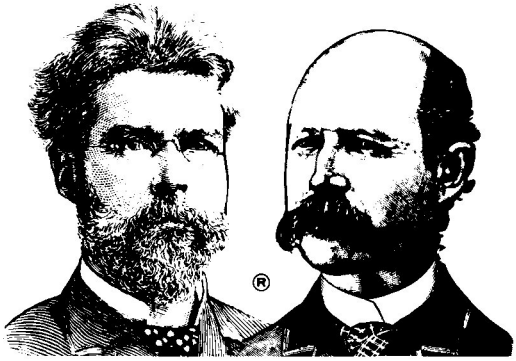
The Beagle Compiler

by ALAN BIRD



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APPLESOFT SPEED-UP PROGRAM

by Alan Bird

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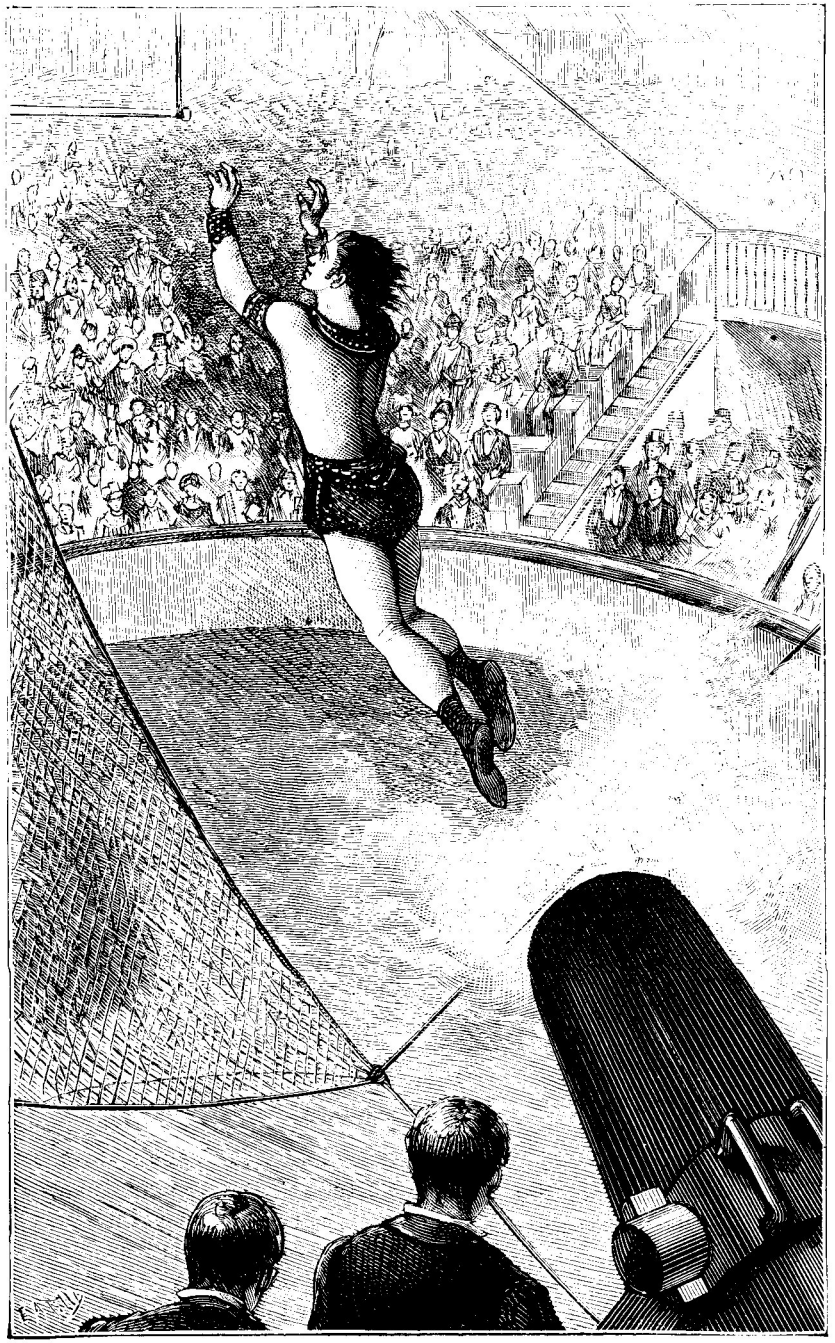
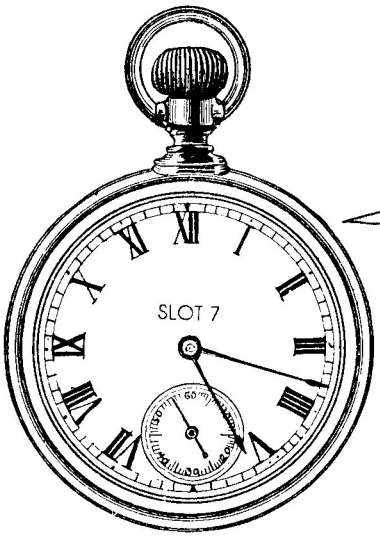


BEAGLE COMPILER AUTHOR, ALAN BIRD, LEAVES FOR WORK

WELCOME TO THE BEAGLE COMPILER!

The Beagle Compiler does one thing–it rewrites Applesoft BASIC programs so they run faster, just as if they were written in machine language. Machine language programs run much faster than Applesoft programs because no time is wasted interpreting "human" commands like HOME, GOTO, IF, THEN, and so on. While the Beagle Compiler doesn't actually convert programs into machine language (it actually converts them into its *own* language), the effect is the same.

Applesoft BASIC may be slower than machine language, but it is far easier (for most of us) to write programs with–and it's easier to read. The Beagle Compiler gives you the best of both worlds–easy-to-write programs *and* machine language speed.




```
1 RESTORE: FOR X=1 TO 5:
  READ A: PRINT CHR$(A);:
  NEXT: S=PEEK(49200): GOTO 1
2 DATA 84,73,67,75,32
```

BACK IT UP

The Beagle Compiler disk is not copy-protected, so you can (and should) make a backup in case something happens to the original. Use the copy program that came with your Apple, or the 35-second DISK.COPY program from our Extra K disk. You may also transfer files from disk to disk using our Big U disk's FILEMOVER program or one of Apple's utilities.

Please don't give copies of our disks and programs away to your friends. Every illegal copy is a vote for copy protection and against friendly software. If you plan on giving copies of your own compiled programs away, read page 6.

COMPILER FACTS

Just like it says in the ads, "after you boot the Beagle Compiler disk, you can run almost any Applesoft program at machine language speed. *FAST!*"

HOW FAST IS IT?

Unscientific testing shows that compiled programs tend to run between 2 and 15 times as fast as Applesoft programs; it depends on what the program actually does. Some functions like string and variable manipulations show a tremendous speed increase. Other things like floating point calculations aren't affected at all.

WHEN SHOULDN'T YOU COMPILE?

Machine language speed isn't always an advantage–some programs, like question-and-answer programs, work just fine in plain old Applesoft. Too much speed will make many programs impossible to use.

Some programs that benefit from compiling may have certain sections that will need to be slowed down. Since you can't compile just part of a program, you'll have to make adjustments in Applesoft before compiling.

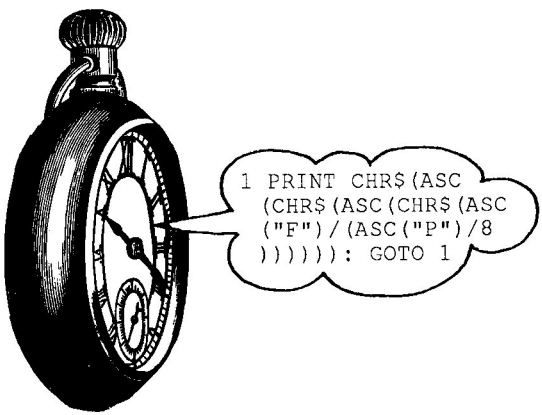
WHEN CAN'T YOU COMPILE?

Most Applesoft programs compile with ease. Occasionally, a program will be too large to compile or contain commands that are incompatible with the compiling process.

Non-Applesoft programs won't compile. (You can't compile AppleWorks for example–it isn't written in Applesoft).

Copy-protected programs won't compile unless you unprotect them first. Don't ask us how–we don't know how.

DOS 3.3 programs will usually compile after you convert them into ProDOS (use one of Apple's programs to do the converting). Make sure a converted program works *before* you compile it.



SPECIAL BENEFITS OF THE BEAGLE COMPILER

The Beagle Compiler is better than any compiler we've ever seen. And we've seen a few.

- Other compilers do not support ProDOS.
- Other compilers will not compile programs "on the spot" using the standard RUN command.
- Other compilers produce code that is significantly larger than the original program. The Beagle Compiler does the opposite.
- Other compilers take minutes instead of seconds to convert programs. And then you still might have problems.
- Other compilers choke on common Applesoft statements like HIMEM, LOMEM, DEF FN, etc.
- Other compilers require many more program changes than the Beagle Compiler requires. For example:

```
10 MAX=100:DIM A$(MAX),B$(MAX),C$(MAX*2)
```

Other compilers would look askance at the above program line and make you change it to:

```
10 MAX=100:DIM A$(100),B$(100),C$(200)
```

Then you have to recompile.

THERE ARE SOME MEMORY RESTRICTIONS

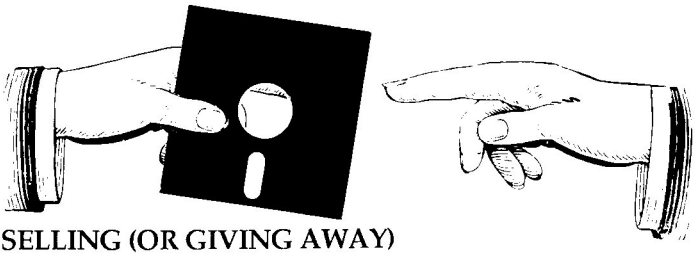
Booting the Beagle Compiler disk will cost you about 11K of main memory. You can cut this figure in half by loading only one of the Compiler's two files–see page 26.

ABOUT PROGRAM EDITORS

Most Applesoft programmers use some kind of program editor. Unfortunately, you cannot have non-relocatable programs like Beagle Bros' **G.P.L.E.** (Global program Line Editor) in memory with the COMPILER.SYSTEM file–sorry, there just isn't room. However **PROGRAM WRITER** by Alan Bird (!) will work just fine.

If you are hooked on G.P.L.E., boot normal ProDOS to use G.P.L.E. to write and test programs, then boot the Beagle Compiler to run them at compiled speed. The COMPILER file (see page 26) *can* be in memory with G.P.L.E. as long as you install G.P.L.E. first, *then* the COMPILER file.

To use PROGRAM WRITER, you must install things in the proper order: (1) the COMPILER.SYSTEM file, (2) PROGRAM WRITER–language card version, (3) the COMPILER file.



SELLING (OR GIVING AWAY) COMPILED PROGRAMS

You may legally sell or give away copies of programs that you own and have compiled with the Beagle Compiler. Since the Compiler itself is protected by copyright laws, the recipient of your programs must use his or her own purchased copy of the Compiler to run them.

There is an alternative: If you want to include the Beagle Compiler's COMPILER.SYSTEM file on disks that you will be selling or giving away, you may do so after paying a very reasonable licensing fee to the Compiler's author, Alan Bird. Call or write for more information:

The Software Touch
c/o Compiler Licensing
9625 Black Mountain Road, #204
San Diego, California 92126 282-7161

Or phone The Software Touch: (619) 549-3091

After a licensing contract has been signed and fees paid, only the file COMPILER.SYSTEM may be put on the disk you are selling or giving away. This is the file that actually runs compiled programs. Under no circumstances are you permitted to include the COMPILER file on disks that you sell or give away.

License Fee - $50 year

Tech
619-452-5502 ↔

Not Compatible with Graphics
Beagle Graphics
Xtra K

IS THIS MANUAL UP TO DATE?
RUN NOTES NOW TO FIND OUT.

Run the Applesoft NOTES program on the Beagle Compiler disk to learn about any changes or corrections that apply to this instruction manual.


```
1 FOR A=800 TO 811:
  READ B: POKE A,B:
  NEXT: CALL 800
2 DATA 185,208,208,
  9,128,32,237,253,2
  00,76,32,3
```

THE BASIC FACTS

In writing this manual, we assume you know the "basics" about loading and saving files, running Applesoft programs and so on. Even if you don't, you still should be able to reap most of the benefits of the Beagle Compiler by reading pages 1-15.

We highly recommend Apple's excellent programming manuals, especially the *Applesoft BASIC Programmer's Reference Manual* and *ProDOS User's Manual*.

HOW TO USE THE BEAGLE COMPILER

RULE #1: APPLESOFT PROGRAMS ONLY

The Beagle Compiler only works with unprotected ProDOS-based Applesoft BASIC programs. You must have a copy of the program you want compiled saved on a ProDOS disk.

When you catalog a disk (by typing **CAT**), "BAS" identifies a file as being Applesoft BASIC:

```
/SAMPLE.DISK
 NAME      TYPE
 FILE.A     BAS   ⇐You can compile BASIC programs.
 FILE.B     BIN   ⇐You can't compile binary files.
 FILE.C     TXT   ⇐You can't compile text files.
 FILE.D     SYS   ⇐Forget it.
 FILE.E     VAR   ⇐Ditto.
 FILE.F     COM*  ⇐Here is a program that has been
                     saved in compiled format.
```

*COM will read as "INT" if the Compiler isn't in memory.

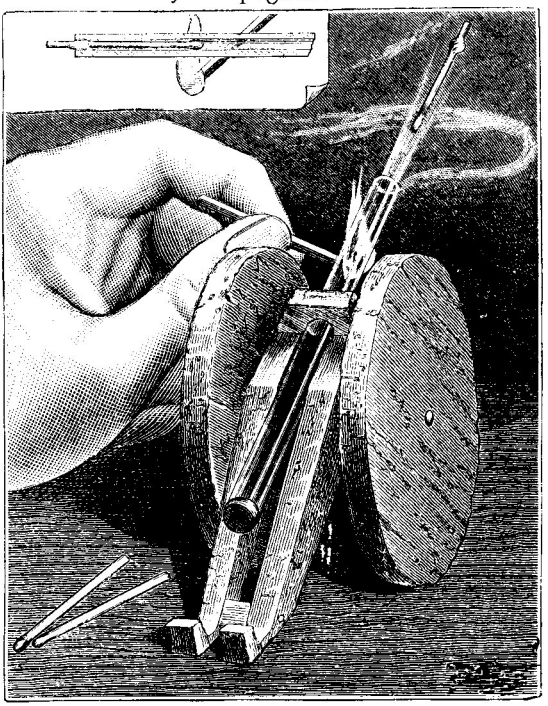
RULE #2: BE SURE THE COMPILER IS INSTALLED

The Compiler's commands won't work until you "install" the Compiler in your Apple's memory. The easiest way to do this is to BOOT THE BEAGLE COMPILER DISK (put the disk in your main drive and turn on your Apple).

There are other ways to install the Compiler that save memory and/or disk space–see pages 26 and 27.

RULE #3:
WATCH OUT FOR CERTAIN THINGS

- ProDOS's CHAIN, STORE and RESTORE commands make programs require special treatment–see pages 18 and 19.
- **Ampersand (&) statements** with parameters and the routines that they call must be altered by someone with assembly language experience–see page 20.
- **Some Applesoft commands** are not compilable–specifically CONT, DEL, LIST, LOAD, NOTRACE, RECALL, SAVE, SHLOAD, TRACE and STORE (*ProDOS's* LOAD, SAVE and STORE *will* compile). Removing any of these commands will not harm 99.6502% of the programs we have seen.
- **Weird memory pokes** are unpredictable. If the program you want to compile pokes values into Zero Page or BASIC.SYSTEM or some other exotic place, go ahead and try compiling–if you're lucky, you'll have no problems at all.
- **Giant Applesoft programs** are usually compilable if you compile them to disk without the COMPILER.SYSTEM file in memory–see page 27.



EXPERIMENT WITH TESTPROGRAM

There is a short Applesoft program called TESTPROGRAM on the Beagle Compiler disk. No big deal, but it uses a lot of Applesoft commands and serves as a good demo of how the Compiler works. In the examples on the following pages, almost any Applesoft program may be substituted for TESTPROGRAM.

HOW TO RUN AN APPLESOFT PROGRAM AT COMPILED SPEED

This is easy. First, be sure the Compiler is installed in memory (it is if you have booted the Beagle Compiler disk). Now just run your program like you always do, by typing:

RUN NAME

or **-NAME**

*(**NAME** is the name–or pathname–of your Applesoft program.)*

After a brief "COMPILING..." message, your program should be running at machine language speed. If this isn't the case, the Compiler probably isn't installed. If you see an error message on the screen, read pages 20-22.

Since compiled programs have no line numbers, the ProDOS command **RUN NAME,@123** will not work (123 represents any program line number).

QUITTING A PROGRAM

You can often quit an Applesoft program by pressing **Control-C**. This might *not* work, however, when you're running at compiled speed (see page 12 for a quick fix).

Control-Reset will almost always let you quit. Some programs, however, are written so you can't quit no matter what, and you may need to reboot to escape.

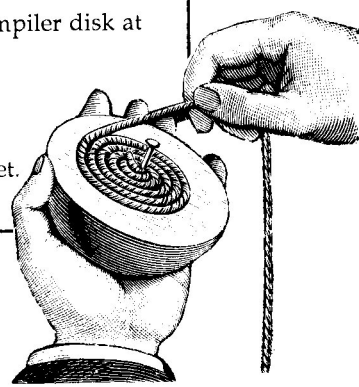
RE-RUNNING A PROGRAM

After you quit running a compiled program, you may type **RUN** to re-run it. If you get a NOT A COMPILED PROGRAM error message, something has disturbed the compiled program in memory.

EXAMPLE

To run TESTPROGRAM from the Beagle Compiler disk at compiled speed:

1. Boot The Beagle Compiler disk.
2. Type **RUN TESTPROGRAM**
   or type **-TESTPROGRAM**
3. To stop the program, press Control-Reset.
4. Type **RUN** to run TESTPROGRAM again.



HOW TO SAVE A PROGRAM ON DISK IN COMPILED FORMAT

To save a compiled version of an Applesoft program on the current disk, type:

```
COMPILE NAME,NEWNAME
```

*(**NAME** is the name–or pathname–of your Applesoft program on disk. **NEWNAME** is the name–or pathname–for saving the compiled file.)*

Your Applesoft program will be loaded, compiled and then saved on disk. A FILE TYPE MISMATCH error message here might mean that you used the same name for both files. You *may* use the same name for the compiled file if you are saving onto another disk or directory. For example, you could type:

```
COMPILE /DISK1/NAME,/DISK2/NAME
```

This command would load NAME from DISK1 and save it as NAME on DISK2 in compiled format.

Cataloging the disk will reveal compiled programs as type COM (that's COM for COMpiled instead of BAS for BASic). If you catalog without the Compiler installed, COM will appear as "INT".

EXAMPLE

To save TESTPROGRAM on disk in compiled format:

1. Be sure the Compiler is installed.
2. Insert the Beagle Compiler disk in drive 1.
3. Set the prefix if necessary by typing **PREFIX,D1**
4. Type **COMPILE TESTPROGRAM,TESTFAST**
   This will save a new version of TESTPROGRAM called TESTFAST on the disk. When you catalog the disk (by typing **CAT**), you will see TESTFAST listed as a COM file.

WHY SAVE IN COMPILED FORMAT?

- You save time by not having to wait for compiling each time you run the program.
- You save disk space because compiled files are generally smaller than Applesoft files.
- You save memory space because the COMPILER file (see page 26) doesn't need to be in memory when you run the program.
- Your programs aren't listable and snoopers can't look at them and change them. (This can be a *dis*advantage).

HOW TO RUN A COMPILED PROGRAM FROM DISK

You run a compiled (COM) file from disk the same way you run an Applesoft (BAS) file. Type:

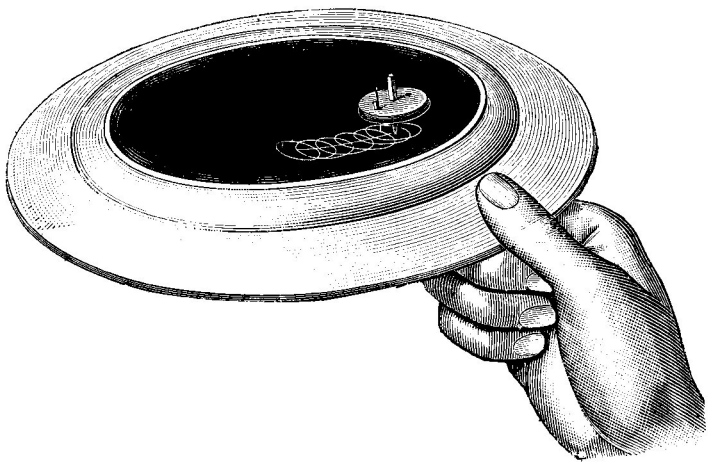
RUN NAME

or **-NAME**

*(**NAME** is the name–or pathname–of your compiled program.)*

> **EXAMPLE**
> To run TESTPROGRAM in compiled format:
> 1. Compile TESTPROGRAM so it creates the COM file TESTFAST (follow the steps in the previous example).
> 2. Type **RUN TESTFAST** or **-TESTFAST**

The COMPILER.SYSTEM file must be installed to run compiled programs (it is if you booted the Beagle Compiler disk). You can save memory by not installing the COMPILER file–see page 27.



HOW TO MAKE A CHANGE TO A COMPILED PROGRAM

You *can't* change a compiled program. Instead, change the Applesoft "source" program (the one you compiled in the first place). Make changes the way you always do, and always be sure to save the changed program to disk before recompiling.

Read the note about program editors G.P.L.E. and PROGRAM WRITER on page 5.

EXAMPLE

To make a change to TESTPROGRAM:

1. Type **`LOAD TESTPROGRAM`**
2. Type **`LIST 10`** to see program line 10.
3. Type **`10 X=5`** to change line 10. This will have the effect of changing the patterns on the screen when the program is running.
4. Type **`SAVE TEST2`** to save the Applesoft change. (Any legal file name may be used.)
5. With the Compiler installed, type **`RUN TEST2`** or **`-TEST2`** to run at compiled speed.
   Or type **`COMPILE TEST2,NEWTEST2`** to save in compiled format.
6. To make more changes type **`LOAD TEST2`** and go back to step 2.

HOW TO MAKE CONTROL-C STOP A COMPILED PROGRAM

Normally Control-C will stop an Applesoft program but have no effect on compiled programs (except in response to INPUT statements). To make Control-C halt a compiled program, add a RESUME statement somewhere in the program you are going to compile. Think twice before using this technique, because it will have the side effect of making your compiled program run somewhat slower.

The RESUME statement has an undesirable effect on Applesoft programs, so you should put it somewhere where it can't possibly get executed–like after the end of your program (END: RESUME).

EXAMPLE

To allow TESTPROGRAM to be halted with Control-C after it is compiled:

1. Type **LOAD TESTPROGRAM**
2. Type **60000 END: RESUME** to add program line 60000. (60000 may be replaced with any line number 1-63999; just be sure the RESUME statement doesn't get executed.)
3. Type **SAVE TESTC** to save the changed version. (Any legal file name may be used.)
4. Type **-TESTC** to run the program.
5. Press Control-C to stop the program.

A NEW ?BREAK MESSAGE

When your compiled program is stopped by Control-C (or a STOP statement or an error), you will see an error message something like ?BREAK AT $0ABC. This tells you the hexadecimal address in memory where the program stopped (instead of which *line number*, because there are no line numbers in compiled programs). See page 23 for more information about this number.

HOW TO RUN A PROGRAM AT NORMAL SPEED

The best way to run a program at normal speed is to remove the Compiler from memory by booting a normal ProDOS disk.

Warning:

The method described below is not guaranteed to work. In fact, with certain programs, it could cause serious problems that require you to reboot.

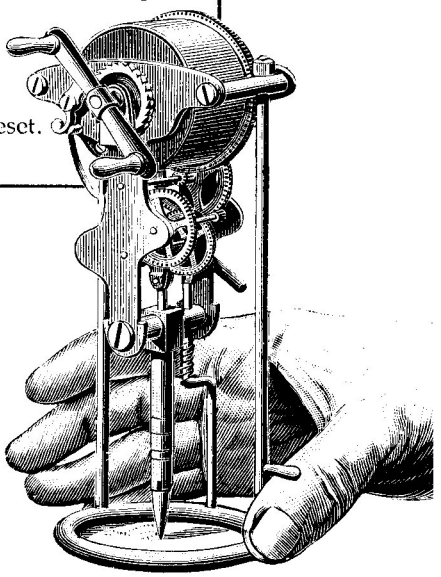
Always SAVE YOUR PROGRAMS before running them!

After taking the warning above into consideration, load an Applesoft program from disk and type **:RUN**. Notice that this command begins with a colon (:). If you omit the colon you'll get a NOT A COMPILED PROGRAM error message.

EXAMPLE

To run TESTPROGRAM at normal speed with the Compiler installed:

0. Read the Warning above.
1. Type **LOAD TESTPROGRAM**
2. Type **:RUN**
3. To quit, press Control-C or Control-Reset.
4. To see it again, type **:RUN** again



HOW TO SPECIFY A NEW ADDRESS FOR A PROGRAM

(for advanced programmers)

Compiled programs normally load and run at address 2049 ($0801), just like Applesoft programs. You may run a compiled program at a different address by changing the Applesoft program before it is compiled.

For example, insert the following line at the beginning of TESTPROGRAM to run it above hi-res page 1 at 16384 ($4000):

```
1 IF PEEK(104)<>64 THEN POKE 16384,0: POKE
  104,64: PRINT CHR$(4)"RUN TESTPROGRAM"
```

Replace the 64's with 96's and the 16384 with 24576 to load the program above hi-res page 2 at 24576 ($6000).

You may also specify an address with a RUN command followed by a comma and the address. The following command will compile and run an Applesoft program–or run a compiled program–above page 1 and page 2 respectively:

```
RUN NAME,A$4000
RUN NAME,A$6000
```

(Note: In this procedure, "RUN" cannot be replaced with a hyphen.)

HOW TO WRITE PROGRAMS FOR MAXIMUM COMPILED SPEED

(for advanced programmers)

The one major point to keep in mind to make compiled programs run faster is avoid using floating point values whenever possible. The Compiler does all of its math using integer values whenever it can–integers process much faster than floating point values.

Floating point is used:

- when a value has a fractional part (i.e. 3.5).
- when a value is greater than 32767 or less than –32767.
- when division is used in an expression.
- when any of the following functions are used:
  ATN, COS, EXP, LOG, RND, SIN, SQR or TAN

BASIC TECHNIQUES DON'T APPLY

The following programming methods DO speed up Applesoft programs but they DO NOT speed up compiled programs (they also don't do any harm).

- Using real variables instead of integer variables.
  (Using A%=3 instead of A=3 will not affect a compiled program's speed.)
- Using variables instead of numeric constants.
  (In a compiled program, A=PI executes no faster than A=3.14159.)
- Putting frequently-executed lines and subroutines near the beginning of a program.
- Putting frequently-used variables near the beginning of a program.

HOW TO COMPILE PROGRAMS THAT USE THE CHAIN COMMAND

The ProDOS CHAIN command works just like the ProDOS RUN command, but existing variables stay intact.

Programs that use CHAIN share common variables and must be given special treatment for compiling to be successful. Otherwise a FILE TYPE MISMATCH error will occur.

All programs involved with a CHAIN command *must* be compiled to disk using the COMPILE command to compile one program and a special COMMON command to compile the other program(s). COMMON's syntax is simlar to COMPILE:

```
COMMON NAME , NEWNAME
```

COMMON must be used *immediately* after COMPILE. If you later make a program change or add a new file that will CHAIN to or from the existing (already compiled) files, you must start over and recompile *all* of the files.

EXAMPLE

Say you have three programs– MAIN.PROG, PROG.A and PROG.B–that share variables. MAIN.PROG is the startup program and it will CHAIN to PROG.A which will CHAIN to PROG.B which will CHAIN back to MAIN.PROG. Here's what you do to compile these programs:

1. Compile MAIN.PROG with the usual COMPILE command:
   ```
   COMPILE MAIN.PROG,MAIN.COMP
   ```
   (Any legal file name may be used.)
2. Immediately compile each program that is to share data by using the COMMON command:
   ```
   COMMON PROG.A,PROG.A.COMP
   COMMON PROG.B,PROG.B.COMP
   ```
3. To run the program(s) with the Compiler installed, type:
   ```
   RUN  MAIN.COMP
   ```
   or
   ```
   -MAIN.COMP
   ```
   (Note: Even the COMMONed files may be run.)

HOW TO COMPILE PROGRAMS THAT USE STORE AND RESTORE COMMANDS

Note: This page applies to the ProDOS STORE and RESTORE commands. The Applesoft RESTORE command will compile just fine. The Applesoft STORE command is obsolete.

The ProDOS STORE command normally saves the variables in memory on disk in a VAR file. RESTORE loads these variables back into memory.

Programs that use STORE and RESTORE share common variables and must be given special treatment for compiling to be successful. The programs *must* be compiled to disk using the COMPILE command on one program and the COMMON command on the other (see CHAIN, previous page).

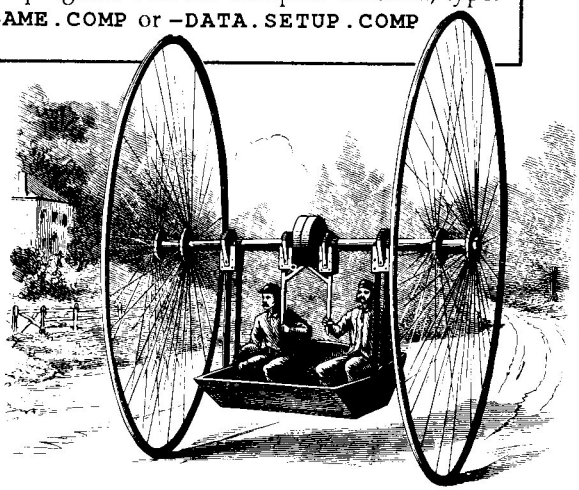
COMMON must be used *immediately* after COMPILE. If you later make a program change or add a new file that shares variables with the existing (already compiled) files, you must start over and recompile *all* of the files.

STORE and RESTORE in compiled programs create and use variable files of type CVR instead of VAR.

EXAMPLE

Say you have a program called DATA.SETUP that uses the STORE command to write variables that will be loaded (using RESTORE) by a program called BIG.GAME. Here's what you do to compile these two programs:

1. Type **COMPILE BIG.GAME,BIG.GAME.COMP**
   (Any legal file name may be used.)
2. Immediately type:
   COMMON DATA.SETUP,DATA.SETUP.COMP
3. To run either program with the Compiler installed, type:
   RUN BIG.GAME.COMP or **-DATA.SETUP.COMP**



HOW TO WRITE AMPERSAND ROUTINES FOR COMPILED PROGRAMS

(For advanced assembly language programmers only.)

An ampersand routine without parameters (& by itself) will compile just fine. Ampersand routines with parameters (like &XXX or &XXX,YYY,ZZZ) are a different story. Both the ampersand command and the machine language routine itself must be modified.

CHANGE #1:
USE && INSTEAD OF &

When calling an ampersand routine from a compiled program, you must use two consecutive ampersands (for example, you would use &&SORT instead of &SORT). This is how the Compiler detects programs that have or have not been modified.

CHANGE #2:
RE-EVALUATE YOUR PARAMETERS

With the Compiler installed, a **JSR to $98FD** will evaluate the next parameter after an ampersand:

- If the parameter is a string, a pointer to the string will be found at **$F6,$F7**. All strings in a compiled program are stored with the length in the first byte.
- If the parameter is a numeric value and the carry flag is *clear*, the value is an integer with its low byte in the X-register and the high byte in the Accumulator.
- If the parameter is a numeric value and the carry flag is *set*, the value is floating point and stored in the FAC (at $9D).

There is no way for the Compiler to determine if the correct parameters are being passed to your ampersand routines. If the correct parameters are not there, the program will most likely crash miserably.

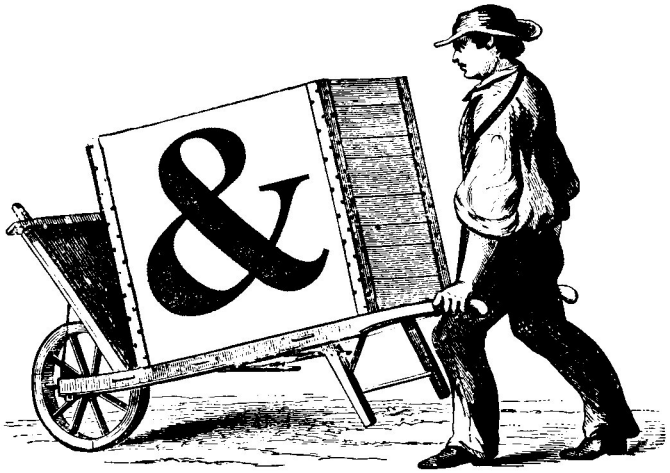
EX&MPLE

Let's write an ampersand routine that prints the first character in string S$, N times. Our Applesoft program looks like this:

```
20 S$="COW": N=80
50 &&N,S$
```

This program's mission is to print 80 C's. The assembly code would look like this:

```
        JSR    $98FD    ;evalute N
        BCS    ERROR    ;reject floating pt.values
        CMP    #0       ;evaluate high-byte
        BNE    ERROR    ;don't accept anything>256
        TXA
        PHA             ;save N
        JSR    $98FD    ;evalute S$
        PLA             ;restore N
        TAX             ;use as counter
        BEQ    DONE     ;counter was 0
        LDY    #0
        LDA    ($F6),Y  ;get length of string
        BEQ    DONE     ;null string
        INY
        LDA    ($F6),Y  ;get 1st character in string
        ORA    #$80     ;set MSB
LOOP    JSR    $FDED    ;print character
        DEX
        BNE    LOOP     ;loop
DONE    RTS             ;return to compiler
ERROR   LDX    #53      ;"ILLEGAL QUANTITY ERROR"
        JMP    $98F1    ;handle error
```




HEY, COME BACK! YOUR PROGRAM JUST CRASHED!

COMPILED PROGRAM EXECUTION ERRORS

An Applesoft or ProDOS program error will cause a compiled program to crash just like an uncompiled program. The only difference is that compiled programs produce strange error messages like:

?ILLEGAL QUANTITY ERROR AT $0ABC.

Uncompiled programs, as you know, produce messages like:

?ILLEGAL QUANTITY ERROR IN 123.

In this comparison, $0ABC is the hexadecimal *location* (address) in memory of the error, and 123 is the *line number* of the error (compiled programs have no line numbers).

Since line numbers are easier to work with than memory locations, the most efficient way to trap errors is to test your programs and **get them working correctly before you compile**.

THE PRINT.LINES PROGRAM CONVERTS $ADDRESSES TO LINE NUMBERS

(For advanced programmers)

If you insist on ignoring our advice above: To determine the line number that is equivalent to a hex error address, compile a program using the COMPILE or RUN command, then:

1. (optional) Turn on your printer by typing **PR#1**.
2. With the Beagle Compiler disk in the current drive, type:
   BRUN PRINT.LINES or **-PRINT.LINES**
3. Type **PR#0** to deactivate your printer if necessary.

The numbers produced by the PRINT.LINES program are the *starting* hex addresses and matching decimal line numbers.

ERRORS FOUND DURING COMPILING

If your Applesoft program contains errors, the Compiler will do its level best to find them during the compiling process. Each offending line will be listed with the approximate location marked. The Compiler will then ask "CONTINUE WITH ERRORS?" to see if you want to go ahead and run the program anyway (some "errors" are intentional or cause no problem). If you answer no, compiling will stop so you can make repairs. Save your repaired program on disk; then recompile it.

Many errors will not be found by the Compiler–this includes most ProDOS errors and errors inside quote marks. Here are some common errors that will be found during compiling:

<?> (SYNTAX ERROR)

- A <?> symbol could mean your program contains an Applesoft keyword that is unacceptable to the Compiler– specifically CONT, DEL, LIST, LOAD, NOTRACE, RECALL, SAVE, SHLOAD, STORE and TRACE. Programs with these commands will not compile. (Note: *ProDOS's* LOAD, SAVE and STORE *will* compile).
- Other culprits are those you have encountered before, such as missing parameters (like HPLOT with no coordinates), type mismatches (like A$=3), misspelled keywords (like PIRNT), missing commas and colons, and so on. Your Applesoft instruction manuals will help you make program repairs.

<#> (UNDEFINED LINE NUMBER ERROR)

A <#> symbol usually means your program used a GOTO or GOSUB to a nonexistent line number.

<A> (ARRAY DIMENSION ERROR)

An <A> means your program has illegally allocated arrays. For example: A(25)=3: A(6,3)=3

<✳> (ILLEGAL QUANTITY ERROR)

The only illegal quantities the Compiler will find are illegal addresses (for example, POKE 90000,0). Other illegal quantities (like HPLOT 90000,0) won't be noticed until your program crashes.

INCLUDE APPENDED MACHINE CODE?

This message means the Compiler has found some extra space at the end of your program. This could be useless garbage or it could be valuable data or a routine that is called by the program. When unsure, play it safe by answering Y (Yes, include the code).

KEYBOARD ERRORS

These errors may occur immediately after you type a command:

FILE TYPE MISMATCH

- Maybe you used the same two names when compiling a file to disk (**COMPILE NAME,NAME**).
- Or you used a command like **COMPILE NAME,NEWNAME** and NEWNAME was already on the disk as a type other than COM.
- Or you ran a program that uses CHAIN, STORE or RESTORE and you didn't compile with the COMMON command (page 18-19).
- Or you wrote an Applesoft (BAS) STARTUP program. STARTUP must be a compiled (COM) file.

NO BUFFERS AVAILABLE

- You may have tried to install the the COMPILER.SYSTEM or COMPILER file more than once. One time is enough.
- Or you may have tried to run a program below address $0801.
- Or you may have pressed Control-Reset during a catalog.

Solution: Try again or reboot.

NOT A COMPILED PROGRAM

With the Compiler in memory, you typed **RUN** after loading an Applesoft program. See pages 10 and 15.

PATH NOT FOUND

Translation: *File* Not Found. If you're sure the not-found file is on the disk and you spelled its name right, try typing **PREFIX/** or **PREFIX,S6,D1** (use your slot and drive numbers) or **PREFIX/DIR/SUB** (use your directory/subdirectory names).

PROGRAM TOO LARGE

- Your Applesoft program is too large to fit in memory.
- Or you are trying to run a program at too high an address.

Try compiling to disk, then removing the COMPILER file (page 27).

?SYNTAX ERROR

- Maybe you spelled a command wrong.
- Or maybe you used the COMPILE or COMMON command without installing the Compiler.
- If you get a ?SYNTAX ERROR as a response to typing something you know is legal (like "LIST"), memory is probably damaged, and you should reboot. Try pressing Control-Reset first. (It might not help, but it feels kind of good.)

COMPILER AND COMPILER.SYSTEM

When you catalog the Beagle Compiler disk, you will see the two files COMPILER (BIN) and COMPILER.SYSTEM (SYS) listed.

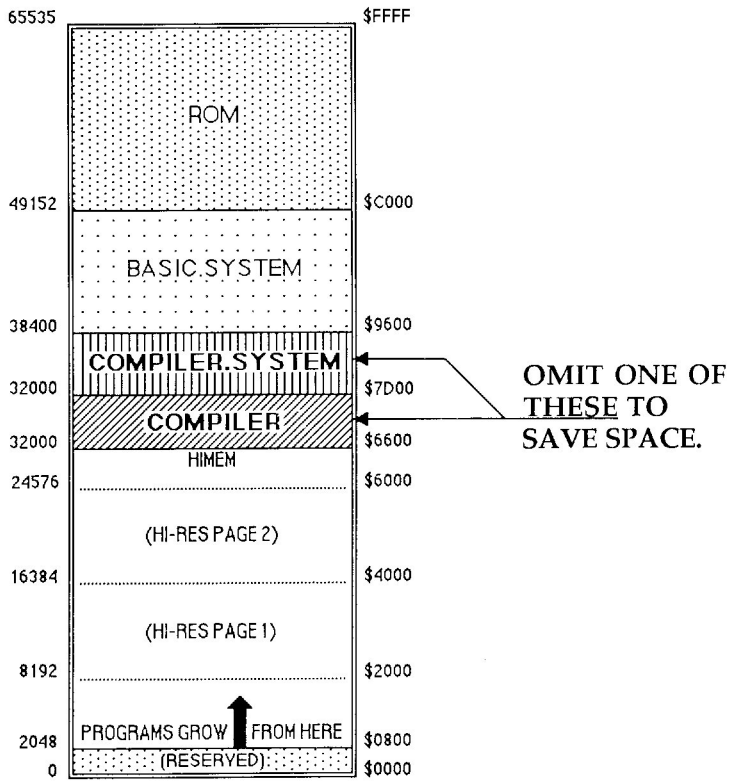
➜ **COMPILER** is the program that converts Applesoft programs into compiled format.

➜ **COMPILER.SYSTEM** is the program that runs programs that have already been compiled.

When you boot the Beagle Compiler disk, here's what happens:

1. COMPILER.SYSTEM is installed into memory.
2. STARTUP is loaded and run.
3. COMPILER is installed in memory.

If no COM file named STARTUP exists on the disk, the above process stops after step 1. Beagle Compiler's STARTUP loads COMPILER, although you may change that if you like by replacing STARTUP with your own version. STARTUP must be a COM file.



OMIT COMPILER TO SAVE SPACE

If you are only going to be running compiled (COM) programs and not converting Applesoft (BAS) programs, you can conserve about 6K of memory by not installing the COMPILER file. Any one of these methods will do the trick:

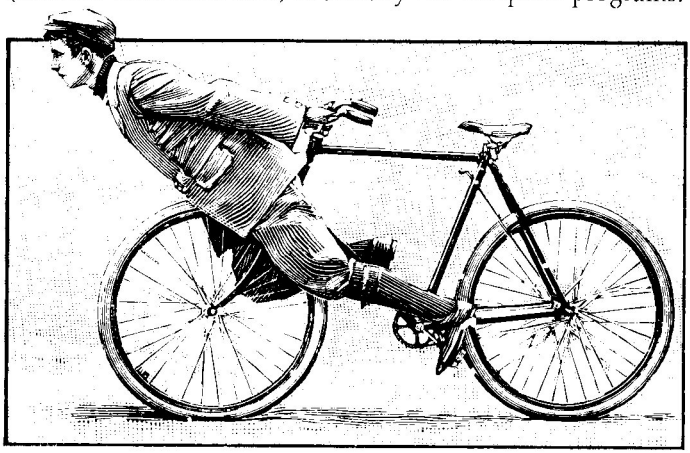
- Rename the STARTUP file on the Beagle Compiler disk before booting. Then boot the disk.
- Or, replace Beagle Compiler's STARTUP with your own version that doesn't install COMPILER. STARTUP must be a COM file.
- Or, copy the COMPILER.SYSTEM file onto another disk that contains the file PRODOS (but not COMPILER or BASIC.SYSTEM). Boot this disk and you will be able to run compiled programs, but not convert Applesoft programs.

OMIT COMPILER.SYSTEM TO COMPILE LARGE PROGRAMS

If you are going to compile a very large Applesoft program, there may not be room in memory for your program and both Beagle Compiler files. A solution might be to install the COMPILER file without COMPILER.SYSTEM, then compile your Applesoft program to disk.

To prevent COMPILER.SYSTEM from loading, boot a normal ProDOS disk that loads BASIC.SYSTEM, then insert the Beagle Compiler disk and type the command **BRUN COMPILER** (or **-COMPILER**). Do this only once because COMPILER eats 6K of memory each time it's installed.

Remember, COMPILER.SYSTEM will have to be installed (alone or with COMPILER) to actually *run* compiled programs.



MENU

MENU is a COM file that lets you select disk drives and programs from an AppleWorks-style menu. You can make MENU run when you boot a disk by renaming it STARTUP. Or you can make your STARTUP program run MENU.

To get MENU going, type **-MENU**. A list of all of the available ProDOS drives will appear at the top of the screen. "S6,D1" means Slot-6 Drive-1, "S6,D2" means Slot-6 Drive-2, etc. S3,D2 represents ProDOS's RAM disk. Below that will be all of the executable files (BAS, BIN and COM) on the highlighted drive.

Do this to run a program from one of your drives:

1. **Press the "< >" keys or a number** to highlight the drive number that contains the program you would like to run. That drive's file names will be displayed on the screen.
2. **Press the ARROW keys** and/or the **TAB** key to highlight the program you would like to run.
3. **Press the RETURN key** to run the highlighted program. If a subdirectory is highlighted when you press RETURN, its file names will be displayed–go back to step 2.

To quit MENU at any time, press the **ESC** key.

MENU ERROR MESSAGES

- **I/O ERROR** might mean a drive door is open.
- **NO DEVICE ERROR** usually means you are trying to read a slot's drive 2 when no drive 2 exists.
- **PATH NOT FOUND** probably means you switched disks.

OTHER POSSIBLE PROBLEMS

- **If a program crashes,** it probably wasn't written to be run (for example, it might be a hi-res picture instead of a program).
- **If you don't see a program listed on the screen** and you know it's on the disk, it might be a non-executable file type like TXT or VAR. Or there might not be room for it on the screen. The limit in 80-columns is 60 file names/10 disk drives. In 40-columns the limit is 30 file names/5 drives.

ENHANCEMENTS TO COMPILER.SYSTEM

The programs on this page make patches to the Compiler. Just BRUN the file after booting the Beagle Compiler disk (COMPILER.SYSTEM must already be in memory).

INPUT.ANYTHING

This patch replaces the Compiler's INPUT statement with one that allows commas and colons. This is very handy when inputting data from text files.

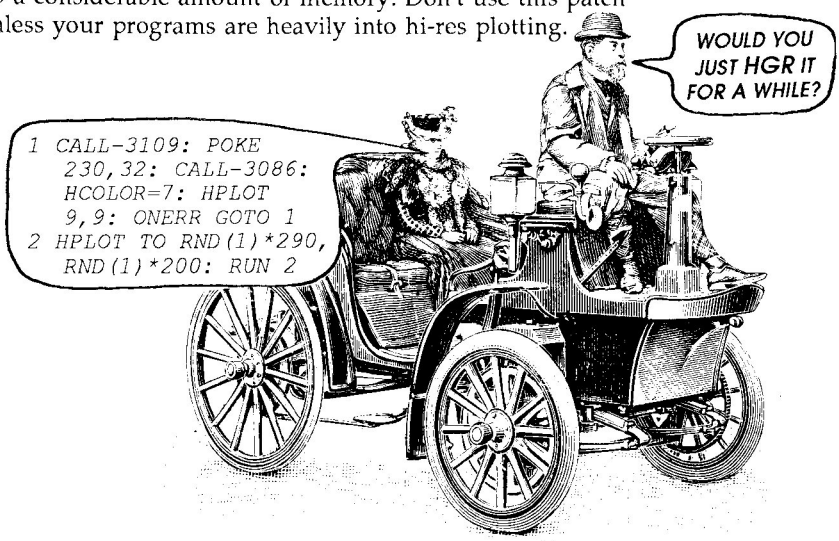
SLOW.PDL

Installing SLOW.PDL puts a small delay in the PDL (paddle) function so you will always get the correct reading.

The *Applesoft BASIC Programmer's Reference Manual* recommends that if you are doing consecutive reads of the game paddle or joystick with the PDL function, that you put a small loop in between the reads such as FOR X = 1 TO 10: NEXT. Because the Compiler causes programs to run much faster, you will have to increase these delays. Or utilize SLOW.PDL.

FAST.HPLOT

FAST.HPLOT replaces the HPLOT statement with one that is much faster. It's not normally installed in the Compiler because it takes up a considerable amount of memory. Don't use this patch unless your programs are heavily into hi-res plotting.



APPLESOFT/PRODOS COMMAND SUMMARY

Use this list for reference. For more complete information, check the nearest Applesoft or ProDOS instruction manual.

A	Applesoft	**f**	file/pathname	**m,n,i,j**	integers
P	ProDOS	**A$**	string	**x,y,z**	real numbers
✳	Beagle Compiler	**X**	variable		

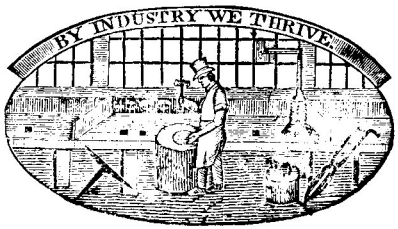
A		**ABS(x)**	Absolute (positive) value of x
A		**AND**	Logical "and" in an IF statement
	P	**APPEND f**	Add data to a sequential text file
A		**ASC("A")**	ASCII value of a character
A		**ASC(A$)**	ASCII value of a string's first character
A		**AT**	See DRAW, XDRAW, HLIN and VLIN
A		**ATN**	Arctangent of x in radians
	P	**BLOAD f**	Load binary file f
	P	**BRUN f**	Load and execute binary program f
	P	**BSAVE f,An,Lm**	Save data; Address n, Length m
A		**CALL n**	Branch to machine language routine at n
	P	**CAT**	Display disk contents in 40 columns
	P	**CATALOG**	Display disk contents in 80 columns
	P	**CHAIN f**	Run file f without clearing variables
A		**CHR$(n)**	Character whose ASCII value is n
A		**CLEAR**	Clear all variables
	P	**CLOSE f**	Stop reading or writing a text file
A		**COLOR=n**	Set lo-res color to n (0-15)
	✳	**COMMON f1,f2**	Compile a share-variables file to disk
	✳	**COMPILE f1,f2**	Load f1 (BAS), compile and save as f2 (COM)
A		**CONT**	Continue a program
A		**COS(x)**	Cosine of x in radians
	P	**CREATE f**	Create a subdirectory file
A		**DATA A$,x,y,z**	Strings and values to be READ
A		**DEF FN A(X)=f(x)**	Define a function
A		**DEL n,m**	Delete program lines n through m
	P	**DELETE f**	Delete file f from disk
A		**DIM X(n)**	Dimension a numerical array
A		**DIM A$(n)**	Dimension a string array
A		**DRAW n AT i,j**	Draw a hi-res shape n at i,j
A		**END**	Stop a program with no message
	P	**EXEC f**	Execute text file f from the keyboard
A		**EXP(x)**	e (2.718289) to the xth power

A		**FLASH**	Set flashing screen output (40-columns)
	P	**FLUSH**	Write buffer to disk without closing file
A		**FN**	See DEF FN
A		**FOR X=n TO m**	Let X=n, X=n+1... until X=m
	P	**FRE**	Free all available memory
A		**FRE(0)**	Amount of free memory available
A		**GET A$**	Wait for one-character user input
A		**GET X**	Wait for one-number user input
A		**GOSUB n**	Branch to subroutine at line n
A		**GOTO n**	Branch to line n
A		**GR**	View and clear lo-res page 1
A		**HCOLOR=n**	Set hi-res color to n (0-7)
A		**HGR**	View and clear upper hi-res page 1
A		**HGR2**	View and clear full hi-res page 2
A		**HIMEM: n**	Set highest memory address available
A		**HLIN n,m AT j**	Draw a horizontal lo-res line
A		**HOME**	Clear text screen to black
A		**HPLOT i,j**	Plot a hi-res point
A		**HPLOT i,j TO n,m**	Draw a hi-res line
A		**HTAB n**	Position cursor at horizontal position n
A		**IF...THEN...**	Logical "if" true, "then" execute
A	P	**IN#n**	Take input from slot n
A		**INPUT X**	(or A$) Wait for user input
A		**INPUT "ABC";A$**	(or X) Print "ABC" and wait for input
A		**INT(RND(1)*n)**	Random integer 0 to n–1
A		**INVERSE**	Set black-on-white text output
A		**LEFT$(A$,n)**	First n characters of a string
A		**LEN(A$)**	Number of characters in a string
A		**LET X=Y**	Set X equal to Y (LET is optional)
A		**LIST**	List a program from the beginning
A		**LIST–n**	List to line n
A		**LIST n–**	List from line n
A		**LIST n–m**	(or n,m) List lines n through m
A		**LOAD**	Load a program from tape (obsolete)
	P	**LOAD f**	Load a file from disk
	P	**LOCK f**	Protect a disk file from alteration
A		**LOG(x)**	Natural logarithm of x
A		**LOMEM: n**	Set start-of-variables location
A		**MID$(A$,n,m)**	m characters of A$, starting at n

COMMAND SUMMARY (continued)

A		**NEW**	Delete current program from memory
A		**NEXT X**	Define the end of a FOR-NEXT loop
A		**NORMAL**	Set normal white-on-black text output
A		**NOT**	Logical "not" in an IF statement
A		**NOTRACE**	Cancel TRACE
A		**ON X GOSUB n,m...**	GOSUB Xth line number
A		**ON X GOTO n,m...**	Branch to Xth line number
A		**ONERR GOTO n**	Branch to line n if an error occurs
	P	**OPEN f**	Begin READ or WRITE of a text file
A		**OR**	Logical "or" in an IF statement
A		**PDL(n)**	Value (0-255) of paddle n (0-3)
A		**PEEK(n)**	Memory value at location n
A		**PLOT i,j**	Plot a lo-res dot
A		**POKE n,m**	Set location n to value m
A		**POP**	Cancel most recent GOSUB
A		**POS(0)**	Horizontal cursor position
	P	**POSITION f**	Locate READ or WRITE in a file
A	P	**PR#n**	Send output to slot n
	P	**PREFIX f**	Change default directory
	P	**PREFIX/**	Cancel current prefix
A		**PRINT**	Skip a text line
A		**PRINT "ABC"**	Print characters within quotes
A		**PRINT X**	Print value of variable X
A		**READ A$**	(or X) Read a DATA string or value
	P	**READ f**	Initiate reading a disk text file
A		**RECALL X**	Retrieve array from tape (obsolete)
A		**REM**	Programmer's remark follows
	P	**RENAME f1,f2**	Rename a file on disk
A		**RESTORE**	Reset pointer to first DATA statement
	P	**RESTORE f**	Retrieve strings and variables from file f
A		**RESUME**	Continue program where error occurred
A		**RETURN**	Branch back to statement after GOSUB
A		**RIGHT$(A$,n)**	Last n characters of a string
A		**RND(0)**	Repeat last random number
A		**RND(1)**	Random number (0 to 0.999999999)
A		**ROT=n**	Set rotation of a shape to n (0-64)
A		**RUN**	Execute a program from beginning
A		**RUN n**	Execute a program from line n
	P	**RUN f**	Load and execute a program from disk
	*	**RUN f**	Load, compile & execute a program from disk

A		**SAVE**	Save a program to tape (obsolete)
A		**SAVE f**	Save a program f to disk
A		**SCALE=n**	Set scale for DRAW or XDRAW (0-255)
A		**SCRN(i,j)**	Lo-res screen color at point i,j
A		**SGN(X)**	Sign of X (+1, –1 or 0)
A		**SHLOAD**	Load shape table from tape (obsolete)
A		**SIN(x)**	Sine of x in radians
A		**SPC(n)**	n spaces in a PRINT statement
A		**SPEED=n**	Character output rate (0-255)
A		**SQR(x)**	Square root of x
A		**STEP n**	Increment-size in a FOR-NEXT loop
A		**STOP**	Stop program and print line number
	P	**STORE f**	Store current variables as VAR file f
A		**STORE X**	Store an array on tape (obsolete)
A		**STR$(x)**	String equivalent of value x
A		**TAB(n)**	Position the cursor in a PRINT statement
A		**TAN(x)**	Tangent of x in radians
A		**TEXT**	Switch to text mode; cancel windows
A		**THEN**	Logical "then" in an IF statement
A		**TO**	See FOR and HPLOT
A		**TRACE**	Print line numbers as executed
	P	**UNLOCK f**	Cancel LOCK
A		**USR(x)**	Pass x to a machine subroutine
A		**VAL(A$)**	Numeric value of a string
	P	**VERIFY f**	Verify that file f is on the disk
A		**VLIN n,m AT i**	Draw a vertical lo-res line
A		**VTAB n**	Move the cursor to text line n
A		**WAIT i,j,k**	Insert a conditional pause
	P	**WRITE f**	Initiate writing to a disk text file
A		**XDRAW n AT i,j**	DRAW in the opposite color
A		**XPLOT**	(Unused Applesoft reserved word)
	P	**–f**	Execute file f
A		**?**	Same as PRINT



MODIFYING APPLESOFT VIA THE BEAGLE COMPILER

Actually, we're not going to tell you *much* on the next few pages, but we do want to give all the hackers, snoopers and other nice people out there *a taste* of how the Compiler works. Please consider this information as a freebie only–don't call Beagle Bros for help in analyzing the Compiler's functions.

HAVE FUN IMPROVING (OR RUINING) APPLESOFT!

Programmers have always had a desire to modify the Applesoft interpreter to add more power and efficiency to a somewhat stale language. Since the interpreter is in ROM, it is a bit difficult to patch. The Beagle Compiler's interpreter, however, is in RAM, and you can change statements and functions at will.

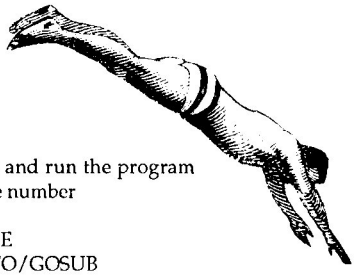
The Jump Table starting on the next page goes from $9900 to $99FF and contains vectors (addresses) to each part of the Compiler that processes statements and functions. A few well-placed pokes from BASIC or machine language will "steer" commands to any area of memory you choose.

For example, the following program, when compiled, will make HOME act like HGR. From there, you're on your own.

```
10 POKE 39208,PEEK(39282): REM $9928,$9972
20 POKE 39209,PEEK(39283): REM $9929,$9973
21 : REM $9928-29 IS THE ADDRESS FOR HOME
22 : REM $9972-73 IS THE ADDRESS FOR HGR
30 HOME: REM HOME NOW WORKS LIKE HGR
40 HCOLOR=3: HPLOT 0,0 TO 279,191
```

Warning: Programs like the one above can quickly open up a whole **Can of worms!**

THE BEAGLE COMPILER JUMP TABLE



Address	*Name*	*Function*
$9900	init	Initialize and run the program
$9902	run	RUN line number
$9904	clear	CLEAR
$9906	restore	RESTORE
$9908	on	ON GOTO/GOSUB
$990A	goto	GOTO
$990C	gosub	GOSUB
$990E	return	RETURN
$9910	pop	POP
$9912	end	END (halts program)
$9914	let	assign value to simple numeric variable
$9916	for	FOR (set TO value and initialize loop)
$9918	step	STEP
$991A	numprt	evaluate and print a numeric value
$991C	strprt	evaluate and print a string value
$991E	spc	SPC
$9920	tab	TAB
$9922	comma	comma function in PRINT statement
$9924	crout	print a RETURN
$9926	text	TEXT
$9928	home	HOME
$992A	normal	NORMAL
$992C	inverse;	INVERSE
$992E	flash	FLASH
$9930	next	NEXT
$9932	nextvar	NEXT statement with a variable
$9934	letstr	assign value to simple string variable
$9936	onerr	ONERR GOTO
$9938	pnum	PR#
$993A	innum	IN#
$993C	readn	READ a numeric value
$993E	reads	READ a string value
$9940	getn	GET a numeric value (shouldn't be used)
$9942	gets	GET a string value
$9944	plot	PLOT
$9946	vlin	VLIN
$9948	hlin	HLIN
$994A	if	IF
$994C	inputn	INPUT a numeric value
$994E	inputs	INPUT a string value

JUMP TABLE (continued)

Address	*Name*	*Function*
$9950	prtqm	print a '?'
$9952	gr	GR
$9954	draw	DRAW
$9956	drawat	DRAW with an AT
$9958	xdraw	XDRAW
$995A	xdrawat	XDRAW with an AT
$995C	hplot	HPLOT
$995E	hplotto	HPLOT TO
$9960	stop	STOP
$9962	hcolor	HCOLOR
$9964	htab	HTAB
$9966	vtab	VTAB
$9968	color	COLOR
$996A	speed	SPEED =
$996C	poke	POKE
$996E	call	CALL
$9970	hgr2	HGR2
$9972	hgr	HGR
$9974	scale	SCALE =
$9976	rot	ROT =
$9978	usr	USR
$997A	pdl	PDL
$997C	peek	PEEK
$997E	letint	assign value to simple integer variable
$9980	letary	assign value to array
$9982	letstrary	assign value to string array
$9984	dim	DIM
$9986	himem	HIMEM
$9988	lomem	LOMEM
$998A	resume	RESUME
$998C	ampersand	& (use 2 of them)
$998E	wait2	WAIT with 2 parameters
$9990	wait3	WAIT with 3 parameters
$9992	def	DEF FN
$9994	byte	byte numeric constant
$9996	integer	integer numeric constant
$9998	fp	floating point constant (packed)
$999A	literal	string constant
$999C	getnvar	get value of numeric variable
$999E	getsvar	get value of string var

Address	*Name*	*Function*
$99A0	or	OR
$99A2	and	AND
$99A4	relop	relational operator determined by the next byte: 0: <, 3: <=, 6: =, 9: <>, 12: >=, 15: >
$99A6	strcomp	string relational operator (see above)
$99A8	add	+ (addition)
$99AA	minus	- (subtraction)
$99AC	times	* (multiplication)
$99AE	div	/ (division)
$99B0	power	^ (exponentiation)
$99B2	not	NOT
$99B4	asc	ASC
$99B6	chr	CHR$
$99B8	pos	POS
$99BA	len	LEN
$99BC	left	LEFT$
$99BE	right	RIGHT$
$99C0	mid2	MID$ with 2 parameters
$99C2	mid3	MID$ with 3 parameters
$99C4	str	STR$
$99C6	abs	ABS
$99C8	rnd	RND
$99CA	sgn	SGN
$99CC	int	INT
$99CE	val	VAL
$99D0	neg	negate
$99D2	concat	+ (string concatenation)
$99D4	scrn	SCRN
$99D6	fre	FRE
$99D8	sqr	SQR
$99DA	log	LOG
$99DC	exp	EXP
$99DE	cos	COS
$99E0	sin	SIN
$99E2	tan	TAN
$99E4	atn	ATN
$99E6	getnary	get value of numeric array
$99E8	getsary	get value of string array
$99EA	fn	FN (user-defined function)
$99EC	savres	save code pointer if RESUME exists (before each statement that can generate an error)
$99EE	error	process an error
$99F0	input	prepare for a numeric or string input
$99F3-$99FF		reserved–you touch and we call the cops!

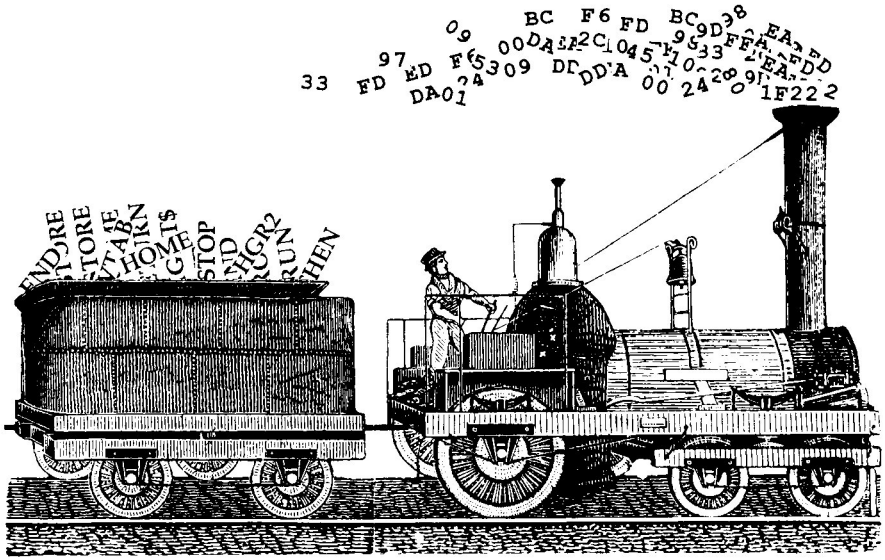
END OF TABLE

[Note: Arithmetic expressions are in prefix (Polish) format.]

USER-AVAILABLE ROUTINES

The following routines are available to help you in writing assembly language routines that will interface with Applesoft:

Address	*Name*	*Function*
$98E8	MOVSTR	Moves a string (no length byte, must end with 0 byte) to string space which has already been allocated with "GETSPA". On entry, A = LSB of string address and X = MSB of string address.
$98EB	BYTE	Evaluates a numeric parameter and verifies that it is a byte value (0-255). Anything else gives ILLEGAL QUANTITY. The value is returned in both A and X.
$98EE	PRTNUM	Prints a numeric value. Set the carry flag if the value is floating point (in the FAC). If the value is integer, clear the carry flag and the value should be in X (LSB) and A (MSB).
$98F1	ERROR	Calls ERROR to report an error. X should contain the number of the error message (see Apple BASIC Reference Manual). If ONERR is not enabled, the program will stop and print the error message.
$98F4	GETSPA	Allocates space in the string area. A = length of the string. One additional byte is allocated because the first byte contains the length of the string. Put the string where $F6,$F7 points.
$98F7	PRTSTR	Prints the string pointed to by $F6,$F7.
$98FA	PROC	Processes the next statement. A jump to this location is done at the end of every BASIC statement. If you are replacing a statement, your code should end with this.
$98FD	EVAL	Evaluates a numeric or string parameter.



VARIABLES

Variables are indicated by a byte value ($00-FF). The values for the variables are accessed by using the byte value as an index into the tables at the addresses indicated by the following pointers:

vtype ($78): Variable type
bit 7 = 1 if array, 0 if not
bit 6 = 1 if string, 0 if numeric
bit 5 = 1 if FN (user-defined function)
bit 4 = 1 if integer
bits 0-3 = number of dimensions if array

The following information depends upon the type of variable involved. FP=floating point. LSB=least significant byte. MSB=most significant byte.

vval1 ($7A): Array: LSB of address of array header
String: LSB of address of string
FP: Non-zero value indicates this is floating point type. 1st byte of packed FP value.
Integer: This value is zero if variable has an integer value.

vval2 ($7C): Array: MSB of address of array header
String: MSB of address of string
FP: 2nd byte of FP value
Integer: LSB of integer value

vval3 ($7E): Array: LSB of address of array
FP: 3rd byte of FP value
Integer:MSB byte of integer value

vval4 ($80): Array: MSB of address of array
FP: 4th byte of FP value

vval5 ($82): Array: Number of dimensions, 0 if not dimensioned yet
FP: 5th byte of FP value

If variable A$ has a variable index of 2, then the following code would assign A$ the string pointed at by PTR:

```
LDY     #2          ;variable A$
LDA     PTR
STA     ($7A),Y     ;store LSB of address
LDA     PTR+1
STA     ($7C),Y     ;store MSB of address
```

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