
LLI 153      Set pointer to current digit storage location
LAM          Fetch the current digit
LLI 150      Change pointer to LSW of working register
LMA          Deposit the current digit in LSW of working register
LEI 154      Set pointer to conversion register LSW
LBI 003      Set precision counter
CAL ADDER    Add current digit to conversion register to complete
JMP RESTHL   Conversion. Exit to caller by restoring CPU registers.
```

## CONVERSION OF FLOATING POINT BINARY TO FIXED AND FLOATING POINT DECIMAL

The final section of the SCELBAL floating point package performs essentially the reverse of the portion just presented. It will convert a number from floating point binary format into fixed or floating point decimal format for display on the user's output device.

Selecting between fixed point and floating point decimal output is automatically determined by the conversion routine. If the number stored in binary floating point format can be represented in 23 binary bits or less, and is greater than one, the number will be displayed in fixed point format with the decimal point positioned as required. If the number is not within this range, it will be outputted in decimal floating point format as a mantissa raised to the appropriate decimal power of ten.

The routine operates in essentially the reverse manner of the input routine. First the floating point binary number is converted to a fixed point binary number (representing the mantissa digits of its decimal equivalent) and an associated binary exponent portion representing the powers of ten to which the decimal mantissa is to be raised (for numbers requiring an exponent). These binary representations are then converted and displayed as decimal digits with the output being the ASCII code for each digit in the number. The output routine also takes care of inserting a decimal point and minus signs if appropriate.

The source listing for this final section of the floating point package is presented next.

```
                                The first portion of the FPOUT subroutine performs
                                initializing operations and then determines whether
                                the output is to be in fixed or floating point format.

FPOUT,   LHI 001        ** Set H to working area for floating point routines
         LLI 157        Set pointer to decimal exponent storage location
         LMI 000        Initialize storage location to zero
         LLI 126        Change pointer to FPACC (number to be outputted)
         LAM            And fetch MSW of FPACC
         NDA            Test the contents of MSW of FPACC
         JTS OUTNEG     If most significant bit of MSW is a one, have a minus nr.
         LAI 240        Else number is positive, set ASCII code for space for a
         JMP AHEAD1     Positive number and go display a space

OUTNEG,  LLI 124        If number in FPACC is negative must negate in order
         LBI 003        To display. Set pntr to LSW of FPACC & set prec. cntr.
         CAL COMPLM     Negate the number in the FPACC to make it positive
         LAI 255        But load ACC with ASCII code for minus sign

AHEAD1,  CAL ECHO       Call user display driver to output space or minus sign
         LLI 110        Set pointer to FIXED/FLOAT indicator
         LAM            Fetch value of FIXED/FLOAT indicator
         NDA            Test contents of indicator. If contents are zero, calling
         JTZ OUTFLT     Routine has directed floating point output format.
         LLI 127        If indicator non-zero, fixed point format requested if
         LAI 027        Possible. Point to FPACC Exponent. Put 23 decimal in
         LBM            Accumulator. Fetch FPACC Exponent into register B
         INB            And exercise the register to test its
         DCB            Original contents. If FPACC Exponent is negative in
         JTS OUTFLT     Value then go to floating point output format. If value
         SUB            Is positive, subtract value from 23 (decimal). If result
         JTS OUTFLT     Negative, number is too big to use fixed format.
         JMP OUTFIX     Else, can use fixed format so skip next routine

OUTFLT,  LLI 110        Set pointer to FIXED/FLOAT indicator.
         LMI 000        Clear indicator to indicate floating point output format
         LAI 260        Load ASCII code for '0' into accumulator
         CAL ECHO       Call user display driver to output '0' as first character in
         LAI 256        Number string. Now load ASCII code for decimal point.
         CAL ECHO       Call user display driver to output '.' as second character.

OUTFIX,  LLI 127        Set pointer to FPACC Exponent
         LAI 377        Load accumulator with minus one
         ADM            Add value in FPACC Exponent
         LMA            Restore compensated exponent value

                        Next portion of routine establishes the value for the
                        decimal exponent that will be outputted by processing
                        the binary exponent value in the FPACC.
```

```
DECEXT,  JFS DECEXD   If compensated exponent value is zero or positive
         LAI 004      Then go multiply FPACC by 0.1 (decimal). Else,
         ADM          Add four to the exponent value.
         JFS DECOUT   If exponent now zero or positive, ready to output
         LLI 210      If exponent negative, multiply FPACC by 10 (decimal)
         LHI 001      ** Set pointer to registers holding 10 (dec) in binary
         CAL FACXOP   Floating point format. Set up for multiplication.
         CAL FPMULT   Perform the multiplication. Answer in FPACC.
         LLI 157      Set pointer to decimal exponent storage location.
         LCM          Each time the FPACC is multiplied by ten, need to
         DCC          Decrement the value in the decimal exponent storage
         LMC          Location. (This establishes decimal exponent value!)

DECREP,  LLI 127      Reset pointer to FPACC Exponent
         LAM          Fetch value in exponent
         NDA          Test value
         JMP DECEXT   Repeat process as required

DECEXD,  LLI 214      If exponent is positive, multiply FPACC by 0.1
         LHI 001      ** Set pointer to registers holding 0.1 (dec) in binary
         CAL FACXOP   Floating point format. Set up for multiplication.
         CAL FPMULT   Perform the multiplication. Answer in FPACC.
         LLI 157      Set pointer to decimal exponent storage location.
         LBM          Each time the FPACC is multiplied by one tenth, need
         INB          To increment the value in the decimal exponent storage
         LMB          Location. (This establishes decimal exponent value!)
         JMP DECREP   Repeat process as required

                      The next section outputs the mantissa (or fixed point
                      number) by converting the value remaining in the
                      FPACC (after the decimal exponent equivalent has been
                      extracted from the original value if required by the pre-
                      vious routines) to a string of decimal digits.

DECOUT,  LEI 164      Set pointer to LSW of output working register
         LDH          Set D to same page value as H
         LLI 124      Set pointer to LSW of FPACC
         LBI 003      Set precision counter
         CAL MOVEIT   Move value in FPACC to output working register
         LLI 167      Set pointer to MSW plus one of output working register
         LMI 000      Clear that location to zero
         LLI 164      Set pointer to LSW of output working register
         LBI 003      Set precision counter
         CAL ROTATL   Rotate register left once to compensate for sign bit
         CAL OUTX10   Multiply output register by 10, overflow into MSW+1

COMPEN,  LLI 127      Set pointer back to FPACC Exponent
         LBM          Compensate for any remainder in the binary exponent
         INB          By performing a rotate right on the output working
         LMB          Register until the binary exponent becomes zero
         JTZ OUTDIG   Go output decimal digits when this loop is finished
```

```
        LLI 167     Binary exponent compensating loop. Set pointer to
        LBI 004     Working register MSW+1. Set precision counter.
        CAL ROTATR  Rotate working register to the right.
        JMP COMPEN  Repeat loop as required.

OUTDIG, LLI 107     Set pointer to output digit counter storage location
        LMI 007     Initialize to value of seven
        LLI 167     Change pointer to output working register MSW+1
        LAM         Fetch MSW+1 byte containing BCD of digit to be
        NDA         Displayed. Test the contents of this byte.
        JTZ ZERODG  If zero jump to ZERODG routine.

OUTDGS, LLI 167     Reset pointer to working register MSW+1
        LAM         Fetch BCD of digit to be outputted
        NDA         Exercise CPU flags
        JFZ OUTDGX  If not zero, go display the digit
        LLI 110     If zero, change pointer to FIXED/FLOAT indicator
        LAM         Fetch the indicator into the accumulator
        NDA         Test value of indicator
        JTZ OUTZER  If in floating point mode, go display the digit
        LLI 157     Else change pointer to decimal exponent storage
        LCM         Location, which, for fixed point, will have a positive
        DCC         Value for all digits before the decimal point. Decrement
        INC         And increment to exercise flags. See if count is positive.
        JFS OUTZER  If positive, must display any zero digit.
        LLI 166     If not, change pointer to MSW of working register
        LAM         And test to see if any significant digits coming up
        NDI 340     By forming a mask and testing for presence of bits
        JFZ OUTZER  If more significant digits coming up soon, display the
        RET         Zero digit. Else, exit to calling routine. Finished.

OUTZER, XRA         Clear the accumulator to restore zero digit value

OUTDGX, ADI 260     Add 260 (octal) to BCD code in ACC to form ASCII
        CAL ECHO    Code and call the user's display driver subroutine

DECRDG, LLI 110     Set pointer to FIXED/FLOAT indicator storage
        LAM         Fetch the indicator to the accumulator
        NDA         Exercise the CPU flags
        JFZ CKDECP  If indicator non-zero, doing fixed point output
        LLI 107     Else, get output digit counter
        LCM
        DCC         Decrement the digit counter & restore to storage
        LMC
        JTZ EXPOUT  When digit counter is zero, go take care of exponent

PUSHIT, CAL OUTX10  Else push next BCD digit out of working register
        JMP OUTDGS  And continue the outputting process

CKDECP, LLI 157     For fixed point output, decimal exponent serves as
        LCM         Counter for number of digits before decimal point
```

```
        DCC         Fetch the counter and decrement it to account for
        LMC         Current digit being processed. Restore to storage.
        JFZ NODECP  If count does not go to zero, jump ahead.
        LAI 256     When count reaches zero, load ASCII code for period
        CAL ECHO    And call user's display driver to display decimal point

NODECP, LLI 107     Set pointer to output digit counter storage location
        LCM         Fetch the digit counter
        DCC         Decrement the value
        LMC         Restore to storage
        RTZ         If counter reaches zero, exit to caller. Finished.
        JMP PUSHIT  Else continue to output the number.

ZERODG, LLI 157     If first digit of floating point number is a zero, set
        LCM         Pointer to decimal exponent storage location.
        DCC         Decrement the value to compensate for skipping
        LMC         Display of first digit. Restore to storage.
        LLI 166     Change pointer to MSW of output working register
        LAM         Fetch MSW of output working register
        NDA         Test the contents
        JFZ DECRDG  If non-zero, continue outputting
        DCL         Else decrement pointer to next byte in working register
        LAM         Fetch its contents
        NDA         Test
        JFZ DECRDG  If non-zero, continue outputting
        DCL         Else decrement pointer to LSW of working register
        LAM         Fetch its contents
        NDA         Test
        JFZ DECRDG  If non-zero, continue outputting
        LLI 157     If decimal mantissa is zero, set pointer to decimal
        LMA         Exponent storage and clear it
        JMP DECRDG  Finish outputting

                    Following routine multiplies the binary number in the
                    output working register by ten to push the most signifi-
                    cant digit out to the MSW+1 byte.

OUTX10, LLI 167     Set pointer to working register MSW+1
        LMI 000     Clear it in preparation for receiving next digit pushed
        LLI 164     Into it. Change pointer to working register LSW.
        LDH         Set up register D to same page as H.
        LEI 160     Set second pointer to LSW of second working register
        LBI 004     Set precision counter
        CAL MOVEIT  Move first working register into second
        LLI 164     Reset pointer to LSW of first working register
        LBI 004     Set precision counter
        CAL ROTATL  Rotate contents of first working register left (X 2)
        LLI 164     Reset pointer to LSW
        LBI 004     Reset precision counter
        CAL ROTATL  Rotate contents left again (X 4)
        LLI 160     Set pointer to LSW of original value in 2'nd register
```

```
        LEI 164     Set pointer to LSW of rotated value
        LBI 004     Set precision counter
        CAL ADDER   Add rotated value to original value (X 5)
        LLI 164     Reset pointer to LSW of first working register
        LBI 004     Set precision counter
        CAL ROTATL  Rotate contents left again (X 10)
        RET         Exit to calling routine
```

The final group of routines in the floating point output section take care of outputting the decimal exponent portion of floating point numbers.

```
EXPOUT, LLI 157     Set pointer to decimal exponent storage location
        LAM         Fetch value to the accumulator
        NDA         Test the value
        RTZ         If zero, then no exponent portion. Exit to caller.
        LAI 305     Else, load ACC with ASCII code for letter E.
        CAL ECHO    Display E for Exponent via user's displav driver rtn
        LAM         Get decimal exponent value back into ACC
        NDA         Test again
        JTS EXOUTN  If value is negative, skip ahead
        LAI 253     If positive, load ASCII code for + sign
        JMP AHEAD2  Jump to display the + sign

EXOUTN, XRI 377     When decimal exponent is negative, must negate
        ADI 001     Value for display purposes. Perform two's complement
        LMA         And restore the negated value to storage location
        LAI 255     Load ASCII code for minus sign

AHEAD2, CAL ECHO    Display the ASCII character in ACC
        LBI 000     Clear register B
        LAM         Fetch the decimal exponent value back into ACC

SUB12,  SUI 012     Subtract 10 (decimal) from value in ACC
        JTS TOMUCH  Break out of loop when accumulator goes negative
        LMA         Else restore value to storage location
        INB         Increment register B as a counter
        JMP SUB12   Repeat loop to form tens value of decimal exponent

TOMUCH, LAI 260     Load base ASCII value for digit into the accumulator
        ADB         Add to the count in B to form tens digit of decimal
        CAL ECHO    Exponent. Display via user's driver subroutine
        LAM         Fetch remainder of decimal exponent value
        ADI 260     Add in ASCII base value to form final digit
        CAL ECHO    Display second digit of decimal exponent
        RET         Finished outputting. Return to caller.
```

# I/O ROUTINES

Because of the wide variety of I/O devices that individual system owners may have connected to their computers, SCELBAL was designed so that individual users could provide their own actual I/O routines. In order to allow this, the reader may have noted in the previous chapters that all references to I/O routines are vectored to one of four locations in the program. Each one of these locations contains a jump or call instruction that the user must complete by supplying the actual address to the user supplied I/O routine. The four locations referred to are discussed here.

The location in the program labeled CINPUT (located at the address 03 221 in the assembled version of the program presented in this publication) is the vector instruction for the user provided OPERATOR INPUT DEVICE. This device would typically be an electronic keyboard or similar device on which the operator would type in commands to the SCELBAL executive and enter statements or programs into the user program buffer. SCELBAL expects all inputs to the program itself to be in the form of ASCII encoded characters with the eighth bit always marking. A list of the octal codes for ASCII encoded characters utilized by the program is shown on the next page. This routine should also provide a duplicate of the character received on the system's output device so that the user may verify the characters inputted to the program.

The vector point for sending data from the program to the system's display device is located in the subroutine labeled ECHO (at address 03 213 in the assembled version of the program). The output device would typically be an electro-mechanical printing device or other suitable display mechanism on which data from the program may be displayed. SCELBAL has the ASCII code for the character to be displayed in the accumulator when this vector point is encountered. It expects the user provided output driver routine to display the character corresponding to the ASCII code on the system's display device. Of course, if the user's display mechanism uses some other type of code, it is possible for the user to insert an appropriate conversion routine in the output routine. (This also applies for inputs.)

There are several extremely important considerations for the reader to bear in mind when preparing to implement the actual I/O driving routines to be used with SCELBAL. (The following two considerations refer to I/O operations involving the system device through which the operator communicates with the program. They do not apply to the I/O routines associated with the system's bulk storage device which will be discussed further on in this chapter.)

1. Only CPU register B and the accumulator may be used by the I/O routines. All the other CPU registers must contain their original values when I/O operations have been completed.

2. For the 8008 version of SCELBAL, the I/O routines themselves may only utilize a maximum of two levels of nesting! This is because, when called, the 8008 internal stack may at times be loaded to the point where pushing the stack down more than two times would result in the loss of stack information.

Consideration number one above causes no real concern for readers who implement SCELBAL on an 8080 system. The 8080, which has the CPU's stack implemented in RAM memory, can easily save CPU registers C through L on the stack if required while performing an I/O operation. The registers may then be restored from the stack when the I/O operation is completed.

For 8008 users, the consideration will be fairly easy for most users to cope with if their I/O device has a parallel type interface with the computer such as commonly found

in devices that utilize a UART device. With such an interface it is generally quite easy to perform the necessary transfer functions using just the accumulator and a CPU register. (Just remember to use register B!)

Users with a serial interface may find the restriction somewhat challenging, especially if restriction number two above also applies. As an aid to those that might find themselves in such a situation, an example input and output routine designed to operate with a serial electro-mechanical keyboard and printer, that satisfies both conditions above, will be provided starting on the next page.

Consideration number two must be strictly adhered to when SCELBAL is operating in an 8008 system. Naturally, for an 8080 based unit with its stack residing in RAM memory, the restriction does not apply provided that the user allocates sufficient room for the stack in memory. Recommendations of suitable areas in memory that may be reserved for 8080 stack use are made in the chapter that contains the object code listing of the SCELBAL program for the 8080 CPU.

| CHARACTER | BINARY | OCTAL | CHARACTER | BINARY | OCTAL |
|---|---|---|---|---|---|
| A | 11 000 001 | 301 | ! | 10 100 001 | 241 |
| B | 11 000 010 | 302 | " | 10 100 010 | 242 |
| C | 11 000 011 | 303 | # | 10 100 011 | 243 |
| D | 11 000 100 | 304 | $ | 10 100 100 | 244 |
| E | 11 000 101 | 305 | % | 10 100 101 | 245 |
| F | 11 000 110 | 306 | & | 10 100 110 | 246 |
| G | 11 000 111 | 307 | ' | 10 100 111 | 247 |
| H | 11 001 000 | 310 | ( | 10 101 000 | 250 |
| I | 11 001 001 | 311 | ) | 10 101 001 | 251 |
| J | 11 001 010 | 312 | * | 10 101 010 | 252 |
| K | 11 001 011 | 313 | + | 10 101 011 | 253 |
| L | 11 001 100 | 314 | , | 10 101 100 | 254 |
| M | 11 001 101 | 315 | - | 10 101 101 | 255 |
| N | 11 001 110 | 316 | . | 10 101 110 | 256 |
| O | 11 001 111 | 317 | / | 10 101 111 | 257 |
| P | 11 010 000 | 320 | 0 | 10 110 000 | 260 |
| Q | 11 010 001 | 321 | 1 | 10 110 001 | 261 |
| R | 11 010 010 | 322 | 2 | 10 110 010 | 262 |
| S | 11 010 011 | 323 | 3 | 10 110 011 | 263 |
| T | 11 010 100 | 324 | 4 | 10 110 100 | 264 |
| U | 11 010 101 | 325 | 5 | 10 110 101 | 265 |
| V | 11 010 110 | 326 | 6 | 10 110 110 | 266 |
| W | 11 010 111 | 327 | 7 | 10 110 111 | 267 |
| X | 11 011 000 | 330 | 8 | 10 111 000 | 270 |
| Y | 11 011 001 | 331 | 9 | 10 111 001 | 271 |
| Z | 11 011 010 | 332 | : | 10 111 010 | 272 |
| [ | 11 011 011 | 333 | ; | 10 111 011 | 273 |
| \ | 11 011 100 | 334 | < | 10 111 100 | 274 |
| ] | 11 011 101 | 335 | = | 10 111 101 | 275 |
| ↑ | 11 011 110 | 336 | > | 10 111 110 | 276 |
| ← | 11 011 111 | 337 | ? | 10 111 111 | 277 |
| SPACE | 11 100 000 | 240 | Control 'C' | 10 000 011 | 203 |

TABLE OF ASCII CODES WITH PARITY BIT MARKING AS USED BY SCELBAL

Routine to receive serial data from an INPUT device connected to bit B7 of an input port. Incoming characters assumed to be in format: 1 start bit, eight data bits (1 to 8) and 2 stop bits. Timing loops in example shown for characters coming in at a rate of 10 characters per second and assuming 8008 CPU clock set at 500 Khz. Received character will be in the accumulator when routine is finished. This routine will automatically echo the character received to an OUTPUT device connected to bit B0 of an output port. To disable the echo replace output instructions with NOPs such as LAA. This routine uses only register B and the accumulator and does not push the CPU stack down more than two levels as it operates.

```
RCV,    INP †††     Sample the current input on the serial line from input
        NDA         Device. Check to see if the line has gone to logic zero
        JTS RCV     Condition indicating a possible START bit. If not, loop
        XRA         To look for the start bit. If have start bit, clear the ACC.
        LBI 104     Set a counter up in register B to cause time delay equal

MORE1,  DCB         To about half a bit. Fall into the first timing loop and
        JFZ MORE1   Time it out until counter in B is zero. Now start the
        OUT †††     Echo process by sending logic zero to output device.
        CAL TIMER   Call subroutine to provide time delay equal to one bit.
        CAL NEXBIT  Input the first bit.
        CAL NEXBIT  Input the second bit.
        CAL NEXBIT  Input the third bit.
        CAL NEXBIT  Input the fourth bit.
        CAL NEXBIT  Input the fifth bit.
        CAL NEXBIT  Input the sixth bit.
        CAL NEXBIT  Input the seventh bit.
        CAL NEXBIT  Input the eighth bit.

STOP,   LAI 001     Set up stop bit for the output device.
        OUT †††     Send a logic one to the output device.
        LAB         Fetch the character from B to the ACC.
        RLC         Format character to compensate for RRC by NEXBIT.
        LBI 314     Set up a counter in register B to cause time delay equal

MORE3,  DCB         To about one and a half bits for STOP bits. Fall into the
        JFZ MORE3   Timing loop and time out until counter is zero.
        RET         Now return to calling routine with character in ACC.

NEXBIT, INP †††     Input a character to bit B7 from the selected input port.
        NDI 200     Mask off bits b6 through B0 to leave just bit B7.
        RLC         Position the bit in B7 to bit B0 to prepare to Echo bit.
        OUT †††     Output bit B0 to the output device.
        RRC         Restore the bit back to B7.
        ADB         Add previous bits in character stored in register B.
        RRC         Rotate all bits to make room for next incoming bit.
```

```
TIMER,  LBI 213      Set up a counter in register B to cause time delay equal
MORE2,  DCB          To about one bit. Fall into the timing loop and
        JFZ MORE2    Time out until counter is zero.
        LBA          Now save the contents of the ACC in register B.
        RET          Return to main inputting routine.
```

Routine to send data in serial format to an OUTPUT device connected to bit B0 of an output port. Character assumed to have same format and is sent at same rate as in the example input routine. Routine expects ASCII encoded character to be in the accumulator when the routine is entered. This routine uses only register B and the accumulator and does not push the CPU stack down more than two levels during its execution.

```
PRINT,  NDA          Clear the carry flag prior to set up for sending START
        RAL          Bit. Rotate the carry status into bit B0. Now output a
        OUT †††      Logic zero level for START bit to output device.
        RAR          Restore the original ASCII character in the ACC.
        CAL TIMER    Provide one bit delay for sending of the START bit.
        CAL BITOUT   Output the first bit.
        CAL BITOUT   Output the second bit.
        CAL BITOUT   Output the third bit.
        CAL BITOUT   Output the fourth bit.
        CAL BITOUT   Output the fifth bit.
        CAL BITOUT   Output the sixth bit.
        CAL BITOUT   Output the seventh bit.
        CAL BITOUT   Output the eighth bit.
        LBA          Save contents of the ACC in register B.
        LAI 001      Set bit B0 to a logic one for sending STOP bit.
        OUT †††      Send a logic one from bit B0 to the output device.
        LAB          Restore the character from register B to the ACC.
        CAL TIMER    Provide time delay for the two STOP bits.
        LBI 103      Finish providing time delay for the STOP bits.
        JMP MORE3    Exit from the PRINT routine when finished timing out.

BITOUT, OUT †††      Output status of B0 to output device.
        RRC          Position the next bit in the ACC to bit position B0.
        CAL TIMER    Provide one bit time delay.
        RET          Return to main outputting routine.
```

It is important to reiterate, as illustrated in the example INPUT subroutine, that the input routine provided by the user for use with SCELBAL should reflect the character inputted on the system's output device. If this is not done, the operator will not be able to see the information as it is inputted. This may be done in the manner illustrated in the example program (where the character is reflected to the output device on a bit-by-bit basis as it is received) or it may be accomplished by simply having the input subroutine

jump to the output subroutine when a character has been completely received. The latter technique, however, generally slows down the overall inputting speed to a level that is unpleasant for many operators if an electromechanical I/O device is being used. This is because the operator must wait an extra fraction of a second for the character to be sent to the output device.

NOTE: The example I/O routines presented serve only as guide lines for the special case mentioned where serial I/O devices are being utilized with an 8008 equipped computer. The actual values used in timing loops, and other parameters would vary depending on the individual system's I/O arrangements. Many reader's will not require such elaborate I/O subroutines.

The two types of I/O subroutines discussed to this point are essential to the operation of SCELBAL as they provide the means for the operator to communicate with the program. There are two more types of I/O routines that might be considered optional by some users. These two routines may be created by the user to provide the capability of saving a program that has been placed in the user program buffer on an external bulk storage device, and vice versa.

The reader who desires to save user programs on a bulk storage device should note that the vector to such a routine is located in the EXECutive portion of SCELBAL in the subsection headed by the label NOSCR (at address 11 104 in the assembled version of the program). This vector is taken when an operator specifies the EXECutive command SAVE.

In order to implement SAVE capability the user need only provide a routine that will effectively dump the contents of the user program buffer and the contents of a pair of memory words on the system's bulk storage device. The pair of words that should be saved is the pair that holds the pointer to the end of the user program buffer! In the assembled version of SCELBAL provided in this manual that register pair is located at 26 364 and 26 365.

Thus, for whatever type of bulk storage device the reader is utilizing, the reader need simply create a routine that will first write out the contents of the user program buffer. (It starts at location 33 000 in the assembled version of SCELBAL provided herein. It ends at the point indicated by the contents of the "end of user program buffer pointer." That point will vary depending on the particular size of a user's program.) Then, the routine should write out the contents of the "end of user program buffer pointer" (which was just used to determine how much of the user program buffer should be written on the bulk storage device)!

The details of such a routine will be entirely a function of the type of bulk storage device the system utilizes. However, for most systems, the creation of such a routine should be quite easy and consist of a series of calls to standard driver routines for the particular device being utilized.

The fourth I/O routine referred to in SCELBAL is the routine that would read in a high level program from the bulk storage device into the user program buffer area and set the "end of user program buffer pointer" to the appropriate value. In essence, all this subroutine does is read back in what the subroutine discussed above wrote on the bulk storage medium, placing it in the appropriate addresses in memory. (The user program buffer and the two bytes of the pointer.)

Reference to this routine is made in the subsection of the EXECutive part of the program labeled NOSCR (at address 11 122 in the assembled version of the program). This routine would be executed when the user issued the LOAD directive.

The two user provided routines for handling the bulk storage device are free to use all of the CPU registers. Additionally, the developer of these routines need only ensure that the use of the CPU stack (by subroutine nest-

ing operations) is kept within the capabilities of the 8008, or, in the case of the 8080, within the boundaries of the memory area reserved for the CPU stack.

Both of the routines associated with the bulk storage device operations should end by directing program operation back to the start of the EXECutive since these operations are essentially independent events. (The EXECutive starts at location 10 266 in the assembled object code listing shown in this book.)

If the reader does not desire to implement the SAVE and LOAD commands, the two vector locations (11 104 and 11 122) can be used to direct the program back to the start of the EXECutive in case a user inadvertently should enter one of those commands.

I/O routines may be placed on page 00 in the system if desired. All of the locations on that page were left for such use in the version of SCELBAL illustrated in this publication. If that page is not suitable, the I/O routines may be tucked into some of the unused memory locations available in the assembled version illustrated on pages 31 and 32 (if the routines are relatively short). Alternately, the reader may reduce the amount of area dedicated to the storage of the user's program (USER PROGRAM BUFFER). If this is done it is recommended that the upper portion of the buffer area be used for that purpose. Then the programmer need only change the "end of buffer page" value (page 12 location 122) so that the buffer area is limited to protect the installed I/O routines.

# SCELBAL ASSEMBLED FOR OPERATION IN AN 8008 BASED SYSTEM

This chapter presents an assembled version of SCELBAL for operation in an 8008 based microcomputer. This version may be loaded into a system along with the user provided I/O subroutines to provide the user with SCELBAL capability.

The user may elect, by choosing the proper machine codes at key locations, to load the program as an 8 K version that does not have the optional DIM statement capability. This version of the program will leave room for about 1,250 bytes in the user program buffer. Or, the user may load the program as a 12 K version with DIM capability. (Leaving about 4,500 bytes for program storage.) Alternately, by changing a few specially marked locations, the user may elect to have the program operate in 8 K of memory with DIM capability. However, this version is not recommended because it will leave only about 500 bytes for storage of a high level language user program. (It is mentioned as an option because some prospective users may desire to run small programs that require the DIM capability.) Finally, the user may opt to place the DIM routines (by changing the associated pointers, etc.) in the upper pages of available RAM memory in any system having more than 8 K of memory (such as a 10 K, 16 K, 32K system) and using the area between the locations used by the main SCELBAL routines and the optional DIM routines as a user program buffer.

The reader who has studied this book to this point should have no difficulty understanding what is involved in selecting the options just mentioned. Many readers may well elect to make other alterations and may, of course, do so at their own discretion. Let it be said, that the version presented is just one way in which the program may be assembled for operation!

The reader should pay careful attention in the following object code listing to all locations marked by a double asterisk (**), double at sign (@@), or double cross (††). The convention established in the earlier chapters for those special indicators will be reviewed here.

A double asterisk (**) is of importance only to those readers who might elect to change the memory pages used for the storage of pointers, counters, temporary buffers and look-up tables. The pages used for these purposes in the version of SCELBAL presented are pages 01, 26 and 27. Readers who take on the task of re-assigning these pages will probably have elected to completely reassemble SCELBAL and should be equipped (mentally and with suitable hardware!) to take on such a task.

A double cross (††) denotes an elective value on the part of the user. These locations generally refer to the starting addresses of user provided routines (such as I/O drivers), or the assignment of the starting and ending address of the user program buffer area. (For the version presented the user program buffer is assumed to start on page 33 and end on page 54. The ending address would be changed to page 37 if an 8 K system was being used and the DIM capability left out. Or, page 34 for an 8 K system with DIM capability provided, etc.)

Locations marked with a @@ should be replaced with the machine code for a no-operation instruction, such as LAA, if the user will not be using the optional DIM statement capability. Alternately, some of these locations relating to addressing values would be altered if the user elected to change the storage areas for the DIM and associated array handling subroutines.

It is suggested that user I/O subroutines be placed on page 00 if possible. Alternately, they may be placed in the upper regions of available memory. If this is done, the ending address of the user program buffer should be altered accordingly.

Hopefully, all this information makes plenty of sense to the serious reader who has read this publication and is ready to implement SCELBAL.

One final word before presenting the object code is in order. Do not attempt to skip over the machine code listings provided for the special pages 01, 26 and 27. The values in the look-up tables must be in memory along with the initial values of many of the locations on those pages when the program is first started. (Those locations where the initial values are irrelevant are denoted by XXX.) The format of the object code listing for these special pages will be slightly different than the rest of the listing in that the mnemonics column will contain comments relating to the use of the locations (since the locations will contain "data" versus actual instructions.)

An assembled listing for an 8008 version of SCELBAL will now be presented.

```
01 000    XXX    Not Assigned
01 001    XXX    Not Assigned
01 002    XXX    Not Assigned
01 003    XXX    Not Assigned
01 004    000    Stores floating
01 005    000    point
01 006    100    constant
01 007    001    value +1.0
01 010    XXX    Not Assigned
01 011    XXX    Not Assigned
01 012    XXX    Not Assigned
01 013    000    Exponent Counter
01 014    000    Stores floating
01 015    000    point
01 016    000    number
01 017    000    temporarily
01 020    XXX    Not Assigned
01 021    XXX    Not Assigned
01 022    XXX    Not Assigned
01 023    XXX    Not Assigned
01 024    000    Stores floating
01 025    000    point
01 026    300    constant
01 027    001    value -1.0
01 030    000    Scratch Pad Area
 .  .     .
 .  .     .
01 047    000    Scratch Pad Area
01 050    001    Stores random
01 051    120    number generator
01 052    162    constant
01 053    002    value
01 054    XXX    Not Assigned
01 055    XXX    Not Assigned
01 056    XXX    Not Assigned
01 057    XXX    Not Assigned
```

| | | |
|---|---|---|
| 01 060 | 003 | Stores random |
| 01 061 | 150 | number generator |
| 01 062 | 157 | constant |
| 01 063 | 014 | value |
| 01 064 | 000 | Scratch Pad Area |
| . . | . | |
| . . | . | |
| 01 077 | 000 | Scratch Pad Area |
| | | |
| 01 100 | 000 | Sign Indicator |
| 01 101 | 000 | Sign Indicator |
| 01 102 | 000 | Bits Counter |
| 01 103 | 000 | Sign Indicator |
| 01 104 | 000 | Sign Indicator |
| 01 105 | 000 | Input Digit Counter |
| 01 106 | 000 | Temp Storage |
| 01 107 | 000 | Output Digit Counter |
| 01 110 | 000 | FP Mode Indicator |
| 01 111 | XXX | Not Assigned |
| . . | . | |
| . . | . | |
| 01 117 | XXX | Not Assigned |
| 01 120 | 000 | FPACC Extension |
| 01 121 | 000 | FPACC Extension |
| 01 122 | 000 | FPACC Extension |
| 01 123 | 000 | FPACC Extension |
| 01 124 | 000 | FPACC LSW |
| 01 125 | 000 | FPACC NSW |
| 01 126 | 000 | FPACC MSW |
| 01 127 | 000 | FPACC Exponent |
| 01 130 | 000 | FPOP Extension |
| 01 131 | 000 | FPOP Extension |
| 01 132 | 000 | FPOP Extension |
| 01 133 | 000 | FPOP Extension |
| 01 134 | 000 | FPOP LSW |
| 01 135 | 000 | FPOP NSW |
| 01 136 | 000 | FPOP MSW |
| 01 137 | 000 | FPOP Exponent |
| 01 140 | 000 | Floating point working area |
| . . | . | |
| . . | . | |
| 01 167 | 000 | Floating point working area |
| 01 170 | XXX | Not Assigned |
| . . | . | |
| . . | . | |
| 01 177 | XXX | Not Assigned |
| 01 200 | 000 | Temporary |
| 01 201 | 000 | register |
| 01 202 | 000 | storage |
| 01 203 | 000 | area (D, E, H & L) |

| | | |
|---|---|---|
| 01 204 | XXX | Not Assigned |
| 01 205 | XXX | Not Assigned |
| 01 206 | XXX | Not Assigned |
| 01 207 | XXX | Not Assigned |
| 01 210 | 000 | Stores floating |
| 01 211 | 000 | point |
| 01 212 | 120 | constant |
| 01 213 | 004 | value +10.0 |
| 01 214 | 147 | Stores floating |
| 01 215 | 146 | point |
| 01 216 | 146 | constant |
| 01 217 | 375 | value +0.1 |
| 01 220 | 000 | GETINP Counter |
| 01 221 | XXX | Not Assigned |
| 01 222 | XXX | Not Assigned |
| 01 223 | XXX | Not Assigned |
| 01 224 | XXX | Not Assigned |
| 01 225 | XXX | Not Assigned |
| 01 226 | XXX | Not Assigned |
| 01 227 | 000 | Arithmetic Stack Pointer |
| 01 230 | 000 | Arithmetic Stack |
| . . | . | |
| . . | . | |
| 01 277 | 000 | Arithmetic Stack |
| 01 300 | 000 | FPACC |
| 01 301 | 000 | temporary |
| 01 302 | 000 | storage |
| 01 303 | 000 | location |
| 01 304 | 000 | STEP value |
| 01 305 | 000 | temporary |
| 01 306 | 000 | storage |
| 01 307 | 000 | location |
| 01 310 | 000 | FOR/NEXT Limit |
| 01 311 | 000 | temporary |
| 01 312 | 000 | storage |
| 01 313 | 000 | location |
| 01 314 | 000 | Array pointer |
| 01 315 | 000 | temporary |
| 01 316 | 000 | storage |
| 01 317 | 000 | location |

Executive & special messages
look-up table and storage area.

| | | |
|---|---|---|
| 01 320 | 004 | (cc) for THEN |
| 01 321 | 324 | T |
| 01 322 | 310 | H |
| 01 323 | 305 | E |
| 01 324 | 316 | N |

| | | |
|---|---|---|
| 01 325 | 002 | (cc) for TO |
| 01 326 | 324 | T |
| 01 327 | 317 | O |
| 01 330 | 004 | (cc) for STEP |
| 01 331 | 323 | S |
| 01 332 | 324 | T |
| 01 333 | 305 | E |
| 01 334 | 320 | P |
| 01 335 | 004 | (cc) for LIST |
| 01 336 | 314 | L |
| 01 337 | 311 | I |
| 01 340 | 323 | S |
| 01 341 | 324 | T |
| 01 342 | 003 | (cc) for RUN |
| 01 343 | 322 | R |
| 01 344 | 325 | U |
| 01 345 | 316 | N |
| 01 346 | 003 | (cc) for SCR |
| 01 347 | 323 | S |
| 01 350 | 303 | C |
| 01 351 | 322 | R |
| 01 352 | 013 | (cc) for READY message |
| 01 353 | 224 | Ctrl T |
| 01 354 | 215 | Carriage-return |
| 01 355 | 212 | Line-feed |
| 01 356 | 322 | R |
| 01 357 | 305 | E |
| 01 360 | 301 | A |
| 01 361 | 304 | D |
| 01 362 | 331 | Y |
| 01 363 | 215 | Carriage-return |
| 01 364 | 212 | Line-feed |
| 01 365 | 212 | Line-feed |
| 01 366 | 011 | (cc) for AT LINE message |
| 01 367 | 240 | Space |
| 01 370 | 301 | A |
| 01 371 | 324 | T |
| 01 372 | 240 | Space |
| 01 373 | 314 | L |
| 01 374 | 311 | I |
| 01 375 | 316 | N |
| 01 376 | 305 | E |
| 01 377 | 240 | Space |

End of page 01.

```
02 000    106 255 002          SYNTAX,  CAL CLESYM
02 003    066 340                       LLI 340
02 005    056 026       **              LHI 026
02 007    076 000                       LMI 000
02 011    066 201                       LLI 201
02 013    076 001                       LMI 001

02 015    066 201              SYNTX1,  LLI 201
02 017    106 240 002                   CAL GETCHR
02 022    150 044 002                   JTZ SYNTX2
02 025    074 260                       CPI 260
02 027    160 061 002                   JTS SYNTX3
02 032    074 272                       CPI 272
02 034    120 061 002                   JFS SYNTX3
02 037    066 340                       LLI 340
02 041    106 314 002                   CAL CONCT1

02 044    066 201              SYNTX2,  LLI 201
02 046    106 003 003                   CAL LOOP
02 051    110 015 002                   JFZ SYNTX1
02 054    066 203                       LLI 203
02 056    076 000                       LMI 000
02 060    007                           RET

02 061    066 201              SYNTX3,  LLI 201
02 063    317                           LBM
02 064    066 202                       LLI 202
02 066    371                           LMB

02 067    066 202              SYNTX4,  LLI 202
02 071    106 240 002                   CAL GETCHR
02 074    150 171 002                   JTZ SYNTX6
02 077    074 275                       CPI 275
02 101    150 210 002                   JTZ SYNTX7
02 104    074 250                       CPI 250
02 106    150 215 002                   JTZ SYNTX8
02 111    106 310 002                   CAL CONCTS
02 114    066 203                       LLI 203
02 116    076 001                       LMI 001
02 120    056 027       **              LHI 027
02 122    066 000                       LLI 000

02 124    036 026       **     SYNTX5,  LDI 026
02 126    046 120                       LEI 120
02 130    106 332 002                   CAL STRCP
02 133    053                           RTZ
02 134    106 356 022                   CAL SWITCH

02 137    060                  SYNTXL,  INL
02 140    307                           LAM
02 141    044 300                       NDI 300
```

```
02 143      110 137 002                     JFZ SYNTXL
02 146      106 356 022                     CAL SWITCH
02 151      066 203                         LLI 203
02 153      056 026         **              LHI 026
02 155      317                             LBM
02 156      010                             INB
02 157      371                             LMB
02 160      106 356 022                     CAL SWITCH
02 163      301                             LAB
02 164      074 015                         CPI 015
02 166      110 124 002                     JFZ SYNTX5

02 171      066 202             SYNTX6,     LLI 202
02 173      056 026         **              LHI 026
02 175      106 003 003                     CAL LOOP
02 200      110 067 002                     JFZ SYNTX4
02 203      066 203                         LLI 203
02 205      076 377                         LMI 377
02 207      007                             RET

02 210      066 203             SYNTX7,     LLI 203
02 212      076 015                         LMI 015
02 214      007                             RET

02 215      066 203             SYNTX8,     LLI 203
02 217      076 016                         LMI 016
02 221      007                             RET

02 222      006 302             BIGERR,     LAI 302
02 224      026 307                         LCI 307

02 226      106 202 003          ERROR,     CAL ECHO
02 231      302                             LAC
02 232      106 202 003                     CAL ECHO
02 235      104 322 012                     JMP FINERR

02 240      307                 GETCHR,     LAM
02 241      074 120                         CPI 120
02 243      120 222 002                     JFS BIGERR
02 246      360                             LLA
02 247      056 026         **              LHI 026
02 251      307                             LAM
02 252      074 240                         CPI 240
02 254      007                             RET

02 255      066 120             CLESYM,     LLI 120
02 257      056 026         **              LHI 026
02 261      076 000                         LMI 000
02 263      007                             RET

02 264      074 301             CONCTA,     CPI 301
```

```
02 266      160 276 002                     JTS CONCTN
02 271      074 333                         CPI 333
02 273      160 310 002                     JTS CONCTS

02 276      074 260                 CONCTN, CPI 260
02 300      160 327 002                     JTS CONCTE
02 303      074 272                         CPI 272
02 305      120 327 002                     JFS CONCTE

02 310      066 120                 CONCTS, LLI 120
02 312      056 026         **              LHI 026

02 314      327                     CONCT1, LCM
02 315      020                             INC
02 316      372                             LMC
02 317      310                             LBA
02 320      106 036 023                     CAL INDEXC
02 323      371                             LMB
02 324      006 000                         LAI 000
02 326      007                             RET

02 327      104 152 011             CONCTE, JMP SYNERR

02 332      307                       STRCP, LAM
02 333      106 356 022                     CAL SWITCH
02 336      317                             LBM
02 337      271                             CPB
02 340      013                             RFZ
02 341      106 356 022                     CAL SWITCH

02 344      106 377 002             STRCPL, CAL ADV
02 347      307                             LAM
02 350      106 356 022                     CAL SWITCH
02 353      106 377 002                     CAL ADV

02 356      277                     STRCPE, CPM
02 357      013                             RFZ
02 360      106 356 022                     CAL SWITCH
02 363      011                             DCB
02 364      110 344 002                     JFZ STRCPL
02 367      007                             RET

02 370      307                     STRCPC, LAM
02 371      106 356 022                     CAL SWITCH
02 374      104 356 002                     JMP STRCPE

02 377      060                         ADV, INL
03 000      013                             RFZ
03 001      050                             INH
03 002      007                             RET
```

```
03 003      317                 LOOP,   LBM
03 004      010                         INB
03 005      371                         LMB
03 006      066 000                     LLI 000
03 010      307                         LAM
03 011      011                         DCB
03 012      271                         CPB
03 013      007                         RET

03 014      026 000             STRIN,  LCI 000

03 016      106 221 003         STRIN1, CAL CINPUT
03 021      074 377                     CPI 377
03 023      110 045 003                 JFZ NOTDEL
03 026      006 334                     LAI 334
03 030      106 202 003                 CAL ECHO
03 033      021                         DCC
03 034      160 014 003                 JTS STRIN
03 037      106 164 003                 CAL DEC
03 042      104 016 003                 JMP STRIN1

03 045      074 203             NOTDEL, CPI 203
03 047      150 313 012                 JTZ CTRLC
03 052      074 215                     CPI 215
03 054      150 102 003                 JTZ STRINF
03 057      074 212                     CPI 212
03 061      150 016 003                 JTZ STRIN1
03 064      106 377 002                 CAL ADV
03 067      020                         INC
03 070      370                         LMA
03 071      302                         LAC
03 072      074 120                     CPI 120
03 074      120 222 002                 JFS BIGERR
03 077      104 016 003                 JMP STRIN1

03 102      312                 STRINF, LBC
03 103      106 113 003                 CAL SUBHL
03 106      372                         LMC
03 107      106 141 003                 CAL CRLF
03 112      007                         RET

03 113      306                 SUBHL,  LAL
03 114      221                         SUB
03 115      360                         LLA
03 116      003                         RFC
03 117      051                         DCH
03 120      007                         RET

03 121      327                 TEXTC,  LCM
03 122      307                         LAM
03 123      240                         NDA
```

```
03 124      053                                 RTZ

03 125      106 377 002                 TEXTCL, CAL ADV
03 130      307                                 LAM
03 131      106 202 003                         CAL ECHO
03 134      021                                 DCC
03 135      110 125 003                         JFZ TEXTCL
03 140      007                                 RET

03 141      006 215                     CRLF,   LAI 215
03 143      106 202 003                         CAL ECHO
03 146      006 212                             LAI 212
03 150      106 202 003                         CAL ECHO
03 153      066 043                             LLI 043
03 155      056 001             **              LHI 001
03 157      076 001                             LMI 001
03 161      353                                 LHD
03 162      364                                 LLE
03 163      007                                 RET

03 164      061                         DEC,    DCL
03 165      060                                 INL
03 166      110 172 003                         JFZ DECN0
03 171      051                                 DCH

03 172      061                         DECN0,  DCL
03 173      007                                 RET

03 174      306                         INDEXB, LAL
03 175      201                                 ADB
03 176      360                                 LLA
03 177      003                                 RFC
03 200      050                                 INH
03 201      007                                 RET

03 202      335                         ECHO,   LDH
03 203      346                                 LEL
03 204      066 043                             LLI 043
03 206      056 001             **              LHI 001
03 210      317                                 LBM
03 211      010                                 INB
03 212      371                                 LMB
03 213      106 ††† †††         ††              CAL ††† †††
03 216      353                                 LHD
03 217      364                                 LLE
03 220      007                                 RET

03 221      104 ††† †††         ††      CINPUT, JMP ††† †††

03 224      066 227                     EVAL,   LLI 227
03 226      056 001             **              LHI 001
```

```
03 230      076 224                          LMI 224
03 232      060                              INL
03 233      056 026          **              LHI 026
03 235      076 000                          LMI 000
03 237      106 255 002                      CAL CLESYM
03 242      066 210                          LLI 210
03 244      076 000                          LMI 000
03 246      066 276                          LLI 276
03 250      317                              LBM
03 251      066 200                          LLI 200
03 253      371                              LMB

03 254      066 200                  SCAN1,  LLI 200
03 256      106 240 002                      CAL GETCHR
03 261      150 301 004                      JTZ SCAN10
03 264      074 253                          CPI 253
03 266      110 300 003                      JFZ SCAN2
03 271      066 176                          LLI 176
03 273      076 001                          LMI 001
03 275      104 351 003                      JMP SCANFN

03 300      074 255                  SCAN2,  CPI 255
03 302      110 357 003                      JFZ SCAN4
03 305      066 120                          LLI 120
03 307      307                              LAM
03 310      240                              NDA
03 311      110 345 003                      JFZ SCAN3
03 314      066 176                          LLI 176
03 316      307                              LAM
03 317      074 007                          CPI 007
03 321      150 345 003                      JTZ SCAN3
03 324      074 003                          CPI 003
03 326      150 152 011                      JTZ SYNERR
03 331      074 005                          CPI 005
03 333      150 152 011                      JTZ SYNERR
03 336      066 120                          LLI 120
03 340      076 001                          LMI 001
03 342      060                              INL
03 343      076 260                          LMI 260

03 345      066 176                  SCAN3,  LLI 176
03 347      076 002                          LMI 002

03 351      106 324 004              SCANFN, CAL PARSER
03 354      104 301 004                      JMP SCAN10

03 357      074 252                  SCAN4,  CPI 252
03 361      110 373 003                      JFZ SCAN5
03 364      066 176                          LLI 176
03 366      076 003                          LMI 003
03 370      104 351 003                      JMP SCANFN
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03 373      074 257                    SCAN5,  CPI 257
03 375      110 007 004                        JFZ SCAN6
04 000      066 176                            LLI 176
04 002      076 004                            LMI 004
04 004      104 351 003                        JMP SCANFN

04 007      074 250                    SCAN6,  CPI 250
04 011      110 033 004                        JFZ SCAN7
04 014      066 230                            LLI 230
04 016      317                                LBM
04 017      010                                INB
04 020      371                                LMB
04 021      106 100 007                        CAL FUNARR
04 024      066 176                            LLI 176
04 026      076 006                            LMI 006
04 030      104 351 003                        JMP SCANFN

04 033      074 251                    SCAN7,  CPI 251
04 035      110 064 004                        JFZ SCAN8
04 040      066 176                            LLI 176
04 042      076 007                            LMI 007
04 044      106 324 004                        CAL PARSER
04 047      106 003 007                        CAL PRIGHT
04 052      066 230                            LLI 230
04 054      056 026          **                LHI 026
04 056      317                                LBM
04 057      011                                DCB
04 060      371                                LMB
04 061      104 301 004                        JMP SCAN10

04 064      074 336                    SCAN8,  CPI 336
04 066      110 100 004                        JFZ SCAN9
04 071      066 176                            LLI 176
04 073      076 005                            LMI 005
04 075      104 351 003                        JMP SCANFN

04 100      074 274                    SCAN9,  CPI 274
04 102      110 143 004                        JFZ SCAN11
04 105      066 200                            LLI 200
04 107      317                                LBM
04 110      010                                INB
04 111      371                                LMB
04 112      106 240 002                        CAL GETCHR
04 115      074 275                            CPI 275
04 117      150 251 004                        JTZ SCAN13
04 122      074 276                            CPI 276
04 124      150 267 004                        JTZ SCAN15
04 127      066 200                            LLI 200
04 131      317                                LBM
04 132      011                                DCB
04 133      371                                LMB
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04 134      066 176                         LLI 176
04 136      076 011                         LMI 011
04 140      104 351 003                     JMP SCANFN

04 143      074 275             SCAN11,     CPI 275
04 145      110 206 004                     JFZ SCAN12
04 150      066 200                         LLI 200
04 152      317                             LBM
04 153      010                             INB
04 154      371                             LMB
04 155      106 240 002                     CAL GETCHR
04 160      074 274                         CPI 274
04 162      150 251 004                     JTZ SCAN13
04 165      074 276                         CPI 276
04 167      150 260 004                     JTZ SCAN14
04 172      066 200                         LLI 200
04 174      317                             LBM
04 175      011                             DCB
04 176      371                             LMB
04 177      066 176                         LLI 176
04 201      076 012                         LMI 012
04 203      104 351 003                     JMP SCANFN

04 206      074 276             SCAN12,     CPI 276
04 210      110 276 004                     JFZ SCAN16
04 213      066 200                         LLI 200
04 215      317                             LBM
04 216      010                             INB
04 217      371                             LMB
04 220      106 240 002                     CAL GETCHR
04 223      074 274                         CPI 274
04 225      150 267 004                     JTZ SCAN15
04 230      074 275                         CPI 275
04 232      150 260 004                     JTZ SCAN14
04 235      066 200                         LLI 200
04 237      317                             LBM
04 240      011                             DCB
04 241      371                             LMB
04 242      066 176                         LLI 176
04 244      076 013                         LMI 013
04 246      104 351 003                     JMP SCANFN

04 251      066 176             SCAN13,     LLI 176
04 253      076 014                         LMI 014
04 255      104 351 003                     JMP SCANFN

04 260      066 176             SCAN14,     LLI 176
04 262      076 015                         LMI 015
04 264      104 351 003                     JMP SCANFN

04 267      066 176             SCAN15,     LLI 176
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04 271      076 016                          LMI 016
04 273      104 351 003                      JMP SCANFN

04 276      106 310 002             SCAN16,  CAL CONCTS

04 301      066 200                 SCAN10,  LLI 200
04 303      056 026          **              LHI 026
04 305      317                              LBM
04 306      010                              INB
04 307      371                              LMB
04 310      066 277                          LLI 277
04 312      307                              LAM
04 313      011                              DCB
04 314      271                              CPB
04 315      110 254 003                      JFZ SCAN1
04 320      104 300 031                      JMP PARSEP
04 323      000                              HLT

04 324      066 120                 PARSER,  LLI 120
04 326      056 026          **              LHI 026
04 330      307                              LAM
04 331      240                              NDA
04 332      150 231 005                      JTZ PARSE
04 335      060                              INL
04 336      307                              LAM
04 337      074 256                          CPI 256
04 341      150 356 004                      JTZ PARNUM
04 344      074 260                          CPI 260
04 346      160 033 005                      JTS LOOKUP
04 351      074 272                          CPI 272
04 353      120 033 005                      JFS LOOKUP

04 356      061                     PARNUM,  DCL
04 357      307                              LAM
04 360      074 001                          CPI 001
04 362      150 005 005                      JTZ NOEXPO
04 365      206                              ADL
04 366      360                              LLA
04 367      307                              LAM
04 370      074 305                          CPI 305
04 372      110 005 005                      JFZ NOEXPO
04 375      066 200                          LLI 200
04 377      106 240 002                      CAL GETCHR
05 002      104 310 002                      JMP CONCTS

05 005      066 227                 NOEXPO,  LLI 227
05 007      056 001          **              LHI 001
05 011      307                              LAM
05 012      004 004                          ADI 004
05 014      370                              LMA
05 015      360                              LLA
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05 016    106 255 022                    CAL FSTORE
05 021    066 120                        LLI 120
05 023    056 026          **            LHI 026
05 025    106 044 023                    CAL DINPUT
05 030    104 231 005                    JMP PARSE

05 033    066 370          LOOKUP,       LLI 370
05 035    056 026          **            LHI 026
05 037    076 000                        LMI 000
05 041    066 120                        LLI 120
05 043    036 027          **            LDI 027
05 045    046 210                        LEI 210
05 047    307                            LAM
05 050    074 001                        CPI 001
05 052    110 061 005                    JFZ LOOKU1
05 055    066 122                        LLI 122
05 057    076 000                        LMI 000

05 061    066 121          LOOKU1,       LLI 121
05 063    056 026          **            LHI 026
05 065    106 356 022                    CAL SWITCH
05 070    307                            LAM
05 071    060                            INL
05 072    317                            LBM
05 073    060                            INL
05 074    106 356 022                    CAL SWITCH
05 077    277                            CPM
05 100    110 111 005                    JFZ LOOKU2
05 103    060                            INL
05 104    301                            LAB
05 105    277                            CPM
05 106    150 201 005                    JTZ LOOKU4

05 111    106 256 006      LOOKU2,       CAL AD4DE
05 114    066 370                        LLI 370
05 116    056 026          **            LHI 026
05 120    317                            LBM
05 121    010                            INB
05 122    371                            LMB
05 123    066 077                        LLI 077
05 125    056 027          **            LHI 027
05 127    301                            LAB
05 130    277                            CPM
05 131    110 061 005                    JFZ LOOKU1
05 134    066 077                        LLI 077
05 136    056 027          **            LHI 027
05 140    317                            LBM
05 141    010                            INB
05 142    371                            LMB
05 143    301                            LAB
05 144    074 025                        CPI 025
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05 146      120 222 002                         JFS BIGERR
05 151      066 121                             LLI 121
05 153      056 026          **                 LHI 026
05 155      016 002                             LBI 002
05 157      106 013 021                         CAL MOVEIT
05 162      364                                 LLE
05 163      353                                 LHD
05 164      250                                 XRA
05 165      370                                 LMA
05 166      060                                 INL
05 167      370                                 LMA
05 170      060                                 INL
05 171      370                                 LMA
05 172      060                                 INL
05 173      370                                 LMA
05 174      306                                 LAL
05 175      024 004                             SUI 004
05 177      340                                 LEA
05 200      335                                 LDH

05 201      106 317 022                 LOOKU4, CAL SAVEHL
05 204      066 227                             LLI 227
05 206      056 001          **                 LHI 001
05 210      307                                 LAM
05 211      004 004                             ADI 004
05 213      370                                 LMA
05 214      360                                 LLA
05 215      106 255 022                         CAL FSTORE
05 220      106 337 022                         CAL RESTHL
05 223      106 356 022                         CAL SWITCH
05 226      106 244 022                         CAL FLOAD

05 231      106 255 002                 PARSE,  CAL CLESYM
05 234      066 176                             LLI 176
05 236      307                                 LAM
05 237      074 007                             CPI 007
05 241      150 332 005                         JTZ PARSE2
05 244      004 240                             ADI 240
05 246      360                                 LLA
05 247      317                                 LBM
05 250      066 210                             LLI 210
05 252      327                                 LCM
05 253      106 036 023                         CAL INDEXC
05 256      307                                 LAM
05 257      004 257                             ADI 257
05 261      360                                 LLA
05 262      301                                 LAB
05 263      277                                 CPM
05 264      150 307 005                         JTZ PARSE1
05 267      160 307 005                         JTS PARSE1
05 272      066 176                             LLI 176
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05 274      317                                 LBM
05 275      066 210                             LLI 210
05 277      327                                 LCM
05 300      020                                 INC
05 301      372                                 LMC
05 302      106 036 023                         CAL INDEXC
05 305      371                                 LMB
05 306      007                                 RET

05 307      066 210                 PARSE1,     LLI 210
05 311      307                                 LAM
05 312      206                                 ADL
05 313      360                                 LLA
05 314      307                                 LAM
05 315      240                                 NDA
05 316      053                                 RTZ
05 317      066 210                             LLI 210
05 321      327                                 LCM
05 322      021                                 DCC
05 323      372                                 LMC
05 324      106 364 005                         CAL FPOPER
05 327      104 231 005                         JMP PARSE

05 332      066 210                 PARSE2,     LLI 210
05 334      056 026             **              LHI 026
05 336      307                                 LAM
05 337      206                                 ADL
05 340      360                                 LLA
05 341      307                                 LAM
05 342      240                                 NDA
05 343      150 104 006                         JTZ PARNER
05 346      066 210                             LLI 210
05 350      327                                 LCM
05 351      021                                 DCC
05 352      372                                 LMC
05 353      074 006                             CPI 006
05 355      053                                 RTZ
05 356      106 364 005                         CAL FPOPER
05 361      104 332 005                         JMP PARSE2

05 364      066 371                 FPOPER,     LLI 371
05 366      056 026             **              LHI 026
05 370      370                                 LMA
05 371      066 227                             LLI 227
05 373      056 001             **              LHI 001
05 375      307                                 LAM
05 376      360                                 LLA
05 377      106 266 022                         CAL OPLOAD
06 002      066 227                             LLI 227
06 004      307                                 LAM
06 005      024 004                             SUI 004
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06 007      370                                 LMA
06 010      066 371                             LLI 371
06 012      056 026          **                 LHI 026
06 014      307                                 LAM
06 015      074 001                             CPI 001
06 017      150 211 020                         JTZ FPADD
06 022      074 002                             CPI 002
06 024      150 032 021                         JTZ FPSUB
06 027      074 003                             CPI 003
06 031      150 046 021                         JTZ FPMULT
06 034      074 004                             CPI 004
06 036      150 322 021                         JTZ FPDIV
06 041      074 005                             CPI 005
06 043      150 263 006                         JTZ INTEXP
06 046      074 011                             CPI 011
06 050      150 121 006                         JTZ LT
06 053      074 012                             CPI 012
06 055      150 136 006                         JTZ EQ
06 060      074 013                             CPI 013
06 062      150 153 006                         JTZ GT
06 065      074 014                             CPI 014
06 067      150 173 006                         JTZ LE
06 072      074 015                             CPI 015
06 074      150 213 006                         JTZ GE
06 077      074 016                             CPI 016
06 101      150 230 006                         JTZ NE
06 104      066 230                  PARNER,    LLI 230
06 106      056 026          **                 LHI 026
06 110      076 000                             LMI 000
06 112      006 311                             LAI 311
06 114      026 250                             LCI 250
06 116      104 226 002                         JMP ERROR

06 121      106 032 021                 LT,     CAL FPSUB
06 124      066 126                             LLI 126
06 126      307                                 LAM
06 127      240                                 NDA
06 130      160 242 006                         JTS CTRUE
06 133      104 247 006                         JMP CFALSE

06 136      106 032 021                 EQ,     CAL FPSUB
06 141      066 126                             LLI 126
06 143      307                                 LAM
06 144      240                                 NDA
06 145      150 242 006                         JTZ CTRUE
06 150      104 247 006                         JMP CFALSE

06 153      106 032 021                 GT,     CAL FPSUB
06 156      066 126                             LLI 126
06 160      307                                 LAM
06 161      240                                 NDA
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06 162    150 247 006                    JTZ CFALSE
06 165    120 242 006                    JFS CTRUE
06 170    104 247 006                    JMP CFALSE

06 173    106 032 021              LE,   CAL FPSUB
06 176    066 126                        LLI 126
06 200    307                            LAM
06 201    240                            NDA
06 202    150 242 006                    JTZ CTRUE
06 205    160 242 006                    JTS CTRUE
06 210    104 247 006                    JMP CFALSE

06 213    106 032 021              GE,   CAL FPSUB
06 216    066 126                        LLI 126
06 220    307                            LAM
06 221    240                            NDA
06 222    120 242 006                    JFS CTRUE
06 225    104 247 006                    JMP CFALSE

06 230    106 032 021              NE,   CAL FPSUB
06 233    066 126                        LLI 126
06 235    307                            LAM
06 236    240                            NDA
06 237    150 247 006                    JTZ CFALSE

06 242    066 004            CTRUE, FPONE, LLI 004
06 244    104 244 022                    JMP FLOAD

06 247    066 127                CFALSE, LLI 127
06 251    076 000                        LMI 000
06 253    104 051 020                    JMP FPZERO

06 256    304                    AD4DE,  LAE
06 257    004 004                        ADI 004
06 261    340                            LEA
06 262    007                            RET

06 263    066 126                INTEXP, LLI 126
06 265    056 001          **            LHI 001
06 267    307                            LAM
06 270    066 003                        LLI 003
06 272    370                            LMA
06 273    240                            NDA
06 274    150 242 006                    JTZ FPONE
06 277    162 202 020                    CTS FPCOMP
06 302    106 000 020                    CAL FPFIX
06 305    066 124                        LLI 124
06 307    317                            LBM
06 310    066 013                        LLI 013
06 312    371                            LMB
06 313    066 134                        LLI 134
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06 315    046 014                          LEI 014
06 317    056 001          **              LHI 001
06 321    335                              LDH
06 322    016 004                          LBI 004
06 324    106 013 021                      CAL MOVEIT
06 327    106 242 006                      CAL FPONE
06 332    066 003                          LLI 003
06 334    307                              LAM
06 335    240                              NDA
06 336    160 362 006                      JTS DVLOOP

06 341    066 014                MULOOP,   LLI 014
06 343    106 277 022                      CAL FACXOP
06 346    106 046 021                      CAL FPMULT
06 351    066 013                          LLI 013
06 353    317                              LBM
06 354    011                              DCB
06 355    371                              LMB
06 356    110 341 006                      JFZ MULOOP
06 361    007                              RET

06 362    066 014                DVLOOP,   LLI 014
06 364    106 277 022                      CAL FACXOP
06 367    106 322 021                      CAL FPDIV
06 372    066 013                          LLI 013
06 374    317                              LBM
06 375    011                              DCB
06 376    371                              LMB
06 377    110 362 006                      JFZ DVLOOP
07 002    007                              RET

07 003    066 230                PRIGHT,   LLI 230
07 005    056 026          **              LHI 026
07 007    307                              LAM
07 010    206                              ADL
07 011    360                              LLA
07 012    307                              LAM
07 013    076 000                          LMI 000
07 015    066 203                          LLI 203
07 017    056 027          **              LHI 027
07 021    370                              LMA
07 022    240                              NDA
07 023    053                              RTZ
07 024    160 000 055      @@              JTS PRIGH1
07 027    074 001                          CPI 001
07 031    150 243 007                      JTZ INTX
07 034    074 002                          CPI 002
07 036    150 360 007                      JTZ SGNX
07 041    074 003                          CPI 003
07 043    150 346 007                      JTZ ABSX
07 046    074 004                          CPI 004
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07 050      150 000 032                         JTZ SQRX
07 053      074 005                             CPI 005
07 055      150 017 010                         JTZ TABX
07 060      074 006                             CPI 006
07 062      150 240 032                         JTZ RNDX
07 065      074 007                             CPI 007
07 067      150 377 007                         JTZ CHRX
07 072      074 010                             CPI 010
07 074      150 ††† †††     ††                  JTZ UDEFX
07 077      000                                 HLT

07 100      066 120                 FUNARR,     LLI 120
07 102      056 026         **                  LHI 026
07 104      307                                 LAM
07 105      240                                 NDA
07 106      053                                 RTZ
07 107      066 202                             LLI 202
07 111      056 027         **                  LHI 027
07 113      076 000                             LMI 000

07 115      066 202                 FUNAR1,     LLI 202
07 117      056 026         **                  LHI 026
07 121      317                                 LBM
07 122      010                                 INB
07 123      371                                 LMB
07 124      026 002                             LCI 002
07 126      066 274                             LLI 274
07 130      056 026         **                  LHI 026
07 132      106 230 007                         CAL TABADR
07 135      036 026         **                  LDI 026
07 137      046 120                             LEI 120
07 141      106 332 002                         CAL STRCP
07 144      150 207 007                         JTZ FUNAR4
07 147      066 202                             LLI 202
07 151      056 027         **                  LHI 027
07 153      307                                 LAM
07 154      074 010                             CPI 010
07 156      110 115 007                         JFZ FUNAR1
07 161      066 202                             LLI 202
07 163      056 027         **                  LHI 027
07 165      076 000                             LMI 000
07 167      104 054 055     @@                  JMP FUNAR2

07 172      066 230                 FAERR,      LLI 230
07 174      056 026         **                  LHI 026
07 176      076 000                             LMI 000
07 200      006 306                             LAI 306
07 202      026 301                             LCI 301
07 204      104 226 002                         JMP ERROR

07 207      066 202                 FUNAR4,     LLI 202
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07 211      056 027          **                    LHI 027
07 213      317                                    LBM
07 214      066 230                                LLI 230
07 216      056 026          **                    LHI 026
07 220      327                                    LCM
07 221      106 036 023                            CAL INDEXC
07 224      371                                    LMB
07 225      104 255 002                            JMP CLESYM

07 230      301                          TABADR,   LAB
07 231      002                          TABAD1,   RLC
07 232      021                                    DCC
07 233      110 231 007                            JFZ TABAD1
07 236      206                                    ADL
07 237      360                                    LLA
07 240      003                                    RFC
07 241      050                                    INH
07 242      007                                    RET

07 243      066 126                        INTX,   LLI 126
07 245      056 001          **                    LHI 001
07 247      307                                    LAM
07 250      240                                    NDA
07 251      120 327 007                            JFS INT1
07 254      066 014                                LLI 014
07 256      106 255 022                            CAL FSTORE
07 261      106 000 020                            CAL FPFIX
07 264      066 123                                LLI 123
07 266      076 000                                LMI 000
07 270      106 064 020                            CAL FPFLT
07 273      066 014                                LLI 014
07 275      106 266 022                            CAL OPLOAD
07 300      106 032 021                            CAL FPSUB
07 303      066 126                                LLI 126
07 305      307                                    LAM
07 306      240                                    NDA
07 307      150 341 007                            JTZ INT2
07 312      066 014                                LLI 014
07 314      106 244 022                            CAL FLOAD
07 317      066 024                                LLI 024
07 321      106 277 022                            CAL FACXOP
07 324      106 211 020                            CAL FPADD

07 327      106 000 020                    INT1,   CAL FPFIX
07 332      066 123                                LLI 123
07 334      076 000                                LMI 000
07 336      104 064 020                            JMP FPFLT

07 341      066 014                        INT2,   LLI 014
07 343      104 244 022                            JMP FLOAD
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07 346    066 126                    ABSX,  LLI 126
07 350    056 001          **               LHI 001
07 352    307                               LAM
07 353    240                               NDA
07 354    160 202 020                       JTS FPCOMP
07 357    007                               RET

07 360    066 126                    SGNX,  LLI 126
07 362    056 001          **               LHI 001
07 364    307                               LAM
07 365    240                               NDA
07 366    053                               RTZ
07 367    120 242 006                       JFS FPONE
07 372    066 024                           LLI 024
07 374    104 244 022                       JMP FLOAD

07 377    106 000 020                CHRX,  CAL FPFIX
10 002    066 124                           LLI 124
10 004    307                               LAM
10 005    106 202 003                       CAL ECHO
10 010    066 177                           LLI 177
10 012    056 026          **               LHI 026
10 014    076 377                           LMI 377
10 016    007                               RET

10 017    106 000 020                TABX,  CAL FPFIX
10 022    066 124                    TAB1,  LLI 124
10 024    307                               LAM
10 025    066 043                           LLI 043
10 027    227                               SUM
10 030    066 177                           LLI 177
10 032    056 026          **               LHI 026
10 034    076 377                           LMI 377
10 036    160 217 031                       JTS BACKSP
10 041    053                               RTZ

10 042    320                        TABC,  LCA
10 043    006 240                           LAI 240
10 045    106 202 003                TABLOP, CAL ECHO
10 050    021                               DCC
10 051    110 045 010                       JFZ TABLOP
10 054    007                               RET

10 055    066 201                    STOSYM, LLI 201
10 057    056 027          **               LHI 027
10 061    307                               LAM
10 062    240                               NDA
10 063    150 100 010                       JTZ STOSY1
10 066    076 000                           LMI 000
10 070    066 204                           LLI 204
10 072    367                               LLM
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10 073    056 057          ††                LHI 057
10 075    104 255 022                        JMP FSTORE

10 100    066 370                 STOSY1,    LLI 370
10 102    056 026          **                LHI 026
10 104    076 000                            LMI 000
10 106    066 120                            LLI 120
10 110    036 027          **                LDI 027
10 112    046 210                            LEI 210
10 114    307                                LAM
10 115    074 001                            CPI 001
10 117    110 126 010                        JFZ STOSY2
10 122    066 122                            LLI 122
10 124    076 000                            LMI 000

10 126    066 121                 STOSY2,    LLI 121
10 130    056 026          **                LHI 026
10 132    106 356 022                        CAL SWITCH
10 135    307                                LAM
10 136    060                                INL
10 137    317                                LBM
10 140    060                                INL
10 141    106 356 022                        CAL SWITCH
10 144    277                                CPM
10 145    110 156 010                        JFZ STOSY3
10 150    060                                INL
10 151    301                                LAB
10 152    277                                CPM
10 153    150 227 010                        JTZ STOSY5

10 156    106 256 006             STOSY3,    CAL AD4DE
10 161    066 370                            LLI 370
10 163    056 026          **                LHI 026
10 165    317                                LBM
10 166    010                                INB
10 167    371                                LMB
10 170    066 077                            LLI 077
10 172    056 027          **                LHI 027
10 174    301                                LAB
10 175    277                                CPM
10 176    110 126 010                        JFZ STOSY2
10 201    066 077                            LLI 077
10 203    056 027          **                LHI 027
10 205    317                                LBM
10 206    010                                INB
10 207    371                                LMB
10 210    301                                LAB
10 211    074 025                            CPI 025
10 213    120 222 002                        JFS BIGERR
10 216    066 121                            LLI 121
10 220    056 026          **                LHI 026
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10 222    016 002                          LBI 002
10 224    106 013 021                      CAL MOVEIT

10 227    106 356 022           STOSY5,    CAL SWITCH
10 232    106 255 022                      CAL FSTORE
10 235    104 255 002                      JMP CLESYM

10 240    066 120               SAVESY,    LLI 120
10 242    056 026         **               LHI 026
10 244    335                              LDH
10 245    046 144                          LEI 144
10 247    104 261 010                      JMP MOVECP

10 252    066 144               RESTSY,    LLI 144
10 254    056 026         **               LHI 026
10 256    335                              LDH
10 257    046 120                          LEI 120

10 261    317                   MOVECP,    LBM
10 262    010                              INB
10 263    104 013 021                      JMP MOVEIT

10 266    066 352                 EXEC,    LLI 352
10 270    056 001         **               LHI 001
10 272    106 121 003                      CAL TEXTC

10 275    066 000               EXEC1,     LLI 000
10 277    056 026         **               LHI 026
10 301    106 014 003                      CAL STRIN
10 304    307                              LAM
10 305    240                              NDA
10 306    150 275 010                      JTZ EXEC1
10 311    066 335                          LLI 335
10 313    056 001         **               LHI 001
10 315    036 026         **               LDI 026
10 317    046 000                          LEI 000
10 321    106 332 002                      CAL STRCP
10 324    110 354 010                      JFZ NOLIST
10 327    066 000                          LLI 000
10 331    056 033         ††               LHI 033

10 333    307                     LIST,    LAM
10 334    240                              NDA
10 335    150 266 010                      JTZ EXEC
10 340    106 121 003                      CAL TEXTC
10 343    106 377 002                      CAL ADV
10 346    106 141 003                      CAL CRLF
10 351    104 333 010                      JMP LIST

10 354    066 342               NOLIST,    LLI 342
10 356    056 001         **               LHI 001
```

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10 360      046 000                          LEI 000
10 362      036 026          **              LDI 026
10 364      046 000                          LEI 000
10 366      106 332 002                      CAL STRCP
10 371      150 070 013                      JTZ RUN
10 374      036 026          **              LDI 026
10 376      046 000                          LEI 000
11 000      066 346                          LLI 346
11 002      056 001          **              LHI 001
11 004      106 332 002                      CAL STRCP
11 007      110 071 011                      JFZ NOSCR
11 012      056 026          **              LHI 026
11 014      066 364                          LLI 364
11 016      076 033          ††              LMI 033
11 020      060                              INL
11 021      076 000                          LMI 000
11 023      066 077                          LLI 077
11 025      056 027          **              LHI 027
11 027      076 001                          LMI 001
11 031      066 075                          LLI 075
11 033      076 000          @@              LMI 000
11 035      066 120          @@              LLI 120
11 037      076 000          @@              LMI 000
11 041      066 210                          LLI 210
11 043      076 000                          LMI 000
11 045      060                              INL
11 046      076 000                          LMI 000
11 050      056 033          ††              LHI 033
11 052      066 000                          LLI 000
11 054      076 000                          LMI 000
11 056      056 057          @@              LHI 057

11 060      076 000          @@    SCRLOP,   LMI 000
11 062      060              @@              INL
11 063      110 060 011      @@              JFZ SCRLOP
11 066      104 266 010                      JMP EXEC

11 071      046 272                NOSCR,    LEI 272
11 073      036 001          **              LDI 001
11 075      056 026          **              LHI 026
11 077      066 000                          LLI 000
11 101      106 332 002                      CAL STRCP
11 104      150 ††† †††      ††              JTZ SAVE
11 107      066 277                          LLI 277
11 111      056 001          **              LHI 001
11 113      036 026          **              LDI 026
11 115      046 000                          LEI 000
11 117      106 332 002                      CAL STRCP
11 122      150 ††† †††      ††              JTZ LOAD
11 125      066 360                          LLI 360
11 127      056 026          **              LHI 026
```

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11 131      076 033          ††                LMI 033
11 133      060                                INL
11 134      076 000                            LMI 000
11 136      106 000 002                        CAL SYNTAX
11 141      066 203                            LLI 203
11 143      056 026          **                LHI 026
11 145      307                                LAM
11 146      240                                NDA
11 147      120 161 011                        JFS SYNTOK

11 152      006 323                 SYNERR,    LAI 323
11 154      026 331                            LCI 331
11 156      104 226 002                        JMP ERROR

11 161      066 340                 SYNTOK,    LLI 340
11 163      307                                LAM
11 164      240                                NDA
11 165      150 211 013                        JTZ DIRECT
11 170      066 360                            LLI 360
11 172      076 033          ††                LMI 033
11 174      060                                INL
11 175      076 000                            LMI 000

11 177      066 201                 GETAUX,    LLI 201
11 201      056 026          **                LHI 026
11 203      076 001                            LMI 001
11 205      066 350                            LLI 350
11 207      076 000                            LMI 000

11 211      066 201                 GETAU0,    LLI 201
11 213      106 123 012                        CAL GETCHP
11 216      150 242 011                        JTZ GETAU1
11 221      074 260                            CPI 260
11 223      160 267 011                        JTS GETAU2
11 226      074 272                            CPI 272
11 230      120 267 011                        JFS GETAU2
11 233      066 350                            LLI 350
11 235      056 026          **                LHI 026
11 237      106 314 002                        CAL CONCT1

11 242      066 201                 GETAU1,    LLI 201
11 244      056 026          **                LHI 026
11 246      317                                LBM
11 247      010                                INB
11 250      371                                LMB
11 251      066 360                            LLI 360
11 253      056 026          **                LHI 026
11 255      327                                LCM
11 256      060                                INL
11 257      367                                LLM
11 260      352                                LHC
```

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11 261      307                                 LAM
11 262      011                                 DCB
11 263      271                                 CPB
11 264      110 211 011                         JFZ GETAU0

11 267      066 360                 GETAU2,     LLI 360
11 271      056 026         **                  LHI 026
11 273      337                                 LDM
11 274      060                                 INL
11 275      367                                 LLM
11 276      353                                 LHD
11 277      307                                 LAM
11 300      240                                 NDA
11 301      110 336 011                         JFZ NOTEND
11 304      104 005 012                         JMP NOSAME

Note open addresses.
This space available
for patching.

11 336      066 350                 NOTEND,     LLI 350
11 340      056 026         **                  LHI 026
11 342      036 026         **                  LDI 026
11 344      046 340                             LEI 340
11 346      106 332 002                         CAL STRCP
11 351      160 073 012                         JTS CONTIN
11 354      110 005 012                         JFZ NOSAME
11 357      066 360                             LLI 360
11 361      056 026         **                  LHI 026
11 363      327                                 LCM
11 364      060                                 INL
11 365      367                                 LLM
11 366      352                                 LHC
11 367      317                                 LBM
11 370      010                                 INB
11 371      106 144 012                         CAL REMOVE
11 374      066 203                             LLI 203
11 376      056 026         **                  LHI 026
12 000      307                                 LAM
12 001      240                                 NDA
12 002      150 266 010                         JTZ EXEC

12 005      066 360                 NOSAME,     LLI 360
12 007      056 026         **                  LHI 026
12 011      337                                 LDM
12 012      060                                 INL
12 013      347                                 LEM
12 014      066 000                             LLI 000
12 016      056 026         **                  LHI 026
12 020      317                                 LBM
12 021      010                                 INB
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12 022    106 205 012                    CAL INSERT
12 025    066 360                        LLI 360
12 027    056 026          **            LHI 026
12 031    337                            LDM
12 032    060                            INL
12 033    347                            LEM
12 034    066 000                        LLI 000
12 036    056 026          **            LHI 026
12 040    106 046 012                    CAL MOVEC
12 043    104 275 010                    JMP EXEC1

12 046    317                  MOVEC,    LBM
12 047    010                            INB

12 050    307                  MOVEPG,   LAM
12 051    106 377 002                    CAL ADV
12 054    106 356 022                    CAL SWITCH
12 057    370                            LMA
12 060    106 377 002                    CAL ADV
12 063    106 356 022                    CAL SWITCH
12 066    011                            DCB
12 067    110 050 012                    JFZ MOVEPG
12 072    007                            RET

12 073    066 360              CONTIN,   LLI 360
12 075    056 026          **            LHI 026
12 077    337                            LDM
12 100    060                            INL
12 101    347                            LEM
12 102    353                            LHD
12 103    364                            LLE
12 104    317                            LBM
12 105    010                            INB
12 106    106 305 012                    CAL ADBDE
12 111    066 360                        LLI 360
12 113    056 026          **            LHI 026
12 115    373                            LMD
12 116    060                            INL
12 117    374                            LME
12 120    104 177 011                    JMP GETAUX

12 123    056 026          **  GETCHP,   LHI 026
12 125    317                            LBM
12 126    066 360                        LLI 360
12 130    337                            LDM
12 131    060                            INL
12 132    347                            LEM
12 133    106 305 012                    CAL ADBDE
12 136    353                            LHD
12 137    364                            LLE
12 140    307                            LAM
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12 141    074 240                          CPI 240
12 143    007                              RET

12 144    106 174 003          REMOVE,     CAL INDEXB
12 147    327                              LCM
12 150    106 113 003                      CAL SUBHL
12 153    372                              LMC
12 154    302                              LAC
12 155    240                              NDA
12 156    150 167 012                      JTZ REMOV1
12 161    106 377 002                      CAL ADV
12 164    104 144 012                      JMP REMOVE

12 167    066 364              REMOV1,     LLI 364
12 171    056 026          **              LHI 026
12 173    337                              LDM
12 174    060                              INL
12 175    307                              LAM
12 176    221                              SUB
12 177    370                              LMA
12 200    003                              RFC
12 201    061                              DCL
12 202    031                              DCD
12 203    373                              LMD
12 204    007                              RET

12 205    066 364              INSERT,     LLI 364
12 207    056 026          **              LHI 026
12 211    307                              LAM
12 212    060                              INL
12 213    367                              LLM
12 214    350                              LHA
12 215    106 174 003                      CAL INDEXB
12 220    305                              LAH
12 221    074 054          ††              CPI 054
12 223    120 222 002                      JFS BIGERR
12 226    106 113 003                      CAL SUBHL

12 231    327                  INSER1,     LCM
12 232    106 174 003                      CAL INDEXB
12 235    372                              LMC
12 236    106 113 003                      CAL SUBHL
12 241    106 277 012                      CAL CPHLDE
12 244    150 255 012                      JTZ INSER3
12 247    106 164 003                      CAL DEC
12 252    104 231 012                      JMP INSER1

12 255    066 000          INSER3, INCLIN, LLI 000
12 257    056 026          **              LHI 026
12 261    317                              LBM
12 262    010                              INB
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12 263     066 364                          LLI 364
12 265     337                              LDM
12 266     060                              INL
12 267     347                              LEM
12 270     106 305 012                      CAL ADBDE
12 273     374                              LME
12 274     061                              DCL
12 275     373                              LMD
12 276     007                              RET

12 277     305                  CPHLDE,     LAH
12 300     273                              CPD
12 301     013                              RFZ
12 302     306                              LAL
12 303     274                              CPE
12 304     007                              RET

12 305     304                  ADBDE,      LAE
12 306     201                              ADB
12 307     340                              LEA
12 310     003                              RFC
12 311     030                              IND
12 312     007                              RET

12 313     006 336              CTRLC,      LAI 336
12 315     026 303                          LCI 303
12 317     104 226 002                      JMP ERROR

12 322     066 340              FINERR,     LLI 340
12 324     056 026         **               LHI 026
12 326     307                              LAM
12 327     240                              NDA
12 330     150 351 012                      JTZ FINER1
12 333     066 366                          LLI 366
12 335     056 001         **               LHI 001
12 337     106 121 003                      CAL TEXTC
12 342     066 340                          LLI 340
12 344     056 026         **               LHI 026
12 346     106 121 003                      CAL TEXTC

12 351     106 141 003          FINER1,     CAL CRLF
12 354     104 266 010                      JMP EXEC

12 357     006 304              DVERR,      LAI 304
12 361     026 332                          LCI 332
12 363     104 226 002                      JMP ERROR

12 366     006 306              FIXERR,     LAI 306
12 370     026 330                          LCI 330
12 372     104 226 002                      JMP ERROR
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12 375      006 311                    NUMERR,  LAI 311
12 377      026 316                             LCI 316
13 001      066 220                             LLI 220
13 003      056 001          **                 LHI 001
13 005      076 000                             LMI 000
13 007      104 226 002                         JMP ERROR

13 012      036 026          **         INSTR,   LDI 026
13 014      046 000                             LEI 000

13 016      106 064 013                INSTR1,  CAL ADVDE
13 021      106 317 022                         CAL SAVEHL
13 024      317                                 LBM
13 025      106 377 002                         CAL ADV
13 030      106 370 002                         CAL STRCPC
13 033      150 337 022                         JTZ RESTHL
13 036      106 337 022                         CAL RESTHL
13 041      066 000                             LLI 000
13 043      056 026          **                 LHI 026
13 045      307                                 LAM
13 046      274                                 CPE
13 047      150 061 013                         JTZ INSTR2
13 052      106 337 022                         CAL RESTHL
13 055      104 016 013                         JMP INSTR1
13 060      000                                 HLT

13 061      046 000                    INSTR2,  LEI 000
13 063      007                                 RET

13 064      040                        ADVDE,   INE
13 065      013                                 RFZ
13 066      030                                 IND
13 067      007                                 RET

13 070      066 073                    RUN,     LLI 073
13 072      056 027          **                 LHI 027
13 074      076 000                             LMI 000
13 076      066 205                             LLI 205
13 100      076 000                             LMI 000
13 102      066 360                             LLI 360
13 104      056 026          **                 LHI 026
13 106      076 033          ††                 LMI 033
13 110      060                                 INL
13 111      076 000                             LMI 000
13 113      104 156 013                         JMP SAMLIN

13 116      066 360                    NXTLIN,  LLI 360
13 120      056 026          **                 LHI 026
13 122      337                                 LDM
13 123      060                                 INL
13 124      347                                 LEM
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13 125      353                              LHD
13 126      364                              LLE
13 127      317                              LBM
13 130      010                              INB
13 131      106 305 012                      CAL ADBDE
13 134      066 360                          LLI 360
13 136      056 026          **              LHI 026
13 140      373                              LMD
13 141      060                              INL
13 142      374                              LME
13 143      066 340                          LLI 340
13 145      056 026          **              LHI 026
13 147      307                              LAM
13 150      240                              NDA
13 151      150 266 010                      JTZ EXEC
13 154      300                              LAA
13 155      300                              LAA

13 156      066 360                SAMLIN,   LLI 360
13 160      056 026          **              LHI 026
13 162      327                              LCM'
13 163      060                              INL
13 164      367                              LLM
13 165      352                              LHC
13 166      036 026          **              LDI 026
13 170      046 000                          LEI 000
13 172      106 046 012                      CAL MOVEC
13 175      066 000                          LLI 000
13 177      056 026          **              LHI 026
13 201      307                              LAM
13 202      240                              NDA
13 203      150 266 010                      JTZ EXEC
13 206      106 000 002                      CAL SYNTAX

13 211      066 203                DIRECT,   LLI 203
13 213      056 026          **              LHI 026
13 215      307                              LAM
13 216      074 001                          CPI 001
13 220      150 116 013                      JTZ NXTLIN
13 223      074 002                          CPI 002
13 225      150 027 016                      JTZ IF
13 230      074 003                          CPI 003
13 232      150 031 015                      JTZ LET
13 235      074 004                          CPI 004
13 237      150 174 015                      JTZ GOTO
13 242      074 005                          CPI 005
13 244      150 345 013                      JTZ PRINT
13 247      074 006                          CPI 006
13 251      150 365 016                      JTZ INPUT
13 254      074 007                          CPI 007
13 256      150 164 017                      JTZ FOR
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13 261      074 010                          CPI 010
13 263      150 013 030                      JTZ NEXT
13 266      074 011                          CPI 011
13 270      150 236 016                      JTZ GOSUB
13 273      074 012                          CPI 012
13 275      150 304 016                      JTZ RETURN
13 300      074 013                          CPI 013
13 302      150 365 055      @@              JTZ DIM
13 305      074 014                          CPI 014
13 307      150 266 010                      JTZ EXEC
13 312      074 015                          CPI 015
13 314      150 013 015                      JTZ LET0
13 317      074 016          @@              CPI 016
13 321      110 152 011                      JFZ SYNERR
13 324      106 153 055      @@              CAL ARRAY1
13 327      066 206          @@              LLI 206
13 331      056 026          @@**            LHI 026
13 333      317              @@              LBM
13 334      066 202          @@              LLI 202
13 336      371              @@              LMB
13 337      106 240 010      @@              CAL SAVESY
13 342      104 042 015      @@              JMP LET1

13 345      066 202                  PRINT,  LLI 202
13 347      056 026          **              LHI 026
13 351      307                              LAM
13 352      066 000                          LLI 000
13 354      277                              CPM
13 355      160 366 013                      JTS PRINT1
13 360      106 141 003                      CAL CRLF
13 363      104 116 013                      JMP NXTLIN

13 366      106 255 002              PRINT1, CAL CLESYM
13 371      066 202                          LLI 202
13 373      056 026          **              LHI 026
13 375      317                              LBM
13 376      010                              INB
13 377      066 203                          LLI 203
14 001      371                              LMB

14 002      066 203                  PRINT2, LLI 203
14 004      106 240 002                      CAL GETCHR
14 007      074 247                          CPI 247
14 011      150 203 014                      JTZ QUOTE
14 014      074 242                          CPI 242
14 016      150 203 014                      JTZ QUOTE
14 021      074 254                          CPI 254
14 023      150 043 014                      JTZ PRINT3
14 026      074 273                          CPI 273
14 030      150 043 014                      JTZ PRINT3
14 033      066 203                          LLI 203
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14 035    106 003 003                    CAL LOOP
14 040    110 002 014                    JFZ PRINT2

14 043    066 202              PRINT3,   LLI 202
14 045    317                            LBM
14 046    010                            INB
14 047    066 276                        LLI 276
14 051    371                            LMB
14 052    066 203                        LLI 203
14 054    317                            LBM
14 055    011                            DCB
14 056    066 277                        LLI 277
14 060    371                            LMB
14 061    066 367                        LLI 367
14 063    307                            LAM
14 064    240                            NDA
14 065    150 075 014                    JTZ PRINT4
14 070    076 000                        LMI 000
14 072    104 125 014                    JMP PRINT6

14 075    106 224 003          PRINT4,   CAL EVAL
14 100    066 177                        LLI 177
14 102    056 026         **             LHI 026
14 104    307                            LAM
14 105    240                            NDA
14 106    066 110                        LLI 110
14 110    056 001         **             LHI 001
14 112    076 377                        LMI 377

14 114    152 314 014          PRINT5,   CTZ PFPOUT
14 117    066 177                        LLI 177
14 121    056 026         **             LHI 026
14 123    076 000                        LMI 000

14 125    066 203              PRINT6,   LLI 203
14 127    106 240 002                    CAL GETCHR
14 132    074 254                        CPI 254
14 134    152 357 014                    CTZ PCOMMA
14 137    066 203                        LLI 203
14 141    056 026         **             LHI 026
14 143    317                            LBM
14 144    066 202                        LLI 202
14 146    371                            LMB
14 147    066 000                        LLI 000
14 151    301                            LAB
14 152    277                            CPM
14 153    160 366 013                    JTS PRINT1
14 156    066 000                        LLI 000
14 160    106 240 002                    CAL GETCHR
14 163    074 254                        CPI 254
14 165    150 116 013                    JTZ NXTLIN
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14 170    074 273                        CPI 273
14 172    150 116 013                    JTZ NXTLIN
14 175    106 141 003                    CAL CRLF
14 200    104 116 013                    JMP NXTLIN

14 203    066 367              QUOTE,    LLI 367
14 205    370                            LMA
14 206    106 255 002                    CAL CLESYM
14 211    066 203                        LLI 203
14 213    317                            LBM
14 214    010                            INB
14 215    066 204                        LLI 204
14 217    371                            LMB

14 220    066 204              QUOTE1,   LLI 204
14 222    106 240 002                    CAL GETCHR
14 225    066 367                        LLI 367
14 227    277                            CPM
14 230    150 263 014                    JTZ QUOTE2
14 233    106 202 003                    CAL ECHO
14 236    066 204                        LLI 204
14 240    106 003 003                    CAL LOOP
14 243    110 220 014                    JFZ QUOTE1

14 246    006 311              QUOTER,   LAI 311
14 250    026 321                        LCI 321
14 252    066 367                        LLI 367
14 254    056 026          **            LHI 026
14 256    076 000                        LMI 000
14 260    104 226 002                    JMP ERROR

14 263    066 204              QUOTE2,   LLI 204
14 265    317                            LBM
14 266    066 202                        LLI 202
14 270    371                            LMB
14 271    301                            LAB
14 272    066 000                        LLI 000
14 274    277                            CPM
14 275    110 366 013                    JFZ PRINT1
14 300    106 141 003                    CAL CRLF
14 303    066 367                        LLI 367
14 305    056 026          **            LHI 026
14 307    076 000                        LMI 000
14 311    104 116 013                    JMP NXTLIN

14 314    066 126              PFPOUT,   LLI 126
14 316    056 001          **            LHI 001
14 320    307                            LAM
14 321    240                            NDA
14 322    150 336 014                    JTZ ZERO
14 325    060                            INL
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14 326      307                              LAM
14 327      240                              NDA
14 330      150 350 014                      JTZ FRAC
14 333      104 165 024                      JMP FPOUT

14 336      006 240                  ZERO,   LAI 240
14 340      106 202 003                      CAL ECHO
14 343      006 260                          LAI 260
14 345      104 202 003                      JMP ECHO

14 350      066 110                  FRAC,   LLI 110
14 352      076 000                          LMI 000
14 354      104 165 024                      JMP FPOUT

14 357      066 000                  PCOMMA, LLI 000
14 361      307                              LAM
14 362      066 203                          LLI 203
14 364      227                              SUM
14 365      063                              RTS
14 366      066 043                          LLI 043
14 370      056 001          **              LHI 001
14 372      307                              LAM
14 373      044 360                          NDI 360
14 375      004 020                          ADI 020
14 377      227                              SUM
15 000      320                              LCA
15 001      006 240                          LAI 240

15 003      106 202 003              PCOM1,  CAL ECHO
15 006      021                              DCC
15 007      110 003 015                      JFZ PCOM1
15 012      007                              RET

15 013      106 240 010              LET0,   CAL SAVSYM
15 016      066 202                          LLI 202
15 020      056 026          **              LHI 026
15 022      317                              LBM
15 023      066 203                          LLI 203
15 025      371                              LMB
15 026      104 141 015                      JMP LET5

15 031      106 255 002              LET,    CAL CLESYM
15 034      066 144                          LLI 144
15 036      056 026          **              LHI 026
15 040      076 000                          LMI 000

15 042      066 202                  LET1,   LLI 202
15 044      056 026          **              LHI 026
15 046      317                              LBM
15 047      010                              INB
15 050      066 203                          LLI 203
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15 052    371                                LMB

15 053    066 203                  LET2,     LLI 203
15 055    106 240 002                        CAL GETCHR
15 060    150 122 015                        JTZ LET4
15 063    074 275                            CPI 275
15 065    150 141 015                        JTZ LET5
15 070    074 250        @@                  CPI 250
15 072    110 113 015                        JFZ LET3
15 075    106 145 055    @@                  CAL ARRAY
15 100    066 206        @@                  LLI 206
15 102    056 026        @@**                LHI 026
15 104    317            @@                  LBM
15 105    066 203        @@                  LLI 203
15 107    371            @@                  LMB
15 110    104 122 015    @@                  JMP LET4

15 113    066 144                  LET3,     LLI 144
15 115    056 026        **                  LHI 026
15 117    106 314 002                        CAL CONCT1

15 122    066 203                  LET4,     LLI 203
15 124    106 003 003                        CAL LOOP
15 127    110 053 015                        JFZ LET2

15 132    006 314                  LETERR,   LAI 314
15 134    026 305                            LCI 305
15 136    104 226 002                        JMP ERROR

15 141    066 203                  LET5,     LLI 203
15 143    056 026        **                  LHI 026
15 145    317                                LBM
15 146    010                                INB
15 147    066 276                            LLI 276
15 151    371                                LMB
15 152    066 000                            LLI 000
15 154    317                                LBM
15 155    066 277                            LLI 277
15 157    371                                LMB
15 160    106 224 003                        CAL EVAL
15 163    106 252 010                        CAL RESTSY
15 166    106 055 010                        CAL STOSYM
15 171    104 116 013                        JMP NXTLIN

15 174    066 350                  GOTO,     LLI 350
15 176    056 026        **                  LHI 026
15 200    076 000                            LMI 000
15 202    066 202                            LLI 202
15 204    317                                LBM
15 205    010                                INB
15 206    066 203                            LLI 203
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15 210      371                                 LMB

15 211      066 203                 GOTO1,      LLI 203
15 213      106 240 002                         CAL GETCHR
15 216      150 240 015                         JTZ GOTO2
15 221      074 260                             CPI 260
15 223      160 250 015                         JTS GOTO3
15 226      074 272                             CPI 272
15 230      120 250 015                         JFS GOTO3
15 233      066 350                             LLI 350
15 235      106 314 002                         CAL CONCT1

15 240      066 203                 GOTO2,      LLI 203
15 242      106 003 003                         CAL LOOP
15 245      110 211 015                         JFZ GOTO1

15 250      066 360                 GOTO3,      LLI 360
15 252      056 026         **                  LHI 026
15 254      076 033         ††                  LMI 033
15 256      060                                 INL
15 257      076 000                             LMI 000

15 261      106 255 002             GOTO4,      CAL CLESYM
15 264      066 204                             LLI 204
15 266      076 001                             LMI 001

15 270      066 204                 GOTO5,      LLI 204
15 272      106 123 012                         CAL GETCHP
15 275      150 315 015                         JTZ GOTO6
15 300      074 260                             CPI 260
15 302      160 340 015                         JTS GOTO7
15 305      074 272                             CPI 272
15 307      120 340 015                         JFS GOTO7
15 312      106 310 002                         CAL CONCTS

15 315      066 204                 GOTO6,      LLI 204
15 317      056 026         **                  LHI 026
15 321      317                                 LBM
15 322      010                                 INB
15 323      371                                 LMB
15 324      066 360                             LLI 360
15 326      327                                 LCM
15 327      060                                 INL
15 330      367                                 LLM
15 331      352                                 LHC
15 332      307                                 LAM
15 333      011                                 DCB
15 334      271                                 CPB
15 335      110 270 015                         JFZ GOTO5

15 340      066 120                 GOTO7,      LLI 120
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15 342      056 026          **                  LHI 026
15 344      036 026          **                  LDI 026
15 346      046 350                              LEI 350
15 350      106 332 002                          CAL STRCP
15 353      150 156 013                          JTZ SAMLIN
15 356      066 360                              LLI 360
15 360      056 026          **                  LHI 026
15 362      337                                  LDM
15 363      060                                  INL
15 364      347                                  LEM
15 365      353                                  LHD
15 366      364                                  LLE
15 367      317                                  LBM
15 370      010                                  INB
15 371      106 305 012                          CAL ADBDE
15 374      066 360                              LLI 360
15 376      056 026          **                  LHI 026
16 000      373                                  LMD
16 001      060                                  INL
16 002      374                                  LME
16 003      066 364                              LLI 364
16 005      303                                  LAD
16 006      277                                  CPM
16 007      110 261 015                          JFZ GOTO4
16 012      060                                  INL
16 013      304                                  LAE
16 014      277                                  CPM
16 015      110 261 015                          JFZ GOTO4

16 020      006 325                  GOTOER,     LAI 325
16 022      026 316                              LCI 316
16 024      104 226 002                          JMP ERROR

16 027      066 202                      IF,     LLI 202
16 031      056 026          **                  LHI 026
16 033      317                                  LBM
16 034      010                                  INB
16 035      066 276                              LLI 276
16 037      371                                  LMB
16 040      106 255 002                          CAL CLESYM
16 043      066 320                              LLI 320
16 045      056 001          **                  LHI 001
16 047      106 012 013                          CAL INSTR
16 052      304                                  LAE
16 053      240                                  NDA
16 054      110 102 016                          JFZ IF1
16 057      066 013                              LLI 013
16 061      056 027          **                  LHI 027
16 063      106 012 013                          CAL INSTR
16 066      304                                  LAE
16 067      240                                  NDA
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16 070      110 102 016                         JFZ IF1

16 073      006 311                   IFERR,    LAI 311
16 075      026 306                             LCI 306
16 077      104 226 002                         JMP ERROR

16 102      066 277                     IF1,    LLI 277
16 104      056 026         **                  LHI 026
16 106      041                                 DCE
16 107      374                                 LME
16 110      106 224 003                         CAL EVAL
16 113      066 126                             LLI 126
16 115      056 001         **                  LHI 001
16 117      307                                 LAM
16 120      240                                 NDA
16 121      150 116 013                         JTZ NXTLIN
16 124      066 277                             LLI 277
16 126      056 026         **                  LHI 026
16 130      307                                 LAM
16 131      004 005                             ADI 005
16 133      066 202                             LLI 202
16 135      370                                 LMA
16 136      310                                 LBA
16 137      010                                 INB
16 140      066 204                             LLI 204
16 142      371                                 LMB

16 143      066 204                     IF2,    LLI 204
16 145      106 240 002                         CAL GETCHR
16 150      110 166 016                         JFZ IF3
16 153      066 204                             LLI 204
16 155      106 003 003                         CAL LOOP
16 160      110 143 016                         JFZ IF2
16 163      104 073 016                         JMP IFERR

16 166      074 260                     IF3,    CPI 260
16 170      160 200 016                         JTS IF4
16 173      074 272                             CPI 272
16 175      160 174 015                         JTS GOTO

16 200      066 000                     IF4,    LLI 000
16 202      307                                 LAM
16 203      066 204                             LLI 204
16 205      227                                 SUM
16 206      310                                 LBA
16 207      010                                 INB
16 210      327                                 LCM
16 211      066 000                             LLI 000
16 213      371                                 LMB
16 214      362                                 LLC
16 215      036 026         **                  LDI 026
```

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16 217      046 001                          LEI 001
16 221      106 013 021                      CAL MOVEIT
16 224      066 202                          LLI 202
16 226      076 001                          LMI 001
16 230      106 067 002                      CAL SYNTAX4
16 233      104 211 013                      JMP DIRECT

16 236      066 340              GOSUB,      LLI 340
16 240      056 026         **               LHI 026
16 242      337                              LDM
16 243      030                              IND
16 244      031                              DCD
16 245      150 255 016                      JTZ GOSUB1
16 250      066 360                          LLI 360
16 252      337                              LDM
16 253      060                              INL
16 254      347                              LEM

16 255      066 073              GOSUB1,     LLI 073
16 257      056 027         **               LHI 027
16 261      307                              LAM
16 262      004 002                          ADI 002
16 264      074 021                          CPI 021
16 266      120 347 016                      JFS GOSERR
16 271      370                              LMA
16 272      066 076                          LLI 076
16 274      206                              ADL
16 275      360                              LLA
16 276      373                              LMD
16 277      060                              INL
16 300      374                              LME
16 301      104 174 015                      JMP GOTO

16 304      066 073              RETURN,     LLI 073
16 306      056 027         **               LHI 027
16 310      307                              LAM
16 311      024 002                          SUI 002
16 313      160 356 016                      JTS RETERR
16 316      370                              LMA
16 317      004 002                          ADI 002
16 321      066 076                          LLI 076
16 323      206                              ADL
16 324      360                              LLA
16 325      337                              LDM
16 326      030                              IND
16 327      031                              DCD
16 330      150 266 010                      JTZ EXEC
16 333      060                              INL
16 334      347                              LEM
16 335      066 360                          LLI 360
16 337      056 026         **               LHI 026
```

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16 341      373                                 LMD
16 342      060                                 INL
16 343      374                                 LME
16 344      104 116 013                         JMP NXTLIN

16 347      006 307                 GOSERR,     LAI 307
16 351      026 323                             LCI 323
16 353      104 226 002                         JMP ERROR

16 356      006 322                 RETERR,     LAI 322
16 360      026 324                             LCI 324
16 362      104 226 002                         JMP ERROR

16 365      106 255 002               INPUT,    CAL CLESYM
16 370      066 202                             LLI 202
16 372      317                                 LBM
16 373      010                                 INB
16 374      066 203                             LLI 203
16 376      371                                 LMB

16 377      066 203                 INPUT1,     LLI 203
17 001      106 240 002                         CAL GETCHR
17 004      150 042 017                         JTZ INPUT3
17 007      074 254                             CPI 254
17 011      150 063 017                         JTZ INPUT4
17 014      074 250                             CPI 250
17 016      110 037 017                         JFZ INPUT2
17 021      106 160 055   @@                    CAL ARRAY2
17 024      066 206       @@                    LLI 206
17 026      056 026       @@**                  LHI 026
17 030      317           @@                    LBM
17 031      066 203       @@                    LLI 203
17 033      371           @@                    LMB
17 034      104 042 017   @@                    JMP INPUT3

17 037      106 310 002               INPUT2,   CAL CONCTS

17 042      066 203                 INPUT3,     LLI 203
17 044      106 003 003                         CAL LOOP
17 047      110 377 016                         JFZ INPUT1
17 052      106 104 017                         CAL INPUTX
17 055      106 055 010                         CAL STOSYM
17 060      104 116 013                         JMP NXTLIN

17 063      106 104 017               INPUT4,   CAL INPUTX
17 066      106 055 010                         CAL STOSYM
17 071      056 026       **                    LHI 026
17 073      066 203                             LLI 203
17 075      317                                 LBM
17 076      066 202                             LLI 202
17 100      371                                 LMB
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17 101      104 365 016                        JMP INPUT

17 104      066 120                 INPUTX,    LLI 120
17 106      307                                LAM
17 107      206                                ADL
17 110      360                                LLA
17 111      307                                LAM
17 112      074 244                            CPI 244
17 114      110 140 017                        JFZ INPUTN
17 117      066 120                            LLI 120
17 121      317                                LBM
17 122      011                                DCB
17 123      371                                LMB
17 124      106 157 017                        CAL FP0
17 127      106 221 003                        CAL CINPUT
17 132      066 124                            LLI 124
17 134      370                                LMA
17 135      104 064 020                        JMP FPFLT

17 140      066 144                 INPUTN,    LLI 144
17 142      056 026         **                 LHI 026
17 144      006 277                            LAI 277
17 146      106 202 003                        CAL ECHO
17 151      106 014 003                        CAL STRIN
17 154      104 044 023                        JMP DINPUT

17 157      056 001         **          FP0,   LHI 001
17 161      104 247 006                        JMP CFALSE

17 164      066 144                     FOR,   LLI 144
17 166      056 026         **                 LHI 026
17 170      076 000                            LMI 000
17 172      066 146                            LLI 146
17 174      076 000                            LMI 000
17 176      066 205                            LLI 205
17 200      056 027         **                 LHI 027
17 202      317                                LBM
17 203      010                                INB
17 204      371                                LMB
17 205      066 360                            LLI 360
17 207      056 026         **                 LHI 026
17 211      337                                LDM
17 212      060                                INL
17 213      347                                LEM
17 214      301                                LAB
17 215      002                                RLC
17 216      002                                RLC
17 217      004 134                            ADI 134
17 221      360                                LLA
17 222      056 027         **                 LHI 027
17 224      373                                LMD
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17 225      060                                 INL
17 226      374                                 LME
17 227      066 325                             LLI 325
17 231      056 001          **                 LHI 001
17 233      106 012 013                         CAL INSTR
17 236      304                                 LAE
17 237      240                                 NDA
17 240      110 252 017                         JFZ FOR1
17 243      006 306                  FORERR,    LAI 306
17 245      026 305                             LCI 305
17 247      104 226 002                         JMP ERROR
17 252      066 202                    FOR1,    LLI 202
17 254      056 026          **                 LHI 026
17 256      317                                 LBM
17 257      010                                 INB
17 260      066 204                             LLI 204
17 262      371                                 LMB
17 263      066 203                             LLI 203
17 265      374                                 LME

17 266      066 204                    FOR2,    LLI 204
17 270      106 240 002                         CAL GETCHR
17 273      150 310 017                         JTZ FOR3
17 276      074 275                             CPI 275
17 300      150 323 017                         JTZ FOR4
17 303      066 144                             LLI 144
17 305      106 314 002                         CAL CONCT1

17 310      066 204                    FOR3,    LLI 204
17 312      106 003 003                         CAL LOOP
17 315      110 266 017                         JFZ FOR2
17 320      104 243 017                         JMP FORERR

17 323      066 204                    FOR4,    LLI 204
17 325      317                                 LBM
17 326      010                                 INB
17 327      066 276                             LLI 276
17 331      371                                 LMB
17 332      066 203                             LLI 203
17 334      317                                 LBM
17 335      011                                 DCB
17 336      066 277                             LLI 277
17 340      371                                 LMB
17 341      106 224 003                         CAL EVAL
17 344      106 252 010                         CAL RESTSY
17 347      066 144                             LLI 144
17 351      056 026          **                 LHI 026
17 353      307                                 LAM
17 354      074 001                             CPI 001
17 356      110 246 031                         JFZ FOR5
17 361      066 146                             LLI 146
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17 363      076 000                          LMI 000
17 365      104 246 031                      JMP FOR5

Note open addresses.
This space available
for patching.

20 000      066 126                  FPFIX,  LLI 126
20 002      056 001          **              LHI 001
20 004      307                              LAM
20 005      066 100                          LLI 100
20 007      370                              LMA
20 010      240                              NDA
20 011      162 202 020                      CTS FPCOMP
20 014      066 127                          LLI 127
20 016      006 027                          LAI 027
20 020      317                              LBM
20 021      010                              INB
20 022      011                              DCB
20 023      160 051 020                      JTS FPZERO
20 026      221                              SUB
20 027      160 366 012                      JTS FIXERR
20 032      320                              LCA
20 033      066 126                  FPFIXL, LLI 126
20 035      016 003                          LBI 003
20 037      106 211 022                      CAL ROTATR
20 042      021                              DCC
20 043      110 033 020                      JFZ FPFIXL
20 046      104 175 020                      JMP RESIGN
20 051      066 126                  FPZERO, LLI 126
20 053      250                              XRA
20 054      370                              LMA
20 055      061                              DCL
20 056      370                              LMA
20 057      061                              DCL
20 060      370                              LMA
20 061      061                              DCL
20 062      370                              LMA
20 063      007                              RET

20 064      016 027                  FPFLT,  LBI 027

20 066      301                      FPNORM, LAB
20 067      056 001          **              LHI 001
20 071      066 127                          LLI 127
20 073      240                              NDA
20 074      150 100 020                      JTZ NOEXCO
20 077      371                              LMB
20 100      061                      NOEXCO, DCL
20 101      307                              LAM
20 102      066 100                          LLI 100
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20 104      370                                 LMA
20 105      240                                 NDA
20 106      120 120 020                         JFS ACZERT
20 111      016 004                             LBI 004
20 113      066 123                             LLI 123
20 115      106 150 022                         CAL COMPLM
20 120      066 126                   ACZERT,   LLI 126
20 122      016 004                             LBI 004
20 124      307                       LOOK0,    LAM
20 125      240                                 NDA
20 126      110 143 020                         JFZ ACNONZ
20 131      061                                 DCL
20 132      011                                 DCB
20 133      110 124 020                         JFZ LOOK0
20 136      066 127                             LLI 127
20 140      250                                 XRA
20 141      370                                 LMA
20 142      007                                 RET
20 143      066 123                   ACNONZ,   LLI 123
20 145      016 004                             LBI 004
20 147      106 177 022                         CAL ROTATL
20 152      307                                 LAM
20 153      240                                 NDA
20 154      160 166 020                         JTS ACCSET
20 157      060                                 INL
20 160      317                                 LBM
20 161      011                                 DCB
20 162      371                                 LMB
20 163      104 143 020                         JMP ACNONZ
20 166      066 126                   ACCSET,   LLI 126
20 170      016 003                             LBI 003
20 172      106 211 022                         CAL ROTATR
20 175      066 100                   RESIGN,   LLI 100
20 177      307                                 LAM
20 200      240                                 NDA
20 201      023                                 RFS
20 202      066 124                   FPCOMP,   LLI 124
20 204      016 003                             LBI 003
20 206      104 150 022                         JMP COMPLM

20 211      066 126                   FPADD,    LLI 126
20 213      056 001             **              LHI 001
20 215      307                                 LAM
20 216      240                                 NDA
20 217      110 235 020                         JFZ NONZAC
20 222      066 124                   MOVOP,    LLI 124
20 224      335                                 LDH
20 225      346                                 LEL
20 226      066 134                             LLI 134
20 230      016 004                             LBI 004
20 232      104 013 021                         JMP MOVEIT
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20 235    066 136          NONZAC,  LLI 136
20 237    307                       LAM
20 240    240                       NDA
20 241    053                       RTZ
20 242    066 127          CKEQEX,  LLI 127
20 244    307                       LAM
20 245    066 137                   LLI 137
20 247    277                       CPM
20 250    150 341 020               JTZ SHACOP
20 253    310                       LBA
20 254    307                       LAM
20 255    231                       SBB
20 256    120 264 020               JFS SKPNEG
20 261    310                       LBA
20 262    250                       XRA
20 263    231                       SBB
20 264    074 030          SKPNEG,  CPI 030
20 266    160 303 020               JTS LINEUP
20 271    307                       LAM
20 272    066 127                   LLI 127
20 274    227                       SUM
20 275    063                       RTS
20 276    066 124                   LLI 124
20 300    104 222 020               JMP MOVOP
20 303    307              LINEUP,  LAM
20 304    066 127                   LLI 127
20 306    227                       SUM
20 307    160 327 020               JTS SHIFTO
20 312    320                       LCA
20 313    066 127          MORACC,  LLI 127
20 315    106 374 020               CAL SHLOOP
20 320    021                       DCC
20 321    110 313 020               JFZ MORACC
20 324    104 341 020               JMP SHACOP
20 327    320              SHIFTO,  LCA
20 330    066 137          MOROP,   LLI 137
20 332    106 374 020               CAL SHLOOP
20 335    020                       INC
20 336    110 330 020               JFZ MOROP
20 341    066 123          SHACOP,  LLI 123
20 343    076 000                   LMI 000
20 345    066 127                   LLI 127
20 347    106 374 020               CAL SHLOOP
20 352    066 137                   LLI 137
20 354    106 374 020               CAL SHLOOP
20 357    335                       LDH
20 360    046 123                   LEI 123
20 362    016 004                   LBI 004
20 364    106 127 022               CAL ADDER
20 367    016 000                   LBI 000
20 371    104 066 020               JMP FPNORM
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20 374      317                          SHLOOP,  LBM
20 375      010                                   INB
20 376      371                                   LMB
20 377      061                                   DCL
21 000      016 004                               LBI 004
21 002      307                          FSHIFT,  LAM
21 003      240                                   NDA
21 004      120 211 022                           JFS ROTATR
21 007      022                          BRING1,  RAL
21 010      104 212 022                           JMP ROTR
21 013      307                          MOVEIT,  LAM
21 014      060                                   INL
21 015      106 356 022                           CAL SWITCH
21 020      370                                   LMA
21 021      060                                   INL
21 022      106 356 022                           CAL SWITCH
21 025      011                                   DCB
21 026      053                                   RTZ
21 027      104 013 021                           JMP MOVEIT

21 032      066 124                        FSUB,  LLI 124
21 034      056 001          **                   LHI 001
21 036      016 003                               LBI 003
21 040      106 150 022                           CAL COMPLM
21 043      104 211 020                           JMP FPADD

21 046      106 166 021                  FPMULT,  CAL CKSIGN
21 051      066 137                      ADDEXP,  LLI 137
21 053      307                                   LAM
21 054      066 127                               LLI 127
21 056      207                                   ADM
21 057      004 001                               ADI 001
21 061      370                                   LMA
21 062      066 102                      SETMCT,  LLI 102
21 064      076 027                               LMI 027
21 066      066 126                      MULTIP,  LLI 126
21 070      016 003                               LBI 003
21 072      106 211 022                           CAL ROTATR
21 075      142 270 021                           CTC ADOPPP
21 100      066 146                               LLI 146
21 102      016 006                               LBI 006
21 104      106 211 022                           CAL ROTATR
21 107      066 102                               LLI 102
21 111      327                                   LCM
21 112      021                                   DCC
21 113      372                                   LMC
21 114      110 066 021                           JFZ MULTIP
21 117      066 146                               LLI 146
21 121      016 006                               LBI 006
21 123      106 211 022                           CAL ROTATR
21 126      066 143                               LLI 143
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21 130    307                          LAM
21 131    022                          RAL
21 132    240                          NDA
21 133    162 302 021                  CTS MROUND
21 136    066 123                      LLI 123
21 140    346                          LEL
21 141    335                          LDH
21 142    066 143                      LLI 143
21 144    016 004                      LBI 004

21 146    106 013 021          EXMLDV, CAL MOVEIT
21 151    016 000                      LBI 000
21 153    106 066 020                  CAL FPNORM
21 156    066 101                      LLI 101
21 160    307                          LAM
21 161    240                          NDA
21 162    013                          RFZ
21 163    104 202 020                  JMP FPCOMP
21 166    066 140              CKSIGN, LLI 140
21 170    056 001          **          LHI 001
21 172    016 010                      LBI 010
21 174    250                          XRA
21 175    370                  CLRNEX, LMA
21 176    060                          INL
21 177    011                          DCB
21 200    110 175 021                  JFZ CLRNEX
21 203    016 004              CLROPL, LBI 004
21 205    066 130                      LLI 130
21 207    370                  CLRNX1, LMA
21 210    060                          INL
21 211    011                          DCB
21 212    110 207 021                  JFZ CLRNX1
21 215    066 101                      LLI 101
21 217    076 001                      LMI 001
21 221    066 126                      LLI 126
21 223    307                          LAM
21 224    240                          NDA
21 225    160 251 021                  JTS NEGFPA
21 230    066 136              OPSGNT, LLI 136
21 232    307                          LAM
21 233    240                          NDA
21 234    023                          RFS
21 235    066 101                      LLI 101
21 237    327                          LCM
21 240    021                          DCC
21 241    372                          LMC
21 242    066 134                      LLI 134
21 244    016 003                      LBI 003
21 246    104 150 022                  JMP COMPLM

21 251    066 101              NEGFPA, LLI 101
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21 253      327                          LCM
21 254      021                          DCC
21 255      372                          LMC
21 256      066 124                      LLI 124
21 260      016 003                      LBI 003
21 262      106 150 022                  CAL COMPLM
21 265      104 230 021                  JMP OPSGNT
21 270      046 141             ADOPPP,  LEI 141
21 272      335                          LDH
21 273      066 131                      LLI 131
21 275      016 006                      LBI 006
21 277      104 127 022                  JMP ADDER
21 302      016 003             MROUND,  LBI 003
21 304      006 100                      LAI 100
21 306      207                          ADM
21 307      370                 CROUND,  LMA
21 310      060                          INL
21 311      006 000                      LAI 000
21 313      217                          ACM
21 314      011                          DCB
21 315      110 307 021                  JFZ CROUND
21 320      370                          LMA
21 321      007                          RET

21 322      106 166 021           FPDIV, CAL CKSIGN
21 325      066 126                      LLI 126
21 327      307                          LAM
21 330      240                          NDA
21 331      150 357 012                  JTZ DVERR
21 334      066 137             SUBEXP,  LLI 137
21 336      307                          LAM
21 337      066 127                      LLI 127
21 341      227                          SUM
21 342      004 001                      ADI 001
21 344      370                          LMA
21 345      066 102             SETDCT,  LLI 102
21 347      076 027                      LMI 027
21 351      106 101 022           DIVIDE, CAL SETSUB
21 354      160 376 021                  JTS NOGO
21 357      046 134                      LEI 134
21 361      066 131                      LLI 131
21 363      016 003                      LBI 003
21 365      106 013 021                  CAL MOVEIT
21 370      006 001                      LAI 001
21 372      032                          RAR
21 373      104 377 021                  JMP QUOROT
21 376      250                   NOGO,  XRA
21 377      066 144               QUOROT, LLI 144
22 001      016 003                      LBI 003
22 003      106 200 022                  CAL ROTL
22 006      066 134                      LLI 134
```

```
22 010      016 003                        LBI 003
22 012      106 177 022                    CAL ROTATL
22 015      066 102                        LLI 102
22 017      327                            LCM
22 020      021                            DCC
22 021      372                            LMC
22 022      110 351 021                    JFZ DIVIDE
22 025      106 101 022                    CAL SETSUB
22 030      160 070 022                    JTS DVEXIT
22 033      066 144                        LLI 144
22 035      307                            LAM
22 036      004 001                        ADI 001
22 040      370                            LMA
22 041      006 000                        LAI 000
22 043      060                            INL
22 044      217                            ACM
22 045      370                            LMA
22 046      006 000                        LAI 000
22 050      060                            INL
22 051      217                            ACM
22 052      370                            LMA
22 053      120 070 022                    JFS DVEXIT
22 056      016 003                        LBI 003
22 060      106 211 022                    CAL ROTATR
22 063      066 127                        LLI 127
22 065      317                            LBM
22 066      010                            INB
22 067      371                            LMB
22 070      066 144              DVEXIT,   LLI 144
22 072      046 124                        LEI 124
22 074      016 003                        LBI 003
22 076      104 146 021                    JMP EXMLDV
22 101      046 131              SETSUB,   LEI 131
22 103      335                            LDH
22 104      066 124                        LLI 124
22 106      016 003                        LBI 003
22 110      106 013 021                    CAL MOVEIT
22 113      046 131                        LEI 131
22 115      066 134                        LLI 134
22 117      016 003                        LBI 003
22 121      106 223 022                    CAL SUBBER
22 124      307                            LAM
22 125      240                            NDA
22 126      007                            RET

22 127      240                  ADDER,    NDA
22 130      307                  ADDMOR,   LAM
22 131      106 356 022                    CAL SWITCH
22 134      217                            ACM
22 135      370                            LMA
22 136      011                            DCB
```

```
22 137      053                          RTZ
22 140      060                          INL
22 141      106 356 022                  CAL SWITCH
22 144      060                          INL
22 145      104 130 022                  JMP ADDMOR

22 150      307                  COMPLM, LAM
22 151      054 377                      XRI 377
22 153      004 001                      ADI 001
22 155      370                  MORCOM, LMA
22 156      032                          RAR
22 157      330                          LDA
22 160      011                          DCB
22 161      053                          RTZ
22 162      060                          INL
22 163      307                          LAM
22 164      054 377                      XRI 377
22 166      340                          LEA
22 167      303                          LAD
22 170      022                          RAL
22 171      006 000                      LAI 000
22 173      214                          ACE
22 174      104 155 022                  JMP MORCOM

22 177      240                  ROTATL, NDA
22 200      307                    ROTL, LAM
22 201      022                          RAL
22 202      370                          LMA
22 203      011                          DCB
22 204      053                          RTZ
22 205      060                          INL
22 206      104 200 022                  JMP ROTL

22 211      240                  ROTATR, NDA
22 212      307                    ROTR, LAM
22 213      032                          RAR
22 214      370                          LMA
22 215      011                          DCB
22 216      053                          RTZ
22 217      061                          DCL
22 220      104 212 022                  JMP ROTR

22 223      240                  SUBBER, NDA
22 224      307                  SUBTRA, LAM
22 225      106 356 022                  CAL SWITCH
22 230      237                          SBM
22 231      370                          LMA
22 232      011                          DCB
22 233      053                          RTZ
22 234      060                          INL
22 235      106 356 022                  CAL SWITCH
```

```
22 240      060                          INL
22 241      104 224 022                  JMP SUBTRA

22 244      036 001          **  FLOAD,  LDI 001
22 246      046 124                      LEI 124
22 250      016 004                      LBI 004
22 252      104 013 021                  JMP MOVEIT

22 255      346              FSTORE,     LEL
22 256      335                          LDH
22 257      066 124                      LLI 124
22 261      056 001          **          LHI 001
22 263      104 272 022                  JMP SETIT

22 266      036 001          **  OPLOAD, LDI 001
22 270      046 134                      LEI 134
22 272      016 004              SETIT,  LBI 004
22 274      104 013 021                  JMP MOVEIT

22 277      106 317 022      FACXOP,     CAL SAVEHL
22 302      066 124                      LLI 124
22 304      056 001          **          LHI 001
22 306      106 266 022                  CAL OPLOAD
22 311      106 337 022                  CAL RESTHL
22 314      104 244 022                  JMP FLOAD

22 317      305              SAVEHL,     LAH
22 320      316                          LBL
22 321      066 200                      LLI 200
22 323      056 001          **          LHI 001
22 325      370                          LMA
22 326      060                          INL
22 327      371                          LMB
22 330      060                          INL
22 331      373                          LMD
22 332      060                          INL
22 333      374                          LME
22 334      350                          LHA
22 335      361                          LLB
22 336      007                          RET

22 337      066 200          RESTHL,     LLI 200
22 341      056 001          **          LHI 001
22 343      307                          LAM
22 344      060                          INL
22 345      317                          LBM
22 346      060                          INL
22 347      337                          LDM
22 350      060                          INL
22 351      347                          LEM
22 352      350                          LHA
```

```
22 353      361                          LLB
22 354      307                          LAM
22 355      007                          RET

22 356      325                SWITCH,   LCH
22 357      353                          LHD
22 360      332                          LDC
22 361      326                          LCL
22 362      364                          LLE
22 363      342                          LEC
22 364      007                          RET

22 365      056 001      **    GETINP,   LHI 001
22 367      066 220                      LLI 220
22 371      327                          LCM
22 372      020                          INC
22 373      021                          DCC
22 374      110 010 023                  JFZ NOT0
22 377      364                          LLE
23 000      353                          LHD
23 001      327                          LCM
23 002      020                          INC
23 003      106 036 023                  CAL INDEXC
23 006      076 000                      LMI 000

23 010      066 220              NOT0,   LLI 220
23 012      056 001      **              LHI 001
23 014      327                          LCM
23 015      020                          INC
23 016      372                          LMC
23 017      364                          LLE
23 020      353                          LHD
23 021      106 036 023                  CAL INDEXC
23 024      307                          LAM
23 025      240                          NDA
23 026      056 001      **              LHI 001
23 030      013                          RFZ
23 031      066 220                      LLI 220
23 033      076 000                      LMI 000
23 035      007                          RET

23 036      306                INDEXC,   LAL
23 037      202                          ADC
23 040      360                          LLA
23 041      003                          RFC
23 042      050                          INH
23 043      007                          RET

23 044      346                DINPUT,   LEL
23 045      335                          LDH
23 046      056 001      **              LHI 001
```

```
23 050      066 150                         LLI 150
23 052      250                             XRA
23 053      016 010                         LBI 010
23 055      370                 CLRNX2,     LMA
23 056      060                             INL
23 057      011                             DCB
23 060      110 055 023                     JFZ CLRNX2
23 063      066 103                         LLI 103
23 065      016 004                         LBI 004
23 067      370                 CLRNX3,     LMA
23 070      060                             INL
23 071      011                             DCB
23 072      110 067 023                     JFZ CLRNX3
23 075      106 365 022                     CAL GETINP
23 100      074 253                         CPI 253
23 102      150 115 023                     JTZ NINPUT
23 105      074 255                         CPI 255
23 107      110 120 023                     JFZ NOTPLM
23 112      066 103                         LLI 103
23 114      370                             LMA

23 115      106 365 022         NINPUT,     CAL GETINP

23 120      074 256             NOTPLM,     CPI 256
23 122      150 201 023                     JTZ PERIOD
23 125      074 305                         CPI 305
23 127      150 221 023                     JTZ FNDEXP
23 132      074 240                         CPI 240
23 134      150 115 023                     JTZ NINPUT
23 137      240                             NDA
23 140      150 311 023                     JTZ ENDINP
23 143      074 260                         CPI 260
23 145      160 375 012                     JTS NUMERR
23 150      074 272                         CPI 272
23 152      120 375 012                     JFS NUMERR
23 155      066 156                         LLI 156
23 157      320                             LCA
23 160      006 370                         LAI 370
23 162      247                             NDM
23 163      110 115 023                     JFZ NINPUT
23 166      066 105                         LLI 105
23 170      317                             LBM
23 171      010                             INB
23 172      371                             LMB
23 173      106 056 024                     CAL DECBIN
23 176      104 115 023                     JMP NINPUT

23 201      310                 PERIOD,     LBA
23 202      066 106                         LLI 106
23 204      307                             LAM
23 205      240                             NDA
```

```
23 206      110 375 012                 JFZ NUMERR
23 211      066 105                     LLI 105
23 213      370                         LMA
23 214      060                         INL
23 215      371                         LMB
23 216      104 115 023                 JMP NINPUT

23 221      106 365 022         FNDEXP, CAL GETINP
23 224      074 253                     CPI 253
23 226      150 241 023                 JTZ EXPINP
23 231      074 255                     CPI 255
23 233      110 244 023                 JFZ NOEXPS
23 236      066 104                     LLI 104
23 240      370                         LMA

23 241      106 365 022         EXPINP, CAL GETINP

23 244      240                 NOEXPS, NDA
23 245      150 311 023                 JTZ ENDINP
23 250      074 260                     CPI 260
23 252      160 375 012                 JTS NUMERR
23 255      074 272                     CPI 272
23 257      120 375 012                 JFS NUMERR
23 262      044 017                     NDI 017
23 264      310                         LBA
23 265      066 157                     LLI 157
23 267      006 003                     LAI 003
23 271      277                         CPM
23 272      160 375 012                 JTS NUMERR
23 275      327                         LCM
23 276      307                         LAM
23 277      240                         NDA
23 300      022                         RAL
23 301      022                         RAL
23 302      202                         ADC
23 303      022                         RAL
23 304      201                         ADB
23 305      370                         LMA
23 306      104 241 023                 JMP EXPINP

23 311      066 103             ENDINP, LLI 103
23 313      307                         LAM
23 314      240                         NDA
23 315      150 327 023                 JTZ FININP
23 320      066 154                     LLI 154
23 322      016 003                     LBI 003
23 324      106 150 022                 CAL COMPLM

23 327      066 153             FININP, LLI 153
23 331      250                         XRA
23 332      370                         LMA
```

```
23 333      335                                 LDH
23 334      046 123                             LEI 123
23 336      016 004                             LBI 004
23 340      106 013 021                         CAL MOVEIT
23 343      106 064 020                         CAL FPFLT
23 346      066 104                             LLI 104
23 350      307                                 LAM
23 351      240                                 NDA
23 352      066 157                             LLI 157
23 354      150 365 023                         JTZ POSEXP
23 357      307                                 LAM
23 360      054 377                             XRI 377
23 362      004 001                             ADI 001
23 364      370                                 LMA

23 365      066 106                   POSEXP,   LLI 106
23 367      307                                 LAM
23 370      240                                 NDA
23 371      150 000 024                         JTZ EXPOK
23 374      066 105                             LLI 105
23 376      250                                 XRA
23 377      227                                 SUM

24 000      066 157                   EXPOK,    LLI 157
24 002      207                                 ADM
24 003      370                                 LMA
24 004      160 033 024                         JTS MINEXP
24 007      053                                 RTZ

24 010      066 210                   FPX10,    LLI 210
24 012      056 001             **              LHI 001
24 014      106 277 022                         CAL FACXOP
24 017      106 046 021                         CAL FPMULT
24 022      066 157                             LLI 157
24 024      327                                 LCM
24 025      021                                 DCC
24 026      372                                 LMC
24 027      110 010 024                         JFZ FPX10
24 032      007                                 RET

24 033      066 214             MINEXP, FPD10,  LLI 214
24 035      056 001             **              LHI 001
24 037      106 277 022                         CAL FACXOP
24 042      106 046 021                         CAL FPMULT
24 045      066 157                             LLI 157
24 047      317                                 LBM
24 050      010                                 INB
24 051      371                                 LMB
24 052      110 033 024                         JFZ FPD10
24 055      007                                 RET
```

```
24 056    106 317 022              DECBIN,  CAL SAVEHL
24 061    066 153                           LLI 153
24 063    302                               LAC
24 064    044 017                           NDI 017
24 066    370                               LMA
24 067    046 150                           LEI 150
24 071    066 154                           LLI 154
24 073    335                               LDH
24 074    016 003                           LBI 003
24 076    106 013 021                       CAL MOVEIT
24 101    066 154                           LLI 154
24 103    016 003                           LBI 003
24 105    106 177 022                       CAL ROTATL
24 110    066 154                           LLI 154
24 112    016 003                           LBI 003
24 114    106 177 022                       CAL ROTATL
24 117    046 154                           LEI 154
24 121    066 150                           LLI 150
24 123    016 003                           LBI 003
24 125    106 127 022                       CAL ADDER
24 130    066 154                           LLI 154
24 132    016 003                           LBI 003
24 134    106 177 022                       CAL ROTATL
24 137    066 152                           LLI 152
24 141    250                               XRA
24 142    370                               LMA
24 143    061                               DCL
24 144    370                               LMA
24 145    066 153                           LLI 153
24 147    307                               LAM
24 150    066 150                           LLI 150
24 152    370                               LMA
24 153    046 154                           LEI 154
24 155    016 003                           LBI 003
24 157    106 127 022                       CAL ADDER
24 162    104 337 022                       JMP RESTHL

24 165    056 001          **       FPOUT,  LHI 001
24 167    066 157                           LLI 157
24 171    076 000                           LMI 000
24 173    066 126                           LLI 126
24 175    307                               LAM
24 176    240                               NDA
24 177    160 207 024                       JTS OUTNEG
24 202    006 240                           LAI 240
24 204    104 220 024                       JMP AHEAD1

24 207    066 124                  OUTNEG,  LLI 124
24 211    016 003                           LBI 003
24 213    106 150 022                       CAL COMPLM
24 216    006 255                           LAI 255
```

```
24 220    106 202 003              AHEAD1,  CAL ECHO
24 223    066 110                           LLI 110
24 225    307                               LAM
24 226    240                               NDA
24 227    150 253 024                       JTZ OUTFLT
24 232    066 127                           LLI 127
24 234    006 027                           LAI 027
24 236    317                               LBM
24 237    010                               INB
24 240    011                               DCB
24 241    160 253 024                       JTS OUTFLT
24 244    221                               SUB
24 245    160 253 024                       JTS OUTFLT
24 250    104 271 024                       JMP OUTFIX

24 253    066 110                  OUTFLT,  LLI 110
24 255    076 000                           LMI 000
24 257    006 260                           LAI 260
24 261    106 202 003                       CAL ECHO
24 264    006 256                           LAI 256
24 266    106 202 003                       CAL ECHO

24 271    066 127                  OUTFIX,  LLI 127
24 273    006 377                           LAI 377
24 275    207                               ADM
24 276    370                               LMA

24 277    120 336 024              DECEXT,  JFS DECEXD
24 302    006 004                           LAI 004
24 304    207                               ADM
24 305    120 360 024                       JFS DECOUT
24 310    066 210                           LLI 210
24 312    056 001          **               LHI 001
24 314    106 277 022                       CAL FACXOP
24 317    106 046 021                       CAL FPMULT
24 322    066 157                           LLI 157
24 324    327                               LCM
24 325    021                               DCC
24 326    372                               LMC

24 327    066 127                  DECREP,  LLI 127
24 331    307                               LAM
24 332    240                               NDA
24 333    104 277 024                       JMP DECEXT

24 336    066 214                  DECEXD,  LLI 214
24 340    056 001          **               LHI 001
24 342    106 277 022                       CAL FACXOP
24 345    106 046 021                       CAL FPMULT
24 350    066 157                           LLI 157
24 352    317                               LBM
```

```
24 353      010                          INB
24 354      371                          LMB
24 355      104 327 024                  JMP DECREP

24 360      046 164             DECOUT,  LEI 164
24 362      335                          LDH
24 363      066 124                      LLI 124
24 365      016 003                      LBI 003
24 367      106 013 021                  CAL MOVEIT
24 372      066 167                      LLI 167
24 374      076 000                      LMI 000
24 376      066 164                      LLI 164
25 000      016 003                      LBI 003
25 002      106 177 022                  CAL ROTATL
25 005      106 223 025                  CAL OUTX10

25 010      066 127             COMPEN,  LLI 127
25 012      317                          LBM
25 013      010                          INB
25 014      371                          LMB
25 015      150 032 025                  JTZ OUTDIG
25 020      066 167                      LLI 167
25 022      016 004                      LBI 004
25 024      106 211 022                  CAL ROTATR
25 027      104 010 025                  JMP COMPEN
25 032      066 107             OUTDIG,  LLI 107
25 034      076 007                      LMI 007
25 036      066 167                      LLI 167
25 040      307                          LAM
25 041      240                          NDA
25 042      150 165 025                  JTZ ZERODG

25 045      066 167             OUTDGS,  LLI 167
25 047      307                          LAM
25 050      240                          NDA
25 051      110 105 025                  JFZ OUTDGX
25 054      066 110                      LLI 110
25 056      307                          LAM
25 057      240                          NDA
25 060      150 104 025                  JTZ OUTZER
25 063      066 157                      LLI 157
25 065      327                          LCM
25 066      021                          DCC
25 067      020                          INC
25 070      120 104 025                  JFS OUTZER
25 073      066 166                      LLI 166
25 075      307                          LAM
25 076      044 340                      NDI 340
25 100      110 104 025                  JFZ OUTZER
25 103      007                          RET
```

```
25 104      250                     OUTZER,  XRA

25 105      004 260                 OUTDGX,  ADI 260
25 107      106 202 003                      CAL ECHO

25 112      066 110                 DECRDG,  LLI 110
25 114      307                              LAM
25 115      240                              NDA
25 116      110 137 025                      JFZ CKDECP

25 121      066 107                          LLI 107
25 123      327                              LCM
25 124      021                              DCC
25 125      372                              LMC
25 126      150 300 025                      JTZ EXPOUT
25 131      106 223 025             PUSHIT,  CAL OUTX10
25 134      104 045 025                      JMP OUTDGS

25 137      066 157                 CKDECP,  LLI 157
25 141      327                              LCM
25 142      021                              DCC
25 143      372                              LMC
25 144      110 154 025                      JFZ NODECP
25 147      006 256                          LAI 256
25 151      106 202 003                      CAL ECHO
25 154      066 107                 NODECP,  LLI 107
25 156      327                              LCM
25 157      021                              DCC
25 160      372                              LMC
25 161      053                              RTZ
25 162      104 131 025                      JMP PUSHIT

25 165      066 157                 ZERODG,  LLI 157
25 167      327                              LCM
25 170      021                              DCC
25 171      372                              LMC
25 172      066 166                          LLI 166
25 174      307                              LAM
25 175      240                              NDA
25 176      110 112 025                      JFZ DECRDG
25 201      061                              DCL
25 202      307                              LAM
25 203      240                              NDA
25 204      110 112 025                      JFZ DECRDG
25 207      061                              DCL
25 210      307                              LAM
25 211      240                              NDA
25 212      110 112 025                      JFZ DECRDG
25 215      066 157                          LLI 157
25 217      370                              LMA
25 220      104 112 025                      JMP DECRDG
```

```
25 223      066 167          OUTX10,  LLI 167
25 225      076 000                   LMI 000
25 227      066 164                   LLI 164
25 231      335                       LDH
25 232      046 160                   LEI 160
25 234      016 004                   LBI 004
25 236      106 013 021               CAL MOVEIT
25 241      066 164                   LLI 164
25 243      016 004                   LBI 004
25 245      106 177 022               CAL ROTATL
25 250      066 164                   LLI 164
25 252      016 004                   LBI 004
25 254      106 177 022               CAL ROTATL
25 257      066 160                   LLI 160
25 261      046 164                   LEI 164
25 263      016 004                   LBI 004
25 265      106 127 022               CAL ADDER
25 270      066 164                   LLI 164
25 272      016 004                   LBI 004
25 274      106 177 022               CAL ROTATL
25 277      007                       RET

25 300      066 157          EXPOUT,  LLI 157
25 302      307                       LAM
25 303      240                       NDA
25 304      053                       RTZ
25 305      006 305                   LAI 305
25 307      106 202 003               CAL ECHO
25 312      307                       LAM
25 313      240                       NDA
25 314      160 324 025               JTS EXOUTN
25 317      006 253                   LAI 253
25 321      104 333 025               JMP AHEAD2

25 324      054 377          EXOUTN,  XRI 377
25 326      004 001                   ADI 001
25 330      370                       LMA
25 331      006 255                   LAI 255

25 333      106 202 003      AHEAD2,  CAL ECHO
25 336      016 000                   LBI 000
25 340      307                       LAM

25 341      024 012          SUB12,   SUI 012
25 343      160 353 025               JTS TOMUCH
25 346      370                       LMA
25 347      010                       INB
25 350      104 341 025               JMP SUB12

25 353      006 260          TOMUCH,  LAI 260
25 355      201                       ADB
```

```
25 356      106 202 003      CAL ECHO
25 361      307              LAM
25 362      004 260          ADI 260
25 364      106 202 003      CAL ECHO
25 367      007              RET
```

Note open addresses.
This space available
for patching.

NOTE: Pages 26 and 27 in memory are used for temporary data registers, pointers, counters and look-up tables. The following data should be placed on those pages. An entry marked XXX indicates the initial contents of the location are irrelevant to the program's operation.

```
26 000      000      (cc) for INPUT LINE BUFF
26 001      XXX      These locations used as the
 .  .        .       INPUT LINE BUFFER
 .  .        .       storage
26 117      XXX      area
26 120      000      These locations used as the
 .  .        .       SYMBOL BUFFER
 .  .        .       storage
26 143      000      area
26 144      000      These locations used as the
 .  .        .       AUXILIARY
 .  .        .       SYMBOL BUFFER
26 175      000      storage area
26 176      000      TEMP SCAN storage register
26 177      000      TAB FLAG
26 200      000      EVAL CURRENT temp. reg.
26 201      000      SYNTAX LINE NUMBER
26 202      000      SCAN temporary register
26 203      000      STATEMENT TOKEN
26 204      000      Temporary working register
26 205      000      Temporary working register
26 206      000      ARRAY pointer
26 207      000      ARRAY pointer
26 210      000      OPERATOR STACK pointer
26 211      XXX      These locations used as the
 .  .        .       OPERATOR STACK
 .  .        .       storage
26 227      XXX      area
26 230      000      FUN/ARRAY STACK pointer
26 231      XXX      These locations used as the
 .  .        .       FUNCTION/ARRAY STACK
 .  .        .       storage
26 237      XXX      area
```

Heirarchy table (for out of stack ops).
Used by PARSER routine.

| | | |
|---|---|---|
| 26 240 | 000 | EOS |
| 26 241 | 003 | Plus sign |
| 26 242 | 003 | Minus sign |
| 26 243 | 004 | Multiplication sign |
| 26 244 | 004 | Division sign |
| 26 245 | 005 | Exponentiation sign |
| 26 246 | 006 | Left parenthesis |
| 26 247 | 001 | Right parenthesis |
| 26 250 | 002 | Not assigned |
| 26 251 | 002 | Less than sign |
| 26 252 | 002 | Equal sign |
| 26 253 | 002 | Greater than sign |
| 26 254 | 002 | Less than or equal combo |
| 26 255 | 002 | Equal to or greater than |
| 26 256 | 002 | Less than or greater than |

Heirarchy table (for into stack ops).
Used by PARSER routine.

| | | |
|---|---|---|
| 26 257 | 000 | EOS |
| 26 260 | 003 | Plus sign |
| 26 261 | 003 | Minus sign |
| 26 262 | 004 | Multiplication sign |
| 26 263 | 004 | Division sign |
| 26 264 | 005 | Exponentiation sign |
| 26 265 | 001 | Left parenthesis |
| 26 266 | 001 | Right parenthesis |
| 26 267 | 002 | Not assigned |
| 26 270 | 002 | Less than sign |
| 26 271 | 002 | Equal sign |
| 26 272 | 002 | Greater than sign |
| 26 273 | 002 | Less than or equal combo |
| 26 274 | 002 | Equal to or greater than |
| 26 275 | 002 | Less than or greater than |
| | | |
| 26 276 | 000 | EVAL (start) pointer |
| 26 277 | 000 | EVAL FINISH pointer |

FUNCTION NAMES TABLE

| | | |
|---|---|---|
| 26 300 | 003 | (cc) for INT |
| 26 301 | 311 | I |
| 26 302 | 316 | N |
| 26 303 | 324 | T |
| 26 304 | 003 | (cc) for SGN |
| 26 305 | 323 | S |
| 26 306 | 307 | G |
| 26 307 | 316 | N |

| | | |
|---|---|---|
| 26 310 | 003 | (cc) for ABS |
| 26 311 | 301 | A |
| 26 312 | 302 | B |
| 26 313 | 323 | S |
| 26 314 | 003 | (cc) for SQR |
| 26 315 | 323 | S |
| 26 316 | 321 | Q |
| 26 317 | 322 | R |
| 26 320 | 003 | (cc) for TAB |
| 26 321 | 324 | T |
| 26 322 | 301 | A |
| 26 323 | 302 | B |
| 26 324 | 003 | (cc) for RND |
| 26 325 | 322 | R |
| 26 326 | 316 | N |
| 26 327 | 304 | D |
| 26 330 | 003 | (cc) for CHR |
| 26 331 | 303 | C |
| 26 332 | 310 | H |
| 26 333 | 322 | R |
| 26 334 | 003 | (cc) for UDF |
| 26 335 | 325 | U |
| 26 336 | 304 | D |
| 26 337 | 306 | F |
| | | |
| 26 340 | 000 | These locations used as the |
| . . | . | LINE NUMBER BUFFER |
| . . | . | storage |
| 26 347 | 000 | area |
| 26 350 | 000 | These locations used as the |
| . . | . | AUX LINE NUMBER |
| . . | . | BUFFER |
| 26 357 | 000 | storage area |
| 26 360 | 000 | USER PGM LINE pointer (pg) |
| 26 361 | 000 | USER PGM LINE pntr (low) |
| 26 362 | 000 | AUX PGM LINE pointer (pg) |
| 26 363 | 000 | AUX PGM LINE pntr (low) |
| 26 364 | 000 | END of USER PGM BFR (pg) |
| 26 365 | 000 | END of USER PGM BFR pntr |
| 26 366 | 000 | Parenthesis counter |
| 26 367 | 000 | QUOTE Indicator |
| 26 370 | 000 | Table counter |
| 26 371 | XXX | Not assigned |
| . . | . | |
| . . | . | |
| 26 377 | XXX | Not assigned |

End of page 26.

STATEMENT KEYWORD TABLE

| | | |
|---|---|---|
| 27 000 | 003 | (cc) for REM |
| 27 001 | 322 | R |
| 27 002 | 305 | E |
| 27 003 | 315 | M |
| 27 004 | 002 | (cc) for IF |
| 27 005 | 311 | I |
| 27 006 | 306 | F |
| 27 007 | 003 | (cc) for LET |
| 27 010 | 314 | L |
| 27 011 | 305 | E |
| 27 012 | 324 | T |
| 27 013 | 004 | (cc) for GOTO |
| 27 014 | 307 | G |
| 27 015 | 317 | O |
| 27 016 | 324 | T |
| 27 017 | 317 | O |
| 27 020 | 005 | (cc) for PRINT |
| 27 021 | 320 | P |
| 27 022 | 322 | R |
| 27 023 | 311 | I |
| 27 024 | 316 | N |
| 27 025 | 324 | T |
| 27 026 | 005 | (cc) for INPUT |
| 27 027 | 311 | I |
| 27 030 | 316 | N |
| 27 031 | 320 | P |
| 27 032 | 325 | U |
| 27 033 | 324 | T |
| 27 034 | 003 | (cc) for FOR |
| 27 035 | 306 | F |
| 27 036 | 317 | O |
| 27 037 | 322 | R |
| 27 040 | 004 | (cc) for NEXT |
| 27 041 | 316 | N |
| 27 042 | 305 | E |
| 27 043 | 330 | X |
| 27 044 | 324 | T |
| 27 045 | 005 | (cc) for GOSUB |
| 27 046 | 307 | G |
| 27 047 | 317 | O |
| 27 050 | 323 | S |
| 27 051 | 325 | U |
| 27 052 | 302 | B |
| 27 053 | 006 | (cc) for RETURN |
| 27 054 | 322 | R |
| 27 055 | 305 | E |
| 27 056 | 324 | T |
| 27 057 | 325 | U |
| 27 060 | 322 | R |

| | | |
|---|---|---|
| 27 061 | 316 | N |
| 27 062 | 003 | (cc) for DIM |
| 27 063 | 304 | D |
| 27 064 | 311 | I |
| 27 065 | 315 | M |
| 27 066 | 003 | (cc) for END |
| 27 067 | 305 | E |
| 27 070 | 316 | N |
| 27 071 | 304 | D |
| 27 072 | 000 | End of Table |
| | | |
| 27 073 | 000 | GOSUB STACK pointer |
| 27 074 | XXX | Not assigned |
| 27 075 | 000 | Number of arrays counter |
| 27 076 | 000 | ARRAY pointer |
| 27 077 | 000 | VARIABLES counter |
| | | |
| 27 100 | 000 | These locations used as the |
| . . | . | GOSUB STACK |
| . . | . | storage |
| 27 117 | 000 | area |
| 27 120 | 000 | These locations used as the |
| . . | . | |
| . . | . | ARRAY VARIABLES |
| . . | . | TABLE |
| 27 137 | 000 | storage area |
| 27 140 | 000 | These locations used as the |
| . . | . | FOR/NEXT STACK |
| . . | . | storage |
| 27 177 | 000 | area |
| | | |
| 27 200 | 000 | FOR/NEXT STACK pointer |
| 27 201 | 000 | ARRAY/VARIABLE flag |
| 27 202 | 000 | STOSYM counter |
| 27 203 | 000 | FUN/ARRAY STACK pointer |
| 27 204 | 000 | ARRAY VALUES pointer |
| 27 205 | XXX | Not assigned |
| . . | . | |
| 27 207 | XXX | Not assigned |
| | | |
| 27 210 | 000 | These locations |
| 27 211 | XXX | used as the |
| . . | . | VARIABLES SYMBOL |
| . . | . | TABLE |
| 27 377 | XXX | storage area |

End of page 27.

Note open addresses at start of page 30. These locations available for patching.

```
30 013    066 144                    NEXT,   LLI 144
30 015    056 026          **                LHI 026
30 017    076 000                            LMI 000
30 021    066 202                            LLI 202
30 023    317                                LBM
30 024    010                                INB
30 025    066 201                            LLI 201
30 027    371                                LMB
30 030    066 201                    NEXT1,  LLI 201
30 032    106 240 002                        CAL GETCHR
30 035    150 045 030                        JTZ NEXT2
30 040    066 144                            LLI 144
30 042    106 314 002                        CAL CONCT1
30 045    066 201                    NEXT2,  LLI 201
30 047    106 003 003                        CAL LOOP
30 052    110 030 030                        JFZ NEXT1
30 055    066 144                            LLI 144
30 057    307                                LAM
30 060    074 001                            CPI 001
30 062    110 071 030                        JFZ NEXT3
30 065    066 146                            LLI 146
30 067    076 000                            LMI 000
30 071    066 205                    NEXT3,  LLI 205
30 073    056 027          **                LHI 027
30 075    307                                LAM
30 076    002                                RLC
30 077    002                                RLC
30 100    004 136                            ADI 136
30 102    056 027          **                LHI 027
30 104    360                                LLA
30 105    036 026          **                LDI 026
30 107    046 145                            LEI 145
30 111    016 002                            LBI 002
30 113    106 370 002                        CAL STRCPC
30 116    150 130 030                        JTZ NEXT4
30 121    006 306                    FORNXT, LAI 306
30 123    026 316                            LCI 316
30 125    104 226 002                        JMP ERROR
30 130    066 360                    NEXT4,  LLI 360
30 132    056 026          **                LHI 026
30 134    337                                LDM
30 135    060                                INL
30 136    347                                LEM
30 137    060                                INL
30 140    373                                LMD
30 141    060                                INL
30 142    374                                LME
30 143    066 205                            LLI 205
30 145    056 027          **                LHI 027
30 147    307                                LAM
30 150    002                                RLC
```

```
30 151    002                        RLC
30 152    004 134                    ADI 134
30 154    360                        LLA
30 155    337                        LDM
30 156    060                        INL
30 157    347                        LEM
30 160    066 360                    LLI 360
30 162    056 026          **        LHI 026
30 164    373                        LMD
30 165    060                        INL
30 166    374                        LME
30 167    353                        LHD
30 170    364                        LLE
30 171    036 026          **        LDI 026
30 173    046 000                    LEI 000
30 175    106 046 012                CAL MOVEC
30 200    066 325                    LLI 325
30 202    056 001          **        LHI 001
30 204    106 012 013                CAL INSTR
30 207    304                        LAE
30 210    240                        NDA
30 211    150 121 030                JTZ FORNXT
30 214    004 002                    ADI 002
30 216    066 276                    LLI 276
30 220    056 026          **        LHI 026
30 222    370                        LMA
30 223    066 330                    LLI 330
30 225    056 001          **        LHI 001
30 227    106 012 013                CAL INSTR
30 232    304                        LAE
30 233    240                        NDA
30 234    110 300 030                JFZ NEXT5
30 237    066 004                    LLI 004
30 241    056 001          **        LHI 001
30 243    106 244 022                CAL FLOAD
30 246    066 304                    LLI 304
30 250    106 255 022                CAL FSTORE
30 253    066 000                    LLI 000
30 255    056 026          **        LHI 026
30 257    317                        LBM
30 260    066 277                    LLI 277
30 262    371                        LMB
30 263    106 224 003                CAL EVAL
30 266    066 310                    LLI 310
30 270    056 001          **        LHI 001
30 272    106 255 022                CAL FSTORE
30 275    104 351 030                JMP NEXT6

30 300    041              NEXT5,    DCE
30 301    066 277                    LLI 277
30 303    056 026          **        LHI 026
```

```
30 305      374                          LME
30 306      106 224 003                  CAL EVAL
30 311      066 310                      LLI 310
30 313      056 001          **          LHI 001
30 315      106 255 022                  CAL FSTORE
30 320      066 277                      LLI 277
30 322      056 026          **          LHI 026
30 324      307                          LAM
30 325      004 005                      ADI 005
30 327      061                          DCL
30 330      370                          LMA
30 331      066 000                      LLI 000
30 333      317                          LBM
30 334      066 277                      LLI 277
30 336      371                          LMB
30 337      106 224 003                  CAL EVAL
30 342      066 304                      LLI 304
30 344      056 001          **          LHI 001
30 346      106 255 022                  CAL FSTORE

30 351      066 144              NEXT6,  LLI 144
30 353      056 026          **          LHI 026
30 355      076 000                      LMI 000
30 357      066 034                      LLI 034
30 361      056 027          **          LHI 027
30 363      106 012 013                  CAL INSTR
30 366      304                          LAE
30 367      240                          NDA
30 370      066 202                      LLI 202
30 372      056 026          **          LHI 026
30 374      370                          LMA
30 375      150 121 030                  JTZ FORNXT
31 000      004 003                      ADI 003
31 002      066 203                      LLI 203
31 004      370                          LMA

31 005      066 203              NEXT7,  LLI 203
31 007      106 240 002                  CAL GETCHR
31 012      150 027 031                  JTZ NEXT8
31 015      074 275                      CPI 275
31 017      150 042 031                  JTZ NEXT9
31 022      066 144                      LLI 144
31 024      106 314 002                  CAL CONCT1

31 027      066 203              NEXT8,  LLI 203
31 031      106 003 003                  CAL LOOP
31 034      110 005 031                  JFZ NEXT7
31 037      104 121 030                  JMP FORNXT

31 042      066 202              NEXT9,  LLI 202
31 044      056 026          **          LHI 026
```

```
31 046    307                          LAM
31 047    004 003                      ADI 003
31 051    066 276                      LLI 276
31 053    370                          LMA
31 054    066 203                      LLI 203
31 056    317                          LBM
31 057    011                          DCB
31 060    066 277                      LLI 277
31 062    371                          LMB
31 063    106 224 003                  CAL EVAL
31 066    066 304                      LLI 304
31 070    056 001          **          LHI 001
31 072    106 277 022                  CAL FACXOP
31 075    106 211 020                  CAL FPADD
31 100    066 314                      LLI 314
31 102    056 001          **          LHI 001
31 104    106 255 022                  CAL FSTORE
31 107    066 310                      LLI 310
31 111    106 277 022                  CAL FACXOP
31 114    106 032 021                  CAL FPSUB
31 117    066 306                      LLI 306
31 121    307                          LAM
31 122    240                          NDA
31 123    066 126                      LLI 126
31 125    307                          LAM
31 126    150 121 030                  JTZ FORNXT
31 131    160 170 031                  JTS NEXT11
31 134    240                          NDA
31 135    160 177 031                  JTS NEXT12
31 140    150 177 031                  JTZ NEXT12

31 143    066 363          NEXT10,     LLI 363
31 145    056 026          **          LHI 026
31 147    347                          LEM
31 150    061                          DCL
31 151    337                          LDM
31 152    061                          DCL
31 153    374                          LME
31 154    061                          DCL
31 155    373                          LMD
31 156    066 205                      LLI 205
31 160    056 027          **          LHI 027
31 162    317                          LBM
31 163    011                          DCB
31 164    371                          LMB
31 165    104 116 013                  JMP NXTLIN

31 170    240              NEXT11,     NDA
31 171    120 177 031                  JFS NEXT12
31 174    104 143 031                  JMP NEXT10
```

```
31 177    066 314              NEXT12,  LLI 314
31 201    056 001        **            LHI 001
31 203    106 244 022                  CAL FLOAD
31 206    106 252 010                  CAL RESTSY
31 211    106 055 010                  CAL STOSYM
31 214    104 116 013                  JMP NXTLIN

31 217    006 215              BACKSP,  LAI 215
31 221    106 202 003                  CAL ECHO
31 224    106 202 003                  CAL ECHO
31 227    066 043                      LLI 043
31 231    056 001        **            LHI 001
31 233    076 001                      LMI 001
31 235    066 124                      LLI 124
31 237    307                          LAM
31 240    240                          NDA
31 241    063                          RTS
31 242    053                          RTZ
31 243    104 022 010                  JMP TAB1

31 246    066 205                FOR5,  LLI 205
31 250    056 027        **            LHI 027
31 252    307                          LAM
31 253    002                          RLC
31 254    002                          RLC
31 255    004 136                      ADI 136
31 257    340                          LEA
31 260    335                          LDH
31 261    066 145                      LLI 145
31 263    056 026        **            LHI 026
31 265    016 002                      LBI 002
31 267    106 013 021                  CAL MOVEIT
31 272    106 055 010                  CAL STOSYM
31 275    104 116 013                  JMP NXTLIN

31 300    066 176              PARSEP,  LLI 176
31 302    076 000                      LMI 000
31 304    106 324 004                  CAL PARSER
31 307    066 227                      LLI 227
31 311    056 001        **            LHI 001
31 313    307                          LAM
31 314    074 230                      CPI 230
31 316    053                          RTZ
31 317    104 152 011                  JMP SYNERR
```

Note open addresses.
This space available
for patching.

```
32 000    066 014                    SQRX,  LLI 014
32 002    056 001          **               LHI 001
32 004    106 255 022                       CAL FSTORE
32 007    066 126                           LLI 126
32 011    307                               LAM
32 012    240                               NDA
32 013    160 217 032                       JTS SQRERR
32 016    150 247 006                       JTZ CFALSE
32 021    066 017                           LLI 017
32 023    307                               LAM
32 024    240                               NDA
32 025    160 041 032                       JTS NEGEXP
32 030    032                               RAR
32 031    310                               LBA
32 032    006 000                           LAI 000
32 034    022                               RAL
32 035    370                               LMA
32 036    104 062 032                       JMP SQREXP

32 041    310                    NEGEXP,    LBA
32 042    250                               XRA
32 043    221                               SUB
32 044    240                               NDA
32 045    032                               RAR
32 046    310                               LBA
32 047    006 000                           LAI 000
32 051    210                               ACA
32 052    370                               LMA
32 053    150 057 032                       JTZ NOREMD
32 056    010                               INB

32 057    250                    NOREMD,    XRA
32 060    221                               SUB
32 061    310                               LBA

32 062    066 013                SQREXP,    LLI 013
32 064    371                               LMB
32 065    066 004                           LLI 004
32 067    046 034                           LEI 034
32 071    335                               LDH
32 072    016 004                           LBI 004
32 074    106 013 021                       CAL MOVEIT
32 077    106 247 006                       CAL CFALSE
32 102    066 044                           LLI 044
32 104    106 255 022                       CAL FSTORE

32 107    066 034                SQRLOP,    LLI 034
32 111    106 244 022                       CAL FLOAD
32 114    066 014                           LLI 014
32 116    106 266 022                       CAL OPLOAD
32 121    106 322 021                       CAL FPDIV
```

```
32 124      066 034                          LLI 034
32 126      106 266 022                      CAL OPLOAD
32 131      106 211 020                      CAL FPADD
32 134      066 127                          LLI 127
32 136      317                              LBM
32 137      011                              DCB
32 140      371                              LMB
32 141      066 034                          LLI 034
32 143      106 255 022                      CAL FSTORE
32 146      066 044                          LLI 044
32 150      106 266 022                      CAL OPLOAD
32 153      106 032 021                      CAL FPSUB
32 156      066 127                          LLI 127
32 160      307                              LAM
32 161      074 367                          CPI 367
32 163      160 203 032                      JTS SQRCNV
32 166      066 034                          LLI 034
32 170      335                              LDH
32 171      046 044                          LEI 044
32 173      016 004                          LBI 004
32 175      106 013 021                      CAL MOVEIT
32 200      104 107 032                      JMP SQRLOP

32 203      066 013                SQRCNV,   LLI 013
32 205      307                              LAM
32 206      066 037                          LLI 037
32 210      207                              ADM
32 211      370                              LMA
32 212      066 034                          LLI 034
32 214      104 244 022                      JMP FLOAD

32 217      006 323                SQRERR,   LAI 323
32 221      026 321                          LCI 321
32 223      104 226 002                      JMP ERROR
```

Note open addresses.
This space available
for patching.

```
32 240      066 064                  RNDX,   LLI 064
32 242      056 001          **              LHI 001
32 244      106 244 022                      CAL FLOAD
32 247      066 050                          LLI 050
32 251      106 266 022                      CAL OPLOAD
32 254      106 046 021                      CAL FPMULT
32 257      066 060                          LLI 060
32 261      106 266 022                      CAL OPLOAD
32 264      106 211 020                      CAL FPADD
32 267      066 064                          LLI 064
32 271      106 255 022                      CAL FSTORE
32 274      066 127                          LLI 127
```

```
32 276      307                                 LAM
32 277      024 020                             SUI 020
32 301      370                                 LMA
32 302      106 000 020                         CAL FPFIX
32 305      066 123                             LLI 123
32 307      076 000                             LMI 000
32 311      066 127                             LLI 127
32 313      076 000                             LMI 000
32 315      106 064 020                         CAL FPFLT
32 320      066 127                             LLI 127
32 322      307                                 LAM
32 323      004 020                             ADI 020
32 325      370                                 LMA
32 326      066 064                             LLI 064
32 330      106 266 022                         CAL OPLOAD
32 333      106 032 021                         CAL FPSUB
32 336      066 064                             LLI 064
32 340      106 255 022                         CAL FSTORE
32 343      066 127                             LLI 127
32 345      307                                 LAM
32 346      024 020                             SUI 020
32 350      370                                 LMA
32 351      007                                 RET
```

Note open addresses
to end of page 32.

Pages 33 to remainder
of memory (or start of
optional ARRAY
handling routines) used as
USER PROGRAM BUFFER.

Optional ARRAY routines
assembled for operation in
the upper three pages of a
12 K system are listed here.

```
55 000      066 126                     PRIGH1, LLI 126
55 002      056 001             **              LHI 001
55 004      307                                 LAM
55 005      240                                 NDA
55 006      160 136 055                         JTS OUTRNG
55 011      106 000 020                         CAL FPFIX
55 014      066 124                             LLI 124
55 016      307                                 LAM
55 017      024 001                             SUI 001
55 021      002                                 RLC
55 022      002                                 RLC
55 023      320                                 LCA
55 024      066 203                             LLI 203
```

```
55 026      056 027          **                  LHI 027
55 030      307                                  LAM
55 031      054 377                              XRI 377
55 033      002                                  RLC
55 034      002                                  RLC
55 035      004 120                              ADI 120
55 037      056 027          **                  LHI 027
55 041      360                                  LLA
55 042      060                                  INL
55 043      060                                  INL
55 044      307                                  LAM
55 045      202                                  ADC
55 046      360                                  LLA
55 047      056 057          ††                  LHI 057
55 051      104 244 022                          JMP FLOAD

55 054      066 202                  FUNAR2,     LLI 202
55 056      056 027          **                  LHI 027
55 060      317                                  LBM
55 061      010                                  INB
55 062      371                                  LMB
55 063      026 002                              LCI 002
55 065      066 114                              LLI 114
55 067      056 027          **                  LHI 027
55 071      106 230 007                          CAL TABADR
55 074      036 026          **                  LDI 026
55 076      046 120                              LEI 120
55 100      106 332 002                          CAL STRCP
55 103      150 124 055                          JTZ FUNAR3
55 106      066 202                              LLI 202
55 110      056 027          **                  LHI 027
55 112      307                                  LAM
55 113      066 075                              LLI 075
55 115      277                                  CPM
55 116      110 054 055                          JFZ FUNAR2
55 121      104 172 007                          JMP FAERR

55 124      066 202                  FUNAR3,     LLI 202
55 126      056 027          **                  LHI 027
55 130      250                                  XRA
55 131      237                                  SBM
55 132      370                                  LMA
55 133      104 207 007                          JMP FUNAR4

55 136      006 317                  OUTRNG,     LAI 317
55 140      026 322                              LCI 322
55 142      104 226 002                          JMP ERROR

55 145      106 252 010                  ARRAY,  CAL RESTSY
55 150      104 160 055                          JMP ARRAY2
```

```
55 153      066 202                 ARRAY1,  LLI 202
55 155      104 162 055                      JMP ARRAY3

55 160      066 203                 ARRAY2,  LLI 203

55 162      056 026          **     ARRAY3,  LHI 026
55 164      317                             LBM
55 165      010                             INB
55 166      066 276                         LLI 276
55 170      371                             LMB
55 171      066 206                         LLI 206
55 173      371                             LMB

55 174      066 206                 ARRAY4,  LLI 206
55 176      106 240 002                      CAL GETCHR
55 201      074 251                          CPI 251
55 203      150 225 055                      JTZ ARRAY5
55 206      066 206                          LLI 206
55 210      106 003 003                      CAL LOOP
55 213      110 174 055                      JFZ ARRAY4
55 216      006 301                          LAI 301
55 220      026 306                          LCI 306
55 222      104 226 002                      JMP ERROR

55 225      066 206                 ARRAY5,  LLI 206
55 227      317                              LBM
55 230      011                              DCB
55 231      066 277                          LLI 277
55 233      371                              LMB
55 234      066 207                          LLI 207
55 236      076 000                          LMI 000

55 240      066 207                 ARRAY6,  LLI 207
55 242      056 026          **              LHI 026
55 244      317                              LBM
55 245      010                              INB
55 246      371                              LMB
55 247      026 002                          LCI 002
55 251      066 114                          LLI 114
55 253      056 027          **              LHI 027
55 255      106 230 007                      CAL TABADR
55 260      046 120                          LEI 120
55 262      036 026          **              LDI 026
55 264      106 332 002                      CAL STRCP
55 267      150 312 055                      JTZ ARRAY7
55 272      066 207                          LLI 207
55 274      056 026          **              LHI 026
55 276      307                              LAM
55 277      066 075                          LLI 075
55 301      056 027          **              LHI 027
55 303      277                              CPM
```

```
55 304    110 240 055                    JFZ ARRAY6
55 307    104 172 007                    JMP FAERR

55 312    106 224 003          ARRAY7,   CAL EVAL
55 315    106 000 020                    CAL FPFIX
55 320    066 207                        LLI 207
55 322    056 026          **            LHI 026
55 324    317                            LBM
55 325    026 002                        LCI 002
55 327    066 114                        LLI 114
55 331    056 027          **            LHI 027
55 333    106 230 007                    CAL TABADR
55 336    060                            INL
55 337    060                            INL
55 340    327                            LCM
55 341    066 124                        LLI 124
55 343    056 001          **            LHI 001
55 345    307                            LAM
55 346    024 001                        SUI 001
55 350    002                            RLC
55 351    002                            RLC
55 352    202                            ADC
55 353    066 204                        LLI 204
55 355    056 027          **            LHI 027
55 357    370                            LMA
55 360    066 201                        LLI 201
55 362    076 377                        LMI 377
55 364    007                            RET

55 365    106 255 002            DIM,    CAL CLESYM
55 370    066 202                        LLI 202
55 372    317                            LBM
55 373    010                            INB
55 374    066 203                        LLI 203
55 376    371                            LMB

55 377    066 203              DIM1,     LLI 203
56 001    106 240 002                    CAL GETCHR
56 004    150 017 056                    JTZ DIM2
56 007    074 250                        CPI 250
56 011    150 032 056                    JTZ DIM3
56 014    106 310 002                    CAL CONCTS

56 017    066 203              DIM2,     LLI 203
56 021    106 003 003                    CAL LOOP
56 024    110 377 055                    JFZ DIM1
56 027    104 337 056                    JMP DIMERR

56 032    066 206              DIM3,     LLI 206
56 034    076 000                        LMI 000
```

```
56 036    066 206                    DIM4,  LLI 206
56 040    056 026          **               LHI 026
56 042    307                               LAM
56 043    002                               RLC
56 044    002                               RLC
56 045    004 114                           ADI 114
56 047    056 027          **               LHI 027
56 051    360                               LLA
56 052    046 120                           LEI 120
56 054    036 026          **               LDI 026
56 056    106 332 002                       CAL STRCP
56 061    150 301 056                       JTZ DIM9
56 064    066 206                           LLI 206
56 066    056 026          **               LHI 026
56 070    317                               LBM
56 071    010                               INB
56 072    371                               LMB
56 073    066 075                           LLI 075
56 075    056 027          **               LHI 027
56 077    307                               LAM
56 100    011                               DCB
56 101    271                               CPB
56 102    110 036 056                       JFZ DIM4
56 105    066 075                           LLI 075
56 107    056 027          **               LHI 027
56 111    317                               LBM
56 112    010                               INB
56 113    371                               LMB
56 114    066 076                           LLI 076
56 116    371                               LMB
56 117    066 206                           LLI 206
56 121    056 026          **               LHI 026
56 123    371                               LMB
56 124    307                               LAM
56 125    002                               RLC
56 126    002                               RLC
56 127    004 114                           ADI 114
56 131    340                               LEA
56 132    036 027          **               LDI 027
56 134    066 120                           LLI 120
56 136    056 026          **               LHI 026
56 140    106 046 012                       CAL MOVEC
56 143    106 255 002                       CAL CLESYM
56 146    066 203                           LLI 203
56 150    056 026          **               LHI 026
56 152    317                               LBM
56 153    010                               INB
56 154    066 204                           LLI 204
56 156    371                               LMB

56 157    066 204                    DIM5,  LLI 204
```

```
56 161    106 240 002                    CAL GETCHR
56 164    150 211 056                    JTZ DIM6
56 167    074 251                        CPI 251
56 171    150 224 056                    JTZ DIM7
56 174    074 260                        CPI 260
56 176    160 337 056                    JTS DIMERR
56 201    074 272                        CPI 272
56 203    120 337 056                    JFS DIMERR
56 206    106 310 002                    CAL CONCTS

56 211    066 204                DIM6,   LLI 204
56 213    106 003 003                    CAL LOOP
56 216    110 157 056                    JFZ DIM5
56 221    104 337 056                    JMP DIMERR

56 224    066 120                DIM7,   LLI 120
56 226    056 026        **              LHI 026
56 230    106 044 023                    CAL DINPUT
56 233    106 000 020                    CAL FPFIX
56 236    066 124                        LLI 124
56 240    307                            LAM
56 241    002                            RLC
56 242    002                            RLC
56 243    320                            LCA
56 244    066 076                        LLI 076
56 246    056 027        **              LHI 027
56 250    307                            LAM
56 251    024 001                        SUI 001
56 253    002                            RLC
56 254    002                            RLC
56 255    004 122                        ADI 122
56 257    360                            LLA
56 260    056 027        **              LHI 027
56 262    317                            LBM
56 263    004 004                        ADI 004
56 265    360                            LLA
56 266    301                            LAB
56 267    202                            ADC
56 270    370                            LMA

56 271    066 204                DIM8,   LLI 204
56 273    056 026        **              LHI 026
56 275    317                            LBM
56 276    066 203                        LLI 203
56 300    371                            LMB

56 301    066 203                DIM9,   LLI 203
56 303    106 240 002                    CAL GETCHR
56 306    074 254                        CPI 254
56 310    150 326 056                    JTZ DIM10
56 313    066 203                        LLI 203
```

```
56 315    106 003 003                    CAL LOOP
56 320    110 301 056                    JFZ DIM9
56 323    104 116 013                    JMP NXTLIN

56 326    066 203              DIM10,    LLI 203
56 330    317                            LBM
56 331    066 202                        LLI 202
56 333    371                            LMB
56 334    104 365 055                    JMP DIM

56 337    006 304              DIMERR,   LAI 304
56 341    026 305                        LCI 305
56 343    104 226 002                    JMP ERROR
```

Note open addresses
to end of page 56.

Page 57 reserved
for use by the
ARRAY VALUES TABLE.

# SCELBAL ASSEMBLED FOR OPERATION IN AN 8080 BASED SYSTEM

This chapter presents an assembled version of SCELBAL for operation in an 8080 based microcomputer. This version may be loaded into a system along with the user provided I/O subroutines to provide the user with SCELBAL capability.

The user may elect, by choosing the proper machine codes at key locations, to load the program as an 8 K version that does not have the optional DIM statement capability. This version of the program will leave room for about 1,250 bytes in the user program buffer. Or, the user may load the program as a 12 K version with DIM capability. (Leaving about 4,500 bytes for program storage.) Alternately, by changing a few specially marked locations, the user may elect to have the program operate in 8 K of memory with DIM capability. However, this version is not recommended because it will leave only about 500 bytes for storage of a high level language user program. (It is mentioned as an option because some prospective users may desire to run small programs that require the DIM capability.) Finally, the user may opt to place the DIM routines (by changing the associated pointers, etc.) in the upper pages of available RAM memory in any system having more than 8 K of memory (such as a 10 K, 16 K, 32 K system) and using the area between the locations used by the main SCELBAL routines and the optional DIM routines as a user program buffer.

The reader who has studied this book to this point should have no difficulty understanding what is involved in selecting the options just mentioned. Many readers may well elect to make other alterations and may, of course, do so at their own discretion. Let it be said, that the version presented is just one way in which the program may be assembled for operation!

The reader should pay careful attention in the following object code listing to all locations marked by a double asterisk (**), double at sign (@@), or double cross (††). The convention established in the earlier chapters for those special indicators will be reviewed here.

A double asterisk (**) is of importance only to those readers who might elect to change the memory pages used for the storage of pointers, counters, temporary buffers and look-up tables. The pages used for these purposes in the version of SCELBAL presented are pages 01, 26 and 27. Readers who take on the task of re-assigning these pages will probably have elected to completely reassemble SCELBAL and should be equipped (mentally and with suitable hardware!) to take on such a task.

A double cross (††) denotes an elective value on the part of the user. These locations generally refer to the starting addresses of user provided routines (such as I/O drivers), or the assignment of the starting and ending address of the user program buffer area. (For the version presented the user program buffer is assumed to start on page 33 and end on page 54. The ending address would be changed to page 37 if an 8 K system was being used and the DIM capability left out. Or, page 34 for an 8 K system with DIM capability provided, etc.)

Locations marked with a @@ should be replaced with the machine code for a no-operation instruction, such as LAA, if the user will not be using the optional DIM statement capability. Alternately, some of these locations relating to addressing values would be altered if the user elected to change the storage areas for the DIM and associated array handling subroutines.

It is suggested that user I/O subroutines be placed on page 00 if possible. Alternately, they may be placed in the upper regions of available memory. If this is done, the ending address of the user program buffer should be altered accordingly.

The 8080 object code presented in this chapter was derived from the source listings presented in detail in earlier chapters with one small exception. Since the 8080 CPU requires an area in memory to be set aside as a stack, the start of the EXECutive routine (refer to the appropriate chapter as required) has been altered to include a stack initializing instruction. For the version presented herein, the 8080 stack is initialized to the address: PAGE 32 LOCATION 000, so that the top region of page 31 is used as the stack area. In order to compensate for the insertion of the stack initializing command at the start of the EXECutive routine, and still maintain the same address references for labels between the two versions of the program presented herein (8008 and 8080), a small subroutine was added (at PAGE 31 LOCATION 330). This subroutine simply contains a pointer initializing command and call to the subroutine TEXTC. This subroutine has been labeled EXECSP in the following listing.

One final word before presenting the object code is in order. Do not attemp to skip over the machine code listings provided for the special pages 01, 26, and 27. The values in the look-up tables must be in memory along with the initial values of many of the locations on those pages when the program is first started. (Those locations where the initial values are irrelevant are denoted by XXX.) The format of the object code listing for these special pages will be slightly different than the rest of the listing in that the mnemonics column will contain comments relating to the use of the locations (since the locations will contain "data" versus actual instructions).

```
01 000      XXX      Not Assigned
01 001      XXX      Not Assigned
01 002      XXX      Not Assigned
01 003      XXX      Not Assigned
01 004      000      Stores floating
01 005      000      point
01 006      100      constant
01 007      001      value +1.0
01 010      XXX      Not Assigned
01 011      XXX      Not Assigned
01 012      XXX      Not Assigned
01 013      000      Exponent Counter
01 014      000      Stores floating
01 015      000      point
01 016      000      number
01 017      000      temporarily
01 020      XXX      Not Assigned
01 021      XXX      Not Assigned
01 022      XXX      Not Assigned
01 023      XXX      Not Assigned
01 024      000      Stores floating
01 025      000      point
01 026      300      constant
01 027      001      value - 1.0
01 030      000      Scratch Pad Area
 .   .       .
 .   .       .
01 047      000      Scratch Pad Area
```

| | | |
|---|---|---|
| 01 050 | 001 | Stores random |
| 01 051 | 120 | number generator |
| 01 052 | 162 | constant |
| 01 053 | 002 | value |
| 01 054 | XXX | Not Assigned |
| 01 055 | XXX | Not Assigned |
| 01 056 | XXX | Not Assigned |
| 01 057 | XXX | Not Assigned |
| 01 060 | 003 | Stores random |
| 01 061 | 150 | number generator |
| 01 062 | 157 | constant |
| 01 063 | 014 | value |
| 01 064 | 000 | Scratch Pad Area |
| . . | . | |
| 01 077 | 000 | Scratch Pad Area |
| | | |
| 01 100 | 000 | Sign Indicator |
| 01 101 | 000 | Sign Indicator |
| 01 102 | 000 | Bits Counter |
| 01 103 | 000 | Sign Indicator |
| 01 104 | 000 | Sign Indicator |
| 01 105 | 000 | Input Digit Counter |
| 01 106 | 000 | Temp Storage |
| 01 107 | 000 | Output Digit Counter |
| 01 110 | 000 | FP Mode Indicator |
| 01 111 | XXX | Not Assigned |
| . . | . | |
| 01 117 | XXX | Not Assigned |
| 01 120 | 000 | FPACC Extension |
| 01 121 | 000 | FPACC Extension |
| 01 122 | 000 | FPACC Extension |
| 01 123 | 000 | FPACC Extension |
| 01 124 | 000 | FPACC LSW |
| 01 125 | 000 | FPACC NSW |
| 01 126 | 000 | FPACC MSW |
| 01 127 | 000 | FPACC Exponent |
| 01 130 | 000 | FPOP Extension |
| 01 131 | 000 | FPOP Extension |
| 01 132 | 000 | FPOP Extension |
| 01 133 | 000 | FPOP Extension |
| 01 134 | 000 | FPOP LSW |
| 01 135 | 000 | FPOP NSW |
| 01 136 | 000 | FPOP MSW |
| 01 137 | 000 | FPOP Exponent |
| 01 140 | 000 | Floating point working area |
| . . | . | |
| 01 167 | 000 | Floating point working area |
| 01 170 | XXX | Not Assigned |
| . . | . | |
| 01 177 | XXX | Not Assigned |
| 01 200 | 000 | Temporary |

| | | |
|---|---|---|
| 01 201 | 000 | register |
| 01 202 | 000 | storage |
| 01 203 | 000 | area (D, E, H & L) |
| 01 204 | XXX | Not Assigned |
| 01 205 | XXX | Not Assigned |
| 01 206 | XXX | Not Assigned |
| 01 207 | XXX | Not Assigned |
| 01 210 | 000 | Stores floating |
| 01 211 | 000 | point |
| 01 212 | 120 | constant |
| 01 213 | 004 | value +10.0 |
| 01 214 | 147 | Stores floating |
| 01 215 | 146 | point |
| 01 216 | 146 | constant |
| 01 217 | 375 | value +0.1 |
| 01 220 | 000 | GETINP Counter |
| 01 221 | XXX | Not Assigned |
| 01 222 | XXX | Not Assigned |
| 01 223 | XXX | Not Assigned |
| 01 224 | XXX | Not Assigned |
| 01 225 | XXX | Not Assigned |
| 01 226 | XXX | Not Assigned |
| 01 227 | 000 | Arithmetic Stack Pointer |
| 01 230 | 000 | Arithmetic Stack |
| . . | . | |
| . . | . | |
| 01 277 | 000 | Arithmetic Stack |
| 01 300 | 000 | FPACC |
| 01 301 | 000 | temporary |
| 01 302 | 000 | storage |
| 01 303 | 000 | location |
| 01 304 | 000 | STEP value |
| 01 305 | 000 | temporary |
| 01 306 | 000 | storage |
| 01 307 | 000 | location |
| 01 310 | 000 | FOR/NEXT Limit |
| 01 311 | 000 | temporary |
| 01 312 | 000 | storage |
| 01 313 | 000 | location |
| 01 314 | 000 | Array pointer |
| 01 315 | 000 | temporary |
| 01 316 | 000 | storage |
| 01 317 | 000 | location |

Executive & special messages
look-up table and storage area.

| | | |
|---|---|---|
| 01 320 | 004 | (cc) for THEN |
| 01 321 | 324 | T |

| | | |
|---|---|---|
| 01 322 | 310 | H |
| 01 323 | 305 | E |
| 01 324 | 316 | N |
| 01 325 | 002 | (cc) for TO |
| 01 326 | 324 | T |
| 01 327 | 317 | O |
| 01 330 | 004 | (cc) for STEP |
| 01 331 | 323 | S |
| 01 332 | 324 | T |
| 01 333 | 305 | E |
| 01 334 | 320 | P |
| 01 335 | 004 | (cc) for LIST |
| 01 336 | 314 | L |
| 01 337 | 311 | I |
| 01 340 | 323 | S |
| 01 341 | 324 | T |
| 01 342 | 003 | (cc) for RUN |
| 01 343 | 322 | R |
| 01 344 | 325 | U |
| 01 345 | 316 | N |
| 01 346 | 003 | (cc) for SCR |
| 01 347 | 323 | S |
| 01 350 | 303 | C |
| 01 351 | 322 | R |
| 01 352 | 013 | (cc) for READY message |
| 01 353 | 224 | Ctrl T |
| 01 354 | 215 | Carriage-return |
| 01 355 | 212 | Line-feed |
| 01 356 | 322 | R |
| 01 357 | 305 | E |
| 01 360 | 301 | A |
| 01 361 | 304 | D |
| 01 362 | 331 | Y |
| 01 363 | 215 | Carriage-return |
| 01 364 | 212 | Line-feed |
| 01 365 | 212 | Line-feed |
| 01 366 | 011 | (cc) for AT LINE message |
| 01 367 | 240 | Space |
| 01 370 | 301 | A |
| 01 371 | 324 | T |
| 01 372 | 240 | Space |
| 01 373 | 314 | L |
| 01 374 | 311 | I |
| 01 375 | 316 | N |
| 01 376 | 305 | E |
| 01 377 | 240 | Space |

End of page 01.

```
02 000    315 255 002          SYNTAX,  CAL CLESYM
02 003    056 340                       LLI 340
02 005    046 026       **              LHI 026
02 007    066 000                       LMI 000
02 011    056 201                       LLI 201
02 013    066 001                       LMI 001

02 015    056 201          SYNTX1,      LLI 201
02 017    315 240 002                   CAL GETCHR
02 022    312 044 002                   JTZ SYNTX2
02 025    376 260                       CPI 260
02 027    372 061 002                   JTS SYNTX3
02 032    376 272                       CPI 272
02 034    362 061 002                   JFS SYNTX3
02 037    056 340                       LLI 340
02 041    315 314 002                   CAL CONCT1

02 044    056 201          SYNTX2,      LLI 201
02 046    315 003 003                   CAL LOOP
02 051    302 015 002                   JFZ SYNTX1
02 054    056 203                       LLI 203
02 056    066 000                       LMI 000
02 060    311                           RET

02 061    056 201          SYNTX3,      LLI 201
02 063    106                           LBM
02 064    056 202                       LLI 202
02 066    160                           LMB

02 067    056 202          SYNTX4,      LLI 202
02 071    315 240 002                   CAL GETCHR
02 074    312 171 002                   JTZ SYNTX6
02 077    376 275                       CPI 275
02 101    312 210 002                   JTZ SYNTX7
02 104    376 250                       CPI 250
02 106    312 215 002                   JTZ SYNTX8
02 111    315 310 002                   CAL CONCTS
02 114    056 203                       LLI 203
02 116    066 001                       LMI 001
02 120    046 027       **              LHI 027
02 122    056 000                       LLI 000

02 124    026 026       **  SYNTX5,     LDI 026
02 126    036 120                       LEI 120
02 130    315 332 002                   CAL STRCP
02 133    310                           RTZ
02 134    315 356 022                   CAL SWITCH

02 137    054              SYNTXL,      INL
02 140    176                           LAM
02 141    346 300                       NDI 300
```

```
02 143    302 137 002                    JFZ SYNTXL
02 146    315 356 022                    CAL SWITCH
02 151    056 203                        LLI 203
02 153    046 026          **            LHI 026
02 155    106                            LBM
02 156    004                            INB
02 157    160                            LMB
02 160    315 356 022                    CAL SWITCH
02 163    170                            LAB
02 164    376 015                        CPI 015
02 166    302 124 002                    JFZ SYNTX5

02 171    056 202              SYNTX6,   LLI 202
02 173    046 026          **            LHI 026
02 175    315 003 003                    CAL LOOP
02 200    302 067 002                    JFZ SYNTX4
02 203    056 203                        LLI 203
02 205    066 377                        LMI 377
02 207    311                            RET

02 210    056 203              SYNTX7,   LLI 203
02 212    066 015                        LMI 015
02 214    311                            RET

02 215    056 203              SYNTX8,   LLI 203
02 217    066 016                        LMI 016
02 221    311                            RET

02 222    076 302              BIGERR,   LAI 302
02 224    016 307                        LCI 307

02 226    315 202 003           ERROR,   CAL ECHO
02 231    171                            LAC
02 232    315 202 003                    CAL ECHO
02 235    303 322 012                    JMP FINERR

02 240    176                  GETCHR,   LAM
02 241    376 120                        CPI 120
02 243    362 222 002                    JFS BIGERR
02 246    157                            LLA
02 247    046 026          **            LHI 026
02 251    176                            LAM
02 252    376 240                        CPI 240
02 254    311                            RET

02 255    056 120              CLESYM,   LLI 120
02 257    046 026          **            LHI 026
02 261    066 000                        LMI 000
02 263    311                            RET

02 264    376 301              CONCTA,   CPI 301
```

```
02 266      372 276 002                     JTS CONCTN
02 271      376 333                         CPI 333
02 273      372 310 002                     JTS CONCTS

02 276      376 260             CONCTN,     CPI 260
02 300      372 327 002                     JTS CONCTE
02 303      376 272                         CPI 272
02 305      362 327 002                     JFS CONCTE

02 310      056 120             CONCTS,     LLI 120
02 312      046 026         **              LHI 026

02 314      116                 CONCT1,     LCM
02 315      014                             INC
02 316      161                             LMC
02 317      107                             LBA
02 320      315 036 023                     CAL INDEXC
02 323      160                             LMB
02 324      076 000                         LAI 000
02 326      311                             RET

02 327      303 152 011         CONCTE,     JMP SYNERR

02 332      176                   STRCP,    LAM
02 333      315 356 022                     CAL SWITCH
02 336      106                             LBM
02 337      270                             CPB
02 340      300                             RFZ
02 341      315 356 022                     CAL SWITCH

02 344      315 377 002           STRCPL,   CAL ADV
02 347      176                             LAM
02 350      315 356 022                     CAL SWITCH
02 353      315 377 002                     CAL ADV

02 356      276                   STRCPE,   CPM
02 357      300                             RFZ
02 360      315 356 022                     CAL SWITCH
02 363      005                             DCB
02 364      302 344 002                     JFZ STRCPL
02 367      311                             RET

02 370      176                   STRCPC,   LAM
02 371      315 356 022                     CAL SWITCH
02 374      303 356 002                     JMP STRCPE

02 377      054                     ADV,    INL
03 000      300                             RFZ
03 001      044                             INH
03 002      311                             RET
```

```
03 003      106                 LOOP,   LBM
03 004      004                         INB
03 005      160                         LMB
03 006      056 000                     LLI 000
03 010      176                         LAM
03 011      005                         DCB
03 012      270                         CPB
03 013      311                         RET

03 014      016 000             STRIN,  LCI 000

03 016      315 221 003         STRIN1, CAL CINPUT
03 021      376 377                     CPI 377
03 023      302 045 003                 JFZ NOTDEL
03 026      076 334                     LAI 334
03 030      315 202 003                 CAL ECHO
03 033      015                         DCC
03 034      372 014 003                 JTS STRIN
03 037      315 164 003                 CAL DEC
03 042      303 016 003                 JMP STRIN1

03 045      376 203             NOTDEL, CPI 203
03 047      312 313 012                 JTZ CTRLC
03 052      376 215                     CPI 215
03 054      312 102 003                 JTZ STRINF
03 057      376 212                     CPI 212
03 061      312 016 003                 JTZ STRIN1
03 064      315 377 002                 CAL ADV
03 067      014                         INC
03 070      167                         LMA
03 071      171                         LAC
03 072      376 120                     CPI 120
03 074      362 222 002                 JFS BIGERR
03 077      303 016 003                 JMP STRIN1

03 102      101                 STRINF, LBC
03 103      315 113 003                 CAL SUBHL
03 106      161                         LMC
03 107      315 141 003                 CAL CRLF
03 112      311                         RET

03 113      175                 SUBHL,  LAL
03 114      220                         SUB
03 115      157                         LLA
03 116      320                         RFC
03 117      045                         DCH
03 120      311                         RET

03 121      116                 TEXTC,  LCM
03 122      176                         LAM
03 123      247                         NDA
```

```
03 124      310                                 RTZ

03 125      315 377 002                 TEXTCL, CAL ADV
03 130      176                                 LAM
03 131      315 202 003                         CAL ECHO
03 134      015                                 DCC
03 135      302 125 003                         JFZ TEXTCL
03 140      311                                 RET

03 141      076 215                     CRLF,   LAI 215
03 143      315 202 003                         CAL ECHO
03 146      076 212                             LAI 212
03 150      315 202 003                         CAL ECHO
03 153      056 043                             LLI 043
03 155      046 001             **              LHI 001
03 157      066 001                             LMI 001
03 161      142                                 LHD
03 162      153                                 LLE
03 163      311                                 RET

03 164      055                         DEC,    DCL
03 165      054                                 INL
03 166      302 172 003                         JFZ DECN0
03 171      045                                 DCH

03 172      055                         DECN0,  DCL
03 173      311                                 RET

03 174      175                         INDEXB, LAL
03 175      200                                 ADB
03 176      157                                 LLA
03 177      320                                 RFC
03 200      044                                 INH
03 201      311                                 RET

03 202      124                         ECHO,   LDH
03 203      135                                 LEL
03 204      056 043                             LLI 043
03 206      046 001             **              LHI 001
03 210      106                                 LBM
03 211      004                                 INB
03 212      160                                 LMB
03 213      315 ††† †††         ††              CAL ††† †††
03 216      142                                 LHD
03 217      153                                 LLE
03 220      311                                 RET

03 221      303 ††† †††         ††      CINPUT, JMP ††† †††

03 224      056 227                     EVAL,   LLI 227
03 226      046 001             **              LHI 001
```

```
03 230      066 224                          LMI 224
03 232      054                              INL
03 233      046 026          **              LHI 026
03 235      066 000                          LMI 000
03 237      315 255 002                      CAL CLESYM
03 242      056 210                          LLI 210
03 244      066 000                          LMI 000
03 246      056 276                          LLI 276
03 250      106                              LBM
03 251      056 200                          LLI 200
03 253      160                              LMB

03 254      056 200                  SCAN1,  LLI 200
03 256      315 240 002                      CAL GETCHR
03 261      312 301 004                      JTZ SCAN10
03 264      376 253                          CPI 253
03 266      302 300 003                      JFZ SCAN2
03 271      056 176                          LLI 176
03 273      066 001                          LMI 001
03 275      303 351 003                      JMP SCANFN

03 300      376 255                  SCAN2,  CPI 255
03 302      302 357 003                      JFZ SCAN4
03 305      056 120                          LLI 120
03 307      176                              LAM
03 310      247                              NDA
03 311      302 345 003                      JFZ SCAN3
03 314      056 176                          LLI 176
03 316      176                              LAM
03 317      376 007                          CPI 007
03 321      312 345 003                      JTZ SCAN3
03 324      376 003                          CPI 003
03 326      312 152 011                      JTZ SYNERR
03 331      376 005                          CPI 005
03 333      312 152 011                      JTZ SYNERR
03 336      056 120                          LLI 120
03 340      066 001                          LMI 001
03 342      054                              INL
03 343      066 260                          LMI 260

03 345      056 176                  SCAN3,  LLI 176
03 347      066 002                          LMI 002

03 351      315 324 004              SCANFN, CAL PARSER
03 354      303 301 004                      JMP SCAN10

03 357      376 252                  SCAN4,  CPI 252
03 361      302 373 003                      JFZ SCAN5
03 364      056 176                          LLI 176
03 366      066 003                          LMI 003
03 370      303 351 003                      JMP SCANFN
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03 373      376 257                     SCAN5,  CPI 257
03 375      302 007 004                         JFZ SCAN6
04 000      056 176                             LLI 176
04 002      066 004                             LMI 004
04 004      303 351 003                         JMP SCANFN

04 007      376 250                     SCAN6,  CPI 250
04 011      302 033 004                         JFZ SCAN7
04 014      056 230                             LLI 230
04 016      106                                 LBM
04 017      004                                 INB
04 020      160                                 LMB
04 021      315 100 007                         CAL FUNARR
04 024      056 176                             LLI 176
04 026      066 006                             LMI 006
04 030      303 351 003                         JMP SCANFN

04 033      376 251                     SCAN7,  CPI 251
04 035      302 064 004                         JFZ SCAN8
04 040      056 176                             LLI 176
04 042      066 007                             LMI 007
04 044      315 324 004                         CAL PARSER
04 047      315 003 007                         CAL PRIGHT
04 052      056 230                             LLI 230
04 054      046 026             **              LHI 026
04 056      106                                 LBM
04 057      005                                 DCB
04 060      160                                 LMB
04 061      303 301 004                         JMP SCAN10

04 064      376 336                     SCAN8,  CPI 336
04 066      302 100 004                         JFZ SCAN9
04 071      056 176                             LLI 176
04 073      066 005                             LMI 005
04 075      303 351 003                         JMP SCANFN

04 100      376 274                     SCAN9,  CPI 274
04 102      302 143 004                         JFZ SCAN11
04 105      056 200                             LLI 200
04 107      106                                 LBM
04 110      004                                 INB
04 111      160                                 LMB
04 112      315 240 002                         CAL GETCHR
04 115      376 275                             CPI 275
04 117      312 251 004                         JTZ SCAN13
04 122      376 276                             CPI 276
04 124      312 267 004                         JTZ SCAN15
04 127      056 200                             LLI 200
04 131      106                                 LBM
04 132      005                                 DCB
04 133      160                                 LMB
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04 134      056 176                     LLI 176
04 136      066 011                     LMI 011
04 140      303 351 003                 JMP SCANFN

04 143      376 275             SCAN11, CPI 275
04 145      302 206 004                 JFZ SCAN12
04 150      056 200                     LLI 200
04 152      106                         LBM
04 153      004                         INB
04 154      160                         LMB
04 155      315 240 002                 CAL GETCHR
04 160      376 274                     CPI 274
04 162      312 251 004                 JTZ SCAN13
04 165      376 276                     CPI 276
04 167      312 260 004                 JTZ SCAN14
04 172      056 200                     LLI 200
04 174      106                         LBM
04 175      005                         DCB
04 176      160                         LMB
04 177      056 176                     LLI 176
04 201      066 012                     LMI 012
04 203      303 351 003                 JMP SCANFN

04 206      376 276             SCAN12, CPI 276
04 210      302 276 004                 JFZ SCAN16
04 213      056 200                     LLI 200
04 215      106                         LBM
04 216      004                         INB
04 217      160                         LMB
04 220      315 240 002                 CAL GETCHR
04 223      376 274                     CPI 274
04 225      312 267 004                 JTZ SCAN15
04 230      376 275                     CPI 275
04 232      312 260 004                 JTZ SCAN14
04 235      056 200                     LLI 200
04 237      106                         LBM
04 240      005                         DCB
04 241      160                         LMB
04 242      056 176                     LLI 176
04 244      066 013                     LMI 013
04 246      303 351 003                 JMP SCANFN

04 251      056 176             SCAN13, LLI 176
04 253      066 014                     LMI 014
04 255      303 351 003                 JMP SCANFN

04 260      056 176             SCAN14, LLI 176
04 262      066 015                     LMI 015
04 264      303 351 003                 JMP SCANFN

04 267      056 176             SCAN15, LLI 176
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04 271    066 016                          LMI 016
04 273    303 351 003                      JMP SCANFN

04 276    315 310 002            SCAN16,   CAL CONCTS

04 301    056 200                SCAN10,   LLI 200
04 303    046 026        **                LHI 026
04 305    106                              LBM
04 306    004                              INB
04 307    160                              LMB
04 310    056 277                          LLI 277
04 312    176                              LAM
04 313    005                              DCB
04 314    270                              CPB
04 315    302 254 003                      JFZ SCAN1
04 320    303 300 031                      JMP PARSEP
04 323    166                              HLT

04 324    056 120                PARSER,   LLI 120
04 326    046 026        **                LHI 026
04 330    176                              LAM
04 331    247                              NDA
04 332    312 231 005                      JTZ PARSE
04 335    054                              INL
04 336    176                              LAM
04 337    376 256                          CPI 256
04 341    312 356 004                      JTZ PARNUM
04 344    376 260                          CPI 260
04 346    372 033 005                      JTS LOOKUP
04 351    376 272                          CPI 272
04 353    362 033 005                      JFS LOOKUP

04 356    055                    PARNUM,   DCL
04 357    176                              LAM
04 360    376 001                          CPI 001
04 362    312 005 005                      JTZ NOEXPO
04 365    205                              ADL
04 366    157                              LLA
04 367    176                              LAM
04 370    376 305                          CPI 305
04 372    302 005 005                      JFZ NOEXPO
04 375    056 200                          LLI 200
04 377    315 240 002                      CAL GETCHR
05 002    303 310 002                      JMP CONCTS

05 005    056 227                NOEXPO,   LLI 227
05 007    046 001        **                LHI 001
05 011    176                              LAM
05 012    306 004                          ADI 004
05 014    167                              LMA
05 015    157                              LLA
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05 016      315 255 022                     CAL FSTORE
05 021      056 120                         LLI 120
05 023      046 026         **              LHI 026
05 025      315 044 023                     CAL DINPUT
05 030      303 231 005                     JMP PARSE

05 033      056 370             LOOKUP,     LLI 370
05 035      046 026         **              LHI 026
05 037      066 000                         LMI 000
05 041      056 120                         LLI 120
05 043      026 027         **              LDI 027
05 045      036 210                         LEI 210
05 047      176                             LAM
05 050      376 001                         CPI 001
05 052      302 061 005                     JFZ LOOKU1
05 055      056 122                         LLI 122
05 057      066 000                         LMI 000

05 061      056 121             LOOKU1,     LLI 121
05 063      046 026         **              LHI 026
05 065      315 356 022                     CAL SWITCH
05 070      176                             LAM
05 071      054                             INL
05 072      106                             LBM
05 073      054                             INL
05 074      315 356 022                     CAL SWITCH
05 077      276                             CPM
05 100      302 111 005                     JFZ LOOKU2
05 103      054                             INL
05 104      170                             LAB
05 105      276                             CPM
05 106      312 201 005                     JTZ LOOKU4

05 111      315 256 006             LOOKU2, CAL AD4DE
05 114      056 370                         LLI 370
05 116      046 026         **              LHI 026
05 120      106                             LBM
05 121      004                             INB
05 122      160                             LMB
05 123      056 077                         LLI 077
05 125      046 027         **              LHI 027
05 127      170                             LAB
05 130      276                             CPM
05 131      302 061 005                     JFZ LOOKU1
05 134      056 077                         LLI 077
05 136      046 027         **              LHI 027
05 140      106                             LBM
05 141      004                             INB
05 142      160                             LMB
05 143      170                             LAB
05 144      376 025                         CPI 025
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05 146    362 222 002                    JFS BIGERR
05 151    056 121                        LLI 121
05 153    046 026          **            LHI 026
05 155    006 002                        LBI 002
05 157    315 013 021                    CAL MOVEIT
05 162    153                            LLE
05 163    142                            LHD
05 164    257                            XRA
05 165    167                            LMA
05 166    054                            INL
05 167    167                            LMA
05 170    054                            INL
05 171    167                            LMA
05 172    054                            INL
05 173    167                            LMA
05 174    175                            LAL
05 175    326 004                        SUI 004
05 177    137                            LEA
05 200    124                            LDH

05 201    315 317 022            LOOKU4, CAL SAVEHL
05 204    056 227                        LLI 227
05 206    046 001          **            LHI 001
05 210    176                            LAM
05 211    306 004                        ADI 004
05 213    167                            LMA
05 214    157                            LLA
05 215    315 255 022                    CAL FSTORE
05 220    315 337 022                    CAL RESTHL
05 223    315 356 022                    CAL SWITCH
05 226    315 244 022                    CAL FLOAD

05 231    315 255 002             PARSE, CAL CLESYM
05 234    056 176                        LLI 176
05 236    176                            LAM
05 237    376 007                        CPI 007
05 241    312 332 005                    JTZ PARSE2
05 244    306 240                        ADI 240
05 246    157                            LLA
05 247    106                            LBM
05 250    056 210                        LLI 210
05 252    116                            LCM
05 253    315 036 023                    CAL INDEXC
05 256    176                            LAM
05 257    306 257                        ADI 257
05 261    157                            LLA
05 262    170                            LAB
05 263    276                            CPM
05 264    312 307 005                    JTZ PARSE1
05 267    372 307 005                    JTS PARSE1
05 272    056 176                        LLI 176
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05 274      106                                 LBM
05 275      056 210                             LLI 210
05 277      116                                 LCM
05 300      014                                 INC
05 301      161                                 LMC
05 302      315 036 023                         CAL INDEXC
05 305      160                                 LMB
05 306      311                                 RET

05 307      056 210                 PARSE1,     LLI 210
05 311      176                                 LAM
05 312      205                                 ADL
05 313      157                                 LLA
05 314      176                                 LAM
05 315      247                                 NDA
05 316      310                                 RTZ
05 317      056 210                             LLI 210
05 321      116                                 LCM
05 322      015                                 DCC
05 323      161                                 LMC
05 324      315 364 005                         CAL FPOPER
05 327      303 231 005                         JMP PARSE

05 332      056 210                 PARSE2,     LLI 210
05 334      046 026             **              LHI 026
05 336      176                                 LAM
05 337      205                                 ADL
05 340      157                                 LLA
05 341      176                                 LAM
05 342      247                                 NDA
05 343      312 104 006                         JTZ PARNER
05 346      056 210                             LLI 210
05 350      116                                 LCM
05 351      015                                 DCC
05 352      161                                 LMC
05 353      376 006                             CPI 006
05 355      310                                 RTZ
05 356      315 364 005                         CAL FPOPER
05 361      303 332 005                         JMP PARSE2

05 364      056 371                 FPOPER,     LLI 371
05 366      046 026             **              LHI 026
05 370      167                                 LMA
05 371      056 227                             LLI 227
05 373      046 001             **              LHI 001
05 375      176                                 LAM
05 376      157                                 LLA
05 377      315 266 022                         CAL OPLOAD
06 002      056 227                             LLI 227
06 004      176                                 LAM
06 005      326 004                             SUI 004
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06 007      167                          LMA
06 010      056 371                      LLI 371
06 012      046 026          **          LHI 026
06 014      176                          LAM
06 015      376 001                      CPI 001
06 017      312 211 020                  JTZ FPADD
06 022      376 002                      CPI 002
06 024      312 032 021                  JTZ FPSUB
06 027      376 003                      CPI 003
06 031      312 046 021                  JTZ FPMULT
06 034      376 004                      CPI 004
06 036      312 322 021                  JTZ FPDIV
06 041      376 005                      CPI 005
06 043      312 263 006                  JTZ INTEXP
06 046      376 011                      CPI 011
06 050      312 121 006                  JTZ LT
06 053      376 012                      CPI 012
06 055      312 136 006                  JTZ EQ
06 060      376 013                      CPI 013
06 062      312 153 006                  JTZ GT
06 065      376 014                      CPI 014
06 067      312 173 006                  JTZ LE
06 072      376 015                      CPI 015
06 074      312 213 006                  JTZ GE
06 077      376 016                      CPI 016
06 101      312 230 006                  JTZ NE
06 104      056 230              PARNER, LLI 230
06 106      046 026          **          LHI 026
06 110      066 000                      LMI 000
06 112      076 311                      LAI 311
06 114      016 250                      LCI 250
06 116      303 226 002                  JMP ERROR

06 121      315 032 021              LT, CAL FPSUB
06 124      056 126                      LLI 126
06 126      176                          LAM
06 127      247                          NDA
06 130      372 242 006                  JTS CTRUE
06 133      303 247 006                  JMP CFALSE

06 136      315 032 021              EQ, CAL FPSUB
06 141      056 126                      LLI 126
06 143      176                          LAM
06 144      247                          NDA
06 145      312 242 006                  JTZ CTRUE
06 150      303 247 006                  JMP CFALSE

06 153      315 032 021              GT, CAL FPSUB
06 156      056 126                      LLI 126
06 160      176                          LAM
06 161      247                          NDA
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06 162    312 247 006                    JTZ CFALSE
06 165    362 242 006                    JFS CTRUE
06 170    303 247 006                    JMP CFALSE

06 173    315 032 021              LE,   CAL FPSUB
06 176    056 126                        LLI 126
06 200    176                            LAM
06 201    247                            NDA
06 202    312 242 006                    JTZ CTRUE
06 205    372 242 006                    JTS CTRUE
06 210    303 247 006                    JMP CFALSE

06 213    315 032 021              GE,   CAL FPSUB
06 216    056 126                        LLI 126
06 220    176                            LAM
06 221    247                            NDA
06 222    362 242 006                    JFS CTRUE
06 225    303 247 006                    JMP CFALSE

06 230    315 032 021              NE,   CAL FPSUB
06 233    056 126                        LLI 126
06 235    176                            LAM
06 236    247                            NDA
06 237    312 247 006                    JTZ CFALSE

06 242    056 004        CTRUE, FPONE,   LLI 004
06 244    303 244 022                    JMP FLOAD

06 247    056 127             CFALSE,    LLI 127
06 251    066 000                        LMI 000
06 253    303 051 020                    JMP FPZERO

06 256    173                 AD4DE,     LAE
06 257    306 004                        ADI 004
06 261    137                            LEA
06 262    311                            RET

06 263    056 126             INTEXP,    LLI 126
06 265    046 001        **              LHI 001
06 267    176                            LAM
06 270    056 003                        LLI 003
06 272    167                            LMA
06 273    247                            NDA
06 274    312 242 006                    JTZ FPONE
06 277    374 202 020                    CTS FPCOMP
06 302    315 000 020                    CAL FPFIX
06 305    056 124                        LLI 124
06 307    106                            LBM
06 310    056 013                        LLI 013
06 312    160                            LMB
06 313    056 134                        LLI 134
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06 315      036 014                          LEI 014
06 317      046 001          **              LHI 001
06 321      124                              LDH
06 322      006 004                          LBI 004
06 324      315 013 021                      CAL MOVEIT
06 327      315 242 006                      CAL FPONE
06 332      056 003                          LLI 003
06 334      176                              LAM
06 335      247                              NDA
06 336      372 362 006                      JTS DVLOOP

06 341      056 014                MULOOP,   LLI 014
06 343      315 277 022                      CAL FACXOP
06 346      315 046 021                      CAL FPMULT
06 351      056 013                          LLI 013
06 353      106                              LBM
06 354      005                              DCB
06 355      160                              LMB
06 356      302 341 006                      JFZ MULOOP
06 361      311                              RET

06 362      056 014                DVLOOP,   LLI 014
06 364      315 277 022                      CAL FACXOP
06 367      315 322 021                      CAL FPDIV
06 372      056 013                          LLI 013
06 374      106                              LBM
06 375      005                              DCB
06 376      160                              LMB
06 377      302 362 006                      JFZ DVLOOP
07 002      311                              RET

07 003      056 230                PRIGHT,   LLI 230
07 005      046 026          **              LHI 026
07 007      176                              LAM
07 010      205                              ADL
07 011      157                              LLA
07 012      176                              LAM
07 013      066 000                          LMI 000
07 015      056 203                          LLI 203
07 017      046 027          **              LHI 027
07 021      167                              LMA
07 022      247                              NDA
07 023      310                              RTZ
07 024      372 000 055      @@              JTS PRIGH1
07 027      376 001                          CPI 001
07 031      312 243 007                      JTZ INTX
07 034      376 002                          CPI 002
07 036      312 360 007                      JTZ SGNX
07 041      376 003                          CPI 003
07 043      312 346 007                      JTZ ABSX
07 046      376 004                          CPI 004
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07 050      312 000 032                         JTZ SQRX
07 053      376 005                             CPI 005
07 055      312 017 010                         JTZ TABX
07 060      376 006                             CPI 006
07 062      312 240 032                         JTZ RNDX
07 065      376 007                             CPI 007
07 067      312 377 007                         JTZ CHRX
07 072      376 010                             CPI 010
07 074      312 ††† †††     ††                  JTZ ††† †††
07 077      166                                 HLT

07 100      056 120                 FUNARR,     LLI 120
07 102      046 026         **                  LHI 026
07 104      176                                 LAM
07 105      247                                 NDA
07 106      310                                 RTZ
07 107      056 202                             LLI 202
07 111      046 027         **                  LHI 027
07 113      066 000                             LMI 000

07 115      056 202                 FUNAR1,     LLI 202
07 117      046 027         **                  LHI 027
07 121      106                                 LBM
07 122      004                                 INB
07 123      160                                 LMB
07 124      016 002                             LCI 002
07 126      056 274                             LLI 274
07 130      046 026         **                  LHI 026
07 132      315 230 007                         CAL TABADR
07 135      026 026         **                  LDI 026
07 137      036 120                             LEI 120
07 141      315 332 002                         CAL STRCP
07 144      312 207 007                         JTZ FUNAR4
07 147      056 202                             LLI 202
07 151      046 027         **                  LHI 027
07 153      176                                 LAM
07 154      376 010                             CPI 010
07 156      302 115 007                         JFZ FUNAR1
07 161      056 202                             LLI 202
07 163      046 027         **                  LHI 027
07 165      066 000                             LMI 000
07 167      303 054 055     @@                  JMP FUNAR2

07 172      056 230                 FAERR,      LLI 230
07 174      046 026         **                  LHI 026
07 176      066 000                             LMI 000
07 200      076 306                             LAI 306
07 202      016 301                             LCI 301
07 204      303 226 002                         JMP ERROR

07 207      056 202                 FUNAR4,     LLI 202
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07 211      046 027          **                LHI 027
07 213      106                                LBM
07 214      056 230                            LLI 230
07 216      046 026          **                LHI 026
07 220      116                                LCM
07 221      315 036 023                        CAL INDEXC
07 224      160                                LMB
07 225      303 255 002                        JMP CLESYM

07 230      170                       TABADR,  LAB
07 231      007                       TABAD1,  RLC
07 232      015                                DCC
07 233      302 231 007                        JFZ TABAD1
07 236      205                                ADL
07 237      157                                LLA
07 240      320                                RFC
07 241      044                                INH
07 242      311                                RET

07 243      056 126                     INTX,  LLI 126
07 245      046 001          **                LHI 001
07 247      176                                LAM
07 250      247                                NDA
07 251      362 327 007                        JFS INT1
07 254      056 014                            LLI 014
07 256      315 255 022                        CAL FSTORE
07 261      315 000 020                        CAL FPFIX
07 264      056 123                            LLI 123
07 266      066 000                            LMI 000
07 270      315 064 020                        CAL FPFLT
07 273      056 014                            LLI 014
07 275      315 266 022                        CAL OPLOAD
07 300      315 032 021                        CAL FPSUB
07 303      056 126                            LLI 126
07 305      176                                LAM
07 306      247                                NDA
07 307      312 341 007                        JTZ INT2
07 312      056 014                            LLI 014
07 314      315 244 022                        CAL FLOAD
07 317      056 024                            LLI 024
07 321      315 277 022                        CAL FACXOP
07 324      315 211 020                        CAL FPADD

07 327      315 000 020                 INT1,  CAL FPFIX
07 332      056 123                            LLI 123
07 334      066 000                            LMI 000
07 336      303 064 020                        JMP FPFLT

07 341      056 014                     INT2,  LLI 014
07 343      303 244 022                        JMP FLOAD
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07 346    056 126                    ABSX,  LLI 126
07 350    046 001          **               LHI 001
07 352    176                               LAM
07 353    247                               NDA
07 354    372 202 020                       JTS FPCOMP
07 357    311                               RET

07 360    056 126                    SGNX,  LLI 126
07 362    046 001          **               LHI 001
07 364    176                               LAM
07 365    247                               NDA
07 366    310                               RTZ
07 367    362 242 006                       JFS FPONE
07 372    056 024                           LLI 024
07 374    303 244 022                       JMP FLOAD

07 377    315 000 020                CHRX,  CAL FPFIX
10 002    056 124                           LLI 124
10 004    176                               LAM
10 005    315 202 003                       CAL ECHO
10 010    056 177                           LLI 177
10 012    046 026          **               LHI 026
10 014    066 377                           LMI 377
10 016    311                               RET

10 017    315 000 020                TABX,  CAL FPFIX
10 022    056 124                    TAB1,  LLI 124
10 024    176                               LAM
10 025    056 043                           LLI 043
10 027    226                               SUM
10 030    056 177                           LLI 177
10 032    046 026          **               LHI 026
10 034    066 377                           LMI 377
10 036    372 217 031                       JTS BACKSP
10 041    310                               RTZ

10 042    117                        TABC,  LCA
10 043    076 240                           LAI 240
10 045    315 202 003                TABLOP, CAL ECHO
10 050    015                               DCC
10 051    302 045 010                       JFZ TABLOP
10 054    311                               RET

10 055    056 201                    STOSYM, LLI 201
10 057    046 027          **               LHI 027
10 061    176                               LAM
10 062    247                               NDA
10 063    312 100 010                       JTZ STOSY1
10 066    066 000                           LMI 000
10 070    056 204                           LLI 204
10 072    156                               LLM
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10 073    046 057          ††                LHI 057
10 075    303 255 022                        JMP FSTORE

10 100    056 370                  STOSY1,   LLI 370
10 102    046 026          **                LHI 026
10 104    066 000                            LMI 000
10 106    056 120                            LLI 120
10 110    026 027          **                LDI 027
10 112    036 210                            LEI 210
10 114    176                                LAM
10 115    376 001                            CPI 001
10 117    302 126 010                        JFZ STOSY2
10 122    056 122                            LLI 122
10 124    066 000                            LMI 000

10 126    056 121                  STOSY2,   LLI 121
10 130    046 026          **                LHI 026
10 132    315 356 022                        CAL SWITCH
10 135    176                                LAM
10 136    054                                INL
10 137    106                                LBM
10 140    054                                INL
10 141    315 356 022                        CAL SWITCH
10 144    276                                CPM
10 145    302 156 010                        JFZ STOSY3
10 150    054                                INL
10 151    170                                LAB
10 152    276                                CPM
10 153    312 227 010                        JTZ STOSY5

10 156    315 256 006              STOSY3,   CAL AD4DE
10 161    056 370                            LLI 370
10 163    046 026          **                LHI 026
10 165    106                                LBM
10 166    004                                INB
10 167    160                                LMB
10 170    056 077                            LLI 077
10 172    046 027          **                LHI 027
10 174    170                                LAB
10 175    276                                CPM
10 176    302 126 010                        JFZ STOSY2
10 201    056 077                            LLI 077
10 203    046 027          **                LHI 027
10 205    106                                LBM
10 206    004                                INB
10 207    160                                LMB
10 210    170                                LAB
10 211    376 025                            CPI 025
10 213    362 222 002                        JFS BIGERR
10 216    056 121                            LLI 121
10 220    046 026          **                LHI 026
```

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10 222    006 002                        LBI 002
10 224    315 013 021                    CAL MOVEIT

10 227    315 356 022          STOSY5,   CAL SWITCH
10 232    315 255 022                    CAL FSTORE
10 235    303 255 002                    JMP CLESYM

10 240    056 120              SAVESY,   LLI 120
10 242    046 026       **               LHI 026
10 244    124                            LDH
10 245    036 144                        LEI 144
10 247    303 261 010                    JMP MOVECP

10 252    056 144              RESTSY,   LLI 144
10 254    046 026       **               LHI 026
10 256    124                            LDH
10 257    036 120                        LEI 120

10 261    106                  MOVECP,   LBM
10 262    004                            INB
10 263    303 013 021                    JMP MOVEIT

10 266    061 000 032              EXEC, LXS 000 032
10 271    315 330 031                    CAL EXECSP
10 274    000                            NOP

10 275    056 000              EXEC1,    LLI 000
10 277    046 026       **               LHI 026
10 301    315 014 003                    CAL STRIN
10 304    176                            LAM
10 305    247                            NDA
10 306    312 275 010                    JTZ EXEC1
10 311    056 335                        LLI 335
10 313    046 001       **               LHI 001
10 315    026 026       **               LDI 026
10 317    036 000                        LEI 000
10 321    315 332 002                    CAL STRCP
10 324    302 354 010                    JFZ NOLIST
10 327    056 000                        LLI 000
10 331    046 033       ††               LHI 033

10 333    176                  LIST,     LAM
10 334    247                            NDA
10 335    312 266 010                    JTZ EXEC
10 340    315 121 003                    CAL TEXTC
10 343    315 377 002                    CAL ADV
10 346    315 141 003                    CAL CRLF
10 351    303 333 010                    JMP LIST

10 354    056 342              NOLIST,   LLI 342
10 356    046 001       **               LHI 001
```

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10 360      036 000                          LEI 000
10 362      026 026          **              LDI 026
10 364      036 000                          LEI 000
10 366      315 332 002                      CAL STRCP
10 371      312 070 013                      JTZ RUN
10 374      026 026          **              LDI 026
10 376      036 000                          LEI 000
11 000      056 346                          LLI 346
11 002      046 001          **              LHI 001
11 004      315 332 002                      CAL STRCP
11 007      302 071 011                      JFZ NOSCR
11 012      046 026          **              LHI 026
11 014      056 364                          LLI 364
11 016      066 033          ††              LMI 033
11 020      054                              INL
11 021      066 000                          LMI 000
11 023      056 077                          LLI 077
11 025      046 027          **              LHI 027
11 027      066 001                          LMI 001
11 031      056 075                          LLI 075
11 033      066 000          @@              LMI 000
11 035      056 120          @@              LLI 120
11 037      066 000          @@              LMI 000
11 041      056 210                          LLI 210
11 043      066 000                          LMI 000
11 045      054                              INL
11 046      066 000                          LMI 000
11 050      046 033          ††              LHI 033
11 052      056 000                          LLI 000
11 054      066 000                          LMI 000
11 056      046 057          @@              LHI 057

11 060      066 000          @@    SCRLOP,   LMI 000
11 062      054              @@              INL
11 063      302 060 011      @@              JFZ SCRLOP
11 066      303 266 010                      JMP EXEC

11 071      036 272                NOSCR,    LEI 272
11 073      026 001          **              LDI 001
11 075      046 026          **              LHI 026
11 077      056 000                          LLI 000
11 101      315 332 002                      CAL STRCP
11 104      312 ††† †††      ††              JTZ SAVE
11 107      056 277                          LLI 277
11 111      046 001          **              LHI 001
11 113      026 026          **              LDI 026
11 115      036 000                          LEI 000
11 117      315 332 002                      CAL STRCP
11 122      312 ††† †††      ††              JTZ LOAD
11 125      056 360                          LLI 360
11 127      046 026          **              LHI 026
```

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11 131    066 033          ††                LMI 033
11 133    054                                INL
11 134    066 000                            LMI 000
11 136    315 000 002                        CAL SYNTAX
11 141    056 203                            LLI 203
11 143    046 026          **                LHI 026
11 145    176                                LAM
11 146    247                                NDA
11 147    362 161 011                        JFS SYNTOK

11 152    076 323                 SYNERR,    LAI 323
11 154    016 331                            LCI 331
11 156    303 226 002                        JMP ERROR

11 161    056 340                 SYNTOK,    LLI 340
11 163    176                                LAM
11 164    247                                NDA
11 165    312 211 013                        JTZ DIRECT
11 170    056 360                            LLI 360
11 172    066 033          ††                LMI 033
11 174    054                                INL
11 175    066 000                            LMI 000

11 177    056 201                 GETAUX,    LLI 201
11 201    046 026          **                LHI 026
11 203    066 001                            LMI 001
11 205    056 350                            LLI 350
11 207    066 000                            LMI 000

11 211    056 201                 GETAU0,    LLI 201
11 213    315 123 012                        CAL GETCHP
11 216    312 242 011                        JTZ GETAU1
11 221    376 260                            CPI 260
11 223    372 267 011                        JTS GETAU2
11 226    376 272                            CPI 272
11 230    362 267 011                        JFS GETAU2
11 233    056 350                            LLI 350
11 235    046 026          **                LHI 026
11 237    315 314 002                        CAL CONCT1

11 242    056 201                 GETAU1,    LLI 201
11 244    046 026          **                LHI 026
11 246    106                                LBM
11 247    004                                INB
11 250    160                                LMB
11 251    056 360                            LLI 360
11 253    046 026          **                LHI 026
11 255    116                                LCM
11 256    054                                INL
11 257    156                                LLM
11 260    141                                LHC
```

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11 261      176                                 LAM
11 262      005                                 DCB
11 263      270                                 CPB
11 264      302 211 011                         JFZ GETAU0

11 267      056 360                 GETAU2,     LLI 360
11 271      046 026         **                  LHI 026
11 273      126                                 LDM
11 274      054                                 INL
11 275      156                                 LLM
11 276      142                                 LHD
11 277      176                                 LAM
11 300      247                                 NDA
11 301      302 336 011                         JFZ NOTEND
11 304      303 005 012                         JMP NOSAME

Note open addresses.
This space available
for patching.

11 336      056 350                 NOTEND,     LLI 350
11 340      046 026         **                  LHI 026
11 342      026 026         **                  LDI 026
11 344      036 340                             LEI 340
11 346      315 332 002                         CAL STRCP
11 351      372 073 012                         JTS CONTIN
11 354      302 005 012                         JFZ NOSAME
11 357      056 360                             LLI 360
11 361      046 026         **                  LHI 026
11 363      116                                 LCM
11 364      054                                 INL
11 365      156                                 LLM
11 366      141                                 LHC
11 367      106                                 LBM
11 370      004                                 INB
11 371      315 144 012                         CAL REMOVE
11 374      056 203                             LLI 203
11 376      046 026         **                  LHI 026
12 000      176                                 LAM
12 001      247                                 NDA
12 002      312 266 010                         JTZ EXEC

12 005      056 360                 NOSAME,     LLI 360
12 007      046 026         **                  LHI 026
12 011      126                                 LDM
12 012      054                                 INL
12 013      136                                 LEM
12 014      056 000                             LLI 000
12 016      046 026         **                  LHI 026
12 020      106                                 LBM
12 021      004                                 INB
```

```
12 022    315 205 012                    CAL INSERT
12 025    056 360                        LLI 360
12 027    046 026          **            LHI 026
12 031    126                            LDM
12 032    054                            INL
12 033    136                            LEM
12 034    056 000                        LLI 000
12 036    046 026          **            LHI 026
12 040    315 046 012                    CAL MOVEC
12 043    303 275 010                    JMP EXEC1

12 046    106                  MOVEC,    LBM
12 047    004                            INB

12 050    176                  MOVEPG,   LAM
12 051    315 377 002                    CAL ADV
12 054    315 356 022                    CAL SWITCH
12 057    167                            LMA
12 060    315 377 002                    CAL ADV
12 063    315 356 022                    CAL SWITCH
12 066    005                            DCB
12 067    302 050 012                    JFZ MOVEPG
12 072    311                            RET

12 073    056 360              CONTIN,   LLI 360
12 075    046 026          **            LHI 026
12 077    126                            LDM
12 100    054                            INL
12 101    136                            LEM
12 102    142                            LHD
12 103    153                            LLE
12 104    106                            LBM
12 105    004                            INB
12 106    315 305 012                    CAL ADBDE
12 111    056 360                        LLI 360
12 113    046 026          **            LHI 026
12 115    162                            LMD
12 116    054                            INL
12 117    163                            LME
12 120    303 177 011                    JMP GETAUX

12 123    046 026          **  GETCHP,   LHI 026
12 125    106                            LBM
12 126    056 360                        LLI 360
12 130    126                            LDM
12 131    054                            INL
12 132    136                            LEM
12 133    315 305 012                    CAL ADBDE
12 136    142                            LHD
12 137    153                            LLE
12 140    176                            LAM
```

```
12 141    376 240                          CPI 240
12 143    311                              RET

12 144    315 174 003          REMOVE,     CAL INDEXB
12 147    116                              LCM
12 150    315 113 003                      CAL SUBHL
12 153    161                              LMC
12 154    171                              LAC
12 155    247                              NDA
12 156    312 167 012                      JTZ REMOV1
12 161    315 377 002                      CAL ADV
12 164    303 144 012                      JMP REMOVE

12 167    056 364              REMOV1,     LLI 364
12 171    046 026        **                LHI 026
12 173    126                              LDM
12 174    054                              INL
12 175    176                              LAM
12 176    220                              SUB
12 177    167                              LMA
12 200    320                              RFC
12 201    055                              DCL
12 202    025                              DCD
12 203    162                              LMD
12 204    311                              RET

12 205    056 364              INSERT,     LLI 364
12 207    046 026        **                LHI 026
12 211    176                              LAM
12 212    054                              INL
12 213    156                              LLM
12 214    147                              LHA
12 215    315 174 003                      CAL INDEXB
12 220    174                              LAH
12 221    376 054        ††                CPI 054
12 223    362 222 002                      JFS BIGERR
12 226    315 113 003                      CAL SUBHL

12 231    116                  INSER1,     LCM
12 232    315 174 003                      CAL INDEXB
12 235    161                              LMC
12 236    315 113 003                      CAL SUBHL
12 241    315 277 012                      CAL CPHLDE
12 244    312 255 012                      JTZ INSER3
12 247    315 164 003                      CAL DEC
12 252    303 231 012                      JMP INSER1

12 255    056 000          INSER3, INCLIN, LLI 000
12 257    046 026        **                LHI 026
12 261    106                              LBM
12 262    004                              INB
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12 263    056 364                          LLI 364
12 265    126                              LDM
12 266    054                              INL
12 267    136                              LEM
12 270    315 305 012                      CAL ADBDE
12 273    163                              LME
12 274    055                              DCL
12 275    162                              LMD
12 276    311                              RET

12 277    174                   CPHLDE,    LAH
12 300    272                              CPD
12 301    300                              RFZ
12 302    175                              LAL
12 303    273                              CPE
12 304    311                              RET

12 305    173                   ADBDE,     LAE
12 306    200                              ADB
12 307    137                              LEA
12 310    320                              RFC
12 311    024                              IND
12 312    311                              RET

12 313    076 336               CTRLC,     LAI 336
12 315    016 303                          LCI 303
12 317    303 226 002                      JMP ERROR

12 322    056 340               FINERR,    LLI 340
12 324    046 026          **              LHI 026
12 326    176                              LAM
12 327    247                              NDA
12 330    312 351 012                      JTZ FINER1
12 333    056 366                          LLI 366
12 335    046 001          **              LHI 001
12 337    315 121 003                      CAL TEXTC
12 342    056 340                          LLI 340
12 344    046 026          **              LHI 026
12 346    315 121 003                      CAL TEXTC

12 351    315 141 003           FINER1,    CAL CRLF
12 354    303 266 010                      JMP EXEC

12 357    076 304               DVERR,     LAI 304
12 361    016 332                          LCI 332
12 363    303 226 002                      JMP ERROR

12 366    076 306               FIXERR,    LAI 306
12 370    016 330                          LCI 330
12 372    303 226 002                      JMP ERROR
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12 375      076 311                 NUMERR,  LAI 311
12 377      016 316                          LCI 316
13 001      056 220                          LLI 220
13 003      046 001          **              LHI 001
13 005      066 000                          LMI 000
13 007      303 226 002                      JMP ERROR

13 012      026 026          **      INSTR,  LDI 026
13 014      036 000                          LEI 000

13 016      315 064 013              INSTR1, CAL ADVDE
13 021      315 317 022                      CAL SAVEHL
13 024      106                              LBM
13 025      315 377 002                      CAL ADV
13 030      315 370 002                      CAL STRCPC
13 033      312 337 022                      JTZ RESTHL
13 036      315 337 022                      CAL RESTHL
13 041      056 000                          LLI 000
13 043      046 026          **              LHI 026
13 045      176                              LAM
13 046      273                              CPE
13 047      312 061 013                      JTZ INSTR2
13 052      315 337 022                      CAL RESTHL
13 055      303 016 013                      JMP INSTR1
13 060      166                              HLT

13 061      036 000                 INSTR2,  LEI 000
13 063      311                              RET

13 064      034                     ADVDE,   INE
13 065      300                              RFZ
13 066      024                              IND
13 067      311                              RET

13 070      056 073                    RUN,  LLI 073
13 072      046 027          **              LHI 027
13 074      066 000                          LMI 000
13 076      056 205                          LLI 205
13 100      066 000                          LMI 000
13 102      056 360                          LLI 360
13 104      046 026          **              LHI 026
13 106      066 033          ††              LMI 033
13 110      054                              INL
13 111      066 000                          LMI 000
13 113      303 156 013                      JMP SAMLIN

13 116      056 360                 NXTLIN,  LLI 360
13 120      046 026          **              LHI 026
13 122      126                              LDM
13 123      054                              INL
13 124      136                              LEM
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13 125      142                          LHD
13 126      153                          LLE
13 127      106                          LBM
13 130      004                          INB
13 131      315 305 012                  CAL ADBDE
13 134      056 360                      LLI 360
13 136      046 026          **          LHI 026
13 140      162                          LMD
13 141      054                          INL
13 142      163                          LME
13 143      056 340                      LLI 340
13 145      046 026          **          LHI 026
13 147      176                          LAM
13 150      247                          NDA
13 151      312 266 010                  JTZ EXEC
13 154      000                          NOP
13 155      000                          NOP

13 156      056 360              SAMLIN, LLI 360
13 160      046 026          **          LHI 026
13 162      116                          LCM
13 163      054                          INL
13 164      156                          LLM
13 165      141                          LHC
13 166      026 026          **          LDI 026
13 170      036 000                      LEI 000
13 172      315 046 012                  CAL MOVEC
13 175      056 000                      LLI 000
13 177      046 026          **          LHI 026
13 201      176                          LAM
13 202      247                          NDA
13 203      312 266 010                  JTZ EXEC
13 206      315 000 002                  CAL SYNTAX

13 211      056 203              DIRECT, LLI 203
13 213      046 026          **          LHI 026
13 215      176                          LAM
13 216      376 001                      CPI 001
13 220      312 116 013                  JTZ NXTLIN
13 223      376 002                      CPI 002
13 225      312 027 016                  JTZ IF
13 230      376 003                      CPI 003
13 232      312 031 015                  JTZ LET
13 235      376 004                      CPI 004
13 237      312 174 015                  JTZ GOTO
13 242      376 005                      CPI 005
13 244      312 345 013                  JTZ PRINT
13 247      376 006                      CPI 006
13 251      312 365 016                  JTZ INPUT
13 254      376 007                      CPI 007
13 256      312 164 017                  JTZ FOR
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13 261    376 010                          CPI 010
13 263    312 013 030                      JTZ NEXT
13 266    376 011                          CPI 011
13 270    312 236 016                      JTZ GOSUB
13 273    376 012                          CPI 012
13 275    312 304 016                      JTZ RETURN
13 300    376 013                          CPI 013
13 302    312 365 055    @@                JTZ DIM
13 305    376 014                          CPI 014
13 307    312 266 010                      JTZ EXEC
13 312    376 015                          CPI 015
13 314    312 013 015                      JTZ LET0
13 317    376 016        @@                CPI 016
13 321    302 152 011                      JFZ SYNERR
13 324    315 153 055    @@                CAL ARRAY1
13 327    056 206        @@                LLI 206
13 331    046 026        @@**              LHI 026
13 333    106            @@                LBM
13 334    056 202        @@                LLI 202
13 336    160            @@                LMB
13 337    315 240 010    @@                CAL SAVESY
13 342    303 042 015    @@                JMP LET1

13 345    056 202                  PRINT,  LLI 202
13 347    046 026        **                LHI 026
13 351    176                              LAM
13 352    056 000                          LLI 000
13 354    276                              CPM
13 355    372 366 013                      JTS PRINT1
13 360    315 141 003                      CAL CRLF
13 363    303 116 013                      JMP NXTLIN

13 366    315 255 002              PRINT1, CAL CLESYM
13 371    056 202                          LLI 202
13 373    046 026        **                LHI 026
13 375    106                              LBM
13 376    004                              INB
13 377    056 203                          LLI 203
14 001    160                              LMB

14 002    056 203                  PRINT2, LLI 203
14 004    315 240 002                      CAL GETCHR
14 007    376 247                          CPI 247
14 011    312 203 014                      JTZ QUOTE
14 014    376 242                          CPI 242
14 016    312 203 014                      JTZ QUOTE
14 021    376 254                          CPI 254
14 023    312 043 014                      JTZ PRINT3
14 026    376 273                          CPI 273
14 030    312 043 014                      JTZ PRINT3
14 033    056 203                          LLI 203
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14 035    315 003 003                      CAL LOOP
14 040    302 002 014                      JFZ PRINT2

14 043    056 202              PRINT3,     LLI 202
14 045    106                              LBM
14 046    004                              INB
14 047    056 276                          LLI 276
14 051    160                              LMB
14 052    056 203                          LLI 203
14 054    106                              LBM
14 055    005                              DCB
14 056    056 277                          LLI 277
14 060    160                              LMB
14 061    056 367                          LLI 367
14 063    176                              LAM
14 064    247                              NDA
14 065    312 075 014                      JTZ PRINT4
14 070    066 000                          LMI 000
14 072    303 125 014                      JMP PRINT6

14 075    315 224 003          PRINT4,     CAL EVAL
14 100    056 177                          LLI 177
14 102    046 026         **               LHI 026
14 104    176                              LAM
14 105    247                              NDA
14 106    056 110                          LLI 110
14 110    046 001         **               LHI 001
14 112    066 377                          LMI 377

14 114    314 314 014          PRINT5,     CTZ PFPOUT
14 117    056 177                          LLI 177
14 121    046 026         **               LHI 026
14 123    066 000                          LMI 000

14 125    056 203              PRINT6,     LLI 203
14 127    315 240 002                      CAL GETCHR
14 132    376 254                          CPI 254
14 134    314 357 014                      CTZ PCOMMA
14 137    056 203                          LLI 203
14 141    046 026         **               LHI 026
14 143    106                              LBM
14 144    056 202                          LLI 202
14 146    160                              LMB
14 147    056 000                          LLI 000
14 151    170                              LAB
14 152    276                              CPM
14 153    372 366 013                      JTS PRINT1
14 156    056 000                          LLI 000
14 160    315 240 002                      CAL GETCHR
14 163    376 254                          CPI 254
14 165    312 116 013                      JTZ NXTLIN
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14 170      376 273                          CPI 273
14 172      312 116 013                      JTZ NXTLIN
14 175      315 141 003                      CAL CRLF
14 200      303 116 013                      JMP NXTLIN

14 203      056 367                  QUOTE,  LLI 367
14 205      167                              LMA
14 206      315 255 002                      CAL CLESYM
14 211      056 203                          LLI 203
14 213      106                              LBM
14 214      004                              INB
14 215      056 204                          LLI 204
14 217      160                              LMB

14 220      056 204                  QUOTE1, LLI 204
14 222      315 240 002                      CAL GETCHR
14 225      056 367                          LLI 367
14 227      276                              CPM
14 230      312 263 014                      JTZ QUOTE2
14 233      315 202 003                      CAL ECHO
14 236      056 204                          LLI 204
14 240      315 003 003                      CAL LOOP
14 243      302 220 014                      JFZ QUOTE1

14 246      076 311                  QUOTER, LAI 311
14 250      016 321                          LCI 321
14 252      056 367                          LLI 367
14 254      046 026          **              LHI 026
14 256      066 000                          LMI 000
14 260      303 226 002                      JMP ERROR

14 263      056 204                  QUOTE2, LLI 204
14 265      106                              LBM
14 266      056 202                          LLI 202
14 270      160                              LMB
14 271      170                              LAB
14 272      056 000                          LLI 000
14 274      276                              CPM
14 275      302 366 013                      JFZ PRINT1
14 300      315 141 003                      CAL CRLF
14 303      056 367                          LLI 367
14 305      046 026          **              LHI 026
14 307      066 000                          LMI 000
14 311      303 116 013                      JMP NXTLIN

14 314      056 126                  PFPOUT, LLI 126
14 316      046 001          **              LHI 001
14 320      176                              LAM
14 321      247                              NDA
14 322      312 336 014                      JTZ ZERO
14 325      054                              INL
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14 326    176                              LAM
14 327    247                              NDA
14 330    312 350 014                      JTZ FRAC
14 333    303 165 024                      JMP FPOUT

14 336    076 240                  ZERO,   LAI 240
14 340    315 202 003                      CAL ECHO
14 343    076 260                          LAI 260
14 345    303 202 003                      JMP ECHO

14 350    056 110                  FRAC,   LLI 110
14 352    066 000                          LMI 000
14 354    303 165 024                      JMP FPOUT

14 357    056 000                  PCOMMA, LLI 000
14 361    176                              LAM
14 362    056 203                          LLI 203
14 364    226                              SUM
14 365    370                              RTS
14 366    056 043                          LLI 043
14 370    046 001          **              LHI 001
14 372    176                              LAM
14 373    346 360                          NDI 360
14 375    306 020                          ADI 020
14 377    226                              SUM
15 000    117                              LCA
15 001    076 240                          LAI 240

15 003    315 202 003              PCOM1,  CAL ECHO
15 006    015                              DCC
15 007    302 003 015                      JFZ PCOM1
15 012    311                              RET

15 013    315 240 010              LET0,   CAL SAVSYM
15 016    056 202                          LLI 202
15 020    046 026          **              LHI 026
15 022    106                              LBM
15 023    056 203                          LLI 203
15 025    160                              LMB
15 026    303 141 015                      JMP LET5

15 031    315 255 002                LET,  CAL CLESYM
15 034    056 144                          LLI 144
15 036    046 026          **              LHI 026
15 040    066 000                          LMI 000

15 042    056 202                  LET1,   LLI 202
15 044    046 026          **              LHI 026
15 046    106                              LBM
15 047    004                              INB
15 050    056 203                          LLI 203
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```
15 052    160                                    LMB

15 053    056 203                       LET2,    LLI 203
15 055    315 240 002                            CAL GETCHR
15 060    312 122 015                            JTZ LET4
15 063    376 275                                CPI 275
15 065    312 141 015                            JTZ LET5
15 070    376 250         @@                     CPI 250
15 072    302 113 015                            JFZ LET3
15 075    315 145 055     @@                     CAL ARRAY
15 100    056 206         @@                     LLI 206
15 102    046 026         @@**                   LHI 026
15 104    106             @@                     LBM
15 105    056 203         @@                     LLI 203
15 107    160             @@                     LMB
15 110    303 122 015     @@                     JMP LET4

15 113    056 144                       LET3,    LLI 144
15 115    046 026         **                     LHI 026
15 117    315 314 002                            CAL CONCT1

15 122    056 203                       LET4,    LLI 203
15 124    315 003 003                            CAL LOOP
15 127    302 053 015                            JFZ LET2

15 132    076 314                       LETERR,  LAI 314
15 134    016 305                                LCI 305
15 136    303 226 002                            JMP ERROR

15 141    056 203                       LET5,    LLI 203
15 143    046 026         **                     LHI 026
15 145    106                                    LBM
15 146    004                                    INB
15 147    056 276                                LLI 276
15 151    160                                    LMB
15 152    056 000                                LLI 000
15 154    106                                    LBM
15 155    056 277                                LLI 277
15 157    160                                    LMB
15 160    315 224 003                            CAL EVAL
15 163    315 252 010                            CAL RESTSY
15 166    315 055 010                            CAL STOSYM
15 171    303 116 013                            JMP NXTLIN

15 174    056 350                       GOTO,    LLI 350
15 176    046 026         **                     LHI 026
15 200    066 000                                LMI 000
15 202    056 202                                LLI 202
15 204    106                                    LBM
15 205    004                                    INB
15 206    056 203                                LLI 203
```

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15 210      160                                 LMB

15 211      056 203                 GOTO1,      LLI 203
15 213      315 240 002                         CAL GETCHR
15 216      312 240 015                         JTZ GOTO2
15 221      376 260                             CPI 260
15 223      372 250 015                         JTS GOTO3
15 226      376 272                             CPI 272
15 230      362 250 015                         JFS GOTO3
15 233      056 350                             LLI 350
15 235      315 314 002                         CAL CONCT1

15 240      056 203                 GOTO2,      LLI 203
15 242      315 003 003                         CAL LOOP
15 245      302 211 015                         JFZ GOTO1

15 250      056 360                 GOTO3,      LLI 360
15 252      046 026         **                  LHI 026
15 254      066 033         ††                  LMI 033
15 256      054                                 INL
15 257      066 000                             LMI 000

15 261      315 255 002             GOTO4,      CAL CLESYM
15 264      056 204                             LLI 204
15 266      066 001                             LMI 001

15 270      056 204                 GOTO5,      LLI 204
15 272      315 123 012                         CAL GETCHP
15 275      312 315 015                         JTZ GOTO6
15 300      376 260                             CPI 260
15 302      372 340 015                         JTS GOTO7
15 305      376 272                             CPI 272
15 307      362 340 015                         JFS GOTO7
15 312      315 310 002                         CAL CONCTS

15 315      056 204                 GOTO6,      LLI 204
15 317      046 026         **                  LHI 026
15 321      106                                 LBM
15 322      004                                 INB
15 323      160                                 LMB
15 324      056 360                             LLI 360
15 326      116                                 LCM
15 327      054                                 INL
15 330      156                                 LLM
15 331      141                                 LHC
15 332      176                                 LAM
15 333      005                                 DCB
15 334      270                                 CPB
15 335      302 270 015                         JFZ GOTO5

15 340      056 120                 GOTO7,      LLI 120
```

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15 342    046 026          **                LHI 026
15 344    026 026          **                LDI 026
15 346    036 350                            LEI 350
15 350    315 332 002                        CAL STRCP
15 353    312 156 013                        JTZ SAMLIN
15 356    056 360                            LLI 360
15 360    046 026          **                LHI 026
15 362    126                                LDM
15 363    054                                INL
15 364    136                                LEM
15 365    142                                LHD
15 366    153                                LLE
15 367    106                                LBM
15 370    004                                INB
15 371    315 305 012                        CAL ADBDE
15 374    056 360                            LLI 360
15 376    046 026          **                LHI 026
16 000    162                                LMD
16 001    054                                INL
16 002    163                                LME
16 003    056 364                            LLI 364
16 005    172                                LAD
16 006    276                                CPM
16 007    302 261 015                        JFZ GOTO4
16 012    054                                INL
16 013    173                                LAE
16 014    276                                CPM
16 015    302 261 015                        JFZ GOTO4

16 020    076 325                  GOTOER,   LAI 325
16 022    016 316                            LCI 316
16 024    303 226 002                        JMP ERROR

16 027    056 202                      IF,   LLI 202
16 031    046 026          **                LHI 026
16 033    106                                LBM
16 034    004                                INB
16 035    056 276                            LLI 276
16 037    160                                LMB
16 040    315 255 002                        CAL CLESYM
16 043    056 320                            LLI 320
16 045    046 001          **                LHI 001
16 047    315 012 013                        CAL INSTR
16 052    173                                LAE
16 053    247                                NDA
16 054    302 102 016                        JFZ IF1
16 057    056 013                            LLI 013
16 061    046 027          **                LHI 027
16 063    315 012 013                        CAL INSTR
16 066    173                                LAE
16 067    247                                NDA
```

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16 070    302 102 016                      JFZ IF1

16 073    076 311                  IFERR,  LAI 311
16 075    016 306                          LCI 306
16 077    303 226 002                      JMP ERROR

16 102    056 277                    IF1,  LLI 277
16 104    046 026          **              LHI 026
16 106    035                              DCE
16 107    163                              LME
16 110    315 224 003                      CAL EVAL
16 113    056 126                          LLI 126
16 115    046 001          **              LHI 001
16 117    176                              LAM
16 120    247                              NDA
16 121    312 116 013                      JTZ NXTLIN
16 124    056 277                          LLI 277
16 126    046 026          **              LHI 026
16 130    176                              LAM
16 131    306 005                          ADI 005
16 133    056 202                          LLI 202
16 135    167                              LMA
16 136    107                              LBA
16 137    004                              INB
16 140    056 204                          LLI 204
16 142    160                              LMB

16 143    056 204                    IF2,  LLI 204
16 145    315 240 002                      CAL GETCHR
16 150    302 166 016                      JFZ IF3
16 153    056 204                          LLI 204
16 155    315 003 003                      CAL LOOP
16 160    302 143 016                      JFZ IF2
16 163    303 073 016                      JMP IFERR

16 166    376 260                    IF3,  CPI 260
16 170    372 200 016                      JTS IF4
16 173    376 272                          CPI 272
16 175    372 174 015                      JTS GOTO

16 200    056 000                    IF4,  LLI 000
16 202    176                              LAM
16 203    056 204                          LLI 204
16 205    226                              SUM
16 206    107                              LBA
16 207    004                              INB
16 210    116                              LCM
16 211    056 000                          LLI 000
16 213    160                              LMB
16 214    151                              LLC
16 215    026 026          **              LDI 026
```

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16 217      036 001                          LEI 001
16 221      315 013 021                      CAL MOVEIT
16 224      056 202                          LLI 202
16 226      066 001                          LMI 001
16 230      315 067 002                      CAL SYNTX4
16 233      303 211 013                      JMP DIRECT

16 236      056 340                GOSUB,    LLI 340
16 240      046 026          **              LHI 026
16 242      126                              LDM
16 243      024                              IND
16 244      025                              DCD
16 245      312 255 016                      JTZ GOSUB1
16 250      056 360                          LLI 360
16 252      126                              LDM
16 253      054                              INL
16 254      136                              LEM

16 255      056 073                GOSUB1,   LLI 073
16 257      046 027          **              LHI 027
16 261      176                              LAM
16 262      306 002                          ADI 002
16 264      376 021                          CPI 021
16 266      362 347 016                      JFS GOSERR
16 271      167                              LMA
16 272      056 076                          LLI 076
16 274      205                              ADL
16 275      157                              LLA
16 276      162                              LMD
16 277      054                              INL
16 300      163                              LME
16 301      303 174 015                      JMP GOTO

16 304      056 073                RETURN,   LLI 073
16 306      046 027          **              LHI 027
16 310      176                              LAM
16 311      326 002                          SUI 002
16 313      372 356 016                      JTS RETERR
16 316      167                              LMA
16 317      306 002                          ADI 002
16 321      056 076                          LLI 076
16 323      205                              ADL
16 324      157                              LLA
16 325      126                              LDM
16 326      024                              IND
16 327      025                              DCD
16 330      312 266 010                      JTZ EXEC
16 333      054                              INL
16 334      136                              LEM
16 335      056 360                          LLI 360
16 337      046 026          **              LHI 026
```

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16 341      162                                 LMD
16 342      054                                 INL
16 343      163                                 LME
16 344      303 116 013                         JMP NXTLIN

16 347      076 307                 GOSERR,     LAI 307
16 351      016 323                             LCI 323
16 353      303 226 002                         JMP ERROR

16 356      076 322                 RETERR,     LAI 322
16 360      016 324                             LCI 324
16 362      303 226 002                         JMP ERROR

16 365      315 255 002                 INPUT,  CAL CLESYM
16 370      056 202                             LLI 202
16 372      106                                 LBM
16 373      004                                 INB
16 374      056 203                             LLI 203
16 376      160                                 LMB

16 377      056 203                 INPUT1,     LLI 203
17 001      315 240 002                         CAL GETCHR
17 004      312 042 017                         JTZ INPUT3
17 007      376 254                             CPI 254
17 011      312 063 017                         JTZ INPUT4
17 014      376 250                             CPI 250
17 016      302 037 017                         JFZ INPUT2
17 021      315 160 055     @@                  CAL ARRAY2
17 024      056 206         @@                  LLI 206
17 026      046 026         @@**                LHI 026
17 030      106             @@                  LBM
17 031      056 203         @@                  LLI 203
17 033      160             @@                  LMB
17 034      303 042 017     @@                  JMP INPUT3

17 037      315 310 002                 INPUT2, CAL CONCTS

17 042      056 203                 INPUT3,     LLI 203
17 044      315 003 003                         CAL LOOP
17 047      302 377 016                         JFZ INPUT1
17 052      315 104 017                         CAL INPUTX
17 055      315 055 010                         CAL STOSYM
17 060      303 116 013                         JMP NXTLIN

17 063      315 104 017                 INPUT4, CAL INPUTX
17 066      315 055 010                         CAL STOSYM
17 071      046 026         **                  LHI 026
17 073      056 203                             LLI 203
17 075      106                                 LBM
17 076      056 202                             LLI 202
17 100      160                                 LMB
```

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17 101      303 365 016                          JMP INPUT

17 104      056 120                  INPUTX,     LLI 120
17 106      176                                  LAM
17 107      205                                  ADL
17 110      157                                  LLA
17 111      176                                  LAM
17 112      376 244                              CPI 244
17 114      302 140 017                          JFZ INPUTN
17 117      056 120                              LLI 120
17 121      106                                  LBM
17 122      005                                  DCB
17 123      160                                  LMB
17 124      315 157 017                          CAL FP0
17 127      315 221 003                          CAL CINPUT
17 132      056 124                              LLI 124
17 134      167                                  LMA
17 135      303 064 020                          JMP FPFLT

17 140      056 144                  INPUTN,     LLI 144
17 142      046 026          **                  LHI 026
17 144      076 277                              LAI 277
17 146      315 202 003                          CAL ECHO
17 151      315 014 003                          CAL STRIN
17 154      303 044 023                          JMP DINPUT

17 157      046 001          **          FP0,    LHI 001
17 161      303 247 006                          JMP CFALSE

17 164      056 144                      FOR,    LLI 144
17 166      046 026          **                  LHI 026
17 170      066 000                              LMI 000
17 172      056 146                              LLI 146
17 174      066 000                              LMI 000
17 176      056 205                              LLI 205
17 200      046 027          **                  LHI 027
17 202      106                                  LBM
17 203      004                                  INB
17 204      160                                  LMB
17 205      056 360                              LLI 360
17 207      046 026          **                  LHI 026
17 211      126                                  LDM
17 212      054                                  INL
17 213      136                                  LEM
17 214      170                                  LAB
17 215      007                                  RLC
17 216      007                                  RLC
17 217      306 134                              ADI 134
17 221      157                                  LLA
17 222      046 027          **                  LHI 027
17 224      162                                  LMD
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17 225      054                                 INL
17 226      163                                 LME
17 227      056 325                             LLI 325
17 231      046 001          **                 LHI 001
17 233      315 012 013                         CAL INSTR
17 236      173                                 LAE
17 237      247                                 NDA
17 240      302 252 017                         JFZ FOR1
17 243      076 306                 FORERR,     LAI 306
17 245      016 305                             LCI 305
17 247      303 226 002                         JMP ERROR
17 252      056 202                   FOR1,     LLI 202
17 254      046 026          **                 LHI 026
17 256      106                                 LBM
17 257      004                                 INB
17 260      056 204                             LLI 204
17 262      160                                 LMB
17 263      056 203                             LLI 203
17 265      163                                 LME

17 266      056 204                   FOR2,     LLI 204
17 270      315 240 002                         CAL GETCHR
17 273      312 310 017                         JTZ FOR3
17 276      376 275                             CPI 275
17 300      312 323 017                         JTZ FOR4
17 303      056 144                             LLI 144
17 305      315 314 002                         CAL CONCT1

17 310      056 204                   FOR3,     LLI 204
17 312      315 003 003                         CAL LOOP
17 315      302 266 017                         JFZ FOR2
17 320      303 243 017                         JMP FORERR

17 323      056 204                   FOR4,     LLI 204
17 325      106                                 LBM
17 326      004                                 INB
17 327      056 276                             LLI 276
17 331      160                                 LMB
17 332      056 203                             LLI 203
17 334      106                                 LBM
17 335      005                                 DCB
17 336      056 277                             LLI 277
17 340      160                                 LMB
17 341      315 224 003                         CAL EVAL
17 344      315 252 010                         CAL RESTSY
17 347      056 144                             LLI 144
17 351      046 026          **                 LHI 026
17 353      176                                 LAM
17 354      376 001                             CPI 001
17 356      302 246 031                         JFZ FOR5
17 361      056 146                             LLI 146
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17 363      066 000                          LMI 000
17 365      303 246 031                      JMP FOR5

Note open addresses.
This space available
for patching.

20 000      056 126                  FPFIX,  LLI 126
20 002      046 001          **              LHI 001
20 004      176                              LAM
20 005      056 100                          LLI 100
20 007      167                              LMA
20 010      247                              NDA
20 011      374 202 020                      CTS FPCOMP
20 014      056 127                          LLI 127
20 016      076 027                          LAI 027
20 020      106                              LBM
20 021      004                              INB
20 022      005                              DCB
20 023      372 051 020                      JTS FPZERO
20 026      220                              SUB
20 027      372 366 012                      JTS FIXERR
20 032      117                              LCA
20 033      056 126                  FPFIXL, LLI 126
20 035      006 003                          LBI 003
20 037      315 211 022                      CAL ROTATR
20 042      015                              DCC
20 043      302 033 020                      JFZ FPFIXL
20 046      303 175 020                      JMP RESIGN
20 051      056 126                  FPZERO, LLI 126
20 053      257                              XRA
20 054      167                              LMA
20 055      055                              DCL
20 056      167                              LMA
20 057      055                              DCL
20 060      167                              LMA
20 061      055                              DCL
20 062      167                              LMA
20 063      311                              RET

20 064      006 027                  FPFLT,  LBI 027

20 066      170                      FPNORM, LAB
20 067      046 001          **              LHI 001
20 071      056 127                          LLI 127
20 073      247                              NDA
20 074      312 100 020                      JTZ NOEXCO
20 077      160                              LMB
20 100      055                      NOEXCO, DCL
20 101      176                              LAM
20 102      056 100                          LLI 100
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20 104    167                              LMA
20 105    247                              NDA
20 106    362 120 020                      JFS ACZERT
20 111    006 004                          LBI 004
20 113    056 123                          LLI 123
20 115    315 150 022                      CAL COMPLM
20 120    056 126                ACZERT,   LLI 126
20 122    006 004                          LBI 004
20 124    176                    LOOK0,    LAM
20 125    247                              NDA
20 126    302 143 020                      JFZ ACNONZ
20 131    055                              DCL
20 132    005                              DCB
20 133    302 124 020                      JFZ LOOK0
20 136    056 127                          LLI 127
20 140    257                              XRA
20 141    167                              LMA
20 142    311                              RET
20 143    056 123                ACNONZ,   LLI 123
20 145    006 004                          LBI 004
20 147    315 177 022                      CAL ROTATL
20 152    176                              LAM
20 153    247                              NDA
20 154    372 166 020                      JTS ACCSET
20 157    054                              INL
20 160    106                              LBM
20 161    005                              DCB
20 162    160                              LMB
20 163    303 143 020                      JMP ACNONZ
20 166    056 126                ACCSET,   LLI 126
20 170    006 003                          LBI 003
20 172    315 211 022                      CAL ROTATR
20 175    056 100                RESIGN,   LLI 100
20 177    176                              LAM
20 200    247                              NDA
20 201    360                              RFS
20 202    056 124                FPCOMP,   LLI 124
20 204    006 003                          LBI 003
20 206    303 150 022                      JMP COMPLM

20 211    056 126                FPADD,    LLI 126
20 213    046 001          **              LHI 001
20 215    176                              LAM
20 216    247                              NDA
20 217    302 235 020                      JFZ NONZAC
20 222    056 124                MOVOP,    LLI 124
20 224    124                              LDH
20 225    135                              LEL
20 226    056 134                          LLI 134
20 230    006 004                          LBI 004
20 232    303 013 021                      JMP MOVEIT
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20 235    056 136              NONZAC,  LLI 136
20 237    176                           LAM
20 240    247                           NDA
20 241    310                           RTZ
20 242    056 127              CKEQEX,  LLI 127
20 244    176                           LAM
20 245    056 137                       LLI 137
20 247    276                           CPM
20 250    312 341 020                   JTZ SHACOP
20 253    107                           LBA
20 254    176                           LAM
20 255    230                           SBB
20 256    362 264 020                   JFS SKPNEG
20 261    107                           LBA
20 262    257                           XRA
20 263    230                           SBB
20 264    376 030              SKPNEG,  CPI 030
20 266    372 303 020                   JTS LINEUP
20 271    176                           LAM
20 272    056 127                       LLI 127
20 274    226                           SUM
20 275    370                           RTS
20 276    056 124                       LLI 124
20 300    303 222 020                   JMP MOVOP
20 303    176                  LINEUP,  LAM
20 304    056 127                       LLI 127
20 306    226                           SUM
20 307    372 327 020                   JTS SHIFTO
20 312    117                           LCA
20 313    056 127              MORACC,  LLI 127
20 315    315 374 020                   CAL SHLOOP
20 320    015                           DCC
20 321    302 313 020                   JFZ MORACC
20 324    303 341 020                   JMP SHACOP
20 327    117                  SHIFTO,  LCA
20 330    056 137              MOROP,   LLI 137
20 332    315 374 020                   CAL SHLOOP
20 335    014                           INC
20 336    302 330 020                   JFZ MOROP
20 341    056 123              SHACOP,  LLI 123
20 343    066 000                       LMI 000
20 345    056 127                       LLI 127
20 347    315 374 020                   CAL SHLOOP
20 352    056 137                       LLI 137
20 354    315 374 020                   CAL SHLOOP
20 357    124                           LDH
20 360    036 123                       LEI 123
20 362    006 004                       LBI 004
20 364    315 127 022                   CAL ADDER
20 367    006 000                       LBI 000
20 371    303 066 020                   JMP FPNORM
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20 374    106                          SHLOOP,  LBM
20 375    004                                   INB
20 376    160                                   LMB
20 377    055                                   DCL
21 000    006 004                               LBI 004
21 002    176                          FSHIFT,  LAM
21 003    247                                   NDA
21 004    362 211 022                           JFS ROTATR
21 007    027                          BRING1,  RAL
21 010    303 212 022                           JMP ROTR
21 013    176                          MOVEIT,  LAM
21 014    054                                   INL
21 015    315 356 022                           CAL SWITCH
21 020    167                                   LMA
21 021    054                                   INL
21 022    315 356 022                           CAL SWITCH
21 025    005                                   DCB
21 026    310                                   RTZ
21 027    303 013 021                           JMP MOVEIT

21 032    056 124                      FSUB,    LLI 124
21 034    046 001                  **           LHI 001
21 036    006 003                               LBI 003
21 040    315 150 022                           CAL COMPLM
21 043    303 211 020                           JMP FPADD

21 046    315 166 021                  FPMULT,  CAL CKSIGN
21 051    056 137                      ADDEXP,  LLI 137
21 053    176                                   LAM
21 054    056 127                               LLI 127
21 056    206                                   ADM
21 057    306 001                               ADI 001
21 061    167                                   LMA
21 062    056 102                      SETMCT,  LLI 102
21 064    066 027                               LMI 027
21 066    056 126                      MULTIP,  LLI 126
21 070    006 003                               LBI 003
21 072    315 211 022                           CAL ROTATR
21 075    334 270 021                           CTC ADOPPP
21 100    056 146                               LLI 146
21 102    006 006                               LBI 006
21 104    315 211 022                           CAL ROTATR
21 107    056 102                               LLI 102
21 111    116                                   LCM
21 112    015                                   DCC
21 113    161                                   LMC
21 114    302 066 021                           JFZ MULTIP
21 117    056 146                               LLI 146
21 121    006 006                               LBI 006
21 123    315 211 022                           CAL ROTATR
21 126    056 143                               LLI 143
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21 130      176                                 LAM
21 131      027                                 RAL
21 132      247                                 NDA
21 133      374 302 021                         CTS MROUND
21 136      056 123                             LLI 123
21 140      135                                 LEL
21 141      124                                 LDH
21 142      056 143                             LLI 143
21 144      006 004                             LBI 004

21 146      315 013 021             EXMLDV,     CAL MOVEIT
21 151      006 000                             LBI 000
21 153      315 066 020                         CAL FPNORM
21 156      056 101                             LLI 101
21 160      176                                 LAM
21 161      247                                 NDA
21 162      300                                 RFZ
21 163      303 202 020                         JMP FPCOMP
21 166      056 140                 CKSIGN,     LLI 140
21 170      046 001         **                  LHI 001
21 172      006 010                             LBI 010
21 174      257                                 XRA
21 175      167                     CLRNEX,     LMA
21 176      054                                 INL
21 177      005                                 DCB
21 200      302 175 021                         JFZ CLRNEX
21 203      006 004                 CLROPL,     LBI 004
21 205      056 130                             LLI 130
21 207      167                     CLRNX1,     LMA
21 210      054                                 INL
21 211      005                                 DCB
21 212      302 207 021                         JFZ CLRNX1
21 215      056 101                             LLI 101
21 217      066 001                             LMI 001
21 221      056 126                             LLI 126
21 223      176                                 LAM
21 224      247                                 NDA
21 225      372 251 021                         JTS NEGFPA
21 230      056 136                 OPSGNT,     LLI 136
21 232      176                                 LAM
21 233      247                                 NDA
21 234      360                                 RFS
21 235      056 101                             LLI 101
21 237      116                                 LCM
21 240      015                                 DCC
21 241      161                                 LMC
21 242      056 134                             LLI 134
21 244      006 003                             LBI 003
21 246      303 150 022                         JMP COMPLM

21 251      056 101                 NEGFPA,     LLI 101
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21 253      116                          LCM
21 254      015                          DCC
21 255      161                          LMC
21 256      056 124                      LLI 124
21 260      006 003                      LBI 003
21 262      315 150 022                  CAL COMPLM
21 265      303 230 021                  JMP OPSGNT
21 270      036 141             ADOPPP,  LEI 141
21 272      124                          LDH
21 273      056 131                      LLI 131
21 275      006 006                      LBI 006
21 277      303 127 022                  JMP ADDER
21 302      006 003             MROUND,  LBI 003
21 304      076 100                      LAI 100
21 306      206                          ADM
21 307      167                 CROUND,  LMA
21 310      054                          INL
21 311      076 000                      LAI 000
21 313      216                          ACM
21 314      005                          DCB
21 315      302 307 021                  JFZ CROUND
21 320      167                          LMA
21 321      311                          RET

21 322      315 166 021           FPDIV, CAL CKSIGN
21 325      056 126                      LLI 126
21 327      176                          LAM
21 330      247                          NDA
21 331      312 357 012                  JTZ DVERR
21 334      056 137             SUBEXP,  LLI 137
21 336      176                          LAM
21 337      056 127                      LLI 127
21 341      226                          SUM
21 342      306 001                      ADI 001
21 344      167                          LMA
21 345      056 102             SETDCT,  LLI 102
21 347      066 027                      LMI 027
21 351      315 101 022           DIVIDE,CAL SETSUB
21 354      372 376 021                  JTS NOGO
21 357      036 134                      LEI 134
21 361      056 131                      LLI 131
21 363      006 003                      LBI 003
21 365      315 013 021                  CAL MOVEIT
21 370      076 001                      LAI 001
21 372      037                          RAR
21 373      303 377 021                  JMP QUOROT
21 376      257                   NOGO,  XRA
21 377      056 144             QUOROT,  LLI 144
22 001      006 003                      LBI 003
22 003      315 200 022                  CAL ROTL
22 006      056 134                      LLI 134
```

```
22 010    006 003                    LBI 003
22 012    315 177 022                CAL ROTATL
22 015    056 102                    LLI 102
22 017    116                        LCM
22 020    015                        DCC
22 021    161                        LMC
22 022    302 351 021                JFZ DIVIDE
22 025    315 101 022                CAL SETSUB
22 030    372 070 022                JTS DVEXIT
22 033    056 144                    LLI 144
22 035    176                        LAM
22 036    306 001                    ADI 001
22 040    167                        LMA
22 041    076 000                    LAI 000
22 043    054                        INL
22 044    216                        ACM
22 045    167                        LMA
22 046    076 000                    LAI 000
22 050    054                        INL
22 051    216                        ACM
22 052    167                        LMA
22 053    362 070 022                JFS DVEXIT
22 056    006 003                    LBI 003
22 060    315 211 022                CAL ROTATR
22 063    056 127                    LLI 127
22 065    106                        LBM
22 066    004                        INB
22 067    160                        LMB
22 070    056 144           DVEXIT,  LLI 144
22 072    036 124                    LEI 124
22 074    006 003                    LBI 003
22 076    303 146 021                JMP EXMLDV
22 101    036 131           SETSUB,  LEI 131
22 103    124                        LDH
22 104    056 124                    LLI 124
22 106    006 003                    LBI 003
22 110    315 013 021                CAL MOVEIT
22 113    036 131                    LEI 131
22 115    056 134                    LLI 134
22 117    006 003                    LBI 003
22 121    315 223 022                CAL SUBBER
22 124    176                        LAM
22 125    247                        NDA
22 126    311                        RET

22 127    247               ADDER,   NDA
22 130    176               ADDMOR,  LAM
22 131    315 356 022                CAL SWITCH
22 134    216                        ACM
22 135    167                        LMA
22 136    005                        DCB
```

```
22 137      310                          RTZ
22 140      054                          INL
22 141      315 356 022                  CAL SWITCH
22 144      054                          INL
22 145      303 130 022                  JMP ADDMOR

22 150      176                  COMPLM, LAM
22 151      356 377                      XRI 377
22 153      306 001                      ADI 001
22 155      167                  MORCOM, LMA
22 156      037                          RAR
22 157      127                          LDA
22 160      005                          DCB
22 161      310                          RTZ
22 162      054                          INL
22 163      176                          LAM
22 164      356 377                      XRI 377
22 166      137                          LEA
22 167      172                          LAD
22 170      027                          RAL
22 171      076 000                      LAI 000
22 173      213                          ACE
22 174      303 155 022                  JMP MORCOM

22 177      247                  ROTATL, NDA
22 200      176                  ROTL,   LAM
22 201      027                          RAL
22 202      167                          LMA
22 203      005                          DCB
22 204      310                          RTZ
22 205      054                          INL
22 206      303 200 022                  JMP ROTL

22 211      247                  ROTATR, NDA
22 212      176                  ROTR,   LAM
22 213      037                          RAR
22 214      167                          LMA
22 215      005                          DCB
22 216      310                          RTZ
22 217      055                          DCL
22 220      303 212 022                  JMP ROTR

22 223      247                  SUBBER, NDA
22 224      176                  SUBTRA, LAM
22 225      315 356 022                  CAL SWITCH
22 230      236                          SBM
22 231      167                          LMA
22 232      005                          DCB
22 233      310                          RTZ
22 234      054                          INL
22 235      315 356 022                  CAL SWITCH
```

```
22 240    054                          INL
22 241    303 224 022                  JMP SUBTRA

22 244    026 001          **  FLOAD,  LDI 001
22 246    036 124                      LEI 124
22 250    006 004                      LBI 004
22 252    303 013 021                  JMP MOVEIT

22 255    135              FSTORE,     LEL
22 256    124                          LDH
22 257    056 124                      LLI 124
22 261    046 001          **          LHI 001
22 263    303 272 022                  JMP SETIT

22 266    026 001          **  OPLOAD, LDI 001
22 270    036 134                      LEI 134
22 272    006 004              SETIT,  LBI 004
22 274    303 013 021                  JMP MOVEIT

22 277    315 317 022          FACXOP, CAL SAVEHL
22 302    056 124                      LLI 124
22 304    046 001          **          LHI 001
22 306    315 266 022                  CAL OPLOAD
22 311    315 337 022                  CAL RESTHL
22 314    303 244 022                  JMP FLOAD

22 317    174              SAVEHL,     LAH
22 320    105                          LBL
22 321    056 200                      LLI 200
22 323    046 001          **          LHI 001
22 325    167                          LMA
22 326    054                          INL
22 327    160                          LMB
22 330    054                          INL
22 331    162                          LMD
22 332    054                          INL
22 333    163                          LME
22 334    147                          LHA
22 335    150                          LLB
22 336    311                          RET

22 337    056 200          RESTHL,     LLI 200
22 341    046 001          **          LHI 001
22 343    176                          LAM
22 344    054                          INL
22 345    106                          LBM
22 346    054                          INL
22 347    126                          LDM
22 350    054                          INL
22 351    136                          LEM
22 352    147                          LHA
```

```
22 353      150                          LLB
22 354      176                          LAM
22 355      311                          RET

22 356      114                SWITCH,   LCH
22 357      142                          LHD
22 360      121                          LDC
22 361      115                          LCL
22 362      153                          LLE
22 363      131                          LEC
22 364      311                          RET

22 365      046 001            **GETINP, LHI 001
22 367      056 220                      LLI 220
22 371      116                          LCM
22 372      014                          INC
22 373      015                          DCC
22 374      302 010 023                  JFZ NOT0
22 377      153                          LLE
23 000      142                          LHD
23 001      116                          LCM
23 002      014                          INC
23 003      315 036 023                  CAL INDEXC
23 006      066 000                      LMI 000

23 010      056 220                NOT0, LLI 220
23 012      046 001            **        LHI 001
23 014      116                          LCM
23 015      014                          INC
23 016      161                          LMC
23 017      153                          LLE
23 020      142                          LHD
23 021      315 036 023                  CAL INDEXC
23 024      176                          LAM
23 025      247                          NDA
23 026      046 001            **        LHI 001
23 030      300                          RFZ
23 031      056 220                      LLI 220
23 033      066 000                      LMI 000
23 035      311                          RET

23 036      175                INDEXC,   LAL
23 037      201                          ADC
23 040      157                          LLA
23 041      320                          RFC
23 042      044                          INH
23 043      311                          RET

23 044      135                DINPUT,   LEL
23 045      124                          LDH
23 046      046 001            **        LHI 001
```

```
23 050      056 150                     LLI 150
23 052      257                         XRA
23 053      006 010                     LBI 010
23 055      167             CLRNX2,     LMA
23 056      054                         INL
23 057      005                         DCB
23 060      302 055 023                 JFZ CLRNX2
23 063      056 103                     LLI 103
23 065      006 004                     LBI 004
23 067      167             CLRNX3,     LMA
23 070      054                         INL
23 071      005                         DCB
23 072      302 067 023                 JFZ CLRNX3
23 075      315 365 022                 CAL GETINP
23 100      376 253                     CPI 253
23 102      312 115 023                 JTZ NINPUT
23 105      376 255                     CPI 255
23 107      302 120 023                 JFZ NOTPLM
23 112      056 103                     LLI 103
23 114      167                         LMA

23 115      315 365 022     NINPUT,     CAL GETINP

23 120      376 256         NOTPLM,     CPI 256
23 122      312 201 023                 JTZ PERIOD
23 125      376 305                     CPI 305
23 127      312 221 023                 JTZ FNDEXP
23 132      376 240                     CPI 240
23 134      312 115 023                 JTZ NINPUT
23 137      247                         NDA
23 140      312 311 023                 JTZ ENDINP
23 143      376 260                     CPI 260
23 145      372 375 012                 JTS NUMERR
23 150      376 272                     CPI 272
23 152      362 375 012                 JFS NUMERR
23 155      056 156                     LLI 156
23 157      117                         LCA
23 160      076 370                     LAI 370
23 162      246                         NDM
23 163      302 115 023                 JFZ NINPUT
23 166      056 105                     LLI 105
23 170      106                         LBM
23 171      004                         INB
23 172      160                         LMB
23 173      315 056 024                 CAL DECBIN
23 176      303 115 023                 JMP NINPUT

23 201      107             PERIOD,     LBA
23 202      056 106                     LLI 106
23 204      176                         LAM
23 205      247                         NDA
```

```
23 206    302 375 012                    JFZ NUMERR
23 211    056 105                        LLI 105
23 213    167                            LMA
23 214    054                            INL
23 215    160                            LMB
23 216    303 115 023                    JMP NINPUT

23 221    315 365 022          FNDEXP,   CAL GETINP
23 224    376 253                        CPI 253
23 226    312 241 023                    JTZ EXPINP
23 231    376 255                        CPI 255
23 233    302 244 023                    JFZ NOEXPS
23 236    056 104                        LLI 104
23 240    167                            LMA

23 241    315 365 022          EXPINP,   CAL GETINP

23 244    247                  NOEXPS,   NDA
23 245    312 311 023                    JTZ ENDINP
23 250    376 260                        CPI 260
23 252    372 375 012                    JTS NUMERR
23 255    376 272                        CPI 272
23 257    362 375 012                    JFS NUMERR
23 262    346 017                        NDI 017
23 264    107                            LBA
23 265    056 157                        LLI 157
23 267    076 003                        LAI 003
23 271    276                            CPM
23 272    372 375 012                    JTS NUMERR
23 275    116                            LCM
23 276    176                            LAM
23 277    247                            NDA
23 300    027                            RAL
23 301    027                            RAL
23 302    201                            ADC
23 303    027                            RAL
23 304    200                            ADB
23 305    167                            LMA
23 306    303 241 023                    JMP EXPINP

23 311    056 103              ENDINP,   LLI 103
23 313    176                            LAM
23 314    247                            NDA
23 315    312 327 023                    JTZ FININP
23 320    056 154                        LLI 154
23 322    006 003                        LBI 003
23 324    315 150 022                    CAL COMPLM

23 327    056 153              FININP,   LLI 153
23 331    257                            XRA
23 332    167                            LMA
```

```
23 333      124                                 LDH
23 334      036 123                             LEI 123
23 336      006 004                             LBI 004
23 340      315 013 021                         CAL MOVEIT
23 343      315 064 020                         CAL FPFLT
23 346      056 104                             LLI 104
23 350      176                                 LAM
23 351      247                                 NDA
23 352      056 157                             LLI 157
23 354      312 365 023                         JTZ POSEXP
23 357      176                                 LAM
23 360      356 377                             XRI 377
23 362      306 001                             ADI 001
23 364      167                                 LMA

23 365      056 106                   POSEXP,   LLI 106
23 367      176                                 LAM
23 370      247                                 NDA
23 371      312 000 024                         JTZ EXPOK
23 374      056 105                             LLI 105
23 376      257                                 XRA
23 377      226                                 SUM

24 000      056 157                   EXPOK,    LLI 157
24 002      206                                 ADM
24 003      167                                 LMA
24 004      372 033 024                         JTS MINEXP
24 007      310                                 RTZ

24 010      056 210                   FPX10,    LLI 210
24 012      046 001             **              LHI 001
24 014      315 277 022                         CAL FACXOP
24 017      315 046 021                         CAL FPMULT
24 022      056 157                             LLI 157
24 024      116                                 LCM
24 025      015                                 DCC
24 026      161                                 LMC
24 027      302 010 024                         JFZ FPX10
24 032      311                                 RET

24 033      056 214         MINEXP, FPD10,      LLI 214
24 035      046 001             **              LHI 001
24 037      315 277 022                         CAL FACXOP
24 042      315 046 021                         CAL FPMULT
24 045      056 157                             LLI 157
24 047      106                                 LBM
24 050      004                                 INB
24 051      160                                 LMB
24 052      302 033 024                         JFZ FPD10
24 055      311                                 RET
```

```
24 056      315 317 022                 DECBIN,  CAL SAVEHL
24 061      056 153                              LLI 153
24 063      171                                  LAC
24 064      346 017                              NDI 017
24 066      167                                  LMA
24 067      036 150                              LEI 150
24 071      056 154                              LLI 154
24 073      124                                  LDH
24 074      006 003                              LBI 003
24 076      315 013 021                          CAL MOVEIT
24 101      056 154                              LLI 154
24 103      006 003                              LBI 003
24 105      315 177 022                          CAL ROTATL
24 110      056 154                              LLI 154
24 112      006 003                              LBI 003
24 114      315 177 022                          CAL ROTATL
24 117      036 154                              LEI 154
24 121      056 150                              LLI 150
24 123      006 003                              LBI 003
24 125      315 127 022                          CAL ADDER
24 130      056 154                              LLI 154
24 132      006 003                              LBI 003
24 134      315 177 022                          CAL ROTATL
24 137      056 152                              LLI 152
24 141      257                                  XRA
24 142      167                                  LMA
24 143      055                                  DCL
24 144      167                                  LMA
24 145      056 153                              LLI 153
24 147      176                                  LAM
24 150      056 150                              LLI 150
24 152      167                                  LMA
24 153      036 154                              LEI 154
24 155      006 003                              LBI 003
24 157      315 127 022                          CAL ADDER
24 162      303 337 022                          JMP RESTHL

24 165      046 001          **          FPOUT,  LHI 001
24 167      056 157                              LLI 157
24 171      066 000                              LMI 000
24 173      056 126                              LLI 126
24 175      176                                  LAM
24 176      247                                  NDA
24 177      372 207 024                          JTS OUTNEG
24 202      076 240                              LAI 240
24 204      303 220 024                          JMP AHEAD1

24 207      056 124                 OUTNEG,      LLI 124
24 211      006 003                              LBI 003
24 213      315 150 022                          CAL COMPLM
24 216      076 255                              LAI 255
```

```
24 220    315 202 003          AHEAD1,  CAL ECHO
24 223    056 110                       LLI 110
24 225    176                           LAM
24 226    247                           NDA
24 227    312 253 024                   JTZ OUTFLT
24 232    056 127                       LLI 127
24 234    076 027                       LAI 027
24 236    106                           LBM
24 237    004                           INB
24 240    005                           DCB
24 241    372 253 024                   JTS OUTFLT
24 244    220                           SUB
24 245    372 253 024                   JTS OUTFLT
24 250    303 271 024                   JMP OUTFIX

24 253    056 110              OUTFLT,  LLI 110
24 255    066 000                       LMI 000
24 257    076 260                       LAI 260
24 261    315 202 003                   CAL ECHO
24 264    076 256                       LAI 256
24 266    315 202 003                   CAL ECHO

24 271    056 127              OUTFIX,  LLI 127
24 273    076 377                       LAI 377
24 275    206                           ADM
24 276    167                           LMA

24 277    362 336 024          DECEXT,  JFS DECEXD
24 302    076 004                       LAI 004
24 304    206                           ADM
24 305    362 360 024                   JFS DECOUT
24 310    056 210                       LLI 210
24 312    046 001              **       LHI 001
24 314    315 277 022                   CAL FACXOP
24 317    315 046 021                   CAL FPMULT
24 322    056 157                       LLI 157
24 324    116                           LCM
24 325    015                           DCC
24 326    161                           LMC

24 327    056 127              DECREP,  LLI 127
24 331    176                           LAM
24 332    247                           NDA
24 333    303 277 024                   JMP DECEXT

24 336    056 214              DECEXD,  LLI 214
24 340    046 001              **       LHI 001
24 342    315 277 022                   CAL FACXOP
24 345    315 046 021                   CAL FPMULT
24 350    056 157                       LLI 157
24 352    106                           LBM
```

```
24 353      004                          INB
24 354      160                          LMB
24 355      303 327 024                  JMP DECREP

24 360      036 164             DECOUT,  LEI 164
24 362      124                          LDH
24 363      056 124                      LLI 124
24 365      006 003                      LBI 003
24 367      315 013 021                  CAL MOVEIT
24 372      056 167                      LLI 167
24 374      066 000                      LMI 000
24 376      056 164                      LLI 164
25 000      006 003                      LBI 003
25 002      315 177 022                  CAL ROTATL
25 005      315 223 025                  CAL OUTX10

25 010      056 127             COMPEN,  LLI 127
25 012      106                          LBM
25 013      004                          INB
25 014      160                          LMB
25 015      312 032 025                  JTZ OUTDIG
25 020      056 167                      LLI 167
25 022      006 004                      LBI 004
25 024      315 211 022                  CAL ROTATR
25 027      303 010 025                  JMP COMPEN
25 032      056 107             OUTDIG,  LLI 107
25 034      066 007                      LMI 007
25 036      056 167                      LLI 167
25 040      176                          LAM
25 041      247                          NDA
25 042      312 165 025                  JTZ ZERODG

25 045      056 167             OUTDGS,  LLI 167
25 047      176                          LAM
25 050      247                          NDA
25 051      302 105 025                  JFZ OUTDGX
25 054      056 110                      LLI 110
25 056      176                          LAM
25 057      247                          NDA
25 060      312 104 025                  JTZ OUTZER
25 063      056 157                      LLI 157
25 065      116                          LCM
25 066      015                          DCC
25 067      014                          INC
25 070      362 104 025                  JFS OUTZER
25 073      056 166                      LLI 166
25 075      176                          LAM
25 076      346 340                      NDI 340
25 100      302 104 025                  JFZ OUTZER
25 103      311                          RET
```

```
25 104    257                    OUTZER,  XRA

25 105    306 260                OUTDGX,  ADI 260
25 107    315 202 003                     CAL ECHO

25 112    056 110                DECRDG,  LLI 110
25 114    176                             LAM
25 115    247                             NDA
25 116    302 137 025                     JFZ CKDECP

25 121    056 107                         LLI 107
25 123    116                             LCM
25 124    015                             DCC
25 125    161                             LMC
25 126    312 300 025                     JTZ EXPOUT
25 131    315 223 025            PUSHIT,  CAL OUTX10
25 134    303 045 025                     JMP OUTDGS

25 137    056 157                CKDECP,  LLI 157
25 141    116                             LCM
25 142    015                             DCC
25 143    161                             LMC
25 144    302 154 025                     JFZ NODECP
25 147    076 256                         LAI 256
25 151    315 202 003                     CAL ECHO
25 154    056 107                NODECP,  LLI 107
25 156    116                             LCM
25 157    015                             DCC
25 160    161                             LMC
25 161    310                             RTZ
25 162    303 131 025                     JMP PUSHIT

25 165    056 157                ZERODG,  LLI 157
25 167    116                             LCM
25 170    015                             DCC
25 171    161                             LMC
25 172    056 166                         LLI 166
25 174    176                             LAM
25 175    247                             NDA
25 176    302 112 025                     JFZ DECRDG
25 201    055                             DCL
25 202    176                             LAM
25 203    247                             NDA
25 204    302 112 025                     JFZ DECRDG
25 207    055                             DCL
25 210    176                             LAM
25 211    247                             NDA
25 212    302 112 025                     JFZ DECRDG
25 215    056 157                         LLI 157
25 217    167                             LMA
25 220    303 112 025                     JMP DECRDG
```

```
25 223      056 167          OUTX10,  LLI 167
25 225      066 000                   LMI 000
25 227      056 164                   LLI 164
25 231      124                       LDH
25 232      036 160                   LEI 160
25 234      006 004                   LBI 004
25 236      315 013 021               CAL MOVEIT
25 241      056 164                   LLI 164
25 243      006 004                   LBI 004
25 245      315 177 022               CAL ROTATL
25 250      056 164                   LLI 164
25 252      006 004                   LBI 004
25 254      315 177 022               CAL ROTATL
25 257      056 160                   LLI 160
25 261      036 164                   LEI 164
25 263      006 004                   LBI 004
25 265      315 127 022               CAL ADDER
25 270      056 164                   LLI 164
25 272      006 004                   LBI 004
25 274      315 177 022               CAL ROTATL
25 277      311                       RET

25 300      056 157          EXPOUT,  LLI 157
25 302      176                       LAM
25 303      247                       NDA
25 304      310                       RTZ
25 305      076 305                   LAI 305
25 307      315 202 003               CAL ECHO
25 312      176                       LAM
25 313      247                       NDA
25 314      372 324 025               JTS EXOUTN
25 317      076 253                   LAI 253
25 321      303 333 025               JMP AHEAD2

25 324      356 377          EXOUTN,  XRI 377
25 326      306 001                   ADI 001
25 330      167                       LMA
25 331      076 255                   LAI 255

25 333      315 202 003      AHEAD2,  CAL ECHO
25 336      006 000                   LBI 000
25 340      176                       LAM

25 341      326 012            SUB12, SUI 012
25 343      372 353 025               JTS TOMUCH
25 346      167                       LMA
25 347      004                       INB
25 350      303 341 025               JMP SUB12

25 353      076 260          TOMUCH,  LAI 260
25 355      200                       ADB
```

```
25 356      315 202 003      CAL ECHO
25 361      176              LAM
25 362      306 260          ADI 260
25 364      315 202 003      CAL ECHO
25 367      311              RET
```

Note open addresses.
This space available
for patching.

NOTE: Pages 26 and 27 in memory are used for temporary data registers, pointers, counters and look-up tables. The following data should be placed on those pages. An entry marked XXX indicates the initial contents of the location are irrelevant to the program's operation.

```
26 000      000              (cc) for INPUT LINE BUFF
26 001      XXX              These locations used as the
 .   .       .               INPUT LINE BUFFER
 .   .       .               storage
26 117      XXX              area
26 120      000              These locations used as the
 .   .       .               SYMBOL BUFFER
 .   .       .               storage
26 143      000              area
26 144      000              These locations used as the
 .   .       .               AUXILIARY
 .   .       .               SYMBOL BUFFER
26 175      000              storage area
26 176      000              TEMP SCAN storage register
26 177      000              TAB FLAG
26 200      000              EVAL CURRENT temp. reg.
26 201      000              SYNTAX LINE NUMBER
26 202      000              SCAN temporary register
26 203      000              STATEMENT TOKEN
26 204      000              Temporary working register
26 205      000              Temporary working register
26 206      000              ARRAY pointer
26 207      000              ARRAY pointer
26 210      000              OPERATOR STACK pointer
26 211      XXX              These locations used as the
 .   .       .               OPERATOR STACK
 .   .       .               storage
26 277      XXX              area
26 230      000              FUN/ARRAY STACK pointer
26 231      XXX              These locations used as the
 .   .       .               FUNCTION/ARRAY STACK
 .   .       .               storage
26 237      XXX              area
```

Heirarchy table (for out of stack ops).
Used by PARSER routine.

| | | |
|---|---|---|
| 26 240 | 000 | EOS |
| 26 241 | 003 | Plus sign |
| 26 242 | 003 | Minus sign |
| 26 243 | 004 | Multiplication sign |
| 26 244 | 004 | Division sign |
| 26 245 | 005 | Exponentiation sign |
| 26 246 | 006 | Left parenthesis |
| 26 247 | 001 | Right parenthesis |
| 26 250 | 002 | Not assigned |
| 26 251 | 002 | Less than sign |
| 26 252 | 002 | Equal sign |
| 26 253 | 002 | Greater than sign |
| 26 254 | 002 | Less than or equal combo |
| 26 255 | 002 | Equal to or greater than |
| 26 256 | 002 | Less than or greater than |

Heirarchy table (for into stack ops).
Used by PARSER routine.

| | | |
|---|---|---|
| 26 257 | 000 | EOS |
| 26 260 | 003 | Plus sign |
| 26 261 | 003 | Minus sign |
| 26 262 | 004 | Multiplication sign |
| 26 263 | 004 | Division sign |
| 26 264 | 005 | Exponentiation sign |
| 26 265 | 001 | Left parenthesis |
| 26 266 | 001 | Right parenthesis |
| 26 267 | 002 | Not assigned |
| 26 270 | 002 | Less than sign |
| 26 271 | 002 | Equal sign |
| 26 272 | 002 | Greater than sign |
| 26 273 | 002 | Less than or equal combo |
| 26 274 | 002 | Equal to or greater than |
| 26 275 | 002 | Less than or greater than |
| | | |
| 26 276 | 000 | EVAL (start) pointer |
| 26 277 | 000 | EVAL FINISH pointer |

FUNCTION NAMES TABLE

| | | |
|---|---|---|
| 26 300 | 003 | (cc) for INT |
| 26 301 | 311 | I |
| 26 302 | 316 | N |
| 26 303 | 324 | T |
| 26 304 | 003 | (cc) for SGN |
| 26 305 | 323 | S |
| 26 306 | 307 | G |
| 26 307 | 316 | N |

| | | |
|---|---|---|
| 26 310 | 003 | (cc) for ABS |
| 26 311 | 301 | A |
| 26 312 | 302 | B |
| 26 313 | 323 | S |
| 26 314 | 003 | (cc) for SQR |
| 26 315 | 323 | S |
| 26 316 | 321 | Q |
| 26 317 | 322 | R |
| 26 320 | 003 | (cc) for TAB |
| 26 321 | 324 | T |
| 26 322 | 301 | A |
| 26 323 | 302 | B |
| 26 324 | 003 | (cc) for RND |
| 26 325 | 322 | R |
| 26 326 | 316 | N |
| 26 327 | 304 | D |
| 26 330 | 003 | (cc) for CHR |
| 26 331 | 303 | C |
| 26 332 | 310 | H |
| 26 333 | 322 | R |
| 26 334 | 003 | (cc) for UDF |
| 26 335 | 325 | U |
| 26 336 | 304 | D |
| 26 337 | 306 | F |
| | | |
| 26 340 | 000 | These locations used as the |
| . . | . | LINE NUMBER BUFFER |
| . . | . | storage |
| 26 347 | 000 | area |
| 26 350 | 000 | These locations used as the |
| . . | . | AUX LINE NUMBER |
| . . | . | BUFFER |
| 26 357 | 000 | storage area |
| 26 360 | 000 | USER PGM LINE pointer (pg) |
| 26 361 | 000 | USER PGM LINE pntr (low) |
| 26 362 | 000 | AUX PGM LINE pointer (pg) |
| 26 363 | 000 | AUX PGM LINE pntr (low) |
| 26 364 | 000 | END of USER PGM BFR (pg) |
| 26 365 | 000 | END of USER PGM BFR pntr |
| 26 366 | 000 | Parenthesis counter |
| 26 367 | 000 | QUOTE Indicator |
| 26 370 | 000 | Table counter |
| 26 371 | XXX | Not assigned |
| . . | . | |
| . . | . | |
| 26 377 | XXX | Not assigned |

End of page 26.

STATEMENT KEYWORD TABLE

| | | |
|---|---|---|
| 27 000 | 003 | (cc) for REM |
| 27 001 | 322 | R |
| 27 002 | 305 | E |
| 27 003 | 315 | M |
| 27 004 | 002 | (cc) for IF |
| 27 005 | 311 | I |
| 27 006 | 306 | F |
| 27 007 | 003 | (cc) for LET |
| 27 010 | 314 | L |
| 27 011 | 305 | E |
| 27 012 | 324 | T |
| 27 013 | 004 | (cc) for GOTO |
| 27 014 | 307 | G |
| 27 015 | 317 | O |
| 27 016 | 324 | T |
| 27 017 | 317 | O |
| 27 020 | 005 | (cc) for PRINT |
| 27 021 | 320 | P |
| 27 022 | 322 | R |
| 27 023 | 311 | I |
| 27 024 | 316 | N |
| 27 025 | 324 | T |
| 27 026 | 005 | (cc) for INPUT |
| 27 027 | 311 | I |
| 27 030 | 316 | N |
| 27 031 | 320 | P |
| 27 032 | 325 | U |
| 27 033 | 324 | T |
| 27 034 | 003 | (cc) for FOR |
| 27 035 | 306 | F |
| 27 036 | 317 | O |
| 27 037 | 322 | R |
| 27 040 | 004 | (cc) for NEXT |
| 27 041 | 316 | N |
| 27 042 | 305 | E |
| 27 043 | 330 | X |
| 27 044 | 324 | T |
| 27 045 | 005 | (cc) for GOSUB |
| 27 046 | 307 | G |
| 27 047 | 317 | O |
| 27 050 | 323 | S |
| 27 051 | 325 | U |
| 27 052 | 302 | B |
| 27 053 | 006 | (cc) for RETURN |
| 27 054 | 322 | R |
| 27 055 | 305 | E |
| 27 056 | 324 | T |
| 27 057 | 325 | U |
| 27 060 | 322 | R |

| | | |
|---|---|---|
| 27 061 | 316 | N |
| 27 062 | 003 | (cc) for DIM |
| 27 063 | 304 | D |
| 27 064 | 311 | I |
| 27 065 | 315 | M |
| 27 066 | 003 | (cc) for END |
| 27 067 | 305 | E |
| 27 070 | 316 | N |
| 27 071 | 304 | D |
| 27 072 | 000 | End of Table |
| | | |
| 27 073 | 000 | GOSUB STACK pointer |
| 27 074 | XXX | Not assigned |
| 27 075 | 000 | Number of arrays counter |
| 27 076 | 000 | ARRAY pointer |
| 27 077 | 000 | VARIABLES counter |
| | | |
| 27 100 | 000 | These locations used as the |
| . . | . | GOSUB STACK |
| . . | . | storage |
| 27 117 | 000 | area |
| 27 120 | 000 | These locations used as the |
| . . | . | ARRAY VARIABLES |
| . . | . | TABLE |
| 27 137 | 000 | storage area |
| 27 140 | 000 | These locations used as the |
| . . | . | FOR/NEXT STACK |
| . . | . | storage |
| 27 177 | 000 | area |
| | | |
| 27 200 | 000 | FOR/NEXT STACK pointer |
| 27 201 | 000 | ARRAY/VARIABLE flag |
| 27 202 | 000 | STOSYM counter |
| 27 203 | 000 | FUN/ARRAY STACK pointer |
| 27 204 | 000 | ARRAY VALUES pointer |
| 27 205 | XXX | Not assigned |
| . . | . | |
| 27 207 | XXX | Not assigned |
| | | |
| 27 210 | 000 | These locations |
| 27 211 | XXX | used as the |
| . . | . | VARIABLES SYMBOL |
| . . | . | TABLE |
| 27 377 | XXX | storage area |

End of page 27.

Note open addresses
at start of page 30.
These locations avail-
able for patching.

```
30 013    056 144                    NEXT,  LLI 144
30 015    046 026          **               LHI 026
30 017    066 000                           LMI 000
30 021    056 202                           LLI 202
30 023    106                               LBM
30 024    004                               INB
30 025    056 201                           LLI 201
30 027    160                               LMB
30 030    056 201                  NEXT1,   LLI 201
30 032    315 240 002                       CAL GETCHR
30 035    312 045 030                       JTZ NEXT2
30 040    056 144                           LLI 144
30 042    315 314 002                       CAL CONCT1
30 045    056 201                  NEXT2,   LLI 201
30 047    315 003 003                       CAL LOOP
30 052    302 030 030                       JFZ NEXT1
30 055    056 144                           LLI 144
30 057    176                               LAM
30 060    376 001                           CPI 001
30 062    302 071 030                       JFZ NEXT3
30 065    056 146                           LLI 146
30 067    066 000                           LMI 000
30 071    056 205                  NEXT3,   LLI 205
30 073    046 027          **               LHI 027
30 075    176                               LAM
30 076    007                               RLC
30 077    007                               RLC
30 100    306 136                           ADI 136
30 102    046 027          **               LHI 027
30 104    157                               LLA
30 105    026 026          **               LDI 026
30 107    036 145                           LEI 145
30 111    006 002                           LBI 002
30 113    315 370 002                       CAL STRCPC
30 116    312 130 030                       JTZ NEXT4
30 121    076 306                  FORNXT,  LAI 306
30 123    016 316                           LCI 316
30 125    303 226 002                       JMP ERROR
30 130    056 360                  NEXT4,   LLI 360
30 132    046 026          **               LHI 026
30 134    126                               LDM
30 135    054                               INL
30 136    136                               LEM
30 137    054                               INL
30 140    162                               LMD
30 141    054                               INL
30 142    163                               LME
30 143    056 205                           LLI 205
30 145    046 027          **               LHI 027
30 147    176                               LAM
30 150    007                               RLC
```

```
30 151    007                          RLC
30 152    306 134                      ADI 134
30 154    157                          LLA
30 155    126                          LDM
30 156    054                          INL
30 157    136                          LEM
30 160    056 360                      LLI 360
30 162    046 026          **          LHI 026
30 164    162                          LMD
30 165    054                          INL
30 166    163                          LME
30 167    142                          LHD
30 170    153                          LLE
30 171    026 026          **          LDI 026
30 173    036 000                      LEI 000
30 175    315 046 012                  CAL MOVEC
30 200    056 325                      LLI 325
30 202    046 001          **          LHI 001
30 204    315 012 013                  CAL INSTR
30 207    173                          LAE
30 210    247                          NDA
30 211    312 121 030                  JTZ FORNXT
30 214    306 002                      ADI 002
30 216    056 276                      LLI 276
30 220    046 026          **          LHI 026
30 222    167                          LMA
30 223    056 330                      LLI 330
30 225    046 001          **          LHI 001
30 227    315 012 013                  CAL INSTR
30 232    173                          LAE
30 233    247                          NDA
30 234    302 300 030                  JFZ NEXT5
30 237    056 004                      LLI 004
30 241    046 001          **          LHI 001
30 243    315 244 022                  CAL FLOAD
30 246    056 304                      LLI 304
30 250    315 255 022                  CAL FSTORE
30 253    056 000                      LLI 000
30 255    046 026          **          LHI 026
30 257    106                          LBM
30 260    056 277                      LLI 277
30 262    160                          LMB
30 263    315 224 003                  CAL EVAL
30 266    056 310                      LLI 310
30 270    046 001          **          LHI 001
30 272    315 255 022                  CAL FSTORE
30 275    303 351 030                  JMP NEXT6

30 300    035                NEXT5,    DCE
30 301    056 277                      LLI 277
30 303    046 026          **          LHI 026
```

```
30 305    163                          LME
30 306    315 224 003                  CAL EVAL
30 311    056 310                      LLI 310
30 313    046 001          **          LHI 001
30 315    315 255 022                  CAL FSTORE
30 320    056 277                      LLI 277
30 322    046 026          **          LHI 026
30 324    176                          LAM
30 325    306 005                      ADI 005
30 327    055                          DCL
30 330    167                          LMA
30 331    056 000                      LLI 000
30 333    106                          LBM
30 334    056 277                      LLI 277
30 336    160                          LMB
30 337    315 224 003                  CAL EVAL
30 342    056 304                      LLI 304
30 344    046 001          **          LHI 001
30 346    315 255 022                  CAL FSTORE

30 351    056 144              NEXT6,  LLI 144
30 353    046 026          **          LHI 026
30 355    066 000                      LMI 000
30 357    056 034                      LLI 034
30 361    046 027          **          LHI 027
30 363    315 012 013                  CAL INSTR
30 366    173                          LAE
30 367    247                          NDA
30 370    056 202                      LLI 202
30 372    046 026          **          LHI 026
30 374    167                          LMA
30 375    312 121 030                  JTZ FORNXT
31 000    306 003                      ADI 003
31 002    056 203                      LLI 203
31 004    167                          LMA

31 005    056 203              NEXT7,  LLI 203
31 007    315 240 002                  CAL GETCHR
31 012    312 027 031                  JTZ NEXT8
31 015    376 275                      CPI 275
31 017    312 042 031                  JTZ NEXT9
31 022    056 144                      LLI 144
31 024    315 314 002                  CAL CONCT1

31 027    056 203              NEXT8,  LLI 203
31 031    315 003 003                  CAL LOOP
31 034    302 005 031                  JFZ NEXT7
31 037    303 121 030                  JMP FORNXT

31 042    056 202              NEXT9,  LLI 202
31 044    046 026          **          LHI 026
```

```
31 046    176                          LAM
31 047    306 003                      ADI 003
31 051    056 276                      LLI 276
31 053    167                          LMA
31 054    056 203                      LLI 203
31 056    106                          LBM
31 057    005                          DCB
31 060    056 277                      LLI 277
31 062    160                          LMB
31 063    315 224 003                  CAL EVAL
31 066    056 304                      LLI 304
31 070    046 001          **          LHI 001
31 072    315 277 022                  CAL FACXOP
31 075    315 211 020                  CAL FPADD
31 100    056 314                      LLI 314
31 102    046 001          **          LHI 001
31 104    315 255 022                  CAL FSTORE
31 107    056 310                      LLI 310
31 111    315 277 022                  CAL FACXOP
31 114    315 032 021                  CAL FPSUB
31 117    056 306                      LLI 306
31 121    176                          LAM
31 122    247                          NDA
31 123    056 126                      LLI 126
31 125    176                          LAM
31 126    312 121 030                  JTZ FORNXT
31 131    372 170 031                  JTS NEXT11
31 134    247                          NDA
31 135    372 177 031                  JTS NEXT12
31 140    312 177 031                  JTZ NEXT12

31 143    056 363              NEXT10, LLI 363
31 145    046 026          **          LHI 026
31 147    136                          LEM
31 150    055                          DCL
31 151    126                          LDM
31 152    055                          DCL
31 153    163                          LME
31 154    055                          DCL
31 155    162                          LMD
31 156    056 205                      LLI 205
31 160    046 027          **          LHI 027
31 162    106                          LBM
31 163    005                          DCB
31 164    160                          LMB
31 165    303 116 013                  JMP NXTLIN

31 170    247                  NEXT11, NDA
31 171    302 177 031                  JFZ NEXT12
31 174    303 143 031                  JMP NEXT10
```

```
31 177      056 314                 NEXT12,  LLI 314
31 201      046 001         **               LHI 001
31 203      315 244 022                      CAL FLOAD
31 206      315 252 010                      CAL RESTSY
31 211      315 055 010                      CAL STOSYM
31 214      303 116 013                      JMP NXTLIN

31 217      076 215                 BACKSP,  LAI 215
31 221      315 202 003                      CAL ECHO
31 224      315 202 003                      CAL ECHO
31 227      056 043                          LLI 043
31 231      046 001         **               LHI 001
31 233      066 001                          LMI 001
31 235      056 124                          LLI 124
31 237      176                              LAM
31 240      247                              NDA
31 241      370                              RTS
31 242      310                              RTZ
31 243      303 022 010                      JMP TAB1

31 246      056 205                   FOR5,  LLI 205
31 250      046 027         **               LHI 027
31 252      176                              LAM
31 253      007                              RLC
31 254      007                              RLC
31 255      306 136                          ADI 136
31 257      137                              LEA
31 260      124                              LDH
31 261      056 145                          LLI 145
31 263      046 026         **               LHI 026
31 265      006 002                          LBI 002
31 267      315 013 021                      CAL MOVEIT
31 272      315 055 010                      CAL STOSYM
31 275      303 116 013                      JMP NXTLIN
31 300      056 176                 PARSEP,  LLI 176
31 302      066 000                          LMI 000
31 304      315 324 004                      CAL PARSER
31 307      056 227                          LLI 227
31 311      046 001         **               LHI 001
31 313      176                              LAM
31 314      376 230                          CPI 230
31 316      310                              RTZ
31 317      303 152 011                      JMP SYNERR
```

Note open addresses.
This space available
for patching.

```
31 330      041 352 001     **       EXECSP, LXH 352 001
31 333      315 121 003                      CAL TEXTC
31 336      311                              RET
```

```
32 000    056 014                    SQRX,  LLI 014
32 002    046 001          **               LHI 001
32 004    315 255 022                     CAL FSTORE
32 007    056 126                         LLI 126
32 011    176                             LAM
32 012    247                             NDA
32 013    372 217 032                     JTS SQRERR
32 016    312 247 006                     JTZ CFALSE
32 021    056 017                         LLI 017
32 023    176                             LAM
32 024    247                             NDA
32 025    372 041 032                     JTS NEGEXP
32 030    037                             RAR
32 031    107                             LBA
32 032    076 000                         LAI 000
32 034    027                             RAL
32 035    167                             LMA
32 036    303 062 032                     JMP SQREXP

32 041    107                    NEGEXP,  LBA
32 042    257                             XRA
32 043    220                             SUB
32 044    247                             NDA
32 045    037                             RAR
32 046    107                             LBA
32 047    076 000                         LAI 000
32 051    217                             ACA
32 052    167                             LMA
32 053    312 057 032                     JTZ NOREMD
32 056    004                             INB

32 057    257                    NOREMD,  XRA
32 060    220                             SUB
32 061    107                             LBA

32 062    056 013                SQREXP,  LLI 013
32 064    160                             LMB
32 065    056 004                         LLI 004
32 067    036 034                         LEI 034
32 071    124                             LDH
32 072    006 004                         LBI 004
32 074    315 013 021                     CAL MOVEIT
32 077    315 247 006                     CAL CFALSE
32 102    056 044                         LLI 044
32 104    315 255 022                     CAL FSTORE

32 107    056 034                SQRLOP,  LLI 034
32 111    315 244 022                     CAL FLOAD
32 114    056 014                         LLI 014
32 116    315 266 022                     CAL OPLOAD
32 121    315 322 021                     CAL FPDIV
```

```
32 124      056 034                          LLI 034
32 126      315 266 022                      CAL OPLOAD
32 131      315 211 020                      CAL FPADD
32 134      056 127                          LLI 127
32 136      106                              LBM
32 137      005                              DCB
32 140      160                              LMB
32 141      056 034                          LLI 034
32 143      315 255 022                      CAL FSTORE
32 146      056 044                          LLI 044
32 150      315 266 022                      CAL OPLOAD
32 153      315 032 021                      CAL FPSUB
32 156      056 127                          LLI 127
32 160      176                              LAM
32 161      376 367                          CPI 367
32 163      372 203 032                      JTS SQRCNV
32 166      056 034                          LLI 034
32 170      124                              LDH
32 171      036 044                          LEI 044
32 173      006 004                          LBI 004
32 175      315 013 021                      CAL MOVEIT
32 200      303 107 032                      JMP SQRLOP

32 203      056 013                SQRCNV,   LLI 013
32 205      176                              LAM
32 206      056 037                          LLI 037
32 210      206                              ADM
32 211      167                              LMA
32 212      056 034                          LLI 034
32 214      303 244 022                      JMP FLOAD

32 217      076 323                SQRERR,   LAI 323
32 221      016 321                          LCI 321
32 223      303 226 002                      JMP ERROR
```

Note open addresses.
This space available
for patching.

```
32 240      056 064                  RNDX,   LLI 064
32 242      046 001          **              LHI 001
32 244      315 244 022                      CAL FLOAD
32 247      056 050                          LLI 050
32 251      315 266 022                      CAL OPLOAD
32 254      315 046 021                      CAL FPMULT
32 257      056 060                          LLI 060
32 261      315 266 022                      CAL OPLOAD
32 264      315 211 020                      CAL FPADD
32 267      056 064                          LLI 064
32 271      315 255 022                      CAL FSTORE
32 274      056 127                          LLI 127
```

```
32 276    167                                  LMA
32 277    326 020                              SUI 020
32 301    167                                  LMA
32 302    315 000 020                          CAL FPFIX
32 305    056 123                              LLI 123
32 307    066 000                              LMI 000
32 311    056 127                              LLI 127
32 313    066 000                              LMI 000
32 315    315 064 020                          CAL FPFLT
32 320    056 127                              LLI 127
32 322    176                                  LAM
32 323    306 020                              ADI 020
32 325    167                                  LMA
32 326    056 064                              LLI 064
32 330    315 266 022                          CAL OPLOAD
32 333    315 032 021                          CAL FPSUB
32 336    056 064                              LLI 064
32 340    315 255 022                          CAL FSTORE
32 343    056 127                              LLI 127
32 345    176                                  LAM
32 346    326 020                              SUI 020
32 350    167                                  LMA
32 351    311                                  RET
```

Note open addresses
to end of page 32.

Pages 33 to remainder
of memory (or start of
optional ARRAY
handling routines) used as
USER PROGRAM BUFFER.

Optional ARRAY routines
assembled for operation in
the upper three pages of a
12 K system are listed here.

```
55 000    056 126                      PRIGH1,  LLI 126
55 002    046 001              **               LHI 001
55 004    176                                   LAM
55 005    247                                   NDA
55 006    372 136 055                           JTS OUTRNG
55 011    315 000 020                           CAL FPFIX
55 014    056 124                               LLI 124
55 016    176                                   LAM
55 017    326 001                               SUI 001
55 021    007                                   RLC
55 022    007                                   RLC
55 023    117                                   LCA
55 024    056 203                               LLI 203
```

```
55 026      046 027          **                  LHI 027
55 030      176                                  LAM
55 031      356 377                              XRI 377
55 033      007                                  RLC
55 034      007                                  RLC
55 035      306 120                              ADI 120
55 037      046 027          **                  LHI 027
55 041      157                                  LLA
55 042      054                                  INL
55 043      054                                  INL
55 044      176                                  LAM
55 045      201                                  ADC
55 046      157                                  LLA
55 047      046 057          ††                  LHI 057
55 051      303 244 022                          JMP FLOAD

55 054      056 202                  FUNAR2,     LLI 202
55 056      046 027          **                  LHI 027
55 060      106                                  LBM
55 061      004                                  INB
55 062      160                                  LMB
55 063      016 002                              LCI 002
55 065      056 114                              LLI 114
55 067      046 027          **                  LHI 027
55 071      315 230 007                          CAL TABADR
55 074      026 026          **                  LDI 026
55 076      036 120                              LEI 120
55 100      315 332 002                          CAL STRCP
55 103      312 124 055                          JTZ FUNAR3
55 106      056 202                              LLI 202
55 110      046 027          **                  LHI 027
55 112      176                                  LAM
55 113      056 075                              LLI 075
55 115      276                                  CPM
55 116      302 054 055                          JFZ FUNAR2
55 121      303 172 007                          JMP FAERR

55 124      056 202                  FUNAR3,     LLI 202
55 126      046 027          **                  LHI 027
55 130      257                                  XRA
55 131      236                                  SBM
55 132      167                                  LMA
55 133      303 207 007                          JMP FUNAR4

55 136      076 317                  OUTRNG,     LAI 317
55 140      016 322                              LCI 322
55 142      303 226 002                          JMP ERROR

55 145      315 252 010                ARRAY,    CAL RESTSY
55 150      303 160 055                          JMP ARRAY2
```

```
55 153    056 202                ARRAY1,  LLI 202
55 155    303 162 055                     JMP ARRAY3

55 160    056 203                ARRAY2,  LLI 203

55 162    046 026          **    ARRAY3,  LHI 026
55 164    106                             LBM
55 165    004                             INB
55 166    056 276                         LLI 276
55 170    160                             LMB
55 171    056 206                         LLI 206
55 173    160                             LMB

55 174    056 206                ARRAY4,  LLI 206
55 176    315 240 002                     CAL GETCHR
55 201    376 251                         CPI 251
55 203    312 225 055                     JTZ ARRAY5
55 206    056 206                         LLI 206
55 210    315 003 003                     CAL LOOP
55 213    302 174 055                     JFZ ARRAY4
55 216    076 301                         LAI 301
55 220    016 306                         LCI 306
55 222    303 226 002                     JMP ERROR

55 225    056 206                ARRAY5,  LLI 206
55 227    106                             LBM
55 230    005                             DCB
55 231    056 277                         LLI 277
55 233    160                             LMB
55 234    056 207                         LLI 207
55 236    066 000                         LMI 000

55 240    056 207                ARRAY6,  LLI 207
55 242    046 026          **             LHI 026
55 244    106                             LBM
55 245    004                             INB
55 246    160                             LMB
55 247    016 002                         LCI 002
55 251    056 114                         LLI 114
55 253    046 027          **             LHI 027
55 255    315 230 007                     CAL TABADR
55 260    036 120                         LEI 120
55 262    026 026          **             LDI 026
55 264    315 332 002                     CAL STRCP
55 267    312 312 055                     JTZ ARRAY7
55 272    056 207                         LLI 207
55 274    046 026          **             LHI 026
55 276    176                             LAM
55 277    056 075                         LLI 075
55 301    046 027          **             LHI 027
55 303    276                             CPM
```

```
55 304    302 240 055                    JFZ ARRAY6
55 307    303 172 007                    JMP FAERR

55 312    315 224 003          ARRAY7,   CAL EVAL
55 315    315 000 020                    CAL FPFIX
55 320    056 207                        LLI 207
55 322    046 026          **            LHI 026
55 324    106                            LBM
55 325    016 002                        LCI 002
55 327    056 114                        LLI 114
55 331    046 027          **            LHI 027
55 333    315 230 007                    CAL TABADR
55 336    054                            INL
55 337    054                            INL
55 340    116                            LCM
55 341    056 124                        LLI 124
55 343    046 001          **            LHI 001
55 345    176                            LAM
55 346    326 001                        SUI 001
55 350    007                            RLC
55 351    007                            RLC
55 352    201                            ADC
55 353    056 204                        LLI 204
55 355    046 027          **            LHI 027
55 357    167                            LMA
55 360    056 201                        LLI 201
55 362    066 377                        LMI 377
55 364    311                            RET

55 365    315 255 002             DIM,   CAL CLESYM
55 370    056 202                        LLI 202
55 372    106                            LBM
55 373    004                            INB
55 374    056 203                        LLI 203
55 376    160                            LMB

55 377    056 203             DIM1,      LLI 203
56 001    315 240 002                    CAL GETCHR
56 004    312 017 056                    JTZ DIM2
56 007    376 250                        CPI 250
56 011    312 032 056                    JTZ DIM3
56 014    315 310 002                    CAL CONCTS

56 017    056 203             DIM2,      LLI 203
56 021    315 003 003                    CAL LOOP
56 024    302 377 055                    JFZ DIM1
56 027    303 337 056                    JMP DIMERR

56 032    056 206             DIM3,      LLI 206
56 034    066 000                        LMI 000
```

```
56 036    056 206              DIM4,  LLI 206
56 040    046 026        **           LHI 026
56 042    176                         LAM
56 043    007                         RLC
56 044    007                         RLC
56 045    306 114                     ADI 114
56 047    046 027        **           LHI 027
56 051    157                         LLA
56 052    036 120                     LEI 120
56 054    026 026        **           LDI 026
56 056    315 332 002                 CAL STRCP
56 061    312 301 056                 JTZ DIM9
56 064    056 206                     LLI 206
56 066    046 026        **           LHI 026
56 070    106                         LBM
56 071    004                         INB
56 072    160                         LMB
56 073    056 075                     LLI 075
56 075    046 027        **           LHI 027
56 077    176                         LAM
56 100    005                         DCB
56 101    270                         CPB
56 102    302 036 056                 JFZ DIM4
56 105    056 075                     LLI 075
56 107    046 027        **           LHI 027
56 111    106                         LBM
56 112    004                         INB
56 113    160                         LMB
56 114    056 076                     LLI 076
56 116    160                         LMB
56 117    056 206                     LLI 206
56 121    046 026        **           LHI 026
56 123    160                         LMB
56 124    176                         LAM
56 125    007                         RLC
56 126    007                         RLC
56 127    306 114                     ADI 114
56 131    137                         LEA
56 132    026 027        **           LDI 027
56 134    056 120                     LLI 120
56 136    046 026        **           LHI 026
56 140    315 046 012                 CAL MOVEC
56 143    315 255 002                 CAL CLESYM
56 146    056 203                     LLI 203
56 150    046 026        **           LHI 026
56 152    106                         LBM
56 153    004                         INB
56 154    056 204                     LLI 204
56 156    160                         LMB

56 157    056 204              DIM5,  LLI 204
```

```
56 161    315 240 002                    CAL GETCHR
56 164    312 211 056                    JTZ DIM6
56 167    376 251                        CPI 251
56 171    312 224 056                    JTZ DIM7
56 174    376 260                        CPI 260
56 176    372 337 056                    JTS DIMERR
56 201    376 272                        CPI 272
56 203    362 337 056                    JFS DIMERR
56 206    315 310 002                    CAL CONCTS

56 211    056 204                DIM6,   LLI 204
56 213    315 003 003                    CAL LOOP
56 216    302 157 056                    JFZ DIM5
56 221    303 337 056                    JMP DIMERR

56 224    056 120                DIM7,   LLI 120
56 226    046 026        **              LHI 026
56 230    315 044 023                    CAL DINPUT
56 233    315 000 020                    CAL FPFIX
56 236    056 124                        LLI 124
56 240    176                            LAM
56 241    007                            RLC
56 242    007                            RLC
56 243    117                            LCA
56 244    056 076                        LLI 076
56 246    046 027        **              LHI 027
56 250    176                            LAM
56 251    326 001                        SUI 001
56 253    007                            RLC
56 254    007                            RLC
56 255    306 122                        ADI 122
56 257    157                            LLA
56 260    046 027        **              LHI 027
56 262    106                            LBM
56 263    306 004                        ADI 004
56 265    157                            LLA
56 266    170                            LAB
56 267    201                            ADC
56 270    167                            LMA

56 271    056 204                DIM8,   LLI 204
56 273    046 026        **              LHI 026
56 275    106                            LBM
56 276    056 203                        LLI 203
56 300    160                            LMB

56 301    056 203                DIM9,   LLI 203
56 303    315 240 002                    CAL GETCHR
56 306    376 254                        CPI 254
56 310    312 326 056                    JTZ DIM10
56 313    056 203                        LLI 203
```

```
56 315      315 003 003                    CAL LOOP
56 320      302 301 056                    JFZ DIM9
56 323      303 116 013                    JMP NXTLIN

56 326      056 203             DIM10,     LLI 203
56 330      106                            LBM
56 331      056 202                        LLI 202
56 333      160                            LMB
56 334      303 365 055                    JMP DIM

56 337      076 304             DIMERR,    LAI 304
56 341      016 305                        LCI 305
56 343      303 226 002                    JMP ERROR
```

Note open addresses
to end of page 56.

Page 57 reserved
for use by the
ARRAY VALUES TABLE.

# OPERATING SCELBAL

This chapter will present detailed information on the use of SCELBAL as a higher level language. Examples of the usage of the various types of commands, statements, and functions will be presented.

It is assumed in the following discussion that the reader has loaded an appropriate version of the program (either for an 8008 or 8080 system) along with the appropriate user provided I/O routines for whatever I/O devices will be used in the user's system. (Information on this subject is presented in a chapter titled "I/O Routines.") For the sake of discussion it will be assumed that an ASCII encoded keyboard is being utilized as the operator's input device and some sort of printing device is being used as the display mechanism.

## STARTING SCELBAL

The SCELBAL program as presented in the assembled object code listings in this publication has a starting address of 10 266. Some users may wish to place a vector to this starting location in one of the RESTART locations available in 8008 or 8080 systems.

When the program is first started, the message:

READY

will be displayed on the output device to notify the operator that the program is in the EXECUTIVE COMMAND mode.

### The SCRatch Command

There are five EXECUTIVE COMMANDS. All commands and other entries by the operator are terminated by entering a carriage return. Perhaps the first command the user should utilize when the program is first started is the SCRatch command. This command is issued by typing in the mnemonic:

SCR

following by a carriage return.

The program will acknowledge receipt of the SCRatch command by displaying the message READY. The SCRatch command effectively clears the USER PROGRAM BUFFER and VARIABLES LOOK-UP table. It should thus be used whenever the operator desires to start entering a new higher level language program into the USER PROGRAM BUFFER.

### CALCULATOR Mode of Operation

SCELBAL is able to operate in two basic modes. The first type of mode will be referred to as the "calculator" mode. This mode is available at any time that the program is not actually performing operations in the second mode which is the stored program mode.

The "calculator" mode will be used to introduce some of the uses of the SCELBAL statement directives. The calculator mode is automatically assumed by the program if a statement is entered without being preceeded by a line number.

### The PRINT Statement

Perhaps the first type of statement to consider is the PRINT statement since this directive must be used whenever an operator desires to obtain some information from the program!

The next several paragraphs will discuss the use of the PRINT statement when the user does not preceed the statement by a line number. The program will then be operating in the calculator mode and will immed-

iately execute the statement directive when it is terminated by a carriage return.

The use of the PRINT statement by itself will simply result in the issuance of a carriage return and line feed combination! This fact may be of little use when SCELBAL is being used in the calculator mode, but it is valuable when it is used in a program as it may simply be used to provide formatting spaces between lines of information outputted by a program!

In its more typical application, however, the PRINT statement may be followed by a variety of terms. These terms may either be interpreted as representing mathematical values (represented as numbers, variables or expressions), or text strings. To signify that terms following a PRINT statement are to be interpreted as a text string, they must be enclosed by single or double quotation marks. For example, the statements:

PRINT "HELLO"

or:

PRINT 'HELLO'

would result in the program displaying the text message:

HELLO

when the statement line was terminated by the operator striking the carriage return key. After displaying the HELLO text message, a carriage return and line feed combination would also be issued. In fact, a carriage return and line feed combination will always be issued at the conclusion of the execution of a PRINT statement unless the statement line is terminated by a comma (,) or semicolon (;). The comma and semicolon signs are special indicators when used in a PRINT statement line. Both signs may be used to separate terms in a line. However, the comma sign, while separating terms, will also provide a special feature. It will cause the display device to space over to the next "tabbing" position in the line being displayed by the program! In the version of SCELBAL presented these "tabbing" positions are set at every sixteenth column in a line. (However, the tabbing positions may be modifed. See the source listing for the PRINT statement.) The semicolon does not provide the tabbing capability. It is used in place of the comma sign when the programmer desires the output of the next term to begin on the next position in the line.

Several examples of the use of the comma and semicolon signs should be helpful to the reader at this point. The statement:

PRINT "HELLO";"HELLO";

would result in the output device displaying:

HELLOHELLO

That is, the two words would be run together. Additionally, since the statement line also ends with a semicolon, the display mechanism would not issue a carriage return and line feed combination after the second word. The display unit would be positioned to start typing at the next character position in the same line.

The statement line:

PRINT "HELLO","HELLO",

would result in the output device displaying:

HELLO HELLO

The second word would start at the sixteenth column position in the line. Since a comma was also used to end the line, no carriage return and line feed combination would be issued and the display device would be positioned to start typing (the next time a PRINT statement was encountered) at the thirty-second column in the line.

It will be mentioned that a text string may consist of letters, numbers, words, and punctuation marks; including the comma and semicolon signs! Whatever is enclosed within quotation marks on a PRINT statement line

will be considered part of the text message. Thus, one may have entire sentences displayed. The statement:

```
PRINT 'HELLO! I AM A COMPUTER.';
```

Will result in then sentence:

```
HELLO! I AM A COMPUTER.
```

being displayed.

When terms on a PRINT statement are not enclosed by single or double quotation marks they are assumed to represent mathematical quantities. Mathematical quantities may be expressed in the form of a number, the name of a variable, or a combination of these two forms coupled by mathematical operators which would be considered an expression.

The statement:

```
PRINT 123456;
```

will result in the display of the number:

```
123456
```

(Some readers might note that in the case of pure simple numbers, one would get the same result when using the PRINT statement when the number was enclosed in quotation marks!)

A statement such as:

```
PRINT A;
```

would result in the current value of the variable named A to be displayed. If the operator entered the above statement immediately after using the SCRatch command, the system would display:

```
0
```

as the variable A would have had no previous value assigned to it.

Perhaps the most common application of the PRINT statement when used in the calculator mode, is to use it to obtain the value of a mathematical expression. For example, typing in:

```
PRINT (412*3.14159/16)*14
```

would result in the program displaying the result of performing the calculations contained in the expression. The number:

```
1132.544
```

would thus be displayed back to the operator. Of course, one does not have to use pure numbers in a mathematical expression that is to be evaluated. If the values for variable names have previously been defined (by the LET statement which will be discussed later) so that, for instance:

```
A = 412
B = 3.14159
C = 16
D = 14
```

and the PRINT statement:

```
PRINT (A*B/C)*D
```

was entered, the result:

```
1132.544
```

would again be displayed back to the operator. Naturally, one may also mix variable names and numeric values in an expression. However, when in the calculator mode, if variables are being used, one must ensure that they are first defined before attempting to use them in an expression. Otherwise, their values will be zero when they are encountered in the expression.

The use of the PRINT statement when it is used as part of a program (in which case the statement is preceeded by a line number) is essentially the same as described. However, in the stored program mode, one is more likely to make use of the capability of having both text messages and mathematical values displayed using a single PRINT statement. An

example of this capability is illustrated here:

```
10 PRINT 'THE ANSWER IS: ';(A*B/C)*D
```

would result in the program displaying:

```
THE ANSWER IS:  1132.544
```

(Assuming the variable values were the same as mentioned earlier in the discussion when the statement was executed!)

The reader should note in the statement line above that a space character was inserted after the colon at the end of the text string just before the quotation character marking the end of the text string. This was done so that there would be normal spacing between the text string and the answer when it was displayed. The prospective high level language programmer should keep the tip in mind when mixing text strings and mathematical values as in the above example.

The PRINT statement is truly a "workhorse" directive in SCELBAL. It controls all the outputting of data to the operator. The above discussion covers the primary forms of its use. However, later the reader will see how several special functions (TAB and CHR) may be used within the statement to provide even more output capability and flexibility.

Remember, when you want some output from SCELBAL, tell it to PRINT.

## PRECEDENCE of Mathematical Operators

The PRINT statement just discussed, and many other statements in SCELBAL may cause the program to evaluate mathematical expressions in order to obtain a numerical value. In order to perform such calculations in a consistent manner, it is necessary to establish a system of "operator precedence," and rules for evaluating an expression. This system must be learned by the high level programmer because it is the system that has been "fixed" in the computer.

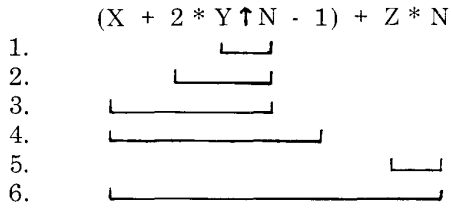
The first rule to learn is that SCELBAL evaluates all expressions by proceeding to "read" expressions on a left to right basis.

As a mathematical expression is read from left to right, mathematical terms (numbers and variable names representing numbers) are joined by operator signs. (These are the parenthesis, exponentiate ("↑"), multiply ("*"), divide ("/"), add ("+") and subtract ("-") signs.) The operator signs are assigned PRECEDENCE values which are used to determine when to perform an operation. The highest operator precedence is assigned to the exponentiate sign. Next, having equal precedence are the multiply and divide signs. Lower in the precedence order are the add and subtract signs (having equal precedence with each other). Terms within parenthesis are always evaluated before proceeding further in a line. (Thus, the left hand parenthesis sign serves as a start of group marker, the right hand one as an end of group marker.)

As an expression is evaluated, each mathematical term (number or variable value) is saved on an ARITHMETIC STACK. Each time an operator is encountered, a test is made to determine if that operator is less than or equal to any previously unprocessed operator that has been encountered. If not, that is, if the operator is higher in precedence than the preceeding one encountered in the line, it is saved on an OPERATOR STACK. If, however, the precedence of the operator is less than or equal to the previous one, the operation dictated by the previous operator is executed upon the two previous mathematical terms contained in the arithmetic stack.

This method of stacking the lower precedence operators results in the higher precedence operations being performed first!

This may be seen more clearly, perhaps, by following the evaluation of an expression which contains a variety of terms with different precedences. Such an expression is presented on the next page.




When the above expression is scanned by SCELBAL the left hand parenthesis will be the first operator detected. A left hand parenthesis is always placed on the operator stack as though it had the highest possible precedence. However, once on the stack, its precedence is changed to be lower than all other operators. This precedence switching "trick" results in all the terms within a pair of parenthesis being evaluated before remaining terms on a line are calculated as will become apparent shortly.

The first term to be encountered in the example expression is the name of a variable called X. This variable is followed by the operator "+" for addition. The "+" operator has a higher precedence than the left hand parenthesis on the operator stack. (Remember, once the left hand parenthesis is on the operator stack, it has the lowest operator sign precedence!) Thus, the "+" sign will be placed on the top of the operator stack. The value of X will be placed on the arithmetic stack.

Next, the program will find the number 2 followed by the "*" multiplication sign. The multiplication sign has higher precedence than the "+" sign on the top of the operator stack so it becomes the top entry on that stack. The number 2 is added to the top of the arithmetic stack.

Continuing to scan the line the program will find the variable name Y and the " ↑ " exponentiate operator. The exponentiate operator has higher precedence than the "*" operator so it is placed on the operator stack. The value for Y is placed on the arithmetic stack.

Next, the variable name N and the minus sign operator "-" will be scanned. This is the first point in the line that will result in actual mathematical operations being performed! This is because the "-" operator has a lower precedence than the exponentiate sign processed earlier in the line. Since it does have a lower precedence, the exponentiate operator must be executed. It will operate on the value for the variable N and Y (stored on the top of the arithmetic stack). The result of that operation will be placed on the top of the arithmetic stack. The exponentiate operator is removed from the top of the operator stack. Now, the top of that stack will contain the "*" operator. The "-" has lower precedence than the "*" operator too, so now the multiplication operation can be performed. It will be performed between the previously calculated quantity Y↑N and the number 2. Those two quantities on the arithmetic stack are replaced by the result of the multiplication operation. The "*" operator is removed from the top of the operator stack. Now the "+" sign will be on the top of that stack. The current "-" sign is equal in precedence to the "+" sign so once again the operation on the stack is performed! The quantity 2 times Y to the N power will be added to the value of X. Those two entries in the arithmetic stack are replaced by the current total. At this point, only the left hand parenthesis sign, having a lower precedence than the "-" sign is left on the operator stack. Thus, the "-" sign is placed on top of the operator stack.

As the program continues to scan the expression it will next encounter the number 1 and the right hand parenthesis operator. The ")" operator has the lowest possible operator sign precedence. Therefore, all operations on the operator stack must be performed until the initiating left hand parenthesis is located! In this case, the "-" operator is on top of the operator stack. So, the quantity one will be subtracted from the quantity X plus 2 times Y raised to the power N. The result is placed on the top of the arithmetic stack replacing the previous entry. The "-" sign is removed from the operator stack leaving just the initial "(" left hand parenthesis sign. This effectively cancels with the right hand parenthesis leaving the operator stack cleared.

At this point the arithmetic stack contains the value of the expression contained in the parenthesis. The operator stack is empty. The program will continue to scan the line and pick up the "+" operator that follows the right hand parenthesis. Since the operator stack is empty, the "+" sign will be placed on the top of the stack. Next, the program will find the variable name Z and the operator "*" for multiplication. The multiplication sign has higher precedence than the "+" sign which is on the operator stack so the "*" sign is placed on the stack with the value for the variable Z going on top of the arithmetic stack.

Finally, the program will encounter the second occurrence of the variable name N at the end of the expression. When the end of an expression is reached, all terms in the line are processed according to the operators contained in the operator stack. The top of the operator stack contains the "*" sign. Thus, the values for the variables Z and N will be multiplied. The result will replace those entries on the top of the arithmetic stack. The "*" sign is removed from the operator stack leaving just the "+" operator. The quantity Z * N will then be added to the quantity in parenthesis which will yield the final result for the entire expression contained on the line!

The lines under the expression on the previous page illustrate the order in which actual operations would be performed when the expression was evaluated by SCELBAL.

Readers who desire a more detailed explanation of the process involved in evaluating mathematical expressions should refer to the appropriate chapters which present and explain the machine language routines which perform the mathematical evaluations.

The user of SCELBAL must realize that the precedence given to mathematical operators is important when writing the mathematical expressions that one desires to have a program solve. If one desires to have an expression such as the quantity N plus 2 multiplied by the quantity M minus 3, it must be written in the form:

$$(N + 2) * (M - 3)$$

and not:

$$N + 2 * M - 3$$

For, the latter format would result in the expression being evaluated as the quantity N plus the quantity 2 times M minus the quantity 3!

Remember, the higher precedence operators are executed first! A good rule of thumb, when in doubt about the precedence rules, is to group terms using parenthesis. Thus, to raise 2 to the N minus one power, write the expression as:

$$2 \uparrow (N - 1)$$

not:

$$2 \uparrow N - 1$$

The second format will result in one being subtracted from the quantity 2 raised to the power N.

What other rules must the programmer know about writing mathematical expressions when using SCELBAL? This: Terms (names of variables, or numbers) must be separated by operators, and, as a general rule, operators must be separated by terms. EXCEPT, when the operator is a parenthesis! A parenthesis must always be followed by an operator other than an opposite parenthesis.

Thus, the following formats are valid:

$$A + B$$
$$(A + B) * (C + D)$$

and the following are not valid:

$$A + * B$$
$$(A + B) (C + D)$$
$$(A + B) N$$

Special mention must be made of the case when the programmer desires to use the minus sign as a unary operator. That is, when it is used to specify a minus number. The mathematical routines in SCELBAL perform the unary minus operation by subtracting the value that follows the minus sign from zero. Thus, if one enters the expression:

A/-B

The program will attempt to perform the operation as:

A/0 - B

This particular example case would result in a program error message being generated for an attempted divide by zero operation!

The proper way to handle expressions containing the unary minus operator is to enclose the term and the unary minus sign in parenthesis. The above example expression would be properly executed if it was written as:

A/(-B)

because the program would execute it as:

A/(0 - B)

(Provided that B is not zero in this case!)

## NUMBERS

Numerical values used in mathematical expressions for SCELBAL programs may be entered in two formats. Decimal fixed point notation and decimal floating point notation.

With either notation, the programmer is limited to six to seven significant decimal digits. SCELBAL will accept six significant digits at all times, and seven significant digits if the number does not exceed 5242879. This limitation on the size of seven digit numbers is related to the manner in which the mathematical input buffer is limited to prevent its overflow. If one attempts to enter numbers larger than this only the first six digits (if the number is larger than 524287) or seven digits (if the number is between 524287 and the number 5242879) will be used. Perhaps the easiest rule of thumb for the novice programmer to remember is to simply limit inputs to six significant digits.

The number of significant digits one can enter of course provides the range in which numbers may be entered using fixed point notation. The limitations of fixed point notation in terms of the magnitude that they may express may be extended by the use of floating point notation. Floating point notation allows the programmer to specify an exponent portion indicating the power to which a number may be raised. Using floating point notation, one may enter numbers having magnitudes from minus the 38'th to plus the 38'th power of ten!

Some examples of numbers that may be entered using fixed and floating point notation are shown below.

```
     1.234567
  1234.567
999999
        .0000123
 105.68E+12
   0.045E-9
```

All numbers entered in a SCELBAL program will be converted to binary floating point notation and manipulated in that format during calculations. Calculations are performed by the floating point mathematical routines contained in the program with all calculations maintained to twenty-three binary bits of precision (for the mantissa portion) and seven binary bits for the exponent. These values limit the precision and range of numbers that the program can successfully handle. Several factors are important from the programmers view point.

One important factor for the programmer to keep in mind is that if calculations exceed the allowable range of the floating point regis-

ters and cause the binary exponent to overflow, that the results will be erroneous. From the programmer's viewpoint, using decimal numbers, this means that the programmer must ensure that a program will not attempt to perform calculations where the decimal exponent value would exceed plus or minus the thirty-eighth power! Thus, performing a calculation such as:

1.0E+24 * 2.0E+20

which would theoretically yield a result of:

0.2E+45

would cause the floating point binary exponent register in SCELBAL to overflow and results displayed to the operator would be meaningless.

It is easy enough for a programmer to remember the allowable range of numbers for SCELBAL when performing routine calculations. However, one must be alert to cases where the possibility of exceeding the allowable range is hidden in a program. This case is more likely to occur in a program where one starts raising numbers to a power. For instance, if one has a program with a calculation such as:

N↑(X)

and proceeds to iterate X, a point will be reached where the allowable range of magnitude as discussed above is exceeded. The user has been cautioned!

Another parameter that the programmer will want to keep in mind relates to the accuracy with which calculations can be maintained in a program. Since the floating point binary registers in which numbers are held are limited to twenty-three binary bits, fractional results from operations such as multiplication and division are rounded off to leave the 23 most significant binary bits. This operation may introduce a small error, particularly when the results of operations involve a non-ending binary series. In a chain of operations such errors can accumulate. These small errors will often affect the least significant decimal digit displayed to the operator. The novice programmer who is not used to digital calculations may be initially surprised to find that a directive such as:

PRINT 999999

will result in the display showing:

999999.5

Or, a directive such as:

PRINT 500 * 500

will result in the answer:

250000.1

The first example above might be particularly surprising to an operator who surmises that the program cannot even display back the same value entered! The result one obtains in the first answer is affected by the fact that the program in performing the directive, actually converts the decimal number to floating point binary notation, and then performs the reverse procedure. The conversion process involves multiplying the binary number (representing 999999) by the value 0.1 (decimal). The value 0.1 in binary notation is a non-ending series that must be rounded to twenty-three binary bits. The rounding process during the conversion results in the error factor shown for the example.

The actual amount of error that can accumulate in a calculation depends on the actual numbers involved, the extent of chaining of calculations involving non-ending series, and so forth. It is not the purpose of this presentation to go into a discussion of the factors relating to the precision and accuracy of calculations performed on a digital machine. The main point being made here is that such deviations are normal.

(Actually, the reason the deviation in the above examples shows up is because the pro-

gram permits the display of seven digits, even though the entry was only six. Users who find the display of the above types of small errors disconcerting may consider revising the appropriate section of the floating point output routine to limit the display to six significant digits!)

Numbers outputted by SCELBAL are automatically displayed in fixed point format if they are in the range:

1.0 to 8388608

Numbers outside this range are automatically displayed in floating point format which appears as shown below.

0.8388609E+07

## VARIABLE NAMES

SCELBAL allows the operator to create mnemonic names to represent variable values. All names must begin with a letter of the alphabet and regular variable names may consist of one or two characters. The second character of a regular name may be a number if desired. Some typical regular variable names might be:

A
AA
A1

Examples of illegal variable names would be:

1A
AAA

Up to twenty regular variable names may be used in a program.

The terminology "regular variables" refers to variables not associated with the optional DIMension or ARRAY handling capabilities of SCELBAL. Names of variables associated with an array will be called ARRAY VARIABLES. An array variable name may only consist of one letter of the alphabet and must always be followed by a subscript enclosed in parenthesis. An example of an array variable name would be:

A(1)

Up to four array names may be assigned in a program (independent of the number of regular variable names assigned). Additionally, since an array variable name is identified by the presence of a subscript, the same letter may be assigned to an array variable and a regular variable in a program.

## The LET Statement

Now that the prospective SCELBAL programmer has been introduced to some of the fundamental aspects of the language - enough so that one may sit at the keyboard and try the various capabilities of SCELBAL as they are explained, it is time to proceed to introduce and explain the use of the various remaining types of STATEMENTS that the program can interpret.

The LET statement is used to define the value of a variable name. This statement actually has two forms. The express form, and the implied form. The express form is implemented by entering the statement keyword LET followed by the name of the variable that is to be defined. The variable name is then followed by the equal ("=") sign. The statement line is concluded by expressing, in mathematical terms, just what the value for the variable name will be when the directive is executed. This may be signified by giving an actual numerical value, by specifying another variable name, or by a mathematical expression. Some typical LET statements are illustrated here:

```
LET X = 100
LET X = Y
LET X = 100 * Y
```

When a LET statement is executed, the value of the variable indicated on the left hand side of the equal sign will be made equal

to whatever quantity is specified to the right of the equal sign.

Because the LET statement is used so frequently in programs, it is the one statement type in SCELBAL that can be interpreted without actually giving the LET keyword at the start of a statement line. Thus, when no keyword is found at the start of a statement line, the program assumes that an IMPLIED LET statement is being processed. The LET statements given as examples previously could have been directed by simply stating:

```
X = 100
X = Y
X = 100 * Y
```

## The IF Statement

The IF statement allows the programmer to have the program make a logical decision based on the value of an expression at the time the statement is encountered.

The IF statement has two basic formats:

```
IF X = Y GOTO LL
```

or,

```
IF X = Y THEN [NEW STATEMENT]
```

That is, a test may be made to see if the value of an expression has reached a certain point (or is within a selected range), and, if so, the program may be directed to jump to a specific statement line number in the program being executed. (This is indicated by the format that has the GOTO directive.) Or, by using the THEN directive, one may have the program proceed to execute a different statement. (That is, execute the statement that immediately follows the THEN directive on the same line.) If the conditional test made in the IF statement should fail (i.e., in the two examples just given the value of X was not equal to Y), then the program does not perform the GOTO or THEN directive and instead proceeds to the next statement line in the program.

Now, remember this: The test specified in the IF statement does not have to be restricted to just testing for simple equality! Any of the following test conditions may be specified in place of the equal sign:

```
>
<
<=
=>
<>
```

Remember too, that both sides of the conditional sign(s) may contain mathematical expressions. They need not be just simple variable names as used in the format examples.

Some typical examples of the IF statement in use are shown next.

```
IF X<>50 THEN GOSUB 120
```

(If X is not equal to 50 then perform the subroutine that starts at line number 120 in the program. Else, continue with the next line in the program.)

```
IF X = (A*B*C) GOTO 90
```

(If X is equal to the value of another mathematical expression, go directly to program line number 90. Else, continue with the next line in the program.)

```
IF X + 5 > Y - 10 THEN LET X = 1
```

(If the quantity (X + 5) is greater than the quantity (Y - 10) then reset X back to 1 by executing the LET statement on the same line. If the condition is not met, then the LET statement on the same line is not executed.)

The IF statement is a powerful statement that has many applications in higher level programming. One particularly effective application for this type of statement is to use it to create an effective conditional CALL instruction as shown in one of the examples above.

### The GOTO Statement

The GOTO statement directive is simply used to direct the program to jump to a specified line number in a program. Its format is:

GOTO LL

where LL stands for any line number assigned in a program.

The GOTO statement is typically used to direct a program around a portion of a program (that might, for instance, contain a subroutine). It is also frequently used to direct a program back to a particular starting point in a program requiring multiple execution of the same series of instructions.

### The GOSUB Statement

The GOSUB statement is similar to the GOTO statement just presented. It will cause the program to jump to a specified line number. However, before doing so, it will effectively save the value of the next line number in the program. (That is, the line number of the line that follows the line on which the GOSUB statement is found.) The line number it saves is placed on the top of a software last-in first-out stack. This process will enable the program to return to the line number following the GOSUB statement when the SUBROUTINE it is directed to has been executed. The GOSUB statement should only be used to cause a jump to another section in a program when that section has been organized as a subroutine (as will be explained in the next statement type to be discussed).

SCELBAL as presented in this publication has enough stack memory allocated to allow the program to nest up to eight subroutines at one time.

The format for the GOSUB statement is exactly the same as the GOTO statement. The statement keyword is given, followed by the line number to which the program is to jump to in order to start the execution of the desired subroutine.

### The RETURN Statement

The RETURN statement line is used to indicate the end of a group of statements that form a subroutine. When a RETURN statement is encountered, the program will return to the program line number found at the top of the last-in first-out GOSUB software stack. It will then remove that line number from the stack.

### The INPUT Statement

The INPUT statement is used when a programmer wants to have a program stop and accept data from an operator. The format for the INPUT statement is:

INPUT A

where A is the name of a variable used in the program. Inputting of data for more than one variable may be specified using a single INPUT directive by separating the names of variables by a comma:

INPUT A, B, C, D, E, .....

When the INPUT statement is encountered during the operation of a program, a question mark ("?") will be displayed and the program will wait for the operator to enter the value of the variable. When the operator has completed the input operation (signified by entering a carriage-return) the program continues operation.

The INPUT statement may be used to have an operator enter a value for a regular variable as well as an array variable (if the optional DIM capabilities are included in the program being operated). Additionally, the INPUT statement is able to perform a special function related to the inputting of alphabetical characters which will be explained in a later section. (See the section on the CHR function further on in this chapter.)

## The FOR/NEXT Statements

The FOR and NEXT statements allow the programmer to form iteration loops in a program with ease.

Essentially, the FOR statement is used to specify a range of values over which a parameter is to be varied in specific increments. Statements following the initial FOR directive may then be used to perform whatever calculations are desired as the specified variable is varied. The program statement lines that are a part of the program loop are delimited from other lines in a program by use of the NEXT statement.

Suppose, for instance, that a programmer wanted to solve a simple formula when a particular variable value was varied in unit increments from 1 to 10. The following program loop using the FOR/NEXT statements could be used:

```
100 FOR X = 1 TO 10
110 LET Z = X*X + 2X + 5
120 PRINT X,Z
130 NEXT X
```

Note that the FOR statement in line number 100 specifies the name of the variable that is to be incremented (X), and the range over which it is to be varied (1 TO 10). Also note, that when not otherwise indicated, the increment or STEP size by which the variable value will be changed each time the FOR/NEXT loop is traversed, will be ONE. That is, the IMPLIED STEP size in a FOR statement is the value 1.0!

Lines number 110 and 120 contain directives to evaluate and display the results of a calculation involving the variable that will be varied by the FOR/NEXT loop.

Line 130 contains the NEXT statement that concludes the FOR/NEXT loop. Note that the NEXT statement must be followed by the name of the variable that is incremented and referred to in the initiating FOR statement!

The format of the FOR directive may be altered to allow the programmer to change the STEP size from the IMPLIED value of 1.0 to any desired value. This is accomplished by adding the STEP directive to the FOR statement line. Thus, if one desired to modify the example program just illustrated so that it evaluated the formula in line number 110 for every odd value of X in the specified range, one would simply make line number 100 appear as:

```
100 FOR X = 1 TO 10 STEP 2
```

The reader may take note of the fact that the range specified in the FOR statement may cover both positive and negative numbers. Furthermore, the STEP size may be made a negative number so that the value of a parameter is decremented over a designated range!

FOR/NEXT loops, like subroutines (using GOSUB statements), may be nested one inside another up to a maximum of eight levels in the version of SCELBAL presented. (This nesting of FOR/NEXT loops is independent of subroutine nesting.) However, the order in which nesting occurs if important. The nesting rule is: Last-in, first-out. For instance, the following order of nesting is valid:

```
200 FOR X = 1 TO 10
 .
 .
250 FOR Z = 1 TO 5
 .
 .
290 NEXT Z
300 NEXT X
```

The nesting order below would be invalid:

```
200 FOR X = 1 TO 10
 .
 .
250 FOR Z = 1 TO 5
 .
 .
290 NEXT X
300 NEXT Z
```

The reader should study the two examples and make sure the difference between the two types of nesting is understood. Stated in different terminology, the rule says that a FOR/NEXT loop inside a FOR/NEXT loop must be COMPLETED before the outer (first) loop is referred to by its delimiting NEXT statement.

### The REMarks Statement

The REMarks statement is used to inform the interpreter that the information on the line is not connected with program execution. The REM directive should be used whenever the programmer wants to make notes that may be of interest to programmers. The information on lines containing the REM statement thus serves to document a program but has no other capability as far as program operation is concerned. During program execution the interpreter will ignore the contents of a line prefaced (after the line number) by the REM keyword.

### The END Statement

The END statement may be used to signify the end of a high level program. When the interpreter encounters an END statement it will return control to the EXECutive portion of the program. (Control will also return to the EXECutive when the interpreter reaches the last line in the USER PROGRAM BUFFER. However, there are many cases in higher level programming, such as when subroutines are used, where the last line in the program may not be the point where program operation is to be halted!)

### The Optional DIM Statement

If the system owner has elected to operate the version of SCELBAL that includes the optional capability of defining and manipulating single dimension arrays, then the DIM statement must be used to reserve space in the ARRAY VALUES TABLE for the variable values that will be associated with an array variable name.

The DIMension statement is simply used to specify how many locations are to be reserved for variable values associated with a particular array variable name.

The basic format of the DIMension statement is shown below.

```
DIM A(††)
```

where A may be any array variable name (remember, array variable names may only consist of one letter), and "††" represents an integer value in the range of 1 to 64 indicating the number of elements in the array.

Now, when the optional array handling capability is installed in SCELBAL as discussed in this publication, a special page in memory is set aside for holding the values of array elements. This page can hold the values for up to 64 elements. These 64 elements may all be referenced by one array name, or, they may be DISTRIBUTED amongst up to four array variable names. Thus, one may assign 32 elements to two array variable names (or split it 63 to 1). Or, assign 16 elements to four array variable names (or split it 56, 4, 2 and 2 if desired). It makes no difference as long as the maximum value of four array variable names, and a total of 64 elements distributed amongst all the variable names is not exceeded!

Since up to four array variable names may be assigned and DIMensioned in a program, the programmer may specify the number of elements in several arrays using a single DIM statement. This is done by separating the array defining terms in a DIM statement line by a comma as illustrated here:

```
DIM A(††),B(††),C(††),D(††)
```

Once an array variable name has been defined and space for elements reserved for it by using the DIM statement, one may refer to in-

dividual elements of the array by using the array name followed by the element number enclosed in parenthesis. An element number may be expressed as an integer digit or digits, a variable name (the variable value should represent an integer number), or a mathematical expression as long as the expression does not contain parenthesis. Thus, the format for specifying a particular element in an array might appear as:

```
A(5)
A(X)
A(X + 5)
```

Notice that while an element of an array may be referenced using a variable name, the actual process of defining how many elements are to be assigned to an array using the DIM statement must be accomplished using an actual integer number and not a variable name or mathematical expression!

Note too, that all arrays in SCELBAL are single dimension. (However, it is possible to perform calculations involving two dimensional matrices using the single dimension array capability of the language.)

## FUNCTIONS

The power of SCELBAL provided by the high level statement types just discussed is further enhanced by the availability of seven special functions that may be used in various types of statements. Additionally, SCELBAL has been provided with capability to recognize an additional function name. When this special function name is recognized by the program, it will direct program operation to an address specified by the system manager. That address would indicate the starting point of a user defined function that the reader may create using machine language programming methods.

The various types of functions provided in SCELBAL are discussed next.

### The INTeger Function

The string of characters INT immediately followed by a parenthesis containing a number (or expression) indicates the program is to calculate the INTeger value of the number or expression. The INTeger value is defined here as the greatest integer number less than or equal to the number specified. For example, the directives (remember, functions must always be part of a valid statement line):

```
INT(1.00001)
```

or

```
INT(1.5)
```

or

```
INT(1.99999)
```

would all result in the answer:

```
1.0
```

being displayed as the number 1 is the largest INTeger number that can be contained in any of the numbers expressed as the argument portion of the directives illustrated.

Remember, when dealing with negative numbers, that if the order of numbers is viewed on a scale that goes from left to right such as:

```
-5  -4  -3  -2  -1  0  +1  +2  +3  +4  +5
```

that the number minus four (-4) is greater than minus five (-5), thus the directive:

```
INT(-1.999)
```

or

```
INT(-1.001)
```

will result in the answer:

```
-2.0
```

being displayed in accordance with the definition given above for the INTeger value of a number!

### The SiGN Function

The mnemonic SGN signifies a function that will check the sign (positive or negative) of a number, variable or expression and return a simple value of +1.0 if the sign of the value is positive. It will return -1.0 if the sign of the value is negative. Zero will be returned if the value is zero.

The value to be tested (typically a variable or expression) must be enclosed in a pair of parenthesis immediately following the SGN mnemonic as illustrated in the following examples:

```
SGN(R1)
```

or

```
SGN(X*2 + 4*X - 16)
```

### The ABSolute Function

The ABSolute function simply returns the magnitude of the number, variable or expression that is enclosed in parenthesis immediately following the mnemonic, without regard to the sign of the value. Thus, the directives:

```
ABS(+8423)
```

and

```
ABS(-8423)
```

would result in the value:

```
8423
```

being returned when the function was executed.

### The SQuare Root Function

This function simply returns the square root of the value that follows the SQR mnemonic. As with the other functions, the value or argument portion of the function must be enclosed in parenthesis. The argument of the function may be a number, a variable, or an expression. However, it must be greater than or equal to zero. Attempting to obtain the square root of a value less than zero will result in an error message being displayed. (A good way to avoid such error messages, suitable in a good many applications, is to take the SQuare Root of an ABSolute value!) Remember, the value from which the square root will be extracted must be enclosed in parenthesis immediately following the function mnemonic as in the example:

```
SQR(49)
```

The result returned for the example would, of course, be the number 7.

### The RaNDom Number Function

The following directive:

```
RND(0)
```

will result in a semi-psuedo-random number being generated in the range from zero to one. The random number obtained may be further manipulated to place it in a range suitable to the user. For instance, if the user desired to generate an integer value in the range 0 to 9 using the random number function, the expression:

```
INT(RND(0)*10)
```

could be used.

NOTE: All functions defined for the high level language SCELBAL require that the function mnemonic be followed by an argument enclosed in parenthesis. Following the RND mnemonic by "(0)" serves merely to satisfy this requirement and has no other significance.

The RaNDom function provided in the language has many applications in programs involving games and in simple statistical analysis. However, the version provided in this publication should not be considered as completely unbiased nor used in applications requiring strict scientific randomness.

### The CHaRacter Function

The mnemonic CHR followed by a number, variable, or expression enclosed in parenthesis, when the value is within the range of those used in the ASCII code set, may be used to display the alphanumeric character that corresponds to the value. Thus, for instance, the directive:

```
CHR(193)
```

contained within a PRINT statement line, or the directive:

```
CHR(X)
```

in such a statement line, when X was equal in value to 193, would result in the character:

```
A
```

being displayed on the system's output device.

NOTE that the CHR function is intended only for use within a PRINT statement line!

A list of the decimal values that correspond to a subset of ASCII characters that SCELBAL is designed to operate with may be obtained by running a sample illustrative program provided later in this chapter.

The CHR function, as just described, allows the programmer to present numerical values as alphanumeric characters. There is a reverse function available in SCELBAL that allows the programmer to have alphanumeric characters which are being inputted using an INPUT statement converted to decimal numeric values corresponding to their ASCII code! The reverse function is specified by following a variable name in an INPUT statement by a dollar ("$") sign. Thus, the following directive in an INPUT statement:

```
X$
```

would indicate that the variable value assigned to X would be the decimal ASCII value for whatever character was entered by the operator when the directive was executed. Thus, if the operator entered the letter:

```
A
```

when the INPUT statement was executed and the program paused for the operator's response, then the value:

```
193
```

would be assigned to the variable name X as that is the decimal representation for the ASCII code that represents the letter A!

When the dollar sign follows the name of a variable in an INPUT statement, meaning that the special conversion function is to be performed upon whatever character is entered, the program will not print a question mark ("?") as it does for a regular variable entry. Instead, the program will simply wait for the operator to enter a character. Furthermore, once a character has been entered, the program will automatically continue operation. It is not necessary to enter a carriage return following the alphanumeric entry as is the case when one desires to terminate a purely numeric entry. This operation, the reader will discover, makes it possible to develop programs whereby the operator may respond with alphanumeric strings as will be illustrated in one of the sample programs in this chapter.

### The TAB Function

The TAB function is also restricted to use only within a PRINT statement. The purpose of this function is quite simple. It permits the programmer to direct that the output device move over (tab) to a specified column number. The column number to which the display device is to move is simply the number that is enclosed in parenthesis immediately following the TAB mnemonic. For in-

stance, if a PRINT statement line contained the directive:

TAB(40)

then the display device would tab over to the fortieth position in the line it was currently on.

There are several powerful features that the programmer will want to remember regarding the TAB function. First, the argument of the function may be specified as a variable value or expression involving variable values. Second, the TAB function can effectively simulate backspacing in the event the column specified has already been passed by the display device. These features make the TAB function valuable for displaying data using graphic techniques. A sample program in this chapter will illustrate the use of the TAB function for such purposes.

### The User DeFined Function

The use of the mnemonic UDF followed by an argument enclosed in parenthesis will cause the program to go to an address specified by the system programmer. That address should be the starting location for a user defined function which has been implemented on the system using machine language programming techniques. If the user does not elect to provide such a function, the use of the mnemonic UDF should be avoided by the high level language programmer. (Users who desire to implement a user defined function should refer to the appropriate chapter which presents the source listing for the FUNCTION subroutines.)

## MORE EXECUTIVE COMMANDS

At the beginning of this chapter, the reader was introduced to the executive SCRatch command which is used to clear out the user program buffer and effectively initialize SCELBAL in preparation for creating a new stored program.

A program may be built up and stored in the user program buffer by simply preceeding statement lines with a line number. Remember, if a statement does not have a line number, it will be immediately executed. Line numbers may be any whole number from 1 to 999999.

Lines preceeded by a line number are placed in the area in memory designated as the user program buffer area according to the value of their line number. If a line number is less than any previous line numbers stored in the program buffer, then the line will be placed as the first entry in the buffer. If it is greater than any already present in the buffer, the line will be appended as the last entry in the buffer. If it is between line numbers already in the storage area, then the line will be inserted in the proper position within the buffer. If the same line number is used again, and the line contains a statement keyword, then the new line will replace the previous line having that number in the buffer.

To remove a line from the user program buffer, simply type the line number by itself! The program will acknowledge the effective delete command by responding with the message:

READY

At any time that the operator is entering information when SCELBAL is in the EXECutive mode, a typographical error may be deleted by depressing the RUBOUT key. Each time the RUBOUT key is depressed, a backslash character will be displayed and the last character entered will be effectively erased. Striking the rubout key several times will effectively erase several characters. Thus, the entry:

100 LET X = 12345\\\

(with the backslash ("\") signs indicating the repeated use of the rubout key), would result in the program accepting the statement:

100 LET X = 12

as the digits 3, 4 and 5 would have been effectively deleted by the three rubout characters.

### The LIST Command

Whenever the operator desires to review the contents of the user program buffer (when the program is in the executive command mode) the word LIST followed by a carriage return should be entered. The LIST command will cause all the lines in the user program buffer to be listed for review purposes.

### The RUN Command

When it is desired to execute a program that has been created and stored in the user program buffer, the executive command RUN must be issued.

When the RUN command is recognized SCELBAL will proceed to the first line in the user program buffer and commence interpreting the program. SCELBAL will remain in the stored program operating mode until one of the following occurs:

1. An END statement is encountered.

2. SCELBAL runs out of program lines while executing a program (such as may occur if a programmer fails to terminate a program with an END statement).

3. A program error condition is detected.

When any of the above conditions occur, the interpreter ceases operation and control is returned to the executive control routine.

### The SAVE Command

The executive SAVE command is used to transfer the contents of the user program buffer to a bulk storage device such as a magnetic tape system. Thus, once high level language programs have been created they may be permanently saved for quick and easy loading back into the computer.

The system operator should check with the person who implements SCELBAL on the individual system in regards to the details of I/O operations when the SAVE command is utilized. This is because the SAVE command simply directs the program to go to a user provided I/O handling routine to perform the necessary transfer operations with the bulk storage device.

If the system does not have a bulk storage device available then the SAVE command should not be issued by the operator.

If the system does not have a bulk storage device available then the LOAD command should not be issued by the operator.

### The LOAD Command

The LOAD command is used to transfer a higher level program, previously stored on a bulk storage device using the SAVE command, back into the user program buffer so that it may be executed. Once again, the system operator should check with the person who implements SCELBAL on the system in regards to the details of I/O operations when the LOAD command is utilized. This is because the LOAD command simply directs the program to a user provided I/O routine.

## ERROR MESSAGES

SCELBAL has been provided with the capability to detect many types of syntax error conditions as well as various types of operating error conditions. When such error conditions are detected, program execution will be halted and an error message will be displayed. If an error is detected when the program is in the executive mode, such as when lines are being entered into the user program buffer, or SCELBAL is being used in the calculator mode, then a simple two letter error code will be issued. When an error is de-

tected while a stored program is being executed, the two letter error code will be followed by a message indicating the line number that was being interpreted when the error was detected.

A list of the error codes used to indicate the various types of errors that SCELBAL can detect, arranged in alphabetical order is presented below. The condition(s) associated with each type of error code is also listed.

| ERROR CODE | ERROR CONDITION |
|---|---|
| AF | Array Format error. An array element is missing a right hand parenthesis. |
| BG | BiG error. An input is too big for a buffer. Used to indicate when user program buffer is filled (line causing overflow of the user program buffer will not be accepted). Also issued if too many characters placed on a line, or variables table filled. |
| DE | Dimension Error. A DIMension statement line is invalid. |
| DZ | Divide by Zero error. A calculation involving division by zero was encountered. |
| FE | For Error condition. The "=" sign is missing in a FOR statement. |
| FN | For/Next error. Invalid FOR statement or improper nesting of FOR/NEXT statements. |
| FX | FiX error. An attempt was made to integerize a number that cannot be displayed as fixed point. |
| GS | GoSub error. More than eight levels of subroutine nesting attempted in a program. |
| IF | IF error. An IF statement does not contain a GOTO or THEN directive. |
| IN | Illegal Number. A number string is invalid, such as: 1..23X45. |
| IQ | Imbalanced Quotes. The type of quotation mark used to commence a text string in a PRINT statement is different from the one used to terminate the string. For example: PRINT "HI'. |
| I( | Imbalanced Parenthesis error condition. |
| LE | Let Error condition. A LET statement does not contain an equal ("=") sign. |
| OR | Out of Range. The number indicated for an array element is not in the range allowed for the array variables storage table. |

| ERROR CODE | ERROR CONDITION |
|---|---|
| RT | ReTurn error. A RETURN statement occurred when a subroutine had not been called (by a GOSUB statement). |
| SQ | SQuare root error. A calculation involving taking the square root of a negative number was encountered. |
| SY | SYntax error. Issued for the use of incorrect keywords or invalid commands. |
| UN | UNdefined line number such as using a GOTO or GOSUB statement keyword and not following it with a line number, or referencing a line number that does not exist in a program. |

### Use of CONTROL/'C'

At times an operator may desire to terminate the operation of a program without having to wait for an END statement to be encountered. If the program includes any INPUT statements, such a program may be terminated at any time that the program is expecting to receive an input from an operator. This is accomplished by the operator simultaneously depressing the CONTROL key and the key for the letter C on the keyboard input device. When this occurs, the program will cease performing the operations dictated by the high level program and go back to the EXECutive mode. As it does this it will display the message:

↑ C AT LINE LL

where LL stands for the line number being processed when the program was aborted.

## ILLUSTRATIVE SCELBAL PROGRAMS

The remainder of this chapter will be devoted to presenting a series of high level programs written in SCELBAL language. As the example programs are presented, brief discussions will highlight points of interest to the prospective SCELBAL programmer.

The first such sample program illustrates the use of the PRINT, INPUT, LET, GOSUB, RETURN and GOTO statements while demonstrating how a small higher language subroutine may be used in place of "extended functions" in a language. The program is one that will calculate the SINE of an angle entered in degrees (when in the range: greater than zero, on up to 90 degrees).

The reader may note that the PRINT statement in line 05 is terminated by a semicolon sign so that a carriage return and line feed combination will NOT be issued after the text message is displayed. Line 20 in the program illustrates the use of a subroutine which starts at line 50 and is terminated by the RETURN statement at line 60. (While it was not necessary to establish a subroutine for this example, and in fact was wasteful of program storage space to do so, the subroutine was presented to illustrate the technique as well as provide the reader with a useful function. The instructions contained in lines 50, 55 and 60 calculate the sine of an angle when the angle is expressed in degrees (the variable value D) using a Taylor series expansion formula. The subroutine should be of value to many readers!)

```
LIST
05 PRINT "ENTER NUMBER OF DEGREES:";
10 INPUT D
20 GOSUB 50
25 PRINT 'THE SINE OF';D;" DEGREES IS EQUAL TO:";SN
30 PRINT
35 GOTO 05
50 LET X = D/57.296
55 LET SN = X - ((X↑3)/(2*3)) + ((X↑5)/(2*3*4*5)) - ((X↑7)/(2*3*4*5*6*7))
60 RETURN


RUN
ENTER NUMBER OF DEGREES:?30
THE SINE OF 30.0 DEGREES IS EQUAL TO: 0.4999980

ENTER NUMBER OF DEGREES:?60
THE SINE OF 60.0 DEGREES IS EQUAL TO: 0.8660190

ENTER NUMBER OF DEGREES:?45
THE SINE OF 45.0 DEGREES IS EQUAL TO: 0.7071040

ENTER NUMBER OF DEGREES:?↑C AT LINE 10
```

The illustration above shows the example program being listed after the executive LIST command was issued. Next, several examples of the program's operation are shown (with program execution being initiated by the operator entering the executive RUN command). The reader should take note of how the PRINT statements used quotation marks and semicolons to obtain the desired formatting of the messages that appear when the program is executed. (Operator inputs during program operation are underlined in the above and following examples.)

The values shown are the actual values that SCELBAL produces. Note, for instance that the answer given for the sine of 30 degrees is quite close to the theoretical value (0.5). The margin of error is attributable to the precision obtainable when using 23 binary bits in calculations, the fact that the number of degrees per radian (line 50) was approximated in the above formula, and that only four terms were used in the expansion formula. Most users should find the degree of accuracy quite suitable for routine calculations.

The last line in the above example illustrates the use of the "CONTROL/C" combination by the operator to terminate the program. Remember, this special directive can be issued whenever a program expects an input from an operator. (Note that the program forms an endless loop and will simply keep asking the operator for new data as long as it is running.)

Prefer to obtain the cosine of a number rather than the sine? Just change line 55 in the above example to read;

```
55 LET CS = 1 - ((X↑2)/(2)) + ((X↑4)/(2*3*4)) - ((X↑6)/(2*3*4*5*6))
```

Changing line 55 to the formula just presented will change lines 50 through 60 to a subroutine for calculating the cosine of an angle in the range zero to ninety degrees. (If one wants to use the same type of program to obtain cosine values, just change line 25 so that the last variable is CS instead of SN!)

The next program to be presented will illustrate the use of another type of statement and the use of a function directive. The statement type to be illustrated is the IF statement. The function demonstrated is the INTeger function.

The program, shown below along with several examples of output from the program when it is in operation, may be used to obtain the lowest common factor between two integer numbers.

```
LIST
10 INPUT A,B
40 X1 = A
50 IF A>B GOTO 80
60 X1 = B
70 B = A
80 X2 = B
90 X3 = X2
100 X2 = INT(X2*(X1/X2 - INT(X1/X2)))
110 X1 = X3
120 IF X2<>0 GOTO 90
130 PRINT 'THE GCF IS';X1
140 GOTO 10


RUN
?20
?40
THE GCF IS 20.0
?112
?1143
THE GCF IS 1.0
?32
?64
THE GCF IS 32.0
```

First, the reader might take note of the use of the IMPLIED LET statements in lines numbered: 40, 60, 70, 80, 90, 100 and 110. The IMPLIED LET statements are simply LET statements without the LET keyword actually having to be stated. They simply save the programmer a little less work when entering programs.

Lines 50 and 120 illustrate the use of the IF statement. In line 50 a single condition (IF A is greater than B) is specified. If the condition is satisfied when the program is executed, then the GOTO directive at the end of the line is followed. The GOTO 80 directive, when executed, causes the program to effectively skip program lines 60 and 70. If the condition is not met, then the above program continues directly on to execute statement lines 60 and 70. The IF statement in line 120

illustrates a double condition specification. That is, IF the value of X2 is less than OR greater than zero, then the GOTO 90 directive is followed. The satisfaction of either of those conditions results in the program effectively looping back to line 90. Otherwise, the program continues on to line 130.

(NOTE: Line 120 in the program being discussed could have been stated as:

120 IF X2 = 0 GOTO 130

provided that another line had been inserted between line 120 and line 130 such as:

125 GOTO 90

When dealing with pure integer values, as is the case in this example with the INTeger function being used, such a test is perfectly sound programming practice. However, in other situations, the use of "less than" or "greater than" tests are generally preferable. This is because the "exactly equal" test may not occur in many situations (even though the programmer may know that theoretically they do occur) due to the small inaccuracies that are often introduced into binary calculations that involve non-ending series of digits that must be limited (rounded) to a finite number of bits. The situation is analogous to dividing the decimal number one by three (yielding .3333333.....), then multiplying by three yielding .99999....., when theoretically the result would be the original value of one! A machine perfoming the calculation and then testing for the theoretical one condition would not find the theoretical result. Thus, the SCELBAL programmer will be wise to limit the use of the exactly equal test in IF statements to calculations involving simple integer quantities!)

Line number 100 in the program illustrates the use of the INTeger function. In fact, the reader may observe that it is permissable to specify a function within a function as in the example statement line.

Finally, line 10 in the program illustrates how more than one input may be requested in an INPUT statement line by separating the names of variable values to be inputted by a comma sign.

The results of the program being operated is illustrated following the program listing.

Earlier in this chapter a discussion of the use of the CHR (character) function was presented. It was pointed out that this function could be used when it was desired to output alphanumeric characters using their decimal ASCII encoded values. A reverse capability, that of converting alphanumeric characters received as inputs into their decimal ASCII encoded equivalents was also mentioned. This capability is implemented by following variable names specified in INPUT statements by a dollar ("$") sign.

The following program serves to demonstrate the use of the CHR function. While doing so, it will generate a list of the decimal and octal values of the ASCII code for a subset of commonly used alphanumeric characters. This list may then be used for reference purposes by SCELBAL programmers. Additionally, the program illustrates the practical application of the FOR and NEXT statements to form a program loop.

Line number 100 in the program (presented on the next page) is used to establish the start of a FOR/NEXT loop. The loop is set up by initializing a variable named N to a decimal value of 160. Since no specific STEP size is indicated in the FOR statement, the program assumes an IMPLIED STEP value of one. The FOR line also indicates that the FOR/NEXT loop is to be terminated after the value of N reaches 223.

Line number 160 contains the NEXT N statement which marks the end of the FOR/NEXT loop connected with the variable N. When this statement is reached, the program will loop back to the original FOR statement.

Line number 170, the next statement line

after the NEXT N statement, is the line to which program operation will be transferred once the value of N exceeds the TO value of 223 indicated in the FOR statement line. The line contains an END statement to indicate to the interpreter that execution of the high level program may be halted and control passed back to the executive. Had line number 160 been the last line in the program, the interpreter would still have ceased operation and returned control to the executive. However, the use of the END statement might be considered better programming practice in such a situation.

The program is presented below. The reader may enter and RUN the program to obtain a list of the data it generates for reference purposes. The output from the program will not be duplicated here.

```
10 PRINT
20 PRINT
30 PRINT 'TABLE OF ASCII CHARACTERS'
40 PRINT
50 PRINT ' CHAR OCTAL DECIMAL'
100 FOR N = 160 TO 223
110 Q1 = INT(N/64)
120 Q2 = INT((N - 64*Q1)/8)
130 Q3 = INT(N - 64*Q1 - Q2)
140 PRINT '     ';CHR(N);'      ';CHR(176 + Q1);CHR(176 + Q2);CHR(176 + Q3);
150 PRINT '     ';N
160 NEXT N
170 END
```

Just about anyone who has a computer system likes to have a game program that will run on the machine. If not for the system owner to play with, at least such a program may be used to amuse those that might not have the deep appreciation for the machine that most readers of this publication undoubtably possess. It would be impolite to say the least, if this publication did not contain some such program written in SCELBAL.

The program on the next page is a game program, which, while it may be used for amusement purposes, will ostensibly be presented to demonstrate the use of the RND (random number generating) function and a few other SCELBAL programming points which will be mentioned in the following discussion.

The only new directive used (in the sense of not having been used in previous sample programs) is the RND function contained in line number 90. Note that this is a case where the random number (generated in the range from zero to one) is immediately multiplied to put it in another range (by multiplying by seven). Note too, that the RND mnemonic must be followed by a pair of parenthesis (enclosing the zero) to identify it to the interpreter as a function! Additionally, the reader may observe that the RND function is contained as part of an expression for another function (the INT directive), which, as pointed out previously, is perfectly valid when using SCELBAL.

The reader has already been introduced to the practical applications of the other types of statements and directives contained in the game program. However, since a few new "twists" are utilized, the following tech-

niques will be pointed out.

Lines 15, 16, 22, 24 and several other IF statements illustrate the use of entire mathematical expressions as test values (instead of just a simple variable name).

Line 20 (and later line 26) establishes a subroutine at line 80 which in turn calls another subroutine at line 90. This is an example of the use of nested subroutines in a program. Remember, this nesting process can be carried up to eight levels if required.

What does the game play? Dice. Be careful! People have reported difficulty in getting computers to pay off after players have had winning streaks!

```
05 LET S = 0
10 PRINT
11 PRINT 'BET';
12 INPUT A
13 PRINT
14 IF A<1 GOTO 50
15 IF (A - 1000)>0 GOTO 50
16 IF (A - INT(A))<>0 GOTO 50
20 GOSUB 80
21 LET X = R
22 IF (R - 7)*(R - 11) = 0 GOTO 60
24 IF (R - 2)*(R - 3) = 3 GOTO 70
26 GOSUB 80
30 IF (R - 7) = 0 GOTO 70
32 IF (X - R) = 0 GOTO 60
40 GOTO 26
50 PRINT 'ILLEGAL BET!'
52 GOTO 10
60 PRINT 'YOU WIN! ';
62 LET S = S + A
64 GOTO 74
70 PRINT 'YOU LOSE. ';
72 LET S = S - A
74 PRINT ' YOUR WINNINGS ARE: ';S
76 GOTO 10
80 GOSUB 90
81 PRINT ' X';
82 LET D1 = R
84 GOSUB 90
85 PRINT
86 LET R = R + D1
88 RETURN
90 LET R = (INT(RND(0)*7))
92 IF R>6 GOTO 90
94 IF R<1 GOTO 90
96 PRINT R;
98 RETURN
```

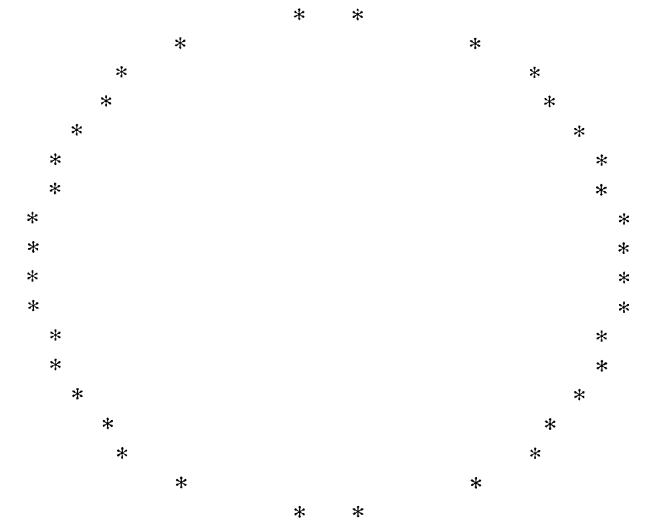
The next example program to be presented was chosen primarily to illustrate the use of the TAB function in a PRINT statement. The program uses the TAB function to plot the points on a circle. The line containing the TAB directives in the program is number 60.

Several other points of interest in the program include the use of the comma sign in line 21 to implement a standard tabbing operation (causes the display device to space over to the next column number that is a multiple of sixteen), the use of a FOR/NEXT loop with the variable value ranging from a negative value to a positive value (line 30) and the use of the SQR function in line 40.

The program followed by a sample of its output is shown below.

```
10 PRINT 'RADIUS';
15 INPUT R
16 K = 1.6
20 R2 = R↑2
21 PRINT 'AREA =';3.14159*R2,'CIRCUM =';3.14159*2*R
22 PRINT
23 PRINT
25 K1 = K*R
30 FOR X = -R TO R + 0.1
40 Y = K*SQR(R2 - X↑2)
50 PRINT TAB(2.5 + K1 - Y);'*';TAB(5.5 + K1 + Y);'*'
60 NEXT X
70 END
```

```
RUN
RADIUS?10
AREA = 314.1592                    CIRCUM = 62.83185
```



The example programs presented to this point in the chapter can all be executed in a version of SCELBAL implemented in a minimum configuration (8 K of memory without the optional array handling routines).

The remaining example programs in this chapter utilize the optional array handling capabilities of SCELBAL. The next two programs could actually be run in an 8 K version of SCELBAL that had the DIMension and array handling routines installed. (In this configuration, the user program buffer would only have 512 bytes available for program storage. As mentioned in an earlier chapter this implementation is not recommended because of the small storage space it leaves for user programs). The final program in this chapter would require more than a minimum system configuration. (The configuration assumed for the assembled listings of the program with array handling routines presented in this book would be more than sufficient.) It requires that the user program buffer have about 1000 bytes available when the array handling routines (and array values table storage area) are installed. Thus, about a 9 K system would be required, as a minimum, to execute the final example program. However, even if one does not have the capability at present to try the program (or any desire to use it, for that matter), one may desire to examine the listing. That is because the program will illustrate how single dimension array handling capability can be utilized to solve problems typically processed using two dimensional array techniques!

The first sample program involving an array is presented on the next page. It is a program that will calculate the mean and standard deviation values after receiving a number of inputs. The important feature of this program is that it shows how the array feature may be used to effectively increase the number of variable values that may be stored and manipulated by a program. Instead of having to use a new variable name for each value, one may simply assign the value to a position (element) in an array that has one name, with elements in the named array being identified by a subscript (number).

Noting the following items in the listing of the example program should prove valuable for the novice programmer who is not familiar with the use of arrays.

Line 10 is the all important DIMensioning statement. The DIMension statement must be given in a SCELBAL program before any attempt is made to reference an array element. The DIMension statement in the example creates an array having the name A and provides for up to 64 elements to be assigned to this array name. (Remember, that is the maximum number of elements that may be assigned amongst all arrays in a SCELBAL program.)

Line number 70 in the program illustrates how the element of an array may be referenced. Note particularly that here it is permissible to use a variable name as a subscript. (It is not permissible to use a variable name when setting up the size of an array using the DIMension statement!)

Lines 80 and 130 illustrate the subscripted variable A(J) being used as part of a mathematical expression just as a regular variable value may be used. In these cases, the value for A(J) will be the value currently existing for the J'th element of the array named A. (The subscript number J, indicating which element in the array is being referenced, is determined by the FOR statement in line 50 or 120. The FOR/NEXT loops, the reader may observe, will step the number for J from a value of 1 to N, where N is the number of values to be entered by the operator.)

The reader may observe that the program uses an array in which to store values as they are inputted by the operator until all the data has been inputted. Then, all the data stored in the array is processed to obtain the desired information. An example of the program being used to calculate the mean score and standard deviation for a group of hypothetical test scores is illustrated following the program listing.

```
10 DIM A(64)
20 PRINT 'NR OF SCORES';
30 INPUT N
40 S = 0.0
50 FOR J = 1.0 TO N
60 PRINT 'SCORE NR.';J;
70 INPUT A(J)
80 S = S + A(J)
90 NEXT J
100 M = S/N
110 D = 0.0
120 FOR J = 1.0 TO N
130 D = D + (M - A(J)) ↑ 2
140 NEXT J
150 PRINT 'M =';M
160 PRINT 'SD =';SQR(D/N)
170 END
```

```
RUN
NR OF SCORES?20
SCORE NR. 1.0?100
SCORE NR. 2.0?76
SCORE NR. 3.0?32
SCORE NR. 4.0?89
SCORE NR. 5.0?72
SCORE NR. 6.0?33
SCORE NR. 7.0?75
SCORE NR. 8.0?76
SCORE NR. 9.0?84
SCORE NR. 10.0?83
SCORE NR. 11.0?16
SCORE NR. 12.0?95
SCORE NR. 13.0?91
SCORE NR. 14.0?55
SCORE NR. 15.0?55
SCORE NR. 16.0?78
SCORE NR. 17.0?70
SCORE NR. 18.0?68
SCORE NR. 19.0?64
SCORE NR. 20.0?88
M = 70.0
SD = 21.67948
```

The next program is a program to demonstrate how the CHR function may be used with arrays to handle the processing of very simple text strings. The technique to be illustrated can be quite useful if one wants to have a program perform an operation such as reading in a name and later displaying it back to the operator. (Note that this capability is quite different from displaying a message previously stored by the programmer!)

Line number 01 in the program contains the DIMension statement, which in this case assigns all 64 array element storage locations to the array named L.

Line 03 contains an INPUT statement that specifies an array element in which the value of the variable to be inputted is to be stored. Following the variable name by a dollar sign ("$") means that the character that is entered by the operator will be converted to its decimal ASCII representation.

The instructions in lines 03 through 07 form a program loop that operates to accept characters and store their decimal ASCII values in elements of the array. The process will continue until 64 characters have been received or the operator enters a carriage return on the input device. (The test in line 04 will identify the inputting of a carriage return!)

Once a character string has been inputted the balance of the program will cause the string to be outputted. Line 12 using the CHR function will output the characters by converting the decimal ASCII values stored in the array to alphanumeric characters.

The example is an extremely simple case, but it demonstrates the capability. Naturally, one may manipulate several smaller text strings within a program by assigning several array variable names and splitting the available storage locations up among the several arrays.

The program listing and a sample of its operation is provided below.

```
01 DIM L(64)
02 LET X = 1
03 INPUT L(X)$
04 IF L(X) = 141 GOTO 10
05 LET X = X + 1
06 IF X>64 GOTO 10
07 GOTO 03
10 PRINT
11 LET X = 1
12 PRINT CHR(L(X));
13 IF L(X) = 141 GOTO 20
14 LET X = X + 1
15 GOTO 12
20 PRINT
30 END
```

```
RUN
ABCDEFGHIJKLMNOPQRSTUVWXYZ 1234567890
ABCDEFGHIJKLMNOPQRSTUVWXYZ 1234567890
```

The final SCELBAL example program to be illustrated is a program that will solve simultaneous equations. The program is presented primarily to demonstrate how the optional single dimension array handling capability may be utilized to solve problems commonly written using two dimensional arrays. The trick, of course, is to manipulate

```
10 DIM A(64)
20 PRINT
40 PRINT 'NO OF EQUATIONS';
50 INPUT N
55 PRINT
60 N2 = N + 1
80 FOR R = 1 TO N
90 FOR C = 1 TO N + 1
100 INPUT A(N2*R - N2 + C)
110 NEXT C
115 PRINT
120 NEXT R
130 PRINT
140 FOR I = 1 TO N
141 FOR J = 1 TO N2
142 PRINT A(N2*I - N2 + J),
143 NEXT J
144 PRINT
145 NEXT I
150 PRINT
160 FOR P = 1 TO N
170 IF A(N2*P - N2 + P) = 0 GOTO 470
190 M = 1/A(N2*P - N2 + P)
200 FOR C = 1 TO N2
210 A(N2*P - N2 + C) = A(N2*P - N2 + C)*M
220 NEXT C
240 FOR R = 1 TO N
250 IF P = R GOTO 380
260 FOR C = N + 1 TO 1 STEP - 1
270 A(N2*R - N2 + C) = A(N2*R - N2 + C) - A(N2*P - N2 + C)*A(N2*R -N2 + P)
280 NEXT C
290 FOR I = 1 TO N
300 FOR J = 1 TO N2
310 PRINT A(N2*I - N2 + J),
320 NEXT J
330 PRINT
340 NEXT I
360 PRINT
380 NEXT R
390 NEXT P
410 FOR R = 1 TO N
420 PRINT A(N2*R - N2 + N + 1)
430 NEXT R
440 END
470 IF P = N GOTO 620
480 X = P
490 FOR R = X + 1 TO N
495 R1 = R
500 IF A(N2*R - N2 + X) <> 0 THEN R = N
520 NEXT R
522 IF A(N2*R1 - N2 + X) = 0 GOTO 620
```

```
530 FOR C = 1 TO N + 1
540 A(N2*N + C) = A(N2*X - N2 + C)
550 A(N2*X - N2 + C) = A(N2*R1 - N2 + C)
560 A(N2*R1 - N2 + C) = A(N2*N + C)
570 NEXT C
580 GOTO 190
620 PRINT 'SINGULAR MATRIX'
630 END
```

the data in the one dimensional array in a manner that simulates having a two dimensional array storage area. This is easy to do with SCELBAL because elements in an array may be identified by using a mathematical expression containing one or more regular variables (as long as no additional parenthesis are required in the expression other than the pair that identify the expression as the subscript of an array name).

Line 100 in the program illustrates how elements in a single dimension array can be mathematically assigned to sections within the array. If those sections were then viewed as being side-by-side, one would effectively obtain a two dimensional array. The formula in the subscript for the array named A in the program, given in line 100, is:

N2*R - N2 + C

By examining lines 60, 80 and 90 in the program, the reader may observe that the regular variable R referred to in the expression will be incremented from a value of 1 to a value of N. (N represents the number of variables/equations to be solved. Taking a two dimensional view, this number would represent the number of entries along the Y axis of a two dimensional matrix.) The variable C will advance from a value of 1 to a value of N + 1. (This represents the number of entries along the X axis if a two dimensional view is considered.) The FOR/NEXT loops established in lines 80 and 90 will cause the value of C to be incremented through its range for each value of R. If one takes for instance, a value of 3 for N and solves the formula for all the possible values as R and C are advanced through their ranges one would obtain a range of values that could be arranged in a two dimensional table as illustrated here:

| | C = 1 | C = 2 | C = 3 | C = 4 |
|---|---|---|---|---|
| R = 1 | (1) | (2) | (3) | (4) |
| R = 2 | (5) | (6) | (7) | (8) |
| R = 3 | (9) | (10) | (11) | (12) |

This table illustrates how a formula for the subscript (element) of a single dimension array may be implemented to effectively create a two dimensional array pattern. This is the technique used in the program for solving simultaneous equations.

The program presented can handle equations with up to 7 unknowns. (An equation with 7 unknowns requires 56 (7 times 8) entries in a matrix. Remember, there are only 64 array elements available. Thus, an equation with 8 unknowns, which would require the storage of 72 (8 times 9) elements, would not fit in the available array storage area.)

Another point of interest in the program is the use of nested FOR/NEXT statements at several points. Note how the inner-most FOR statement is terminated by its corresponding NEXT statement before an earlier FOR statement may be closed. (See, for example, lines 80 and 90, then 110 and 120.)

Finally, notice in line number 260 the use of the STEP directive in the FOR statement line, and how the step directive may be used to decrement a value over a range going from high to low just as easily as one may use it to increment a value over a range.

```
RUN

NO OF EQUATIONS?3

?1
?1
?1
?6

?3
?- 2
?1
?2

?10
?6
?- 3
?13


1.0             1.0             1.0             6.0
3.0             - 2.0           1.0             2.0
10.0            6.0             - 3.0           13.0

1.0             1.0             1.0             6.0
0               - 5.0           - 2.0           - 16.0
10.0            6.0             - 3.0           13.0

1.0             1.0             1.0             6.0
0               - 5.0           - 2.0           - 16.0
0               - 4.0           - 13.0          - 47.0

1.0             0               0.5999999       2.8
0               1.0             0.3999999       3.199999
0               - 4.0           - 13.0          - 47.0

1.0             0               0.5999999       2.8
0               1.0             0.3999999       3.199999
0               0               - 11.4          - 34.2

1.0             0               0               1.0
0               1.0             0.3999999       3.199999
0               0               1.0             3.0

1.0             0               0               1.0
0               1.0             0               1.999999
0               0               1.0             3.0

1.0
1.999999
3.0
```

The preceeding page shows a sample of the output from the program when it is given the task of solving for the unknowns in the three equations:

$$X + Y + Z = 6$$
$$3X - 2Y + Z = 2$$
$$10X + 6Y - 3Z = 13$$

Readers should now have a pretty good grasp of how to use SCELBAL. At this point the process of creating programs will be left to the individual user. Between the examples, explanations, and error messages table presented in this chapter, the reader who gets down to practical experience should have little difficulty in learning how to enjoy SCELBAL.

# SUGGESTIONS FOR PROGRAM TINKERERS

The whole purpose of presenting the program SCELBAL in the form of this publication was so that readers could acquire the knowledge that would give them the freedom to modify and adapt the program to meet their individual requirements. It is fully expected that many readers will want to take advantage of this aspect. The purpose of this final chapter is to provide some assistance and suggestions to those readers who contemplate modifying the program.

Perhaps one of the first aspects of the program that a user might have need to alter is the storage area assigned to the user program buffer. In the assembled version of SCELBAL presented (for a 12 K system with the optional array capability installed) the buffer is assigned memory locations starting at address page 33 location 000 and extending up to page 54 location 377. The most common alteration to this buffer size will undoubtably be simply to reduce or extend the upper limit depending on the amount of memory available in the user's system and whether the optional array routines are installed in the upper portion (3 pages) of available memory. Changing the upper limit of the user program buffer only requires changing one location. In the assembled listing provided the address of this location is at page 12 location 222. This is the address of the second byte in a CPI instruction in the INSERT routine that checks to see if adding a line to the user program buffer will cause it to overflow. This byte should contain the page value of the highest page in memory that is to be allocatted to the buffer! Thus, if a user only has an 8 K system, this location should contain a value of 037 (page 37), assuming that the optional array routines were not included. If they were included, one would need to reduce this value to 034. If one had, say, a 10 K system; and intended to install the array handling routines on pages 45 and 46 (reserving page 47 for the array values table), then the limit value in the CPI instruction at the address indicated would simply be 044. (Remember, the buffer will use the locations on the page specified as the upper limit, the limit specifies that the buffer is not to extend beyond that page!)

Since changing the upper limit of the user program instruction only requires altering one byte in the entire SCELBAL program, one may see that it is easiest to make additions to the program by placing routines in the area originally assigned to be the highest address region of the user program buffer and then simply lower the buffer size by changing the indicated location. Thus, for instance, a user who might not be able to place the I/O routines required by the program on page 00 as suggested in the chapter on I/O operations, might place them on page 37 (in an 8 K system without arrays) and change the buffer limit value to page 36. Or, a user that wanted to append a lengthy machine language routine that was executed as part of a user defined function, would probably find it easiest to place the new routine in the highest locations available for the buffer and then lower the buffer limit value as required.

Of course, there may be instances when the user desires to change the lower boundaries of the user program buffer area. Doing so, however, requires altering considerably more than a single location in the program. Altering this limit requires changing the data in the following addresses (as they appear in the assembled listing provided):

10 332
11 017
11 051
11 132
11 173
13 107
15 255

All of the above locations would have to be changed from their original values of 033 to whatever value represented the page number at which the programmer desired the user program buffer to start.

Another type of alteration that some readers may wish to implement actually is related to the user provided I/O routines. This has to do with processing and displaying relatively short lines such as may be required by some CRT and TV display systems. Such systems often are limited to 32 or 40 characters to a line. While many users might not be concerned with having such short lines, and would be content with simply writing all SCELBAL programs in forms that did not exceed this limitation, some users might be hampered by such a limitation. (While all statement types and commands can easily be handled in such a short line length, the line length of some types of statements will be a function of the complexity of the mathematical expressions contained in the line. A short line length can thus affect the manner in which one writes mathematical formulas.)

When inputting lines to SCELBAL, the user with such a display system can handle the situation without any modification to SCELBAL itself. This may be done by having the user provided input subroutine simply screen for a special character such as a line feed. When the routine encountered the special character it could simply issue a "new line" directive to the display device (assumed to be echoing the input) and discard the character so that it was not processed by the main program. Thus, whenever inputting information the operator would simply enter the special character on the keyboard so that the display would go to a new line, yet only relevant characters would go into the line input buffer used by the program. (Remember, however, that the line input buffer used in SCELBAL is limited to holding 72 characters at a time!)

On the outputting side, one could make a minor modification to the ECHO subroutine in SCELBAL (using patching techniques) along the following line. Examine the output character counter. When it reaches the value equal to the maximum length of a line issue a "new line" directive to the display device. Then, reset the output character counter. This capability may be inserted just before the end of the ECHO subroutine. (The ECHO subroutine starts on page 03 location 202 in the assembled listing. The source listing for the subroutine is presented in the chapter that discusses the SYNTAX routine.) This procedure would take care of the displaying of lengthy statements or cases where the programmer failed to properly format PRINT statements. (One would, of course, plan on formatting PRINT statements to suit the display device being utilized.)

The program in this publication was developed and presented in a fashion that would lend itself to easy modification by the reader. Indeed, with the organizational and conceptual information that has been presented, along with the multitude of routines, serious students of this manual are in a position to customize the higher level language to their individual desires. Some thoughts on such customizing will be presented in the next few pages.

One area in which a user might desire additional capability, for example, could be in the number of user defined functions that the user could add to the program. The FUNCTION LOOK-UP table only provides for the mnemonic UDF. How could one easily add the capability to perform several different user defined routines?

One way this could be accomplished would be to let the argument associated with the mnemonic specify a particular subfunction! For instance, the terms:

UDF(1)
UDF(2)
UDF(3)
UDF(4)

could represent four different types of functions. To determine what type of function was to be performed, the programmer would simply arrange the first part of the user provided UDF subroutine so that it checked the value of the argument (which would be residing in the FPACC) and then directed

the program to the appropriate subfunction!

It is important to note that while some readers might automatically relate functions with the performance of mathematical operations, such a narrow interpretation is not necessary. One can have a user defined function perform practically any useful type of operation such as control an external device. One interesting and useful idea for such a user defined function is to have it control a tape unit. Thus, one could read in the next section of a multiple-segment program if the user program buffer was too small to hold all the needed directives for a large program. (Be careful, though, when organizing the high level program, not to overlay when inside a nested statement type such as a FOR/NEXT loop or a GOSUB directive!)

Going on to another area of customizing, consider the mnemonics for statement names, and indeed, the specific tasks that the various statement types perform. The user who doesn't like the statement keywords as presented, can change the statement keyword table quite readily. If one takes care not to exceed the space allotted to the table, and keeps the same order (so that the token value structure is not altered as discussed in the chapter dealing with the SYNTAX routines) among the various types, one can simply rename the offensive mnemonics with no further alterations to the program! Thus, if a user prefers to use the mnemonic SET instead of the mnemonic LET, a simple change to the name in the STATEMENT KEYWORD table is all it takes.

The next step is to alter the operation of a statement type, or substitute a different type of statement. Perhaps a particular user finds that the FOR/NEXT statement types are of no particular benefit to the user's applications. Presto! Change two entries in the keyword table, to say, do THIS and do THAT as the mnemonics for two new statement types. Then, remove the subroutines relating to the FOR/NEXT statements and substitute routines that perform THIS and THAT.

Suppose a user likes all the statement types presented but could use a few more? Well, the names assigned to the various statement types are almost all longer than necessary. By compacting those keyword names (thereby opening up room in the keyword table) to just one or two characters, assigning some new token values, and adding the appropriate tests for the new token values in the DIRECT routine (refer to the chapter that presents the source listings for the statement type routines), one can enhance the program by adding new statement types. The actual routines to perform the new statements may be placed in areas in memory formerly used as the user program buffer by appropriately limiting the size of the buffer as mentioned at the beginning of this chapter.

The reader with a little imagination will soon find all kinds of possibilities for enhancing the described package. With all the various utility routines available within the program, one will find that many kinds of capabilities that a user might desire can be added to the program with relative ease. Suppose, for instance, that one is interested in manipulating text strings and would like to implement some string function capabilities in SCELBAL. A little review of some of the kinds of subroutines already present in the program described will show that there are a number of routines available that may be combined to rapidly build up some string handling functions. Just to name a few, consider the following:

The MOVEIT subroutine can transfer strings of characters from one area in memory to another.

The CONCTA and associated subroutines can concatenate (append) characters from one buffer to another.

The STRCP subroutine can determine if character strings in buffers are the same length.

The STRCPL and associated routines can

determine whether character strings match one another.

(NOTE. The locations of the routines mentioned within the assembled program provided, as well as the chapter and page number in which the source listing was presented, may be found in the Appendix.)

These types of routines, coupled with appropriate user provided linking instructions, etc., can very quickly be capitalized upon by the adventurous and ambitious programmer to add string handling type functions to the language if desired.

The amount of creative additions of the above nature, given the base that one has to start within the SCELBAL package, is virtually unlimited.

There are a few other aspects about the package that will be interest to those that desire to tinker with the program. The machine language programmer with even a modest amount of experience will find the program quite easy to modify using patching or compressing techniques. This is because several design guidelines followed during program development for this publication have side effects that are useful in this regards.

For example, perhaps the most significant decision made regarding the package's development had to do with whether or not to utilize locations on page zero in memory. Doing so would have meant the program could have been organized and compressed to reside in about 1.5 K bytes less memory from this one factor alone! Why wasn't it done? Experience indicated that many small system owners dedicated all or part of page zero in their systems to monitor functions or similar permanent or semi-permanent programs. Requiring the use of page zero would have meant these users would have to re-assemble SCELBAL for use on their systems. Furthermore, the features that would have been so useful to capitalize on, had page zero been used, would have made such re-assembly a somewhat difficult task.

For instance, the RST (Restart) locations on page zero could have been used to hold commonly used instructional sequences (particularly in the 8008 version) such as:

```
LBM
INB
LMB
```

or

```
LAM
NDA
```

Just being able to replace those two and three byte instructions by one byte RST instructions, would have enabled some two to three pages of memory to be saved! But, woe to the poor user who had to re-assemble the program. That would require finding all the RST instructions, replacing them with the multibyte sequences, and greatly expanding the size of the program. One is far more likely to be upset about seeing a program expand than to discover that with a little effort the program can be made to contract!

Secondly, using page zero for most of the pointers and counters, say, would have meant a good many LHI XXX type instructions (to set the page portion of the memory pointer) could have been reduced to a one byte LHX instruction (because quite often a CPU register will contain the value zero) or eliminated altogether because of less frequent changes to the pointer page. Again, woe to the user who might have been forced to re-assemble because page zero was not available. All such single byte (or worse, non-existent) set ups would have had to be located and the multibyte LHI XXX inserted!

As the package has been presented, if it is necessary to relocate the program, the reassembly process can be made quite straightforward. If the pages containing pointers, counters and buffers must be altered, then only the page value byte in the LHI XXX instructions need be altered. All such locations have been marked in the book by the double asterisk "**" indicator. Program size, the relative locations or subroutines, etc., would all remain fixed. In many instances

involving relocation, only one data page, or a few might have to be relocated, so the number of LHI XXX instructions that would be altered would be even less. (Re-assembly might also affect the values in locations marked by "††.")

These guidelines provide additional benefits for the user. Those with systems that do have page zero available will find they have a package with the potential for being considerably reduced in size if they wish to reassemble the package to take advantage of the possibilities.

Those not interested in that type of project, but that should find they desire to make minor changes or patches to various portions of the program, will find that frequently it is possible to compress even one lengthy routine by quite a few bytes. This may be done in many cases by replacing a few of the frequently used instructional sequences with one byte RST instructions and placing the instructions in the sequence on page zero at the appropriate restart address. Room can thus readily be made to accomodate some extra instructions in the routine one desires to alter.

The use of page zero could save up to 1.5 K bytes of memory in the 8008 version of the program. It hardly need be mentioned that the amount of compression that can be obtained in the 8080 version is considerably more. This is because some of the frequently used small subroutines and instructional sequences used in the program actually have shorter (in terms of the number of bytes required) equivalent commands available in the 8080 instruction set. A good machine language programmer who wants to take the time and effort, should have little difficulty getting an 8080 version of SCELBAL (say, without array capability, in order to allow for a decent sized user program buffer) in a 4 K system.

But, such undertakings are not at all necessary to enjoy SCELBAL. Using the program as it has been presented may keep many readers occupied for years. But, should any start to get bored, it is always nice to know that the freedom to make changes is right in this book!

# APPENDIX A - SCELBAL LABELS

The following is a list of the names used as labels to identify routines and subroutines in SCELBAL. The list is arranged in alphabetical order. The first column shows the name, the second column shows the address of the label in the assembled version of the program provided in the book, and the last column indicates the chapter and page within the chapter where the label appears in the source listing.

| | | |
|---|---|---|
| ABSX | 07 346 | 9-8 |
| ACCSET | 20 166 | 10-4 |
| ACNONZ | 20 143 | 10-4 |
| ACZERT | 20 120 | 10-4 |
| ADBDE | 12 305 | 4-11 |
| ADDER | 22 127 | 10-14 |
| ADDEXP | 21 051 | 10-8 |
| ADDMOR | 22 130 | 10-14 |
| ADOPPP | 21 270 | 10-10 |
| ADV | 02 377 | 5-8 |
| ADVDE | 13 064 | 4-12 |
| AD4DE | 06 256 | 8-14 |
| AHEAD1 | 24 220 | 10-24 |
| AHEAD2 | 25 333 | 10-28 |
| ARRAY | 55 145 | 9-12 |
| ARRAY1 | 55 153 | 9-12 |
| ARRAY2 | 55 160 | 9-12 |
| ARRAY3 | 55 162 | 9-12 |
| ARRAY4 | 55 174 | 9-14 |
| ARRAY5 | 55 225 | 9-14 |
| ARRAY6 | 55 240 | 9-14 |
| ARRAY7 | 55 312 | 9-14 |
| BACKSP | 31 217 | 9-9 |
| BIGERR | 02 222 | 5-6 |
| BRING1 | 21 007 | 10-6 |
| CFALSE | 06 247 | 8-14 |
| CHRX | 07 377 | 9-9 |
| CINPUT | 03 221 | 5-10 |
| CKDECP | 25 137 | 10-26 |
| CKEQEX | 20 242 | 10-5 |
| CKSIGN | 21 166 | 10-9 |
| CLESYM | 02 255 | 5-7 |
| CLRNEX | 21 175 | 10-10 |
| CLRNX1 | 21 207 | 10-10 |
| CLRNX2 | 23 055 | 10-19 |
| CLRNX3 | 23 067 | 10-19 |
| CLROPL | 21 203 | 10-10 |
| COMPEN | 25 010 | 10-25 |
| COMPLM | 22 150 | 10-14 |
| CONCTA | 02 264 | 5-7 |
| CONCTE | 02 327 | 5-7 |
| CONCTN | 02 276 | 5-7 |
| CONCTS | 02 310 | 5-7 |
| CONCT1 | 02 314 | 5-7 |
| CONTIN | 12 073 | 4-9 |
| CPHLDE | 12 277 | 4-11 |
| CRLF | 03 141 | 5-10 |
| CROUND | 21 307 | 10-11 |
| CTRLC | 12 313 | 4-11 |
| CTRUE | 06 242 | 8-14 |
| DEC | 03 164 | 5-10 |
| DECBIN | 24 056 | 10-22 |
| DECEXD | 24 336 | 10-25 |
| DECEXT | 24 277 | 10-25 |
| DECN0 | 03 172 | 5-10 |
| DECOUT | 24 360 | 10-25 |
| DECRDG | 25 112 | 10-26 |
| DECREP | 24 327 | 10-25 |
| DIM | 55 365 | 6-42 |
| DIM1 | 55 377 | 6-42 |
| DIM2 | 56 017 | 6-42 |
| DIM3 | 56 032 | 6-42 |
| DIM4 | 56 036 | 6-42 |
| DIM5 | 56 157 | 6-46 |
| DIM6 | 56 211 | 6-46 |
| DIM7 | 56 224 | 6-46 |
| DIM8 | 56 271 | 6-47 |
| DIM9 | 56 301 | 6-47 |
| DIM10 | 56 320 | 6-47 |
| DIMERR | 56 337 | 6-47 |
| DINPUT | 23 046 | 10-19 |
| DIRECT | 13 211 | 6-4 |
| DIVIDE | 21 351 | 10-12 |
| DVERR | 12 357 | 4-11 |
| DVEXIT | 22 070 | 10-13 |
| DVLOOP | 06 362 | 8-15 |
| ECHO | 03 202 | 5-10 |
| ENDINP | 23 311 | 10-21 |
| EQ | 06 136 | 8-14 |
| ERROR | 02 226 | 5-6 |
| EVAL | 03 224 | 7-2 |