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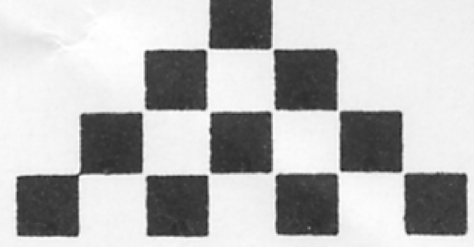

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Anonymous variables aren't the only way to implement local variables. An alternative is to copy or move items from the stack to storage allocated in the word that uses them. We can achieve this *and* preserve a convenient and readable syntax.

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Forth definitions typically deal with memory locations within the dictionary boundaries. But special problems arise with PROM-based systems. Usually, a target system will have a separate area of RAM for the storing variables. The task is to evolve a system of vectoring variable operations into this RAM area.

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These entrepreneurs went from college courses to professional programming, followed quickly by designing, writing, and selling Mach 2, their Forth for 68000-based micros. Michael Ham continues his series of interviews with Lori Chavez and Derrick Miley, advocates of an integrated, interactive Forth environment.

TRANSCENDENTAL FUNCTIONS • BY PHIL KOOPMAN, JR.
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The author of *MVP-FORTH Integer and Floating Point Math* had to implement quick, accurate, and relatively compact math functions. His research resulted in the equations presented here. (Don't even ask about the derivations....)

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EDITORIAL

Time was, computer-users groups were the loci of the micro revolutionaries, or at least of those who iconized them. They were like open-seating concerts for LED-heads who derived their main satisfaction from affiliation itself. At the meetings, whiz kids and garage-shop pioneers found other seekers of the satisfaction that accrues from each computing challenge well met. They ran improvisational meetings, or else surrendered to the procedural overhead created by the perennial joiners and organizers, who showed up in the lukewarm footsteps of the very first hackers.

The icons are gone now: the garage is full of cars, Woz went for his degree, and if you ask someone about Captain Crunch, chances are they'll give you directions to a grocery store. (Which, you might say, shows that not everything changes for the worse.)

The computer market broadened, and members began to expect their users groups to perform more like professional associations. Services and meeting agendas shifted (or groups splintered) because many new users were more interested in software, applications, and usefulness than in hardware, system utilities, and tricky code. Today, many members want more from their meetings than a visiting hacker; and groups need more from their members than physical attendance.

Participation and open communication enliven a group's responsiveness to its members and to changing conditions. I'd expect a healthy, long-lived group to offer orderly proceedings, educational and special-interest programs, both transactional and transformational platforms for members, aid and comfort, and relevant public service. In every case, local leaders must step forward who will intelligently apply a group's general resources to the specific interests of its members.

I mention all this hoping that the leaders and organizing committees of FIG chapters (and potential ones) will take enough time, every year, to consider their groups' overall activities, goals, and interests. They should provide opportunities for consensual change in which members are directly involved; encourage diversity in order to stay flexible and lively; and use creative strategies to foster participation, enjoyment, and growth. A users group should rub minds together, returning more warmth and light than it requires.

* * *

The fall season brings two of the Forth Interest Group's major events. Many of you will see this issue first at the Forth National Convention or the following FORML conference. We will cover highlights of those events in upcoming issues for those who cannot attend.

Meanwhile, keep working on your letters and articles for *Forth Dimensions*. We intend to publish the best and most interesting work from the Forth community, which is only possible if every reader thinks of himself as a potential contributing author. Write to the FIG office for a copy of the latest writers guidelines, we'd like to hear from you!

—Marlin Ouverson
Editor

Forth Dimensions
Published by the

Forth Interest Group
Volume IX, Number 4
November/December 1987
Editor
Marlin Ouverson
Advertising Manager
Kent Safford
Design and Production
Berglund Graphics
ISSN#0884-0822

Forth Dimensions welcomes editorial material, letters to the editor, and comments from its readers. No responsibility is assumed for accuracy of submissions.

Subscription to *Forth Dimensions* is included with membership in the Forth Interest Group at $30 per year ($42 overseas air). For membership, change of address, and to submit items for publication, the address is: Forth Interest Group, P.O. Box 8231, San Jose, California 95155. Administrative offices and advertising sales: 408-277-0668.

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The Forth Interest Group is the association of programmers, managers, and engineers who create practical, Forth-based solutions to real-world needs. Many research hardware and software designs that will advance the general state of the art. FIG provides a climate of intellectual exchange and benefits intended to assist each of its members. Publications, conferences, seminars, telecommunications, and area chapter meetings are among its activities.

"*Forth Dimensions* is published bi-monthly for $24/36 per year by the Forth Interest Group, 1330 S. Bascom Ave., Suite D, San Jose, CA 95128. Second-class postage pending at San Jose, CA 95101. POSTMASTER: Send address changes to *Forth Dimensions*, P.O. Box 8231, San Jose, CA 95155."

LETTERS

Novix Finbonacci

Dear Mr. Ouverson:

The July and August 1987 editions of *BYTE* compare various personal computers running six benchmarks. The August edition contains a comparison of the times given for their first benchmark, an algorithm that computes the 24th Fibonacci number 100 times. The times I have achieved on two systems using the Novix NC4016 Forth engine are:

System	Time (secs)
Delta Board:	
(4 Mhz NC4016 CPU)	28.2
PC4000:	
(5 Mhz NC4016 CPU)	22.6

As can be seen by comparing these times to those in the article, the NC4016 — running at a clock rate four times as slow as a DESKPRO 386 — executes this benchmark nearly twice as fast. Also, the cmFORTH implementation is much more concise and (to me, at least) less cryptic than the C version. And, of course, the word `FIB` can be run interactively and used independently of `FIBTEST`.

With this benchmark, the power of Forth and the NC4016 is directly shown. Just imagine what can be done with an NC4016 running at 16 Mhz!

```
100 CONSTANT NTIMES   ( NUMBER OF TIMES TO COMPUTE FIB VALUE  )
 24 CONSTANT NUM      ( BIGGEST ONE WE CAN COMPUTE IN 16 BITS )

: FIB ( U1 -- U2 )  RECURSIVE
     DUP 2 > IF DUP 1 - FIB SWAP 2 - FIB +
             ELSE DROP 1
             THEN ;

: FIBTEST ( -- )
     CR NTIMES U. ." ITERATIONS: "
     0 ( MAKE SURE SOMETHING IS ON STACK )
     NTIMES 1 - FOR DROP NUM FIB NEXT
     CR ." Fibonacci(" NUM 2 U.R ." ) = " U. ;
```

Douglas Ross
NASA
Goddard Space Flight Center
Greenbelt, Maryland 20771

New SEARCH for (Z80) F83

Dear Mr. Ouverson,

R.L. Hoffpauer's code `SEARCH` (*FD* IX/2) was a very welcome addition to my already cluttered desk. I had been trying, off and on, to write machine code to replace the high-level F83 `SEARCH` on my Z80-based system, and was getting nowhere fast. Not being an 8088 programmer, I hadn't thought of using an index, not only to point, but also to count. This is what comes of not working on IBM PCs.

But while I was doing the conversion, I realized that Mr. Hoffpauer's code can be improved, both from a theoretical and a practical standpoint.

Theory first: Mr. Hoffpauer uses an `UNTIL` structure for his main loop. This is erroneous, since it means the routine will go right through a loop even if the string sought is longer than the buffer. What is actually needed is a `WHILE` (because we may not do any comparing at all). On the other hand, Mr. Hoffpauer uses a `WHILE` for his inner loop, i.e., comparison of the string once the first character has been found. This is again mistaken: an `UNTIL` structure really is necessary this time because we will, in any event, make at least one comparison. All we have to do is initialize the inner-loop string pointer/counter to zero, then increment it at the start of the loop, rather than at the end. And, of course, change the test.

Forth is, after all, a structured language. Let's keep it that way, even when we're translating our algorithms into machine code; and it's essential that algorithms use the correct structures for a given problem.

On the practical side, I decided to shorten the code by storing the initial character of the string in an anonymous variable. This way, it is only tested for capitalization once, before the main loop begins, and thereafter is read directly in the form needed for comparison. (This gives rise to some stack gymnastics at assembly time.) I also took advantage of the fact that F83 uses pure flags to test by INCing BX instead of CMPing it with zero, saving space and time on each test.

The accompanying screens give my Z80 version (in 8080, because that was the assembler incorporated in the F83 I bought; and I cannot metacompile a version with a Z80 assembler, because my

```
ASSEMBLER LABEL >UP          ASCII a # AL CMP >=
             IF ASCII z # AL CMP <= IF 20 # AL SUB THEN THEN RET

HERE ( Hold address)     NOP    \ Reserve one byte for string initial

CODE SEARCH        (s sadr slen badr blen -- offset flag)
   CLD                                          \ Direction
   CX POP       BX POP                          \ CX <- blen   BX <- badr
   DX POP       DI POP                          \ DX <- slen   DI <- sadr
   DX CX SUB    BX CX ADD                       \ CX <- last address
   SI PUSH      BX PUSH                         \ Save IP and badr
   BX SI XCHG                                   \ SI <- badr
   0 [DI] AL MOV                                \ 1st char of string
   CAPS #) BX MOV    BX INC    0=               \ Case sensitive?
   IF >UP #) CALL THEN                          \ Convert if not
   AL  OVER ( Assemble  address) #) MOV         \ Store it
   BEGIN
      CX SI CMP <=                              \ Loop WHILE in buffer
   WHILE
      4 ROLL ( Assemble  adr)  #) AH MOV        \ Get str-initial to AH
      AL LODS                                   \ Get char from buffer
      CAPS #) BX MOV    BX INC    0=            \ Case sensitive?
      IF >UP #) CALL THEN                       \ Convert if not
      AH AL CMP 0=                              \ Check for match
      IF                                        \ First char matched
         SI PUSH                                \ Save current b-ptr
         0 # BX MOV                             \ Initialize s-index
         BEGIN                                  \ Check string
            BX INC                              \ Next s-char
            0 [DI+BX] AL MOV                    \
            BX PUSH                             \ Save s-index
            CAPS #) BX MOV    BX INC    0=      \ Case sensitive?
            IF >UP #) CALL THEN                 \ Convert if not
            AH AL XCHG                          \ Keep char
            AL LODS                             \ Get char from buffer
            CAPS #) BX MOV    BX INC    0=      \ Case sensitive?
            IF >UP #) CALL THEN                 \ Convert if not
            BX POP                              \ Get s-index
            AH AL CMP 0<>                       \ Match?
         UNTIL                                  \ Loop UNTIL different
         SI POP                                 \ Buffer pointer
         DX BX CMP >=                           \ Found >= Sought?
         IF                                     \ Yes: have match
            BX POP                              \ Buffer start adr
            BX SI SUB      SI DEC               \ Calculate offset
            DX POP                              \ Get Forth IP
            DX SI XCHG                          \ SI is IP
            -1 # AX MOV                         \ Send true flag
            2PUSH
         THEN
      THEN
   REPEAT
   DX POP                                       \ Clean up stack
   SI POP                                       \ Get Forth IP
   AX AX XOR                                    \ Send false flag
   2PUSH
END-CODE
```

computer only has about 12K workspace — see note on IBMs above). I also propose my modification of Mr. Hoffpauer's code.

Thanks a lot to the whole team for the magazine.

Sincerely,
Martin Guy
9 rue de la Peupleraie
71500 Chateaurenaud
France

Batcher's Last Re-Sort

Dear Marlin,

I was very gratified to see the responses to the article about Batcher's Sort. I would like the chance to comment on some of the things that were not clear in the article.

Mr. Anway is correct. The flag-passing involving `Q` is not as clear as it could be. Originally, `Q` existed only as a stack value, and was made explicit only for publication. Doing this as an afterthought resulted in a messy structure, which was cleared up thanks to Mr. Anway's help.

Mr. Thomas' letter initially shocked me. It is a fundamental characteristic of Batcher's method that it is data independent, so I was really surprised by Mr. Thomas' claim to the contrary. I double-checked Knuth and verified that duplicate data values are explicitly allowed. Then I tried sorting data with duplicates, as Mr. Thomas suggested. No difficulty: He reads the word 2**N as the square of an argument N, whereas the intended meaning is to return 2 raised to the Nth power. Mr. Anway's code presents a correct implementation of 2**N. I had thought this was in the Forth-79 Standard Reference Word Set, so I didn't define it in the article. On checking, I find that it is not there, and I apologize for this omission and the confusion it may have caused.

I have since found an unusual use of sorting I'd like to share: I have an application that acquires a signal from a fast ADC and plots it in graphics. Useful insights into the experiment being performed can be obtained by sorting the data and replotting it. The sorted data is often grouped around several fixed levels, rather than being smoothly distributed, as I had expected — this was not obvious from looking at plots of the original data.

Sincerely yours,
John Konopka
c/o Kevex Corporation
1101 Chess Drive
Foster City, California 94404

Tim Lee's Long Names

Dear Marlin,

I was pleased to receive the courtesy copies of *Forth Dimensions* containing Mike Ham's interview with me. Thank you!

While reading the interview, I had an impression similar to hearing my own voice on tape ("Is that what I sound like?"). One thing in particular made me laugh, the part that has me endorsing the use of long definitions without comments!

Well, I'd like to set the record straight on this: what I meant to say is that I'm using longer word *names* and shorter definitions. When I write a new definition, I try to make the words it contains read in English as well as in Forth. For example:

```
: dither_screen ( -- )
  dither_color
  graphics_page_fill ;
```

If it happens that, after combining definitions made this way, the resulting definition doesn't express a clear idea in English, it is often a clue that I haven't partitioned the problem correctly. Then I revise the names and/or functions of the words that compose the current definition.

I've been using this method for the past year, and continue to find it rewarding in the solutions that it reveals. The few extra characters required to specify a longer name each time I type it, is a cost that is offset by being able to work at a higher level of abstraction. (There are functions that cannot be accurately identified with a single word. The blurring of distinctions that results from combining fuzzily named functions limits the level of abstraction that can be attained.)

Please publish this clarification so impressionable new Forth programmers don't start writing lengthy, uncommented definitions; and so my more experienced friends won't point and laugh when I show up at the Forth Convention!

Sincerely,
Tim Lee
Binary Systems

(Continued on page 15.)

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Guy screens:

```
   Ecran      8                                                   Ecran     23
 0 \ Code SEARCH                                        22aug87mjg \ Code SEARCH                                        23aug87mjg
 1 HEX             : IX  dd c, [ assembler ] h ;                     Defining IX here makes life easier in a few seconds.
 2 label ?UP                                                       ?UP converts the character in A to uppercase if CAPS is ON.
 3    h push  caps h lxi m l mov l inr h pop
 4    rnz 61 cpi rc 7B cpi rnc 20 sui ret                          N.B. 52ED ,   is for instruction SBC HL,DE
 5 code NSEARCH
 6    ix pop d pop h pop psw pop b push psw push b pop a ora xchg  Lots of stack work to get the following allocations:
 7    ix push xthl 52ED , xthl ix pop xchg dd c, d dad d push        DE is buffer pointer,   BC points at start of string to seek,
 8    BEGIN                                                          HL holds string length, IX address of last possible match.
 9          ix push xthl a ora 52ED , h pop 0>=                    Check if last address has been reached, and
10    WHILE                                                          while it hasn't, do the loop.
11          b ldax ?up call b push a b mov d ldax d inx ?up call   Get first char from string and compare with next one in buffer.
12          b cmp b pop 0=
13          IF                                                     If the first character matches,
14              d push h push 0 h lxi                                save b-ptr and s-len, and use HL as index into string.
15                                                 -->

   Ecran      9                                                   Ecran     24
 0 \ Code SEARCH                                        23aug87mjg \ Code SEARCH                                        23aug87mjg
 1
 2              BEGIN
 3                   h inx h push b dad m a mov ?up call           Get next character from string, convert if necessary, and
 4                   b push a b mov d ldax d inx ?up call            compare with next character in buffer.
 5                   b cmp b pop h pop 0<>                           Loop on this until we find different characters.
 6              UNTIL
 7              d pop 52ED , e l mov d h mov d pop 0>=             Then subtract s-len from found-len, restore HL = s-len.
 8              IF                                                 If found-len >= s-len, we have a match.
 9                  h pop xchg 52ED , h dcx xchg                     So calculate the offset and store it in DE.
10                  b pop -1 h lxi dpush jmp                         Then restore the Forth IP and send back offset and true flag.
11              THEN
12          THEN
13    REPEAT                                                       End of main loop : we leave here if end of buffer and no match.
14    d pop b pop 0 h lxi dpush jmp                                  So get junk (=b-adr) to DE, restore IP, send back false flag.
15 end-code
```


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FORTH-83

LOCAL VARIABLES

PETER ROSS - BRISBANE, AUSTRALIA

The anonymous variables of Leonard Morgenstern (*FD* VI/1) are not the only way to ease the problems of juggling the stack and writing readable code by implementing local variables. An alternative is to copy or move items from the stack to storage allocated in the word that uses them. Suppose we have a double and a single number on the stack, and that we would like them copied to local variables DBL and SNGL. We can achieve this, together with a convenient and readable syntax, by defining compiler words {, }, DBL, and SNGL so that we can write, for example,

```
: TEST   ( d n -- )
  { DBL SNGL }
  SNGL @   DBL @
  D. . D.  ;
```

where the curly brace construction causes the enclosed items to be copied to storage but not removed from the stack, and the later references SNGL and DBL push the appropriate storage addresses to the stack so that values may be fetched or stored. Since SNGL and DBL are compiler words, they can be used in the same way in other definitions without interference. How can we define the required words?

Definitions

Definitions are given in the accompanying screen listings. The word { is very simple. It is an immediate word that initializes a counter and switches from compilation state to interpret state. Local variable reference words that follow must leave their parameter field addresses on the stack and increment the counter. The word } then has enough information to allocate the required amount of storage in the dictionary and to store the appropriate dictionary addresses in the local variable reference words, making them temporary pointers to the local storage. It also compiles the address of a primitive word ({}) that copies the stack items at run time, together with the number of items. Finally, it resets the compile state.

All that remains is to ensure that the local variable reference words DBL and SNGL, etc., push the appropriate storage addresses (now stored in their parameter fields) to the stack at run time. This is easily achieved by compiling the addresses as literals. It is most convenient to use a special defining word LOCAL to define these words. LOCAL takes from the stack a value specifying the number of cells the variable occupies, and compiles it into the parameter field after the space allocated for the storage address. LOCAL defines the word to be IMMEDIATE and specifies its behavior during interpreting, when it must push its parameter field address to the stack and increment the word pointer; and its behavior during compiling, when it must compile the address in its parameter field as a literal. Our words above can then be defined very easily as:

```
2 LOCAL DBL
1 LOCAL SNGL
```

where there is no restriction other than stack size on the number of cells a local variable can use.

The primitive ({}) to copy stack items is given in Forth but, for speed comparable with other stack operations, it should be written as a code word in assembly language. The Forth definition assumes that the top item of the return stack points to the next item in the parameter field of the word using ({}), i.e., to the number of stack items to be copied. Not all Forth systems satisfy this assumption, and appropriate adjustments may be needed.

Forth's power is shown by the compactness of the words defined so far. However, this is an invitation to add more. One useful extension is to define a word -} with the accompanying primitive ({-}) to move items from the stack to storage, instead of copying them. Thus, we can write

```
{ DBL SNGL -}
```

where the syntax shows that items are removed from the stack. The definition of -} is identical to that of }, except that the primitive ({-}) is compiled in place of ({}).

Another useful extension is to push values to the stack, like CONSTANT, rather than addresses, like VARIABLE. I have used a defining word LOCALVALUE which acts like LOCAL except that, during compilation, one of two special primitives (1LV@) and (LV@) is compiled. (LV@) is the more general, pushing a value of any cell length to the stack at run time; but it requires the length to be stored in the following byte, followed by the storage address. (1LV@) assumes a cell length of one, and requires only the address. Special primitives could also be defined for double and triple numbers. Again, the primitives should be code words so that references to local values will take no more time than

(Continued on page 13.)

```
SCR # 2
 0 ( Local variables )
 1
 2 : ({}) ( ... n0 -- ... n0)
 3   R@ 1+ R> C@   ( storage addr, # of 16-bit items k)
 4   1+ 1 DO I PICK OVER ! 2+ LOOP   ( copy items)
 5   >R   ( update instruction pointer) ;
 6
 7 : {   ( --)
 8   0 [COMPILE] [ ;   IMMEDIATE
 9
10 : }   ( pfan ... pfa1 n --) ( ... n0 -- ... n0)
11   COMPILE ({}) HERE >R 1 ALLOT ( for item count k)
12   0 ( item count) SWAP 0
13   DO SWAP HERE OVER !   ( storage addr -> reference word)
14     2+ C@ ( # of items in variable) DUP 2 * ALLOT + LOOP
15   R> C! ( total # of items k) ] ;

SCR # 3
 0 ( Local variables )
 1
 2 : LOCAL   ( c --) ( --) ( n -- pfa n+1)
 3   CREATE 0 , C, IMMEDIATE
 4   DOES> STATE @
 5     IF   @ [COMPILE] LITERAL   ELSE   SWAP 1+   THEN ;
 6
 7 : ({--})   ( nk ... n0 -- nk)
 8   R@ 1+ R> C@ 0   DO SWAP OVER ! 2+ LOOP   >R ;
 9
10 : --}   ( pfan ... pfa1 n --) ( nk ... n0 -- nk)
11   COMPILE ({--}) HERE >R 1 ALLOT 0 SWAP 0
12   DO   SWAP HERE OVER !   2+ C@ DUP 2 * ALLOT +   LOOP
13   R> C! ] ;
14
15

SCR # 4
 0 ( Local values )
 1
 2 : (1LV@)   ( -- value)
 3   R> DUP 2+ >R @ @ ;
 4
 5 : (LV@)   ( -- value)
 6   R@ C@ DUP 2 *   R> 1+ DUP 2+ >R @ +   SWAP 0
 7   DO 2- DUP @ SWAP LOOP DROP ;
 8
 9 : LOCALVALUE   ( c --) ( --) ( n -- pfa n+1)
10   CREATE 0 , C, IMMEDIATE
11   DOES> STATE @
12     IF DUP 2+ C@ DUP 1 =
13       IF COMPILE (1LV@) DROP
14       ELSE COMPILE (LV@) C, THEN   @ ,
15     ELSE SWAP 1+ THEN ;
```

```
SCR # 5
 0 ( Local variables - example )
 1
 2 ( Assumes floating point extensions that use the Forth stack )
 3 ( Local variables are then highly desirable )
 4
 5 1 LOCAL v1
 6 1 LOCAL v2
 7 1 LOCALVALUE n
 8 DECIMAL
 9
10 : IP    ( addr1 addr2 n -- r)
11 ( get inner product r of fp vectors at addr1 and addr2 )
12    { v1 v2 n --}
13    0E0 n 0
14    DO    v1 @ F@ v2 @ F@ F* F+    F#BYTES DUP v1 +! v2 +!    LOOP ;
15

SCR # 6
 0 ( Local variables - primitives )
 1 ( for MM MasterForth 6502 Assembler )
 2
 3 CODE    ({}) ( ... n0 -- ... n0)
 4 ( copy top k items from stack to local storage )
 5        XSAVE STX IP )Y LDA .A ASL N STA N 1+ STA INY
 6    1 L: BOT LDA IP )Y STA INX INY N 1+ DEC 1 L# BNE
 7        N INC CLC N LDA IP ADC IP STA 2 L# BCC IP 1+ INC
 8    2 L: XSAVE LDX NEXT JMP C;
 9
10 CODE    ({--}) ( nk ... n0 -- nk)
11 ( move top k items from stack to local storage )
12        IP )Y LDA .A ASL N STA N 1+ STA INY
13    1 L: BOT LDA IP )Y STA INX INY N 1+ DEC 1 L# BNE
14        N INC CLC N LDA IP ADC IP STA 2 L# BCC IP 1+ INC
15    2 L: NEXT JMP C;

SCR # 7
 0 ( Local values - primitives )
 1 ( for MM MasterForth 6502 Assembler )
 2
 3 CODE    (1LV@) ( -- value)
 4 ( push a single value to the stack )
 5        IP )Y LDA N STA INY IP )Y LDA N 1+ STA DEY
 6        CLC 2 # LDA IP ADC IP STA 1 L# BCC IP 1+ INC
 7    1 L: N )Y LDA PHA INY N )Y LDA PUSH JMP C;
 8
 9 CODE    (LV@) ( -- value)
10 ( push multi-celled value to the stack )
11        2 # LDY IP )Y LDA N 1+ STA DEY IP )Y LDA N STA
12        DEY IP )Y LDA .A ASL TAY
13    1 L: DEX DEY N )Y LDA BOT STA 0 # CPY 1 L# BNE
14        CLC 3 # LDA IP ADC IP STA 2 L# BCC IP 1+ INC
15    2 L: NEXT JMP C;
```

CONSIDERATIONS:

VARIABLES FOR PROM-BASED PROGRAMS

RICHARD A. ALTIMUS -HIGHLAND HEIGHTS, OHIO

Forth is a dictionary-oriented language. Definitions typically deal with memory locations within the dictionary boundaries. The standard treatment of variables in Forth locates variables in the dictionary, right alongside definitions of executable words and constants. Problems arise, however, when a particular application is targeted for a PROM-based system. Although this presents no problems with a majority of definitions, variables must be handled separately, or they will quickly become constants. Usually, a target system which will run from PROM will have a separate area of RAM set aside for the purpose of storing variables. The task is to evolve a system of vectoring variable operations into this RAM area.

Constraints on Method Design

Several constraints must be observed. The method must monitor RAM address allocation in order to produce a vector address into RAM which is unique to one variable, and to ensure that these addresses are within legal RAM boundaries. The method must compile pertinent parameters into the dictionary, so that they are retained in the PROM-based system. The method must produce definitions which yield, on execution, an address into RAM which is consistent with existing Forth definitions, such as `@` and `!`. The method must produce variable definitions that perform identically, whether the dictionary is based in RAM or in PROM.

There are several other desirable performance characteristics the method should have. It should shield the user from address and allocation details, so that variables can be dealt with as a high-level function. The method should be capable of handling multi-dimensional variables, so that arrays and string variables are possible. The method should be capable of handling variables of differing width, such as one-byte, two-byte, etc. The method should be capable of some diagnostic capability, such as array overrun detection and RAM boundary-violation detection. The method should provide "familiar looking" subscripting; in other words, a subscripted variable reference should resemble, as closely as possible, array-access formats of other high-level language, so that the resulting expression is easily recognizable as an array function (example: variable-name { a , b , c }).

By observing these constraints, a method will be developed which will be fully compatible with existing Forth utilities while, at the same time, approaching the variable-handling capabilities of high-level languages. This method will be relatively simple to implement while, more importantly, being consistent and flexible in use.

Specifying the Structure of the Method

Under the new method, two pointers are needed. The first pointer contains the address of the next free byte of RAM, which will be used for defining the next variable. A utility must perform the 'allot' function on the RAM area. The second pointer contains the address of the last usable byte of RAM, which can be used to detect boundary violations. Preferably, these two pointers are located in RAM, so the user can alter the pointer values and deal with multiple RAM areas. These pointers can be defined in two ways: as a constant (that constant being the address containing the pointer) or as a colon definition (the name of the word is the pointer name, and the definition consists of placing the address containing the pointer on top of the stack). These pointers must be initialized, by the user, to handle the RAM area in the system being used.

By storing these pointers as constants in the dictionary (prior to burning PROMs) and defining a word to restore these constants on power-up, a user can take advantage of the unused RAM area for interactive variable definition in a PROM-based system. This procedure guarantees that variables defined interactively will not interfere with previously defined variables in the PROM-based dictionary.

The dictionary entry for a RAM-based variable should consist of a standard Forth header (NFA, LFA, CFA, and PFA). Compiled into the PFA, consecutively, should be the following:

- base address vector
- number of dimensions
- individual dimensions limits
- number of bytes in each entry

These values will be retained in the PROM-based dictionary. Upon execution, the PFA is left on the stack. The subscript-handling words will construct the absolute address from the information supplied in the array reference. The opening bracket will create

an intermediate stack that contains pertinent information for the next subscript-handling word. The subscript separator will resolve the previously given dimension and add this count to the offset, leaving the intermediate stack for the next subscript-handling word. The closing bracket resolves the supplied dimension, resolves any undeclared dimensions to zero, and produces the absolute address.

Each subscript entered in a variable reference is verified against the limit for that dimension, to prevent boundary violations. If a boundary violation is detected, an appropriate message is generated and the maximum value for the dimensions is substituted. This yields a usable address, although it is not the requested location. This also prevents altering data outside the area being accessed.

Summary

The need exists for a method of handling high-level variables which can be used in PROM-based systems. By observing the above-mentioned constraints, a method can be derived which is easy to use, yet flexible enough to meet future needs.

Richard A. Altimus is a test engineer in the Programmable Controller Systems division of Allen-Bradley.

(Continued form page 9.)

other stack operations.

Note that local variable and value references remain valid until they appear in another curly brace construction. Note also that any number of curly brace constructions can appear in the same definition, although more storage will be allocated each time. Except for simple definitions, the storage penalty for using local variables will be partly offset by a saving in stack manipulations, and the code should run faster. The biggest benefits are in ease of programming and in readability. Using lower case for local variable and value reference words further enhances readability.

Peter Ross is a research scientist who uses Forth professionally for instrument control and data acquisition, and is a member of the Australian Society of Soil Science.

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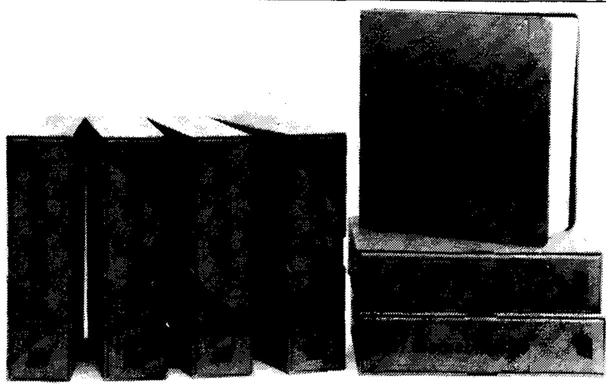

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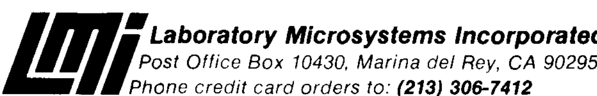

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FORTH-83

READABLE FORTH

CARL A. WENRICH - TAMPA, FLORIDA

There seems to be an ongoing argument between those who do and those who do not feel that Forth code is readable. It is probably safe to say that Forth allows programmers to write eminently intelligible or horrendous code. In this article, I will describe one way to achieve better readability

The Method

One of the most powerful features of Forth is its extensible compiler. It allows us to create cross-assemblers and metacompilers, even other languages. We will focus here on the idea of creating a language within a language.

Let us assume a hypothetical case where we have a talented, software-department manager supervising a less-than-talented crew. (Of course, I have never encountered this sort of thing myself, but in an infinite universe, all things are possible.) Mr. Manager would dearly love to use the Laxen & Perry F83 package to develop software for all of his company's projects. But he knows he will have a difficult time finding people who know how to use it.

What he needs to do is write a little, easy-to-learn language (one that, perhaps, looks like the Pascal taught in school), and place it on top of the Forth.

The Language

Before we get into an actual example, it might be a good idea to list some probable design specifications. The first thing we will need is a postfix-to-infix convertor. This will help make the listings more readable, not only for raw recruits, but also for other department heads.

Another feature would be a data-type declaration capability. Of course Forth already has this, but since we don't want the junior varsity getting their hands on it, we had better bring a version of it into the new language. The list of features that could be included is, of course, limited only by the imagination of Mr. Manager.

> ***"We will focus here on the idea of creating a language within a language."***

The Example

There is an excellent article by Michael Stolowitz (*FD* IV/6) and another by Craig A. Lindley (*FD* VII/1,2) describing how algebraic (infix) expressions can be evaluated. The first three screens of this example are a variation on that theme, so there is no need to explain them here.

What I have added to it begins in screen 4. The defining word `INTEGER` is a cross between `CONSTANT` and `VARIABLE`. Actually, it is nothing more than a self-fetching variable. But in the new language, we will use it to declare single-length integers, so the name `INTEGER` is more appropriate.

The `LET ... NOW` pair allows us to assign a value to a previously declared integer. After declaring X to be an integer, we could assign it an initial value by writing:

```
LET X = 0 NOW
```

There are a few syntax rules to be observed (even though none are being checked in this example). The first word after `LET` must be a declared integer, and the second word must be the equal sign. Between the equal sign and the word `NOW`, there must be an algebraic expression.

The algebraic expression may be a single-length literal (such as the zero above), or a combination of single-length literals and declared integers. So an expression to the right of the equal sign can be evaluated, and the result is assigned to the declared integer on the left. This allows us to set up a loop counter by writing:

```
LET X = X + 1 NOW
```

The `DISPLAY` word allows us to display the value of a declared integer at the terminal. It does essentially the same thing as `.` (dot) in Forth, except that instead of popping a value from the data stack, it takes it from the input stream. So we can display the value of `X` by writing:

```
DISPLAY X
```

The `SHOW` word does the same thing as `DISPLAY`, except that instead of displaying the value of `X`, it interprets it as an ASCII code and displays the corresponding character (like `EMIT` does in Forth). If `X` were set to 7, then `DISPLAY X` would display a 7 at the terminal, whereas `SHOW X` would beep it.

Control structures will have to be changed so that we can get away from the data stack. Don't get me wrong ... I love the data stack. But phrases like `SWAP OVER DUP` are notorious for adding confusion, so I would suggest avoiding its use. It is easy enough to do and well worth the effort.

All we have to do is define `IF` so that it simply begins the evaluation of an alge-

braic expression whose result will be interpreted as a Boolean value (true or false). `THEN` will terminate and evaluate the expression and conditionally branch, depending upon the Boolean result. `ELSE` is the same as it is in Forth, but `ENDIF` will now serve where Forth's `THEN` used to go. For example, we might write:

```
IF X < 33 THEN
  DISPLAY X
ELSE
  SHOW X
ENDIF
```

Looping is again easily converted to an infix version. `BEGIN` simply marks the start of a loop as in Forth. `FOREVER` marks the end of an infinite loop like Forth's `AGAIN`.

The `WHILE` function is duplicated by the `IF ... STAY` pair. As long as the algebraic expression between `IF` and `STAY` is true, the looping between `BEGIN` and `END` will continue. For example, we could display the digits zero through nine by writing:

```
LET X = NOW
BEGIN
  IF X < 10 STAY
  DISPLAY X
  LET X = X + 1 NOW
END
```

The `UNTIL` function is similarly duplicated by the `IF ... LEAVE` pair. In this case, the looping will continue until the algebraic expression between `IF` and `LEAVE` is true. We could display those digits just as easily by writing:

```
LET X = 0 NOW
BEGIN
 DISPLAY X
  LET X = X + 1 NOW
  IF X = 10 LEAVE
END
```

Just for jollies, Figure One is a little program that will display ASCII codes.

```
                INTEGER X       LET X = 0 NOW
                INTEGER CR      LET CR = 13 NOW
                INTEGER LF      LET LF = 10 NOW
                INTEGER SP      LET SP = 32 NOW

: EXAMPLE       BEGIN
                  DISPLAY X
                  IF X > 32 THEN
                    SHOW X
                  ENDIF
                  IF X / 8 * 8 = X THEN
                    SHOW CR SHOW LF
                  ELSE
                    SHOW SP
                  ENDIF
                  LET X = X + 1 NOW
                  IF X = 128 LEAVE
                END
;
```

The author points out that he wrote this article to make a point, not to provide readers with a new language. For that, his usual rates apply.

(Continued from page 6.)

F83 Execution Security

Dear Marlin,

It is now time to look at execution security for F83 on the PC, especially because of the lack of a reset button. This works the same as before (*FD* IX/2). `XSECUR` is the patch. `XSECURITY` installs it, and `UNSECURE` uninstalls it.

Sincerely,

G.R. Jaffray, Jr.
3536 Angelus Ave.
Glendale, California 91208

```
HEX ASSEMBLER
LABEL XSECU1  0 [BX] JMP
LABEL XSECUR AX LODS 89 C, C3, C,
   0 [BX] AX MOV AX PUSH AX DEC AX DEC
   BX AX CMP AX POP XSECU1 JE
    ' QUIT    @ # AX CMP XSECU1 JE
    ' UNNEST  @ # AX CMP XSECU1 JE
    ' RMARGIN @ # AX CMP XSECU1 JE
    ' BL      @ # AX CMP XSECU1 JE
    ' BASE    @ # AX CMP XSECU1 JE
    ' KEY     @ # AX CMP XSECU1 JE
    ' EMIT    @ # AX CMP XSECU1 JE
   AX BX MOV 0 [BX] AL MOV
   E9 # AL CMP XSECU1 JE 103 #) JMP

CODE XSECURITY
   >NEXT # BX MOV E9 # AL MOV
   AL 0 [BX] MOV BX INC XSECUR
   >NEXT 3 + - # AX MOV
   AX 0 [BX] MOV >NEXT # JMP C;

CODE UNSECURE >NEXT # BX MOV
   AD # [BX] MOV BX INC
   8B # [BX] MOV BX INC
   D8 # [BX] MOV >NEXT #) JMP C;
DECIMAL FORTH
```

Wenrich screens:

```
      1
 0 \ FTICEAPL - OPSTK @TOS PUSH_OP POP_OP              17feb86cw
 1
 2   vocabulary FTICEAPL          FTICEAPL also definitions
 3
 4   create OPSTK 44 allot        \ operand stack
 5
 6 : @TOS (S -- adr )             \ fetch top of operand stack
 7   OPSTK dup @ + ;
 8
 9 : PUSH_OP (S cfa prec -- )     \ cfa & prec to operand stack
10   4 OPSTK +! @TOS 2! ;
11
12 : POP_OP (S -- )               \ drop prec & interpret cfa
13   @TOS 2@ -4 OPSTK +! drop
14   state @ if , else execute then ;
15
```

```
      2
 0 \ FTICEAPL - PREC INFIX * / + - < > = NOT AND OR      16feb86cw
 1
 2 : PREC (S -- prec ) @TOS @ ;    \ fetch precedence from TOS
 3
 4 : INFIX ' create swap , , immediate    \ create an operator
 5   does> 2@ begin dup PREC > not while
 6   >r >r POP_OP r> r> repeat PUSH_OP ;
 7
 8   7 INFIX * *    7 INFIX / /          \ set PREC and cfa
 9   6 INFIX + +    6 INFIX - -
10   5 INFIX < <    5 INFIX > >
11   5 INFIX = =
12   4 INFIX NOT NOT
13   3 INFIX AND AND
14   2 INFIX OR  OR
15
```

```
      3
 0 \ FTICEAPL - )MISSING ( ) EVAL[ ]EVAL               17feb86cw
 1
 2 : )MISSING 1 abort" Missing )" ;    \ error cfa to patch
 3
 4 : ( ['] )MISSING 1 PUSH_OP ;        \ algebraic left parenthesis
 5
 6 : ) begin 1 PREC < while            \ algebraic right parenthesis
 7   POP_OP repeat 1 PREC =
 8   if -4 OPSTK +! else 1 abort"
 9   Missing (" then ; immediate
10
11 : EVAL[ 0 OPSTK ! ;                 \ begin expression evaluation
12
13 : ]EVAL begin PREC while            \ end expression evaluation
14   POP_OP repeat ;
15
```

```
      4
 0 \ FTICEAPL - INTEGER LET NOW                                17feb86cw
 1
 2 label DOINTEGER
 3   W INC   W INC   0 [W] AX MOV   1PUSH   END-CODE
 4
 5 : INTEGER create 0 , ;uses DOINTEGER ,
 6
 7 : LET state @ if compile (lit) ' 2+ ' drop , compile EVAL[
 8   else ' 2+ ' drop EVAL[ then ; immediate
 9
10 : NOW ]EVAL state @ if compile swap compile !
11   else swap ! then ; immediate
12
13
14
15
```

```
      5
 0 \ FTICEAPL - ?COMP DISPLAY SHOW                             17feb86cw
 1
 2 : ?COMP (S -- ) state @ 0= abort" Not Compiling" ;
 3
 4 : DISPLAY (S -- )             \ display following integer
 5   state @ if compile (lit) ' ,
 6   compile 2+ compile @ compile .
 7   else ' 2+ @ . then ; immediate
 8
 9 : SHOW (S -- )                \ emitfollowing ascii code
10   state @ if compile (lit) ' ,
11   compile 2+ compile @ compile emit
12   else ' 2+ @ emit then ; immediate
13
14
15
```

```
      6
 0 \ FTICEAPL - IF THEN ELSE ENDIF BEGIN STAY LEAVE END  18feb86cw
 1
 2 : IF ?COMP EVAL[ ; immediate
 3 : THEN ?COMP ]EVAL compile ?branch ?>mark ; immediate
 4 : ELSE ?COMP [compile] else ; immediate
 5 : ENDIF ?COMP ?>resolve ; immediate
 6
 7 : BEGIN ?COMP ?<mark ; immediate
 8 : STAY ?COMP ]EVAL compile ?branch ?>mark ; immediate
 9 : LEAVE ?COMP ]EVAL compile 0=
10   compile ?branch ?>mark ; immediate
11 : END ?COMP [compile] 2swap [compile] again
12   ?>resolve ; immediate
13 : FOREVER ?COMP compile branch ?<resolve ; immediate
14
15
```

PALO ALTO SHIPPING CO.

AN INTERVIEW WITH LORI CHAVEZ AND DERRICK MILEY

Analysts like to proclaim the end of the low-budget, high-tech startup, but more than a few challengers disprove the rule. FD *interviewer Michael Ham caught up with Lori Chavez and Derrick Miley a year after their company first released its Forth system for the Macintosh.*

MH: How did you get involved in Forth?

DM: Stanford has a "smart products" course in which mechanical engineers for the Master's year learn how to integrate mechanical systems and control them with microcomputers. That's where, basically, our entire company came from: the Smart Products Design Lab at Stanford.

MH: Were you all in it the same year?

DM: No. Aleksey Novicov taught us, and then I taught Lori.

MH: Three generations of a Master's Degree program.

LC: Actually four generations, because the next year they used the core of our Forth.

MH: How big is Palo Alto Shipping Company?

DM: Oh, we have about 1400 square feet! [laughs] There are three of us now. Aleksey decided that Europe was very interesting, so that's where he is.

MH: And Terry Noyes is on sabbatical now, right?

DM: Terry just got done jamming on the Atari, and now he's doing some consulting independently. Tim Lee is going to help us with Atari maintenance and things. Also, to get the Amiga done, we are going to work Tim into the schedule.

MH: I wanted to ask about the high quality of packaging for Palo Alto Shipping Company's products. Who is the packaging genius in your company?

LC: What do you mean by packaging? The components of the product?

> ***"I was ecstatic when we hit two sales."***

MH: I mean that what you sell looks like a product. It has a box, a binder, documentation — it looks complete, it looks like a real product.

LC: Our first product, for those who got it, wasn't quite as glossy. It's been a learn-as-you-go process. We didn't know how to make a manual, how to put a package together, and what you saw at this show was a year's worth of knowledge. It came together nicely. It took us a while to realize that the binder format was the way to go.

MH: Why is that the way to go?

LC: Well, it's the way to go if you can afford it. At $49.95 we couldn't — we had to do the manual's binding like a paperback book. A binder is the way to go, because you can keep the customers updated on documentation. When you print the manual as a paperback, you pretty much have to buy a new version whenever there's a change.

DM: And Apple changes. The Mac is our big product and it changes almost monthly. They'll bring out a new manager and surprise everyone. Or a new machine.

MH: How has Apple been about keeping you vendors informed?

DM: We have a line to Apple, we get all their technical docs, and we're always there. They have a mechanism that allows us to get the documentation we need.

MH: How did you decide to target the Mac?

DM: Availability. And we didn't want to compete with the company targeting the PC.

MH: And it's getting hot again.

LC: Well, it was a hot, new machine then. And, being at school, we found a lot of Macs. Apple really pushes it at the university.

MH: The Mac seems to be on the move again, and they're not going to let it die.

DM: I also had PDP-11 background; that was my first assembly language. And when

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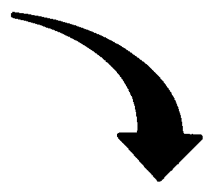

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you see PDP-11 and then you see 68000, you just know you don't want to go with Intel.

MH: Three graduate students fresh out of school starting a company — interesting. Did any of you do other work outside the university before starting this company?

DM: We met at a start-up in Fremont funded by Dysan. They were developing a new Forth, and that was where we learned Forth and how to write it. And we saw limitations in the product we were using. We saw there was a way to do an even better implementation; that's where we learned how to do it and how to do it better.

MH: That was before the Stanford course, or after?

DM: After Stanford.

LC: A year after graduating.

MH: How was the company born? One night you were sitting around saying, "Hey, I've got a garage, and you've got a computer; we could get together and put on a real show!"

DM: Lori and I were graduating, Terry came back from a winter in Germany, and we just came together and said, "Let's do it."

MH: Was there a historic placemat, as with Compaq?

DM: We were all sitting around a queen-sized bed—

LC: —crammed in a dorm room—

MH: How did the jobs parcel out among the four of you in the start-up year?

DM: Aleksey was the vision. He and I would bat around what it was going to be. He did the research and looked at everything that we would do. And Lori did the documentation; the whole manual was written by Lori. Terry and I did the grunt work — we did the coding! I did more Forth, he did the assembler and the debugger.

MH: Interesting that there was no marketing person, *per se*.

LC: And our marketing presence, I think, shows that.

DM: In terms of where we are going, that's the final step.

MH: If you had it to do over again at the company, knowing what you now know, what would you do differently?

LC: I think we would not have initially come out at the low price we did. It was very altruistic, and coming out of school, our thought of marketing was, "low price, high sales." But you learn that there are many more factors than price involved in whether a person buys your product. In fact, price has very little to do with it. That's the major thing.

MH: Rick, what would you do differently?

DM: The pricing; Lori answered the big one. But also running ourselves too thin — don't spread yourself too thin.

MH: In the number of processors?

DM: No, we never really switched processors — we stayed with the Motorola. It was the number of computers we tried. When you only have two or three people, you can't afford to lose three months on any project. You have to ship. When the Atari and the Amiga came out, we tried to get them all. We came up short on the Amiga.

MH: Probably the right one to come up short on.

DM: Yes, it would have been better just to have all of that work back.

MH: To spend on another machine.

DM: Or anything else.

MH: Had you done any programming before the Smart Products Design Lab, Lori?

LC: Just college courses: 68000 programming, Pascal. No real programming, never

on a microcomputer.

MH: And it sounds like only in a class environment, with assigned problems and such.

LC: You find out that real programming is very different.

MH: You are all mechanical engineers?

DM: Yes. Lori doesn't have a Masters, she's the baby.

MH: What is your future direction? Let's start with where you are now. You have a product for the Mac, and it's now version 2.0, which is Mach 2.

DM: Another thing we'd do differently is not pick names that people sue us for. We got into litigation over the name Mach 1, so we had to switch to Mach 2. That has caused confusion in the marketplace.

MH: Not too bad. Perhaps you should let Mach 2 mean version 2.0, and when you come out with version three, call it Mach 3. I thought it was a clever ploy, that every new version was going that much faster.

DM: Except that we were advertising. We had labels of Mach 1 and product of Mach 2, and ads...

MH: Is your Atari version released now?

DM: It's out.

MH: And your Amiga product?

DM: That's not shipping yet.

LC: I think the biggest thing that's happened this year is that people know the name of Palo Alto Shipping.

MH: How did you get the name?

DM: Detroit Diesel was taken.

MH: Right. Now, how did you get the name?

DM: We were sitting around on the bed and we wanted a generic name. We were all just gabbing away.

MH: Seemed like a good idea at the time?

DM: Yes, and it is a good name. People think we're much larger than we are.

LC: Everyone has to ask why we have it, so for that reason it sticks in their mind. It's so — odd.

MH: I certainly agree that "Palo Alto Shipping Co." is established now. How do you make yourself known?

DM: MacWorld.

LC: For shows and conventions, we try to stay in the area.

DM: We've gone to Chicago for conventions, and Silicon Valley conventions are big. A lot of Mac conventions are out here.

MH: Is the 68000 your future? Any 68000 machine that comes out, you'll at least look at?

DM: Right. We're on the OS-9, we're on the CD-I stuff that we're hoping is a market, and the EPROM version. 68000 across the board.

MH: You have a target compiler that people can order and get now?

DM: Yes.

MH: What is your product line?

DM: Macintosh, number one, biggest; Atari, smaller; and OS-9; and EPROM, the target compiler.

MH: What is the OS-9?

DM: It's a multi-tasking operating system from a company in Iowa. It's the operating system that was chosen by Sony and Phillips for CD-I (Compact Disk—Interactive). It's like a simple Unix.

MH: You don't see any departures from the 68000?

DM: The IBM market is attractive, but it's

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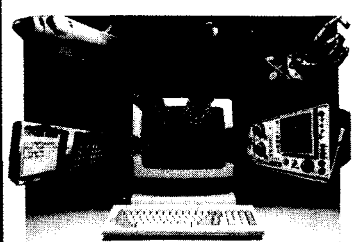

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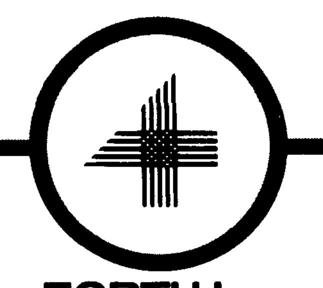

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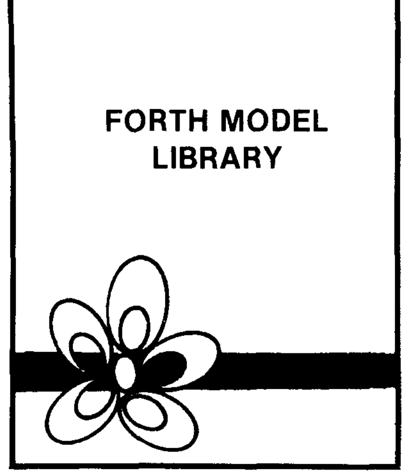

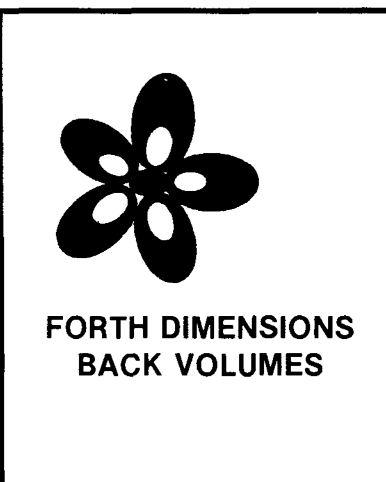

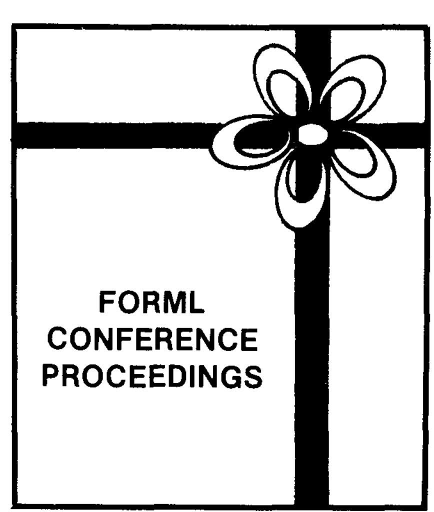

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very competitive.

MH: I think the opening ante in that market is fairly substantial now. When did Mach first hit the market?

LC: December 15th of 1985.

MH: A Christmas present for people.

DM: We barely had it done; I don't think we'd delivered it.

MH: What other goals do you have?

DM: We want to make Forth more mainstream.

MH: In what way?

DM: We're advocates of having text files, infix assemblers, and standard debuggers and linkers. Our goal is to have Forth be an interactive environment. That's its strength. And then on top of that, use all the other strengths of all the other languages. I want to be a Forth programmer who can converse with C programmers and not be ostracized or put off.

LC: It seems as if the emphasis today is going away from what language you use — C, Pascal, or Forth — and toward how good your environment is. Other languages are very powerful and give access to things you didn't have before, but the big thing now is your environment: how nice it is, how well the tools are integrated, how fast it gets work done, how much it helps you. Forth doesn't usually have that much of an environment around it. So we're trying to add that environment, which other languages seem to have as a standard.

MH: In almost every company, particularly among start-ups, there is a particular black moment, a moment when you say, "This is not going to work." Did you have a black moment?

DM: I 've been with start-ups since I was seventeen. I've had a sound and light show, I've installed stage lighting, all contract work. I've had a flight-case company, I have been manufacturing as a single person for eight years. This is nothing. Black moments are—

MH: —a dime a dozen.

DM: You see, for me, I've worked man years and then sold one. So I was ecstatic when we hit two sales.

MH: I see; the secret is to have a low threshold of satisfaction.

DM: Well, I'd been in business, as a young person with the drive to be in business. This is phenomenal success for me, even if from an engineering or accounting perspective it is mediocre or survival. To me, survival is success. If I can sell in singles, I'm happy.

MH: What's a flight case?

DM: A heavy-duty metal transport case. I was into sound and light shows, and—

MH: —you needed something to carry them around in.

DM: Right, it was a natural evolution. I was getting reamed at the stores, so I started making them.

MH: So how did you get this entrepreneurial bent?

DM: I've got brain damage.

MH: [laugh] No, no, come on now. That's evasive.

DM: It's inside of me. It's not something—

MH: Not from a parental example, or a competitive brother or a teacher who said, "Young Rick, I want you to..." Just something on your own?

DM: Yes, it's what I have; it's the ability to never give up. I could say, as long as it pays the rent, I'm in the game.

MH: It seems that one needs two things. One is persistence. That's the one you just described. The other is initiative, taking the step that wasn't required. Stepping up above where you are.

(Continued on page 37.)

TRANSCENDENTAL FUNCTIONS

PHIL KOOPMAN, JR. - NORTH KINGSTOWN, RHODE ISLAND

One of the things no developer of a complete floating-point math package can escape is the horror of designing transcendental functions. While writing my book *MVP-FORTH Integer and Floating Point Math*[1], I found myself faced with the dilemma of how to implement quick, accurate, and relatively compact math functions (optimizing for any two of these qualities is easy — all three at once is no fun at all).

My first step was a simple engineer's reflex: I picked up my CRC math handbook[2]. This handbook has a complete set of formulas for implementing almost every function that exists. However, there was a slight problem. Watching a Taylor-Maclaurin expansion for arc-tangent converge is like watching grass grow. I decided there had to be a better way.

After surviving a numerical analysis course and many hours of research in the dusty corners of a university library, I emerged with a set of equations that I believe are relatively efficient, accurate, and compact. I have not presented derivations for these formulas, as each equation takes at least an hour and many sheets of paper to derive. All the equations given here are designed to be used with 31-bit mantissa intermediate calculations, and produce an accurate (seven to eight decimal digit), 24-bit mantissa result with the minimum number of required terms. Readers who desire different precisions (such as 16-bit scaled integer), or who want to understand the theory behind these equations, are invited to wade through a book like *Numerical Analysis*[3], and books on computer arithmetic, such as *Computer Approximations*[4], *Mathematical Functions and Their Approximations*[5], and *Mathematical Methods for Digital Computers*[6].

SIN(X)

Sine is the basic trigonometric function. The equation given is a Chebyshev polynomial, and is valid on the range $-\pi/4$ to $\pi/4$ radians.

```
SIN(X) =
 0.9999999995           X^1
-0.1666666663           X^3
+0.008333328785         X^5
-0.0001983920268        X^7
+0.000002717349463      X^9
```

COS(X)

The cosine equation given is a Chebyshev polynomial, and is valid on the range $-\pi/4$ to $\pi/4$ radians.

```
COS(X) =
 1.0
-0.4999999943           X^2
+0.0416666167           X^4
-0.001388661862         X^6
+0.00002437988031       X^8
```

ATAN(X)

Arctangent is the primary inverse trig function, and may be heavily used by graphics applications. Series approximations for this function can be painfully slow when the range is near ±1 (and the resultant angle is near 45°). The equation given is a Chebyshev polynomial, is valid on the range -1 to 1, and gives a result in radians.

```
ATAN(X) =
 0.9999999842           X^1
-0.3333306679           X^3
+0.1999248354           X^5
-0.1420257041           X^7
+0.1063675406           X^9
-0.0749544546           X^11
+0.0425876076           X^13
-0.0160050306           X^15
+0.0028340643           X^17
```

LOG2(X)

Log base 2 is a crucial function for calculating any logarithm, and for output formatting. The equation given is valid on the range 0.5 to 1.0, and was derived by taking the Taylor-Maclaurin expansion for ln(x) and dividing it by ln(2). The choice of base 2 as the primitive logarithm reduces the number of terms in the expansion by limiting the range, and provides for efficient range reduction in a binary-exponent, floating-point package.

Let Y = (X-1) / (X+1)

```
LOG2(X) =
 2.885390082            Y^1
+0.9617966939           Y^3
+0.5770780164           Y^5
+0.4121985831           Y^7
+0.3205988980           Y^9
+0.2623081893           Y^11
+0.2219530832           Y^13
+0.1923593388           Y^15
+0.1697288283           Y^17
```

2^X

A primitive exponential function is required to complement the logarithm function, and is useful for output format-

ting. The equation given is a Chebyshev polynomial, and is valid on the range 0.0 to 1.0.

```
2^X =
 1.0
+0.69314718              X^1
+0.24022636              X^2
+0.055505294             X^3
+0.0096135358            X^4
+0.0013429811            X^5
+0.00014299401           X^6
+0.000021651724          X^7
```

Range Reduction

By now, you have noticed that the equations given have restricted ranges for the input variable X. This limits the number of terms in the equation, while keeping accuracy high. Simple trigonometric and algebraic identities can be used to force all inputs into the required ranges. Some of the more useful identities are given below (all arguments are in radians):

```
SIN(X) = SIN(X+2π)
-SIN(X) = SIN(-X)
COS(X) = COS(-X)
SIN(X) = COS(X-π/2)
LOG(X*Y) = LOG(X) + LOG(Y)
```

Derived Functions

The formulas given in this article may be used to derive all desired transcendental functions. The CRC handbook gives useful identities for creating any desired function. Special care must be taken when using these identities, to avoid exceeding range limitations and to avoid division by zero.

```
TAN(X) = SIN(X) / COS(X)
SEC(X) = 1 / COS(X)
CSC(X) = 1 / SIN(X)
COT(X) = COS(X) / SIN(X)

ARCSIN(X) = ARCTAN(X/SQRT(1-
  X^2))
ARCCOS(X) = π/2 - ARCSIN(X)
ARCCOT(X) = π/2 - ARCTAN(X)
ARCSEC(X) = ARCTAN(SQRT(X^2 -
  1))
ARCCSC(X) = ARCTAN( 1 /SQRT(X^2
  - 1))
```

Logarithms and exponentials use the formula:

```
LOG (base a) (X) =
  LOG (base b) (X) /
  LOG (base b) (a)

LOG (base 10) (X) =
  LOG (base 2) (X) /
  LOG (base 2) (10)

LN(X) =
  LOG (base 2) (X) /
  LOG (base 2) (e)

10^X = 2^( X * LOG2(10))

E^X = 2^( X * LOG2(e))
```

References

1. P. Koopman, Jr., *MVP-FORTH Integer and Floating Point Math*, Mountain View Press, 1985.
(This is a complete, machine-independent mathematics package written in MVP-FORTH. The equations presented in this paper are the same approximations used by the math package included in this book.)

2. S. Selby, ed., *CRC Standard Mathematical Tables*, CRC Press, 1975.
(This old standby is filled with useful mathematical formulas and tables. It should be owned by anyone interested enough in mathematics and/or computers to get this far in the article.)

3. R. Burden, J.D. Faires, and A. Reynolds, *Numerical Analysis*, Prindle, Weber & Schmidt, 1978.
(This is a college textbook full of algorithms for numerical methods and approximations.)

4. J. Hart, et al., *Computer Approximations*, John Wiley and Sons, 1968. Reprinted by R. Krieger Publishing Co. Inc., 1978.

5. Y. Luke, *Mathematical Functions and Their Approximations*, Academic Press, 1975.
(This book contains pre-computed, 20-digit coefficient tables for just about any function you would care to approximate. These tables were used for the equations in this article. A considerable amount of work is required to transform these raw coefficients into an approximation with appropriate accuracy.)

6. A. Ralston, and H. Wilf, *Mathematical Methods for Digital Computers*, John Wiley & Sons, 1967.
(This book has a great deal of theory on how approximations can work, and covers many methods.)

Phil Koopman, Jr., is the vice-president and chief engineer for WISC Technologies.

BIT-BASED TRUTH TABLES

JEAN-PIERRE SCHACHTER - LONDON, ONTARIO

Possibly, the logic most learned on university campuses is truth-functional logic. What makes this attractive to undergraduates and their teachers is exactly what makes it attractive to the programmer; namely, that it utilizes a mechanical decision procedure for testing logical validity. This procedure is based on a matrix called a "truth table."

p	q	p -> q	(p -> q) & q	[(p -> q) & p] -> q
T	T	T	T	T
T	F	F	F	T
F	T	T	T	T
F	F	T	F	T

Figure One. *Modus Ponens*: If ((if p then q) and p) then q

Truth-Functional Logic

Logic, in general, has only one objective. That is to determine whether arguments are, or are not, valid. We say that an argument is valid when it is impossible, short of embracing a contradiction, for its premises to be true while its conclusion is false. This criterion is often picturesquely expressed by the dictum that an argument is valid if and only if the conditional that corresponds to it is true in "all possible worlds."

When using truth-functional logic, it is possible to give this way of putting it a very concrete form. Truth-functional logic is, in a sense, the least sensitive logic, taking as its smallest particle the unopened sentence and testing compounds of sentences to see if they could possibly be false. Since the logic stops at the level of the sentence, the content of a sentence is of no interest, only its truth-value.

However, truth value in the actual world is also of no interest, for logic's only concern is whether there exists a pattern of possible truth values for a set of sentences in a logical compound, such that the compound itself is false. This leads us to the connectives used in forming compounds, called the truth-functional connectives. These connectives, including AND, OR, and IF THEN, among others, are themselves defined in terms of patterns of truth-values. The connective OR, for example, is defined as follows:

p	q	p OR q
T	T	T
T	F	T
F	T	T
F	F	T

The p's and q's stand for any propositions whatever, and the matrix is an example of a truth-table (here used not to test for validity, but to define). The four rows under p and q generate all the possible worlds for two propositions, and the column under p OR q defines the OR connective for each of the four worlds: OR compounds are true in all worlds except those in which both (or all) its disjuncts are false. Once the connectives have been defined, a compound based on those connectives can be evaluated for truth-value; if it evaluates as true in every distribution of truth values across its constituent propositions, then it is a tautology and the argument that corresponds to it is valid. The argument form called *Modus Ponens*, for example, which reads "If ((if p then q) and p) then q," is shown in Figure One to be valid.

With the exception of languages such as Prolog and Lisp, the coding of a logical, validity-testing algorithm presents intimidating obstacles. While most languages support at least a minimal set of logical operators, typically NOT, AND, OR, and XOR (a few having also IMP and EQV), they are there primarily in the interest of allowing compound tests; it is not obvious how they could be easily adapted to the evaluation of statements in the propositional calculus.

It is important to note, initially, the difference between the IF THEN supported by all languages and the IMP supported by some; the IF THEN is, in fact, what I'll call an "executive" conditional, in view of the fact that its consequent is an operation to be executed, not a proposition. IMP is the operator found in propositional logic, where it occurs as "material implication" and is commonly represented by the "horseshoe" symbol (I have used -> above).

When approaching the problem ini-

tially, the inclination is to think in terms of byte arrays set up to receive 1's and 0's in the pattern of a truth table. The memory overhead for this strategy is quite large, and the code for it is cumbersome. A better solution would be one capable of taking advantage of the built-in logical functions without having to administer a large array. In what follows, I offer an algorithm which does just that, turning the microcomputer into an interactive, propositional logic calculator.

Number Representation Reviewed

The algorithm takes advantage of the fact that the microcomputer stores its information at the byte level in binary code. One byte can represent the decimal numbers from 0 to 255, covering thereby every possible combination of 1's and 0's on eight registers. The standard, eight-bit micro, however , normally uses sixteen bits to represent signed integersbetween -32768 and +32767 (thus utilizing, in effect, fifteen 1's, the sixteenth being used for the sign). Some computer languages allow for unsigned integers, extending the positive integers to 65535 (sixteen 1's). In addition, Forth very conveniently supports double-precision numbers, which utilize 32 bits. It is a short step from seeing that our decimal integers are represented in the machine as bit arrays containing 1's and 0's, to realizing it is possible to determine the distribution of those 1's and 0's and to generate exceptionally memory-efficient truth tables.

Since Forth supports 32-bit numbers, I will set the algorithm up to generate a 32-row table. I will add, however, that Forth's extensibility and plasticity are such as to allow for the generation of 64-bit and higher numbers. As will become obvious when we look at the algorithm itself, Forth was the perfect vehicle for this exercise, not only for its interactivity, but because its ability to switch radix made debugging much easier and because only a language as extensible as Forth could allow the programmer to create the necessary new functions for evaluating 32-bit numbers.

The essential part of the program actually does nothing more than to generate n integers to be the values of the n propositional variables heading the truth table. Since we are assuming a truth table with 32 rows, we are also assuming arguments having no more than five variables. The integers will be so chosen as to create a truth table array, thereby generating all possible worlds for five elements. While the code could be made general enough to allow the program user to decide the size of the truth table, there are coding obstacles — such as the absence of a square-root function — that make such efforts not worth the prize. The best approach for the user is to code, once and for all, the largest case and use that code for smaller cases as well.

```
        p XOR q
T : T :    F
T : F :    T
F : T :    T
F : F :    F
```

decimal 480 =
binary 0000000111100000
decimal 3278 =
binary 0000110011001110
and the XOR =
binary 0000110100101110, or
decimal 3374

Figure Two. Truth-Functional Definition of XOR.

Logical Connectives

To understand how the program works, one must take a closer look at how the logical connectives work in computer languages. As I indicated earlier, they are primarily taught to be used in the construction of complex tests and, thus, occur in the antecedents of executive conditionals, or in the test positions of other control structures. Typically, we would see a line like:

```
10 IF A=1 AND B=1
THEN PRINT (A+B)
```

This is intuitively satisfying because the conjuncts themselves are Boolean, capable of bearing truth value. In non-symbol-processing languages, the only Booleans are those based on the arithmetic comparison operators, e.g., =, <, >, etc. Since we are taught to use the connectives with these Boolean conjuncts, and since this is intuitively well supported, we tend to forget that their use in this situation is, in fact, *derivative*. The logical connectives do their work natively, not at the macro but at the micro level; not at the level of Booleans, but at the level of bits. AND, for example, typically (in an eight-bit environment) compares a two-byte value with another two-byte value on a *bit-by-bit* basis, generating a new two-byte value whose bits are 1, where those compared were both 1 and 0, where at least one of those compared was 0. As an example, let us consider the decimal numbers 480 and 3278 connected by XOR. The truth-functional definition for XOR illustrated in Figure Two.

The two, two-byte values compared are typically returns from the evaluations of Booleans, but *they need not be*. They could have been any integers at all. In a word, the logical connectives actually operate on integers, and they do so at the bit level.

But! If it is really integers that we logically connect, and integers can be made to have appropriate bit patterns, then using appropriate integers in propositional formulae is *the same thing as running them through a truth table*. The point may, perhaps, be best seen by looking at the actual integers and their binary representation in Figure Three.

Var	Column	Decimal	Binary
q	1	65535	00000000000000001111111111111111
r	2	16711935	00000000111111110000000011111111
s	3	252645135	00001111000011110000111100001111
t	4	858993459	00110011001100110011001100110011
u	5	1431655765	01010101010101010101010101010101
tautology		8589934591	11111111111111111111111111111111
contradiction		0	00000000000000000000000000000000

Figure Three. Integer Representation as Truth Table.

Tilting one's head to the right (looking at the binary rows as columns) reveals a standard truth table for five variables. To check whether a formula is a tautology, contradiction, or contingency, we simply enter the formula, using as propositional variables double-number variables whose values are the above numbers with 32-bit versions of the logical connectives binding them together. Forth will evaluate the formula and yield either 8589934591 (all 1's), 0 (all 0's), or a number in between. As might be expected, 8589934591 implies tautology (true in all possible worlds), 0 implies contradiction (false in all possible worlds), and between implies contingency (true in some worlds, false in others).

The Code

Screen 1 contains all the variable declarations, as well as a mixed mode multiplication operator `D*` (d n - - d) borrowed from Alan Winfield's excellent book, *The Complete Forth*, and a double = operator. It should be noticed that the variables `q`, `r`, `s`, `t`, and `u`, which will hold the propositional variable values, are allotted four bytes each, since they have to hold double-precision numbers.

Screen 2 holds defined, 32-bit logical connectives (`~`, `v`, `&`, `xv`, `->`) and five short words, `q1` through `u1`, included only to make the entered formulae easier to read by making the `@` unnecessary.

Screen 3 contains, first, `TVCOLM`, which generates the double integers listed earlier, and which could be expanded to yield a similar set of numbers for 64 bits. This enterprise would involve not only machinery for representing numbers of that size, but all of the supporting functions as well; not only the bigger multiplier and the bigger connectives, but a bigger `@`, `!`, `DUP`, and so on; items supplied already for this code, since Forth substantially supports double numbers.

The task is not impossible, but if undertaken, perhaps it should be done with numbers much larger than 64 bits in mind, since moving to 64 would only add one more propositional variable or column. Should one choose to set the program up for 10 variables, one would need numbers 1024 bits long. The ten numbers being logically connected would jointly occupy 1280 bytes of memory, plus another 128 bytes for the evaluation column itself. While this may seem a lot, consider that doing the same with a byte array would use 10240 bytes plus another 1024 for evaluation; 11264 bytes vs. 1408. The other word, `?V`, simply checks the top of the stack for the result, yielding the appropriate screen printout for the formula in question.

One sets the stage for an evaluation by running `TVCOLM`, which not only generates the five numbers, but stores them in the variables q through u. After that, it is only a matter of noting that we will use the words `q1` through `u1` instead of the variables `q` through `u`, the former automatically leaving their values on the stack, and becoming accustomed to reverse Polish, or postfix, notation. Most philosophers were taught their logic in algebraic notations, but RPN is not totally unknown, is not difficult to master, is easier for the machine to digest, and may, for all that, be aesthetically superior. At any rate, notations come in three unsurprising options: prefix, found in Polish Notation and Lisp; Infix, found in algebra and BASIC; and postfix, found in Forth and on Hewlett-Packard calculators. Using the 32-bit connectives defined on screen 1, Hypothetical Syllogism is entered as follows:

```
q1 r1 -> r1 s1 -> & q1 s1 ->
->
```

Evaluation proceeds: `q1` and `r1` go on the stack, two double numbers taking up four sixteen-bit locations; they are `IMP`ed by `->`, leaving one double number on the stack; `r1` and `s1` are pushed onto the stack and we get six sixteen-bit locations taken up until the last two are `IMP`ed and we are back to four; the two doubles are `AND`ed by `&`, leaving again one double number. The `IMP`ing is repeated for `q1` and `s1`, leaving a total of two doubles, `IMP`ed again for one double number remaining on the stack. If the trick works, the remainder should be 8589934591, or 32 binary 1's, indicating a tautology.

Conclusion

Once it is realized that the key to the above procedure lies in generating the integer whose binary form has the bit distribution appropriate to the left-hand column of a truth table for the given number of variables, one also realizes that a language which handles larger integers is more adapted to our purpose. It should now be apparent that the choice of Forth for coding this program was not casual; no other language could have provided the capability for creating integers of any size, the operators for manipulating them, and the debuggng ease and extensibility that was necessary. Where *plasticity* is called for, Forth is unquestionably the language of choice; as logicians once were wont to say at the end, Q.E.D.

Jean-Pierre Schachter is the Dean of Arts and Social Science at Ontario's Huron College.

```
( Scr 1 - TV alg for 5 vars using double numbers )

Variable Eu Variable El Variable Fu Variable Fl
Variable q 4 allot Variable r 4 allot Variable s 4 allot
Variable t 4 allot Variable u 4 allot Variable H 4 allot
Variable N 8 allot

: D*     s->d  Eu ! El ! Fu ! Fl !    ( d n __ d              )
         El @ Fu @ u*                 ( mixed-mode * operator )
         El @ Fu @ u* drop +
         Eu @ Fl @ u* drop + ;

: s~     65535 xor ;                  ( 16 bit bit-not        )

: D=      rot = rot rot = * 1 = if 1 else 0 then ;
                                                            -->
```

```
( Scr 2 - TV alg for 5 vars using double numbers )

( 32 bit logic operators )
                                                  : q1 q 2@ ;
: xv     rot xor rot rot xor swap    ; ( xor     ) : r1 r 2@ ;
: ~      swap s~ swap s~             ; ( bit not ) : s1 s 2@ ;
: &      rot and rot rot and swap    ; ( and     ) : t1 t 2@ ;
: v      rot or rot rot or swap      ; ( or      ) : u1 u 2@ ;
: ->     rot s~ or swap rot s~ or    ; ( imp    ant cons ___ )

                                                            -->
```

```
( SCR 3 - TV alg for 5 vars using double numbers )

: TVCOLM 65535.          ( makes 5 ints, 1 for each column )
         2dup H 2! 2 4 16 256
         8 0 do N I + ! 2 +loop
         8 0 do
           H 2@ 2dup N I + @ D* xv 2dup H 2!
         2  +loop
         q 2! r 2! s 2! t 2! u 2! ;

: ?V     2dup 8589934591. D= if ( outputs decision )
                  ." TAUTOLOGY - VALID " drop drop else
         0. D= if ." CONTRADICTION - INVALID "     else
                  ." CONTINGENT - INVALID "   then then ;
```

FULLY INTERACTIVE
fig-FORTH

LARS-ERIK SVAHN - TYRESO, SWEDEN

Would you like to use all Forth words from the interpreter—including words like DO, IF, and BEGIN? Without having to redefine them? Then just patch QUIT and ?COMP as described below.

First of all, you have to reserve a block of memory:

THERE (-- adr)
  address of reserved memory
SIZE (-- #bytes)
  number of bytes reserved

It really doesn't matter how you do this, but there are two obvious ways:

```
512 CONSTANT SIZE
0 VARIABLE THERE SIZE 2- ALLOT
```

In this case, you put the field in the word list. Another way is to permanently decrease the number of screen buffers by one. In my system, that could be done like this:

```
1028 CONSTANT SIZE
FLUSH SIZE MINUS LIMIT$ +!
LIMIT CONSTANT THERE
```

In this memory, all nested blocks of words that begin with a word containing ?COMP will be precompiled and executed when interpreted! Now you can do conditional loading (as in screen 3) and alternative loading (as in screen 4).

The principles are:

(1) every leading structure word (e.g., DO, IF, and BEGIN) starts with ?COMP, and (2) every leading structure word pushes a value on the stack (to be checked by ?PAIRS).

The PRECOMPILE routine compiles every word from the first structure word to the last, and the last structure word pops the stack back to the initial level, thereby exiting the WHILE loop in PRECOMPILE.

When a structure block has been compiled THERE, PRECOMPILE makes it execute by pushing THERE on the return stack. PRECOMPILE, itself, runs every time a word containing (the patched) ?COMP is interpreted.

There are no special limitations to nesting different structures, since the code is

(Continued on page 36.)

```
scr #1

 0 ( Interpretive fig-FORTH; Lars-Erik Svahn jan86)
 1 DECIMAL 0 VARIABLE OLDP
 2 : >THERE ( -- ) !CSP HERE OLDP ! THERE DP ! ] ;
 3 : THERE? ( -- f ) THERE SIZE + HERE < 0= HERE THERE < 0= AND ;
 4
 5 : PRECOMPILE ( -- )
 6     BEGIN SP@ CSP @ <
 7     WHILE -FIND
 8       IF STATE @ < IF CFA , ELSE CFA EXECUTE THEN
 9       ELSE HERE NUMBER DPL @ 1+
10         IF [COMPILE] DLITERAL
11         ELSE DROP [COMPILE] LITERAL
12         THEN
13       THEN
14     REPEAT [COMPILE] [ ' ;S CFA ,
15 OLDP @ DP ! THERE >R ; -->
```

```
scr #2

 0 ( Interpretive fig-FORTH )
 1
 2 : PREPARE ( -- ) >THERE
 3     R> R> ' PRECOMPILE >R >R >R ;
 4
 5 : (?COMP) ( -- ) STATE @ 0=
 6     IF PREPARE THEN R> DROP ;
 7
 8 : (QUIT) ( -- ) THERE? IF OLDP @ DP ! THEN ( new part )
 9     0 BLK ! [COMPILE] [ ( old QUIT )
10     BEGIN CR RP! QUERY INTERPRET
11       STATE @ IF ." ok" THEN
12     AGAIN ;
13
14 ( And now - the patch! )
15 ' (QUIT) DUP NFA FENCE ! CFA ' QUIT ! ' (?COMP) CFA ' ?COMP
```

```
scr #3

0 ( Load screen ) DECIMAL
1
2 -FIND TEST IF DROP DROP ELSE 40 LOAD THEN
3
4 50 40 DO I LOAD LOOP ;S
5
```

```
scr #4

 0 ( Menu screen ) DECIMAL
 1
 2 ." MENU" CR CR
 3 ." 1 alternative A" CR
 4 ." 2 alternative B" CR
 5 ." 3 alternative C" 2 SPACES
 6
 7 BEGIN KEY CASE ASCII 1 OF 10 LOAD ENDOF
 8                ASCII 2 OF 20 LOAD ENDOF
 9                ASCII 3 OF 30 LOAD ENDOF
10                    DUP OF 7 EMIT 0 START ! ENDOF
11           ENDCASE START @
12 UNTIL CR CR START @ EXECUTE ;S
13 It is a good idea to start the execution of the loaded
14 words outside the precompiled block! Then there is no
15 importante code left THERE.
```

EXTENSIONS
FOR F83

ANTHONY T. SCARPELLI - PORTLAND, MAINE

This article explains a number of new screens I created for F83. They cover a wide range of subjects. Two are a revamp of the screen checksum calculation presented in *Forth Dimensions* some time ago, but here are modified to compensate for the special words of F83. Others include a special set of words to access some of the BIOS and PC DOS interrupts. There are also screens that allow you to set and print the date and time, so they can be inserted into your index and screen lists.

One of the first things we need is a set of words that can utilize the BIOS and DOS interrupts. In this way, we have at our disposal a host of routines for most any purpose. I did not want to use the few simple interrupt calls available in F83, but a set that would be more versatile.

In screen #1, we have created our first BIOS word, `INTCALL`. It is not your usual BIOS call word, since it looks like it only calls interrupt 0. But we don't really use it for that purpose. The 0 is actually the location where we install any interrupt number we want. So, first, we create a variable `INTADR` to hold the address of that location in the word. Next we create a code word `INTCALL` that pops four numbers off the stack and puts them into their respective registers. We save the two registers, SI and BP (by necessity), and then see the `0 INT`.

This is where the interrupt number will go. It is nine bytes from the beginning of the code field address. We then return BP and SI, and push all the registers back onto the stack.

To use this routine, we merely put all the required register values on the parameter stack, as well as the interrupt number. What is left, after the word is used, are all the registers — intact, so that any one or more returned values can be used.

This, then, is our basic word to call any BIOS interrupt.

The routine in line 9 finds the address of `INTCALL`, adds nine to it, and saves it. Finally the word `BIOSINT` is created. It merely finds the interrupt number on top of the stack and places it in the byte before the `INT` instruction. Thus, we have made a universal call word that can handle almost any interrupt need.

To show this, screen #2, creates some general routines that all have a similar structure; they only differ in what they leave behind. The use of any of them is determined by which interrupt you are using, and which registers you need returned.

The word `FUNCREQ` in line 12, for instance, is used for the BIOS call 21H, that requires a function number in the AH register, and some value in the DX register. It leaves the AX register on the stack.

As some other examples, I've created some more handy words that demonstrate how these interrupt words can be easily used. Screen #3 has two very handy words that get the time and date. The word `GETTIME` in line 4 first calls function request 2CH via interrupt 21H. It leaves the time on the stack, which can be cleaned up for various uses. Some later words show how this can be done.

The word `GETDATE` in line 9, in a similar manner, leaves the date.

There are two words in the next screen that either must be in your dictionary, or they must be loaded in with their own screen. They are `"MONTH` and `"DAY`. They are found in F83's `CLOCK.BLK`, screen #2. The word that creates these arrays, `"ARRAY`, must also be available.

Screen #4 uses the `GETTIME` and `GETDATE` words to form two more usable words. The word `(DATE)` in line 2 first gets the date, prints the month (from the `"MONTH` array), and then prints out the day, a comma, and then the year. The word `DATE` in line 12 merely adds a space. Thus, this word can then be used when printing out a listing of screens.

The word in line 8, `(TIME)` works in a similar manner, but first determines whether the time is after noon or not, then adjusts for 12-hour timekeeping. The hour is printed, a colon, and then the minute (after we add a zero if the number is less than ten). This is just to keep the alignment correct. Finally we determine whether we are in the a.m. or p.m. with the word in line 5, and print it. The word in line 13, `TIME`, is the general-use word and adds a space. This word, and the `DATE` word above, make documenting screen and index listings a breeze. No longer do you need to hand-print the date and time.

To show how the date and time can be easily added to an index listing, screen #5 shows my word called `PINDEX` (Print Index). The word on line 2, `ITITL` (Index title), first prints the file name, and then the date and time. The `PINDEX` word on line 5 includes my word `PRINT`, which turns on the printing command. It is defined as `PRINTING ON`. The word `CRT` is defined as `PRINTING OFF`. These words go back to when all I used was MMS-FORTH. It's hard to change some habits that seem so logical. The word `FF` is a form feed, and is

defined as 12 EMIT 12 EMIT.

These words are all right as long as you have already set the date and time from DOS. But if you haven't, you need some words to set the time and date from Forth. That is done with the two words in screen #6.

The word INPUT? in this screen is also from F83's CLOCK.BLK, screen #4, and is used to get the numbers we need for the set words. If you have this word already in your dictionary, you won't need to load it; otherwise, place it at the beginning of this screen.

The word SET-DATE is a continuous loop that won't exit until you input the correct form for the date. That is, as an example, you can't enter 13 for a month or 32 for a day. In line 4, after the BEGIN, we set up some of the parameters for the interrupt. We next get the year, month, and day, and adjust them for interrupt 33D, function 43D. This interrupt leaves a zero for a valid date, and an FFH if the date is invalid. We then will get an error message if we don't put in the right data.

The word in line 10, GET-TIME, works in a like manner; however, it waits for you to press a key to set the time. This allows for a more accurate setting of the time, which can be down to the second.

There is one other time word I find useful. That word allows us to time intervals. To do that to a greater degree than the TIME word, we use all the stack values that are left by the GETTIME word. This allows accuracies to 1/100 second. The word is in line 2 of screen #7. Of course you have to allow for various timing inconsistencies in any use of this word, but it will allow for the timing of the execution of loops, words, etc.

The next word I had to develop, on a lower level, was for stopping the system when it was executing various words. That is, I needed a true Control-Break routine that would cause a jump to the warm-start word. The screen #8 shows how this was done.

F83's warm start can be executed by either typing the word WARM, or it can be jumped to via a vector that is located at offset 0103H. The jump has to be done with machine code, so in line 10 we create an interrupt routine called INTRTN. We use the LABEL word to create it, so the address of the routine is left on the stack when we use it.

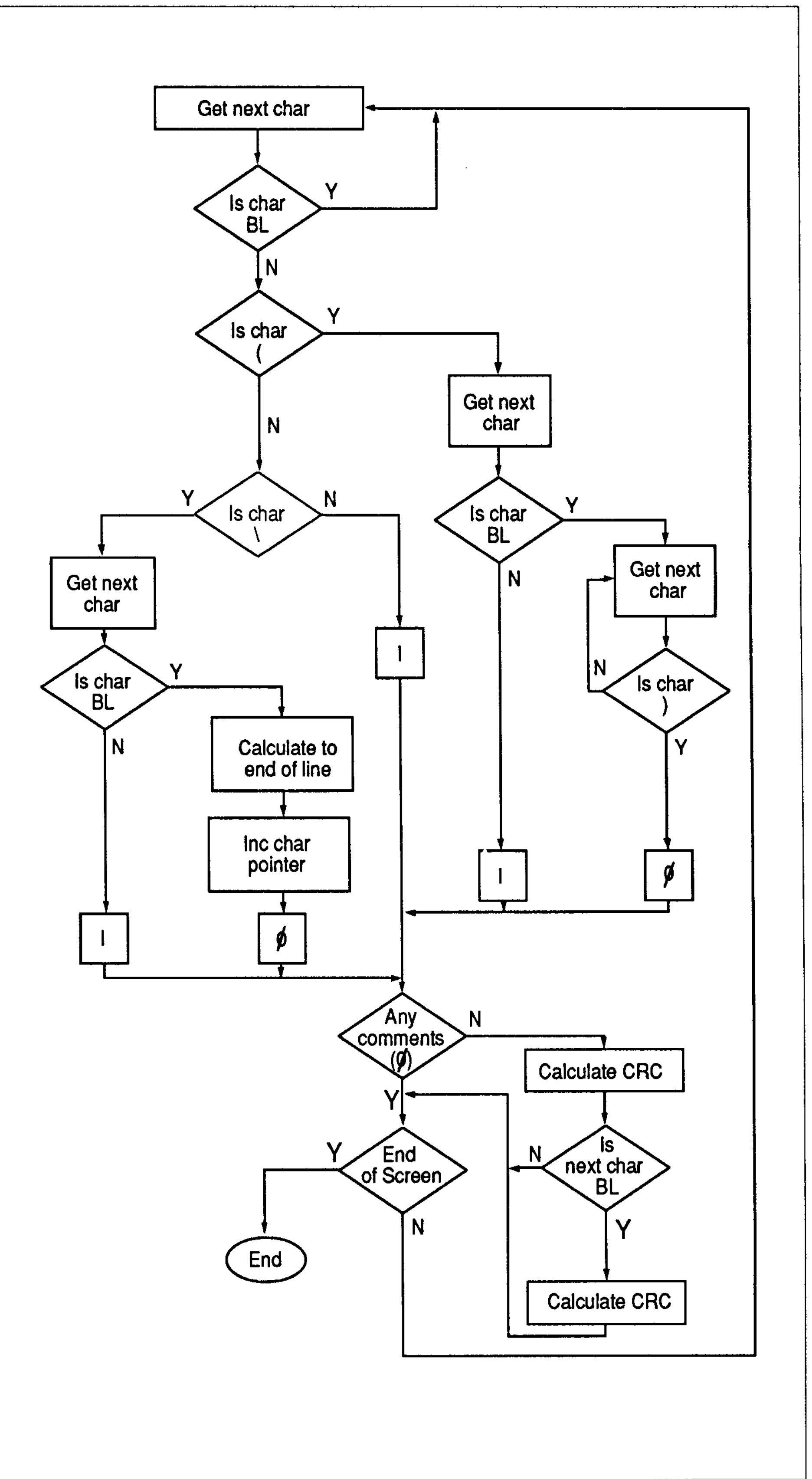

Figure One. Checksum flow chart.

```
Screen # 1              crc ver = 17675

 0 \ BIOS INTERRUPTS -- intcall                            09FEB86ats
 1
 2 HEX
 3 VARIABLE INTADR
 4 CODE   INTCALL  DX POP   CX POP   BX POP   AX POP
 5                 SI PUSH  BP PUSH  0 INT
 6                 BP POP   SI POP
 7                 AX PUSH  BX PUSH  CX PUSH  DX PUSH
 8                 NEXT  END-CODE
 9 ' INTCALL  9 +  INTADR !
10
11 : BIOSINT  ( ax bx cx dx int# -- ax bx cx dx )
12            INTADR @  C!  INTCALL ;
13
14
15 DECIMAL        -->
Screen # 2              crc ver = 23233

 0 \ BIOS INTERRUPTS -- int0,1,2,3, funcreq                09FEB86ats
 1
 2 HEX
 3 : INT0   ( ax bx cx dx int# -- )
 4            BIOSINT 2DROP 2DROP ;
 5 : INT1   ( ax bx cx dx int# -- ax )
 6            BIOSINT 2DROP DROP ;
 7 : INT2   ( ax bx cx dx int# -- cx dx )
 8            BIOSINT ROT DROP ROT DROP ;
 9 : INT3   ( ax bx cx dx int# -- ax bx )
10            BIOSINT 2DROP ;
11
12 : FUNCREQ  ( func# dx -- ax   !  int 21 )
13            SWAP 100 * SWAP 0 0 ROT 21 INT1 ;
14
15 DECIMAL   -->
Screen # 3              crc ver = 47261

 0 \ DOS FUNCTIONS -- gettime & getdate                    09FEB86ats
 1
 2 HEX
 3
 4 : GETTIME  ( -- 1/100sec seconds minutes hours )
 5            2C 100 * 0 0 0  21 INT2
 6            DUP  00FF AND  SWAP 100 /
 7            ROT DUP  00FF AND  SWAP 100 / ;
 8
 9 : GETDATE  ( -- year day month )
10            2A 100 * 0 0 0  21 INT2
11            DUP  00FF AND  SWAP 100 / ;
12
13 DECIMAL
14
15 -->
```

```
Screen # 4              crc ver = 40071

 0 \ date & time                                               06JAN86ats
 1
 2 : (DATE)    ( -- date )   GETDATE
 3    1- "MONTH TYPE  SPACE  (U.) TYPE  ." , "  (U.) TYPE  ;
 4
 5 : ?AM/PM    ( -- )    11 >
 6    IF ." pm" ELSE ." am" THEN  ;
 7
 8 : (TIME)    ( -- time )   GETTIME
 9    DUP  DUP  12 >  IF 12 - THEN  (U.) TYPE ." :"  SWAP
10    DUP 10 < IF ." 0" THEN (U.) TYPE  ?AM/PM  DROP DROP ;
11
12 : DATE    ( -- mon day, year )   (DATE) SPACE ;
13 : TIME    ( -- hour:min am/pm )   (TIME) SPACE ;
14
15 -->
Screen # 5              crc ver = 43911

 0 \ EXTENSION WORDS -- pindex                                 09FEB86ats
 1
 2 : ITITL    CR  ." INDEX FOR:    "  FILE?
 3           20 SPACES  DATE  SPACE  TIME ;
 4
 5 : PINDEX    ( from to -- )
 6   PRINT   ITITL  CR  INDEX   FF  CRT ;
 7
 8
 9
10
11
12
13
14
15 -->
Screen # 6              crc ver = 25080

 0 \ DATE AND TIME -- set-date, set-time                       09FEB86ats
 1
 2 : SET-DATE    ( -- )     BEGIN   43 256 *  0
 3    CR ." Year? " INPUT? DROP
 4    CR ." Month? " INPUT? DROP  256 *
 5    CR ." Day? " INPUT? DROP  OR  33 INT1  255 AND
 6    IF CR ." Invalid date!" 0  ELSE -1 THEN  UNTIL  ;
 7
 8 : SET-TIME    ( -- )     BEGIN   45 256 *  0
 9    CR ." Hour? " INPUT? DROP  256 *
10    CR ." Minute? " INPUT? DROP  OR
11    CR ." Second? " INPUT? DROP  256 *
12    CR ." Hit any key to start." CR  KEY DROP  33 INT1
13    255 AND  IF CR ." Invalid time!" 0 ELSE -1 THEN  UNTIL ;
14
15 -->
```

```
Screen # 7              crc ver = 16488

 0 \ INTERVAL TIME -- itime                                  09FEB86ats
 1
 2 : (ITIME)    ( -- time )    GETTIME
 3    (U.) TYPE  ." :"  (U.) TYPE  ." :"
 4    (U.) TYPE  ." :"  (U.) TYPE ;
 5
 6 : ITIME    ( -- hr:min:sec:1/100s )    (ITIME) SPACE ;
 7
 8
 9
10
11
12
13
14
15 -->
Screen # 8              crc ver = 22508

 0 \ CTRL-BREAK SCREEN                                       09FEB86ats
 1
 2 \ The warm start vector is at location 0103H. By jumping to it,
 3 \ you can execute the WARM word which initiates a warm start.
 4 \ In order to allow the keyboard CTRL/BREAK to use this vector,
 5 \ it has to be installed into the DOS interrupt vector table via
 6 \ an interrupt routine which can be done by the SETINT word.
 7
 8 HEX
 9
10 LABEL  INTRTN   STI  20 # AL MOV  20 # AL OUT  ( send EOI )
11                 0103 #) JMP   ( jump to WARM vector )  FORTH
12 : SETINT   ( set the interrupt address into interrupt vector )
13          2523 0 0 INTRTN 21 INTO ;
14
15 SETINT   ( Execute it )      DECIMAL          -->
Screen # 9              crc ver = 65086

 0 \ CHECKSUM FOR SCREENS  --  1                             17JAN86ats
 1   VARIABLE BADDR   VARIABLE CHRCNT
 2 : GETBLOCK   ( block # -- )  BLOCK  BADDR !  -1 CHRCNT ! ;
 3 : GETCHR   ( -- chr )  BADDR @  CHRCNT @  +  C@ ;
 4 : DECCNT   -1 CHRCNT +!  1 ;
 5 : GETNXTCHR   1 CHRCNT +!  GETCHR ;
 6 : CHKEND   CHRCNT @  1023 >= ;
 7 : ?<>BL   BEGIN  GETNXTCHR  BL = NOT  CHKEND  OR  UNTIL ;
 8
 9 : ?(    GETCHR  40 = ;
10 : ?)    BEGIN GETNXTCHR  41 =  UNTIL 0 ;
11 : SKIP(   GETNXTCHR  BL =  IF ?)  ELSE DECCNT  THEN ;
12
13 : ?\    GETCHR  92 = ;
14 : SKIPLINE   C/L  CHRCNT @  C/L MOD  -  1-  CHRCNT +!  0 ;
15 : SKIP\   GETNXTCHR  BL =  IF SKIPLINE  ELSE DECCNT  THEN ; -->
```

The first instruction, STI, SeT Interrupt flag, is used to be sure that other interrupts can occur when this routine is called. The next instructions, MOV AL,20 and OUT 20,AL, sends an End Of Interrupt command to the 8259 interrupt controller chip so that other interrupts can be collected by the chip. And, finally, we jump to the warm start vector.

That's the whole interrupt routine. We have to do all these things because, in a normal interrupt sequence, the routine would have to save all registers, and return with an IRET instruction. Since we are not returning from the interrupt routine, certain things must be done — not only those mentioned above, but also the stack has to be cleared. This is done by the warm-start routine. The only things we haven't done is to determine the need for more than one EOI command, and the possibility of having to reset some of the I/O boards. I haven't used this interrupt in all occasions, so if you are having difficulty with this routine, these two things might have to be done.

Next, we have to make sure this routine can be used. To do that we have to insert its address into the control-break interrupt vector. The interrupt vectors are all located starting at 0:0 (segment 0, offset 0), but we don't have to know where the control-break vector is: we have a DOS interrupt that takes care of that. All we have to do is feed it the address of the interrupt routine. Line 12 creates the word that does it. 25H is the function number of the interrupt that does the moving and it goes into the AH register. It transfers the address of our interrupt routine INTRTN (which goes into the DX register), into the interrupt vector table. AL must be loaded with the control break interrupt function #23H. Once the these words have been created, line 15 executes them.

This screen should be one of the first that gets loaded to be sure the interrupt can occur early on. Then whenever you press the Control-Break key combination, you should see a "warm start" message. Thus, you should be able to break out of most I/O operations. Some notes, though: if you don't load this screen to compile it (that is, if you were to make this screen part of your system by metacompiling it), you have to execute this SETINT word some other way so that it will take effect. Also, it is a good idea to set the DOS BREAK ON command before you enter Forth. This will ensure that a Control-Break will operate whenever a program requests any DOS function. If it is not set, Control-Break is checked only on standard I/O operations. You can automatically set this command 'on' during boot-up by creating a CONFIG.SYS file that specifies BREAK=ON. Also note that if your computer runs away, a Control-Break may not work at all, whereas a system reset, or even a power-up reset, may be the only way to get running again.

Back a long time ago in *Forth Dimensions* (IV/3), Klaxon Suralis and Leo Brodie had an article called "Checksum for Hand-Entered Source Screens." The article concerned itself with the fact that, when you enter screens by hand, you can make typing mistakes. They suggested a method to calculate a checksum for a screen and print it before the screen is listed. Thus, after you enter your own screen you can compare the checksum with that of the original, and if they differ you know that, somewhere, there could be a typing mistake. All you have to do is compare the screens to find the error. The program skips over comments and spaces, so they won't be counted in the total.

The program was such a good idea, I have been using it ever since the article. When I got F83 however, I found a few new words that messed up the checksum. One of the words used a lot in F83 screens is \. This allows a comment on a line and causes compiling to skip to the end of the line. After trying to modify Suralis' and Brodie's program to compensate for this word and finding, for myself, no easy way of doing it, I decided to rewrite the program to fix the problem.

The way I did it was to count characters. There not only are no line delimiters in an F83 screen, but there are no screen delimiters. So, in order to know where you are in a line when the \ word occurs, you have to be able to count characters in order to get to the end of the line.

To show how I developed the program, take a look at the flow chart for the program which is shown in Figure One. The first thing we do is get the character in the text stream and check to see if it is a blank. If it is, we get the next character. If the character is a (we have to check to see whether it is a true comment or not by checking the next character. If the character is a blank, we know it is a comment and can skip to the) word.

If we don't have a (comment we check to see if the character is a \ word. We also have to see if the next character is a blank, which would indicate a comment. If it is, we can then calculate to the end of the line.

If there were no comments in this check, we can then go to the routine that does the checksum calculation. If the character did turn out to be a comment, we have to check to see if we reached the end of the screen and then start again on the next character. The checksum is the same as that used in the original version, so the end result will be the same.

Screens #9 and 10 contain all the words for the checksum program. In line 1 we define two variables, one to hold the block address of the screen we are checking, and one to hold the running total of the number of characters we have checked. The word GETBLOCK in line 2 not only saves the block address, but initializes the character count to -1, which is necessary since we increment the count before we do any work.

The word GETCHR in line 3 gets the block address, adds the character count offset, and then fetches the character. We also need a word to decrement the count when we are checking for spaces after the (and \ words. That is done, of course, with DECCNT.

GETNXTCHR is self-explanatory, and CHKEND indicates when we have reached the total of 1024 characters in a screen. The word ?<>BL in line 7 asks whether the next character is a blank or not, and will keep on getting a new character until it is either non-blank or the end of the screen.

The three words in lines 9 to 11 are set up to find and skip over (comments. The three words in lines 13 to 15 are set up to find and skip over \ comments. The word SKIPLINE merely calculates the number of characters to the end of the line and increments the character count by that amount.

In screen #10, line 2, we have the same algorithm used in the old version. Thus, we can be sure the results will be the same.

The word in line 6, CHKCHR, combines the words that check for both types of

comments. The word in the next line, CHKWORD, is used because the space after a word has to be included in the checksum calculation.

The word CHKSUM does all the work in the program and requires an initial value of zero on the stack. It will leave the checksum on the stack when it has finished. I have timed both this version and the older version, and though both take a few seconds to do the calculation, my version is slightly longer. When I get more time, I'd like to speed up the process by doing some of the work in assembly code. The time taken is well worth it, though, since errors found save more time in the long run.

The word CRCCHK is the next step in the process. It requires the block number of the screen to check and leaves the checksum. The final word VER is the same as that used in the old version; in this way you don't have to change the name if you use this word in your screen-listing words.

Even though this checksum method checks for the two typical comment words, there are two other words in F83 that it doesn't check for, (S and \S. One indicates a stack comment, and the other jumps to the end of the screen so that numerous lines of comment can be added to the end of a screen. Since I rarely use these words, I felt the time to add them to the program was not worth it to me. If you wish to add them, the method I used in the checksum program makes it not too difficult to do. Let us all know how you did it, if you decide to add them.

I have shown in this article a number of words I have created to do a number of low-level and high-level operations. Especially important and interesting are the ones that get to the BIOS and DOS interrupts. These words allow you to do many new things with Forth that make programming a lot easier.

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```
Screen # 10              crc ver = 55006

 0 \ CHECKSUM FOR SCREENS  --  2                          12JAN86ats
 1
 2 : CALCCRC  ( oldcrc chr -- newcrc )  256 * XOR  8 0 DO  DUP 0<
 3   IF 16386 XOR DUP +  1+ ELSE  DUP +  THEN  LOOP ;
 4
 5
 6 : CHKCHR   ?(  IF SKIP(  ELSE ?\  IF SKIP\  ELSE 1  THEN THEN ;
 7 : CHKWORD   GETNXTCHR  BL =  IF BL CALCCRC  THEN  DECCNT DROP ;
 8
 9 : CHKSUM   BEGIN  ?<>BL  CHKEND NOT  IF  CHKCHR
10   IF GETCHR  CALCCRC  CHKWORD  THEN  THEN  CHKEND  UNTIL ;
11 : CRCCHK   ( block # -- crcvalue )  GETBLOCK  0 CHKSUM ;
12
13 : VER   SCR @  CRCCHK  U. ;
14
15
```

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STEP UP TO PROCESSING ARRAYS WITH REVERSE POLISH!

Wayland Software Systems, an innovator in processing arrays with Reverse Polish Notation, announces a new interpreter, vector Rudimentary Language (vecRL). It is now available in pre-release form for people interested in experimenting with this new approach. Right now vecRL operates under DOS, but eventually it will become a stand-alone DOS compatible operating system. You can own either the source or the object at a very reasonable cost.

VecRL is metacompiled with several arithmetic vocabularies, and more to come. For example, + under the I vocabulary adds untyped 16 bit integers while + under the L vocabulary adds untyped 32 bit long integers. The untyped arithmetic vocabularies, C I L E, provide full FORTH capabilities of 8, 16, 32 bit processing and 16 bit pointers respectively.

Arithmetic vocabularies are under development that process typed array data. For example, the + under the i vocabulary will add 16 bit integer arrays element by element while + under the l vocabulary adds 32 bit long integer arrays element by element. The + under the v vocabulary will add typed arrays element by element using the appropriate addition. These array arithmetic vocabularies will be available in later versions.

Wayland Software Systems offers VecRL because it improves programmer and computer performance. Please call or write for details.

Wayland Software Systems
Advancing the Processing of Arrays with Reverse Polish

10 Shore Drive
Wayland Mass. 01778 USA
(617) 877-9099

(Continued form page 27.)

compiled just as it normally would have been.

Perhaps it seems to be a bit wasteful of memory, to have a field like the one THERE. But I often need just such a field, to be used temporarily. You can use it — with care — instead of the restless PAD field. The patches don't change the normal behavior of the system, in case of normal compiling or normal interpreting. It is still a Forth system!

However, the method does have some limitations:

1. You cannot interpret structures that nest ?EXEC words. For example:

```
IF : TASK ; THEN
```

will not work, since PRECOMPILE tries to compile the word : (which is prohibited by ?EXEC).

2. You must be careful with the code compiled THERE, while it is still running. For example, if you interpret a structure that nests the sequence

```
QUERY INTERPRET
```

and you try to interpret a ?COMP word by this sequence, it will overwrite the code that already runs THERE, and the system will probably crash.

Interpret Forth!

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(Continued from page 20.)

DM: That's what you have to do to be in the game, I felt.

MH: [to Lori] How did you get into this game?

LC: It started when I took programming in school and liked it. It's rare to find something you really like to do. I don't think I have the entrepreneurial spirit that Rick does, but it's definitely something I like doing.

MH: What about it do you like?

LC: The programming, and — we have a high sense of responsibility, and that comes out. You feel you have a direct effect on what happens.

MH: And that's the part you like — seeing your Machs going out the door?

LC: Yes, and you don't see that in a big company. Rarely do you see it.

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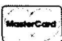

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