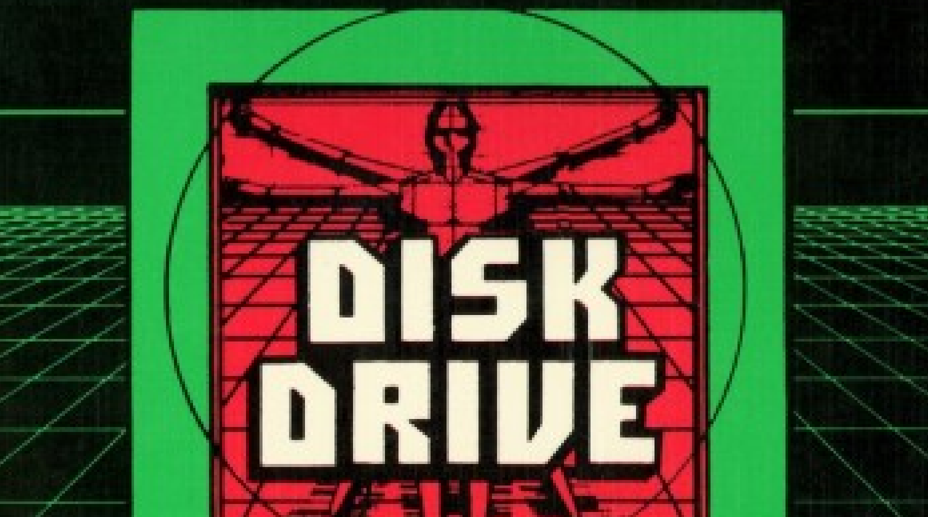
THE ANATOMY OF THE 1541



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THE ANATOMY OF THE 1541 DISK DRIVE

A Complete Guide to Using The Commodore Disk Drive

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PREFACE

The VIC-1541 disk drive represents a very efficient external storage medium for the Commodore user. It is an affordable peripheral. In order to get the most from your 1541, you need the appropriate information. In months of long, detailed work, Lothar Englisch and Norbert Szczepanowski have discovered many secrets of the 1541.

This book progresses from simple storage techniques, to direct access commands , to program chaining techniques. Beginners will welcome the numerous sample programs that are fully explained in clear text. Machine language programmers will particularly like the detailed documentation listing of the Disk Operating System (DOS).

This book contains many useful and ready-to-run programs that need only be typed in. Some of these programs are: routines for extending BASIC, helpful routines such as spooling, efficient address management, a complete household budget planner and an easy-to-use DOS monitor to manipulate individual sectors. Have fun with this book and your VIC-1541 disk drive.

TABLE OF CONTENTS

Chapter 1: Programming the VIC-1541

1.1 Getting Started

There it sits, your new Commodore VIC-1541 disk drive. It's fast and efficient but also intimidating. But have no fear. We will instruct you in the ways of disk programming. The first part of this book gives the beginner an intensive look at the VIC-1541. At least one example follows each command, thereby explaining its functions and capabilities. You will be surprised how easy the operation of your disk drive can be, when you understand the "basics".

The beginner probably uses the disk drive mainly to store programs. Perhaps he has not realized that there are many other ways to use the disk drive. This book attempts to uncover these other ways.

Experienced programmers should not ignore the first chapter. There may be some sections that may shed light on disk usage. This is especially true concerning relative files and data management.

1.1.1 The Disk Operating System

The disk drive is a rather complicated device which coordinates mechanical hardware and electronic circuitry to allow the storage of data on the diskette. When the Commodore 64 or VIC-20 needs to read from or write to the disk drive, it sends commands to the disk drive along the heavy black cable that connects the drive to the computer. The commands sent by the Commodore 64 or VIC-20 are understood at the disk drive by a by a built in program called the Disk Operating System (**DOS**).

The DOS is a lengthy program contained on ROM in the disk drive and carries out the activities of the disk drive as commanded by the Commodore 64 or VIC-20. The version of DOS contained in the VIC-1541 carries the designation CBM DOS V2.6.

The Commodore 64 and VIC-20 contain a version of BASIC called COMMODORE BASIC 2.0. Other versions of BASIC (e.g. BASIC 4.0 found of the Commodore 8032) have more advanced disk commands which the VIC-1541 can also understand. In order to use these advanced disk commands, you have to simulate them using BASIC 2.0.

At the end of the chapter is a listing of the BASIC 2.0

commands with corresponding commands of the easier BASIC 4.0, as found on the larger Commodore computers.

1.1.2 The TEST/DEMO Diskette

The VIC-1541 disk drive is packaged with a diskette called TEST/DEMO. Some of the programs contained on it cannot be used without adequate knowledge of the way the disk drive works. For now, lay this diskette aside.

The TEST/DEMO diskette is described in detail later.

1.1.3 Formatting New Diskettes

Brand new diskettes must be prepared before using them to store data. Preparing them is called **formatting.**

What does formatting mean? Each disk drive mechanism has its own special characteristics. A diskette is divided into tracks and information is written along each track (similar to the grooves of a phonographic record). The number of tracks per diskette is varies from one manufacturer to another. Each track is divided into sectors, whose number can also vary.

During formatting empty sectors are written to the diskette. A sector is written to each track and sector location and each sector receives its own "address". This allows the DOS to identify its position on the diskette. A sector is also given a code so that the DOS can recognize if this diskette was formatted by this type of disk drive. The code for the VIC-1541 disk drive is **2A.** The remainder of the sector (called a block) is used to store data and accommodates exactly 256 characters.

The final purpose of formatting is to construct the **directory** for the diskette. The directory is a "table of contents" of the files stored on the diskette. There is also a special data block (called the bit availability map or BAM) which indicates if a given block on the diskette is already in use or available for use. The directory and BAM are kept on track 18 of the diskette.

1.1.4 Some Facts about a 1541 Diskette

Diskette:

Number of Tracks:	35
Sectors per Track:	17 to 21 (depending on track)
Bytes per block:	256
Total number of blocks:	683
Number of free blocks	644 (the directory occupies the remainder)
Entries in the directory:	144 per diskette

Mechanism:

- intelligent peripheral with its own processor and control system
- connection to serial bus from CBM 64 or VIC-20, device number 4-15 (8 standard)

1.2 Storing Programs on Diskette

The most common use of the disk drive is for storage of programs. Storing programs with a disk drive is considerably easier than with a cassette recorder. The greatest advantage of the disk drive is the speed of data transfer to and from the computer. Here's a comparison:

Saving a 3 Kbyte program takes:
- 75 seconds with the VIC-1530 Datasette
- 12 seconds with the VIC-1541 disk drive

An additional advantage is that a diskette can store more programs than the cassette. To load a program, you can consult the directory to view the selection of programs. Even though the cassette drive allows you to store more than one program on a tape, searching for that program is very time consuming.

Before trying any of the following examples in this chapter, you should remember that the diskette must be previously formatted as explained in section 1.3.2 in order to be able to save programs onto it.

1.2.1 SAVE - Storing BASIC Programs

Perhaps you previously owned a datasette on which you stored programs. In this case the commands to save programs onto diskette should be familiar to you. The SAVE command for the disk drive is essentially the same as for the cassette drive. You need only tell the computer that the program is to be saved onto the disk drive and not on cassette. This is done by adding the device number (usually 8) to the command SAVE. Normally the drive is preset to respond to this device number. Now write a small BASIC program and save it with the command:

```
SAVE"TEST",8
```

type in a the **NEW** command so the program in the computer's memory is erased. In the following section you will learn how the program can be retrieved.

1.2.2 LOAD - Loading BASIC Programs

As with the SAVE command, this command is similar to the LOAD command for the datasette with the addition of the device number. Now load in the previously saved program with:

LOAD "TEST",8

You can check the program by using the **LIST** command. Any previous program in memory has now been replaced by the program "TEST". It is possible to load a program into the memory without replacing the previous program in memory. Combining two program in memory is called "merging" An example of merging is presented in a later section.

1.2.3 VERIFY - Checking Stored Programs

When you have saved a program on disk with the SAVE command, it is often desirable to make sure that the program was written error-free. You can do this by using the VERIFY command. It has the following format:

VERIFY"filename",8

Earlier you saved a program with **SAVE "TEST",8.** This program should still be in memory. Using VERIFY, the program in memory is checked against the program stored on diskette. If both programs are identical, the computer responds with OK.

To try this out, type a few BASIC lines and then give the following commands:

```
SAVE   "TEST2",8
VERIFY "TEST2",8
```

Your computer will respond with OK if it is performing correctly.

1.2.4 SAVE"@:..." - Replacing Programs

If you try to save your small TEST program on the disk again, the computer will respond with a **FILE EXISTS** error and will not complete the SAVE. The operating system of the VIC-1541 disk drive does not allow two programs to be saved under the same name. This is logical because the computer would not be able to distinguish between two programs with the same name.

However you may want to update a program on diskette that was previously saved. There are three ways to accomplish this:

1. Save the program under a different name
2. First erase the old program from the disk and save the new one under the old name

3. Use the addition @: in front of the file name in the SAVE command

This is used as follows:

SAVE"@:TEST",8

If you forget to use the characters @: in front of the filename, and try to save a program whose name is already contained on the diskette, you get the **FILE EXISTS** error.

If you are replacing a program on a diskette then the DOS carries this out as follows:

1. A free block is designated as the first block of the program and its location is stored in the directory entry of the old copy.

2. The new copy of the program is stored in a free area of the diskette.

3. All of the blocks of the old copy are marked as free.

1.2.5 Loading Machine Language Programs

Machine language programs are handled a little differently from BASIC programs. A machine language program is transferred to the computer by using a secondary address of 1. When secondary address 1 is used, the program is loaded "absolutely", that is, loaded into memory beginning at the address specified in the first two bytes of the disk file. An example:

LOAD "MACHPGRM",8,1

loads the machine language program at an absolute address.

For example, the program may be set up to load at the decimal address 49152, and is started by the command : **SYS 49152.** Should you load a machine language program without the secondary address, you will most likely see the message "SYNTAX ERROR IN ...." if you type RUN.

Likewise, trying to LIST the machine language program will display nonsense. Unfortunately, machine language programs are not differentiated from BASIC programs in the directory. Both have the file type **PRG.**

Usually, if typing **RUN** results in **SYNTAX ERROR IN ....,** you know that the program is not written in BASIC and should be treated as a machine language program. In this case it must be loaded with the command **LOAD "program",8,1.** It cannot be started with RUN however! You must first find the execution address of this program.

In a later section is a program that lists all the file parameters of a program. One of the parameters is a load address. This load address is usually the initial execution address of the program and can be called with the command **SYS load address.** You can find the load address of a program with the following program:

```
10 OPEN 1,8,2,"programname,S,R"
20 GET#1,X$:IF X$="" THEN X$=CHR$(0)
30 LB=ASC(X$)
40 GET#1,X$:IF X$="" THEN X$=CHR$(0)
50 HB=ASC(X$)
60 CLOSE 1
70 AD=HB*256+LB
80 PRINT"LOAD ADDRESS:";AD
```

The program shows the load address of "programname". Here the program file is opened as a sequential data file. The starting address is stored as the first two bytes of the file and read using the GET command and appropriately constructed. The first byte is the low byte and the second byte the high byte of the two-byte address. If the function of this program is unclear, handling sequential files clarified in the next sections.

1.2.6 Storing Machine Language Programs

Machine language programs are usually written with an assembler or a machine language monitor and saved using this program. Machine language programs can also be written from BASIC with the individual bytes of the program written in decimal values in DATA statements. A machine language program written in BASIC with the help of DATA statements follows:

```
10 SA=starting address
20 EA=ending address
30 FOR I=SA TO EA
40 READ X
50 POKE I,PEEK(X)
60 NEXT I
80 DATA ....................................
90 DATA ....................................
```

In this example, the decimal value of the starting address is placed in line 10 and the ending address in line 20. The decimal values of the individual bytes of the machine language program are typed into the DATA statements of the program, separated by commas.

Naturally, you can save any machine language program that you find in this book in the form of a BASIC program. This is, however, a tedious and complicated process. A more elegant and time-saving method is to store the machine language program in true form. This way, you can immediately execute the program after LOADing without requiring any complicated conversion.

The following program will save such a program that is already in memory:

```
10 SA=starting address
20 EA=ending address
30 OPEN 1,8,1,"programname"
40 HB=INT(SA/256):LB=SA-HB*256
50 PRINT#1,CHR$(LB);CHR$(HB);
60 FOR I=SA TO EA
70 PRINT#1,CHR$(PEEK(I));
80 NEXT I
90 CLOSE 1
```

This routine assumes that the machine language program is already in the memory of the computer. If a program is already encoded into DATA statements, the following routine can be used to produced a pure machine language program:

```
10 SA=starting address
20 EA=ending address
30 OPEN 1,8,1,"programname"
40 HB=INT(SA/256):LB=SA-HB*256
50 PRINT#1,CHR$(LB);CHR$(HB);
60 FOR I=SA TO EA
70 READ X
80 PRINT#1,CHR$(X);
90 NEXT I
100 CLOSE 1
110 DATA ..........................
120 DATA ..........................
```

Here the addresses and DATA statements are filled in also. The above program writes a machine language program to diskette which can later be loaded with the command **LOAD "programname",8,1.** Then the program can be executed with the command: **SYS (starting address).** Machine language programs can also be loaded and executed from a BASIC program. Such a program might have this form:

```
10 IF A=0 THEN A=1:LOAD"programname",8,1
20 SYS (starting address)
```

The **IF** command in line 10 is puzzling at first. It must be present because after performing a **LOAD** from within a program, the BASIC interpreter begins executing again at the first line of the new BASIC program. Because the machine language program doesn't usually overlay the BASIC program in memory, the original BASIC program remains intact and is therefore is re-executed. If you use the routine:

```
10 LOAD"programname",8,1
20 SYS (starting address)
```

the program continues to LOAD "programname" again, and the SYS command is never executed. If the variable A is present, the program branches to line 20 at the end of the first command on line 10. This loader can be placed on the diskette together with the machine language program. To execute the machine language program, you need only give the commands:

```
LOAD"loader",8
RUN
```

This has the advantage that the starting address of the machine language program need not be known, because it is included in the SYS of the loader.

1.3 Disk System Commands

As already mentioned, the VIC-1541 disk drive is similar to the the earlier, larger disk drives of the Commodore family - the CBM 4040, 8050, 8250. They are all intelligent peripheral device with their own processor and control system. The Disk Operating System (DOS) occupies no space in the memory of the Commodore 64 or VIC-20 and yet offers a flexible set of efficient commands. These commands effectively expand the builtin commands of your Commodore computer.

Because the disk drive is an intelligent peripheral, the commands of the DOS can be executed independently of the computer. But because the commands are not found in the version of BASIC supplied in the Commodore 64 or VIC-20, you will have to communicate to the disk using a special method. When the commands are sent to the disk drive, the DOS interprets and carries out the desired task.

1.3.1 Transmitting commands to the Disk Drive

Commands intended for the disk drive, are sent over a **channel.** You can communicate with the disk drive over any of the 15 available channels. But channel 15 is reserved as the **command channel.** Data transfer over this channel takes place as follows:

- opening the channel (OPEN)
- data transfer (PRINT)
- close the channel (CLOSE)

In the OPEN command you specify a logical file number (arbitrary between 1 and 127), a device number of the disk drive (usually 8) and the secondary address (15 for the command channel). You can also send a command to the device as illustrated below:

OPEN lfn,8,15,"command"
or
OPEN lfn,8,15:PRINT#lfn,"command"

The number 8 is the device number of the disk drive and the number 15 is the secondary address or channel number. The parameter **lfn** is the logical file number which is used in subsequent commands (PRINT#, INPUT#, GET#). It can be a number in the range 1-127. The **"command"** can either follow the OPEN statement directly, or can be transferred with a PRINT# command following the opening. Any number of system commands can be transmitted until the channel is closed, but must be referenced by the logical file number used in the OPEN command.

1.3.2 NEW - Formatting Diskettes

The command to format a diskette is called **NEW** and can, as every other command, be abbreviated to its first letter (**N**). As already mentioned, the command can follow an OPEN command or be given in a PRINT# command. The NEW command has the following format:

NEW:diskname,id

The parameter **diskname** may contain up to 16 characters and is stored in the header of the diskette directory. The parameter ID (identification) consists of two arbitrary characters, so that the DOS can recognize if a different diskette has been used. Since you can freely choose the id, this allows you to uniquely identify each diskette. Here is an example for formatting a disk:

OPEN 1,8,15,"NEW:ABCDISK,KL"

The command can be abbreviated to:

OPEN 1,8,15,"N:ABCDISK,KL"

You need only use the command once - when you first use a brand new diskette. Formatting takes about 80 seconds. Formatting uses the processor of the 1541 drive while the processor of the computer is not needed; you can continue to work with the computer.

To use the command with a PRINT# statement, the following commands must be given:

```
OPEN 1,8,15              to open the channel
PRINT#1,"N:ABCDISK,KL"
```

The number 1 in the PRINT# command is the logical file number corresponding to the OPEN command. Other commands may also be transmitted over this channel after the PRINT# statement. When no more commands are to be transmitted, the channel must be closed. This is accomplished through the use of the CLOSE statement. Give the following command after formatting:

CLOSE 1

Now the command channel is closed. The number 1 is again the logical file number of the corresponding OPEN command.

1.3.3 Reading the Error Channel

When the Commodore 64 or VIC-20 is incorrectly programmed, it responds with an error message. Disk commands are carried out and verified by the processor of the disk drive. Therefore the computer cannot directly display error messages that are detected by the disk drive. Errors are indicated by the flashing red LED on the disk drive. In order to determine which error has occurred, the computer must read the error from channel 15. Therefore channel 15 must be OPENed, if this has not already been done. Then the error can be read with the INPUT# command. An error is sent back to the computer in four fields -

Field 1: Error number
Field 2: Description of the error (string)
Field 3: Track number
Field 4: Sector number

The track and sector information may indicate where the error occurred (if these fields are relevant to the command). These four fields of the error message must be read into four variables. You can use an INPUT# statement followed by four variables. An example of reading the error channel:

```
OPEN 1,8,15          (if not already done)
INPUT#1,EN,DE$,TR,SE
CLOSE 1
```

The INPUT# statement must be entered from within a program. It is not proper to issue an INPUT# statement from command mode.

```
10 OPEN 1,8,15
20 INPUT#1,EN,DE$,TR,SE
30 PRINT EN;DE$;TR;SE      (to display the error)
40 CLOSE 1
```

To understand the operation of this program, first create the following error:

```
OPEN 1,8,15,"NEW ABCDISK,T1"
CLOSE 1
```

When you have given these commands, the red LED on the disk drive begins to blink. Did you spot the error? A colon is missing from the command **NEW**. Now type the program to read the error channel and type RUN. The error will appear on the screen:

34 SYNTAX ERROR 0 0

The 34 is the number of the error, which is explained later. The track and sector fields are 0 because this information is not relevant to this error.

If you read the error channel when an error had not occurred, the message:

0 OK 0 0

is returned. In any case, if the red LED on the drive blinks, check the syntax of the command, since most errors can be easily recognized. Otherwise, you can simply read the error channel to find the error which the DOS has detected. A detailed description of the error message and their causes follows in section 1.6.

1.3.4 LOAD"$",8 - Loading the Directory

The **directory** is a "table of contents" of the diskette. All the files on the diskette are cataloged here. Be sure to note that loading the directory has a disadvantage: any program previously in memory is overlayed by the directory information. The directory is loaded by typing:

LOAD "$",8

and can be viewed with the **LIST** command. Try LOADing the directory of the TEST/DEMO diskette that accompanies your disk drive. Insert this diskette into the disk drive and enter: **LOAD "$",8** to load the directory. Then display the directory by using the LIST command. What follows should be shown on the screen

```
0     "1541test/demo     " zx 2a
13    "how to use"         prg
5     "how part two"       prg
4     "vic-20 wedge"       prg
1     "c-64 wedge"         prg
4     "dos 5.1"            prg
11    "copy/all"           prg
4     "disk addr change"   prg
4     "dir"                prg
6     "view bam"           prg
4     "check disk"         prg
14    "display t&s"        prg
9     "performance test"   prg
5     "sequential file"    prg
13    "random file"        prg
```

A lot of information is kept in the directory. Let's look at the first line, the header of the directory. The number **0** in this line means that the directory is of the diskette in drive 0. Other disk drives such as the 4040, contain two disk drives - drive 0 or drive 1. On the 1541 the drive number is always 0. Next follows the name and ID of the diskette as set up by formatting. The characters **2A** symbolize the disk format. If this format is not **2A** then this diskette was not formatted with a 1541 drive.

Next are the individual file names, their lengths in blocks in the first column and the file type in the last column. This diskette contains three different file types:

PRG These are PROGRAM files, written in either BASIC or machine language

SEQ Sequential data files, explained later

REL This is another form of data storage, also explained later

The length of the files is given in blocks. Each block contains 256 bytes. You can find the approximate size a program. by subtracting 2 bytes from each 256-byte block that the file occupies. Finally at the end of the directory is the number of free blocks remaining on the disk. When you add the lengths of the files and the number of free blocks, the result is the total number of available blocks on a diskette (664).

If you own a printer, this directory can be printed as you would print a program listing. Use the following commands:

OPEN 1,4	open the printer
CMD 1	the printer is now linked to the screen
LIST	the directory will be printed
PRINT#1	send a RETURN to the printer
CLOSE 1	close the printer again

It is assumed that the directory is already loaded with the **LOAD"$",8** command before these commands are executed. By inserting a wildcard when loading the directory, you can cause only part of the directory to be loaded, such as only the programs. This is explained in section 1.3.10

1.3.5 SCRATCH - Deleting Files

Sometimes an unneeded file must be removed from the diskette. The SCRATCH command is provided for doing so. Before using this command, you must be sure that the name given in the SCRATCH command corresponds with the file to be deleted. An unintentionally deleted file can ruin many hours or even days of work, so be careful before using the SCRATCH command.

To delete a file, the following format should be used:

PRINT#lfn,"SCRATCH: filename1, filename2,..."

More than one file can be deleted by using a single command. But remember that only 40 characters at a time can be sent over the transmission channel to the disk drive.

For example, to erase a file with the name **TEST**, the following commands are used:

```
OPEN 1,8,15,"S:TEST"
CLOSE 1
```

If channel 15 is already open, only the PRINT# command is required:

```
PRINT#1,"S:TEST"
```

It is possible to delete the entire contents of a diskette. This is discussed in section 1.3.10, the **wildcard** character (*):

```
PRINT#1,"S:*"
```

But be very careful! Make sure that you do not need any of the files on the diskette before using this command. After completing the operation the error channel transfers the message:

01 FILES SCRATCHED nn 00

where **nn** is the number of deleted files. This message can be read with the routine given in section 1.3.3.

1.3.6 RENAME - Renaming Files

You can also change the name of a file on the diskette. The command **RENAME** is provided for this purpose. It has the following format:

RENAME:newname=oldname

For example, if you want to change the name of the file from **TEST** to **PEST** you would use the following commands:

```
OPEN 1,8,15,"R:PEST=TEST"
CLOSE 1
```

or

```
OPEN 1,8,15
PRINT#1,"R:PEST=TEST"
CLOSE 1
```

Note that you cannot rename a file until it is CLOSEd.

1.3.7 COPY - Copying Files

Using this command, a file can by copied on a diskette. Several different sequential files can be used to create a new file. If, for example, you have a data record for each month of your household expenses and they have the names EXP.01, EXP.02, etc. you can combine them into quarters (EXP.Q1 for example) with this command. The COPY command has the format:

```
COPY:newfile=oldfile1,oldfile2,...
```

So, the named data records can be combined as follows:

```
OPEN 1,8,15,"C:EXP.Q1=EXP.01,EXP.02,EXP.03"
CLOSE 1
```

This method of combining data records **cannot** be used for programs. Only a single program can be copied on the diskette. Also the name of the new file must not already exist on the diskette.

The COPY command is seldom used. This is because copying files onto the same diskette usually makes no sense. The only sensible use of the command is to combine several sequential or user files into a single file.

Copying files from one diskette to another diskette is much more sensible. This is indispensible for data security. If you own two disk drives, you can assign the device number 9 to one of them and use the program COPY/ALL to copy files from one to the other. This program is found on the TEST/DEMO diskette.

We have also thought of you who have only one disk drive. A utility program is included in section 4.1 to allow you to copy individual files and even the entire diskette.

1.3.8 INITIALIZE - Initializing the Diskette

The DOS requires a BAM (Block Allocation Map) to be present on each disk. The BAM is a layout of the usage of the blocks on each diskette. It marks each block on the diskette as free for use or allocated (already in use). If you change diskettes in the drive and the new diskette has the same **id** as the old diskette, the DOS will not recognize the fact that you have changed diskettes. The BAM of the new diskette will be different, but the DOS will still be working with the old BAM.

Therefore, each diskette should be given a unique **id** when you format it. It is a good practice to give each diskette a different **id**. You can force the disk drive to read the BAM of a new diskette by issuing the **INITIALIZE** command. This command has the following format:

PRINT#lfn,"INITIALIZE"

or shortened to

PRINT#lfn,"I"

Example:

```
OPEN 1,8,15,"I"
CLOSE 1
```

If you change diskettes and also change data records, then we strongly recommend that you use the INITIALIZE command after changing the diskettes, to be safe.

1.3.9 VALIDATE - "Cleaning Up" the Diskette

The command **VALIDATE** frees all allocated blocks that are not assigned to normally CLOSEd files. For example, if you OPEN a file, and transfer data to that file, but forget to CLOSE the file, the **VALIDATE** command can be used to free the data blocks that were written to. If you use the direct access commands, be sure to allocate them (using the BLOCK-ALLOCATE command) or the VALIDATE command will free them again.

The command has an additional function: If a file is deleted using the SCRATCH command, the file type in the first byte of the file entry is set to 0. It no longer appears in the directory. If you now change this byte back to its old file type with the DOS monitor (described later) or other direct access commands, VALIDATE will restore the file. If it has not been overwritten, it will be the same as before the SCRATCH command. The command has the following format:

PRINT#lfn,"VALIDATE"

or the shorter form

PRINT#lfn,"V"

An example:

```
OPEN 1,8,15,"V"
CLOSE 1
```

If you have a diskette such that the sum of the file lengths plus the number of free blocks does not equal the total number available (664), use the VALIDATE command to restore it.

Another example: If you want to store a program or data record that uses more than the number of free blocks, the DOS will give the error **DISK FULL.** If the disk had shown some blocks free before, the number is now zero. The VALIDATE command will restore the original free blocks.

1.3.10 ? * - The Wildcards

There are two wildcard characters - the asterisk (*) and the characters of the first file on the disk that begins with the characters which precede the asterisk. An example:

```
LOAD"TEST*",8
```

This command loads the first program that begins with the first four letters "TEST". The command:

```
LOAD"*",8
```

loads the first program on the diskette because there are no characters in front of the asterisk. The asterisk in the SCRATCH command has a different effect. If used in the SCRATCH command, not only the first file will be deleted, but all files. For instance, the command:

```
OPEN 1,8,15,"S:TEST*"
CLOSE 1
```

erases all files beginning with the the letters "TEST". This must be taken into account! Loading the directory with an asterisk can also select certain files. An example:

```
LOAD"$A*",8
```

loads only the directory of the files that begin with the letter "A".

The DOS offers an additional use of the asterisk that has not been mentioned yet. It can also select file types if the asterisk is followed by the first letter of the desired file type. Here is a summary:

*=S	selects only sequential files
*=P	selects program files
*=R	selects relative files
*=U	selects user-files

For example, the command:

```
LOAD "$*=P",8
```

causes only the directory entries of programs to be loaded and shown when you type **LIST.** This can also be used with the SCRATCH command to delete all sequential files, for instance. Here is the command:

```
OPEN 1,8,15,"S:*=S"
CLOSE 1
```

With the question mark, certain characters of a file name can be declared "not relevant". To illustrate the function of the question mark, here are two examples of shortened file names and their effects:

A?????	- refers to a six-letter filename of which first character is A
????TEST	- refers to an eight-character filename, the last four letters of which are **TEST**

A combination of asterisks and question marks is allowed. You should notice, however, that an asterisk followed by question marks has no meaning. Two examples of combinations of asterisks and question marks:

????.*	- refers to all file names that have four characters before a period
TEST.??*	- refers to all file names having at least 7 characters, of which the first five are **TEST.**
TEST-??01*=S	- refers to all sequential files whose names have at least nine characters, the first five being **TEST-** and the eighth and ninth being **01**

1.4 Sequential Data Storage

A disk drive need not be used exclusively for storing programs. If you have written a program that manages a large quantity of data, you need a fast way of organizing it. Sequential data storage is not the fastest, but it is the easiest method of managing data. This method is comparable to sequential storage on a cassette, which can be maintained in a program as such:

1. Load the program

2. Read the entire data file into the memory of the computer

3. Work with the data in memory (change, delete, combine)

4. Write the new file on an external medium (cassette, diskette)

5. Exit the program

The maximum number of data items that the program can handle depends on the size of the computer's memory, because a single data item cannot be changed or erased directly on the cassette or diskette. To that end, the entire set of data items must be read in, changed, and then rewritten again. Reading and rewriting the data occurs remarkably faster on a disk drive than on cassette.

It is worth mentioning that programs which work with sequential data on cassettes can be easily modified to work with disk. Only the corresponding OPEN commands need be changed.

1.4.1 The Principle

A sequential data file consists of several data records that are further divided into fields. The following is a name and address file and illustrates the principle of sequential data storage. Individual names and addresses comprise the data records of this file. A record consists of several fields (last name, first name, etc.). The structure of the file looks something like this:

```
===========================================================
Field 1 : Field 2 : Field 3 : Field 1 : Field 2 : Field 3 :
===========================================================
       Data record 1         :         Data record 2
-----------------------------------------------------------
                            FILE
-----------------------------------------------------------
```

Only two records are shown above. The data records of a file are stored one after another (sequentially) as are the the fields within each record. The fields and records may be of any length. For example, field 1 of record 1 may be longer than field 1 of record 2. This is possible because the fields are separated from each other by a special character (the RETURN character), which is generated by the PRINT# statement. When read back into the computer by the INPUT# statement, the RETURN character is recognized as a field separator.

Each field is associated with a variable when written with a PRINT# statement or read with an INPUT# statement.

How does the computer know, when reading the data, where each field ends? Each field ends with a RETURN character. The RETURN character has the decimal ASCII value 13. An example of a telephone directory file illustrates this. Our telephone directory file has three fields:

```
FIELD 1 : LAST NAME
FIELD 2 : FIRST NAME
FIELD 3 : TELEPHONE EXTENSION
```

Let's look at a section of this previously written file (the character + symbolizes a RETURN):

```
Position:          1111111111222222222233333333334444444
          1234567890123456789012345678901234567890123456
          ----------------------------------------------
Data:     SMITH+JOHN+236+LONG+TIM+121+HARRIS+SAM+654+...
          ----------------------------------------------
```

You can see that the fields are of different lengths and are all separated by a RETURN character. This RETURN character is automatically written after the data field by a PRINT# statement, provided the PRINT# statement is not followed by a semicolon (which suppresses the RETURN character).

These data items are assigned to the variables with an INPUT# statement. After that, another INPUT# must follow in order to read the next field, and so on. The following sections explain the fundamentals of writing programs using sequential data storage.

1.4.2 Opening a Sequential Data File

To create a sequential data file, you must first OPEN the file. When opening a file to be written to, the following is carried out:

1. The diskette is checked to see if an existing file has

the same name. If so, the error message **FILE EXISTS** is given by the DOS.

2. The file entry in the directory is written. In the file type it is noted that this file is not yet CLOSEd. This appears in a directory listing with an asterisk which preceeds the file type.

3. A free block is found, into which the first data items are written. The address (track and sector) of this free block is stored in the file entry of the directory.

4. The number of blocks in the file is set to 0, because no blocks of the file have been written yet.

The OPEN command specifies for what purpose (mode) the file is to be used (reading or writing). The format of the OPEN command looks like this:

OPEN lfn,8,sa,"filename,filetype,mode"

When the logical file number is between 1 and 127, a PRINT# statement sends a RETURN character to the file after each variable. If the logical file number is greater than 127 (128-255), the PRINT# statement sends an additional line-feed after each RETURN. This is necessary for printers, for example, that do not provide an automatic line-feed after a RETURN character.

The secondary address (sa) can be a value between 2 and 14. The secondary address indicates the channel over which the computer is to transfer data to and from the disk drive. Secondary addresses 0 and 1 are reserved by the DOS for saving and loading programs. Secondary address 15 is designated as the command and error channel. Should several files be open at once, they must all use different secondary addresses, as only one file can use a channel. If, however, a file is opened with the secondary address of a previously opened file, the previous file is closed.

A maximum of 3 channels can be opened with the VIC-1541 at a time. When utilizing relative data files, the DOS requires 2 channels per file. Therefore, the following maximum combinations are possible:

- 1 relative and 1 sequential file

or - 3 sequential files

When specifying the filename to be written to (in the OPEN command), you must be sure that the file name does not already exist on the diskette. If a file that already exists is to be to opened for writing, an at sign followed by a colon (@:) must be placed in front of the file name (same as in the SAVE command). For example:

OPEN 1,8,2,"@:ADDRESSES,S,W"

The file type must be given when the file is opened. The file type may be shortened to one of following:

S - sequential file
U - user file
P - program
R - relative file

User files are sequential files that are listed in the directory with the file type **USR.** It is not a data file in the true sense. This file type is usually used when output that normally goes to the screen (BASIC listing, directory) is sent to the disk. In section 1.4.6 you find a description of this technique.

The last parameter (mode) establishes how the channel will used. There are four possibilities:

W - Write a file (WRITE - section 1.4.3)
R - Read a file (READ - section 1.4.4)
A - Add to a sequential file
(APPEND - section 1.4.4)
M - read a file that has not been closed
("discovered" by us in the DOS listing and
explained in section 1.4.5)

Now open a sequential file with the name **SEQU.TEST** for writing:

OPEN 1,8,2,"SEQU.TEST,S,W"

If you now load the directory with **LOAD"$",8** and then LIST it, you see this file listed with an asterisk before the file type:

```
0     SEQU.TEST          *SEQ
```

But you are no longer allowed to close this file! After a file is OPENed and data written to it, it must be closed before the directory is loaded!

While a file is open, the command/error channel 15 may be opened, but when channel 15 is closed, all other channels are closed as well. You must take note of this.

Now some examples of the OPEN command:

OPEN 1,8,2,"SEQU.TEST,S,R"	- open a sequential file for reading
OPEN 2,8,3,"SEQU.TEST,U,W"	- open a user file for writing
OPEN 3,8,4,"TEST,P,R"	- open a program file for reading

OPEN 4,8,5,"SEQU.TEST,S,A"	- open a sequential file for appending data
OPEN 5,8,6,"CSTMRS.1983,S,M"	- open the unclosed customer file for reading

1.4.3 Transferring Data Between Disk and Computer

After opening a file for writing, you transfer data to be stored to the diskette with the PRINT# statement. This statement transmits an additional RETURN that is required for separating data. In the following example, a file is OPENed, data written to it, and CLOSEd again. PRINT# can also be used as a direct command, that is, outside of the program, so the following commands can be typed one after the other and executed. Now open a file with the name "TEST":

```
OPEN 1,8,2,"TEST,S,W"
```

You should notice that the red LED on the disk drive was lit. It signals the fact that a file was OPENed. You can now write to the file named **TEST.** Here is how we would write a name and address record consisting of 4 fields:

```
PRINT#1,"SAM"
PRINT#1,"HARRIS"
PRINT#1,"2001 MAIN STREET"
PRINT#1,"ANYTOWN"
```

Now these data items have been written to the file so we can close the file with **CLOSE 1.** The red LED should go out. In order to read this data again, you must open the file in the read mode (R). Because the INPUT# statement cannot be used directly, a small program must be written:

```
10 OPEN 1,8,2,"TEST,S,R"
20 INPUT#1,FN$
30 INPUT#1,LN$
40 INPUT#1,ST$
50 INPUT#1,CT$
60 CLOSE 1
70 PRINT"FIRST NAME:  ";FN$
80 PRINT"LAST NAME:   ";LN$
90 PRINT"STREET:      ";ST$
100 PRINT"CITY:       ";CT$
```

The program is simple to explain:

Line 10 The file TEST is opened for reading

Lines 20-50 The data are read in the same order as they were written. Variables are used so that the data can be printed later.

Line 60 The file is closed.

Lines 70-100 The data are printed out on the screen.

When you enter this program and type **RUN**, the data will appear as written earlier, on the screen:

```
FIRST NAME:    SAM
LAST NAME:     HARRIS
STREET:        2001 MAIN STREET
CITY:          ANYTOWN
```

Four INPUT# statements were used to read the data because the name and address record is composed of four fields. But when a record is written that has, say, 20 fields, it is very time-consuming to type out 20 INPUT# statements. A loop can make this much simpler. This is obvious in this example:

```
10 OPEN 1,8,2,"TEST,S,R"
20 FOR I=1 TO 4
30 INPUT#1,D$(I)
40 NEXT I
50 CLOSE 1
60 PRINT"FIRST NAME:    ";D$(1)
70 PRINT"LAST NAME:     ";D$(2)
80 PRINT"STREET:        ";D$(3)
90 PRINT"CITY:          ";D$(4)
```

Here, instead of four separate string variables, an array with index 1-4 is used. It should be noted that in BASIC 2.0, if an index higher than 10 is used, the array must be dimensioned with a DIM statement. Should we want to read in 20 fields, the statement **DIM D$(20)** must be given before any are read.

There are still more ways of shortening input and output of data. With the INPUT statement for keyboard input, several variables can be given in one line, separated by commas. For example:

```
INPUT FN$,LN$,TE
```

With this statement, three variables must be entered, such as:

```
NICHOLAS,MULLER,7465
```

The read data can be printed on the screen with:

```
PRINT FN$,LN$,TE
```

In this manner, sequential data can be written and later read back in again. The only difference is that the string variables containing the data to be written must be separated by commas enclosed in quotes. For example, if you wish to write the previous variables to a file, the PRINT# statement command must changed as follows:

PRINT#1,FN$",",LN$",",TE

Numeric variables need only be separated with a comma from the other variables. To read the data, use the command:

INPUT#1,FV$,LN$,TE

Because the maximum number of characters read by an INPUT# statement may not exceed 88, this method of reading is only marginally useful. If a field in a record is more than 88 characters long, a different statement must be used. This is the GET# statement, which reads each individual character, one at a time. Suppose you want to read a record of which a field is 100 characters long. This record can be placed in a string variable with the following routine:

```
10 OPEN 1,8,..............
20 D$=""
30 FOR I=1 TO 100
40 GET#1,X$
50 D$=D$+X$
60 NEXT I
70 GET#1,X$
80 CLOSE 1
```

At the end of this program, the string variable D$ will contain the 100 characters of the data field. After opening a sequential data file, the DOS establishes a pointer that always points to next character to be read. We assume that the data was written with a PRINT# statement without a trailing semicolon, so that a RETURN was written at the end of the data item. After reading the first 100 characters, the pointer points to this RETURN. The next GET# in line 70 is necessary to read the RETURN found at the end of the field. Then the next GET# statement can read the next field and not the RETURN.

In the above example, we used data records with a constant length of 100 characters. According to the rules of sequential access, the length of data records need not be constant. Since the INPUT# statement can only read a maximum of 88 characters, we will use the GET# statement to recognize the RETURN as the end of a field. Such a routine looks like this:

```
10 OPEN 1,8,.....................
20 S$=""
30 GET#1,X$
40 IF X$=CHR$(13) THEN 80
```

```
50 S$=S$+X$
60 IF ST<>64 THEN 30
70 CLOSE 1:END
80 PRINT S$
90 GOTO 20
```

Here a file with variable record length is read and printed on the screen. Naturally, you can use the data in other ways instead of printing it on the screen.

To avoid the problem of reading data records of more than 88 characters, divide the record into several parts, which you can combine after reading them.

1.4.4 Adding Data to Sequential Files

If you want to add data to a sequential file, you have to read the entire file into memory, add the data, and write the new file back to the diskette again. This is a very time-consuming process. For this reason, the DOS offers an easier alternative to add to a sequential data file without reading the entire file. This is made possible through the OPEN mode **A** (Append). If you have a sequential data file, as in the previous section, you can add data to it by selecting the **A** mode in the OPEN command. An example follows.

Give the following commands:

```
OPEN 1,8,2,"TEST2,S,W"
PRINT#1,"1. DATA RECORD"
CLOSE 1
```

Now you have a sequential data file containing one data record. This file can be expanded with two more records as follows:

```
OPEN 1,8,2,"TEST2,S,A"
PRINT#1,"2. DATA RECORD"
PRINT#1,"3. DATA RECORD"
CLOSE 1
```

Now the file **TEST2** has three data records. You can check this with the following program:

```
100 OPEN 1,8,2,"TEST2,S,R"
110 FOR I=1 TO 3
120 INPUT#1,DR$
130 PRINT DR$
140 NEXT I
150 CLOSE 1
```

After the program starts, the data records is read and printed on the screen.

You can see that the append A mode makes it quick and easy to expand a sequential data files.

1.4.5 Closing a Sequential File

OPENed data files can be closed with the CLOSE command. This command has the format:

CLOSE lfn

The parameter **lfn** is the logical file number of the file that was used in the OPEN statement. Should several files need to be closed a CLOSE statement must be given for each one. When the last file is closed, the red LED on the drive goes out.

As you already know, data is sent to the disk drive over a channel. This channel uses storage inside the disk (called a buffer) in which the data transmitted by the computer is stored. When this buffer is full, its contents are written to the diskette.

When the file is closed, any data still in the buffer is written to the diskette. An unclosed file is incomplete and is also not recognized by the DOS as a properly closed file. The DOS allows no read access in the **R** (Read) mode and responds **WRITE FILE OPEN** when trying to read an unclosed file.

This could be a problem if the DOS did not allow read access to a file. For this reason, the DOS offers the M mode. A file that is marked as an improperly closed file can be read in this mode. It is logical to then write these records to a second file which can then be properly closed. In this way one can "rescue" a file.

The following program will transfer an improperly closed file (original file) to a correctly closed file (destination file):

```
100 INPUT"ORIGINAL FILE NAME";S$
110 INPUT"DESTINATION FILE NAME";D$
120 OPEN 1,8,2,S$+",S,M"
130 OPEN 2,8,3,D$+",S,W"
140 INPUT#1,X$
150 PRINT#2,X$
160 IF ST<>64 THEN 140
170 CLOSE 1:CLOSE 2
180 OPEN 1,8,15,"S:"+S$
190 CLOSE 1
```

At the completion of the program, the unneeded original file is deleted (scratched).

1.4.6 Redirecting the Screen Output

Any output appearing on the video screen (PRINT, LIST, etc) can be redirected to a sequential data file. This is accomplished through the CMD command, which has the following format:

CMD lfn

For this to occur, a file of type **USR** must be opened. To transfer a BASIC program listing, for instance, as a sequential file on diskette, use the following commands:

```
OPEN 1,8,2,"TEST.LIST,U,W"
CMD 1
LIST
CLOSE 1
```

The command **CLOSE** 1 causes further output to be sent to the screen.

Storing a program as a sequential file on disk is very useful, if, for example, you would like to read a program with a word processor to edit it. It is assumed that the word processor in this case reads data stored in ASCII code.

This is how the listings in this book were transferred from a Commodore 64 to a Commodore 8032.

In order to print this file on the screen again, you need the following routine:

```
10 OPEN 1,8,2,"TEST.LIST,U,R"
20 GET#1,X$
30 PRINT X$
40 IF ST<>64 THEN 20
50 CLOSE 1
```

This routine is a loop that reads every character (byte) of the file and displays it on the screen. The end of the file is signalled by the status variable which is set to 64 at the end. To send a sequential file to the printer, use the following program:

```
10 OPEN 1,8,2,"TEST.LIST,U,R"
20 OPEN 2,4
30 GET#1,X$
40 PRINT#2,X$
50 IF ST<>64 THEN 30
60 CLOSE 1
```

Here it assumed that the printer is connected as device address 4.

1.4.7 Sequential Files as Tables in the Computer

Sequential data files must reside completely in the computer for data management. Most of the time, a two dimensional table can be used. This table is also called an array or matrix, because a data element can be addressed through the input of two coordinates. To this end, you use a two dimensional variable, which must be reserved with a DIM statement. The first dimension corresponds to the data record, the second dimension to the field inside the record. The following diagram shows an example of a table:

```
                 Field 1       Field 2       Field 3
           ¶-----------------------------------------¶
Record 1   ¶   D$(1,1)   ¶   D$(1,2)   ¶   D$(1,3)   ¶
           ¶-----------------------------------------¶
Record 2   ¶   D$(2,1)   ¶   D$(2,2)   ¶   D$(1,3)   ¶
           ¶-----------------------------------------¶
Record 3   ¶   D$(3,1)   ¶   D$(3,2)   ¶   D$(3,3)   ¶
           ¶-----------------------------------------¶
Record 4   ¶   D$(4,1)   ¶   D$(4,2)   ¶   D$(4,3)   ¶
           ¶-----------------------------------------¶
Record 5   ¶   D$(5,1)   ¶   D$(5,2)   ¶   D$(5,3)   ¶
           ¶-----------------------------------------¶
Record 6   ¶   D$(6,1)   ¶   D$(6,2)   ¶   D$(6,3)   ¶
           ¶-----------------------------------------¶
```

This table is a file composed of six records which have three fields each. The variable D$ is reserved with **DIM D$(6,3)**. To read a sequential file as a table, it is necessary to create such a file with, for example, six records with three fields each. For this purpose, use the following program:

```
100 OPEN 1,8,2,"TABFILE,S,W"
110 FOR X=1 TO 6
120 PRINT CHR$(147)
130 PRINT"RECORD ";X
140 PRINT"---------"
150 FOR Y=1 TO 3
160 PRINT"FIELD ";Y;": ";
170 INPUT X$
180 PRINT#1,X$
190 NEXT Y
200 NEXT X
210 CLOSE 1
```

Two nested loops are used here, whose variables are numbered with the record and field. Enter six data records. When the program is done, these records will be contained on the diskette with the filename of **TABFILE.** A tip: save this program with **SAVE"TABPROG",8** so you can use it later.

This file can now be loaded into the computer as a table. Two nested loops indexed for the table are necessary:

```
100 OPEN 1,8,2,"TABFILE.SEQ,S,R"
110 DIM D$(6,3)
120 FOR X=1 TO 6
130 FOR Y=1 TO 3
140 INPUT#1,D$(X,Y)
150 NEXT Y
160 NEXT X
170 CLOSE 1
```

This program places data into the table. You can check this with a PRINT statements, to see if the data has been stored in the right place. Because each field can be addressed with indices, you can give a command like **PRINT D$(1,2)** to see the second field of record one. It is meaningful to be able to display the fields of a given record. Use the following routine for this purpose, after you have saved the previous program:

```
100 INPUT"RECORD NUMBER: ";X
110 PRINT"------------------"
120 PRINT"FIELD 1: ";D$(X,1)
130 PRINT"FIELD 2: ";D$(X,2)
140 PRINT"FIELD 3: ";D$(X,3)
```

Notice that the first index (the record number) after the question is used as the variable in the field output. The second index (field number) is then constant.

This table can now be altered as desired. Add the following lines to the preceeding program:

```
160 PRINT"------------------"
170 INPUT"FIELD TO CHANGE:";Y
180 INPUT"NEW CONTENTS:    ";D$(X,Y)
190 PRINT"OK"
200 PRINT"FURTHER CHANGES (Y/N)?"
210 GET X$:IF X$="" THEN 210
220 IF X$="Y" THEN 100
230 IF X$="N" THEN END
240 GOTO 210
```

Here the number of the field to be changed is used as the second index, which is adjacent to the index of the desired record to input the new table element.

This modified table must now be written to the diskette again. You can use the following routine. Don't forget to save the previous edit program first!

```
100 OPEN 1,8,2,"@:TABFILE,S,W"
110 FOR X=1 TO 6
120 FOR Y=1 TO 3
130 PRINT#1,D$(X,Y)
140 NEXT Y
150 NEXT X
160 CLOSE 1
```

This routine also is relatively short because of the use of nested loops. The @: in line 10 is necessary in order to overwrite the existing file.

Accessing data through the use of the table is very fast. The access time is independent of the size of the table. The size of the table and therefore the quantity of data is dependent on the memory capacity of the computer, however. The large storage area of the Commodore 64 is excellent for table management. If you write a data management program that occupies 8K bytes, then 30K bytes still remain for storing data. If you consider that storing a name and address record of about 80 characters, you can still store 384 records in memory! And this with an access time that cannot be surpassed by refined data management techniques (indexed sequential, relative). But with larger quantities of data, sequential storage is no longer feasible.

1.4.8 Searching Tables

As mentioned in the table processing section, each data record of a table can be indexed. Because the table is two dimensional, the first index selects the data record. If a record of the table is to be changed or accessed, the operator must know the record number. The record number can be a part or customer number. There are files, however, for which there is no suitable method of numbering. In such files, the number of the record must be found through a

search of all the records. Here is a practical example:

First of all, create a data file with the following program. Names and telephone numbers are saved in the example:

```
100 OPEN 1,8,2,"TELEDAT,S,W"
110 PRINT CHR$(147)
120 INPUT"LAST NAME    :";LN$
130 INPUT"FIRST NAME   :";FN$
140 INPUT"AREA CODE    :";AC$
150 INPUT"NUMBER       :";NU$
160 PRINT"INFORMATION CORRECT (Y/N)?"
170 GETX$:IF X$="" OR X$<>"Y" AND X$<>"N" THEN 170
180 IF X$="N" THEN 110
190 PRINT#1,LN$","FN$","AC$","NU$
```

```
200 PRINT"MORE INPUT (Y/N)?"
210 GETX$:IF X$="" OR X$<>"Y" AND X$<>"N" THEN 200
220 IF X$="N" THEN 240
230 GOTO 110
240 CLOSE 1
```

Program Documentation:

Line 100	The sequential file "TELEDAT" is opened for writing
Line 110	The screen is cleared
Lines 120-150	The four fields are entered from the keyboard
Lines 160-180	If the data are not correct, they can entered again
Line 190	The four fields are written to disk
Lines 200-220	Here the execution of the program can be ended
Line 230	Input will be continued
Line 240	The file opened in line 100 is closed

Type this program in, RUN it, and enter some data. Save the the program on diskette, so you can combine it with other routines later if you like. In the last section of this chapter, is a complete program for managing your telephone numbers.

If you have entered some data, you would probably like to find a telephone number. To do so, you could print the entire file on the screen or printer and find it yourself. This is, however, a wasteful method, especially if you have entered many records.

The search for the telephone number corresponding to a given name can be performed by the computer. It runs through the whole list, looking for the desired name. Once found, it gives you the complete record which contained that name. The following routine accomplishes this:

```
100 OPEN 1,8,2,"TELEDAT,S,R"
110 DIM D$(100,4):X=1
120 INPUT#1,D$(X,1),D$(X,2),D$(X,3),D$(X,4)
130 IF ST<>64 THEN X=X+1:GOTO 120
140 CLOSE 1
150 PRINT CHR$(147)
160 PRINT"DESIRED NAME:  ";N$
170 FOR I=1 TO X
180 ID D$(I,1)=N$ THEN 210
190 NEXT I
```

```
200 PRINT"NAME NOT FOUND!":GOTO 280
210 PRINT"NAME FOUND:"
220 PRINT"-----------"
230 PRINT"LAST NAME:  ";D$(I,1)
240 PRINT"FIRST NAME: ";D$(I,2)
250 PRINT"AREA CODE:  ";D$(I,3)
260 PRINT"NUMBER:     ";D$(I,4)
270 PRINT"-----------"
280 PRINT"MORE (Y/N)?"
290 GETX$:IF X$="" OR X$<>"Y" AND X$<>"N" THEN 290
300 IF X$="Y" THEN 150
310 PRINT"PROGRAM DONE":END
```

Program Documentation

Line 100	The sequential file "TELEDAT" is opened for reading
Line 110	The table is dimensioned for 100 records and the index is set to one
Line 120	The data records are read into the table
Line 130	The status variable ST is checked for end of file (indicated by a value of 64). If the end has not been reached, the index is incremented and a new record is read.
Line 140	The file opened in line 100 is closed
Line 150	The screen is cleared
Line 160	The last name to be searched for is read from the keyboard and placed in the variable N$
Lines 170-190	The loop searches the table of records, checking the name fields against the desired name. If the position is found, the program branches to the output routine
Line 200	The name was not found
Lines 210-270	The record containing the desired name is displayed
Lines 280-310	The possibility to search for a new name is allowed

You will notice that this search is quite fast when the data is already loaded into the computer. Searching the computer's memory is faster than searching the diskette. The program can be easily changed to search for a desired field other than the name. You might want to search for an area code, for instance. The first program stops the search when the first matching data record is found. This is not always desired, however. If, for instance, you wish to search the table looking for a particular area code and want all matches to be displayed, a different routine is needed. The routine must continue the search after the first match is found. The next program takes care of this:

```
100 OPEN 1,8,2,"TELEDAT,S,R"
110 DIM D$(100,4):X=1
120 INPUT#1,D$(X,1),D$(X,2),D$(X,3),D$(X,4)
130 IF ST<>64 THEN X=X+1:GOTO 120
140 CLOSE 1
150 PRINT CHR$(147)
160 PRINT"AREA CODE TO SEARCH FOR: ";AC$
170 FOR I=1 TO X
180 IF D$(I,3)=AC$ THEN 210
190 NEXT I
200 PRINT"END OF DATA!":GOTO 270
210 PRINT"----------------"
220 PRINT"LAST NAME:      ";D$(I,1)
230 PRINT"FIRST NAME:     ";D$(I,2)
240 PRINT"AREA CODE:      ";D$(I,3)
250 PRINT"NUMBER:         ";D$(I,4)
260 PRINT"----------------"
270 PRINT"MORE (Y/N)?"
280 GETX$:IF X$="" OR X$<>"Y" AND X$<>"N" THEN 280
290 IF X$="Y" THEN 190
300 PRINT"SEARCH DONE!":END
```

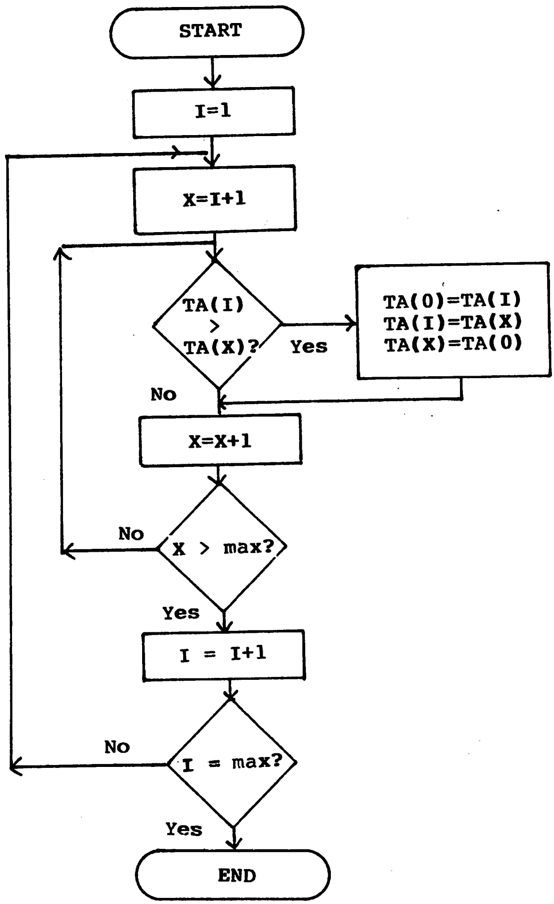
Here the search is continued if a record with the appropriate area code is found. This happens in line 290, which branches back to the loop instead of ending the program. After searching all of the records, the program responds **END OF DATA**. If you understand the operation of this program, you can now develop a search for the last name. With the help of the previous programs, this should present no difficulty.

1.4.9 Simple Sorting of Tables

In data processing, it is often necessary to sort data into numeric or alphabetic order. This has always been a time consuming task, which the programmer has tried to shorten by using better sorting methods. Sorting is certainly a time consuming task when performed with the programming language BASIC, which is relatively slow.

Why should we sort the data at all? Suppose you had a telephone book in which the names were not ordered. You would have search the entire book from beginning to end to find a name. Sorting offers advantages when searching data. The computer can also search sorted data faster.

There are several search methods which differ mainly in their speed of execution. The simplest method compares each data item with every other. If a table is supposed to be sorted in ascending order, the first item in the table is compared to the second. If the first is greater, it is exchanged with the second. After that, the first will be compared to the third, and so on, until the last item is reached. Now the smallest item is at the beginning, in the right place. The next time through, the first item is no longer needed. A flowchart of the program logic appears below.



This sort program starts using an index of 1, which is stored in the variable I. The second index is the variable X, which receives a value one greater than I. Then the first item is compared to the second. If the value of TA(I) is greater then TA(X), the program must use a temporary variable, TA(0), to make the exchange between the two. After this, the value of X is incremented, to three, and TA(I) is again compared to TA(X), etc. When the last item in the table is reached, (X > last index), the first item will be the smallest, and the index I is incremented by one. Now the second item is compared to every other (starting with the third), and so on.
This sort method looks quite complicated at first glance. Comparisons in memory are done relatively quickly, however. This method is sufficient for small quantities of data.

In order to run this program, a table must be built. This example uses a table with twelve items containing alphanumeric data (strings). The table is filled by the following routine:

```
100 DIM TA$(12)
110 FOR I=1 TO 12
120 INPUT TA$(I)
130 NEXT I
```

This program allows you to enter twelve strings, which are then sorted with the following program:

```
140 I=1
150 X=I+1
160 IF TA$(I) < TA$(X) THEN 180
170 TA$(0)=TA$(I):TA$(I)=TA$(X):TA$(X)=TA$(0)
180 X=X+1
190 IF X <= 12 THEN 160
200 I=I+1
210 IF I <> 12 THEN 150
220 FOR I=1 TO 12
230 PRINT TA$(12)
240 NEXT I
```

The table is sorted and displayed on the screen. If, instead of a one dimensional table, you want to sort a two dimensional table such as our telephone file, exchange the fields by changing lines 160-170 as below:

```
160 IF D$(I,1) < D$(X,1) THEN 180
170 D$(0,1)=D$(I,1):D$(I,1)=D$(X,1):
    D$(X,1)=D$(0,1)
171 D$(0,2)=D$(I,2):D$(I,2)=D$(X,2):
    D$(X,2)=D$(0,2)
172 D$(0,3)=D$(I,3):D$(I,3)=D$(X,3):
    D$(X,3)=D$(0,3)
173 D$(0,4)=D$(I,4):D$(I,4)=D$(X,4):
    D$(X,4)=D$(0,4)
```

It is very time consuming to sort a greater amount of data with this method. If you have a large amount of data to be sorted, we recommend that you use the very fast machine language sort routine from our book Commodore 64 Tips & Tricks.

1.4.10 MAILING LIST MANAGEMENT with Sequential Data Storage

At the end of this section, is a mailing list management program that every user will hopefully find easy to use. At the same time, this program provides insight into the operation of many data processing techniques.

A mailing list record of this program consists of the following fields:

- NAME 1
- NAME 2
- STREET
- CITY, STATE
- ZIP CODE
- TELEPHONE NUMBER
- NOTES

The use of the fields 'NAME 1' and 'NAME 2' are up to the user. For instance, 'NAME 1' can be the first name and 'NAME 2' the last name, or 'NAME 1' the company name and "to the attention of..." in 'NAME 2'. The field 'NOTES' can be used for grouping the addresses (family, business, friends, etc.).

The program offers the following Main Menu options:

-1- LOAD DATA
-2- SAVE DATA
-3- INPUT DATA
-4- EDIT DATA
-5- SELECT/PRINT DATA
-6- DELETE DATA
-0- END PROGRAM

-1- LOAD DATA

Use this function to enter the name of the mailing list file that is to be maintained. If the file exists on the diskette, it is loaded and ready to be used. The number of records in the file is displayed. If an error is encountered while loading, or if the file does not exist, the message **DISK ERROR!** is displayed. At the conclusion of this function, the Main Menu reappears.

-2- SAVE DATA

Use this function to write an updated or expanded copy of the mailing list to the diskette. If the file name already exists, then the file is overwritten.

The mailing list should be saved often while using the program in case a power outage should erase the computer's memory. After saving, the file can be used further, without having to reload it in again.

-3- INPUT DATA

Use this function to add records to the mailing list:

1. When no data has been previously loaded.

   First a file name for the mailing list is entered. Enter a file name which does not already exist on the diskette or the old file is overwritten. All records that are inputted are new to the mailing list.

2. When data has been previously loaded.

   All records that are inputted are added to the existing mailing list.

After entering an mailing list entry, the message **CORRECT (Y/N)?** is displayed. Here you may correct the data. If the entry is not correct, press the **N** key. If the entry is correct, press **Y**. Now the message **MORE INPUT (Y/N)?** is displayed. If you want to enter another mailing list entry, press **Y**. If you press N, the Main Menu appears again.

-4- EDIT DATA

Use this function to change existing mailing list records. Both Name 1 and Name 2 must be entered. If both names are not known, the other can be found with the **SELECT/PRINT DATA** routine. After entering the names, the mailing list is searched for matching names. When they are found, the complete address is displayed with the fields numbered. Now you must enter the number of the field which you want to change. The new contents are requested. The record is once again displayed in its updated form. If no more changes to this record are required, press **9**. The program asks if another record is to be changed. This question is to be answered by pressing **Y** or **N**.

-5- SELECT/PRINT DATA

Use this function to search for certain records and print or display them. You must first specify if the selected records are to be printed on the screen (S) or the printer (P). If you have selected the printer, you must again choose if the data is to be printed with all fields on normal paper (P), or if fields 1-5 are to be printed on mailing labels (M). The address labels must be in a single column and measure 89mm x 36mm.

In order to select the data, enter search criteria. For fields which are not relevant, simply press RETURN. If, for example, you want to find all addresses in Grand Rapids, press RETURN for the first three fields and type **GRAND RAPIDS, MI** for the fourth, and press RETURN for the next three.

An example:

```
NAME 1           : M
NAME 2           : <return>
STREET           : <return>
CITY, STATE      : <return>
ZIP CODE         : <return>
TELEPHONE NUMBER : <return>
NOTES            : FAMILY
```

All family members whose name 1 begins with 'M' will be displayed.

You can see how versatile this search is. Try it out yourself.

-6- DELETE DATA

Use this function to delete records. After entering the first and second names of the record, the record is read and the remaining fields are displayed. Then you are asked to confirm that the record is to be deleted. If you press **Y**, the record is deleted.

-0- END PROGRAM

Use this function to leave the program. Before the program is ended, you are reminded that you can restart the program without losing data by typing **GOTO 110**. This is important if you forget to save the data before ending the program.

Here is the program listing:

```
100 POKE 53280,5:POKE53281,2:PRINTCHR$(158);:DIMD$(100,7)
110 GOSUB2030
120 PRINT"SELECT THE DESIRED FUNCTION:"
130 PRINT"----------------------------":PRINT
140 PRINT"     -1- LOAD DATA"
150 PRINT"     -2- SAVE DATA"
160 PRINT"     -3- INPUT DATA"
170 PRINT"     -4- EDIT DATA"
180 PRINT"     -5- SELECT/PRINT DATA"
190 PRINT"     -6- DELETE DATA":PRINT
200 PRINT"     -0- END PROGRAM"
210 PRINT
220 PRINT"          CHOICE (0-6)?"
230 GETX$:IFX$<"0"ORX$>"6"THEN230
240 IF X$<>"0"THEN340
250 PRINT:PRINT"          ARE YOU SURE (Y/N)?"
260 GETX$:IFX$<>"N"ANDX$<>"Y"THEN260
270 IFX$="N"THEN110
280 GOSUB2030
290 PRINT"THE PROGRAM CAN BE RESTARTED WITH
300 PRINT"          'GOTO 110'"
310 PRINT"   WITHOUT LOSS OF DATA"
330 END
340 ONVAL(X$)GOSUB360,540,680,880,1190,1770
350 GOTO 110
360 REM *********
370 REM LOAD DATA
380 REM *********
390 GOSUB 2030
400 INPUT"NAME THE FILE :";FN$
410 OPEN 15,8,15
420 OPEN1,8,2,FN$+",S,R"
430 INPUT#15,FE:IF FE=0 THEN 460
440 PRINT"DISK ERROR!"
450 GOTO 510
460 X=1
470 INPUT#1,D$(X,1),D$(X,2),D$(X,3),D$(X,4),D$(X,5),D$(X,6),
    D$(X,7)
480 IF ST<>64 THEN X=X+1:GOTO470
490 PRINT"FILE IS LOADED AND CONTAINS";X;"RECORDS."
500 PRINT
510 CLOSE:CLOSE15
520 PRINT"RETURN FOR MORE"
530 INPUTX$:RETURN
540 REM *********
550 REM SAVE DATA
560 REM *********
570 IF X>0 THEN 590
580 GOSUB2230:RETURN
590 GOSUB 2030
600 OPEN 1,8,2,"@:"+FN$+",S,W"
610 FORI=1TOX
620 PRINT#1,D$(I,1)","D$(I,2)","D$(I,3);
```

```
630 PRINT#1,D$(I,4)",",D$(I,5)",",D$(I,6)",",D$(I,7)
640 NEXT
650 PRINT"DATA IS SAVED":CLOSE1:RETURN
660 PRINT"RETURN FOR MORE"
670 INPUTX$:RETURN
680 REM **********
690 REM INPUT DATA
700 REM **********
710 IFX>0THEN730
720 GOSUB2030:INPUT"FILENAME ";FN$
730 X=X+1
740 GOSUB2030
750 PRINT"INPUT DATA:"
760 PRINT"-----------":PRINT
770 I=X:GOSUB2110
780 FORI=1TO7:PRINTCHR$(145);:NEXT
790 FORI=1TO7:PRINTTAB(12);:INPUTD$(X,I):NEXT
800 PRINT:PRINT"CORRECT (Y/N)?"
810 GETX$:IFX$<>"N"ANDX$<>"Y"THEN810
820 IFX$="Y"THEN840
830 GOTO 740
840 PRINT"MORE INPUT (Y/N)?"
850 GETX$:IFX$<>"N"ANDX$<>"Y"THEN850
860 IFX$="Y"THEN730
870 RETURN
880 REM *********
890 REM EDIT DATA
900 REM *********
910 IF X>0THEN930
920 GOSUB2230:RETURN
930 GOSUB2030
940 INPUT"NAME 1:  ";N1$
950 INPUT"NAME 2:  ";N2$
960 FORI=1TOX
970 IF D$(I,1)=N1$ANDD$(I,2)=N2$THEN1010
980 NEXTI
990 PRINT"NAME NOT FOUND!"
1000 PRINT"RETURN FOR MORE":INPUTX$:RETURN
1010 GOSUB2030
1020 PRINT"-1- NAME 1      :";D$(I,1)
1030 PRINT"-2- NAME 2      :";D$(I,2)
1040 PRINT"-3- STREET      :";D$(I,3)
1050 PRINT"-4- CITY, STATE :";D$(I,4)
1060 PRINT"-5- ZIP CODE    :";D$(I,5)
1070 PRINT"-6- TELEPHONE   :";D$(I,6)
1080 PRINT"-7- NOTES       :";D$(I,7)
1090 PRINT"NO. OF FIELD TO CHANGE: ":PRINT"(9=NO
     CHANGES)"
1100 GETX$:IFVAL(X$)<1ORVAL(X$)>7ANDVAL(X$)<>9THEN1100
1110 IFVAL(X$)=9THEN1150
1120 Y=VAL(X$)
1130 INPUT"NEW CONTENTS";D$(I,Y):PRINT
1140 GOTO 1010
1150 PRINT"MORE CHANGES (Y/N)?"
1160 GETX$:IFX$<>"Y"ANDX$<>"N"THEN1160
```

```
1170 IFX$="Y"THEN880
1180 RETURN
1190 REM *****************
1200 REM SELECT/PRINT DATA
1210 REM *****************
1220 IF X>0THEN1240
1230 GOSUB2230:RETURN
1240 GOSUB2030:PRINT"OUTPUT TO PRINTER (P) OR SCREEN (S)?"
1250 GETX$:IFX$<>"S"ANDX$<>"P"THEN1250
1260 O$=X$:IFO$="S"THEN1300
1270 PRINT:PRINT"PAPER (P) OR MAILING LABELS (M)?"
1280 GETX$:IFX$<>"P"ANDX$<>"M"THEN1280
1290 D$=X$
1300 GOSUB2030
1310 PRINT"ENTER THE SEARCH DATA:"
1320 PRINT"PRESS RETURN BY IRRELEVANT FIELDS."
1330 PRINT"-----------------------------------":PRINT
1340 I=0:GOSUB2110
1350 FORI=1TO7:PRINTCHR$(145);:S$(I)="":NEXT
1360 FORI=1TO7:PRINTTAB(12);:INPUTS$(I):NEXT
1370 IFO$="S"ORD$="M"THEN1450
1380 GOSUB2030:PRINT"PRINTER READY (Y)?"
1390 GETX$:IFX$<>"Y"THEN1390
1400 OPEN 1,4
1410 PRINT#1,"NAME 1";SPC(8);"NAME 2";SPC(8);"STREET";
     SPC(10);
1420 PRINT#1,"CITY, STATE";SPC(4);"ZIP CODE TELEPHONE NOTES"
1430 FORI=1TO79:PRINT#1,"=";:NEXT:PRINT#1
1440 CLOSE1
1450 FORI=1TOX
1460 FORY=1TO7
1470 IFS$(Y)=LEFT$(D$(I,Y),LEN(S$(Y)))THENZ=Z+1:GOTO1480
1480 NEXTY
1490 IFZ=7THENGOSUB1550
1500 Z=0:NEXTI
1510 PRINT:PRINT"END OF DATA!":PRINT
1520 PRINT"RETURN FOR MORE":PRINT
1530 INPUTX$
1540 RETURN
1550 IFO$="S"THEN1730
1560 IFD$="M"THEN1670
1570 OPEN1,4
1580 PRINT#1,D$(I,1);SPC(14-LEN(D$(I,1)));
1590 PRINT#1,D$(I,2);SPC(14-LEN(D$(I,2)));
1600 PRINT#1,D$(I,3);SPC(16-LEN(D$(I,3)));
1610 PRINT#1,D$(I,4);SPC(15-LEN(D$(I,4)));
1620 PRINT#1,D$(I,5);SPC(8-LEN(D$(I,5)));
1630 PRINT#1,D$(I,6);SPC(12-LEN(D$(I,6)));
1640 PRINT#1,D$(I,7)
1650 PRINT#1:CLOSE1
1660 RETURN
1670 OPEN2,4
1680 PRINT#2
1690 FORJ=1TO5:PRINT#2,D$(I,J):NEXT
1700 PRINT#2:PRINT#2:PRINT#2
```

```
1710 CLOSE2
1720 RETURN
1730 GOSUB2030:GOSUB2110
1740 PRINT:PRINT"MORE (Y)?"
1750 GETX$:IFX$<>"Y"THEN1750
1760 RETURN
1770 REM ***********
1780 REM DELETE DATA
1790 REM ***********
1800 IFX>0THEN1820
1810 GOSUB2230:RETURN
1820 GOSUB2030
1830 INPUT"NAME 1 : ";N1$
1840 INPUT"NAME 2 : ";N2$
1850 FORI=1TOX
1860 IFD$(I,1)=N1$ANDD$(I,2)=N2$THEN1900
1870 NEXTI
1880 PRINT"NAME NOT FOUND!":PRINT
1890 PRINT"RETURN FOR MORE":INPUTX$:RETURN
1900 GOSUB2030:GOSUB2110
1910 PRINT:PRINT"DELETE RECORD (Y/N)?"
1920 GETX$:IFX$<>"Y"ANDX$<>"N"THEN1920
1930 IFX$="N"THENRETURN
1940 FORY=ITOX-1
1950 FORJ=1TO6
1960 D$(Y,J)=D$(Y+1,J)
1970 NEXTJ,Y
1980 FORJ=1TO6:D$(X,J)="":NEXTJ
1990 X=X-1
2000 PRINT"RECORD IS DELETED!"
2010 PRINT"RETURN FOR MORE"
2020 INPUTX$:RETURN
2030 REM ***************
2040 REM PROGRAM HEADING
2050 REM ***************
2060 PRINTCHR$(147);
2070 PRINTTAB(8);"======================="
2080 PRINTTAB(8);"M A I L I N G   L I S T
2090 PRINTTAB(8);"======================="
2100 RETURN
2110 REM ************
2120 REM PRINT RECORD
2130 REM ************
2140 PRINT"NAME 1       : ";D$(I,1)
2150 PRINT"NAME 2       : ";D$(I,2)
2160 PRINT"STREET       : ";D$(I,3)
2170 PRINT"CITY, STATE  : ";D$(I,4)
2180 PRINT"ZIP CODE     : ";D$(I,5)
2190 PRINT"TELEPHONE    : ";D$(I,6)
2200 PRINT"NOTES        : ";D$(I,7)
2220 RETURN
2230 REM ********
2240 REM NO DATA!
2250 REM ********
2260 GOSUB2030
```

```
2270 PRINT"NO DATA IN MEMORY!":PRINT
2280 PRINT"RETURN FOR MORE"
2290 INPUTX$:RETURN
```

1.4.11 Uses for Sequential Storage

The great advantage of sequential storage as compared to relative and direct access storage, is that a lot of data can be written to the diskette quickly. Data of varying lengths can be stored together, without requiring the records to be of a definite length. It makes sense to make use of this advantage, where the the file must not be permanently divided into parts. Examples are:

* Bookkeeping files
  In a bookkeeping journal, all entries are recorded continuously. Changes should not be made to these entries. Instead, adjustment entries should be made to effect changes.

* Analysis files
  You analyze a direct access file, looking for, say, all customers with whom you have done more than 2000 dollars of business in a certain zip code, and write the found records in a sequential file for later access.

Naturally, sequential files also offer a substitute for direct access files, as discussed in this chapter, if the user does not possess further programming knowledge. We must certainly recommend that you work through the other methods of data storage, which offer other advantages.

1.5 Relative Data Storage

Relative data storage and its programming is not described in the VIC-1541 user's manual. The reason may lie in the fact that the Commodore 64 and the VIC-20 have no commands to process relative files using BASIC 2.0. Therefore, it is in principle not possible to use relative data storage on the Commodore 64 and VIC-20 - but only in principle. We have developed a few tricks that work within the limitations of BASIC 2.0 and permit the Commodore 64 and also the VIC-20 to use relative data storage. The examples may seem to be somewhat complicated at first. For example, information about the record lengths will be transmitted to the disk using CHR$(x) codes. But they provide for a very easy method of data storage.

1.5.1 The Principle

When using relative record data processing, the data records are numbered. It is assumed that all records in a relative file have the same length and that the record number of every record is known or can be calculated. To find a record, it is not necessary to search through the entire file. Only the record number need be given to access the record. Using the record number, the DOS can find where the record is "relative" to the beginning of the file on the diskette and can read it directly. Therefore, you don't have to read an entire file into the computer, only the desired records.

Managing a relative file follows this pattern:

Create a relative file:

1. The file is opened. With this the length of a record is established.
2. The last record is marked.
3. The file is closed.

Writing a record:

1. The file is opened.
2. The file is positioned on the record to be written.
3. The record is written.
4. The file is closed.

Reading a record:

1. The file is opened.
2. The file is positioned over the record to be read.
3. The record is read.
4. The file is closed.

This is only an outline. In the following sections these processes will be explained in detail.

1.5.2 The Advantage over Sequential Storage

The greatest advantages of relative storage are:

* faster access to individual records
* does not require much of the computer's memory

It has already been mentioned that the sequential file must reside completely in the computer's memory for processing. Using sequential techniques, it may be necessary to search the entire file to find a given record. The record must be read and compared during the search process. But if a sequential file cannot be entirely loaded into memory, this method of search is impossible.

Using relative data files, the processing is much simpler. By using the record number, a desired record can be read individually. The file size is not limited to the computer's memory. So, for example, a program that uses all 3.5K bytes of a standard VIC-20 can manage a file with up to 163 Kbytes!

The advantages of relative over sequential file management are large enough that many of you, once acquainted with the techniques will prefer to use them.

1.5.3 Opening a Relative File

Relative files are also opened with the OPEN command. The command differs only slightly from that for sequential files. Take a look at the format of the OPEN command:

OPEN lfn,da,channel,"filename,L,"+CHR$(recordlength)

The first four parameters are identical to those for sequential files. They are logical file number, device address (normally 8), channel (2-14), and name of the file. Next follows an L which informs the DOS that a relative file should be opened, whose record length follows. This record length is transmitted with a CHR$ code. The length is between one and 254. Thus each record of a relative file is limited to a maximum of 254 characters.

If the record length is smaller than 88, the record can be read with an INPUT# statement. For this, it is necessary that the PRINT# statement transfers the record with a trailing RETURN. A PRINT# statement sends a RETURN when it is not ended with a semicolon. This RETURN is now a part of the record. When you want to read records with INPUT#, the record length must be increased by one.

A file composed of 80-character records, to be read by the INPUT# statement would be opened as follows:

```
OPEN 1,8,2,"FILE.REL,L,"+CHR$(81)
```

Here a relative file with the name "FILE.REL" is opened using channel 2. The record length should total 81 characters. Records comprised of 80 characters should be sent with a PRINT# statement, with no trailing semicolon.

It is important to note that only one relative file can be opened at a time. If you want to work with two relative files, you must always close the first before opening the second. One sequential file may be opened in addition to one relative file.

When a relative file is opened for the first time, the DOS creates as many "null" or unused records that can fit in a single 254 byte block. It creates these "null" records by writing a record with a CHR$(255) at the beginning of each record. This is called formatting a relative file.

If you want to expand a relative file beyond the initial number of records that the DOS formatted, then you can reference the last record number that you want to write (by positioning to that record number) and the DOS automatically formats the records between the current end of file and the new last record number by writing records containing CHR$(255). Formatiing takes time to complete.

If you try to read a record whose number greater than that of the last record, the DOS returns the error **RECORD NOT PRESENT.** However, if you write a record which is greater than the highest current record, all records less than the new record number are also written with CHR$(255). Subsequently accessing these record does not result in an error.

If you want to avoid long delays as relative records are formatted (as the file is expanded), then you should reference the last record number immediately after opening the file. The formatting of the null records takes place at that time instead of at a more inconvenient time.

To position the DOS for a specific relative record you must send a position command over the command channel (15), as shown here:

PRINT#lfn,"P"+CHR$(channel)+CHR$(low)+CHR$(high)+CHR$(byte)

If you are positioning to a record which is beyond the current end of file, the DOS presents the message **RECORD NOT PRESENT** appears to the disk error channel. If this record is to be written, then you can ignore the message. The following PRINT# statement is carried out in spite of the error message.

The parameters **low** and **high** in the P command designate the record number. The maximum value that can be given with one byte is 255, but a relative file contains up to 65535 records. Therefore, the record number must be transmitted in two bytes. These two bytes are calculated with the following formula:

```
HB=INT(RN/256)
LB=RN-HB*256
```

HB = High Byte (parameter high)
LB = Low Byte (parameter low)
RN = Record Number

The last parameter (byte) serves to position to a specific location within the given record. An example:

PRINT#2,"P"+CHR$(2)+CHR$(10)+CHR$(1)+CHR$(5)

Here the file is positioned to the fifth byte of the 266th record. This 266 is coded as a low byte of 10 and a high byte of 1 (high byte * 256 + low byte = record number).

To read or write a complete record, the file is positioned to the first byte of the record. If the last parameter is not given, the trailing RETURN (CHR$(13)) is taken as the character location.

The corresponding BASIC program to establish a file of 100 80-character records looks like this:

```
100 RN=100
110 HB=INT(RN/256)
120 LB=RN-HB*256
130 OPEN1,8,2,"FILE.REL,L,"+CHR$(80)
140 OPEN2,8,15
150 PRINT#2,"P"+CHR$(2)+CHR$(LB)+CHR$(HB)+CHR$(1)
160 PRINT#1,CHR$(255)
170 CLOSE 1:CLOSE 15
```

Freeing 100 records takes some time. The creation of this file takes about ten minutes. Notice that of the 80 characters in a record, only 79 can be used to hold data, because transferring data with a PRINT# command adds a trailing RETURN.

1.5.4 Preparing Data for Relative Storage

As already mentioned, you cannot change the record length of a relative file. If a record consists of several fields, these fields must be combined. It is important that these fields always be in the same position so that they can be separated later. Let's work through a problem:

We want to manage an inventory using relative storage techniques. To that end, the following fields are necessary:

```
PART NUMBER      4 CHARACTERS
DESCRIPTION     15 CHARACTERS
QUANTITY         5 CHARACTERS
COST             6 CHARACTERS
PRICE            6 CHARACTERS
                --------------
Record length 36 bytes
                ==============
```

The inventory contains approximately 200 items with a record length of 36 bytes. This inventory file can now be created:

```
100 RN=200:REM NUMBER OF INVENTORY ITEMS
110 RL=36 :REM RECORD LENGTH
120 OPEN 1,8,2,"INVEN,L,"+CHR$(36)
130 OPEN 2,8,15
140 PRINT#2,"P"+CHR$(2)+CHR$(200)+CHR$(0)+CHR$(1)
150 PRINT#1,CHR$(255)
160 CLOSE 1:CLOSE 2
```

Now the file is created and all records are written. Let's suppose that the inventory is present as a sequential file. It consists of 200 records, the fields of which are ordered one after the other. These fields must be written to the relative file. This is not simple, however, because many of the descriptions are not the full fifteen characters in length, for example. The structure of the relative file looks as follows:

```
                    111111111122222222223333333
Position : 123456789012345678901234567890123456
===============================================
Field    : PN$-DE$------------Q$---C$----P$----
===============================================
Contents : 1    1/8 in. sheet   1344 11.40 20.30
         : 2    No. 10 screw    1231  4.00  7.00
         : 3    Valve A3A4      1243 11.45 16.40
         :            .
         :            .
         :            .
         : 200 1/2 in. tubing 2321  3.35  4.10
```

The fields will be read from the sequential file into the following variables:

Part number	PN$
Description	DE$
Quantity	Q$
Cost	C$
Price	P$

The following command chains these fields together:

```
RC$ = PN$ + DE$ + Q$ + C$ + P$
```

The record variable RC$ does not have the desired structure. The reason is that the quantity immediately follows the description. Because the quantity must begin at position 20 and the description is not always fifteen characters, we have a problem. In order to read the records from the relative file, the structure must be observed. Therefore, all fields that are shorter than the planned length must be padded with blanks. Taking this into account, the chaining goes like this:

```
BL$="               "
RC$=PN$+LEFT$(BL$,4-LEN(PN$))
RC$=RC$+DE$+LEFT$(BL$,15-LEN(DE$))
RC$=RC$+Q$+LEFT$(BL$,5-LEN(Q$))
RC$=RC$+C$+LEFT$(BL$,6-LEN(C$))
RC$=RC$+P$+LEFT$(BL$,6-LEN(P$))
```

This concatenation looks more complicated than it really is. Each field must be filled with enough blanks to bring it to its appropriate length. The blanks are added to the individual fields from the string BL$, defined at the beginning. T

Let's go through an example:

Suppose the first part number is 8. The length of this string, LEN(PN$), is then one. The maximum length of this field (4) minus the actual length (1) is 3. The string PN$ must therefore be padded with three blanks, LEFT$(BL$,3).

Each record of the old sequential file must be prepared in this manner before it can be transferred to the relative file.

Naturally, the above is true for all input values to be used in a relative file. Therefore, you must always remember to use a routine to fill each field with blanks to its full length when working with relative data processing.

1.5.5 Transferring Data

In principle, transferring data to and from a relative file does not differ from sequential storage. Records are written with PRINT# and read with INPUT# or GET#. The only difference is that before a record is be written or read, the file must be positioned to that record. This is accomplished with the P command. This example program illustrates what we have discussed:

```
100 BL$="               "
105 OPEN 1,8,2,"TEST.REL,L,"+CHR$(41)
110 OPEN 2,8,15
120 PRINT#2,"P"+CHR$(2)+CHR$(100)+CHR$(0)+CHR$(1)
130 PRINT#1,CHR$(255)
140 PRINT CHR$(147)
150 PRINT"INPUT RECORD:"
160 PRINT"-------------"
170 INPUT"RECORD NUMBER (1-100)   : ";RN
180 IF RN<1 OR RN>100 THEN PRINTCHR$(145);:GOTO160
190 INPUT"FIELD 1 (MAX.10 CHAR.) : ";F1$
200 IF LEN(F1$)>10 THEN PRINTCHR$(145);:GOTO190
210 INPUT"FIELD 2 (MAX. 5 CHAR.) : ";F2$
220 IF LEN(F2$)>5 THEN PRINTCHR$(145);:GOTO210
230 INPUT"FIELD 3 (MAX.10 CHAR.) : ";F3$
240 IF LEN(F3$)>10 THEN PRINTCHR$(145);:GOTO230
250 INPUT"FIELD 4 (MAX.15 CHAR.) : ";F4$
260 IF LEN(F4$)>15 THEN PRINTCHR$(145);:GOTO250
270 PRINT"CORRECT (Y/N)?"
280 GETX$:IF X$<>"Y" AND X$<>"N" THEN 280
290 IF X$="N" THEN 140
300 RC$=F1$+LEFT$(BL$,10-LEN(F1$))
310 RC$=RC$+F2$+LEFT$(BL$,5-LEN(F2$))
320 RC$=RC$+F3$+LEFT$(BL$,10-LEN(F3$))
330 RC$=RC$+F4$+LEFT$(BL$,15-LEN(F4$))
340 PRINT#2,"P"+CHR$(2)+CHR$(RN)+CHR$(0)+CHR$(1)
350 PRINT#1,RC$
360 PRINT"MORE INPUT (Y/N)?"
370 GETX$:IF X$<>"Y" AND X$<>"N" THEN 370
380 IF X$="Y" THEN 140
390 CLOSE 1:CLOSE 2:END
```

The following line-oriented documentation explains the operation of the program:

100	A blank-character string with 15 blanks is defined.
105	The relative file is opened with a length of 15.
110	The command channel 15 is opened.
120	To initialize the relative file, the head is positioned over the first byte of the last (100th) record.
130	The last record is freed and the initialization begun.
140	The screen is erased.

150-260	The record no. and fields 1-4 are entered and checked for correct length.
270-290	The entered data can be corrected.
300-330	The record is prepared.
340	The head is positioned over the first byte of the record.
350	The record is written to the disk.
360-380	New data can be entered.
390	The program ends.

Now write some records with this program, but don't forget to save in case you need it later.

Certainly, it also necessary to read and change existing records. To do this, the relative file is opened, the file is positioned to the appropriate record, and the record is read. This record must then be divided into its fields. Let's read a record that was recorded with the previous program. The following routine reads the record:

```
100 OPEN 1,8,2,"TEST.REL,L,"+CHR$(41)
110 OPEN 2,8,15
115 PRINT CHR$(147)
120 INPUT"RECORD NUMBER :";RN
130 PRINT#2,"P"+CHR$(2)+CHR$(RN)+CHR$(0)+CHR$(1)
140 INPUT#1,RC$
160 IF ASC(RC$)<>255 THEN PRINT"RECORD NOT FOUND!":
    GOTO250
170 PRINT RC$
250 CLOSE 1:CLOSE 2
```

This routine reads a specified record. If this record has never been written, it is recognized by the value 255 with which every record was marked at the establishment of the file.

A record that is found is displayed. You can see that the four fields are in the same positions. If you want to divide the record into its individual parts, you must use the function MID$. For example, in order to extract field 1 of the record, give the following statements in the direct mode after the record is found and read:

```
F1$=MID$(RC$,1,10)
PRINT F1$
```

Now the variable F1$ contains the first field, as written by the first program. The division of records into individual fields is accomplished by building on the previous program. Add or change the following lines:

```
170 F1$=MID$(RC$,1,10)
180 F2$=MID$(RC$,11,5)
190 F3$=MID$(RC$,16,10)
200 F4$=MID$(RC$,26,15)
```

```
210 PRINT"FIELD 1: ";F1$
220 PRINT"FIELD 2: ";F2$
230 PRINT"FIELD 3: ";F3$
240 PRINT"FIELD 4: ";F4$
250 PRINT"MORE (Y/N)?"
260 GETX$:IF X$<>"Y" AND X$<>"N" THEN 260
270 IF X$="Y" THEN 115
280 CLOSE 1:CLOSE 2
```

Here the record is separated into the individual fields and the fields are displayed. It is important for the MID$ function that the exact positions of the fields within the record be maintained. The first parameter within the parentheses is the string variable containing the record. The second parameter is the position at which the number of characters represented by the parameter will be taken out. Further work may done with the selected fields inside the program.

So far, we have read the records with the INPUT# statement. If the record is longer than 88 characters, it can no longer be read with the INPUT# statement. The way to get around the limited INPUT# statement is with the GET# statement. The bytes of a record are read one at a time with this command and assembled into a single string. Suppose you have a relative file with 128-character records. Now you want to read the tenth record of this file and place it in the variable RC$. The example of the following routine illustrates reading this with GET#:

```
100 OPEN 1,8,2,"TEST.GET,L,"+CHR$(128)
110 OPEN 2,8,15
120 PRINT#2,"P"+CHR$(2)+CHR$(10)+CHR$(0)+CHR$(1)
130 RC$=""
140 FOR I=1 TO 128
150 GET#1,X$
160 RC$=RC$+X$
170 NEXT I
    .
    .
    .
    .
```

After running this routine, the record is contained in the variable RC$. If this record had been written with a PRINT# statement without a trailing semicolon, the last character in the string will be a RETURN. To ignore this RETURN, allow the loop in line 140 to run only to 127. The last character of the record RETURN is not read.

As already mentioned, the last parameter of the P command specifies at which character the transfer of data should begin. If, for instance, in the 127-character record of the previous example, you want to read positions 40-60 into a field, the head must be positioned over the 40th character and the next 21 bytes read. The following routine clarifies this:

```
100 OPEN 1,8,2,"TEST.GET,L,"+CHR$(128)
110 OPEN 2,8,15
120 PRINT#2,"P"+CHR$(2)+CHR$(10)+CHR$(0)+CHR$(40)
130 F$=""
140 FOR I=1 TO 21
150 GET#1,X$
160 F$=F$+X$
170 NEXT I
    .
    .
    .
    .
```

In line 120, the head is positioned over the the 40th byte of the tenth record in line 120 and the loop in lines 140-170 reads the following 21 bytes (bytes 40-60 of the record) into F$.

You see then that the entire record need not be read if you only want to work with part of it.

1.5.6 Closing a Relative File

There is no difference between closing a relative file and sequential file. Because the command channel must always be open to send the position command when working with relative storage, it must also be closed.

1.5.7 Searching Records with the Binary Method

Normally each record is accessed by record number. But what if you want to search for a specific name in a relative file and the record number is not known. It is possible to read each record and compare each for the desired name. But this is very time consuming if the file has many records.

If the file is kept in name order, the records can be searched using an alternative method. This method is called a binary search. In order to use a binary search, the relative file must be arranged in sorted order. Using the above example, relative record 1 must contain a name with the lowest collating sequence while the last relative record must contain a name with the highest collating sequence. Thus the name AARON might be contained in relative record 1 and ZYPHER might be contained in the last relative record of the file and all other names would be ordered throughout.

When records are added to the file, then the records must be reordered. Similarly if a name is changed, then the records must be reordered.

The binary search can be explained using a simple example. When you want to find a name in the telephone book, you don't search through it sequentially. You open the book in the middle and compare the first letter of the desired name with the first letter of names on the page. If the desired name comes before these, you turn halfway into the first section of the book, and so on. You go through it systematically.

The binary search is not a sequential search. It identifies a record halfway through the remaining number of records. The following example will clarify this:

There exists the following relative file, sorted in ascending order:

Record number	Contents
1	1985
2	1999
3	2005
4	2230
5	2465
6	2897
7	3490
8	3539
9	4123
10	5000
11	5210
12	6450
13	6500
14	6550
15	6999

Out of these fifteen records we will search for a contents of 3490. It is not known which record it is stored in.

We must first know how many records are in the file. In this case, there are fifteen. We divide this by two. The middle of the file is record eight with the contents 3539. We determine if the contents of this record equal to the target value, and if not, whether it is larger or smaller. In this case, it (3539) is larger. This means the record we are looking for is in the first half of the file. So we divide eight by two and examine the contents of record four, 2230. Since 2230 is less than 3490, it lies between four and eight. We again divide by two and add this to record 4 which and results in record 6 whose contents is 2897. 2897 is less than 3490, so our target lies between records six and eight. Record seven is indeed the record we are looking for.

The principle of the binary search is to determine by the result of each comparison whether to search upwards or downwards until the search data is found. The maximum number of comparisons can be found using the following formula:

```
S=INT(LOG(N)/LOG(2)+1)
```

S is the number of comparisons (searches) and N is the number of records in the file. In a sorted relative data file with 1000 records, no more than ten comparisons will be necessary to find the desired record!

Let's create a relative data file with fifteen records to test the binary search:

```
100 OPEN1,8,2,"BINARY.REL,L,"+CHR$(5)
110 FORI=1TO15
120 READ RC$
130 PRINT#1,RC$
140 NEXT I
150 CLOSE 1:CLOSE 2:END
160 DATA 1985,1999,2005,2230,2465,2897,3490,3539
170 DATA 4123,5000,5210,6450,6500,6550,6999
```

This program puts the fifteen records in a file called **BINARY.REL** using the values given in lines 160-170. The position command is not necessary because the data will be written straight through from first to last record. After opening the file the pointer points to the first record. This file is designed to be searched with the binary method. The following program is based on the logic of the binary search:

```
100 OPEN1,8,2,"BINARY.REL,L,"+CHR$(5)
110 OPEN2,8,15
120 PRINTCHR$(147)
140 N=15: REM NUMBER OF RECORDS
150 I=LOG(N)/LOG(2)
160 IF I-INT(I)<>0 THEN I=INT(I)+1
170 M=I-1
180 I=2^I
190 X=I/2
210 INPUT"RECORD TO FIND (* TO END): ";SR$
220 IF SR$="*" THEN 320
230 IF M<0 THEN PRINT"RECORD NOT FOUND":GOTO140
240 M=M-1
250 PRINT#2,"P"+CHR$(2)+CHR$(X)+CHR$(0)+CHR$(1)
260 INPUT#1,RC$
270 IF SR$=RC$ THEN 340
280 IF SR$<RC$ THEN X=X-2^M:GOTO230
290 X=X+2^M
300 IF X>I THEN PRINT"END OF FILE EXCEEDED!"
310 GOTO 230
320 CLOSE 1:CLOSE 2
```

```
330 END
340 PRINT"RECORD FOUND!"
350 PRINT"CONTENTS : ";RC$
360 GOTO 140
```

Program Documentation:

100	The relative file "BINARY.REL" is opened.
110	The command channel is opened.
120	The screen is erased.
140	The number of records is assigned to the variable N.
150-190	If the maximum number of records does not represent a power of two, the next higher power of two is formed. The file will be expanded, but no records are lost. The exponent of this power of two is used as the index. X is the value of I/2. I/2 indicates the exact middle of the (expanded) file. After that, the variable M receives the value of I-1.
210-220	The record to be found is read. To end the program, enter a '*'.
230	If M<0, the record was not found.
240	M is decremented by one. The next Mth power represents half of the rest of the file.
250-260	The file is positioned over the record containing in the variable X.
270	If the target record is found, the search is ended and the record displayed.
280-310	It is determined if the target record is larger or smaller than the record just read. The middle of the upper or lower half (as appropriate) is stored in the variable X.
320-330	The file is closed and the program is ended.
340-360	The found record is displayed.

This binary search, coded in BASIC, is implemented universally. Only the number of records and the appropriate record to be searched for need be changed. You can use this routine for finding records in your sorted relative data files.

1.5.8 Searching Records with a Separate Index File

If you work with individual records frequently and need quick access with alphanumeric keys that don't correspond to the logical record number, and your file is not sorted, we recommend another method.

Create an index file for each desired key field, in which each record is composed of

- an index key
- the corresponding record number

This entire index file is to be loaded into the computer's memory. An example:

You have constructed your name and address manager as a relative file consisting of

- First name
- Last name
- Street
- City, State
- Zip code
- Telephone number

You want to be able to search the file based on the last name. So you create an additional sequential file that contains the desired key (in this case the last name) and the record number of the corresponding record in the relative file.

The index file is read completely into the computer so the search can be accomplished as quickly as possible. If you want to access a record that has the last name **HARRIS**, then you search through the appropriate index in memory and when found, read the corresponding relative record by using the record number also contained in the index.

Here is an example:

We assume that a data file and an index file exist for the names:

```
Data file:                                Index file:
==========                                ===========
Last name First name   more fields        Index              Record No.
                                          (last name)          LB   HB
---------------------------------------------------------------------------
Smith     John         ...........        Smith                01   00
Harris    Sam          ...........        Harris               02   00
Hanson    Carl         ...........        Hanson               03   00
Johnson   Mark         ...........        Johnson              04   00
  .         .                               .                  .
  .         .                               .                  .
  .         .                               .                  .
Green     Simon        ...........        Green                99   00
---------------------------------------------------------------------------
```

The file contains 99 records. Before the program can be used, the index file must be read in. This can be a sequential file, which can be read into a memory table reserved with DIM IT$(99). The first twenty characters of each index table position comprise the last name. The next to the last byte (no. 21) is the low byte and the last byte (no. 22) is the high byte of the record number. With these conditions, a desired record can be found with the following routine:

```
        .
        .
100 INPUT "LAST NAME";N$
110 FOR I=1 TO 99
120 IF LEFT$(IT$(I),20)=N$ THEN 150
130 NEXT I
140 PRINT "NAME NOT FOUND!":END
150 PRINT "RECORD FOUND!"
160 OPEN1,8,2,"ADDRESS,L,"+CHR$(81)
170 OPEN 2,8,15
180 PRINT#2,"P"+CHR$(2)+MID$(IT$(I),21,1)+CHR$(0)
    +CHR$(1)
190 INPUT#1,RC$
        .
        .
```

The loop in lines 110-130 goes through the index table sequentially, searching for the target name contained in the twenty leftmost characters. If the name is not found, an appropriate message is given (line 140), before the program is ended.

If, in line 120, the target name matches the index entry, the program branches to line 150. After giving the message, the address file is opened. After opening the command channel, the position command is sent to the disk. Because the next to the last byte of the index entry contains the low byte of the record number, it must be extracted using the MID$ function. The high byte is known to be zero since there are fewer than 255 record.

Finally the relative record is read in line 190.

The access of index files is an equally fast and extraordinarily flexible form of data organization. One can theoretically have as many index files as desired. Above all, you must take note of two important restrictions:

1. Changes in the main data file which affect the key fields must also be made to the corresponding index file. With several index files this can become very time-consuming.

2. The number and size of the index files that are kept in the computer's memory for fast access are limited by the availability of memory.

1.5.9 Changing Records

The logical process for changing a record is this:

1. Read the record
2. Split the record into its fields
3. Change the appropriate field
4. Rebuild the record (combine fields)
5. Rewrite the record

In section 1.5.5 we wrote some records in the file "TEST.REL". This file had the following properties:

```
Record length                      41 bytes
Number of records                 100
Number of fields                    4
Length, position field 1 :  10,  1-10
  "    ,    "      field 2 :   5, 11-15
  "    ,    "      field 3 :  10, 16-25
  "    ,    "      field 4 :  15, 26-40
Trailing RETURN in position 41
```

A file description such as the one above should be made for each of your files. This is very important if other programs are to use these data. The file description defines the order and length of the fields of the file.

In this file, we allow for the contents of the records to be changed. The following program allows changes:

```
100 REM ===================
110 REM     PREPARATION
120 REM ===================
130 BL$="                "
140 OPEN 1,8,2,"TEST.REL,L,"+CHR$(41)
150 OPEN 2,8,15
160 REM ===================
170 REM     READ RECORD
180 REM ===================
190 PRINT CHR$(147)
200 INPUT"RECORD NUMBER (1-100): ";RN
205 IF RN<1 OR RN>100 THEN PRINTCHR$(145);:GOTO200
210 PRINT"---------------------------"
220 PRINT#2,"P"+CHR$(2)+CHR$(RN)+CHR$(0)+CHR$(1)
230 INPUT#1,RC$
240 IF ASC(RC$)<>255 THEN 270
250 PRINT "RECORD NOT WRITTEN"
260 GOTO 630
270 REM =====================
280 REM     PREPARE RECORD
290 REM =====================
300 F$(1)=MID$(RC$,1,10)
310 F$(2)=MID$(RC$,11,5)
320 F$(3)=MID$(RC$,16,10)
330 F$(4)=MID$(RC$,26,15)
```

```
340 REM =====================
350 REM     DISPLAY FIELDS
360 REM =====================
370 PRINT CHR$(147)
380 FOR I=1 TO 4
390 PRINT"FIELD";I;": ";F$(I)
400 NEXT I
410 PRINT"-------------------------"
420 REM =====================
430 REM     CHANGE FIELDS
440 REM =====================
450 PRINT"CHANGE WHICH FIELD (1-4)?"
460 GETX$:IFX$<"1" OR X$>"4" THEN 460
470 INPUT"NEW CONTENTS : ";F$(VAL(X$))
480 PRINT"RECORD IS CHANGED"
490 PRINT"MORE CHANGES IN THIS RECORD (Y/N)?"
500 GETX$:IF X$<>"Y" AND X$<>"N" THEN 500
510 IF X$="Y" THEN 340
520 REM ====================
530 REM     CHAIN FIELDS
540 REM ====================
550 RC$=F$(1)+LEFT$(BL$,10-LEN(F$(1)))
560 RC$=RC$+F$(2)+LEFT$(BL$,5-LEN(F$(2)))
570 RC$=RC$+F$(3)+LEFT$(BL$,10-LEN(F$(3)))
580 RC$=RC$+F$(4)+LEFT$(BL$,15-LEN(F$(4)))
590 REM ========================
600 REM     WRITE RECORD BACK
610 REM ========================
620 PRINT#1,RC$
630 REM ====================
640 REM     END PROGRAM?
650 REM ====================
660 PRINT"MORE CHANGES TO FILE (Y/N)?"
670 GETX$:IF X$<>"Y" AND X$<>"N" THEN 670
680 IF X$="Y" THEN 160
690 CLOSE 1:CLOSE 2:END
```

After this program is RUN you can change any desired record. This record must have been written with the program in section 1.5.5.

This editing program does not check the new field data for correct length.

The important commands in this program have already been explained in the corresponding sections.

1.5.10 Expanding a Relative File

Every relative file has a user-determined number of records that ranges from 1 to 65538. This number is the record with the highest record number and is written to the file with a value of CHR$(255). Writing this last record also formats all records in the file that precede this record number with CHR$(255).

You can expand the size of a relative file at a later time. For example, consider a relative file that is initially created with three records. After the file is OPENed, you position the file at record number 3 and write the record with CHR$(255). Here's an example of how you might do this:

```
10 OPEN 1,8,2,"RELFILE,L,"+CHR$(50)
20 OPEN 15,8,15
30 PRINT#15,"P"+CHR$(2)+CHR$(3)+CHR$(0)+CHR$(1)
40 PRINT#1,CHR$(255)
```

When statement 40 is performed, not only is record 3 written, but records 1 and 2 are also formatted by the DOS. Subsequently, if you position and write a 90th record, the DOS formats records 4 through 89 (see lines 150 and 160 below). Each time the file is expanded, the DOS formats records between the current high record number and the new high record number.

```
 .
150 PRINT#15,"P"+ CHR$(2)+CHR$(90)+CHR$(0)+CHR$(1)
160 PRINT#1,CHR$(255)
 .
 .
500 PRINT#15,"P"+CHR$(2)+CHR$(175)+CHR$(0)+CHR$(1)
510 PRINT#1,CHR$(255)
 .
 .
```

An existing relative file can be expanded at any time, provided there is sufficient room on the disk. To do so, the new last record is written with CHR$(255). At the same time, all records between the old and new end of file are also formatted.

When writing a record to a relative file whose record number is higher than the current high record number, a DOS error is not returned. If there is room on the diskette for the new records (current high record number through the new high record number) the file is simply expanded. If there is a lack of space on the diskette for the new records, the DOS error **FILE TOO LARGE** is returned. When reading a record from a relative file whose record number is higher than the current high record number, the DOS error **RECORD NOT PRESENT** is returned to the error channel.

1.5.11 Home Accounting with Relative Data Storage

A complete example of problem solving using relative files offers you a good insight into the organization of relative file processing. It can be used by most readers of this book. Few examples of relative file usage have been explained elsewhere, so here is such a program.

In this application, individual accounts are numbered. This account number is used as a key to the corresponding records.

This provides that each account contain a clear text description. The first field of each record is this account name. Twenty characters are allowed for the name.

Since information is needed for each month, twelve fields are necessary for each record. These summary fields are each ten characters long. The account summaries are stored as strings which are converted to numbers with the help of the VAL function. The record consists of 141 characters (twenty for the name, 12*10 for the month summaries and one for RETURN).

The layout of the records follows:

Field	Length	Position
Account name	20	1-20
January summary	10	21-30
February summary	10	31-40
.		
.		
.		
.		
November summary	10	121-130
December summary	10	131-140

The maximum number of accounts per year is set to twenty. Therefore, a year's file consists of twenty records of 141 bytes each.

We also specified the functions that this program is to perform.

* Create accounts

* Post to accounts

* Display summary by Account

* Display account names

* Display Monthly summary

* Display Year-end summary

Create accounts:

This function creates the file for a year. It asks for the number and names of the accounts. The records are then written with the account name and the summary fields are set to zero. Should a data file already exist with the same name, the old file is deleted.

Post to accounts:

This function asks for the account number to be posted and whether the posting is an income or expense. For example, the category "SALARY" is an income account and the category "RENT" is an expense account.

After this, the current contents of the account are displayed. When you post the appropriate amount, which is always positive. If you are making a correction entry, use a negative amount.

Now the updated contents are displayed. You may then make a new entry.

Producing account summary:

After entering the account number, the summary of the twelve months and the year's total are displayed for that account.

Display account names:

Each account is determined by its number. Should you forget a number, this function lists all accounts by name and corresponding number.

Display monthly summary:

Here the income or expenses of all accounts are displayed. The monthly balance of all accounts is also displayed.

Display year-end summary:

This function shows the summary of all accounts and the year-end balance. This display takes some time, since all monthly fields of each record must be read and totaled. It accesses the entire file.

Here's the program listing:

```
100 POKE 53280,2:POKE53281,2:PRINTCHR$(158);:
    BL$="                              ":DIMS(12)
110 GOSUB 2050
120 INPUT"CURRENT YEAR : ";Y$
130 IF Y$<"1984"ORY$>"1999"THENPRINTCHR$(145);:GOTO120
140 GOSUB 2050
150 PRINT"SELECT A FUNCTION:
160 PRINT"------------------":PRINT
170 PRINT"      -1- CREATE ACCOUNTS"
180 PRINT"      -2- POST TO ACCOUNTS"
190 PRINT"      -3- ACCOUNT SUMMARY"
200 PRINT"      -4- DISPLAY ACCOUNT NAMES"
210 PRINT"      -5- MONTHLY SUMMARY"
220 PRINT"      -6- YEAR SUMMARY":PRINT
230 PRINT"      -0- END PROGRAM"
240 GETX$:IFX$<"0"ORX$>"9"THEN240
250 IFX$<>"0"THEN270
260 END
270 ONVAL(X$)GOSUB 290,560,920,1160,1370,1720
280 GOTO 140
290 REM ======================
300 REM    CREATE ACCOUNTS
310 REM ======================
320 GOSUB 2050
330 PRINT"CAUTION! ANY PREVIOUS FILE FOR THIS YEAR"
340 PRINT"WILL BE ERASED!":PRINT
350 PRINT"CONTINUE (Y/N)?"
360 GETX$:IFX$<>"Y"ANDX$<>"N"THEN360
370 IFX$="Y"THEN390
380 CLOSE1:CLOSE2:RETURN
390 OPEN2,8,15,"S:ACCOUNTS"+Y$
400 OPEN1,8,2,"ACCOUNTS"+Y$+",L,"+CHR$(141)
410 GOSUB 2050
420 INPUT"HOW MANY ACCOUNTS (1-20): ";AN
430 PRINT
440 IFAN<1ORAN>20THENPRINTCHR$(145);:GOTO420
450 FORI=1TOAN
460 PRINT"NAME OF ACCOUNT NO.";I;": ";
470 INPUTAN$
480 IFLEN(AN$)>20THENPRINTCHR$(145);:GOTO420
490 RC$=AN$+LEFT$(BL$,20-LEN(AN$))
500 FORX=1TO12
510 RC$=RC$+STR$(0)+LEFT$(BL$,8)
520 NEXTX
530 PRINT#1,RC$
540 NEXT I
550 CLOSE 1:CLOSE 2:RETURN
560 REM ============
570 REM    POSTING
580 REM ============
590 GOSUB2050
600 INPUT"ACCOUNT NUMBER";AN
610 IFAN<1ORAN>20THENPRINTCHR$(145);:GOTO600
620 GOSUB2140
630 PRINT"----------------------------"
```

```
640 PRINT"NO.";AN;" - ";AN$
650 PRINT"------------------------"
660 PRINT"INCOME OR EXPENSE (I/E)?"
670 PRINT"------------------------"
680 GETX$:IFX$<>"I"ANDX$<>"E"THEN680
690 INPUT"MONTH (1-12)    : ";M
700 IFM<1ORM>12THENPRINTCHR$(145);:GOTO690
710 PRINT"----------------------------"
720 PRINT"OLD CONTENTS    : ";S(M)
730 PRINT"----------------------------"
740 INPUT"POSTING AMOUNT : ";PA
750 PRINT"----------------------------"
760 IFX$="I"THENS(M)=S(M)+PA:GOTO780
770 S(M)=S(M)-PA
780 PRINT"NEW CONTENTS    : ";S(M)
790 PRINT"----------------------------"
800 RC$=AN$+LEFT$(BL$,20-LEN(AN$))
810 FORI=1TO12
820 S$=STR$(S(I))
830 RC$=RC$+S$+LEFT$(BL$,10-LEN(S$))
840 NEXTI
850 PRINT#2,"P"+CHR$(2)+CHR$(AN)+CHR$(0)+CHR$(1)
860 PRINT#1,RC$
870 CLOSE1:CLOSE2
880 PRINT"FURTHER POSTING (Y/N)?"
890 GETX$:IFX$<>"Y"ANDX$<>"N"THEN890
900 IFX$<>"Y"THENGOSUB2050:GOTO600
910 RETURN
920 REM ===================
930 REM   ACCOUNT SUMMARY
940 REM ===================
950 GOSUB2050
960 INPUT"ACCOUNT NUMBER : ";AN
970 IFAN<1ORAN>20THENPRINTCHR$(145);:GOTO960
980 GOSUB2140
990 GOSUB2050:PRINTCHR$(145);CHR$(145);
1000 PRINT"-------------------------"
1010 PRINT"NO.";AN;" - ";AN$
1020 PRINT"-------------------------"
1030 PRINT"MONTH  TOTAL"
1040 PRINT"-------------------------"
1050 TL=0
1060 FORI=1TO12
1070 PRINTI;TAB(8);S(I)
1080 TL=TL+S(I)
1090 NEXTI
1100 PRINT"-------------------------"
1110 PRINT"TOTAL";TAB(8);TL
1120 PRINTTAB(9);"======="
1130 PRINT"RETURN FOR MORE"
1140 INPUTX$
1150 CLOSE1:CLOSE2:RETURN
1160 REM ====================
1170 REM DISPLAY ACCOUNT NAMES
1180 REM ====================
```

```
1190 GOSUB2050
1200 OPEN1,8,2,"ACCOUNTS"+Y$+",L,"+CHR$(141)
1210 OPEN2,8,15
1220 I=1
1230 PRINT#2,"P"+CHR$(2)+CHR$(I)+CHR$(0)+CHR$(1)
1240 RC$=""
1250 FORX=1TO20
1260 GET#1,X$
1270 RC$=RC$+X$
1280 NEXTX
1290 INPUT#2,X
1300 IFX=50THEN1340
1320 PRINTI;" - ";RC$
1330 I=I+1:GOTO1230
1340 PRINT"RETURN FOR MORE"
1350 INPUTX$
1360 CLOSE1:CLOSE2:RETURN
1370 REM ===============
1380 REM  MONTH SUMMARY
1390 REM ===============
1400 GOSUB2050
1410 INPUT"MONTH : ";M
1420 GOSUB2050
1430 PRINT"-----------------------------------"
1440 PRINT"NO.  NAME                   CONTENTS"
1450 PRINT"-----------------------------------"
1460 OPEN1,8,2,"ACCOUNTS"+Y$+",L,"+CHR$(141)
1470 OPEN2,8,15
1480 TL=0
1490 FORAN=1TO20
1500 AN$="":S$=""
1510 PRINT#2,"P"+CHR$(2)+CHR$(AN)+CHR$(0)+CHR$(1)
1520 FORI=1TO20
1530 GET#1,X$
1540 AN$=AN$+X$
1550 NEXTI
1560 INPUT#2,F
1570 IFF<>50THEN1590
1580 GOTO1670
1590 PRINT#2,"P"+CHR$(2)+CHR$(AN)+CHR$(0)+CHR$(20+(M-1)*10)
1600 FORI=1TO10
1610 GET#1,X$
1620 S$=S$+X$
1630 NEXT I
1640 TL=TL+VAL(S$)
1650 PRINT AN;TAB(6);AN$;TAB(26);S$
1660 NEXT AN
1670 PRINT"-----------------------------------"
1680 PRINT"TOTAL BALANCE";TAB(26);STR$(TL)
1690 PRINTTAB(26);"======="
1700 PRINT"RETURN FOR MORE";
1710 INPUTX$:CLOSE1:CLOSE2:RETURN
1720 REM ==============
1730 REM  YEAR SUMMARY
1740 REM ==============
```

```
1750 GOSUB2050
1760 OPEN1,8,2,"ACCOUNTS"+Y$+",L,"+CHR$(141)
1770 OPEN2,8,15
1780 PRINT"-----------------------------------"
1790 PRINT"NO. NAME                    YEAR BALANCE"
1800 PRINT"-----------------------------------"
1810 TL=0
1820 FOR AN=1TO20
1830 PRINT#2,"P"+CHR$(2)+CHR$(AN)+CHR$(0)+CHR$(1)
1840 RC$=""
1850 FORI=1TO140
1860 GET#1,X$
1870 RC$=RC$+X$
1880 NEXTI
1890 INPUT#2,F:IFF=50THEN1980
1900 AN$=LEFT$(RC$,20)
1910 YB=0
1920 FORI=1TO10
1930 YB=YB+VAL(MID$(RC$,20+(I-1)*10,10))
1940 NEXTI
1950 TL=TL+YB
1960 PRINTAN;TAB(6);AN$;TAB(26);YB
1970 NEXTAN
1980 PRINT"----------------------------"
1990 CLOSE1:CLOSE2
2000 PRINT"TOTAL BALANCE";TAB(26);TL
2010 PRINTTAB(26);"======="
2020 PRINT"RETURN FOR MORE"
2030 INPUTX$
2040 RETURN
2050 REM ===================
2060 REM   PROGRAM HEADING
2070 REM ===================
2080 PRINTCHR$(147);
2090 PRINTTAB(4);"============================="
2100 PRINTTAB(4);"H O M E  A C C O U N T I N G"
2110 PRINTTAB(4);"============================="
2120 PRINT:PRINT
2130 RETURN
2140 REM ================
2150 REM   READ ACCOUNT
2160 REM ================
2170 OPEN1,8,2,"ACCOUNTS"+Y$+",L,"+CHR$(141)
2180 OPEN2,8,15
2190 PRINT#2,"P"+CHR$(2)+CHR$(AN)+CHR$(0)+CHR$(1)
2200 RC$=""
2210 FORI=1TO140
2220 GET#1,X$
2230 RC$=RC$+X$
2240 NEXT I
2250 INPUT#2,F
2260 IFF<>50THEN2300
2270 PRINT"YEAR FILE OR ACCOUNT NOT FOUND!":PRINT
2280 PRINT"RETURN FOR MORE":INPUTX$
2290 CLOSE1:CLOSE2:RETURN
```

```
2300 AN$=LEFT$(RC$,20)
2310 TL=0
2320 FORI=1TO12
2330 S(I)=VAL(MID$(RC$,20+(I-1)*10,10))
2340 TL=TL+S(I)
2350 NEXT I
2360 RETURN
```

Program Documentation:

Initialization:

100	Screen and character color set; blank character string defined; variable for account summaries dimensioned.
110-130	Program heading displayed and current year read.
140-280	Program functions displayed and choice read; corresponding subprogram called.

Establish Accounts:

390-400	Any existing files of this year are erased and the new file is opened.
480	Account name is placed in positions 1-20 of the record RC$.
500-540	Month summaries are set to zero and placed in the record as string variables.
530	The record is transferred with a trailing RETURN.

Posting:

590	The routine "Read Account" is called. This routine places the month summaries of the account in the variables S(1) to S(12).
800	Account name is placed in the record.
810-840	Account summary is placed in the record.
850-860	Record is transferred.

Account Summary:

980	Desired account is read and the month summaries are placed in variables S(1) to S(12).
1050-1090	Month summaries are displayed and the total (TL) is added up.
1110	Total displayed.

Display Account Names:

1220	Account number is initialized.
1230	The head is positioned over the corresponding

	record.
1240-1280	Account name is read out of the record in RC$.
1290-1300	If RECORD NOT PRESENT is sent over the error channel (error 50), the routine is broken off.
1320	Account number and name are displayed.

Month Summary:

1490-1660	Loop to read all accounts.
1510	Position head over record.
1520-1550	Read account name.
1560-1580	Determine if account exists; stop if all twenty accounts have been defined.
1590	Position over summary field of the desired month.
1600-1630	Read the month summary.
1640	Add month summary to total.
1650	Account number, account name and month summary are displayed.
1680	Total balance displayed.

Year Summary:

1820-1970	Loop to read all accounts
1830	Position head over record.
1850-1880	Complete record read into RC$.
1890	Test if RECORD NOT PRESENT.
1900	Get account name from record.
1920-1940	Read month summary, convert to numerical form and add to year summary (YS).
1950	Year summary (YS) is added to total (TL).
1960	Account number, account name and year summary displayed.
2000	Total balance (month balance) displayed.

Read Account:

2190	Position over record given in AN.
2210-2240	Read record into RC$.
2250-2260	Test if RECORD NOT PRESENT.
2300	Account name read from record.
2320-2350	Month summaries read from record, converted to numerical form and placed into the table S(1) to S(12).

1.6 Disk Error Messages and their Causes

If you cause an error while working with the disk drive, the drive signals this by blinking the red LED. The LED blinks until you read the error channel of the disk drive or until you send a new command. First we want to see how to read the error message from the disk drive.

In order to do this, the error/command channel must be opened with the secondary address 15:

```
100 OPEN 15,8,15
110 INPUT#15,A,B$,C,D
120 PRINT A,B$,C,D
```

If no error has occurred, the following is displayed:

```
0    OK    0    0
```

The first number is the error number, in this case zero, which means no error has occurred. Next follows the error message (variable B$). The variables C and D contain the track and sector numbers, respectively, in which the error occurred, which is dependent on the type of error (mainly associated with hardware errors and block-oriented commands).

This routine accomplishes the same function:

```
100 OPEN15,8,15
110 GET#15,A$:PRINTA$;:IFST<>64THEN110
```

```
00, OK,00,00
```

Here characters are read from the error channel until the end is recognized (status = 64). This gives the error message exactly as the BASIC 4.0 command

PRINT DS$

When using BASIC 4.0, variables DS$ and DS are reserved variables which contain the complete error message and error number. Each access of these variables gives the error status of the last disk operation. Unfortunately, the Commodore 64 does not use BASIC 4.0, so these variables are meaningless in Commodore 64 BASIC (BASIC 2.0).

Next follows the list of error messages that the DOS can recognize:

00, OK,00,00
This message occurs when the last disk operation was error free or if no command or data was sent after the last error message.

01,FILES SCRATCHED,XX,00
This is the message after a SCRATCH command. The number XX denotes the number of filed that were erased. Since this is not really an error message, the LED does not blink.

20,READ ERROR,TT,SS
This error means that the 'header' of a block was not found. It is usually the result of a defective diskette. TT and SS designate the track and sector in which the error occurred. Remedy: change defective diskette.

21,READ ERROR,TT,SS
This is also a read error. The SYNC (synchronous) marker of a block was not found. The cause may be an unformatted disk, or no disk in the drive. This error can also be caused by a misaligned read/write head. Remedy: Either insert a diskette, format the disk, or have the read/write head aligned.

22,READ ERROR,TT,SS
This error message means that a checksum error has occurred in the header of a data block, which can be caused by the incorrect writing of a block.

23,READ ERROR,TT,SS
The error implies that a data block was read into the DOS buffer, but a checksum error occurred. One or more data bytes are incorrect. Remedy: Save as many files as possible onto another diskette.

24,READ ERROR,TT,SS
This error also results from a checksum error in the data block or in the preceding data header. Incorrect bytes have been read. Remedy: same as error 23.

25,WRITE ERROR,TT,SS
This error is actually a VERIFY ERROR. After writing every block the data is read again checked against the data in the buffer. This error is produced if the data are not identical. Remedy: Repeat the command that caused the error. If this doesn't work, the corresponding block must be locked out from further use with the block-allocate command.

26,WRITE PROTECT ON,TT,SS
An attempt was made to write to a disk with a write protect tab on it. Remedy: Remove write protect tab.

27,READ ERROR,TT,SS
A checksum error occurred in the header of a data block. Remedy: Repeat command or rescue block.

28,WRITE ERROR,TT,SS
After writing a data block, the SYNC characters of the next data block were not found. Remedy: Format disk again, or exchange it.

29,DISK ID MISMATCH,TT,SS
The ID (two character disk identification) in the DOS memory does not agree with the ID on the diskette. The diskette was either not initialized or there is an error in the header of a data block. Remedy: Initialize diskette.

30,SYNTAX ERROR,00,00
A command was sent over the command channel that the DOS could not understand. Remedy: Check and correct command.

31,SYNTAX ERROR,00,00
A command was not recognized by the DOS; for example, the BACKUP command (Duplicate) on the 1541. Remedy: Do not use the command.

32,SYNTAX ERROR,00,00
The command sent over the command channel was longer than 40 characters. Remedy: Shorten command.

33,SYNTAX ERROR,00,00
A wildcard ('*' or '?') was used in an OPEN or SAVE command. Remedy: Remove wildcard.

34,SYNTAX ERROR,00,00
The DOS cannot find the filename in a command. This may be because a colon was forgotten after the command word. Remedy: Check and correct command.

39,FILE NOT FOUND,00,00
User program of type 'USR' was not found for automatic execution. Remedy: Check filename.

50,RECORD NOT PRESENT,00,00
A record was addressed in a relative data file that has not yet been written. When writing a record this is not really an error. You can avoid this error message if you write the highest record number of the file with CHR$(255) when initializing it. This error will no longer occur upon later access.

51,OVERFLOW IN RECORD,00,00
The number of characters sent when writing a record in a relative file was greater than the record length. The excess characters are ignored.

52,FILE TOO LARGE,00,00
The record number of a relative file is too big; the diskette does not have enough capacity. Remedy: Use another diskette or reduce the record number.

60,WRITE FILE OPEN,00,00
An attempt was made to OPEN a file that had not previously been CLOSEd after writing. Remedy: Use mode 'M' in the OPEN command to read the file.

61,FILE NOT OPEN,00,00
A file was accessed that had not been OPENed. Remedy: Open the file or check the filename.

62,FILE NOT FOUND,00,00
An attempt was made to load a program or open a file that does not exist on the diskette. Remedy: Check the filename.

63,FILE EXISTS,00,00
An attempt was made to establish a new file with the name of a file already on the diskette. Remedy: Use a different filename or @: (to replace the old file).

64,FILE TYPE MISMATCH,00,00
The file type use in the OPEN command does not agree with the file type in the directory. Remedy: Correct file type.

65,NO BLOCK,TT,SS
This error message is given in association with the BLOCK-ALLOCATE command when the specified block is no longer free. In this case, the DOS automatically searches for a free block with a higher sector and/or track number and gives these values as the track and sector number in the error message. If no block with a greater number is free, two zeroes will be given.

66,ILLEGAL TRACK OR SECTOR,TT,SS
If you attempt to use a block with the block commands that does not exist, this error is returned.

67,ILLEGAL TRACK OR SECTOR,TT,SS
The track-sector combination of a file produces a non-existent track or sector.

70,NO CHANNEL,00,00
An attempt was made to open more files than channels available or a direct access channel is already reserved.

71,DIR ERROR,TT,SS
The number of free blocks in the DOS storage does not agree with the BAM. Usually this means the disk has not been initialized.

72,DISK FULL,00,00
Fewer than three blocks are free on the diskette or the maximum number of directory entries have been used (144 on the VIC 1541).

73,CBM DOS V.26 1541,00,00
The message is the power-up message of the VIC 1541. As an error message, it appears when an attempt is made to write to a disk that was not formatted with the same DOS version, for example, the forerunner of the CBM 4040, the CBM 2040 (DOS version 1.0).

74,DRIVE NOT READY,00,00
When one attempts to use the disk without a diskette in the drive, this error message is returned.

75,FORMAT SPEED ERROR,00,00
This error message occurs only on the CBM 8250. It indicates a deviation from the normal revolutions per minute while formatting.

1.7 Overview of Commands with a Comparison of BASIC 2.0 - BASIC 4.0 - DOS 5.1

BASIC 2.0	BASIC 4.0 (abbrev)	DOS 5.1
OPEN - Mode 'A'	APPEND (aP)	
	BACKUP (bA)	
LOAD"$",8 & LIST	CATALOG (cA)	@$ or >$
V(alidate)	COLLECT (coL)	@V or >V
	CONCAT (conC)	
C(opy)	COPY (coP)	@C:.. or >C:..
CLOSE ...	DCLOSE (dC)	
LOAD"...",8	DLOAD (dL)	©file or /file
OPEN ...,8,...	DOPEN (dO)	
OPEN 1,8,15 ...	DS$, DS	@ or >
SAVE"...",8	DSAVE (dS)	
N(ew)	HEADER (hE)	@N:.. or >N:..
I(nitialize)	I(initialize)	@I or >I
P	RECORD (reC)	
R(ename)	RENAME (reN)	@R:.. or >R:..
S(cratch)	SCRATCH (sC)	@S:.. or >S:..

This table lists the different versions of BASIC. The DOS 5.1 is found on the TEST/DEMO disk and will be described in section 4.2.1.

The essential difference between BASIC 2.0 and BASIC 4.0 is that with BASIC 2.0, each command is executed by the disk control system (DOS) and must be sent over channel 15. The disk commands of BASIC 4.0 manage this channel themselves (with the exception of INITIALIZE). For example, the command HEADER D0,"DISK1",IHJ generates the same sequence of commands necessary in BASIC 2.0, namely:

```
OPEN 1,8,15,"N:DISK1,HJ"
CLOSE 1
```

Here are are the specifics of the BASIC 4.0 commands:

Note the following parameters:

lfn = logical file number
dn = drive number - drive 0 (D0) or drive 1 (D1) with a double drive, or D0 for a single drive
da = device address of the disk drive (U4 to U31)

Information in parentheses is optional. The standard parameters D0 and U8 will be used (meaning Drive 0 and Unit 8).

APPEND:
This command allows data to be added to a sequential file, which is accomplished in BASIC 2.0 with the OPEN-command mode A.

This command has the following format:

```
APPEND#lfn,"filename"(,Ddn,Uda)
```

For example, should the sequential file "SEQU.1" be on drive 0, the following statements are necessary to add a data record to it:

```
100 APPEND#1,"SEQU.1",D0
110 PRINT#1,X$
120 CLOSE 1
```

BACKUP:
With this command, a complete diskette can be copied. The BACKUP command can only be used with a dual disk drive (such as the 4040), however. Notice the format of this command:

```
BACKUP Ddn TO Ddn(,Uda)
```

It is important that either D0 to D1 or D1 to D0 be given. An example:

The diskette in drive 1 is supposed to be copied onto the disk in drive 0. To this end, give the following command:

```
BACKUP D1 TO D0
```

CATALOG:
The CATALOG command of BASIC 4.0 has the advantage that the program in the computer's memory is not erased, as is true in BASIC 2.0. The format of the command:

```
CATALOG (Ddn,Uda)
```

If no drive number is given for a double drive, the contents of both drives are given. With a single drive, CATALOG D0 is assumed. An example:

```
CATALOG D0
```

The contents of the disk in drive 0 will be displayed.

COLLECT:
This command corresponds with the VALIDATE command of BASIC 2.0. The syntax of this command looks like this:

```
COLLECT (Ddn)
```

CONCAT:
CONCAT concatenates sequential files, in which one file is to be made from the data of two files. The format:

```
CONCAT (Ddn,)"file1" TO (Ddn,)"file2" (ON Uda)
```

Suppose you want to combine the data of the files "SEQU.2" in drive 0 and "SEQU.1" in D1. To accomplish this, issue the following command:

```
CONCAT D0,"SEQU.2" TO D1,"SEQU.1"
```

COPY:
With this command files can be copied from one drive to the other (except relative files). The command is useless with a single drive. The syntax looks like this:

```
COPY (Ddn,)("file1") TO (Ddn,)("file2")
```

To copy all files (for example, from drive 0 to drive 1), use the following command:

```
COPY D0 TO D1
```

DCLOSE:
The command DCLOSE has the same function as the simple CLOSE command, with the following exceptions:

DCLOSE	closes all files
DCLOSE#1	closes file number 1
DCLOSE#1 ON U9	closes the logical file #1 on device address 9
DCLOSE U8	closes all files on device address 8

The command has the following syntax:

```
DCLOSE (#lfn) (ON Uda)
```

DLOAD:
The command DLOAD has the advantage that the standard device address 8 used. The format:

```
DLOAD "program" (,Ddn)(,Uda)
```

For instance, if you want to load the program "PRG.2" from drive 0 or from a single drive, give the following command:

```
DLOAD "PRG.2"
```

Drive 0 (D0) is the default value.

DOPEN:
This command of BASIC 4.0 is very comprehensive. The following format verifies this:

```
DOPEN#lfn,"file"(,Ddn)(,Uda)(,fileparameter)
```

The peculiarity of this method of opening is the file parameter. There are two file parameters, that have the following function:

'L'-parameter	'W'-parameter	Mode of operation
YES	NO	A relative file is opened.
NO	YES	A sequential file is opened for writing.
NO	NO	A file is opened for reading(REL,SEQ,PRG,USR)

In addition to the 'L' parameter the record length must be given (such as L80). A DOPEN command of this type looks like this:

```
DOPEN#1,"FILE.REL",D0,L80
```

Here a relative file is opened with a record length of 80 bytes. The declaration of the file parameter is only necessary once, at the establishment of the file. All later openings of the file can occur without the parameter declaration.

DS$ & DS:
After a disk error, the complete error message can be displayed with PRINT DS$ or just the error number with PRINT DS. Of course, the error can be read within a program and the appropriate branch made. For example:

```
100 IF DS = 26 THEN GOTO ...
```

DSAVE:
A program can be saved on disk with this command. The following format is to be noted:

```
DSAVE (Ddn,)"programname"(,Uda)
```

HEADER:
A disk is formatted with the HEADER command in BASIC 4.0. It corresponds to the NEW command in BASIC 2.0. The syntax of the command:

```
        HEADER "diskname",D0,Iid(U,da)
or      HEADER Ddn,"diskname",Iid
```

Here there are two possibilities to designate the drive. The id is the diskette identification. If it is not given, the disk is presumed to be formatted and is merely given a new name and all files are erased.

RECORD:
This command corresponds to the position command of BASIC 2.0 (DOS 2.6). The read/write head can be positioned over a record in a relative file, without the need to send the position over channel 15. The syntax of this command illustrates how easy this positioning is:

```
RECORD#lfn,rn(,bp)
```

The logical file number is obtained from the opened relative file. 'rn' is the record number (1-65535) and 'bp' is the position within this record (1-254).

An example: You want to position the head over the twelfth byte of the 128th record of a relative file opened with the logical file number 2. The following command accomplishes this:

```
RECORD#2,128,12
```

RENAME:
This RENAME is similar to the RENAME of BASIC 2.0. The format of this command:

```
RENAME (Ddn,)"old name" TO "new name"(,Uda)
```

SCRATCH:
This method of erasing files is essentially easier because files can be erased with one command. The format of this command:

```
SCRATCH (Ddn,)"file"(,Uda)
```

After entering a SCRATCH command the message "ARE YOU SURE?" which allows the command to be stopped. If the file is really supposed to be erased, answer 'Y' else 'N'. After erasing the file, the message "FILES SCRATCHED" appears on the screen.

Chapter 2: Advanced Disk Programming

2.1 Direct Access of any Block of the Diskette

When handling files and programs on the diskette, as described in Chapter 1, we didn't have to concern ourselves with the organization on the diskette, because the disk operating system (DOS) took care of these details for us.

But the DOS offers the capability of accessing each individual block on the diskette. This gives us a lot of flexibility - ranging from manipulation of individual files to creating completely new data structures.

In order to access a block directly, a channel is OPENed to a data buffer within the 1541 disk drive. It is over this channel that data is transmitted. The data buffer serves as an intermediate storage place for the data that is read from the diskette or written to the diskette. In order to inform the DOS that we want to work with direct access commands, we use a special filename in the OPEN command:

```
OPEN 1,8,2,"#"
```

Using this command, logical file number 1 on device 8 (the disk drive), is associated with a direct access file. Channel 2 serves to transmit data to and from the disk drive. The channel number (secondary address in the OPEN command) may be 2 through 14. Channels 0 and 1 are reserved for LOAD and SAVE and channel 15 is the command channel. The choice of a secondary address is arbitrary. You may not use the same secondary address simultaneously, since the DOS, upon encountering the second OPEN command with the same secondary address, closes the previous file using this channel number. This also occurs when working with sequential or relative files.

This form of the OPEN command causes the DOS to search for a free data buffer and assign it to that channel. By using a GET# statement immediately after the OPEN we can find the buffer number that the DOS assigns:

```
100 OPEN 1,8,2,"#"
110 GET#1, A$
120 PRINT ASC(A$+CHR$(0))
RUN

3
```

In this case, buffer three was assigned. The buffer numbers range from 0 to 4. Each buffer can hold 256 characters of data. The buffers are located in the following memory locations in the VIC 1541:

Buffer number	Memory location
0	\$300-\$3FF, 768-1023
1	\$400-\$4FF, 1024-1279
2	\$500-\$5FF, 1280-1535
3	\$600-\$6FF, 1536-1791
4	\$700-\$7FF, 1792-2047

Buffer 4 is normally unavailable, because the BAM is stored there. If we work with sequential or relative files at the same time, buffer 3 is also unavailable, because it is used for the directory. If we want to associate a specific data buffer for direct access, we can assign it with the OPEN command.

```
OPEN 1,8,2,"#3"
```

This associates buffer 3 ($600-$6FF) with channel number 2, assuming it is still free. Unless you have a pressing reason to use a specific buffer, you should leave the choice of the buffer up to the DOS, because the choice of a definite buffer increases the possibility that it will not be available.

After opening a channel, you should check the error channel.

```
130 OPEN 15,8,15
140 GET#15, A$ : PRINT A$; : IF ST<>64 THEN 140
```

If the buffer is already in use, you will receive the error message

```
70,NO CHANNEL,00,00
```

If no other files are open, you can open up to 4 channels for direct access. The following example illustrates this:

```
 10 OPEN 1,8,15,"I0" : I=2 : REM ERROR CHANNEL
 20 OPEN 2,8,2, "#" : GOSUB 100
 30 OPEN 3,8,3, "#" : GOSUB 100
 40 OPEN 4,8,4, "#" : GOSUB 100
 50 OPEN 5,8,5, "#" : GOSUB 100
 60 OPEN 6,8,6, "#" : GOSUB 100
 70 END
100 GET#I,A$:PRINT ASC(A$+CHR$(0))
110 I=I+1 : REM BUFFER NUMBER
120 GET#1,A$ : PRINT A$; : IF ST<>64 THEN 120
130 RETURN
```

When RUN, the above program produces the following output:

```
3
```

```
00, OK,00,00
 2
00, OK,00,00
 1
00, OK,00,00
 0
00, OK,00,00
 199
70,NO CHANNEL,00,00
```

As you see, attempting to open a fifth channel for direct access fails.

Transmitting data to and from the buffer usually takes place using the GET#, INPUT# and PRINT# statements.

If a buffer contains pure text (alphanumeric data) which is not longer than 88 characters and is separated using CR (Carriage Return, CHR$(13)), it can be read using INPUT#. However, if the buffer contains control characters or the text is separated using commas or colons, the INPUT# statement fails. Then we must use the GET# statement, which retrieves only one character at a time. GET# does not allow null values (CHR$(0)) to be read. In this case, GE1# receives an empty string and you must check for this condition as below:

```
100 GET#2, A$ : IF A$ + "" THEN A$ = CHR$(0)
```

A simpler alternative to the GET# statement is to use the statement **INPUT***, as is described in section 4.3.1. Here you can declare how many characters are to be read into a string. It also handles null values (CHR$(0)). You can read almost the entire buffer (255 characters are possible) with one command.

In the next section, all commands used for direct access are described in detail. Keep the following points in mind when using direct access commands.

When using direct access commands, you must explicitly cause the blocks on the diskette to be read or written. The direct access commands are transmitted over command channel 15. The data that is read from or written to a buffer are transmitted over a separate channel that is associated with that buffer. Both channel 15 and the separate channel must be OPENed before transmission can begin.

1) A PRINT# statement to command channel 15, sends a direct access command to the DOS.

2) A PRINT# statement to channels 2 thru 14 sends data to a buffer.

3) An INPUT# or GET# statement to command channel 15 re-

turns any error messages detected by the DOS.

4) An INPUT# or GET# statement to channels 2 thru 14, reads the data from the buffer.

If you are ready to work with the block commands and want to display individual blocks on the screen or change them, you can use the DOS monitor in section 4.6, which provides a simple and easy way of doing so.

2.2 The Direct Access Commands

2.2.1 The Block-Read Command B-R

The block-read command instructs the 1541 to read a block from the diskette into a buffer of a previously opened direct access file. The block-read command is sent over the command channel (secondary address 15) to the disk drive. The block-read command can be shortened to **B-R.** Because this command does not read the first byte of the block, you can substitute the command **U1** to read a block. The command has the following syntax:

U1 channelnumber drive track sector

You must give the channel number that you used when OPENing the direct access file. Next follows the drive number, which is always zero for the VIC 1541, and then the track and sector numbers of the block you want to read.

```
10 OPEN 1,8,15
20 OPEN 2,8,2, "#"
30 PRINT#1, "U1 2 0 18 0"
```

This reads the contents of track 18 sector 0 into the buffer belonging to channel 2. Now you can read the data from this buffer with GET#2.

```
40 GET#2, A$,B$
50 PRINT ASC(A$), ASC(B$)

18       1
```

Now we have read and displayed the first two bytes in the buffer. Sector 0 of track 18 contains a pointer to the first directory block (track and sector) and the BAM for the diskette.

In the demo program DISPLAY T&S on the TEST/DEMO diskette (section 4.2.7) this command is used in order to read the BAM from the disk and to graphically display each record on the disk.

We can read all 256 bytes of the block from the buffer with the GET# statement; in our example we will read the diskette name and ID from position 144.

The blocks which comprise a file are chained to each other. The first two bytes of each file block contains a pointer to the track and sector of the following block. Using this information, you can piece together the usage of disk space for a file. A track pointer of zero indicates the last block of the file and the pointer which usually contains the sector number now contains the number of bytes of the last block which are part of this file. The first sector of a file can be read with our program in section 4.1.1. The following small program displays all of the remaining tracks and sectors that are part of the file.

```
100 OPEN 1,8,15
110 OPEN 2,8,2, "#"
120 INPUT "TRACK AND SECTOR ";T,S
130 PRINT#1,"U1 2 0";T;S
140 GET#2, T$, S$
150 T = ASC(T$+CHR$(0)): S = ASC(S$+CHR$(0))
160 IF T=0 THEN CLOSE 2 : CLOSE 1 : END
170 PRINT "TRACK";T,"SECTOR";S
180 GOTO 130
```

Enter 18 and 0 as track and sector to follow the blocks for the BAM and directory.

2.2.2 The Block-Pointer Command B-P

The diskette name is located starting at position 144 of track 18, sector 0. Using the above example, we have to read the first 143 bytes of the buffer in order to be positioned at the diskette name. But the DOS has an easier way to do this. To access any desired byte of a buffer, you can use the block-pointer command. Using the block-pointer command the DOS moves to an exact position within the buffer. The block-pointer command can be shortened to B-P. The syntax is the following:

B-P channelnumber position

Now we can read the diskette name directly:

```
100 OPEN 1,8,15
110 OPEN 2,8,2, "#"
120 PRINT#1,"U1 2 0 18 0"
130 PRINT#1,"B-P 2 144"
140 FOR I = 1 TO 16 : REM MAXIMUM LENGTH
150 GET#2, A$ : IF A$=CHR$(160) THEN 170
160 PRINT A$; : NEXT
170 CLOSE 2 : CLOSE 1
```

Here we first read the block, set the buffer pointer to position 144 and then read and print the diskette name which has a maximum length of 16 characters. A shifted space (CHR$(160)) indicates the end of the diskette name.

The bytes in the buffer are numbered 0 through 255, the first byte having the number 0. The buffer pointer is automatically set to zero by reading a block with **U1**. You can, for example, read byte number 2 after reading the name. You do this by setting the buffer pointer to this value.

```
PRINT#1, "B-P 2 2"
```

2.2.3 The Block-Write Command B-W

The block-write command allows us to write the contents of a buffer to a desired block on the diskette. With this, you can write the block one has sent to the buffer within the disk drive.

It is possible to read a block into the buffer with the block-read command, change some bytes, and then write the block back. The block-write command can be shortened to **B-W.** Because this B-W command writes the contents of the buffer pointer, one usually uses the **U2** command which always sets the buffer pointer to 1. The syntax of the command is analogous to the B-R command:

U2 channelnumber drive track sector

```
100 OPEN 1,8,15
110 OPEN 2,8,2, "#"
120 PRINT#2, "TEST DATA"
130 PRINT#1, "U2 2 0 1 0"
140 CLOSE 2 : CLOSE 1
```

Here the text "TEST DATA" will be written to the buffer associated to channel 2 and then written to track 1 sector 0 of the diskette. The **U2** command does not change the contents of the buffer.

Here's an example of using the block-write command to change the diskette name that we read in the last section. For this we must fill the new name with 16 characters ending with a shifted spaces CHR$(160), so that we can write it to the disk. We will again use the block-pointer command to set the buffer pointer directly to the desired position within the buffer.

```
100 OPEN 1,8,15
110 OPEN 2,8,2, "#"
120 PRINT#1,"U1 2 0 18 0"
130 PRINT#1,"B-P 2 144"
140 A$="NEW FILE NAME"
150 IF LEN(A$)<16 THEN A$=A$+CHR$(160) : GOTO 150
160 PRINT#2,A$;
170 PRINT#1,"U2 2 0 18 0"
180 CLOSE 2
190 PRINT#1,"I0" : CLOSE 1
```

First we read track 18 sector 0 into the buffer, set the buffer pointer to the position of the diskette name and write a new 16 character name to the buffer. Note that the diskette name is changed in the buffer only. But in line 170, the buffer contents are written to the same block which changes the name permanently on the diskette. Next channel 2 is closed. Finally the diskette is initialized so the BAM and name in the DOS memory are updated. Get the directory with

```
LOAD"$",8
LIST
```

on the screen to verify that the diskette name has changed.

2.2.4 The Block-Allocate Command B-A

The block-allocate command has the task of indicating in the BAM (block availability map) is a particular diskette block is being used. The block allocate command can be shortened to **B-A**. For program, sequential or relative files, as diskette blocks are used, the BAM is updated to note that the block is no longer available. But blocks written using the direct access commands are not automatically allocated. When blocks used in this manner are not allocated, the possibility exists that they will be overwritten when other files are used. The block-allocate command can be used to prevent this overwriting. The block-allocate command has the following syntax:

B-A drive track sector

With this the corresponding block in the BAM is marked as allocated and is protected from being overwritten by other files. If the block was already allocated, the error channel returns error message 65,'NO BLOCK'.

```
100 OPEN 1,8,15
110 INPUT "TRACK, SECTOR ";T,S
120 PRINT#1, "B-A 0";T;S
130 INPUT#1, A$,B$,C$,D$
140 PRINT A$","B$","C$","D$
```

Using this program you can input a track and sector number of a block that you want to allocate. If the block is still free, it was allocated and the message **00, OK,00,00** is returned. If that block is already allocated, the message **65,NO BLOCK,TT,SS** is returned. In this case TT and SS contain the next higher numbered free block on the diskette. This tells you that the requested block is allocated but the block at TT,SS is still available. If error message 65 returns zeroes as the track and sector numbers, it means that no block with a higher track and/or sector number is available. The following program automatically allocates the next free sector:

```
100 OPEN 1,8,15
110 INPUT "TRACK, SECTOR ";T,S
120 PRINT#1, "B-A 0";T;S
130 INPUT#1, A$,B$,TT,SS
140 IF A$ = "00" THEN 190
150 IF A$<>"65" THEN PRINT A$","B$","TT","SS : END
160 IF TT=0 THEN PRINT "NO MORE FREE BLOCKS" : END
170 IF TT=18 THEN TT=19 : SS=0
180 T=TT : S=SS : GOTO 120
190 PRINT "TRACK" TT "SECTOR" SS "ALLOCATED."
```

The test for track 18 in line 180 prevents a block in the directory from being allocated. An additional error message in connection with the **B-A** command is interesting. If one attempts to allocate a block that does not exist, for example, track 20 sector 21, one received the error message

66,ILLEGAL TRACK OR SECTOR,20,21

Marking a block as allocated in the BAM prevents it from being overwritten by other files. The block will be recognized as allocated until the command **VALIDATE** (COLLECT in BASIC 4.0) is issued. The VALIDATE command rebuilds a new BAM by rechaining the blocks of individual files and marking each block as belonging to a a new BAM. Unclosed files, marked in the directory with * are deleted. All blocks allocated with the B-A command and those not belonging to a properly closed file are freed. So, if you allocate blocks that do not belong to a file that appears in the directory, you should not use the VALIDATE command, or the blocks will be freed, thus destroying your file.

2.2.5 The Block-Free Command B-F

The block-free command performs the opposite function of the block-allocate command. It marks a block as not allocated (free) in the BAM. The block-free command can be shortened to **B-F**.The syntax is analogous to the block-allocate command:

B-F drive track sector

```
100 OPEN 1,8,15
110 PRINT#1, "B-F 0 20 9"
```

Here the block in track 20 sector 9 is freed in the BAM. If this block is already free, no error occurs.

Allocating and freeing blocks has an effect only on the blocks used by program, sequential or relative file by the DOS. The block-write and block-read commands do not check the BAM before overwriting blocks. With these commands you can write to blocks marked as allocated in the BAM. If, for example, you have a disk containing only direct access files, it is in principle unnecessary to allocate written blocks because no other files will be written on the diskette. In this case, you can use the directory blocks in track 18 and have 672 blocks available on the VIC 1541 diskette.

2.2.6 The Block-Execute Command B-E

The block-execute command allows a block to be read from diskette into a buffer and then the contents of the buffer to be executed as a machine language program. You can can write routines that the DOS is supposed to execute with the B-W or U2 command to a sector and later load it into a buffer with the block-execute program where it will be executed as a machine language program. Naturally, this presupposes knowledge of the internal workings of the DOS. If you want to use the **B-E** command, you usually give the buffer number in the OPEN command, in case the machine language program is not relocatable and is written for a specific buffer. The block-execute command has the following syntax:

B-E channelnumber drive track sector

```
100 OPEN 1,8,15
110 OPEN 2,8,2, "#3"
120 PRINT#1, "B-E 2 0 17 12"
```

Here buffer 3 ($600-$6FF) is assigned to channel 2. The contents of track 17 sector 12 is loaded into this buffer and there the machine language program is executed.

The block-execute command is a combination of the block-read and memory-execute commands. Examples of the design of machine language programs to execute in the DOS are found in section 2.4 by the memory commands.

2.3 Uses of direct access

What do the direct access commands permit us to do?

Here is a sample of their use:

By manipulating individual sectors you can make changes to the BAM sector (Track 18, Sector 0) such as changing the diskette name or ID.

You can make changes to the DIRECTORY (beginning at Track 18, Sector 1). Each file entry in the directory has unused space. You can use the unused space to store additional information.

You can change file names in the directory by using direct access commands.

You can follow the "chaining" of the blocks in a file to determine if the file is intact.

You can CLOSE an unclosed file by setting bit 7 of the file type indicator in the directory. For example, you can change the file type indicator from $02 to $82. Normally these files are indicated in the directory with an asterisk; after the above change the asterisk will disappear.

Each file entry also contains a "lock" which disallows deletion (SCRATCH command). If you set bit 6 of the file type then the file is said to be locked and not available for deletion. These entries have the < symbol after the type designation in the directory listing. Using this bit of knowledge, you can protect important programs on your diskette from accidental erasure. More information on this topic is found in section 4.1.

If you are interested in making such changes, you may want to read an entire sector and display it on the screen, change it, and write it back again. Such a program called the DISK MONITOR is described in section 4.6. Before you begin with such experiments, however, you should make a copy of your diskette. A directory or BAM error can result in the loss of the entire diskette contents.

Have you ever accidentally scratched a program or file from a diskette? As long as you haven't written any other programs or data to the diskette, you can recover this scratched file. Scratching a file simply sets the file type to 0 in the directory and frees the allocated blocks. You need only search the directory entries for the file and restore the file type: $81 for SEQ, $82 for PRG, $83 for USR, and $84 for REL. After restoring the file type, you should use the VALIDATE command to reallocate the blocks again (for example: OPEN 1,8,15:PRINT#1,"V0").

Other uses of direct access can provide the means for creating new data structures that the DOS normally does not recognize. You can undertake the management of the new file yourself, and use the direct access commands for reading and writing. Such a data structure is the ISAM file. ISAM is an abbreviation for Indexed Sequential Access Method. With an ISAM file, you can directly access each record, similar to the relative file. However, access is not by the record number, however, but by a **key** or **index**. This index is a field within the record. If, for example, a record consists of 5 fields, last name, first name, street, city/state and zip code, last name can be defined as the access key. To to read the record **Muller**, the command is simply 'read record "Muller"'. We need not concern ourselves with record number or other ordering criteria and can select which record we want to read, change, write or erase with clear text. In such an ISAM file system, the index is usually saved separately, together with the information where the data record can be found on the disk. Such an ISAM file management with very powerful additions as described here, is found along with other features in the program development system **MASTER 64**, also available for the Commodore 64 from Abacus Software.

2.4 Accessing the DOS - The Memory Commands

In section 2.2.6 we saw a way to load a program into DOS memory and execute it. With the memory commands, we can access each byte of the DOS and execute programs in RAM and ROM. For instance, we can access the work space of the DOS and read the number of free blocks on the disk or get the disk name from the BAM buffer. By writing into the DOS RAM we can change constants such as the device number of the drive or the number of read attempts for a block until an error message results. Furthermore, we can execute routines inside the DOS memory. These can be DOS ROM routines or your own, that are stored in a buffer and executes there. Of course this presumes knowledge of 6502 machine language and of the method of operation of the DOS. We hope this book is be helpful for the latter. Now follows a description of the commands and examples of their use.

2.4.1 The Memory-Read Command M-R

Using this command, you can access each byte of the DOS. The memory-read command can be shortened to **M-R.** The memory-read command is transmitted over the command channel. The byte read is then returned over the command channel where it can be retrieved with GET#. The syntax of the command looks like this:

M-R CHR$(LO) CHR$(HI)

LO and HI signify the low and high bytes of the address in the DOS that should be read. The following program asks for an address and reads the contents of the address out of the DOS.

```
100 INPUT"ADDRESS ";A
110 HI = INT (A/256)
120 LO = A-256*HI
130 OPEN 1,8,15
140 PRINT#1, "M-R";CHR$(LO);CHR$(HI)
150 GET#1,A$
160 PRINT ASC(A$+CHR$(0))
```

For instance, if we want to know the number of free blocks on a diskette, we don't have to read the entire directory, rather we can read the appropriate bytes directly from the DOS storage. This may be necessary if files are to be established by a program and you don't know if there is enough space on the disk.

```
100 OPEN 1,8,15,"I0"
110 PRINT#1, "M-R" CHR$(250) CHR$(2)
120 GET#1, A$ : IF A$="" THEN A$=CHR$(0)
```

```
130 PRINT#1, "M-R" CHR$(252) CHR$(2)
140 GET#1, B$ : IF B$="" THEN B$=CHR$(0)
150 PRINT ASC(A$) + 256 * ASC(B$) "BLOCKS FREE"
160 CLOSE 1
```

With this syntax, an M-R command must be given for each byte that is to be read. As you can gather from the DOS listing and through checking and verifying, one can read more than one byte at a time with a **M-R** command. You need only give the number of bytes to be read as the third parameter:

M-R CHR$(LO) CHR$(HI) CHR$(NUMBER)

We can use this to read the name of a diskette from the BAM buffer storage. Before this can be done, the diskette must be initialized so that the current diskette name is stored in the buffer at address $700, out of which we will read the name of the disk with the M-R command.

```
100 OPEN 1,8,15, "I0"
110 PRINT#1, "M-R" CHR$(144) CHR$(7) CHR$(16)
120 INPUT#1, A$
130 PRINT A$
```

This is a simple way to read the name of the diskette (16 characters padded with shifted spaces (CHR$(160)). With this you can check if the correct diskette is in the drive.

The disk buffer can also be read using this method. It also allows parts of the DOS to be manipulated by copying the contents of the ROM to a buffer where it can be changed and executed. This is explained in the next two sections.

2.4.2 The Memory-Write Command M-W

The complement command of memory-read is the command to write data in the DOS storage memory-write or **M-W.** Writing is allowed only to DOS RAM - page zero, stack, and buffers. It is possible to send several bytes with one command. The syntax look like this:

M-W CHR$(LO) CHR$(HI) CHR$(NUMBER) CHR$(DATA1) CHR$(DATA2)

The number of bytes as specified by NUMBER can be transmitted, theoretically 255, but because the input buffer holds only 40 characters, the number of bytes is limited to 34. A possible use of this command is to change the address number (see program 'DISK ADDRESS CHANGE', section 4.2.3). The address is stored in two memory locations in page zero. The device number plus $20 (32 decimal) is stored in address $77 (119 decimal) for LISTEN, for receiving data from the computer. The address immediately following contains the device number plus $40 (64 decimal) for TALK, for sending data to the computer. Because the addresses are saved separately. It is possible to use different send and receive addresses. In the following example, the receive address is set to 9 and the send address to 10.

```
100 OPEN 1,8,15
110 PRINT#1, "M-W" CHR$(119) CHR$(0) CHR$(2)
                   CHR$(9+32) CHR$(10+64)
120 CLOSE 1
140 OPEN 1,9,15
150 OPEN 2,10,15
160 PRINT#1,"I0"
170 INPUT#2,A$,B$,C$,D$
180 PRINT A$","B$","C$","D$

00, OK,00,00
```

Programs cannot be loaded this way because the DOS will try to load the program using the same address that the filename was sent under.

Changing the device number is necessary if you want to use more than one disk drive with a single computer. To this end, change the device address of the second drive to 9. This software change remains in effect only until a reset (for example, turning the drive off). If the change needs to be permanent, you can change the with DIP switches or cut the circuit board jumper inside the drive.

Because many parameters of the DOS are in RAM, you can make extensive changes to the function of the DOS, such as the step size, with which the number of sectors per track is determined (address $69 (105 decimal), normally contains 10). We can also specify the number of attempted reads until an error results (address $6A (106 decimal), contains 5). More addresses of parameters can be found in section 3.1.2.

2.4.3 The Memory-Execute Command M-E

Using this command you can call up and execute machine language programs in the DOS memory. The memory-execute command can be shortened to **M-E.** The programs must end with RTS (Return from Subroutine, $60). The syntax of the command:

M-E CHR$(LO) CHR$(HI)

Again, LO and HI are the low and high bytes of the starting address of the machine language routine. It is possible to call up routines in the DOS ROM as well as our own routines written to a buffer with **M-W** and there executed. As an example, you can call up a routine that creates an error message. For example, address $EFC9 is the entry point for message **72, 'DISK FULL'**. The example looks like this:

```
100 OPEN 1,8,15
110 PRINT#1,"M-E" CHR$(201) CHR$(239)
120 INPUT#1,A$,B$,C$,D$
130 PRINT A$ "," B$ "," C$ "," D$
```

In line 110, the address $EFC9 is divided into a low byte of $C9 (201) and high byte of $EF (239) and sent as the parameters of the **M-E** command. Then the error channel is read and the message displayed.

72,DISK FULL,00,00

If you want to run your own programs in the 1541 drive, the program should be written to a buffer and there called with **M-E**. Should this program be used more often, the contents of the buffer can be written to a block on the diskette. It can then be executed with the B-**E** command, which loads the contents of the block in the buffer and then automatically starts the routine. As a suggestion for your own program in DOS, you can display the directory in a different form, with additional parameters, similar to the program in section 4.1.1. In addition, you could count the number of files on the disk and display that. Using such a routine you can get a much clearer understanding of how the directory is created in the DOS listing. If you are clear on the matter of the new directory format, you are ready to take the additional parameters from the directory entries and assemble them in the desired format.

2.4.4 The User Commands U

Using the USER commands there are two possible ways of executing programs in the drive. The user commands have the following syntax:

UX

X can be a letter from A to J or a digit from 1 to 9 or ':' (which takes the place of 10). When a command is called, a jump is made to the following addresses in DOS:

UA	U1	$CD5F	substitute for 'Block-Read'
UB	U2	$DC97	substitute for 'Block-Write'
UC	U3	$0500	
UD	U4	$0503	
UE	U5	$0506	
UF	U6	$0509	
UG	U7	$050C	

UH	U8	$050F	
UI	U9	$FF01	
UJ	U:	$EAA0	reset

You are already acquainted with the commands U1 and U2 (also UA and UB); they serve as substitutes for BLOCK-READ and BLOCK-WRITE. The commands U3 to U8 (UC to UH) jump to addresses within buffer 2 (address $500 (1280) - see section 2.1). If you want to use several commands, a jump table to individual routines can be placed there; if only one user command (U3) is used, the program can begin directly at $500.

The user command UJ jumps to the reset vector; the disk drive is then reset.

```
100 OPEN 1,8,15
110 PRINT#1,"UJ"
120 FOR I=1 TO 1000 : NEXT
130 GET#1,A$ : PRINT A$ : IF ST<>64 THEN 130

73,CBM DOS V2.6 1541,00,00
```

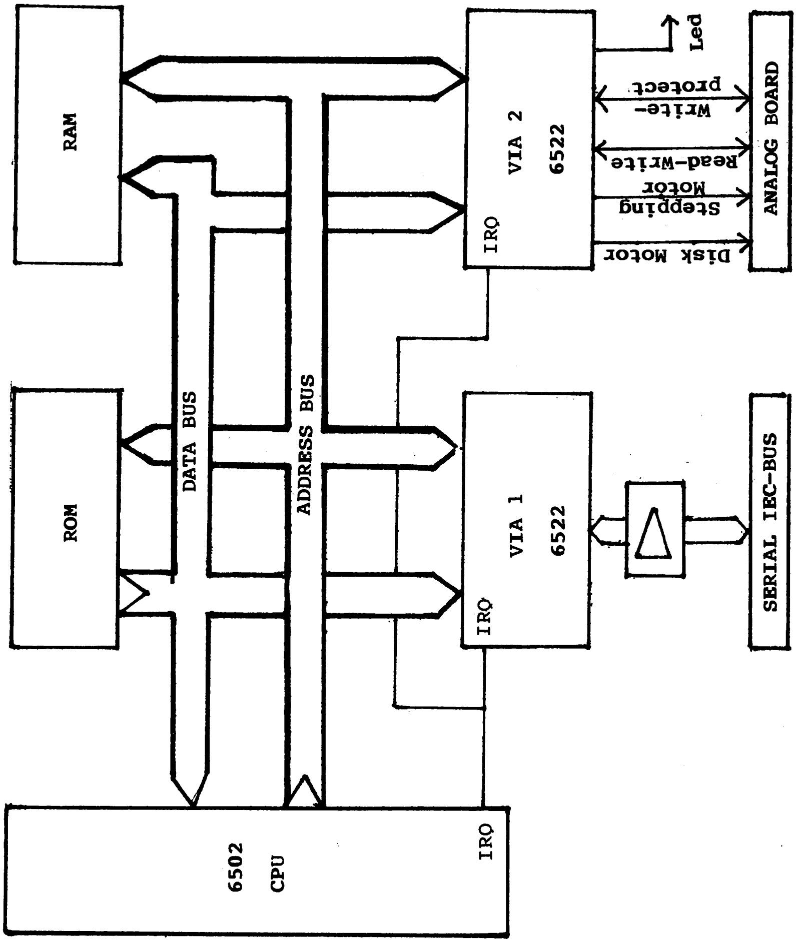
Line 120 waits for the reset to take place. Then the initialization message is retrieved in line 130.

By using the user commands, parameters can be passed to the routines. The complete command string is put in the input buffer at $200 (512). Possible parameters are addresses, command codes, and filenames. This way, the user commands can be utilized to expand the commands of the disk or to realize a new data structure. Whole user commands can replace the M-E command with its corresponding addresses; the user-call is shorter and clearer.

Chapter 3: Technical Information

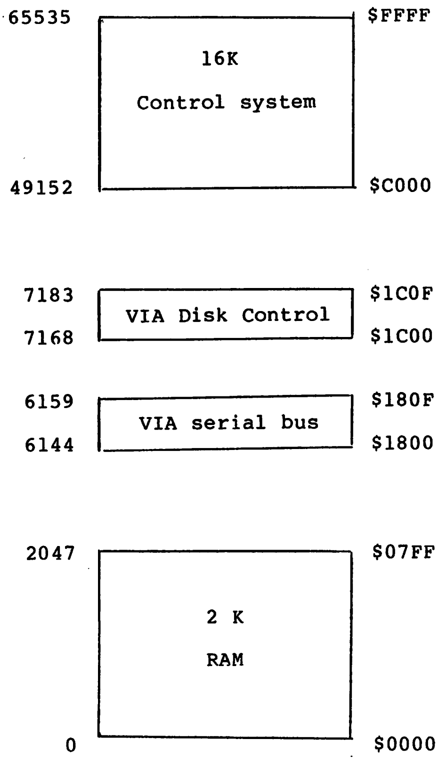
3.1 The Construction of the VIC 1541

3.1.1 Block Diagram of the Disk Drive



3.1.2 DOS Memory Map - ROM, RAM, I/O

Memory map of the VIC 1541 disk drive



Layout of the I/O Ports (VIA 6522)

VIA 6522 1, Port for Serial Bus

$1800	Port B
$1801	Port A
$1802	Direction of Port B
$1803	Direction of Port A
$1805	Timer
PB 0:	DATA IN
PB 1:	DATA OUT
PB 2:	CLOCK IN
PB 3:	CLOCK OUT
PB 4:	ATN A
PB 5,6:	Device address
CB 2:	ATN IN

VIA 6522 2, Port for Motor and Read/Write Head Control

$1C00	Port B, control port
$1C01	Port A, data to and from read/write head
$1C02	Direction of Port A
$1C03	Direction of Port B

PB 0:	STP I	
PB 1:	STP O	step motor for head movement
PB 2:	MTR	drive motor
PB 3:	ACT	LED on drive
PB 4:	WPS	Write Protect Switch
PB 7:	SYNC	
CA 1:	Byte ready	
CA 2:	SOE	

The Layout of the Important Memory Locations

0	$00	Command code for buffer 0
1	$01	Command code for buffer 1
2	$02	Command code for buffer 2
3	$03	Command code for buffer 3
4	$04	Command code for buffer 4
6	$06-$07	Track and sector for buffer 0
8	$08-$09	Track and sector for buffer 1
10	$0A-$0B	Track and sector for buffer 2
12	$0C-$0D	Track and sector for buffer 3
14	$0E-$0F	Track and sector for buffer 4
18	$12-$13	ID for drive 0
20	$14-$15	ID for drive 1
22	$16-$17	ID
32	$20-$21	Flag for head transport
48	$30-$31	Buffer pointer for disk controller
57	$39	Constant 8, mark for beginning of data block header
58	$3A	Parity for data buffer
61	$3D	Drive number for disk controller
63	$3F	Buffer number for disk controller
67	$43	Number of sectors per track for formatting
71	$47	Constant 7, mark for beginning of data block header
73	$49	Stack pointer
74	$4A	Step counter for head transport
81	$51	Actual track number for formatting
105	$69	Step size for sector division (10)
106	$6A	Number of read attempts (5)
111	$6F-$70	Pointer to address for M & B commands
119	$77	Device number + $20 for listen
120	$78	Device number + $40 for talk
121	$79	Flag for listen (1/0)
122	$7A	Flag for talk (1/0)
124	$7C	Flag for ATN from serial bus receiving
125	$7D	Flag for EOI from serial bus
127	$7F	Drive number
128	$80	Track number
129	$81	Sector number
130	$82	Channel number
131	$83	Secondary address
132	$84	Secondary address
133	$85	Data byte
139	$8B-$8D	Work storage for division
148	$94-$95	Actual buffer pointer
153	$99-$9A	Address of buffer 0 $300
155	$9B-$9C	Address of buffer 1 $400
157	$9D-$9E	Address of buffer 2 $500
159	$9F-$A0	Address of buffer 4 $600
161	$A1-$A2	Address of buffer 5 $700
163	$A3-$A4	Pointer to input buffer $200
165	$A5-$A6	Pointer to buffer for error message $2D5

181	$B5-$BA	Record # lo, block # lo
187	$BB-$C0	Record # hi, block # hi
193	$C1-$C6	Write pointer for rel. file
199	$C7-$CC	Record length for rel. files
212	$D4	Pointer in record for rel. file
213	$D5	Side sector number
214	$D6	Pointer to data block in side sector
215	$D7	Pointer to record in rel. file
231	$E7	File type
249	$F9	Buffer number
256-325	$100-$145	Stack
512-552	$200-$228	Buffer for command string
586	$24A	File type
600	$258	Record length
601	$259	Track side-sector
602	$25A	Sector side-sector
628	$274	Length of input line
632	$278	Number of file names
663	$297	File control method
640-644	$280-$284	Track of a file
645-649	$285-$289	Sector of a file
725-761	$2D5-$2F9	Buffer for error message
762/764	$2FA/$2FC	Number of free blocks
768-1023	$300-$3FF	Buffer 0
1024-1279	$400-$4FF	Buffer 1
1280-1535	$500-$5FF	Buffer 2
1536-1791	$600-$6FF	Buffer 3
1792-2047	$700-$7FF	Buffer 4

3.2 Operation of the DOS - An Overview

The VIC-1541 is an intelligent disk drive with its own microprocessor and control system (Disk Operation System, DOS). This means that no memory space or processing time is taken from the computer. The computer needs only transmit commands to the disk drive, which it then executes on its own.

The disk performs three tasks simultaneously: Firstly, it manages data traffic to and from the computer. Secondly, it interprets the commands and performs the management of files and the associated communications channels and block buffer. Thirdly, it handles the hardware-oriented related functions of the disk drive - formatting, reading and writing, etc.

These tasks are carried out simultaneously by the 6502 microprocessor in the VIC 1541. This is possible with the help of the interrupt technique. Only in this way can three tasks be executed simultaneously.

Most of the DOS is concerned with interpreting and executing

the transmitted commands. The reception of data and commands from the computer is controlled by interrupts. If the computer wants to talk to a peripheral device, it sends a pulse along the ATN line (ATteNtion, see section 5.1). This generates an interrupt at the disk drive. The DOS stops its current task and notices that the computer wants to send data. The DOS then finishes the original task. After that, the DOS will accept further data and commands from the the computer. If the command is finished, the DOS stays in a wait loop until new commands arrive from the disk.

The execution of a command at this level is limited to the logical processing of the command, the management of the communications channel to and from the computer and the preparation and retrieval of data to be written or read, respectively. The tasks of a disk controller, formatting diskettes and writing and reading individual blocks, must also be performed by the processor.

These tasks are again interrupt controlled. Regular programs in the disk are interrupted every 14 milliseconds by a built-in timer, and control branches to a program that fulfills the tasks of a disk controller. Communications between the two independent programs is handled through a common area of memory, in which the main program places codes for the disk controller program. If the interrupt program is active, it looks at the memory locations to determine which activities are demanded, such as formatting a diskette. if this is the case, the drive and head motors are set in motion. At the end of the interrupt routine, the main program examines the memory locations to determine if the task was carried out by the disk controller, or if it must wait yet. In this way, the main program is informed in case of an error, such as a read error or if a write protect tab is present. The main program can then react appropriately and display the error message, for example.

In the large CBM disks, two 6504 microprocessors are used as a disk controller. Communication again occurs over a common area of memory.

An overview of the storage layout of the DOS such as the I/O primitives for managing the diskette and serial bus can be found in the previous section.

This overview of the work of the DOS is naturally just a rough outline. If you want more exact information, refer to the DOS listing of the VIC 1541 in section 3.5, in which the complete 16K control system is documented.

3.3 The Structure of the VIC 1541 Diskette

The diskette of the 1541 is divided into 35 tracks. Each track contains from 17 to 21 sectors. The total number of sectors is 683. Because the directory occupies track 18, 664 data are available for use, each containing 256 bytes. The tracks are layed out as follows:

TRACK	NUMBER OF SECTORS
1 TO 17	21
18 TO 24	19
25 TO 30	18
31 TO 35	17

The varying number of sectors per track is necessitated by the shortening of the tracks from the midpoint on.

3.3.1 The BAM of the VIC 1541

BAM is an abbreviation for Block Availability Map. The BAM indicates whether a block on the diskette is free or allocated to a file. After every manipulation of blocks (saving, deleting, etc.) the BAM is updated. When the BAM indicates that a file to be saved requires more blocks than are available, an error message is given. When a file is OEPNed, the BAM in the DOS storage is updated, and is rewritten to disk when the file is CLOSEd. Commands that have a write or delete function read the BAM, update it, and rewrite it to the diskette. The BAM is organized as follows on track 18 sector 0:

Track 18, sector 0

BYTE	CONTENTS	MEANING
0,1 ($00-$01)	$12,$01	Track and sector of the 1st block of the directory
2 ($02)	$41	ASCII character 'A'; indicates 1541 format
3 ($03)	$00	Zero flag for future use
4-143 ($04-$8F)		Bit map of free and allocated blocks *

* 1 = block free; 0 = block allocated

The bit map of the blocks is organized so that 4 bytes represent the sectors on a track. As can be inferred from the following table, the first of the 4 bytes contain the number of free blocks in the track. The other 3 bytes (24 bits) indicate which blocks are free and which are allocated in this track.

Structure of the BAM entry of a track:

BYTE	CONTENTS
0	Number of available blocks in this track
1	Bit map of sectors 0-7
2	Bit map of sectors 8-15
3	Bit map of sectors 16-23

4 bytes of a track designation in the BAM:

Track 18, sector 0, bytes 4-7 (track 1)	
00001010 ($0A)	00000000 00000011 11111111 ($00) ($03) ($FF)
10 free blocks	1 = free 0 = allocated

Using a simple program, you can read the first byte of each track entry in the bit map, add them up and find the total number of free blocks on the diskette.

3.3.2 The Directory

The directory is the table of contents of the diskette. It contains the following information:

- disk name
- disk ID
- DOS version number
- filenames
- file types
- blocks per file
- free blocks

This directory is loaded into memory with the command **LOAD "$",8.** A program previously in memory will be destroyed! It can be displayed on the screen with the LIST command.

The directory occupies all of track 18 on the disk. The file entries follow the directory header. Each block accommodates a maximum of 8 file entries. Because the BAM and the header occupy one block, 18 blocks are left for file entries. A total of 144 files may reside on one diskette (18 blocks with 8 entries each).

Format of the directory header:

Track 18, sector 0

BYTE	CONTENTS	MEANING
144-161 ($90-$A1)		Disk name (padded with shifted spaces)
162,163 ($A2-$A3)		Disk ID marker
164 ($A4)	$A0	Shifted Space
165,166 ($A5-$A6)	$32,$41	ASCII characters "2A" (format)
167-170 ($A7-$AA)	$A0	Shifted Space
171-255 ($AB-$FF)	$00	not used, filled with 0

* Bytes 180 to 191 have the contents "BLOCKS FREE" on many diskettes

The Diskette Name:

The name of the diskette can be a maximum of 16 characters in length and is established when the diskette is formatted. If fewer then 16 characters are given, the rest is filled with shifted spaces ($A0). The following BASIC routine reads the name and saves it in the string variable DN$:

```
100 OPEN 15,8,15,"I0"            : REM COMMAND CHANNEL 15
                                    AND DISK INITIALIZED
110 OPEN 2,8,2,"#"               : REM DATA CHANNEL 2 OPENED
120 PRINT#15,"B-R";2;0;18;0      : REM TRACK 18, SECTOR 0 READ
                                    AND PLACED IN CHANNEL 2
130 PRINT#15,"B-P";2;144         : REM BUFFER-POINTER TO BYTE
                                    144
140 DN$=""                       : REM STRING DN$ IS ERASED
150 REM LOOP TO READ THE 16 BYTES OF THE NAME
160 FOR I=1 TO 16
170 ::GET#2,X$                   : REM READ A BYTE
180 ::IF ASC(X$)=160 THEN 200    : REM IGNORE SHIFT SPACE
190 ::DN$=DN$+X$                 : REM BYTE ADDED TO DN$
200 NEXT I
210 CLOSE 2:CLOSE 15             : REM CLOSE CHANNELS
```

After running the routine, the string DN$ contains the disk name.

Diskette ID:

The diskette ID is two characters in length and is specified when formatting the diskette. The DOS uses this ID to detect if a diskette in the drive has been replaced. If so, then the DOS performs an INITIALIZE. Initializing a diskette loads the BAM into memory in the drive. This way, the actual BAM is always in memory, provided the ID given when formatting is always different. Should this not be the case, a diskette must be initialized explicitly by using the INITIALIZE command.

3.3.3 The Directory Format

Blocks 1 through 19 on track 18 contain the file entries. The first two bytes of a block point to the next directory block with file entries. If no more directory blocks follow, these bytes contain $00 and $FF, respectively.

Track 18, sector 1		
Byte		Contents
0,1	($00,$01)	Track and sector number of the next directory block
2-31	($02-$1F)	Entry of 1st file
34-63	($22-$3F)	Entry of 2nd file
66-95	($42-$5F)	Entry of 3rd file
98-127	($62-$7F)	Entry of 4th file
130-159	($82-$9F)	Entry of 5th file
162-191	($A2-$BF)	Entry of 6th file
194-223	($C2-$DF)	Entry of 7th file
226-255	($E2-$FF)	Entry of 8th file

Format of a Directory Entry:

Each file entry consists of 30 bytes, the functions of which are described below:

BYTE		CONTENTS
0	($00)	File type
1,2	($01,$02)	Track and sector number of the first data block
3-18	($03-$12)	Filename (padded with "SHIFT SPACE"
19,20	($13,$14)	Only used for relative files (track and sector of the first side-sector block)
21	($15)	Only used for relative files (record length)
22-25	($16-$19)	Not used
26,27	($1A-$1B)	Track and sector number of the new file when overwritten with the @:
28,29	($1C-$1D)	Number of blocks in the file (low byte, high byte)

File Type Marker:

Byte 0 of the file entry denotes the file type. Bits 0-2 are used to indicate the 5 file types. Bit 7 indicates if the file has been CLOSEd properly. Closing a file sets bit 7. An unclosed file is denoted with an asterisk in front of the file type in the directory listing. If, for example, a sequential file "TEST" is opened and the directory is listed, this file will be represented like this:

```
12    "TEST"        *SEQ
```

If the file is CLOSEd again, the asterisk does not appear in future directory listings. If this file remains unclosed and later opened, the error message "WRITE FILE OPEN" will appear.

The File Type:

In order to understand the function of byte 0 in the file entry, the file type, a table of all file types follows:

File type	Bit mask opened 7654 3210	HEX	Bit mask closed 7654 3210	HEX
DELeted	0000 0000	$00	1000 0000	$80
SEQuential	0000 0001	$01	1000 0001	$81
ProGram	0000 0010	$02	1000 0010	$82
USeR	0000 0011	$03	1000 0011	$83
RELative	0000 0100	$04	1000 0100	$84

Perhaps you have noticed that bits 3-6 have no function. But we verified with help from the DOS listing, bit 6 has a function:

BIT 6 OF THE FILE TYPE DENOTES A PROTECTED FILE!

If you set this bit to 1, the corresponding file can no longer be deleted. This is designated in the directory listing with a < next to the file type. Because setting this bit requires some complicated commands, you will find a program in chapter 4 of this book with which you can protect, unprotect, and delete files.

Track and sector of the first Data Block

Bytes 1 and 2 of the file entry point to the first data block of the file. The first byte contains the track and the second the sector number where the file begins. The first data block, in turn contains a pointer to the second block of the file (also contained in the first two bytes of the block). The last data block of the file is indicated by a first-byte value of $00. The second byte contains the number of bytes used in this last sector.

This concatenation can be explained with the help of the DOS MONITOR, contained in this book:

```
>:B0   A0 A0 A0 A0 A0 00 00 00          ...
>:B8   00 00 00 00 00 00 0B 00     ........
>:C0   00 00 81 13 09 54 31 32     .....T12
>:C8   2F 53 30 31 A0 A0 A0 A0     /S01
>:D0   A0 A0 A0 A0 A0 00 00 00          ...
>:D8   00 00 00 00 00 00 06 00     ........
>:E0   00 00 82 10 00 44 49 53     .....DIS
>:E8   4B 20 41 44 44 52 20 43     K ADDR C
>:F0   48 41 4E 47 45 00 00 00     HANGE...
>:F8   00 00 00 00 00 00 04 00
```

This is an extract from the directory (track 18, sector 1) of the TEST/DEMO diskette. You can follow the organization of the file DISK ADDR CHANGE. The entry of this file begins at byte $E2 and ends with byte $FF. This is a PRG file, which can be recognized by the file type $82 in byte $E2. This file comprises 4 blocks on the disk. This is evident from bytes $FE and $FF. Bytes $E3 and $E4 of the entry address the first data block of the file ($10, $00, corresponding to track 16, sector 0).

Let's look at a section of this block:

```
>:00   10 0A 01 04 0F 04 64 00     ......$.
>:08   97 35 39 34 36 38 2C 31     .59468,1
>:10   32 00 39 04 6E 0D 99 22     2.9...."
>:18   93 13 11 11 11 11 44 52     ......DR
>:20   49 56 45 20 41 44 44 52     IVE ADDR
>:28   45 53 53 20 43 48 41 4E     ESS CHAN
```

```
>:30  47 45 20 50 52 4F 47 52  GE PROGR
>:38  41 4D 22 00 59 04 6F 00  AM".Y./.
>:40  99 22 11 54 55 52 4E 20  .".TURN
>:48  4F 46 46 20 41 4C 4C 20  OFF ALL
```

This block contains the first part of the program. It is stored on the diskette exactly as it is stored in the computer's memory. The BASIC commands are converted to one byte codes called tokens. This is why only the text can be recognized in the right hand translation of the hexadecimal codes. The first two bytes of this data block indicate the second data block ($10 and $0A, track 16, sector 10) from with this section follows:

```
>:00  10 14 34 30 00 1D 05 A0  ..40...
>:08  00 8D 20 33 30 30 3A 20  .. 300:
>:10  8F 20 46 49 4E 44 20 44  . FIND D
>:18  52 49 56 45 20 54 59 50  DRIVE TYP
>:20  45 00 39 05 AA 00 8D 20  E.9.  ..
>:28  36 30 30 3A 20 8F 20 43  600: . C
>:30  48 41 4E 47 45 20 41 44  HANGE AD
>:38  44 52 45 53 53 00 68 05  DRESS.(.
>:40  B4 00 99 22 11 54 48 45   ..".THE
>:48  20 53 45 4C 45 43 54 45   SELECTE
```

The program is continued in this block. Bytes $00 and $01 point to the third data block of the file ($10, $14, track 16, sector 20):

```
>:00  10 08 31 30 30 30 00 23  ..1000.#
>:08  06 54 01 8B 20 43 B2 32  .T.. C 2
>:10  35 34 20 A7 20 4D 54 B2  54   MT
>:18  31 31 39 3A 20 8F 3A 20  119: .:
>:20  32 30 33 31 20 56 32 2E  2031 V2.
>:28  36 00 45 06 5E 01 8B 20  6.E. ..
>:30  43 B2 32 32 36 20 A7 20  C 226
>:38  4D 54 B2 35 30 3A 20 8F  MT 50: .
>:40  3A 20 32 30 34 30 20 56  : 2040 V
>:48  31 2E 32 00 67 06 68 01  1.2. .(.
```

This is the next to the last block of the program. You have no doubt recognized that the data blocks are in the same track, but are not contiguously. The first data block is block 0. The next is block 10, 10 blocks from the first block. 9 blocks are always skipped between data blocks of a file. The third data block is block number 20. The DOS begins again with the first block if the calculated block oversteps the highest block. Because track 16 contains 21 blocks, the last data block is block number 8. The first two bytes of this third block address it:

```
>:00  00 F8 5A 42 B2 31 20 A7  . ZB 1
>:08  20 34 34 30 00 14 07 A3   440...
>:10  01 8B 20 53 54 20 A7 20  .. ST
>:18  31 30 30 30 00 45 07 B8  1000.E.
```

```
>:20  01 98 31 35 2C 22 4D 2D  ..15,"M-
>:28  52 22 C7 28 31 37 32 29  R" (172)
>:30  C7 28 31 36 29 3A A1 23   (16): #
>:38  31 35 2C 5A 43 24 3A 5A  15,ZC$:Z
>:40  43 B2 C6 28 5A 43 24 AA  C F(ZC$
>:48  C7 28 30 29 29 00 66 07  G(0)).&.
```

Here the end of the program is marked by the value $00 in byte $00. Byte $01 gives the number of bytes in this last block that belong to the program. ($F8 corresponds to 248 bytes). Now we can find out the size of the program:

```
3 blocks with 254 bytes each = 762 bytes
last block                   = 248 bytes
                              ----------
Size of the program           1100 bytes
                              ==========
```

The Filename:

The filename is contained in bytes 3-18 of the file entry. It consists of a maximum of 16 characters. Should the name be shorter than 16 characters, the rest of the name is padded with shifted spaces ($A0).

Track and Sector of the new File for "Overwriting":

If a file is overwritten by using the @:, the new file is first completely saved. No filename entry is made in the directory for this file because the file already exists under this same name. Instead the address of the first block of the new file is placed in bytes 26 and 27 of the filename entry. If the new program is removed, the old one is deleted, which merely designates the blocks allocated to the file as free in the BAM. Now the address of the first data block of the new file is placed into the filename entry in bytes 1 and 2 is used and the file is "overwritten".

Number of Blocks in the File:

The length of a file is given in bytes 28 and 29 of its file entry. A file consists of at least one block and as many as 664 blocks. The first byte is the low byte, and the second is the high byte. If, for example, you discovered the file length $1F,$00 with the DISK MONITOR, the file consists of 31 blocks.

3.4 The Organization of Relative Files

Relative files differ from sequential files in that each data record can be accessed directly by a record number. The 1541 DOS takes care of most of the tasks required to support relative records. Let's take a closer look at the organization of a relative file.

First OPEN a relative file with a record length of 100:

```
OPEN 2,8,2, "REL-FILE,L,"+CHR$(100)
```

Now write data record number 70:

```
OPEN 1,8,15
PRINT#1,"P"+CHR$(2)+CHR$(70)+CHR$(0)+CHR$(1)
PRINT#2,"DATA FOR RECORD 70"
CLOSE 2 : CLOSE 1
```

The directory entry then looks like this:

```
>:00 .. .. 84 11 00 52 45 4C   ...REL
>:08 2D 46 49 4C 45 A0 A0 A0 -FILE
>:10 A0 A0 A0 A0 A0 11 0A 64       ..$
>:18 00 00 00 00 00 00 1D 00 ........
```

The first byte $84 denotes a relative file. The next two bytes denote the first track and sector of the data ($11, $00; track 17 sector 0); exactly as with a sequential file. As usual, the name of the file follows (16 characters, padded with shifted spaces, $A0). Following are two fields not used with sequential files. The first field is a two byte pointer to the track and sector of the first **side-sector** block. A side-sector contains the pointers to each data record and is described more in detail later ($11, $0A; track 17, sector 10). The second field is a byte which contains the record length, a value between 1 and 254, in our case $64 (100).

The convenience of being able to access each record individually requires a definite length for each record that must be defined when establishing a relative file. The rest of the fields in the directory entry have the usual significance; the last two bytes contain the number of blocks in the file (lo and hi byte, $1D and $00 (29)).

What does such a side-sector block look like and what is its function?

The side-sector blocks contain the track and sector pointers to the individual data records. For example, if we want to read the 70th record in the relative file, the DOS consults the side-sector block to determine which track and sector contains the record and then read this record directly. As a result, you can read the 70th record of the file without having to read the entire file. Now let's take a look at the exact construction of a side-sector block. This side-sector block is from our previous file.

```
>:00   00 47 00 64 11 0A 00 00   .G.$....
>:08   00 00 00 00 00 00 00 00   ........
>:10   11 00 11 0B 11 01 11 0C   ........
>:18   11 02 11 0D 11 03 11 0E   ........
>:20   11 04 11 0F 11 05 11 10   ........
>:28   11 06 11 11 11 07 11 12   ........
>:30   11 08 11 13 11 09 11 14   ........
>:38   10 08 10 12 10 06 10 10   ........
>:40   10 04 10 0E 10 02 10 0C   ........
>:48   00 00 00 00 00 00 00 00   ........
>:50   00 00 00 00 00 00 00 00   ........
 etc.
```

The first two bytes point to the track and sector of the next side-sector block, as usual. In our case, no further side-sector blocks exist ($00) and only $47 = 71 bytes of this sector are used. Byte 2 contains the number of the side-sector block, 00. A relative file can contain a maximum of 6 such blocks; the numbering goes from 0 to 5. The record length, $64 (100), is in byte 3. The next twelve bytes (bytes 4 through 15) contain the track and sector pointers (two bytes each) to the 6 side-sector blocks (00,00 means the block is not yet used). Starting at byte 16 ($10) are the pointers to the data, and the track and sector pointers to the first 120 data blocks (in our case, only 28 pointers). Using the record number and record length, the DOS can calculate in which block the data lies and at which position within the block the record begins. Take the following example, for instance:

To read the 70th record from the file with a record length of 100 characters, you can perform the following calculations:

    (70-1) * 100 / 254

We get a quotient of 27 and a remainder of 42. The DOS now knows that the record can be found in the 27th data block at the 42+2 or 44th position.

Here's an explanation of the calculation. Each block contains 256 bytes, the first two of which are used as a pointer to the next block. 254 bytes are then left over for data storage. We can calculate the byte number from the start of the file (which is record 1) from the record number and record length. If we divide this value by the number of bytes per block, we get the number of the block containing the record. The remainder of the division gives the position within the block (add 2, because the first two bytes serve as a pointer). If the record overlaps the end of the block, the next block must also be read.

In our example, the 27th data block lies in track \$10 = 16 and sector \$0C = 12. If we read this block, we get the following picture:

```
>:00   00 F3 00 00 00 00 00 00   ........
>:08   00 00 00 00 00 00 00 00   ........
>:10   00 00 00 00 00 00 00 00   ........
>:18   00 00 00 00 00 00 00 00   ........
>:20   00 00 00 00 00 00 00 00   ........
>:28   00 00 00 00 44 41 54 41   ....DATA
>:30   20 46 4E 52 20 52 45 43    FOR REC
>:38   46 52 44 20 37 30 0D 00   ORD 70..
>:40   00 00 00 00 00 00 00 00   ........
>:48   00 00 00 00 00 00 00 00   ........
>:50   00 00 00 00 00 00 00 00   ........
>:58   00 00 00 00 00 00 00 00   ........
>:60   00 00 00 00 00 00 00 00   ........
>:68   00 00 00 00 00 00 00 00   ........
>:70   00 00 00 00 00 00 00 00   ........
>:78   00 00 00 00 00 00 00 00   ........
>:80   00 00 00 00 00 00 00 00   ........
>:88   00 00 00 00 00 00 00 00   ........
>:90   FF 00 00 00 00 00 00 00   ........
>:98   00 00 00 00 00 00 00 00   ........
>:A0   00 00 00 00 00 00 00 00   ........
>:A8   00 00 00 00 00 00 00 00   ........
>:B0   00 00 00 00 00 00 00 00   ........
>:B8   00 00 00 00 00 00 00 00   ........
>:C0   00 00 00 00 00 00 00 00   ........
>:C8   00 00 00 00 00 00 00 00   ........
>:D0   00 00 00 00 00 00 00 00   ........
>:D8   00 00 00 00 00 00 00 00   ........
>:E0   00 00 00 00 00 00 00 00   ........
>:E8   00 00 00 00 00 00 00 00   ........
>:F0   00 00 00 00 FF 00 00 00   ........
>:F8   00 00 00 00 00 00 00 00   ........
```

If we get a block number greater than 120 from the calculation, the pointer can no longer be found on the first side-sector block, rather in the next side-sector blocks. In this case, you divide the block number by 120, the quotient being the number of the side-sector block. The remainder gives the location of the pointer within this block. For instance, to find record number 425, divide by 120 and get a quotient 3, remainder 65. Therefore, you must read side-sector block 3 and get the pointer to the 65th data block. Between 2 and 4 block accesses are necessary to access a record of a relative data file.

When creating or expanding a relative file, the following takes place:

First, a directory entry is created for the relative file, containing the record length. Two channels are reserved for the relative file,one for the data, the other for the side-sectors. If a record pointer is set to a specific record, the DOS first checks to see if the record already exists. If so, the corresponding block is read and the buffer pointer set so that the contents can be accessed. If not, the record is created. All records preceding this record number that do not already exist are also created. The first byte of a new record is written to contain $FF (255), and the rest of the record is filled with $00.

If the corresponding record is at the beginning of a block, the rest of the block is filled with empty records. Each time a non-existing record is accessed, the error message **50,RECORD NOT PRESENT** is returned. When writing a new record, this is not considered an error, but indicates that a new record was created.

You can use this method for creating a new file if you know the maximum number of data records. You simply set the record pointer to this record and write $FF (CHR$(255)) to this record. By allocating a file like this, the error message 50 no longer appears. You also know if there is sufficient space on the diskette. If not, the error message **52, FILE TOO LARGE** is returned.

With a maximum of 6 side sectors, a relative file can contain 6 * 120 * 254 = 182,880 bytes. In the case of the VIC 1541, this is more than the capacity of the whole diskette. With the bigger 8050 drive, which contains more than 500K of storage, this may present a limitation. But DOS version 2.7 has an expansion of the side-sector procedure ('super side-sector'), with which a relative file may contain up to 23 MB. DOS 2.7 is contained in the CBM 8250 and the Commodore hard drives as well as the newer 8050 drives (see section 5.2).

Because a relative file requires two data channels, and the VIC 1541 has only 3 channels available, only one relative file can be open at a time. The third channel can still be used for a sequential file open at the same time. With the larger CBM drives, more channels are available (3 relative files open simultaneously, see also section 5.2).

3.5 DOS 2.6 ROM LISTINGS

```
******************************   turn LED on
C100    78          SEI
C101    A9 F7       LDA #$F7       erase LED bit
C103    2D 00 1C    AND $1C00
C106    48          PHA
C107    A5 7F       LDA $7F        drive number
C109    F0 05       BEQ $C110      0?
C10B    68          PLA
C10C    09 00       ORA #$00       not drive 0, turn LED off
C10E    D0 03       BNE $C113
C110    68          PLA
C111    09 08       ORA #$08       turn LED on
C113    8D 00 1C    STA $1C00
C116    58          CLI
C117    60          RTS

******************************   turn LED on
C118    78          SEI
C119    A9 08       LDA #$08
C11B    0D 00 1C    ORA $1C00      LED on
C11E    8D 00 1C    STA $1C00
C121    58          CLI
C122    60          RTS

******************************   erase error flags
C123    A9 00       LDA #$00
C125    8D 6C 02    STA $026C
C128    8D 6D 02    STA $026D
C12B    60          RTS

******************************
C12C    78          SEI
C12D    8A          TXA            save X register
C12E    48          PHA
C12F    A9 50       LDA #$50
C131    8D 6C 02    STA $026C
C134    A2 00       LDX #$00
C136    BD CA FE    LDA $FECA,X    8
C139    8D 6D 02    STA $026D
C13C    0D 00 1C    ORA $1C00
C13F    8D 00 1C    STA $1C00      turn LED on
C142    68          PLA
C143    AA          TAX            get x register back
C144    58          CLI
C145    60          RTS

******************************   interpret command from
                                   computer
C146    A9 00       LDA #$00
C148    8D F9 02    STA $02F9
C14B    AD 8E 02    LDA $028E      last drive number
```

```
C14E    85 7F       STA $7F        drive number
C150    20 BC E6    JSR $E6BC      prepare 'ok' message
C153    A5 84       LDA $84        secondary address
C155    10 09       BPL $C160
C157    29 0F       AND #$0F
C159    C9 0F       CMP #$0F       15, command channel
C15B    F0 03       BEQ $C160      yes
C15D    4C B4 D7    JMP $D7B4      to OPEN command
C160    20 B3 C2    JSR $C2B3      determine line length and
                                   erase flags
C163    B1 A3       LDA ($A3),Y    get first character
C165    8D 75 02    STA $0275      and store
C168    A2 0B       LDX #$0B       11
C16A    BD 89 FE    LDA $FE89,X    commands
C16D    CD 75 02    CMP $0275      compare to first character
C170    F0 08       BEQ $C17A      found?
C172    CA          DEX
C173    10 F5       BPL $C16A
C175    A9 31       LDA #$31       not found
C177    4C C8 C1    JMP $C1C8      31, 'syntax error'
C17A    8E 2A 02    STX $022A      number of command words
C17D    E0 09       CPX #$09
C17F    90 03       BCC $C184      command number < 9?
C181    20 EE C1    JSR $C1EE      test for 'R', 'S', and 'N'
C184    AE 2A 02    LDX $022A      command number
C187    BD 95 FE    LDA $FE95,X    jump address lo
C18A    85 6F       STA $6F
C18C    BD A1 FE    LDA $FEA1,X    jump address hi
C18F    85 70       STA $70
C191    6C 6F 00    JMP ($006F)    jump to command

******************************     prepare error message after
                                   executing command
C194    A9 00       LDA #$00
C196    8D F9 02    STA $02F9
C199    AD 6C 02    LDA $026C      flag set?
C19C    D0 2A       BNE $C1C8      yes, then set error message
C19E    A0 00       LDY #$00
C1A0    98          TYA            error number 0
C1A1    84 80       STY $80        track number 0
C1A3    84 81       STY $81        sector number 0
C1A5    84 A3       STY $A3
C1A7    20 C7 E6    JSR $E6C7      prepare 'ok' message
C1AA    20 23 C1    JSR $C123      erase error flag
C1AD    A5 7F       LDA $7F        drive number
C1AF    8D 8E 02    STA $028E      save as last drive number
C1B2    AA          TAX
C1B3    A9 00       LDA #$00
C1B5    95 FF       STA $FF,X
C1B7    20 BD C1    JSR $C1BD      erase input buffer
C1BA    4C DA D4    JMO $D4DA      close internal channel

******************************     erase input buffer
C1BD    A0 28       LDY #$28       erase 41 characters
C1BF    A9 00       LDA #$00
```

```
C1C1    99 00 02    STA $0200,Y    $200 to $228
C1C4    88          DEY
C1C5    10 FA       BPL $C1C1
C1C7    60          RTS
******************************     give error message
                                   (track & sector)
C1C8    A0 00       LDY #$00
C1CA    84 80       STY $80        track = 0
C1CC    84 81       STY $81        sector = 0
C1CE    4C 45 E6    JMP $E645      error number acc, generate
                                   error message

******************************     check input line
C1D1    A2 00       LDX #$00
C1D3    8E 7A 02    STX $027A      pointer to drive number
C1D6    A9 3A       LDA #$3A       ':'
C1D8    20 68 C2    JSR $C268      test line to ':' or to end
C1DB    F0 05       BEQ $C1E2      no colon found?
C1DD    88          DEY
C1DE    88          DEY
C1DF    8C 7A 02    STY $027A      point to drive number
                                   (before colon)
C1E2    4C 68 C3    JMP $C368      get drive # and turn LED on

******************************     check input line
C1E5    A0 00       LDY #$00       pointer to input buffer
C1E7    A2 00       LDX #$00       counter for commas
C1E9    A9 3A       LDA #$3A       ':'
C1EB    4C 68 C2    JMP $C268      test line to colon or to end

******************************     check input line
C1EE    20 E5 C1    JSR $C1E5      test line to ':' or end
C1F1    D0 05       BNE $C1F8      colon found?
C1F3    A9 34       LDA #$34
C1F5    4C C8 C1    JMP $C1C8      34, 'syntax error'
C1F8    88          DEY
C1F9    88          DEY            set pointer to colon
C1FA    8C 7A 02    STY $027A      position of the drive no.
C1FD    8A          TXA            comma before the colon
C1FE    D0 F3       BNE $C1F3      yes, then 'syntax error'
C200    A9 3D       LDA #$3D       '='
C202    20 68 C2    JSR $C268      check input to '='
C205    8A          TXA            comma found?
C206    F0 02       BEQ $C20A      no
C208    A9 40       LDA #$40       bit 6
C20A    09 21       ORA #$21       and set bit 0 and 5
C20C    8D 8B 02    STA $028B      flag for syntax check
C20F    E8          INX
C210    8E 77 02    STX $0277
C213    8E 78 02    STX $0278
C216    AD 8A 02    LDA $028A      wildcard found?
C219    F0 0D       BEQ $C228      no
C21B    A9 80       LDA #$80
C21D    0D 8B 02    ORA $028B      set bit 7
C220    8D 8B 02    STA $028B
```

```
C223    A9 00       LDA #$00
C225    8D 8A 02    STA $028A      reset wildcard flag
C228    98          TYA            '=' found?
C229    F0 29       BEQ $C254      no
C22B    9D 7A 02    STA $027A,X
C22E    AD 77 02    LDA $0277      number of commas before '='
C231    8D 79 02    STA $0279
C234    A9 8D       LDA #$8D       shift CR
C236    20 68 C2    JSR $C268      check line to end
C239    E8          INX            increment comma counter
C23A    8E 78 02    STX $0278      store # of commas
C23D    CA          DEX
C23E    AD 8A 02    LDA $028A      wildcard found?
C24A    F0 02       BEQ $C245      no
C243    A9 08       LDA #$08       set bit 3
C245    EC 77 02    CPX $0277      comma after '='?
C248    F0 02       BEQ $C24C      no
C24A    09 04       ORA #$04       set bit 2
C24C    09 03       ORA #$03       set bits 0 and 1
C24E    4D 8B 02    EOR $028B
C251    8D 8B 02    STA $028B      as flag for syntax check
C254    AD 8B 02    LDA $028B      syntax flag
C257    AE 2A 02    LDX $022A      command number
C25A    3D A5 FE    AND $FEA5,X    combine with check byte
C25D    D0 01       BNE $C260
C25F    60          RTS
C260    8D 6C 02    STA $026C      set error flag
C263    A9 30       LDA #$30
C265    4C C8 C1    JMP $C1C8      30, 'syntax error'

******************************     search characters in input
                                   buffer
C268    8D 75 02    STA $0275      save character
C26B    CC 74 02    CPY $0274      already done?
C26E    B0 2E       BCS $C29E      yes
C270    B1 A3       LDA ($A3),Y    get char from buffer
C272    C8          INY
C273    CD 75 02    CMP $0275      compared with char
C276    F0 28       BEQ $C2A0      found
C278    C9 2A       CMP #$2A       '*'
C27A    F0 04       BEQ $C280
C27C    C9 3F       CMP #$3F       '?'
C27E    D0 03       BNE $C283
C280    EE 8A 02    INC $028A      set wildcard flag
C283    C9 2C       CMP #$2C       ','
C285    D0 E4       BNE $C26B
C287    98          TYA
C288    9D 7B 02    STA $027B,X    note comma position
C28B    AD 8A 02    LDA $028A      wildcard flag
C28E    29 7F       AND #$7F
C290    F0 07       BEQ $C299      no wildcard
C292    A9 80       LDA #$80
C294    95 E7       STA $E7,X      note flag
C296    8D 8A 02    STA $028A      and save as wildcard flag
C299    E8          INX            inc comma counter
```

```
C29A    E0 04       CPX #$04        4 commas already?
C29C    90 CD       BCC $C26B       no, continue
C29E    A0 00       LDY #$00
C2A0    AD 74 02    LDA $0274       set flag for line end
C2A3    9D 7B 02    STA $027B,X
C2A6    AD 8A 02    LDA $028A       wildcard flag
C2A9    29 7F       AND #$7F
C2AB    F0 04       BEQ $C2B1       no wildcard
C2AD    A9 80       LDA #$80
C2AF    95 E7       STA $E7,X       set flag
C2B1    98          TYA
C2B2    60          RTS

******************************      check line length
C2B3    A4 A3       LDY $A3         ptr to command input buffer
C2B5    F0 14       BEQ $C2CB       zero?
C2B7    88          DEY
C2B8    F0 10       BEQ $C2CA       one?
C2BA    B9 00 02    LDA $0200,Y     pointer to input buffer
C2BD    C9 0D       CMP #$0D        'CR'
C2BF    F0 0A       BEQ $C2CB       yes, line end
C2C1    88          DEY
C2C2    B9 00 02    LDA $0200,Y     preceding character
C2C5    C9 0D       CMP #$0D        'CR'
C2C7    F0 02       BEQ $C2CB       yes
C2C9    C8          INY
C2CA    C8          INY             pointer to old value again
C2CB    8C 74 02    STY $0274       same line length
C2CE    C0 2A       CPY #$2A        compare with 42 characters
C2D0    A0 FF       LDY #$FF
C2D2    90 08       BCC $C2DC       smaller, ok
C2D4    8C 2A 02    STY $022A
C2D7    A9 32       LDA #$32
C2D9    4C C8 C1    JMP $C1C8       32, 'syntax error' line too
                                    long

******************************      erase flag for input command
C2DC    A0 00       LDY #$00
C2DE    98          TYA
C2DF    85 A3       STA $A3         pointer to input buffer lo
C2E1    8D 58 02    STA $0258       record length
C2E4    8D 4A 02    STA $024A       file type
C2E7    8D 96 02    STA $0296
C2EA    85 D3       STA $D3
C2EC    8D 79 02    STA $0279       comma counter
C2EF    8D 77 02    STA $0277           "
C2F2    8D 78 02    STA $0278           "
C2F5    8D 8A 02    STA $028A       wildcard flag
C2F8    8D 6C 02    STA $026C       error flag
C2FB    A2 05       LDX #$05
C2FD    9D 79 02    STA $0279,X     flags for line analysis
C300    95 D7       STA $D7,X       directory sectors
C302    95 DC       STA $DC,X       buffer pointer
C304    95 E1       STA $E1,X       drive number
C306    95 E6       STA $E6,X       wildcard flag
```

```
C308    9D 7F 02    STA $027F,X    track number
C30B    9D 84 02    STA $0284,X    sector number
C30E    CA          DEX
C30F    D0 EC       BNE $C2FD
C311    60          RTS

*******************************    preserve drive number
C312    AD 78 02    LDA $0278      number of commas
C315    8D 77 02    STA $0277      save
C318    A9 01       LDA #$01
C31A    8D 78 02    STA $0278      number of drive numbers
C31D    8D 79 02    STA $0279
C320    AC 8E 02    LDY $028E      last drive number
C323    A2 00       LDX #$00
C325    86 D3       STX $D3
C327    BD 7A 02    LDA $027A,X    position of the colon
C32A    20 3C C3    JSR $C33C      get drive no. before colon
C32D    A6 D3       LDX $D3
C32F    9D 7A 02    STA $027A      save exact position
C332    98          TYA
C333    95 E2       STA $E2,X      drive number in table
C335    E8          INX
C336    EC 78 02    CPX $0278      got all drive numbers?
C339    90 EA       BCC $C325      no, continue
C33B    60          RTS

*******************************    search for drive number
C33C    AA          TAX            note position
C33D    A0 00       LDY #$00
C33F    A9 3A       LDA #$3A       ':'
C341    DD 01 02    CMP $0201,X    colon behind it?
C344    F0 0C       BEQ $C352      yes
C346    DD 00 02    CMP $0200,X    colon here?
C349    D0 16       BNE $C361      no
C34B    E8          INX
C34C    98          TYA
C34D    29 01       AND #$01       drive number
C34F    A8          TAY
C350    8A          TXA
C351    60          RTS

C352    BD 00 02    LDA $0200,X    get drive number
C355    E8          INX
C356    E8          INX
C357    C9 30       CMP #$30       '0'?
C359    F0 F2       BEQ $C34D      yes
C35B    C9 31       CMP #$31       '1'?
C35D    F0 EE       BEQ $C34D      yes
C35F    D0 EB       BNE $C34C      no, use last drive number
C361    98          TYA            last drive number
C362    09 80       ORA #$80       set bit 7, uncertain drive #
C364    29 81       AND #$81       erase remaining bits
C366    D0 E7       BNE $C34F

*******************************    get drive number
```

```
C368    A9 00       LDA #$00
C36A    8D 8B 02    STA $028B       erase syntax flag
C36D    AC 7A 02    LDY $027A       position in command line
C370    B1 A3       LDA ($A3),Y     get chars from command buffer
C372    20 BD C3    JSR $C3BD       get drive number
C375    10 11       BPL $C388       certain number?
C377    C8          INY             increment pointer
C378    CC 74 02    CPY $0274       line end?
C37B    B0 06       BCS $C383       yes
C37D    AC 74 02    LDY $0274
C380    88          DEY
C381    D0 ED       BNE $C370       search line for drive no.
C383    CE 8B 02    DEC $028B
C386    A9 00       LDA #$00
C388    29 01       AND #$01
C38A    85 7F       STA $7F         drive number
C38C    4C 00 C1    JMP $C100       turn LED on

******************************      reverse drive number
C38F    A5 7F       LDA $7F         drive number
C391    49 01       EOR #$01        switch bit 0
C393    29 01       AND #$01
C395    85 7F       STA $7F
C397    60          RTS

******************************      establish file type
C398    A0 00       LDY #$00
C39A    AD 77 02    LDA $0277       '=' found?
C39D    CD 78 02    CMP $0278
C3A0    F0 16       BEQ $C3B8       no
C3A2    CE 78 02    DEC $0278       get pointer
C3A5    AC 78 02    LDY $0278
C3A8    B9 7A 02    LDA $027A,Y     set pointer to character
                                    behind '='
C3AB    A8          TAY
C3AC    B1 A3       LDA ($A3),Y     pointer to buffer
C3AE    A0 04       LDY #$04        compare with marker for
                                    file type
C3B0    D9 BB FE    CMP $FEBB,Y     'S', 'P', 'U', 'R'
C3B3    F0 03       BEQ $C3B8       agreement
C3B5    88          DEY
C3B6    D0 F8       BNE $C3B0
C3B8    98          TYA
C3B9    8D 96 02    STA $0296       note file type (1-4)
C3BC    60          RTS

******************************      check drive number
C3BD    C9 30       CMP #$30        '0'
C3BF    F0 06       BEQ $C3C7
C3C1    C9 31       CMP #$31        '1'
C3C3    F0 02       BEQ $C3C7
C3C5    09 80       ORA #$80        no zero or one, then set bit 7
C3C7    29 81       AND #$81
C3C9    60          RTS
```

```
******************************   verify drive number
C3CA   A9 00      LDA #$00
C3CC   85 6F      STA $6F
C3CE   8D 8D 02   STA $028D
C3D1   48         PHA
C3D2   AE 78 02   LDX $0278      number of drive numbers
C3D5   68         PLA
C3D6   05 6F      ORA $6F
C3D8   48         PHA
C3D9   A9 01      LDA #$01
C3DB   85 6F      STA $6F
C3DD   CA         DEX
C3DE   30 0F      BMI $C3EF
C3E0   B5 E2      LDA $E2,X
C3E2   10 04      BPL $C3E8
C3E4   06 6F      ASL $6F
C3E6   06 6F      ASL $6F
C3E8   4A         LSR A
C3E9   90 EA      BCC $C3D5
C3EB   06 6F      ASL $6F
C3ED   D0 E6      BNE $C3D5
C3EF   68         PLA
C3F0   AA         TAX
C3F1   BD 3F C4   LDA $C43F,X    get syntax flag
C3F4   48         PHA
C3F5   29 03      AND #$03
C3F7   8D 8C 02   STA $028C
C3FA   68         PLA
C3FB   0A         ASL A
C3FC   10 3E      BPL $C43C
C3FE   A5 E2      LDA $E2
C400   29 01      AND #$01       isolate drive number
C402   85 7F      STA $7F
C404   AD 8C 02   LDA $028C
C407   F0 28      BEQ $C434
C409   20 3D C6   JSR $C63D      initialze drive
C40C   F0 12      BEQ $C420      error?
C40E   20 8F C3   JSR $C38F      switch to other drive
C411   A9 00      LDA #$00
C413   8D 8C 02   STA $028C
C416   20 3D C6   JSR $C63D      initialize drive
C419   F0 1E      BEQ $C439      no error?
C41B   A9 74      LDA #$74
C41D   20 C8 C1   JSR $C1C8      74, 'drive not ready'
C420   20 8F C3   JSR $C38F

C423   20 3D C6   JSR $C63D      initialize drive
C426   08         PHP
C427   20 8F C3   JSR $C38F      switch to other drive
C42A   28         PLP
C42B   F0 0C      BEQ $C439      no error?
C42D   A9 00      LDA #$00
C42F   8D 8C 02   STA $028C      number of drives
C432   F0 05      BEQ $C439
C434   20 3D C6   JSR $C63D      initialize drive
```

```
C437    D0 E2       BNE $C41B     error?
C439    4C 00 C1    JMP $C100     Turn LED on
C43C    2A          ROL A         drive # from carry after bit 0
C43D    4C 00 C4    JMP $C400

******************************    flags for drive check
C440    00 80 41 01 01 01 01 81
C448    81 81 81 42 42 42 42

******************************    search for file in directory
C44F    20 CA C3    JSR $C3CA     initialize drive
C452    A9 00       LDA #$00
C454    8D 92 02    STA $0292     pointer
C457    20 AC C5    JSR $C5AC     read first directory block
C45A    D0 19       BNE $C475     entry present?
C45C    CE 8C 02    DEC $028C     drive number clear?
C45F    10 01       BPL $C462     no
C461    60          RTS

C462    A9 01       LDA #$01
C464    8D 8D 02    STA $028D
C467    20 8F C3    JSR $C38F     change drive
C46A    20 00 C1    JSR $C100     Turn LED on
C46D    4C 52 C4    JMP $C452     and search

C470    20 17 C6    JSR $C617     search next file in directory
C473    F0 10       BEQ $C485     not found?
C475    20 D8 C4    JSR $C4D8     verify directory entry
C478    AD 8F 02    LDA $028F
C47B    F0 01       BEQ $C47E     more files?
C47D    60          RTS

C47E    AD 53 02    LDA $0253
C481    30 ED       BMI $C470     file not found?
C483    10 F0       BPL $C475     yes
C485    AD 8F 02    LDA $028F
C488    F0 D2       BEQ $C45C
C48A    60          RTS

C48B    20 04 C6    JSR $C604     search next directory block
C48E    F0 1A       BEQ $C4AA     not found?
C490    D0 28       BNE $C4BA

C492    A9 01       LDA #$01
C494    8D 8D 02    STA $028D
C497    20 8F C3    JSR $C38F     change drive
C49A    20 00 C1    JSR $C100     turn LED on
C49D    A9 00       LDA #$00
C49F    8D 92 02    STA $0292
C4A2    20 AC C5    JSR $C5AC     read directory block
C4A5    D0 13       BNE $C4BA     found?
C4A7    8D 8F 02    STA $028F
C4AA    AD 8F 02    LDA $028F
C4AD    D0 28       BNE $C4D7
C4AF    CE 8C 02    DEC $028C
```

```
C4B2   10 DE       BPL $C492
C4B4   60          RTS

C4B5   20 17 C6    JSR $C617     next entry in directory
C4B8   F0 F0       BEQ $C4AA     not found?
C4BA   20 D8 C4    JSR $C4D8     check entry
C4BD   AE 53 02    LDX $0253
C4C0   10 07       BPL $C4C9     file found?
C4C2   AD 8F 02    LDA $028F
C4C5   F0 EE       BEQ $C4B5     yes
C4C7   D0 0E       BNE $C4D7     no, then done

C4C9   AD 96 02    LDA $0296
C4CC   F0 09       BEQ $C467
C4CE   B5 E7       LDA $E7,X     file type
C4D0   29 07       AND #$07
C4D2   CD 96 02    CMP $0296     same as desired file type?
C4D5   D0 DE       BNE $C4B5     no
C4D7   60          RTS

C4D8   A2 FF       LDX #$FF
C4DA   8E 53 02    STX $0253     flag for data found
C4DD   E8          INX
C4DE   8E 8A 02    STX $028A
C4E1   20 89 C5    JSR $C589     set pointer to data
C4E4   F0 06       BEQ $C4EC
C4E6   60          RTS

C4E7   20 94 C5    JSR $C594     pointer to next file
C4EA   D0 FA       BNE $C4E6     end, then done
C4EC   A5 7F       LDA $7F       drive number
C4EE   55 E2       EOR $E2,X
C4F0   4A          LSR A
C4F1   90 0B       BCC $C4FE
C4F3   29 40       AND #$40
C4F5   F0 F0       BEQ $C4E7
C4F7   A9 02       LDA #$02
C4F9   CD 8C 02    CMP $028C     search both drives?
C4FC   F0 E9       BEQ $C4E7     yes
C4FE   BD 7A 02    LDA $027A,X
C501   AA          TAX
C502   20 A6 C6    JSR $C6A6     get length of filename
C505   A0 03       LDY #$03
C507   4C 1D C5    JMP $C51D

C50A   BD 00 02    LDA $0200,X   get chars out of command line
C50D   D1 94       CMP ($94),Y   same character in directory?
C50F   F0 0A       BEQ $C51B     yes
C511   C9 3F       CMP #$3F      '?'
C513   D0 D2       BNE $C4E7     no
C515   B1 94       LDA ($94),Y
C517   C9 A0       CMP #$A0      shift blank, end of name?
C519   F0 CC       BEQ $C4E7     yes
C51B   E8          INX           increment pointer
C51C   C8          INY
```

```
C51D    EC 76 02   CPX $0276      end of the name in the command?
C520    B0 09      BCS $C52B      yes
C522    BD 00 02   LDA $0200,X    next character
C525    C9 2A      CMP #$2A       '*'
C527    F0 0C      BEQ $C535      yes, file found
C529    DO DF      BNE $C50A      continue search

C52B    C0 13      CPY #$13       19
C52D    B0 06      BCS $C535      reached end of name
C52F    B1 94      LDA ($94),Y
C531    C9 A0      CMP #$A0       shift blank, end of name
C533    D0 B2      BNE $C4E7      not found
C535    AE 79 02   LDX $0279
C538    8E 53 02   STX $0253
C53B    B5 E7      LDA $E7,X
C53D    29 80      AND #$80
C53F    8D 8A 02   STA $028A
C542    AD 94 02   LDA $0294
C545    95 DD      STA $DD,X
C547    A5 81      LDA $81        sector number of the directory
C549    95 D8      STA $D8,X      enter in table
C54B    A0 00      LDY #$00
C54D    B1 94      LDA ($94),Y    file type
C54F    C8         INY
C550    48         PHA
C551    29 40      AND #$40       isolate scratch-protect bit
C553    85 6F      STA $6F        (6) and save
C555    68         PLA
C556    29 DF      AND #$DF       erase bit 7
C558    30 02      BMI $C55C
C55A    09 20      ORA #$20       set bit 5
C55C    29 27      AND #$27       erase bits 3 and 4
C55E    05 6F      ORA $6F        get bit 6 again
C560    85 6F      STA $6F
C562    A9 80      LDA #$80
C564    35 E7      AND $E7,X      isolate flag for wildcard
C566    05 6F      ORA $6F,X
C568    95 E7      STA $E7,X      write in table
C56A    B5 E2      LDA $E2,X
C56C    29 80      AND #$80
C56E    05 7F      ORA $7F        drive number
C570    95 E2      STA $E2,X
C572    B1 94      LDA ($94),Y
C574    9D 80 02   STA $0280,X    first track of file
C577    C8         INY
C578    B1 94      LDA ($94),Y
C57A    9D 85 02   STA $0285,X    get sector from directory
C57D    AD 58 02   LDA $0258      record length
C580    D0 07      BNE $C589
C582    A0 15      LDY #$15
C584    B1 94      LDA ($94),Y    record length
C586    8D 58 02   STA $0258      get from directory
C589    A9 FF      LDA #$FF
C58B    8D 8F 02   STA $028F
C58E    AD 78 02   LDA $0278
```

```
C591   8D 79 02   STA $0279
C594   CE 79 02   DEC $0279
C597   10 01      BPL $C59A
C599   60         RTS

C59A   AE 79 02   LDX $0279
C59D   B5 E7      LDA $E7,X      wildcard flag set?
C59F   30 05      BMI $C5A6      yes
C5A1   BD 80 02   LDA $0280,X    track number already set
C5A4   D0 EE      BNE $C594      yes
C5A6   A9 00      LDA #$00
C5A8   8D 8F 02   STA $028F
C5AB   60         RTS

C5AC   A0 00      LDY #$00
C5AE   8C 91 02   STY $0291
C5B1   88         DEY
C5B2   8C 53 02   STY $0253
C5B5   AD 85 FE   LDA $FE85      18, directory track
C5B8   85 80      STA $80
C5BA   A9 01      LDA #$01
C5BC   85 81      STA $81        sector 1
C4BE   8D 93 02   STA $0293
C5C1   20 75 D4   JSR $D475      read sector
C5C4   AD 93 02   LDA $0293
C5C7   D0 01      BNE $C5CA
C5C9   60         RTS

C5CA   A9 07      LDA #$07
C5CC   8D 95 02   STA $0295      number of directory entries (-1)
C5CF   A9 00      LDA #$00
C5D1   20 F6 D4   JSR $D4F6      get pointer from buffer
C5D4   8D 93 02   STA $0293      save as track number
C5D7   20 E8 D4   JSR $D4E8      set buffer pointer
C5DA   CE 95 02   DEC $0295      decrement counter
C5DD   A0 00      LDY #$00
C5DF   B1 94      LDA ($94),Y    first byte from directory
C5E1   D0 18      BNE $C5FB
C5E3   AD 91 02   LDA $0291
C5E6   D0 2F      BNE $C617
C5E8   20 3B DE   JSR $DE3B      get track and sector number
C5EB   A5 81      LDA $81
C5ED   8D 91 02   STA $0291      sector number
C5F0   A5 94      LDA $94
C5F2   AE 92 02   LDX $0292
C5F5   8D 92 02   STA $0292      buffer pointer
C5F8   F0 1D      BEQ $C617
C5FA   60         RTS

C5FB   A2 01      LDX #$01
C5FD   EC 92 02   CPX $0292      buffer pointer to one?
C600   D0 2D      BNE $C62F
C602   F0 13      BEQ $C617

C604   AD 85 FE   LDA $FE85      18, track number of BAM
```

```
C607    85 80       STA $80        track number
C609    AD 90 02    LDA $0290
C60C    85 81       STA $81        sector number
C60E    20 75 D4    JSR $D475      read block
C611    AD 94 02    LDA $0294
C614    20 C8 D4    JSR $D4C8      set buffer pointer
C617    AD FF       LDA #$FF
C619    8D 53 02    STA $0253      erase-file found flag
C61C    AD 95 02    LDA $0295
C61F    30 08       BMI $C629      all directory entries checked?
C621    A9 20       LDA #$20
C623    20 C6 D1    JSR $D1C6      inc buffer ptr by 32, next entry
C626    4C D7 C5    JMP $C567      and continue

C629    20 4D D4    JSR $D44D      set buffer pointer
C62C    4C C4 C5    JMP $C5C4      read next block

C62F    A5 94       LDA $94
C631    8D 94 02    STA $0294
C634    20 3B DE    JSR $DE3B      get track & sector no. from buffer
C637    A5 81       LDA $81
C639    8D 90 02    STA $0290      save sector number
C63C    60          RTS

******************************     test and initialize drive
C63D    A5 68       LDA $68
C63F    D0 28       BNE $C669
C641    A6 7F       LDX $7F        drive number
C643    56 1C       LSR $1C,X      disk changed?
C645    90 22       BCC $C669      no, then done
C647    A9 FF       LDA $FF
C649    8D 98 02    STA $0298      set error flag
C64C    20 0E D0    JSR $D00E      read directory track
C64F    A0 FF       LDY #$FF
C651    C9 02       CMP #$02       20, 'read error'?
C653    F0 0A       BEQ $C65F      yes
C655    C9 03       CMP #$03       21, 'read error'?
C657    F0 06       BEQ $C65F      yes
C659    C9 0F       CMP #$0F       74, 'drive not ready'?
C65B    F0 02       BEQ $C65F      yes
C65D    A0 00       LDY #$00
C65F    A6 7F       LDX $7F        drive number
C661    98          TYA
C662    95 FF       STA $FF,X      save error flag
C664    D0 03       BNE $C669      error?
C666    20 42 D0    JSR $D042      load BAM
C669    A6 7F       LDX $7F        drive number
C66B    B5 FF       LDA $FF,X      transmit error code
C66D    60          RTS

******************************     name of file in directory buffer
C66E    48          PHA
C66F    20 A6 C6    JSR $C6A6      get end of the name
C672    20 88 C6    JSR $C688      write filename in buffer
C675    68          PLA
```

```
C676    38          SEC
C677    ED 4B 02    SBC $024B       compare len with max length
C67A    AA          TAX
C67B    F0 0A       BEQ $C687
C67D    90 08       BCC $C687
C67F    A9 A0       LDA #$A0        pad with 'Shift blank'
C681    91 94       STA ($94),Y
C683    C8          INY
C684    CA          DEX
C685    D0 FA       BNE $C681
C687    60          RTS

*******************************
C688    98          TYA             buffer number
C689    0A          ASL A
C68A    A8          TAY             times 2 as pointer
C68B    B9 99 00    LDA $0099,Y
C68E    85 94       STA $94
C690    B9 9A 00    LDA $009A       buffer pointer after $94/$95
C693    85 95       STA $95
C695    A0 00       LDY #$00
C697    BD 00 02    LDA $0200,X     transmit characters in buffer
C69A    91 94       STA ($94),Y
C69C    C8          INY
C69D    F0 06       BEQ $C6A5       buffer already full?
C69F    E8          INX
C6A0    EC 76 02    CPX $0276
C6A3    90 F2       BCC $C697
C6A5    60          RTS

*******************************     search for end of name in command
C6A6    A9 00       LDA #$00
C6A8    8D 4B 02    STA $024B
C6AB    8A          TXA
C6AC    48          PHA
C6AD    BD 00 02    LDA $0200,X     get characters out of buffer
C6B0    C9 2C       CMP #$2C        ','
C6B2    F0 14       BEQ $C6C8
C6B4    C9 3D       CMP #$3D        '='
C6B6    F0 10       BEQ $C6C8
C6B8    EE 4B 02    INC $024B       increment length of name
C6BB    E8          INX
C6BC    A9 0F       LDA #$0F        15
C6BE    CD 4B 02    CMP $024B
C6C1    90 05       BCC $C6C8       greater?
C6C3    EC 74 02    CPX $0274       end of input line?
C6C6    90 E5       BCC $C6AD
C6C8    8E 76 02    STX $0276
C6CB    68          PLA
C6CC    AA          TAX             pointer to end of name
C6CD    60          RTS

*******************************
C6CE    A5 83       LDA $83
C6D0    48          PHA             secondary address and channel no.
```

```
C6D1    A5 82       LDA $82
C6D3    48          PHA
C6D4    20 DE C6    JSR $C6DE       create file entry for directory
C6D7    68          PLA
C6D8    85 82       STA $82
C6DA    68          PLA             get data back
C6DB    85 83       STA $83
C6DD    60          RTS

*******************************
C6DE    A9 11       LDA #$11        17
C6E0    85 83       STA $83         secondary address
C6E2    20 EB D0    JSR $D0EB       open channel to read
C6E5    20 E8 D4    JSR $D4E8       set buffer pointer
C6E8    AD 53 02    LDA $0253
C6EB    10 0A       BPL $C6F7       not yet last entry?
C6ED    AD 8D 02    LDA $028D
C6F0    D0 0A       BNE $C6FC
C6F2    20 06 C8    JSR $C806       write 'blocks free.'
C6F5    18          CLC
C6F6    60          RTS
C6F7    AD 8D 02    LDA $028D
C6FA    F0 1F       BEQ $C71B
C6FC    CE 8D 02    DEC $028D
C6FF    D0 0D       BNE $C70E
C701    CE 8D 02    DEC $028D
C704    20 8F C3    JSR $C38F       change drive
C707    20 06 C8    JSR $C806       write 'blocks free.'
C70A    38          SEC
C70B    4C 8F C3    JMP $C38F       change drive

C70E    A9 00       LDA #$00
C710    8D 73 02    STA $0273       drive no. for header, hi-byte
C713    8D 8D 02    STA $028D
C716    20 B7 C7    JSR $C7B7       write header
C719    38          SEC
C71A    60          RTS

C71B    A2 18       LDX #$18
C71D    A0 1D       LDY #$1D
C71F    B1 94       LDA ($94),Y     number of blocks hi
C721    8D 73 02    STA $0273       in buffer
C724    F0 02       BEQ $C728       zero?
C726    A2 16       LDX #$16
C728    88          DEY
C729    B1 94       LDA ($94),Y     number of blocks lo
C72B    8D 72 02    STA $0272       in buffer
C72E    E0 16       CPX #$16
C730    F0 0A       BEQ $C73C
C732    C9 0A       CMP #$0A        10
C734    90 06       BCC $C73C
C736    CA          DEX
C737    C9 64       CMP #$64        100
C739    90 01       BCC $C73C
C73B    CA          DEX
```

```
C73C   20 AC C7   JSR $C7AC     erase buffer
C73F   B1 94      LDA ($94),Y   file type
C741   48         PHA
C742   0A         ASL A         bit 7 in carry
C743   10 05      BPL $C74A     bit 6 not set?
C745   A9 3C      LDA #$3C      '<' for protected file
C747   9D B2 02   STA $02B2,X   write behind file type
C74A   68         PLA
C74B   29 0F      AND #$0F      isolate bits 0-3
C74D   A8         TAY           as file type marker
C74E   B9 C5 FE   LDA $FEC5,Y   3rd letter of the file type
C751   9D B1 02   STA $02B1,X   in buffer
C754   CA         DEX
C755   B9 C0 FE   LDA $FEC0,Y   2nd letter of file type
C758   9D B1 02   STA $02B1,X   in buffer
C75B   CA         DEX
C75C   B9 BB FE   LDA $FEBB,Y   1st letter of file type
C75F   9D B1 02   STA $02B1,X   in buffer
C762   CA         DEX
C763   CA         DEX
C764   B0 05      BCS $C76B     file not closed?
C766   A9 2A      LDA #$2A      '*'
C768   9D B2 02   STA $02B2,X   before file type in buffer
C76B   A9 A0      LDA #$A0      pad with 'shift blank'
676D   9D B1 02   STA $02B1,X   in buffer
C770   CA         DEX
C771   A0 12      LDY #$12
C773   B1 94      LDA ($94),Y   filenames
C775   9D B1 02   STA $02B1,X   write in buffer
C778   CA         DEX
C779   88         DEY
C77A   C0 03      CPY #$03
C77C   B0 F5      BCS $C773
C77E   A9 22      LDA #$22      '='
C780   9D B1 02   STA $02B1,X   write before file type
C783   E8         INX
C784   E0 20      CPX #$20
C786   B0 0B      BCS $C793
C788   BD B1 02   LDA $02B1,X   character from buffer
C78B   C9 22      CMP #$22      '='?
C78D   F0 04      BEQ $C793
C7BF   C9 A0      CMP #$A0      'shift blank' at end of name
C791   D0 F0      BNE $C783
C793   A9 22      LDA #$22      fill through '='
C795   9D B1 02   STA $02B1,X
C798   E8         INX
C799   E0 20      CPX #$20
C89B   B0 0A      BCS $C7A7
C79D   A9 7F      LDA #$7F      bit 7
C79F   3D B1 02   AND $02B1,X
C7A2   9D B1 02   STA $02B1,X   erase in the remaining chars
C7A5   10 F1      BPL $C798
C7A7   20 B5 C4   JSR $C4B5     search for next directory entry
C7AA   38         SEC
C7AB   60         RTS
```

```
******************************     erase directory buffer
C7AC   A0 1B      LDY #$1B
C7AE   A9 20      LDA #$20       ' ' blank
C7B0   99 B0 02   STA $02B0,Y    write in buffer
C7B3   88         DEY
C7B4   D0 FA      BNE $C7B0
C7B6   60         RTS

******************************     create header with disk name
C7B7   20 19 F1   JSR $F119      initialize if needed
C7BA   20 DF F0   JSR $F0DF      read disk name
C7BD   20 AC C7   JSR $C7AC      erase buffer
C7C0   A9 FF      LDA #$FF
C7C2   85 6F      STA $6F
C7C4   A6 7F      LDX $7F        drive number
C7C6   8E 72 02   STX $0272      as block no. lo in buffer
C7C9   A9 00      LDA #$00
C7CB   8D 73 02   STA $0273      block number lo
C7CE   A6 F9      LDX $F9        buffer number
C7D0   BD E0 FE   LDA $FEE0,X    hi-byte of the buffer address
C7D3   85 95      STA $95
C7D5   AD 88 FE   LDA $FE88      $90, position of disk name
C7D8   85 94      STA $94        save
C7DA   A0 16      LDY #$16
C7DC   B1 94      LDA ($94),Y    pad buffer with 'shift blank'
C7DE   C9 A0      CMP #$A0
C7E0   D0 0B      BNE $C7ED
C7E2   A9 31      LDA #$31       '1'
C7E4   2C         .BYTE $2C
C7E5   B1 94      LDA ($94),Y    character from buffer
C7E7   C9 A0      CMP #$A0       compare with 'shift blank'
C7E9   D0 02      BNE $C7ED
C7EB   A9 20      LDA #$20       ' ' blank
C7ED   99 B3 02   STA $02B3      in buffer
C7F0   88         DEY
C7F1   10 F2      BPL $C7E5
C7F3   A9 12      LDA #$12       'RVS ON'
C7F5   8D B1 02   STA $02B1      in buffer
C7F8   A9 22      LDA #$22       '"'
C7FA   8D B2 02   STA $02B2      write before
C7FD   8D C3 02   STA $02C3      and after disk name
C800   A9 20      LDA #$20       ' ' blank
C802   8D C4 02   STA $02C4      behind it
C805   60         RTS

******************************     create last line
C806   20 AC C7   JSR $C7AC      erase buffer
C809   A0 0B      LDY #$0B       12 characters
C80B   B9 17 C8   LDA $C817,Y    'blocks free.'
C80E   99 B1 02   STA $02B1,Y    write in buffer
CB11   88         DEY
C812   10 F7      BPL $C80B
C814   4C 4D EF   JMP $EF4D      number of free blocks in front
```

```
*******************************
C817    42 4C 4F 43 4B 53 20 46   'blocks f'
C81F    52 45 45 2E               'ree.'

*******************************   S command   'scratch'
C823    20 98 C3    JSR $C398     ascertain file type
C826    20 20 C3    JSR $C320     get drive number
C829    20 CA C3    JSR $C3CA     initialize drive if needed
C82C    A9 00       LDA #$00
C82E    85 86       STA $86       counter for erased files
C830    20 9D C4    JSR $C49D     search for file in directory
C833    30 3D       BMI $C872     not found?
C835    20 B7 DD    JSR $DDB7     is file open
C838    90 33       BCC $C86D     yes
C83A    A0 00       LDY #$00
C83C    B1 94       LDA ($94),Y   file type
C83E    29 40       AND #$40      scratch protect
C840    D0 2B       BNE $C86D     yes
C842    20 B6 C8    JSR $C8B6     erase file and note in directory
C845    A0 13       LDY #$13
C847    B1 94       LDA ($94),Y   track no. of the first side-sector
C849    F0 0A       BEQ $C855     none present?
C84B    85 80       STA $80       note track number
C84D    C8          INY
C84E    B1 94       LDA ($94),Y   and sector number
C850    85 81       STA $81
C852    20 7D C8    JSR $C87D     erase side-sector
C855    AE 53 02    LDX $0253     file number
C858    A9 20       LDA #$20
C85A    35 E7       AND $E7,X     bit 5 set?
C85C    D0 0D       BNE $C86B     yes, file not closed
C85E    BD 80 02    LDA $0280,X   get track
C861    85 80       STA $80
C863    BD 85 02    LDA $0285,X   and sector
C866    85 81       STA $81
C868    20 7D C8    JSR $C87D     erase file
C86B    E6 86       INC $86       increment number of erased files
C86D    20 8B C4    JSR $C48B     search for next file
C870    10 C3       BPL $C835     if present, erase
C872    A5 86       LDA $86       number of erased files
C874    85 80       STA $80       save as 'track'
C876    A9 01       LDA #$01      1 as disk status
C878    A0 00       LDY #$00      0 as 'sector'
C87A    4C A3 C1    JMP $C1A3     message 'files scratched'

*******************************   erase file
C87D    20 5F EF    JSR $EF5F     free block in BAM
C880    20 75 D4    JSR $D475
C883    20 19 F1    JSR $F119     get buffer number in BAM
C886    B5 A7       LDA $A7,X
C888    C9 FF       CMP #$FF
C88A    F0 08       BEQ $C894
C88C    AD F9 02    LDA $02F9
C88F    09 40       ORA #$40
C891    8D F9 02    STA $02F9
```

```
C894    A9 00       LDA #$00
C896    20 C8 D4    JSR $D4C8      buffer pointer to zero
C899    20 56 D1    JSR $D156      get track
C89C    85 80       STA $80
C89E    20 56 D1    JSR $D156      get sector
C8A1    85 81       STA $81
C8A3    A5 80       LDA $80        track number
C8A5    D0 06       BNE $C8AD      not equal to zero
C8A7    20 F4 EE    JSR $EEF4      write BAM
C8AA    4C 27 D2    JMP $D227      close channel

C8AD    20 5F EF    JSR $EF5F      free block in BAM
C8B0    20 4D D4    JSR $D44D      read next block
C8B3    4C 94 C8    JMP $C894      and continue

******************************     erase directory entry
C8B6    A0 00       LDY #$00
C8B8    98          TYA
C8B9    91 94       STA ($94),Y    set file type to zero
C8BB    20 5E DE    JSR $DE5E      write block
C8BE    4C 99 D5    JMP $D599      and check

******************************     D-command  'backup'
C8C1    A9 31       LDA #$31
C8C3    4C C8 C1    JMP $C1C8      31, 'syntax error'

******************************     format diskette
C8C6    A9 4C       LDA #$4C       JMP-command
C8C8    8D 00 06    STA $0600
C8CB    A9 C7       LDA #$C7
C8CD    8D 01 06    STA $0601      JMP $FAC7 in $600 to $602
C8D0    A9 FA       LDA #$FA
C8D2    8D 02 06    STA $0602
C8D5    A9 03       LDA #$03
C8D7    20 D3 D6    JSR $D6D3      set track and sector number
C8DA    A5 7F       LDA $7F        drive number
C8DC    09 E0       ORA #$E0       command code for formatting
C8DE    85 03       STA $03        transmit
C8E0    A5 03       LDA $03
C8E2    30 FC       BMI $C8E0      wait until formatting done
C8E4    C9 02       CMP #$02
C8E6    90 07       BCC $C8EF      smaller than two, then ok
C8E8    A9 03       LDA #$03
C8EA    A2 00       LDX #$00
C8EC    4C 0A E6    JMP $E60A      21, 'read error'
C8EF    60          RTS

******************************     C-command  'copy'
C8F0    A9 E0       LDA #$E0
C8F2    8D 4F 02    STA $024F
C8F5    20 D1 F0    JSR $F0D1
C8F8    20 19 F1    JSR $F119      get buffer number of BAM
C8FB    A9 FF       LDA #$FF
C8FD    95 A7       STA $A7,X
C8FF    A9 0F       LDA #$0F
```

```
C901  8D 56 02   STA $0256
C904  20 E5 C1   JSR $C1E5      check input line
C907  D0 03      BNE $C90C
C909  4C C1 C8   JMP $C8C1      31, 'syntax error'

C90C  20 F8 C1   JSR $C1F8      check input
C90F  20 20 C3   JSR $C320      test drive number
C912  AD 8B 02   LDA $028B      flag for syntax check
C915  29 55      AND #$55
C917  D0 0F      BNE $C928
C919  AE 7A 02   LDX $027A
C91C  BD 00 02   LDA $0200,X    character of the command
C91F  C9 2A      CMP #$2A       '*'
C921  D0 05      BNE $C928
C923  A9 30      LDA #$30
C925  4C C8 C1   JMP $C1C8      30, 'syntax error'

C928  AD 8B 02   LDA $028B      syntax flag
C92B  29 D9      AND #$D9
C92D  D0 F4      BNE $C923      30, 'syntax error'
C92F  4C 52 C9   JMP $C952
C932  A9 00      LDA #$00
C934  8D 58 02   STA $0258
C937  8D 8C 02   STA $028C      number of drives
C93A  8D 80 02   STA $0280      track number in directory
C93D  8D 81 02   STA $0281
C940  A4 E3      LDA $E3
C942  29 01      AND #$01
C944  85 7F      STA $7F        drive number
C946  09 01      ORA #$01
C948  8D 91 02   STA $0291
C94B  AD 7B 02   LDA $027B
C94E  8D 7A 02   STA $027A
C951  60         RTS

C952  20 4F C4   JSR $C44F      search for file in directory
C955  AD 78 02   LDA $0278      number of filenames in command
C958  C9 03      CMP #$03       smaller than three?
C95A  90 45      BCC $C9A1      yes
C95C  A5 E2      LDA $E2        first drive number
C95E  C5 E3      CMP $E3        second drive number
C960  D0 3F      BNE $C9A1      not on same drive?
C962  A5 DD      LDA $DD        directory block of the 1st file
C964  C5 DE      CMP $DE        same dir block as second file?
C966  D0 39      BNE $C9A1      no
C968  A5 D8      LDA $D8        directory sector of first file
C96A  C5 D9      CMP $D9        same dir sector as second file?
C96C  D0 33      BNE $C9A1      no
C96E  20 CC CA   JSR $CACC      is file present
C971  A9 01      LDA #$01
C973  8D 79 02   STA $0279
C976  20 FA C9   JSR $C9FA
C979  20 25 D1   JSR $D125      get data type
C97C  F0 04      BEQ $C982      rel-file?
C97E  C9 02      CMP #$02       prg-file
```

```
C980   D0 05      BNE $C987    no
C982   A9 64      LDA #$64
C984   20 C8 C1   JSR $C1C8    64, 'file type mismatch'
C987   A9 12      LDA #$12     18
C989   85 83      STA $83      secondary address
C98B   AD 3C 02   LDA $023C
C98E   8D 3D 02   STA $023D
C991   A9 FF      LDA #$FF
C993   8D 3C 02   STA $023C
C996   20 2A DA   JSR $DA2A    prepare append
C999   A2 02      LDX #$02
C99B   20 B9 C9   JSR $C9B9    copy file
C99E   4C 94 C1   JMP $C194    done

C9A1   20 A7 C9   JSR $C9A7    copy file
C9A4   4C 94 C1   JMP $C194    done

C9A7   20 E7 CA   JSR $CAE7
C9AA   A4 E2      LDA $E2      drive no. of first file
C9AC   29 01      AND #$01
C9AE   85 7F      STA $7F      drive number
C9B0   20 86 D4   JSR $D486
C9B3   20 E4 D6   JSR $D6E4    enter file in directory
C9B6   AE 77 02   LDX $0277
C9B9   8E 79 02   STX $0279
C9BC   20 FA C9   JSR $C9FA
C9BF   A9 11      LDA #$11     17
C9C1   85 83      STA $83
C9C3   20 EB D0   JSR $D0EB
C9C6   20 25 D1   JSR $D125    get data type
C9C9   D0 03      BNE $C9CE    no rel-file?
C9CB   20 53 CA   JSR $CA53
C9CE   A9 08      LDA #$08
C9D0   85 F8      STA $F8
C9D2   4C D8 C9   JMP $C9D8

C9D5   20 9B CF   JSR $CF9B    write byte in buffer
C9D8   20 35 CA   JSR $CA35    and get byte
C9DB   A9 80      LDA #$80
C9DD   20 A6 DD   JSR $DDA6    test bit 7
C9E0   F0 F3      BEQ $C9D5    not set?
C9E2   20 25 D1   JSR $D125    check file type
C9E5   F0 03      BEQ $C9EA    rel-file?
C9E7   20 9B CF   JSR $CF9B    get data byte in buffer
C9EA   AE 79 02   LDX $0279
C9ED   E8         INX
C9EE   EC 78 02   CPX $0278
C9F1   90 C6      BCC $C9B9
C9F3   A9 12      LDA #$12     18
C9F5   85 83      STA $83
C9F7   4C 02 DB   JMP $DB02    close channel

C9FA   AE 79 02   LDX $0279
C9FD   B5 E2      LDA $E2,X    drive number
C9FF   29 01      AND #$01
```

```
CA01   85 7F      STA $7F       save
CA03   AD 85 FE   LDA $FE85     18, directory track
CA06   85 80      STA $80       save
CA08   B5 D8      LDA $D8,X     directory sector
CA0A   85 81      STA $81
CA0C   20 75 D4   JSR $D475     read block
CA0F   AE 79 02   LDX $0279
CA12   B5 DD      LDA $DD,X     pointer in block
CA14   20 C8 D4   JSR $D4C8     set buffer pointer
CA17   AE 79 02   LDX $0279
CA1A   B5 E7      LDA $E7,X     file type
CA1C   29 07      AND #$07      isolate
CA1E   8D 4A 02   STA $024A     and save
CA21   A9 00      LDA #$00
CA23   8D 58 02   STA $0258
CA26   20 A0 D9   JSR $D9A0     get parameters for rel-file
CA29   A0 01      LDY #$01
CA2B   20 25 D1   JSR $D125     get file type
CA2E   F0 01      BEQ $CA31     rel-file?
CA30   C8         INY
CA31   98         TYA
CA32   4C C8 D4   JMP $D4C8     set buffer pointer
CA35   A9 11      LDA #$11      17
CA37   85 83      STA $83
CA39   20 9B D3   JSR $D39B     open channel and get byte
CA3C   85 85      STA $85
CA3E   A6 82      LDX $82       channel number
CA40   B5 F2      LDA $F2,X
CA42   29 08      AND #$08      isolate end marker
CA44   85 F8      STA $F8
CA46   D0 0A      BNE $CA52     not set?
CA48   20 25 D1   JSR $D125     get data type
CA4B   F0 05      BEQ $CA52     rel-file?
CA4D   A9 80      LDA #$80
CA4F   20 97 DD   JSR $DD97     set bit 7
CA52   60         RTS

CA53   20 D3 D1   JSR $D1D3     set drive number
CA56   20 CB E1   JSR $E1CB
CA59   A5 D6      LDA $D6
CA5B   48         PHA
CA5C   A5 D5      LDA $D5
CA5E   48         PHA
CA5F   A9 12      LDA #$12      18
CA61   85 83      STA $83
CA63   20 07 D1   JSR $D107     open write channel
CA66   20 D3 D1   JSR $D1D3     set drive number
CA69   20 CB E1   JSR $E1CB
CA6C   20 9C E2   JSR $E29C
CA6F   A5 D6      LDA $D6
CA71   85 87      STA $87
CA73   A5 D5      LDA $D5
CA75   85 86      STA $86
CA77   A9 00      LDA #$00
CA79   85 88      STA $88
```

```
CA7B    85 D4       STA $D4
CA7D    85 D7       STA $D7
CA7F    68          PLA
CA80    85 D5       STA $D5
CA82    68          PLA
CA83    85 D6       STA $D6
CA85    4C 3B E3    JMP $E33B

******************************      R-command,   'rename'
CA88    20 20 C3    JSR $C320       get drive no. from command line
CA8B    A5 E3       LDA $E3
CA8D    29 01       AND #$01
CA8F    85 E3       STA $E3         2nd drive number
CA91    C5 E2       CMP $E2         compare with 1st drive number
CA93    F0 02       BEQ $CA97       same?
CA95    09 80       ORA #$80
CA97    85 E2       STA $E2
CA99    20 4F C4    JSR $C44F       search for file in directory
CA9C    20 E7 CA    JSR $CAE7       does name exist?
CA9F    A5 E3       LDA $E3
CAA1    29 01       AND #$01
CAA3    85 7F       STA $7F         drive number
CAA5    A5 D9       LDA $D9
CAA7    85 81       STA $81         sector number
CAA9    20 57 DE    JSR $DE57       read block from directory
CAAC    20 99 D5    JSR $D599       ok?
CAAF    A5 DE       LDA $DE         pointer to directory entry
CAB1    18          CLC
CAB2    69 03       ADC #$03        pointer plus 3 to file name
CAB4    20 C8 D4    JSR $D4C8       set buffer pointer
CAB7    20 93 DF    JSR $DF93       get buffer number
CABA    A8          TAY
CABB    AE 7A 02    LDX $027A
CABE    A9 10       LDA #$10        16 characters
CAC0    20 6E C6    JSR $C66E       write name in buffer
CAC3    20 5E DE    JSR $DE5E       write block to directory
CAC6    20 99 D5    JSR $D599       ok?
CAC9    4C 94 C1    JMP $C194       done, prepare disk status

******************************      check if file present
CACC    A5 E8       LDA $E8         file type
CACE    29 07       AND #$07
CAD0    8D 4A 02    STA $024A       save
CAD3    AE 78 02    LDX $0278
CAD6    CA          DEX
CAD7    EC 77 02    CPX $0277
CADA    90 0A       BCC $CAE6
CADC    BD 80 02    LDA $0280,X     track number
CADF    D0 F5       BNE $CAD6       not zero?
CAE1    A9 62       LDA #$62
CAE3    4C C8 C1    JMP $C1C8       62, 'file not found'
CAE6    60          RTS

CAE7    20 CC CA    JSR $CACC       does file exist with old name?
CAEA    8D 80 02    LDA $0280,X     track number of new file
```

```
CAED    F0 05       BEQ $CAF4       file erased?
CAEF    A9 63       LDA #$63
CAF1    4C C8 C1    JMP $C1C8       63, 'file exists'
CAF4    CA          DEX
CAF5    10 F3       BPL $CAEA
CAF7    60          RTS

******************************      M-command,  'memory'
CAF8    AD 01 02    LDA $0201       2nd character from buffer
CAFB    C9 2D       CMP #$2D        '-'
CAFD    D0 4C       BNE $CB4B
CAFF    AD 03 02    LDA $0203
CB02    85 6F       STA $6F         address in $6F/$70
CB04    AD 04 02    LDA $0204
CB07    85 70       STA $70
CB09    A0 00       LDY #$00
CB0B    AD 02 02    LDA $0202       3rd character from buffer
CB0E    C9 52       CMP #$52        'R'
CB10    F0 0E       BEQ $CB20       to memory read
CB12    20 58 F2    JSR $F258       (RTS)
CB15    C9 57       CMP #$57        'W'
CB17    F0 37       BEQ $CB50       to memory write
CB19    C9 45       CMP #$45        'E'
CB1B    D0 2E       BNE $CB4B
CB1D    6C 6F 00    JMP ($006F)     memory-execute

******************************      M-R,  'Memory-Read'
CB20    B1 6F       LDA ($6F),Y     read byte
CB22    85 85       STA $85
CB24    AD 74 02    LDA $0274       length of command line
CB27    C9 06       CMP #$06        less than 6?
CB29    90 1A       BCC $CB45       yes
CB2B    AE 05 02    LDX $0205       number
CB2E    CA          DEX
CB2F    F0 14       BEQ $CB45       only one byte?
CB31    8A          TXA             number of bytes
CB32    18          CLC
CB33    65 6F       ADC $6F         plus start address
CB35    E6 6F       INC $6F
CB37    8D 49 02    STA $0249       end pointer
CB3A    A5 6F       LDA $6F
CB3C    85 A5       STA $A5         buffer pointer for error message
CB3E    A5 70       LDA $70         set to start address for 'M-R'
CB40    85 A6       STA $A6
CB42    4C 43 D4    JMP $D443       byte out

CB45    20 EB D0    JSR $D0EB       open read channel
CB48    4C 3A D4    JMP $D43A       byte out

CB4B    A9 31       LDA #$31
CB4D    4C C8 C1    JMP $C1C8       31, 'syntax error'

******************************      M-W,  'memory-write'
CB50    B9 06 02    LDA $0206,Y     read character
CB53    91 6F       STA ($6F),Y     and save
```

```
CB55    C8          INY
CB56    CC 05 02    CPY $0205      number of characters
CB59    90 F5       BCC $CB50      all characters?
CB5B    60          RTS

******************************     U-command,   'user'
CB5C    AC 01 02    LDY $0201      second char
CB5F    C0 30       CPY #$30       '0'
CB61    D0 09       BNE $CB6C      no
CB63    A9 EA       LDA #$EA
CB65    85 6B       STA $6B        ptr to table of user-addresses
CB67    A9 FF       LDA #$FF       $FFEA
CB69    85 6C       STA $6C
CB6B    60          RTS

CB6C    20 72 CB    JSR $CB72
CB6F    4C 94 C1    JMP $C194      done, prepare error message

CB72    88          DEY
CB73    98          TYA
CB74    29 0F       AND #$0F       number
CB76    0A          ASL A          times 2
CB77    A8          TAY
CB78    B1 6B       LDA ($6B),Y    as pointer in table
CB7A    85 75       STA $75
C87C    C8          INY            address at $75/$76
CB7D    B1 6B       LDA ($6B),Y
CB7F    85 76       STA $76
CB81    6C 75 00    JMP ($0075)    execute function

******************************     open direct access channel, '#'
CB84    AD 8E 02    LDA $028E      last drive number
CB87    85 7F       STA $7F        drive number
CB89    A5 83       LDA $83        channel number
CB8B    48          PHA
CB8C    20 3D C6    JSR $C63D      check drive and initialize
CB8F    68          PLA
CB90    85 83       STA $83
CB92    AE 74 02    LDX $0274      length of filename
CB95    CA          DEX
CB96    D0 0D       BNE $CBA5      greater than one?
CB98    A9 01       LDA #$01
CB9A    20 E2 D1    JSR $D1E2      layout buffer and channel
CB9D    4C F1 CB    JMP $CBF1      set flags, done

CBA0    A9 70       LDA #$70
CBA2    4C C8 C1    JMP $C1C8      70, 'no channel'
CBA5    A0 01       LDY #$01
CBA7    20 7C CC    JSR $CC7C      get buffer number
CBAA    AE 85 02    LDX $0285      buffer number
CBAD    E0 05       CPX #$05       bigger than 5?
CBAF    B0 EF       BCS $CBA0      70, 'no channel'
CBB1    A9 00       LDA #$00
CBB3    85 6F       STA $6F
CBB5    85 70       STA $70
```

```
CBB7    38          SEC
CBB8    26 6F       ROL $6F
CBBA    26 70       ROL $70
CBBC    CA          DEX
CBBD    10 F9       BPL $CBB8
CBBF    A5 6F       LDA $6F
CBC1    2D 4F 02    AND $024F
CBC4    D0 DA       BNE $CBA0
CBC6    A5 70       LDA $70
CBC8    2D 50 02    AND $0250
CBCB    D0 D3       BNE $CBA0
CBCD    A5 6F       LDA $6F
CBCF    0D 4F 02    ORA $024F
CBD2    8D 4F 02    STA $024F
CBD5    A5 70       LDA $70
CBD7    0D 50 02    ORA $0250
CBDA    8D 50 02    STA $0250
CBDD    A9 00       LDA #$00
CBDF    20 E2 D1    JSR $D1E2      search channel
CBE2    A6 82       LDX $82        channel number
CBE4    AD 85 02    LDA $0285      buffer number
CBE7    95 A7       STA $A7,X
CBE9    AA          TAX
CBEA    A5 7F       LDA $7F        drive number
CBEC    95 00       STA $00,X
CBEE    9D 5B 02    STA $025B,X
CBF1    A6 83       LDX $83        secondary address
CBF3    BD 2B 02    LDA $022B,X
CBF6    09 40       ORA #$40       set READ and WRITE flags
CBF8    9D 2B 02    STA $022B,X
CBFB    A4 82       LDY $82        channel number
CBFD    A9 FF       LDA #$FF
CBFF    99 44 02    STA $0244,Y    end pointer
CC02    A9 89       LDA #$89
CC04    99 F2 00    STA $00F2,Y    set READ and WRITE flags
CC07    B9 A7 00    LDA $00A7,Y    buffer number
CC0A    99 3E 02    STA $023E,Y
CC0D    0A          ASL A          times 2
CC0E    AA          TAX
CC0F    A9 01       LDA #$01
CC11    95 99       STA $99,X      buffer pointer to one
CC13    A9 0E       LDA #$0E
CC15    99 EC 00    STA $00EC,Y    flag for direct access
CC18    4C 94 C1    JMP $C194      done

******************************     B-command,  'Block'
CC1B    A0 00       LDY #$00
CC1D    A0 00       LDX #$00
CC1F    A9 2D       LDA #$2D       '-'
CC21    20 68 C2    JSR $C268      search for minus sign
CC24    D0 0A       BNE $CC30      found?
CC26    A9 31       LDA #$31
CC28    4C C8 C1    JMP $C1C8      31, 'syntax error'
```

```
CC2B    A9 30       LDA #$30
CC2D    4C C8 C1    JMP $C1C8       30, 'syntax error'

CC30    8A          TXA
CC31    D0 F8       BNE $CC2B       comma, then error
CC33    A2 05       LDX #$05
CC35    B9 00 02    LDA $0200,Y     char from buffer
CC38    DD 5D CC    CMP $CC5D,X     compare with 'AFRWEP'
CC3B    F0 05       BEQ $CC42       found?
CC3D    CA          DEX
CC3E    10 F8       BPL $CC38       compare with all characters
CC40    30 E4       BMI $CC26       not found, error
CC42    8A          TXA
CC43    09 80       ORA #$80        command number, set bit 7
CC45    8D 2A 02    STA $022A
CC48    20 6F CC    JSR $CC6F       get parameters
CC4B    AD 2A 02    LDA $022A
CC4E    0A          ASL A           number times 2
CC4F    AA          TAX             as index
CC50    BD 64 CC    LDA $CC64,X     address of command hi
CC53    85 70       STA $70
CC55    BD 63 CC    LDA $CC63,X     address lo
CC58    85 6F       STA $6F
CC5A    6C 6F 00    JMP ($006F)     jump to command

******************************      names of the various block cmds
CC5D    41 46 52 57 45 50           'AFRWEP'

******************************      addresses of block commands
CC63    03 CD                       $CD03, B-A
CC65    F5 CC                       $CCF5, B-F
CC67    56 CD                       $CD56, B-R
CC69    73 CD                       $CD73, B-W
CC6B    A3 CD                       $CDA3, B-E
CC6D    BD CD                       $CDBD, B-P

******************************      get parameters for block commands
CC6F    A0 00       LDY #$00
CC71    A2 00       LDX #$00
CC73    A9 3A       LDA #$3A        ':'
CC75    20 68 C2    JSR $C268       test line to colon
CC78    D0 02       BNE $CC7C       found?
CC7A    A0 03       LDY #$03        no, begin at 4th character
CC7C    B9 00 02    LDA $0200,Y     search for separating char
CC7F    C9 20       CMP #$20        ' ' blank
CC81    F0 08       BEQ $CC8B
CC83    C9 1D       CMP #$1D        cursor right
CC85    F0 04       BEQ $CC8B
CC87    C9 2C       CMP #$2C        ',' comma
CC89    D0 07       BNE $CC92
CC8B    C8          INY
CC8C    CC 74 02    CPY $0274       line end?
CC8F    90 EB       BCC $CC7C
CC91    60          RTS
```

```
CC92   20 A1 CC   JSR $CCA1     preserve next parameter
CC95   EE 77 02   INC $0277     increment parameter counter
CC98   AC 79 02   LDY $0279
CC9B   E0 04      CPX #$04      compare with maximum number
CC9D   90 EC      BCC $CC8B
CC9F   B0 8A      BCS $CC2B     30, 'syntax error'
CCA1   A9 00      LDA #$00
CCA3   85 6F      STA $6F
CCA5   85 70      STA $70       erase storage area for decimal #s
CCA7   85 72      STA $72
CCA9   A2 FF      LDX #$FF
CCAB   B9 00 02   LDA $0200,Y   get characters from input buffer
CCAE   C9 40      CMP #$40
CCB0   B0 18      BCS $CCCA     no digits?
CCB2   C9 30      CMP #$30      '0'
CCB4   90 14      BCC $CCCA     no digits?
CCB6   29 0F      AND #$0F      convert ASCII digits to hex
CCB8   48         PHA           and save
CCB9   A5 70      LDA $70
CCBB   85 71      STA $71       move digits one further
CCBD   A4 6F      LDA $6F
CCBF   85 70      STA $70
CCC1   68         PLA
CCC2   85 6F      STA $6F       note read number
CCC4   C8         INY           increment pointer in input buffer
CCC5   CC 74 02   CPY $0274     line end reached
CCC7   90 E1      BCC $CCAB     no
CCCA   8C 79 02   STY $0279     save pointer
CCCD   18         CLC
CCCE   A9 00      LDA #$00
CCD0   E8         INX
CCD1   E0 03      CPX #$03
CCD3   B0 0F      BCS $CCE4     convert hex digits to one byte
CCD5   B4 6F      LDY $6F,X
CCD7   88         DEY
CCD8   30 F6      BMI $CCD0
CCDA   7D F2 CC   ADC $CCF2,X   add decimal value
CCDD   90 F8      BCC $CCD7
CCDF   18         CLC
CCE0   E6 72      INC $72
CCE2   D0 F3      BNE $CCD7
CCE4   48         PHA
CCE5   AE 77 02   LDX $0277     counter for parameters
CCE8   A5 72      LDA $72
CCEA   9D 80 02   STA $0280,X   hi-byte
CCED   68         PLA
CCEE   9D 85 02   STA $0285,X   lo-byte
CCF1   60         RTS

******************************  decimal values
CCF2   01 0A 64                 1, 10, 100

******************************  B-F command, 'Block-Free'
CCF5   20 F5 CD   JSR $CDF5     get track, sector and drive no.
CCF8   20 5F EF   JSR $EF5F     free block
```

```
CCFB    4C 94 C1    JMP $C194       done, prepare error message

*******************************
CCFE    A9 01       LDA #$01
CD00    8D F9 02    STA $02F9

*******************************     B-A command,  'Block-Allocate'
CD03    20 F5 CD    JSR $CDF5       get track, sector and drive no.
CD06    A5 81       LDA $81         sector
CD08    48          PHA             save
CD09    20 FA F1    JSR $F1FA       find block in BAM
CD0C    F0 0B       BEQ $CD19       block allocated?
CD0E    68          PLA             desired sector
CD0F    C5 81       CMP $81         = next free sector?
CD11    D0 19       BNE $CD2C       no
CD13    20 90 EF    JSR $EF90       allocate block in BAM
CD16    4C 94 C1    JMP $C194       done

CD19    68          PLA
CD1A    A9 00       LDA #$00
CD1C    85 81       STA $81         sector 0
CD1E    E6 80       INC $80         next track
CD20    A5 80       LDA $80         track number
CD22    CD D7 FE    CMP $FED7       36, last track number + 1
CD25    B0 0A       BCS $CD31       >=, then 'no block'
CD27    20 FA F1    JSR $F1FA       find free block in next track
CD2A    F0 EE       BEQ $CD1A       not found, check next track
CD2C    A9 65       LDA #$65
CD2E    20 45 E6    JSR $E645       65, 'no block' next free block
CD31    A9 65       LDA #$65
CD33    20 C8 C1    JSR $C1C8       65,'no block' no more free blocks

*******************************
CD36    20 F2 CD    JSR $CDF2       open channel, set parameters
CD39    4C 60 D4    JMP $D460       read block from disk

*******************************     get byte from buffer
CD3C    20 2F D1    JSR $D12F       set pointer to buffer
CD3F    A1 99       LDA ($99,X)     get byte
CD41    60          RTS

*******************************     read block from disk
CD42    20 36 CD    JSR $CD36       open channel, read block
CD45    A9 00       LDA #$00
CD47    20 C8 D4    JSR $D4C8       set buffer pointer to zero
CD4A    20 3C CD    JSR $CD3C       get a byte from the buffer
CD4D    99 44 02    STA $0244,Y
CD50    A9 89       LDA $89         set read and write flag
CD52    99 F2 00    STA $00F2,Y
CD55    60          RTS

*******************************     B-R command,  'Block-Read'
CD56    20 42 CD    JSR $CD42       read block from disk
CD59    20 EC D3    JSR $D3EC       prepare byte from buffer
CD5C    4C 94 C1    JMP $C194       prepare error message
```

```
********************************   U1 command, sub. for 'Block-Read'
CD5F    20 6F CC   JSR $CC6F       get parameters of the command
CD62    20 42 CD   JSR $CD42       read block from disk
CD65    B9 44 02   LDA $0244,Y     end pointer
CD68    99 3E 02   STA $023E,Y     save as data byte
CD6B    A9 FF      LDA #$FF
CD6D    99 44 02   STA $0244,Y     end pointer to $FF
CD70    4C 94 C1   JMP $C194       done, prepare error message

********************************   B-W command,  'Block-Write'
CD73    20 F2 CD   JSR $CDF2       open channel
CD76    20 E8 D4   JSR $D4E8       set buffer pointer
CD79    A8         TAY
CD7A    88         DEY
CD7B    C9 02      CMP #$02        buffer pointer lo less than 2?
CD7D    B0 02      BCS $CD81       no
CD7F    A0 01      LDY #$01
CD81    A9 00      LDA #$00
CD83    20 C8 D4   JSR $D4C8       buffer pointer to zero
CD86    98         TYA
CD87    20 F1 CF   JSR $CFF1       write byte in buffer
CD8A    8A         TXA
CD8B    48         PHA
CD8C    20 64 D4   JSR $D464       write block to disk
CD8F    68         PLA
CD90    AA         TAX
CD91    20 EE D3   JSR $D3EE       get byte from buffer
CD94    4C 94 C1   JMP $C194       done, error message

********************************   U2, sub for 'Block-Write'
CD97    20 6F CC   JSR $CC6F       get command parameters
CD9A    20 F2 CD   JSR $CDF2       open channel
CD9D    20 64 D4   JSR $D464       and write block to disk
CDA0    4C 94 C1   JMP $C194       done

********************************   'B-E' command,  'Block-Execute'
CDA3    20 58 F2   JSR $F258       (RTS)
CDA6    20 36 CD   JSR $CD36       open channel and read block
CDA9    A9 00      LDA #$00
CDAB    85 6F      STA $6F         address low
CDAD    A6 F9      LDX $F9         buffer number
CDAF    BD E0 FE   LDA $FEE0,X     buffer address high
CDB2    85 70      STA $70
CDB4    20 BA CD   JSR $CDBA       execute routine
CDB7    4C 94 C1   JMP $C194       done
CDBA    6C 6F 00   JMP ($006F)     jump to routine

********************************   'B-P' command,  'Block-Pointer'
CDBD    20 D2 CD   JSR $CDD2       open channel, get buffer number
CDC0    A5 F9      LDA $F9         buffer number
CDC2    0A         ASL A           * 2
CDC3    AA         TAX             as index
CDC4    AD 86 02   LDA $0286       pointer value
CDC7    95 99      STA $99,X       save as buffer pointer
```

```
CDC9    20 2F D1    JSR $D12F      prepare a byte in buffer
CDCC    20 EE D3    JSR $D3EE      for output
CDCF    4C 94 C1    JMP $C194      done

******************************     open channel
CDD2    A6 D3       LDX $D3
CDD4    E6 D3       INC $D3
CDD6    BD 85 02    LDA $0285,X    buffer number
CDD9    A8          TAY
CDDA    88          DEY
CDDB    88          DEY
CDDC    C0 0C       CPY #$0C       buffer number smaller than 14?
CDDE    90 05       BCC $CDE5      yes
CDE0    A9 70       LDA #$70
CDE2    4C C8 C1    JMP $C1C8      70, 'no channel'

CDE5    85 83       STA $83        secondary address
CDE7    20 EB D0    JSR $D0EB      open channel
CDEA    B0 F4       BCS $CDE0      already allocated,70 'no channel'
CDEC    20 93 DF    JSR $DF93      buffer number
CDEF    85 F9       STA $F9        set
CDF1    60          RTS

******************************
CDF2    20 D2 CD    JSR $CDD2      check buffer no. and open channel
CDF5    A6 D3       LDX $D3        channel number
CDF7    BD 85 02    LDA $0285,X    buffer address
CDFA    29 01       AND #$01
CDFC    85 7F       STA $7F        drive number
CDFE    BD 87 02    LDA $0287,X
CE01    85 81       STA $81        sector
CE03    BD 86 02    LDA $0286,X
CE06    85 80       STA $80        track
CE08    20 5F D5    JSR $D55F      track and sector ok?
CE0B    4C 00 C1    JMP $C100      turn LED on

******************************     set pointer for rel-file
CE0E    20 2C CE    JSR $CE2C      record number * record length
CE11    20 6E CE    JSR $CE6E      divide by 254
CE14    A5 90       LDA $90        remainder = pointer in data block
CE16    85 D7       STA $D7        data pointer
CE18    20 71 CE    JSR $CE71      divide by 120 = side-sector #
CE1B    E6 D7       INC $D7
CE1D    E6 D7       INC $D7        data ptr + 2 (track/sector ptr!)
CE1F    A5 8B       LDA $8B        result of division
CE21    85 D5       STA $D5        equals side-sector number
CE23    A5 90       LDA $90        remainder
CE25    0A          ASL A          times 2
CE26    18          CLC
CE27    69 10       ADC #$10       plus 16
CE29    85 D6       STA $D6        =ptr in side-sector to data block
CE2B    60          RTS

******************************
CE2C    20 D9 CE    JSR $CED9      erase work storage
```

```
CE2F   85 92      STA $92
CE31   A6 82      LDX $82       channel number
CE33   B5 B5      LDA $B5,X     record number lo
CE35   85 90      STA $90
CE37   B5 BB      LDA $BB,X     record number hi
CE39   85 91      STA $91
CE3B   D0 04      BNE $CE41
CE3D   A5 90      LDA $90
CE3F   F0 0B      BEQ $CE4C     record number not zero?
CE41   A5 90      LDA $90
CE43   38         SEC
CE44   E9 01      SBC #$01      then subtract one
CE46   85 90      STA $90
CE48   B0 02      BCS $CE4C
CE4A   C6 91      DEC $91
CE4C   B5 C7      LDA $C7,X     record length
CE4E   85 6F      STA $6F
CE50   46 6F      LSR $6F
CE52   90 03      BCC $CE57
CE54   20 ED CE   JSR $CEED     record number * record length
CE57   20 E5 CE   JSR $CEE5     shift register left
CE5A   A5 6F      LDA $6F
CE5C   D0 F2      BNE $CE50
CE5E   A5 D4      LDA $D4
CE60   18         CLC
CE61   65 8B      ASC $8B
CE63   85 8B      STA $8B
CE65   90 06      BCC $CE6D     result in $8B/$8C/$8D
CE67   E6 8C      INC $8C
CE69   D0 02      BNE $DE6D
CE6B   E6 8D      INC $8D
CE6D   60         RTS

******************************  divide by 254, calculate block #
CE6E   A9 FE      LDA #$FE      254
CE70   2C         .BYTE $2C

******************************  divide by 120, calculate
CE71   A9 78      LDA #$78      side-sector number
CE73   85 6F      STA $6F       divisor
CE75   A2 03      LDX #$03
CE77   B5 8F      LDA $8F,X
CE79   48         PHA
CE7A   B5 8A      LDA $8A,X
CE7C   95 8F      STA $8F,X
CE7E   68         PLA
CE7F   95 8A      STA $8A,X
CE81   CA         DEX
CE82   D0 F3      BNE $CE77
CE84   20 D9 CE   JSR $CED9     erase work storage
CE87   A2 00      LDX #$00
CE89   B5 90      LDA $90,X
CE8B   95 8F      STA $8F,X
CE8D   E8         INX
CE8E   E0 04      CPX #$04
```

```
CE90    90 F7       BCC $CE89
CE92    A9 00       LDA #$00
CE94    85 92       STA $92
CE96    24 6F       BIT $6F
CE98    30 09       BMI $CEA3
CE9A    06 8F       ASL $8F
CE9C    08          PHP
CE9D    46 8F       LSR $8F
CE9F    28          PLP
CEA0    20 E6 CE    JSR $CEE6       shift register 1 left
CEA3    20 ED CE    JSR $CEED       add register 0 to register 1
CEA6    20 E5 CE    JSR $CEE5       shift register 1 left
CEA9    24 6F       BIT $6F
CEAB    30 03       BMI $CEB0
CEAD    20 E2 CE    JSR $CEE2       left-shift register 1 twice
CEB0    A5 8F       LDA $8F
CEB2    18          CLC
CEB3    65 90       ADC $90
CEB5    85 90       STA $90
CEB7    90 06       BCC $CEBF
CEB9    E6 91       INC $91
CEBB    D0 02       BNE $CEBF
CEBD    E6 92       INC $92
CEBF    A5 92       LDA $92
CEC1    05 91       ORA $91
CEC3    D0 C2       BNE $CE87
CEC5    A5 90       LDA $90
CEC7    38          SEC
CEC8    E5 6F       SBC $6F         quotient in $8B/$8C/$8D
CECA    90 0C       BCC $CED8
CECC    E6 8B       INC $8B
CECE    D0 06       BNE $CED6
CED0    E6 8C       INC $8C
CED2    D0 02       BNE $CED6
CED4    85 90       STA $90         remainder in $90
CED8    60          RTS

******************************      erase work storage
CED9    A9 00       LDA #$00
CEDB    85 8B       STA $8B
CEDD    85 8C       STA $8C
CEDF    85 8D       STA $8D
CEE1    60          RTS

******************************      left-shift 3-byte register twice
CEE2    20 E5 CE    JSR $CEE5

******************************      left-shift 3-byte register once
CEE5    18          CLC
CEE6    29 90       ROL $90
CEE8    26 91       ROL $91
CEEA    26 92       ROL $92
CEEC    60          RTS

******************************
```

```
CEED   18          CLC
CEEE   A2 FD       LDX #$FD
CEF0   B5 8E       LDA $8E,X      register $90/$91/$92
CEF2   75 93       ADC $93,X      add to register $8B/$8C/$8D
CEF4   95 8E       STA $8E,X
CEF6   E8          INX
CEF7   D0 F7       BNE $CEF0
CEF9   60          RTS

CEFA   A2 00       LDX #$00
CEFC   8A          TXA
CEFD   95 FA       STA $FA,X
CEFF   E8          INX
CF00   E0 04       CPX #$04
CF02   D0 F8       BNE $CEFC
CF04   A9 06       LDA #$06
CF06   95 FA       STA $FA,X
CF08   60          RTS

CF09   A0 04       LDY #$04
CF0B   A6 82       LDX $82        channel number
CF0D   B9 FA 00    LDA $00FA,Y
CF10   96 FA       STX $FA,Y
CF12   C5 82       CMP $82        channel number
CF14   F0 07       BEQ $CF1D
CF16   88          DEY
CF17   30 E1       BMI $CEFA
CF19   AA          TAX
CF1A   4C 0D CF    JMP $CF0D
CF1D   60          RTS

CF1E   20 09 CF    JSR $CF09
CF21   20 B7 DF    JSR $DFB7
CF24   D0 46       BNE $CF6C
CF26   20 D3 D1    JSR $D1D3      set drive number
CF29   20 8E D2    JSR $D28E
CF2C   30 48       BMI $CF76
CF2E   20 C2 DF    JSR $DFC2
CF31   A5 80       LDA $80        track
CF33   48          PHA
CF34   A5 81       LDA $81        sector
CF36   48          PHA
CF37   A9 01       LDA #$01
CF39   20 F6 D4    JSR $D4F6      get byte 1 from buffer
CF3C   85 81       STA $81        sector
CF3E   A9 00       LDA #$00
CF40   20 F6 D4    JSR $D4F6      get byte 0 from buffer
CF43   85 80       STA $80        track
CF45   F0 1F       BEQ $CF66
CF47   20 25 D1    JSR $D125      check file type
CF4A   F0 0B       BEQ $CF57      rel-file?
CF4C   20 AB DD    JSR $DDAB
CF4F   D0 06       BNE $CF57
CF51   20 8C CF    JSR $CF8C
CF54   4C 5D CF    JMP $CF5D
```

```
CF57    20 8C CF    JSR $CF8C
CF5A    20 57 DE    JSR $DE57
CF5D    68          PLA
CF5E    85 81       STA $81         get sector
CF60    68          PLA
CF61    85 80       STA $80         and track number
CF63    4C 6F CF    JMP $CF6F

CF66    68          PLA
CF67    85 81       STA $81         get back sector
CF69    68          PLA
CF6A    85 80       STA $80         and track number
CF6C    20 8C CF    JSR $CF8C
CF6F    20 93 DF    JSR $DF93
CF72    AA          TAX
CF73    4C 99 D5    JMP $D599       and verify

CF76    A9 70       LDA #$70
CF78    4C C8 C1    JMP $C1C8       70, 'no channel'

CF7B    20 09 CF    JSR $CF09
CF7E    20 B7 DF    JSR $DFB7
CF81    D0 08       BNE $CF8B
CF83    20 8E D2    JSR $D28E
CF86    30 EE       BMI $CF76
CF88    20 C2 DF    JSR $DFC2
CF8B    60          RTS

******************************  change buffer
CF8C    A6 82       LDX $82         channel number
CF8E    B5 A7       LDA $A7,X
CF90    49 80       EOR #$80
CF92    95 A7       STA $A7,X
CF94    B5 AE       LDA $AE,X       rotate bit 7 in table
CF96    49 80       EOR #$80
CF98    95 AE       STA $AE,X
CF9A    60          RTS

******************************  write data byte in buffer
CF9B    A2 12       LDX #$12        channel 18
CF9D    86 83       STX $83
CF9F    20 07 D1    JSR $D107       open write channel
CFA2    20 00 C1    JSR $C100       turn LED on
CFA5    20 25 D1    JSR $D125       check file type
CFA8    90 05       BCC $CFAF       no rel-file
CFAA    A9 20       LDA #$20
CFAC    20 9D DD    JSR $DD9D       change buffer
CFAF    A5 83       LDA $83         secondary address
CFB1    C9 0F       CMP #$0F        15?
CFB3    F0 23       BEQ $CFD8       yes
CFB5    D0 08       BNE $CFBF       no

CFB7    A5 84       LDA $84         secondary address
CFB9    29 8F       AND #$8F
```

```
CFBB    C9 0F       CMP #$0F      greater than 15?
CFBD    B0 19       BCS $CFD8     then input buffer
CFBF    20 25 D1    JSR $D125     check file type
CFC2    B0 05       BCS $CFC9     rel-file or direct access?
CFC4    A5 85       LDA $85       data byte
CFC6    4C 9D D1    JMP $D19D     write in buffer

CFC9    D0 03       BNE $CFCE     direct access file?
CFCB    4C AB E0    JMP $E0AB     write data byte in rel-file

CFCE    A5 85       LDA $85
CFD0    20 F1 CF    JSR $CFF1     write data byte in buffer
CFD3    A4 82       LDY $82       channel number
CFD5    4C EE D3    JMP $D3EE     prepare next byte for output

CFD8    A9 04       LDA #$04      channel 4
CFDA    85 82       STA $82       corresponding input buffer
CFDC    20 E8 D4    JSR $D4E8     set buffer pointer
CFDF    C9 2A       CMP #$2A      40
CFE1    F0 05       BEQ $CFE8     buffer end?
CFE3    A5 85       LDA $85
CFE5    20 F1 CF    JSR $CFF1     write data byte in buffer
CFE8    A5 F8       LDA $F8       end flag set?
CFEA    F0 01       BEQ $CFED     yes
CFEC    60          RTS

CFED    EE 55 02    INC $0255     set command flag
CFF0    60          RTS

******************************    write data byte in buffer
CFF1    48          PHA           save data byte
CFF2    20 93 DF    JSR $DF93     get buffer number
CFF5    10 06       BPL $CFFD     associated buffer?
CFF7    68          PLA
CFF8    A9 61       LDA #$61
CFFA    4C C8 C1    JMP $C1C8     61, 'file not open'
CFFD    0A          ASL A         buffer number times 2
CFFE    AA          TAX           as index
CFFF    68          PLA           data byte
D000    81 99       STA ($99,X)   write in buffer
D002    F6 99       INC $99,X     increment buffer pointer
D004    60          RTS

******************************    I-command, Initialize
D005    20 D1 C1    JSR $C1D1     find drive number
D008    20 42 D0    JSR $D042     load BAM
D00B    4C 94 C1    JMP $C194     prepare disk status

******************************
D00E    20 0F F1    JSR $F10F
D011    A8          TAY
D012    B6 A7       LDX $A7,Y
D014    E0 FF       CPX #$FF
D016    48          PHA
D019    20 8E D2    JSR $D28E
```

```
D01C   AA          TAX
D01D   A9 70       LDA #$70
D021   20 48 E6    JSR $E648      70, 'no channel'
D024   68          PLA
D025   A8          TAY
D026   8A          TXA
D027   09 80       ORA #$80
D029   99 A7 00    STA $00A7,Y
D02C   8A          TXA
D02D   29 0F       AND #$0F
D02F   85 F9       STA $F9
D031   A2 00       LDA #$00
D033   86 81       STX $81        sector 0
D035   AE 85 FE    LDX $FE85      18
D038   86 80       STX $80        track 18
D03A   20 D3 D6    JSR $D6D3      transmit param to disk controller
D03D   A9 B0       LDA #$B0       command code 'read block header'
D03F   4C 8C D5    JMP $D58C      transmit to disk controller

******************************    load BAM
D042   20 D1 F0    JSR $F0D1
D045   20 13 D3    JSR $D313
D048   20 0E D0    JSR $D00E      read block
D04B   A6 7F       LDX $7F        drive number
D04D   A9 00       LDA #$00
D04F   9D 51 02    STA $0251,X    reset flag for 'BAM changed'
D052   8A          TXA
D053   0A          ASL A
D054   AA          TAX
D055   A5 16       LDA $16
D057   95 12       STA $12,X
D059   A4 17       LDA $17        save ID
D05B   95 13       STA $13,X
D05D   20 86 D5    JSR $D586
D060   A5 F9       LDA $F9        buffer number
D062   0A          ASL A
D063   AA          TAX
D064   A9 02       LDA #$02       buffer pointer to $200
D066   95 99       STA $99,X
D068   A1 99       LDA ($99,X)    get character from buffer
D06A   A6 7F       LDX $7F        drive number
D06C   9D 01 01    STA $0101,X
D06F   A9 00       LDA #$00
D071   95 1C       STA $1C,X      flag for write protect
D073   95 FF       STA $FF,X      flag for read error

******************************    calculate blocks free
D075   20 3A EF    JSR $EF3A      buffer address to $6D/$6E
D078   A0 04       LDY #$04       begin at position 4
D07A   A9 00       LDA #$00
D07C   AA          TAX
D07D   18          CLC
D07E   71 6D       ADC ($6D),Y    add no. of free blocks per track
D080   90 01       BCC $D083
D082   E8          INX            X as hi-byte
```

```
D083    C8          INY
D084    C8          INY             plus 4
D085    C8          INY
D086    C8          INY
D087    C0 48       CPY #$48        track 18?
D089    F0 F8       BEQ $D083       then skip
D08B    C0 90       CPY #$90        last track number?
D08D    D0 EE       BNE $D07D       no
D08F    48          PHA             lo-byte
D090    8A          TXA             hi-byte
D091    A6 7F       LDX $7F         drive number
D093    9D FC 02    STA $02FC,X     hi-byte to $2FC
D096    68          PLA             lo-byte
D097    9D FA 02    STA $02FA,X     to $2FA
D09A    60          RTS

*****************************
D09B    20 D0 D6    JSR $D6D0       parameters to disk controller
D09E    20 C3 D0    JSR $D0C3       read block
D0A1    20 99 D5    JSR $D599       ok?
D0A4    20 37 D1    JSR $D137       get byte from buffer
D0A7    85 80       STA $80         track
D0A9    20 37 D1    JSR $D137       next byte from buffer
D0AC    85 81       STA $81         sector
D0AE    60          RTS

D0AF    20 9B D0    JSR $D09B
D0B2    A5 80       LDA $80         track
D0B4    D0 01       BNE $D0B7
D0B6    60          RTS
D0B7    20 1E CF    JSR $CF1E       change buffer
D0BA    20 D0 D6    JSR $D6D0       parameters to disk controller
D0BD    20 C3 D0    JSR $D0C3       read block
D0C0    4C 1E CF    JMP $CF1E       change buffer

*****************************       read block
D0C3    A9 80       LDA #$80        code for 'read'
D0C5    D0 02       BNE $D0C9

*****************************       write block
D0C7    A9 90       LDA #$90        code for 'write'
D0C9    8D 4D 02    STA $024D       save
D0CC    20 93 DF    JSR $DF93       get buffer number
D0CF    AA          TAX
D0D0    20 06 D5    JSR $D506       get track/sector, read/write blk
D0D3    8A          TXA
D0D4    48          PHA
D0D5    0A          ASL A           buffer pointer times 2
D0D6    AA          TAX
D0D7    A9 00       LDA #$00
D0D9    95 99       STA $99,X       pointer in buffer to zero
D0DB    20 25 D1    JSR $D125       get file type
D0DE    C9 04       CMP #$04        rel-file or direct access?
D0E0    B0 06       BCS $D0E8       yes
D0E2    F6 B5       INC $B5,X
```

```
D0E4    D0 02       BNE $D0E8      increment block counter
D0E6    F6 BB       INC $BB,X
D0E8    68          PLA
D0E9    AA          TAX
D0EA    60          RTS

******************************     open channel for reading
D0EB    A5 83       LDA $83        secondary address
D0ED    C9 13       CMP #$13       19
D0EF    90 02       BCC $D0F3      smaller?
D0F1    29 0F       AND #$0F
D0F3    C9 0F       CMP #$0F
D0F5    D0 02       BNE $D0F9
D0F7    A9 10       LDA #$10       16
D0F9    AA          TAX
D0FA    38          SEC
D0FB    BD 2B 02    LDA $022B,X
D0FE    30 06       BMI $D106
D100    29 0F       AND #$0F
D102    85 82       STA $82
D104    AA          TAX
D105    18          CLC            flag for ok
D106    60          RTS

******************************     open channel for writing
D107    A4 83       LDA $83        secondary address
D109    C9 13       CMP #$13       19
D10B    90 02       BCC $D10F      smaller?
D10D    29 0F       AND #$0F
D10F    AA          TAX
D110    BD 2B 02    LDA $022B,X    channel number
D113    A8          TAY
D114    0A          ASL A
D115    90 0A       BCC $D121
D117    30 0A       BMI $D123
D119    98          TYA
D11A    29 0F       AND #$0F
D11C    85 82       STA $82
D11E    AA          TAX
D11F    18          CLC            flag for ok
D120    60          RTS

D121    30 F6       BMI $D119
D123    38          SEC            flag for channel allocated
D124    60          RTS

******************************     check for file type 'REL'
D125    A6 82       LDX $82
D127    B5 EC       LDA $EC,X
D129    4A          LSR A
D12A    29 07       AND #$07
D12C    C9 04       CMP #$04       'REL'?
D12E    60          RTS

******************************     get buffer and channel numbers
```

```
D12F    20 93 DF   JSR $DF93     get buffer number
D132    0A         ASL A
D133    AA         TAX
D134    A4 82      LDY $82
D136    60         RTS

*****************************    get a byte from buffer
D137    20 2F D1   JSR $D12F     get buffer and channel number
D13A    B9 44 02   LDA $0244,Y   end pointer
D13D    F0 12      BEQ $D151
D13F    A1 99      LDA ($99,X)   get byte from buffer
D141    48         PHA
D142    B5 99      LDA $99,X     buffer pointer
D144    D9 44 02   CMP $0244,Y   equal end pointer?
D147    D0 04      BNE $D14D     no
D149    A9 FF      LDA #$FF
D14B    95 99      STA $99,X     buffer pointer to -1
D14D    68         PLA           data byte
D14E    F6 99      INC $99,X     increment buffer pointer
D150    60         RTS
D151    A1 99      LDA ($99,X)   get character from buffer
D153    F6 99      INC $99,Y     increment buffer pointer
D155    60         RTS

*****************************    get byte and read next block
D156    20 37 D1   JSR $D137     get byte from buffer
D159    D0 36      BNE $D191     not last character?
D15B    85 85      STA $85       save data byte
D15D    B9 44 02   LDA $0244,Y   end pointer
D160    F0 08      BEQ $D16A     yes
D162    A9 80      LDA #$80
D164    99 F2 00   STA $00F2,Y   READ-flag
D167    A5 85      LDA $85       data byte
D169    60         RTS

D16A    20 1E CF   JSR $CF1E     change buffer and read next block
D16D    A9 00      LDA #$00
D16F    20 C8 D4   JSR $D4C8     set buffer pointer to zero
D172    20 37 D1   JSR $D137     get first byte from buffer
D175    C9 00      CMP #$00      track number zero
D177    F0 19      BEQ $D192     yes, then last block
D179    85 80      STA $80       save last track number
D17B    20 37 D1   JSR $D137     get next byte
D17E    85 81      STA $81       save as following track
D180    20 1E CF   JSR $CF1E     change buffer and read next block
D183    20 D3 D1   JSR $D1D3     save drive number
D186    20 D0 D6   JSR $D6D0     param to disk controller
D189    20 C3 D0   JSR $D0C3     transmit read command
D18C    20 1E CF   JSR $CF1E     change buffer and read block
D18F    A5 85      LDA $85       get data byte
D191    60         RTS

D192    20 37 D1   JSR $D137     get next byte from buffer
D195    A4 82      LDY $82
D197    99 44 02   STA $0244,Y   save as end pointer
```

```
D19A   A5 85      LDA $85      get data byte back
D19C   60         RTS
*******************************  byte in buffer and write block
D19D   20 F1 CF   JSR $CFF1    byte in buffer
D1A0   F0 01      BEQ $D1A3    buffer full?
D1A2   60         RTS

D1A3   20 D3 D1   JSR $D1D3    get drive number
D1A6   20 1E F1   JSR $F11E    find free block in BAM
D1A9   A9 00      LDA #$00
D1AB   20 C8 D4   JSR $D4C8    buffer pointer to zero
D1AE   A5 80      LDA $80
D1B0   20 F1 CF   JSR $CFF1    track number as first byte
D1B3   A5 81      LDA $81
D1B5   20 F1 CF   JSR $CFF1    sector number as second byte
D1B8   20 C7 D0   JSR $D0C7    write block
D1BB   20 1E CF   JSR $CF1E    change buffer
D1BE   20 D0 D6   JSR $D6D0    param to disk controller
D1C1   A9 02      LDA #$02
D1C3   4C C8 D4   JMP $D4C8    buffer pointer to 2

*******************************  increment buffer pointer
D1C6   85 6F      STA $6F
D1C8   20 E8 D4   JSR $D4E8    get buffer pointer
D1CB   18         CLC
D1CC   65 6F      ADC $6F
D1CE   95 99      STA $99,X    and increment
D1D0   85 94      STA $94
D1D2   60         RTS

*******************************  get drive number
D1D3   20 93 DF   JSR $DF93    get drive number
D1D6   AA         TAX
D1D7   BD 5B 02   LDA $025B,X
D1DA   29 01      AND #$01     isolate drive number
D1DC   85 7F      STA $7F      and save
D1DE   60         RTS

*******************************  find write channel and buffer
D1DF   38         SEC          flag for writing
D1E0   B0 01      BCS $D1E3

*******************************  find read channel and buffer
D1E2   18         CLC          flag for reading
D1E3   08         PHP          save
D1E4   85 6F      STA $6F      buffer number
D1E6   20 27 D2   JSR $D227    close channel
D1E9   20 7F D3   JSR $D37F    allocate free channel
D1EC   85 82      STA $82      channel number
D1EE   A6 83      LDX $83      secondary address
D1F0   28         PLP
D1F1   90 02      BCC $D1F5    read channel?
D1F3   09 80      ORA #$80     flag for writing
D1F5   9D 2B 02   STA $022B,X  set
D1F8   29 3F      AND #$3F
```

```
D1FA    A8          TAY
D1FB    A9 FF       LDA #$FF        default value
D1FD    99 A7 00    STA $00A7,Y
D200    99 AE 00    STA $00AE,Y     write in associated table
D203    99 CD 00    STA $00CD,Y
D206    C6 6F       DEC $6F         decrement buffer number
D208    30 1C       BMI $D226       done already?
D20A    20 8E D2    JSR $D28E       find buffer
D20D    10 08       BPL $D217       found?
D20F    20 5A D2    JSR $D25A       erase flags in table
D212    A9 70       LDA #$70
D214    4C C8 C1    JMP $C1C8       70, 'no channel'
D217    99 A7 00    STA $00A7,Y     buffer number in table
D21A    C6 6F       DEC $6F         buffer number
D21C    30 08       BMI $D226       already done?
D21E    20 8E D2    JSR $D28E       find buffer
D221    30 EC       BMI $D20F       not found?
D223    99 AE 00    STA $00AE,Y     buffer number in table
D226    60          RTS

*****************************       close channel
D227    A5 83       LDA $83         secondary address
D229    C9 0F       CMP #$0F        15?
D22B    D0 01       BNE $D22E       no
D22D    60          RTS             else done already

D22E    A6 83       LDX $83
D230    BD 2B 02    LDA $022B,X     channel number
D233    C9 FF       CMP #$FF        not associated?
D235    F0 22       BEQ $D259       then done
D237    29 3F       AND #$3F
D239    85 82       STA $82         channel number
D23B    A9 FF       LDA #$FF
D23D    9D 2B 02    STA $022B,X     erase association in table
D240    A6 82       LDX $82
D242    A9 00       LDA #$00
D244    95 F2       STA $F2,X       erase READ and WRITE flag
D246    20 5A D2    JSR $D25A       free buffer
D249    A6 82       LDX $82         channel number
D24B    A9 01       LDA #$01        set bit 0
D24D    CA          DEX
D24E    30 03       BMI $D253       shift to correct position
D250    0A          ASL A
D251    D0 FA       BNE $D24D
D253    0D 56 02    ORA $0256       free in allocation register
D256    8D 56 02    STA $0256
D259    60          RTS

*****************************       free buffer
D25A    A6 82       LDX $82         channel number
D25C    B5 A7       LDA $A7,X       buffer number
D25E    C9 FF       CMP #$FF
D260    F0 09       BEQ $D26B       not associated?
D262    48          PHA
D263    A9 FF       LDA #$FF
```

```
D265    95 A7       STA $A7,X     erase buffer association
D267    68          PLA
D268    20 F3 D2    JSR $D2F3     erase buffer allocation register
D26B    A6 82       LDX $82       channel number
D26D    B5 AE       LDA $AE,X
D26F    C9 FF       CMP #$FF      associated in second table?
D271    F0 09       BEQ $D27C     no
D273    48          PHA
D274    A9 FF       LDA #$FF
D276    95 AE       STA $AE,X     erase association
D278    68          PLA
D279    20 F3 D2    JSR $D2F3     erase buffer in allocation reg.
D27C    A6 82       LDX $82       channel number
D27E    B5 CD       LDA $CD,X
D280    C9 FF       CMP #$FF      associated in 3rd table?
D282    F0 09       BEQ $D28D     no
D284    48          PHA
D285    A9 FF       LDA #$FF
D287    95 CD       STA $CD,X     erase association
D289    68          PLA
D28A    20 F3 D2    JSR $D2F3     erase buffer in allocation reg
D28D    60          RTS

******************************   find buffer
D28E    98          TYA
D28F    48          PHA
D290    A0 01       LDY #$01
D292    20 BA D2    JSR $D2BA
D295    10 0C       BPL $D2A3
D297    88          DEY
D298    20 BA D2    JSR $D2BA
D29B    10 06       BPL $D2A3
D29D    20 39 D3    JSR $D339
D2A0    AA          TAX
D2A1    30 13       BMI $D2B6
D2A3    B5 00       LDA $00,X
D2A5    30 FC       BMI $D2A3
D2A7    A5 7F       LDA $7F
D2A9    95 00       STA $00,X
D2AB    9D 5B 02    STA $025B,X
D2AE    8A          TXA
D2AF    0A          ASL A
D2B0    A8          TAY
D2B1    A9 02       LDA #$02
D2B3    99 99 00    STA $0099,Y
D2B6    68          PLA
D2B7    A8          TAY
D2B8    8A          TXA
D2B9    60          RTS

D2BA    A2 07       LDX #$07
D2BC    B9 4F 02    LDA $024F,Y
D2BF    3D E9 EF    AND $EFE9,Y   erase bit
D2C2    F0 04       BEQ $D2C8
D2C4    CA          DEX
```

```
D2C5    10 F5       BPL $D2BC
D2C7    60          RTS

D2C8    B9 4F 02    LDA $024F,Y
D2CB    5D E9 EF    EOR $EFE9,X    rotate bit
D2CE    99 4F 02    STA $024F,Y
D2D1    8A          TXA            buffer number
D2D2    88          DEY
D2D3    30 03       BMI $D2D8
D2D5    18          CLC
D2D6    69 08       ADC #$08
D2D8    AA          TAX            buffer number
D2D9    60          RTS
D2DA    A6 82       LDX $82
D2DC    B5 A7       LDA $A7,X
D2DE    30 09       BMI $D2E9
D2E0    8A          TXA
D2E1    18          CLC
D2E2    69 07       ADC #$07
D2E4    AA          TAX
D2E5    B5 A7       LDA $A7,X
D2E7    10 F0       BPL $D2D9
D2E9    C9 FF       CMP #$FF
D2EB    F0 EC       BEQ $D2D9
D2ED    48          PHA
D2EE    A9 FF       LDA #$FF
D2F0    95 A7       STA $A7,X
D2F2    68          PLA
D2F3    29 0F       AND #$0F
D2F5    A8          TAY            buffer number
D2F6    C8          INY
D2F7    A2 10       LDX #$10       16
D2F9    6E 50 02    ROR $0250
D2FC    6E 4F 02    ROR $024F      rotate 16-bit allocation reg.
D2FF    88          DEY
D300    D0 01       BNE $D303
D302    18          CLC            erase bit for buffer
D303    CA          DEX
D304    10 F3       BPL $D2F9
D306    60          RTS

******************************     close all channels
D307    A9 0E       LDA #$0E       14
D309    85 83       STA $83        secondary address
D30B    20 27 D2    JSR $D227      close channel
D30E    C6 83       DEC $83        next secondary address
D310    D0 F9       BNE $D30B
D312    60          RTS

******************************     close channels of other drives
D313    A9 0E       LDA #$0E       14
D315    85 83       STA $83        secondary address
D317    A6 83       LDX $83
D319    BD 2B 02    LDA $022B,X    association table
D31C    C9 FF       CMP #$FF       channel associated?
```

```
D31E    F0 14       BEQ $D334      no
D320    29 3F       AND #$3F
D322    85 82       STA $82        channel number
D324    20 93 DF    JSR $DF93      get buffer number
D327    AA          TAX
D328    BD 5B 02    LDA $025B,X    drive number
D32B    29 01       AND #$01       isolate
D32D    C5 7F       CMP $7F        equal to actual drive number
D32F    D0 03       BNE $D334      no
D331    20 27 D2    JSR $D227      close channel
D334    C6 83       DEC $83        next channel
D336    10 DF       BPL $D317
D338    60          RTS

******************************
D339    A5 6F       LDA $6F
D33B    48          PHA
D33C    A0 00       LDY #$00
D33E    B6 FA       LDX $FA,Y
D340    B5 A7       LDA $A7,X
D342    10 04       BPL $D348
D344    C9 FF       CMP #$FF
D346    D0 16       BNE $D35E
D348    8A          TXA
D349    18          CLC
D34A    69 07       ADC #$07
D34C    AA          TAX
D34D    B5 A7       LDA $A7,X
D34F    10 04       BPL $D355
D351    C9 FF       CMP #$FF
D353    D0 09       BNE $D35E
D355    C8          INY
D356    C0 05       CPY #$05
D358    90 E4       BCC $D33E
D35A    A2 FF       LDX #$FF
D35C    D0 1C       BNE $D37A
D35E    86 6F       STX $6F
D360    29 3F       AND #$3F
D362    AA          TAX
D363    B5 00       LDA $00,X
D365    30 FC       BMI $D363
D367    C9 02       CMP #$02
D369    90 08       BCC $D373
D36B    A6 6F       LDX $6F
D36D    E0 07       CPX #$07
D36F    90 D7       BCC $D348
D371    B0 E2       BCS $D355

D373    A4 6F       LDY $6F
D375    A9 FF       LDA #$FF
D377    99 A7 00    STA $00A7,Y
D37A    68          PLA
D37B    85 6F       STA $6F
D37D    8A          TXA
D37E    60          RTS
```

```
******************************  find channel and allocate
D37F    A0 00       LDY #$00
D381    A9 01       LDA #$01        set bit 0
D383    2C 56 02    BIT $0256
D386    D0 09       BNE $D391       channel free?
D388    C8          INY
D389    0A          ASL A           rotate bit to left
D38A    D0 F7       BNE $D383       all channels checked?
D38C    A9 70       LDA #$70
D38E    4C C8 C1    JMP $C1C8       70, 'no channel'

D391    49 FF       EOR #$FF        rotate bit model
D393    2D 56 02    AND $0256       erase bit
D396    8D 56 02    STA $0256       allocate channel
D399    98          TYA
D39A    60          RTS

******************************  get byte for output
D39B    20 EB D0    JSR $D0EB       open channel for reading
D39E    20 00 C1    JSR $C100       turn LED on
D3A1    20 AA D3    JSR $D3AA       get byte in output register
D3A4    A6 82       LDX $82         channel number
D3A6    BD 3E 02    LDA $023E,X     get byte
D3A9    60          RTS

D3AA    A6 82       LDX $82         channel number
D3AC    20 25 D1    JSR $D125       check file type
D3AF    D0 03       BNE $D3B4       no rel-file?
D3B1    4C 20 E1    JMP $E120       get byte from rel-file

D3B4    A5 83       LDA $83         secondary address
D3B6    C9 0F       CMP #$0F        15
D3B8    F0 5A       BEQ $D414       yes, read error channel
D3BA    B5 F2       LDA $F2,X
D3BC    29 08       AND #$08        end flag set?
D3BE    D0 13       BNE $D3D3       no
D3C0    20 25 D1    JSR $D125       check file type
D3C3    C9 07       CMP #$07        direct access file?
D3C5    D0 07       BNE $D3CE       no
D3C7    A9 89       LDA #$89        set READ and WRITE flag
D3C9    95 F2       STA $F2,X
D3CB    4C DE D3    JMP $D3DE

D3CE    A9 00       LDA #$00
D3D0    95 F2       STA $F2,X       erase READ and WRITE flag
D3D2    60          RTS

D3D3    A5 83       LDA $83         secondary address
D3D5    F0 32       BEQ $D409       zero, LOAD?
D3D7    20 25 D1    JSR $D125       check file type
D3DA    C9 04       CMP #$04        rel-file or direct access?
D3DC    90 22       BCC $D400       no
D3DE    20 2F D1    JSR $D12F       get buffer and channel number
D3E1    B5 99       LDA $99,X       buffer pointer
```

```
D3E3    D9 44 02    CMP $0244,Y     equal end pointer?
D3E6    D0 04       BNE $D3EC       no
D3E8    A9 00       LDA #$00
D3EA    95 99       STA $99,X       buffer pointer to zero
D3EC    F6 99       INC $99,X       increment buffer pointer
D3EE    A1 99       LDA ($99,X)     get byte from buffer
D3F0    99 3E 02    STA $023E,Y     into output register
D3F3    B5 99       LDA $99,X       buffer pointer
D3F5    D9 44 02    CMP $0244,Y     equal end pointer?
D3F8    D0 05       BNE $D3FF       no
D3FA    A9 81       LDA #$81
D3FC    99 F2 00    STA $00F2,Y     set flags
D3FF    60          RTS

D400    20 56 D1    JSR $D156       get byte from buffer
D403    A6 82       LDX $82         channel number
D405    9D 3E 02    STA $023E,X     byte in output register
D408    60          RTS

D409    AD 54 02    LDA $0254       flag for directory?
D40C    F0 F2       BEQ $D400       no
D40E    20 67 ED    JSR $ED67       create directory line
D411    4C 03 D4    JMP $D403

D414    20 E8 D4    JSR $D4E8       set buffer pointer
D417    C9 D4       CMP #$D4
D419    D0 18       BNE $D433
D41B    A5 95       LDA $95
D41D    C9 02       CMP #$02
D41F    D0 12       BNE $D433
D421    A9 0D       LDA #$0D        CR
D423    85 85       STA $85         in output register
D425    20 23 C1    JSR $C123       erase error flags
D428    A9 00       LDA #$00
D42A    20 C1 E6    JSR $E6C1       create 'ok' message
D42D    C6 A5       DEC $A5         set buffer pointer back
D42F    A9 80       LDA #$80        set READ flag
D431    D0 12       BNE $D445

D433    20 37 D1    JSR $D137       get byte from buffer
D436    85 85       STA $85         into output register
D438    D0 09       BNE $D443
D43A    A9 D4       LDA #$D4
D43C    20 C8 D4    JSR $D4C8       set buf ptr in front of error ptr
D43F    A9 02       LDA #$02
D441    95 9A       STA $9A,X       hi-address
D443    A9 88       LDA #$88        set READ flag
D445    85 F7       STA $F7
D447    A5 85       LDA $85         data byte
D449    8D 43 02    STA $0243       into output register
D44C    60          RTS

********************************    read next block
D44D    20 93 DF    JSR $DF93       get buffer number
D450    0A          ASL A           times 2
```

```
D451   AA          TAX
D452   A9 00       LDA #$00
D454   95 99       STA $99,X      buffer pointer to zero
D456   A1 99       LDA ($99,X)    get first byte from buffer
D458   F0 05       BEQ $D45F      no block following?
D45A   D6 99       DEC $99,X      buffer pointer to -1
D45C   4C 56 D1    JMP $D156      read next block
D45F   60          RTS

******************************    read block
D460   A9 80       LDA #$80       command code for reading
D462   D0 02       BNE $D466

******************************    write block
D464   A9 90       LDA #$90       command code for writing
D466   05 7F       ORA $7F        drive number
D468   8D 4D 02    STA $024D      save code
D46B   A5 F9       LDA $F9
D46D   20 D3 D6    JSR $D6D3      param to disk controller
D470   A6 F9       LDX $F9
D472   4C 93 D5    JMP $D593      execute command

******************************    allocate buffer and read block
D475   A9 01       LDA #$01
D477   8D 4A 02    STA $024A      file type to sequential
D47A   A9 11       LDA #$11       17
D47C   85 83       STA $83        secondary address
D47E   20 46 DC    JSR $DC46      allocate buffer and read block
D481   A9 02       LDA #$02
D483   4C C8 D4    JMP $D4C8      buffer pointer to 2

******************************    allocate new block
D486   A9 12       LDA #$12       18
D488   85 83       STA $83        secondary address
D48A   4C DA DC    JMP $DCDA      allocate new block

******************************    write directory block
D48D   20 3B DE    JSR $DE3B      get track and sector number
D490   A9 01       LDA #$01
D492   85 6F       STA $6F        a block
D494   A5 69       LDA $69        save step width 10 for block
D496   48          PHA            allocation
D497   A9 03       LDA #$03
D499   85 69       STA $69
D49B   20 2D F1    JSR $F12D      find free block in BAM
D49E   68          PLA
D49F   85 69       STA $69        get step width back
D4A1   A9 00       LDA #$00
D4A3   20 C8 D4    JSR $D4C8      buffer pointer to zero
D4A6   A5 80       LDA $80
D4A8   20 F1 CF    JSR $CFF1      track number in buffer
D4AB   A5 81       LDA $81
D4AD   20 F1 CF    JSR $CFF1      sector number in buffer
D4B0   20 C7 D0    JSR $D0C7      write block to disk
D4B3   20 99 D5    JSR $D599      and verify
```

```
D4B6    A9 00       LDA #$00
D4B8    20 C8 D4    JSR $D4C8       buffer pointer to zero
D4BB    20 F1 CF    JSR $CFF1       fill buffer with zeroes
D4BE    D0 FB       BNE $D4BB
D4C0    20 F1 CF    JSR $CFF1       zero as following track
D4C3    A9 FF       LDA #$FF
D4C5    4C F1 CF    JMP $CFF1       $FF as number of bytes

******************************      set buffer pointer
D4C8    85 6F       STA $6F         save pointer
D4CA    20 93 DF    JSR $DF93       get buffer number
D4CD    0A          ASL A           times 2
D4CE    AA          TAX
D4CF    B5 9A       LDA $9A,X       buffer pointer hi
D4D1    85 95       STA $95
D4D3    A5 6F       LDA $6F
D4D5    95 99       STA $99,X       buffer pointer lo, new value
D4D7    85 94       STA $94
D4D9    60          RTS

******************************      close internal channel
D4DA    A9 11       LDA #$11        17
D4DC    85 83       STA $83
D4DE    20 27 D2    JSR $D227       close channel
D4E1    A9 12       LDA #$12        18
D4E3    85 83       STA $83
D4E5    4C 27 D2    JMP $D227       close channel

******************************      set buffer pointer
D4E8    20 93 DF    JSR $DF93       get buffer number
D4EB    0A          ASL A
D4EC    AA          TAX
D4ED    B5 9A       LDA $9A,X       buffer pointer hi
D4EF    85 95       STA $95
D4F1    B5 99       LDA $99,X       buffer pointer lo
D4F3    85 94       STA $94
D4F5    60          RTS

******************************      get byte from buffer
D4F6    85 71       STA $71         pointer lo
D4F8    20 93 DF    JSR $DF93       get buffer number
D4FB    AA          TAX
D4FC    BD E0 FE    LDA $FEE0,X     hi-byte buffer address
D4FF    85 72       STA $72         pointer hi
D501    A0 00       LDY #$00
D503    B1 71       LDA ($71),Y     get byte from buffer
D505    60          RTS

******************************      check track and sector numbers
D506    BD 5B 02    LDA $025B,X     command code for disk controller
D509    29 01       AND #$01        drive number
D50B    0D 4D 02    ORA $024D       plus command code
D50E    A8          PHA             save
D50F    86 F9       STX $F9         buffer number
D511    8A          TXA
```

```
D512    0A         ASL A        times 2
D513    AA         TAX
D514    B5 07      LDA $07,X    sector
D516    8D 4D 02   STA $024D    save
D519    B5 06      LDA $06,X    track
D51B    F0 2D      BEQ $D54A    66, 'illegal track or sector'
D51D    CD D7 FE   CMP $FED7    36, highest track number + 1
D520    B0 28      BCS $D54A    66, 'illegal track or sector'
D522    AA         TAX
D523    68         PLA          command code
D524    48         PHA
D525    29 F0      AND #$F0
D527    C9 90      CMP #$90     code for writing?
D529    D0 4F      BNE $D57A    no
D52B    68         PLA
D52C    48         PHA
D52D    4A         LSR A
D52E    B0 05      BCS $D535
D530    AD 01 01   LDA $0101
D533    90 03      BCC $D538
D535    AD 02 01   LDA $0102
D538    F0 05      BEQ $D53F
D53A    CD D5 FE   CMP $FED5    'A', format marker
D53D    D0 33      BNE $D572    73, 'cbm dos v2.6 1541'
D53F    8A         TXA          track number
D540    20 4B F2   JSR $F24B    get maximum sector number
D543    CD 4D 02   CMP $024D    compare with sector number
D546    F0 02      BEQ $D54A    equal, then error
D548    B0 30      BCS $D57A    smaller?
D54A    20 52 D5   JSR $D552    get track and sector number
D54D    A9 66      LDA #$66
D54F    4C 45 E6   JMP $E645    66, 'illegal track or sector'

******************************  get track and sector number
D552    A5 F9      LDA $F9      buffer number
D554    0A         ASL A        *2
D555    AA         TAX          as index
D556    B5 06      LDA $06,X
D558    85 80      STA $80      track
D55A    B5 07      LDA $07,X
D55C    85 81      STA $81      sector
D55E    60         RTS

D55F    A5 80      LDA $80      track
D561    F0 EA      BEQ $D54D    zero, then error
D563    CD D7 FE   CMP $FED7    36, maximum track number + 1
D566    B0 E5      BCS $D54D    66, 'illegal track or sector'
D568    20 4B F2   JSR $F24B    get maximum sector number
D56B    C5 81      CMP $81      sector
D56D    F0 DE      BEQ $D54D
D56F    90 DC      BCC $D54D    error
D571    60         RTS

D572    20 52 D5   JSR $D552    get track and sector number
D575    A9 73      LDA #$73
```

```
D577   4C 45 E6   JMP $E645      73, 'cbm dos v2.6 1541'

D57A   A6 F9      LDX $F9        buffer number
D57C   68         PLA
D57D   8D 4D 02   STA $024D      command code for disk controller
D580   95 00      STA $00,X      in command register
D582   9D 5B 02   STA $025B,X    and write in table
D585   60         RTS

*******************************  read block
D586   A9 80      LDA #$80       code for read
D588   D0 02      BNE $D58C

*******************************  write block
D58A   A9 90      LDA #$90       code for write
D58C   05 7F      ORA $7F        drive number
D58E   A6 F9      LDX $F9        buffer number
D590   8D 4D 02   STA $024D
D593   AD 4D 02   LDA $024D      command code
D596   20 0E D5   JSR $D50E      check track and sector

*******************************  verify execution
D599   20 A6 D5   JSR $D5A6      verify execution
D59C   B0 FB      BCS $D599      wait for end
D59E   48         PHA
D59F   A9 00      LDA #$00
D5A1   8D 98 02   STA $0298      erase error flag
D5A4   68         PLA
D5A5   60         RTS

D5A6   B5 00      LDA $00,X      cmd code (bit 7) still in reg?
D5A8   30 1A      BMI $D5C4      yes
D5AA   C9 02      CMP #$02
D5AC   90 14      BCC $D5C2      error-free execution
D5AE   C9 08      CMP #$08       8
D5B0   F0 08      BEQ $D5BA      write protect
D5B2   C9 0B      CMP #$0B       11
D5B4   F0 04      BEQ $D5BA      ID mismatch
D5B6   C9 0F      CMP #$0F       15
D5B8   D0 0C      BNE $D5C6
D5BA   2C 98 02   BIT $0298
D5BD   30 03      BMI $D5C2
D5BF   4C 3F D6   JMP $D63F      create error message
D5C2   18         CLC            execution ended
D5C3   60         RTS

D5C4   38         SEC            execution not yet ended
D5C5   60         RTS

D5C6   98         TYA
D5C7   48         PHA
D5C8   A5 7F      LDA $7F        drive number
D5CA   48         PHA
D5CB   BD 5B 02   LDA $025B,X
```

```
D5CE   29 01      AND #$01     drive number
D5D0   85 7F      STA $7F
D5D2   A8         TAY
D5D3   B9 CA FE   LDA $FECA,Y  bit model for drive
D5D6   8D 6D 02   STA $026D
D5D9   20 A6 D6   JSR $D6A6    read attempt
D5DC   C9 02      CMP #$02
D5DE   B0 03      BCS $D5E3    not ok?
D5E0   4C 6D D6   JMP $D66D    done
D5E3   BD 5B 02   LDA $025B,X  command code
D5E6   29 F0      AND #$F0     isolate
D5E8   48         PHA
D5E9   C9 90      CMP #$90     code for write
D5EB   D0 07      BNE $D5F4    no
D5ED   A5 7F      LDA $7F      drive number
D5EF   09 B8      ORA #$B8
D5F1   9D 5B 02   STA $025B,X
D5F4   24 6A      BIT $6A
D5F6   70 39      BVS $D631
D5F8   A9 00      LDA #$00
D5FA   8D 99 02   STA $0299    cntr for searches next to track
D5FD   8D 9A 02   STA $029A
D600   AC 99 02   LDY $0299    counter
D603   AD 9A 02   LDA $029A
D606   38         SEC
D607   F9 DB FE   SBC $FEDB,Y  constants for read attempts
D60A   8D 9A 02   STA $029A
D60D   B9 DB FE   LDA $FEDB,Y
D610   20 76 D6   JSR $D676    position head next to track
D613   EE 99 02   INC $0299    increment counter
D616   20 A6 D6   JSR $D6A6    read atempt
D619   C9 02      CMP #$02     return message
D61B   90 08      BCC $D625    smaller than 2, ok?
D61D   AC 99 02   LDY $0299    load counter
D620   B9 DB FE   LDA $FEDB,Y  get constants
D623   D0 DB      BNE $D600    not yet zero (table end)?
D625   AD 9A 02   LDA $029A
D628   20 76 D6   JSR $D676    position head
D62B   B5 00      LDA $00,X
D62D   C9 02      CMP #$02     return message
D62F   90 2B      BCC $D65C    ok?
D631   24 6A      BIT $6A
D633   10 0F      BPL $D644
D635   68         PLA          command code
D636   C9 90      CMP #$90     for writing?
D638   D0 05      BNE $D63F    no
D63A   05 7F      ORA $7F      drive number
D63C   9D 5B 02   STA $025B,X  command code in table
D63F   B5 00      LDA $00,X    return message
D641   20 0A E6   JSR $E60A    set error message
D644   68         PLA
D645   2C 98 02   BIT $0298
D648   30 23      BMI $D66D
D64A   48         PHA
D64B   A9 C0      LDA #$C0     command code for head positioning
```

```
D64D    05 7F       ORA $7F         drive number
D64F    95 00       STA $00,X       in command register
D651    B5 00       LDA $00,X
D653    30 FC       BMI $D651       wait for execution
D655    20 A6 D6    JSR $D6A6       attempt command execution again
D658    C9 02       CMP #$02        return message
D65A    B0 D9       BCS $D635       incorrect?
D65C    68          PLA
D65D    C9 90       CMP #$90        command code for writing
D65F    D0 0C       BNE $D66D       no
D661    05 7F       ORA $7F         drive number
D663    9D 5B 02    STA $025B,X     in table
D666    20 A6 D6    JSR $D6A6       attempt execution again
D669    C9 02       CMP #$02        return message
D66B    B0 D2       BCS $D63F       error?
D66D    68          PLA
D66E    85 7F       STA $7F         get drive number back
D670    68          PLA
D671    A8          TAY
D672    B5 00       LDA $00,X       error code
D674    18          CLC             end-of-execution flag
D675    60          RTS

D676    C9 00       CMP #$00
D678    F0 18       BEQ $D692
D67A    30 0C       BMI $D688
D67C    A0 01       LDY #$01
D67E    20 93 D6    JSR $D693       transmit data for head position
D681    38          SEC
D682    E9 01       SBC #$01
D684    D0 F6       BNE $D67C
D686    F0 0A       BEQ $D692

D688    A0 FF       LDY #$FF
D68A    20 93 D6    JSR $D693       transmit data for head position
D68D    18          CLC
D68E    69 01       ADC #$01
D690    D0 F6       BNE $D688
D692    60          RTS

D693    48          PHA
D694    98          TYA
D695    A4 7F       LDY $7F         drive number
D697    99 FE 02    STA $02FE,Y
D69A    D9 FE 02    CMP $02FE,Y     wait for return message from
D69D    F0 FB       BEQ $D69A
D69F    A9 00       LDA #$00        disk controller
D6A1    99 FE 02    STA $02FE,Y
D6A4    68          PLA
D6A5    60          RTS

D6A6    A5 6A       LDA $6A         maximum number of repetitions
D6A8    29 3F       AND #$3F
D6AA    A8          TAY
D6AB    AD 6D 02    LDA $026D       bit for LED
```

```
D6AE    4D 00 1C    EOR $1C00
D6B1    8D 00 1C    STA $1C00
D6B4    BD 5B 02    LDA $025B,X    command
D6B7    95 00       STA $00,X      transmit to disk controller
D6B9    B5 00       LDA $00,X      and return message
D6BB    30 FC       BMI $D6B9      wait
D6BD    C9 02       CMP #$02       ok?
D6BF    90 03       BCC $D6C4      yes
D6C1    88          DEY            decrement counter
D6C2    D0 E7       BNE $D6AB      attempt again
D6C4    48          PHA
D6C5    AD 6D 02    LDA $026D
D6C8    0D 00 1C    ORA $1C00      LED off
D6CB    8D 00 1C    STA $1C00
D6CE    68          PLA
D6CF    60          RTS

******************************     transmit param to disk controller
D6D0    20 93 DF    JSR $DF93      get buffer number
D6D3    0A          ASL A
D6D4    A8          TAY
D6D5    A5 80       LDA $80        track number
D6D7    99 06 00    STA $0006,Y    transmit
D6DA    A5 81       LDA $81        sector number
D6DC    99 07 00    STA $0007,Y    transmit
D6DF    A5 7F       LDA $7F        drive number
D6E1    0A          ASL            times 2
D6E2    AA          TAX
D6E3    60          RTS

******************************     enter file in directory
D6E4    A5 83       LDA $83        secondary address
D6E6    48          PHA
D6E7    A5 82       LDA $82        channel number
D6E9    48          PHA
D6EA    A5 81       LDA $81        sector number
D6EC    48          PHA
D6ED    A5 80       LDA $80        track number
D6EF    48          PHA            save
D6F0    A9 11       LDA #$11
D6F2    85 83       STA $83        secondary address 17
D6F4    20 3B DE    JSR $DE3B      get track and sector number
D6F7    AD 4A 02    LDA $024A      file type
D6FA    48          PHA            save
D6FB    A4 E2       LDA $E2        drive number
D6FD    29 01       AND #$01
D6FF    85 7F       STA $7F        set
D701    A6 F9       LDX $F9        buffer number
D703    5D 5B 02    EOR $025B,X
D706    4A          LSR A
D707    90 0C       BCC $D715      equal drive number?
D709    A2 01       LDX #$01
D70B    8E 92 02    STX $0292      pointer in directory
D70E    20 AC C5    JSR $C5AC      load dir and find first entry
D711    F0 1D       BEQ $D730      not found?
```

```
D713    D0 28      BNE $D73D      found?

D715    AD 91 02   LDA $0291      sector number in directory
D718    F0 0C      BEQ $D726      equal zero
D71A    C5 81      CMP $81        equal sector number?
D71C    F0 1F      BEQ $D73D      yes
D71E    85 81      STA $81        save sector number
D720    20 60 D4   JSR $D460      read block
D723    4C 3D D7   JMP $D73D

D726    A9 01      LDA #$01
D728    8D 92 02   STA $0292      pointer to one
D72B    20 17 C6   JSR $C617      find next entry in directory
D72E    D0 0D      BNE $D73D      found?
D730    20 8D D4   JSR $D48D      write directory block
D733    A5 81      LDA $81        sector number
D735    8D 91 02   STA $0291
D738    A9 02      LDA #$02
D73A    8D 92 02   STA $0292      pointer to 2
D73D    AD 92 02   LDA $0292
D740    20 C8 D4   JSR $D4C8      set buffer pointer
D743    68         PLA
D744    8D 4A 02   STA $024A      file type
D747    C9 04      CMP #$04       rel-file?
D749    D0 02      BNE $D74D      no
D74B    09 80      ORA #$80       set bit 7
D74D    20 F1 CF   JSR $CFF1      and write in buffer
D750    68         PLA
D751    8D 80 02   STA $0280      following track
D754    20 F1 CF   JSR $CFF1      in buffer
D757    68         PLA
D758    8D 85 02   STA $0285      following sector
D75B    20 F1 CF   JSR $CFF1      in buffer
D75E    20 93 DF   JSR $DF93      get buffer number
D761    A8         TAY
D762    AD 7A 02   LDA $027A      pointer to drive number
D765    AA         TAX
D766    A9 10      LDA #$10       16, length of filename
D768    20 6E C6   JSR $C66E      write filename in buffer
D76B    A0 10      LDY #$10
D76D    A9 00      LDA #$00
D76F    91 94      STA ($94),Y    fill with zeroes at pos 16
D771    C8         INY
D772    C0 1B      CPY #$1B       position 27 already?
D774    90 F9      BCC $D76F      no
D776    AD 4A 02   LDA $024A      file type
D779    C9 04      CMP #$04       rel-file
D77B    D0 13      BNE $D790      no
D77D    A0 10      LDY #$10
D77F    AD 59 02   LDA $0259      track
D782    91 94      STA ($94),Y
D784    C8         INY
D785    AD 5A 02   LDA $025A      and sector
D788    91 94      STA ($94),Y    the side-sectors in dir entry
D78A    C8         INY
```

```
D78B    AD 58 02    LDA $0258      record length
D78E    91 94       STA ($94),Y    in directory
D790    20 64 D4    JSR $D464      write block
D793    68          PLA
D794    85 82       STA $82        channel number
D796    AA          TAX
D797    68          PLA
D798    85 83       STA $83        secondary address
D79A    AD 91 02    LDA $0291
D79D    85 D8       STA $D8
D79F    9D 60 02    STA $0260,X
D7A2    AD 92 02    LDA $0292
D7A5    85 DD       STA $DD
D7A7    9D 66 02    STA $0266,X
D7AA    AD 4A 02    LDA $024A      file type
D7AD    85 E7       STA $E7
D7AF    A5 7F       LDA $7F        drive number
D7B1    85 E2       STA $E2
D7B3    60          RTS

******************************     OPEN command, secondary adr <> 15
D7B4    A5 83       LDA $83        secondary address
D7B6    8D 4C 02    STA $024C
D7B9    20 B3 C2    JSR $C283      get line length, erase flags
D7BC    8E 2A 02    STX $022A
D7BF    AE 00 02    LDX $0200      first character from buffer
D7C2    AD 4C 02    LDA $024C      secondary address
D7C5    D0 2C       BNE $D7F3      not equal 0 (LOAD)?
D7C7    E0 2A       CPX #$2A       '*'
D7C9    D0 28       BNE $D7F3
D7CB    A5 7E       LDA $7E        last track number
D7CD    F0 4D       BEQ $D81C
D7CF    85 80       STA $80        track number
D7D1    AD 6E 02    LDA $026E      last drive number
D7D4    85 7F       STA $7F        drive number
D7D6    85 E2       STA $E2
D7D8    A9 02       LDA #$02
D7DA    85 E7       STA $E7        set data type to program
D7DC    AD 6F 02    LDA $026F      last sector number
D7DF    85 81       STA $81        sector
D7E1    20 00 C1    JSR $C100      turn LED on
D7E4    20 46 DC    JSR $DC46      allocate buffer, read block
D7E7    A9 04       LDA #$04       file type
D7E9    05 7F       ORA $7F        drive number
D7EB    A6 82       LDX $82        channel number
D7ED    99 EC 00    STA $00EC,Y    set flag
D7F0    4C 94 C1    JMP $C194      done

D7F3    E0 24       CPX #$24       '$'
D7F5    D0 1E       BNE $D815      no
D7F7    AD 4C 02    LDA $024C      secondary address
D7FA    D0 03       BNE $D7FF      not equal to zero?
D7FC    4C 55 DA    JMP $DA55      OPEN $

D7FF    20 D1 C1    JSR $C1D1      analyze line to end
```

```
D802   AD 85 FE   LDA $FE85    18, directory track
D805   85 80      STA $80      track
D807   A9 00      LDA #$00
D809   85 81      STA $81      sector 0
D80B   20 46 DC   JSR $DC46    allocate buffer, read block
D80E   A5 7F      LDA $7F      drive number
D810   09 02      ORA #$02
D812   4C EB D7   JMP $D7EB    continue as above

D815   E0 23      CPX #$23     '#'
D817   D0 12      BNE $D82B
D819   4C 84 CB   JMP $CB84    open direct access file

D81C   A9 02      LDA #$02
D81E   8D 96 02   STA $0296    file type program
D821   A9 00      LDA #$00
D823   85 7F      STA $7F      drive 0
D825   8D 8E 02   STA $028E
D828   20 42 D0   JSR $D042    load BAM
D82B   20 E5 C1   JSR $C1E5    analyze line
D82E   D0 04      BNE $D834    colon found?
D830   A2 00      LDX #$00
D832   F0 0C      BEQ $D840
D834   8A         TXA          comma found?
D835   F0 05      BEQ $D83C    no
D837   A9 30      LDA #$30
D839   4C C8 C1   JMP $C1C8    30, 'syntax error'

D83C   88         DEY
D83D   F0 01      BEQ $D840
D83F   88         DEY
D840   8C 7A 02   STY $027A    pointer to drive number
D843   A9 8D      LDA #$8D     shift CR
D845   20 68 C2   JSR $C268    analyze line to end
D848   E8         INX
D849   8E 78 02   STX $0278    comma counter
D84C   20 12 C3   JSR $C312    get drive number
D84F   20 CA C3   JSR $C3CA    check drive number
D852   20 9D C4   JSR $C49D    find file entry in directory
D855   A2 00      LDX #$00     default values
D857   8E 58 02   STX $0258    record length
D85A   8E 97 02   STX $0297
D85D   8E 4A 02   STX $024A    file type
D860   E8         INX
D861   EC 77 02   CPX $0277    comma before equal sign?
D864   B0 10      BCS $D876    no
D866   20 09 DA   JSR $DA09    get file type and control mode
D869   E8         INX
D86A   EC 77 02   CPX $0277    additional comma?
D86D   B0 07      BCS $D876    no
D86F   C0 04      CPY #$04
D871   F0 3E      BEQ $D8B1
D873   20 09 DA   JSR $DA09    get file type and control method
D876   AE 4C 02   LDX $024C
D879   86 83      STX $83      secondary address
```

```
D87B    E0 02       CPX #$02        greater than 2?
D87D    B0 12       BCS $D891       yes
D87F    8E 97 02    STX $0297       0 or 1 (LOAD or SAVE)
D882    A9 40       LDA #$40
D884    8D F9 02    STA $02F9
D887    AD 4A 02    LDA $024A       file type
D88A    D0 1B       BNE $D8A7       not deleted
D88C    A9 02       LDA #$02        PRG
D88E    8D 4A 02    STA $024A       as file type
D891    AD 4A 02    LDA $024A
D894    D0 11       BNE $D8A7
D896    A5 E7       LDA $E7
D898    29 07       AND #$07        get file type and command line
D89A    8D 4A 02    STA $024A
D89D    AD 80 02    LDA $0280       track number
D8A0    D0 05       BNE $D8A7       not equal zero?
D8A2    A9 01       LDA #$01
D8A4    8D 4A 02    STA $024A       file type sequential
D8A7    AD 97 02    LDA $0297       control method
DBAA    C9 01       CMP #$01        'W'
DBAC    F0 18       BEQ $D8C6       yes
D8AE    4C 40 D9    JMP $D940

D8B1    BC 7A 02    LDY $027A,X     pointer behind second comma
D8B4    B9 00 02    LDA $0200,Y     get value
D8B7    8D 5B 02    STA $025B       record length
D8BA    AD 80 02    LDA $0280       track number
D8BD    D0 B7       BNE $D876
D8BF    A9 01       LDA #$01        'W'
D8C1    8D 97 02    STA $0297       as control method
D8C4    D0 B0       BNE $D876

D8C6    A5 E7       LDA $E7         file type
D8C8    29 80       AND #$80        isolate wildcard flag
D8CA    AA          TAX
D8CB    D0 14       BNE $D8E1       wildcard in name
D8CD    A9 20       LDA #$20
D8CF    24 E7       BIT $E7         was file closed?
D8D1    F0 06       BEQ $D8D9       yes
D8D3    20 B6 C8    JSR $C8B6       byte 0 in buffer and write block
D8D6    4C E3 D9    JMP $D9E3

D8D9    A9 80 02    LDA $0280       track number of the first block
D8DC    D0 03       BNE $D8E1       already existing
D8DE    4C E3 D9    JMP $D9E3
D8E1    AD 00 02    LDA $0200       first character from input buffer
D8E4    C9 40       CMP #$40        '@'?
D8E6    F0 0D       BEQ $D8F5       yes
D8E8    8A          TXA
D8E9    D0 05       BNE $D8F0       wildcard set?
D8EB    A9 63       LDA #$63
D8ED    4C C8 C1    JMP $C1C8       63, 'file exists'
D8F0    A9 33       LDA #$33
D8F2    4C C8 C1    JMP $C1C8       33, 'syntax error'
```

```
********************************   open a file with overwriting
D8F5   A5 E7      LDA $E7          file type
D8F7   29 07      AND #$07         isolate
D8F9   CD 4A 02   CMP $024A
D8FC   D0 67      BNE $D965        file type different?
D8FE   C9 04      CMP #$04         rel-file?
D900   F0 63      BEQ $D965        64, 'file type mismatch'
D902   20 DA DC   JSR $DCDA
D905   A5 82      LDA $82
D907   8D 70 02   STA $0270        save channel number
D90A   A9 11      LDA #$11
D90C   20 EB D0   JSR $D0EB        open read channel
D911   AD 94 02   LDA $0294
D914   20 C8 D4   JSR $D4C8        set buffer pointer for directory
D917   A0 00      LDY #$00
D919   B1 94      LDA ($94),Y      file type
D91B   09 20      ORA #$20         set bit 5, open file
D91D   91 94      STA ($94),Y
D91F   A0 1A      LDY #$1A
D921   A5 80      LDA $80          track
D923   91 94      STA ($94),Y
D925   C8         INY
D926   A5 81      LDA $81          and sector
D928   91 94      STA ($94),Y      for open with at-sign
D92A   AE 70 02   LDX $0270        channel number
D92D   A5 D8      LDA $D8
D92F   9D 60 02   STA $0260,X      pointer to directory block
D932   A5 DD      LDA $DD
D934   9D 66 02   STA $0266,X
D937   20 3B DE   JSR $DE3B        get track and sector number
D93A   20 64 D4   JSR $D464        write block
D93D   4C EF D9   JMP $D9EF        prepare trk, sector, and drive #

D940   AD 80 02   LDA $0280        first track number
D943   D0 05      BNE $D94A        file not erased?
D945   A9 62      LDA #$62
D947   4C C8 C1   JMP $C1C8        62, 'file not found'
D94A   AD 97 02   LDA $0297        control mode
D94D   C9 03      CMP #$03         'M'
D94F   F0 0B      BEQ $D95C        yes,then no test of unclosed file
D951   A9 20      LDA #$20         bit 5
D953   24 E7      BIT $E7          test in file type
D955   F0 05      BEQ $D95C        not set, ok
D957   A9 60      LDA #$60
D959   4C C8 C1   JMP #$C1C8       60, 'write file open'
D95C   A5 E7      LDA $E7
D95E   29 07      AND #$07         isolate file type
D960   CD 4A 02   CMP $024A
D963   F0 05      BEQ $D96A
D965   A9 64      LDA #$64
D967   4C C8 C1   JMP $C1C8        64, 'file type mismatch'
D96A   A0 00      LDY #$00
D96C   8C 79 02   STY $0279
D96F   AE 97 02   LDX $0297        control mode
D972   E0 02      CPX #$02         'A', append
```

```
D974    D0 1A       BNE $D990      no
D976    C9 04       CMP #$04       rel-file?
D978    F0 EB       BEQ $D965
D97A    B1 94       LDA ($94),Y
D97C    29 4F       AND #$4F
D97E    91 94       STA ($94),Y
D980    A5 83       LDA $83
D982    48          PHA
D983    A9 11       LDA #$11
D985    85 83       STA $83        channel 17
D987    20 3B DE    JSR $DE3B      get track and sector number
D98A    20 64 D4    JSR $D464      write block
D98D    68          PLA
D98E    85 83       STA $83        get channel # back
D990    20 A0 D9    JSR $D9A0
D993    AD 97 02    LDA $0297      control mode
D996    C9 02       CMP #$02
D998    D0 55       BNE $D9EF
D99A    20 2A DA    JSR $DA2A
D99D    4C 94 C1    JMP $C194      done

D9A0    A0 13       LDA #$13
D9A2    B1 94       LDA ($94),Y    track
D9A4    8D 59 02    STA $0259
D9A7    C8          INY
D9A8    B1 94       LDA ($94),Y
D9AA    8D 5A 02    STA $025A
D9AD    C8          INY
D9AE    B1 94       LDA ($94),Y    record length
D9B0    AE 58 02    LDX $0258      last record len
D9B3    8D 58 02    STA $0258
D9B6    8A          TXA
D9B7    F0 0A       BEQ $D9C3
D9B9    CD 58 02    CMP #$0258
D9BC    F0 05       BEQ $D9C3
D9BE    A9 50       LDA #$50
D9C0    20 C8 C1    JSR $C1C8      50, 'record not present'
D9C3    AE 79 02    LDX $0279
D9C6    BD 80 02    LDA $0280,X
D9C9    85 80       STA $80        track
D9CB    BD 85 02    LDA $0285,X
D9CE    85 81       STA $81        sector
D9D0    20 46 DC    JSR $DC46
D9D3    A4 82       LDY $82
D9D5    AE 79 02    LDX $0279
D9D8    B5 D8       LDA $D8,X
D9DA    99 60 02    STA $0260,Y
D9DD    B5 DD       LDA $DD,X
D9DF    99 66 02    STA $0266,Y
D9E2    60          RTS

D9E3    A5 E2       LDA $E2        drive #
D9E5    29 01       AND #$01
D9E7    85 7F       STA $7F
D9E9    20 DA DC    JSR $DCDA
```

```
D9EC    20 E4 D6    JSR $D6E4
D9EF    A5 83       LDA $83        channel #
D9F1    C9 02       CMP #$02
D9F3    B0 11       BCS $DA06
D9F5    20 3E DE    JSR $DE3E
D9F8    A5 80       LDA $80
D9FA    85 7E       STA $7E
D9FC    A5 7F       LDA $7F
D9FE    8D 6E 02    STA $026E
DA01    A5 81       LDA $81
DA03    8D 6F 02    STA $026F
DA06    4C 99 C1    JMP $C199

******************************  check file type and control mode
DA09    BC 7A 02    LDY $027A,X    pointer in command line
DA0C    B9 00 02    LDA $0200,Y    get characters from line
DA0F    A0 04       LDY #$04
DA11    88          DEY
DA12    30 08       BMI $DA1C
DA14    D9 B2 FE    CMP $FEB2,Y    control modes 'R', 'W', 'A', 'M'
DA17    D0 F8       BNE $DA11
DA19    8C 97 02    STY $0297      save
DA1C    A0 05       LDY #$05
DA1E    88          DEY
DA1F    30 08       BMI $DA29
DA21    D9 B6 FE    CMP $FEB6,Y    file types 'D','S','P','U','L'
DA24    D0 F8       BNE $DA1E
DA26    8C 4A 02    STY $024A      save
DA29    60          RTS

******************************  preparation for Append
DA2A    20 39 CA    JSR $CA39      open channel to read, get byte
DA2D    A9 80       LDA #$80
DA2F    20 A6 DD    JSR $DDA6      last byte?
DA32    F0 F6       BEQ $DA 2A     no
DA34    20 95 DE    JSR $DE95      get track and sector number
DA37    A6 81       LDX $81        sector number
DA39    E8          INX
DA3A    8A          TXA
DA3B    D0 05       BNE $DA42      not $FF?
DA3D    20 A3 D1    JSR $D1A3      close buffer, write block
DA40    A9 02       LDA #$02
DA42    20 C8 D4    JSR $D4C8      buffer pointer to 2
DA45    A6 82       LDX $82        channel number
DA47    A9 01       LDA #$01
DA49    95 F2       STA $F2,X      set flag for WRITE
DA4B    A9 80       LDA #$80
DA4D    05 82       ORA $82
DA4F    A6 83       LDX $83
DA51    9D 2B 02    STA $022B,X    channel number in table
DA54    60          RTS

******************************  OPEN "$"
DA55    A9 0C       LDA #$0C       command number 12
DA57    8D 2A 02    STA $022A
```

```
DA5A    A9 00       LDA #$00
DA5C    AE 74 02    LDX $0274
DA5F    CA          DEX
DA60    F0 0B       BEQ $DA6D
DA62    CA          DEX
DA63    D0 21       BNE $DA86
DA65    AD 01 02    LDA $0201      second character
DA68    20 BD C3    JSR $C3BD      get drive number
DA6B    30 19       BMI $DA86      not a plain number?
DA6D    85 E2       STA $E2
DA6F    EE 77 02    INC $0277
DA72    EE 78 02    INC $0278
DA75    EE 7A 02    INC $027A
DA78    A9 80       LDA #$80
DA7A    85 E7       STA $E7        set wildcard flag
DA7C    A9 2A       LDA #$2A       '*'
DA7E    8D 00 02    STA $0200      as file name in command buffer
DA81    8D 01 02    STA $0201
DA84    D0 18       BNE $DA9E      absolute jump
DA86    20 E5 C1    JSR $C1E5      test input line to ':'
DA89    D0 05       BNE $DA90      found?
DA8B    20 DC C2    JSR $C2DC      erase flags
DA8E    A0 03       LDY #$03
DA90    88          DEY
DA91    88          DEY
DA92    8C 7A 02    STY $027A      pointer to drive no. in command
DA95    20 00 C2    JSR $C200      analyze line
DA98    20 98 C3    JSR $C398      ascertain file type
DA9B    20 20 C3    JSR $C320      get drive number
DA9E    20 CA C3    JSR $C3CA      initialize drive if necessary
DAA1    20 B7 C7    JSR $C7B7      prepare disk title
DAA4    20 9D C4    JSR $C49D      load directory
DAA7    20 9E EC    JSR $EC9E      create and prepare directory
DAAA    20 37 D1    JSR $D137      get byte from buffer
DAAD    A6 82       LDX $82        channel number
DAAF    9D 3E 02    STA $023E      byte in output register
DAB2    A4 7F       LDA $7F        drive number
DAB4    8D 8E 02    STA $028E      save as last drive number
DAB7    09 04       ORA #$04
DAB9    95 EC       STA $EC,X      PRG-flag
DABB    A9 00       LDA #$00
DABD    85 A3       STA $A3        set pointer back in input buffer
DABF    60          RTS

******************************     CLOSE-routine
DAC0    A9 00       LDA #$00
DAC2    8D F9 02    STA $02F9
DAC5    A5 83       LDA $83        secondary address
DAC7    D0 08       BNE $DAD4      not zero?
DAC9    A9 00       LDA #$00       secondary address 0, LOAD
DACB    8D 54 02    STA $0254
DACE    20 27 D2    JSR $D227      close channel
DAD1    4C DA D4    JMP $D4DA      close internal channels 17 & 18

DAD4    C9 0F       CMP #$0F       15
```

```
DAD6    F0 14       BEQ $DAEC      yes, close all channels
DAD8    20 02 DB    JSR $DB02      close file
DADB    A5 83       LDA $83        secondary address
DADD    C9 02       CMP #$02
DADF    90 F0       BCC $DAD1      smaller than 2?
DAE1    AD 6C 02    LDA $026C
DAE4    D0 03       BNE $DAE9
DAE6    4C 94 C1    JMP $C194      termination

DAE9    4C AD C1    JMP $C1AD
DAEC    A9 0E       LDA #$0E       14
DAEE    85 83       STA $83        secondary address
DAF0    20 02 DB    JSR $DB02      close file
DAF3    C6 83       DEC $83        next secondary address
DAF5    10 F9       BPL $DAF0
DAF7    AD 6C 02    LDA $026C
DAFA    D0 03       BNE $DAFF
DAFC    4C 94 C1    JMP $C194      termination
DAFF    4C AD C1    JMP $C1AD

********************************   close file
DB02    A6 83       LDX $83        secondary address
DB04    BD 2B 02    LDA $022B,X    get channel number
DB07    C9 FF       CMP #$FF       no channel associated?
DB09    D0 01       BNE $DB0C
DB0B    60          RTS            no, then done

DB0C    29 0F       AND #$0F       isolate channel number
DB0E    85 82       STA $82
DB10    20 25 D1    JSR $D125      check data type
DB13    C9 07       CMP #$07       direct access?
DB15    F0 0F       BEQ $DB26      yes
DB17    C9 04       CMP #$04       rel-file?
DB19    F0 11       BEQ $DB2C      yes
DB1B    20 07 D1    JSR $D107      channel for writing open
DB1E    B0 09       BCS $DB29      no file for writing?
DB20    20 62 DB    JSR $DB62      write last block
DB23    20 A5 DB    JSR $DBA5      write entry in dir and block
DB26    20 F4 EE    JSR $EEF4      write BAM
DB29    4C 27 D2    JMP $D227      close channel

DB2C    20 F1 DD    JSR $DDF1      get buffer number, write block
DB2F    20 1E CF    JSR $CF1E      change buffer
DB32    20 CB E1    JSR $E1CB      get last side-sector
DB35    A6 D5       LDX $D5        side-sector number
DB37    86 73       STX $73
DB39    E6 73       INC $73
DB3B    A9 00       LDA #$00
DB3D    85 70       STA $70
DB3F    85 71
DB41    A5 D6       LDA $D6
DB43    38          SEC
DB44    E9 0E       SBC #$0E       minus 14 for pointer
CB46    85 72       STA $72
DB48    20 51 DF    JSR $DF51      calculate block number of file
```

```
DB4B   A6 82      LDX $82       channel number
DB4D   A5 70      LDA $70
DB4F   95 B5      STA $B5,X     record number lo
DB51   A5 71      LDA $71
DB53   95 BB      STA $BB,X     record number hi
DB55   A9 40      LDA #$40
DB57   20 A6 DD   JSR $DDA6     bit 6 set?
DB5A   F0 03      BEQ $DB5F     no
DB5C   20 A5 DB   JSR $DBA5     enter in dirctory
DB5F   AC 27 D2   JMP $D227     close channel

******************************  write last block
DB62   A6 82      LDX $82       channel number
DB64   B5 B5      LDA $B5,X     record number lo
DB66   15 BB      ORA $BB,X     record number hi
DB68   D0 0C      BNE $DB76     not zero?
DB6A   20 E8 D4   JSR $D4E8     set buffer pointer
DB6D   C9 02      CMP #$02
DB6F   D0 05      BNE $DB76     not 2
DB71   A9 0D      LDA #$0D      CR
DB73   20 F1 CF   JSR $CFF1     in buffer
DB76   20 E8 D4   JSR $D4E8     set buffer pointer
DB79   C9 02      CMP #$02      now equal to 2?
DB7B   D0 0F      BNE $DB8C     no
DB7D   20 1E CF   JSR $CF1E     change buffer
DB80   A6 82      LDX $82       channel number
DB82   B5 B5      LDA $B5,X     record number lo
DB84   D0 02      BNE $DB88
DB86   D6 BB      DEC $BB,X     decrement block number hi
DB88   D6 B5      DEC $B5,X     and block number lo
DB8A   A9 00      LDA #$00
DB8C   38         SEC
DB8D   E9 01      SBC #$01      set pointer to end
DB8F   48         PHA
DB90   A9 00      LDA #$00
DB92   20 C8 D4   JSR $D4C8     buffer pointer to zero
DB95   20 F1 CF   JSR $CFF1     write zero in buffer
DB98   68         PLA           second byte = pointer to end
DB99   20 F1 CF   JSR $CFF1     write in buffer
DB9C   20 C7 D0   JSR $D0C7     write block to disk
DB9F   20 99 D5   JSR $D599     and verify
DBA2   4C 1E CF   JMP $CF1E     change buffer

******************************  directory entry
DBA5   A6 82      LDX $82       channel number
DBA7   8E 70 02   STX $0270     save
DBAA   A5 83      LDA $83       secondary address
DBAC   48         PHA           save
DBAD   BD 60 02   LDA $0260,X   sector number in directory
DBB0   85 81      STA $81       set
DBB2   BD 66 02   LDA $0266,X   pointer in directory
DBB5   8D 94 02   STA $0294
DBB8   B5 EC      LDA $EC,X
DBBA   29 01      AND #$01
DBBC   85 7F      STA $7F       drive number
```

```
DBBE   AD 85 FE   LDA $FE85      18, directory track
DBC1   85 80      STA $80        set
DBC3   20 93 DF   JSR $DF93      increment buffer number
DBC6   48         PHA
DBC7   85 F9      STA $F9
DBC9   20 60 D4   JSR $D460      read directory block
DBCC   A0 00      LDY #$00
DBCE   BD E0 FE   LDA $FEE0,X    buffer address
DBD1   85 87      STA $87
DBD3   AD 94 02   LDA $0294      buffer pointer
DBD6   85 86      STA $86
DBD8   B1 86      LDA ($86),Y    file type
DBDA   29 20      AND #$20       file closed?
DBDC   F0 43      BEQ $DC21      yes
DBDE   20 25 D1   JSR $D125      check file type
DBE1   C9 04      CMP #$04       rel-file?
DBE3   F0 44      BEQ $DC29      yes
DBE5   B1 86      LDA ($86),Y
DBE7   29 8F      AND #$8F       erase bits 4,5, and 6
DBE9   91 86      STA ($86),Y    in file type
DBEB   C8         INY
DBEC   B1 86      LDA ($86),Y    track number
DBEE   85 80      STA $80
DBF0   84 71      STY $71
DBF2   A0 1B      LDY #$1B
DBF4   B1 86      LDA ($86),Y    sector # of the file for
DBF6   48         PHA            overwriting
DBF7   88         DEY
DBF8   B1 86      LDA ($86),Y    track # for overwriting
DBFA   D0 0A      BNE $DC06      set?
DBFC   85 80      STA $80        set track number
DBFE   68         PLA
DBFF   85 81      STA $81        sector number
DC01   A9 67      LDA #$67
DC03   20 45 E6   JSR $E645      67, 'illegal track or sector'
DC06   48         PHA
DC07   A9 00      LDA #$00
DC09   91 86      STA ($86),Y    erase track number
DC0B   C8         INY
DC0C   91 86      STA ($86),Y    and sector number of the
DC0E   68         PLA            substitute file
DC0F   A4 71      LDY $71
DC11   91 86      STA ($86),Y
DC13   C8         INY            set track & sec # of the new file
DC14   B1 86      LDA ($86),Y
DC16   85 81      STA $81
DC18   68         PLA
DC19   91 86      STA ($86),Y
DC1B   20 7D C8   JSR $C87D      erase all files
DC1E   4C 29 DC   JMP $DC29

DC21   B1 86      LDA ($86),Y    get file type
DC23   29 0F      AND #$0F       isolate bits 0-3
DC25   09 80      ORA #$80       set bit 7 for closed file
DC27   91 86      STA ($86),Y
```

```
DC29    AE 70 02    LDX $0270       channel number
DC2C    A0 1C       LDY #$1C
DC2E    B5 B5       LDA $B5,X       block number lo
DC30    91 86       STA ($86),Y     in directory entry
DC32    C8          INY
DC33    B5 BB       LDA $BB,Y       and block number hi
DC35    91 86       STA ($86),Y     write
DC37    68          PLA             buffer number
DC38    AA          TAX
DC39    A9 90       LDA #$90        code for 'writing'
DC3B    20 90 D5    JSR $D590       write block
DC40    68          PLA
DC41    85 83       STA $83         secondary address
DC43    4C 07 D1    JMP $D107       open channel for writing

******************************      read block, layout buffer
DC46    A9 01       LDA #$01
DC48    20 E2 D1    JSR $D1E2       find channel and buffer for read
DC4B    20 B6 DC    JSR $DCB6       set pointer
DC4E    AD 4A 02    LDA $024A       file type
DC51    48          PHA             save
DC52    0A          ASL A
DC53    05 7F       ORA $7F         drive number
DC55    95 EC       STA $EC,X
DC57    20 9B D0    JSR $D09B       read block in buffer
DC5A    A6 82       LDX $82         channel number
DC5C    A5 80       LDA $80         track
DC5E    D0 05       BNE $DC65       following track?
DC60    A5 81       LDA $81         sector
DC62    9D 44 02    STA $0244,X     as end pointer
DC65    68          PLA             file type
DC66    C9 04       CMP #$04        rel-file?
DC68    D0 3F       BNE $DCA9       no
DC6A    A4 83       LDA $83         secondary address
DC6C    B9 2B 02    LDA $022B,Y     channel number
DC6F    09 40       ORA #$40
DC71    99 2B 02    STA $022B,Y     set flag for READ and WRITE
DC74    AD 58 02    LDA $0258       record length
DC77    95 C7       STA $C7,X
DC79    20 8E D2    JSR $D28E       find buffer for side-sector
DC7C    10 03       BPL $DC81       found?
DC7E    4C 0F D2    JMP $D20F       70, 'no channel'

DC81    A6 82       LDX $82         channel number
DC83    95 CD       STA $CD,X
DC85    AC 59 02    LDY $0259
DC88    84 80       STY $80         track for side-sector
DC8A    AC 5A 02    LDA $025A
DC8D    84 81       STY $81         sector for side-sector
DC8F    20 D3 D6    JSR $D6D3       transmit parameters to disk cont.
DC92    20 73 DE    JSR $DE73       read block
DC95    20 99 D5    JSR $D599       and verify
DC98    A6 82       LDX $82         channel number
DC9A    A9 02       LDA #$02
DC9C    95 C1       STA $C1,X       pointer for writing
```

```
DC9E    A9 00       LDA #$00
DCA0    20 C8 D4    JSR $D4C8       buffer pointer to zero
DCA3    20 53 E1    JSR $E153       find next record
DCA6    4C 3E DE    JMP $DE3E       get track and sector number

DCA9    20 56 D1    JSR $D156       get byte from buffer
DCAC    A6 82       LDX $82         channel number
DCAE    9D 3E 02    STA $023E,X     byte in output register
DCB1    A9 88       LDA #$88        set flag for READ
DCB3    95 F2       STA $F2,X
DCB5    60          RTS

******************************      reset pointer
DCB6    A6 82       LDX $82         channel number
DCB8    B5 A7       LDA $A7,X       buffer number
DCBA    0A          ASL A           times 2
DCBB    A8          TAY
DCBC    A9 02       LDA #$02
DCBE    99 99 00    STA $0099,Y     buffer pointer lo
DCC1    B5 AE       LDA $AE,X
DCC3    09 80       ORA #$80        set bit 7
DCC5    95 AE       STA $AE,X
DCC7    0A          ASL A
DCC8    A8          TAY
DCC9    A9 02       LDA #$02
DCCB    99 99 00    STA $0099,Y     buffer pointer lo
DCCE    A9 00       LDA #$00
DCD0    95 B5       STA $B5,X       block number lo
DCD2    95 BB       STA $BB,X       block number hi
DCD4    A9 00       LDA #$00
DCD6    9D 44 02    STA $0244,X     end pointer
DCD9    60          RTS

******************************      construct a new block
DCDA    20 A9 F1    JSR $F1A9       find free sector in BAM
DCDD    A9 01       LDA #$01
DCDF    20 DF D1    JSR $D1DF       open channel
DCE2    20 D0 D6    JSR $D6D0       transmit param to disk controller
DCE5    20 B6 DC    JSR $DCB6       reset pointer
DCE8    A6 82       LDX $82         channel number
DCEA    AD 4A 02    LDA $024A       file type
DCED    48          PHA
DCEE    0A          ASL A
DCEF    05 7F       ORA $7F         drive number
DCF1    95 EC       STA $EC,X       save as flag
DCF3    68          PLA
DCF4    C9 04       CMP #$04        rel-file?
DCF6    F0 05       BEQ $DCFD       yes
DCF8    A9 01       LDA #$01
DCFA    95 F2       STA $F2,X       set WRITE flag
DCFC    60          RTS

DCFD    A4 83       LDY $83         secondary address
DCFF    B9 2B 02    LDA $022B,Y     channel number in table
DD02    29 3F       AND #$3F        erase the top two bits
```

```
DD04    09 40       ORA #$40       set bit 6
DD06    99 2B 02    STA $022B,Y    READ and WRITE flag
DD09    AD 58 02    LDA $0258      record length
DD0C    95 C7       STA $C7,X      in table
DD0E    20 8E D2    JSR $D28E      find buffer
DD11    10 03       BPL $DD16      found?
DD13    4C 0F D2    JMP $D20F      70, 'no channel'

DD16    A6 82       LDX $82        channel number
DD18    95 CD       STA $CD,X      buffer number for side-sector
DD1A    20 C1 DE    JSR $DEC1      erase buffer
DD1D    20 1E F1    JSR $F11E      find free block in BAM
DD20    A5 80       LDA $80        track
DD22    8D 59 02    STA $0259      for side-sector
DD25    A5 81       LDA $81        sector
DD27    8D 5A 02    STA $025A      for side-sector
DD2A    A6 82       LDX $82        channel number
DD2C    B5 CD       LDA $CD,X      buffer number
DD2E    20 D3 D6    JSR $D6D3      transmit param to disk controller
DD31    A9 00       LDA #$00
DD33    20 E9 DE    JSR $DEE9      buffer pointer to zero
DD36    A9 00       LDA #$00
DD38    20 8D DD    JSR $DD8D
DD3B    A9 11       LDA #$11       17
DD3D    20 8D DD    JSR $DD8D      as end pointer in buffer
DD40    A9 00       LDA #$00       zero
DD42    20 8D DD    JSR $DD8D      as side-sector number in buffer
DD45    AD 58 02    LDA $0258      record length
DD48    20 8D DD    JSR $DD8D      in buffer
DD4B    A5 80       LDA $80        track number of this block
DD4D    20 8D DD    JSR $DD8D      in buffer
DD50    A5 81       LDA $81        sector number
DD52    20 8D DD    JSR $DD8D      in buffer
DD55    A9 10       LDA #$10       16
DD57    20 E9 DE    JSR $DEE9      buffer pointer to 16
DD5A    20 3E DE    JSR $DE3E      get track and sector number
DD5D    A5 80       LDA $80        track # of the first data block
DD5F    20 8D DD    JSR $DD8D      in buffer
DD62    A5 81       LDA $81        sector # of the first data block
DD64    20 8D DD    JSR $DD8D      in buffer
DD67    20 6C DE    JSR $DE6C      write block to disk
DD6A    20 99 D5    JSR $D599      and check
DD6D    A9 02       LDA #$02
DD6F    20 C8 D4    JSR $D4C8      buffer pointer to 2
DD72    A6 82       LDX $82        channel number
DD74    38          SEC
DD75    A9 00       LDA #$00
DD77    F5 C7       SBC $C7,X      record length
DD79    95 C1       STA $C1,X      pointer for writing
DD7B    20 E2 E2    JSR $E2E2      erase buffer
DD7E    20 19 DE    JSR $DE19      write link bytes in buffer
DD81    20 5E DE    JSR $DE5E      write block to disk
DD84    20 99 D5    JSR $D599      and check
DD87    20 F4 EE    JSR $EEF4      write BAM
DD8A    4C 98 DC    JMP $DC98      and done
```

```
******************************        write byte in side-sector block
DD8D    48          PHA               save byte
DD8E    A6 82       LDX $82           channel number
DD90    B5 CD       LDA $CD,X         buffer # of the side-sector
DD92    4C FD CF    JMP $CFFD         write byte in buffer

******************************        manipulate flags
DD95    90 06       BCC $DD9D
DD97    A6 82       LDX $82           channel number
DD99    15 EC       ORA $EC,X         set flag
DD9B    D0 06       BNE $DDA3
DD9D    A6 82       LDX $82           channel number
DD9F    49 FF       EOR #$FF
DDA1    35 EC       AND $EC,X         erase flag
DDA3    95 EC       STA $EC,X
DDA5    60          RTS
DDA6    A6 82       LDX $82           channel number
DDA8    35 EC       AND $EC,X         test flag
DDAA    60          RTS

******************************        check command code for writing
DDAB    20 93 DF    JSR $DF93         get buffer number
DDAE    AA          TAX
DDAF    BD 5B 02    LDA $025B,X
DDB2    29 F0       AND #$F0          isolate command code
DDB4    C9 90       CMP #$90          code for writing?
DDB6    60          RTS

******************************
DDB7    A2 00       LDX #$00
DDB9    86 71       STX $71           counter for secondary address
DDBB    BD 2B 02    LDA $022B,X       get channel number from table
DDBE    C9 FF       CMP #$FF
DDC0    D0 08       BNE $DDCA         file open?
DDC2    A6 71       LDX $71
DDC4    E8          INX               increment counter
DDC5    E0 10       CPX #$10          smaller than 16?
DDC7    90 F0       BCC $DDB9
DDC9    60          RTS

DDCA    86 71       STX $71
DDCC    29 3F       AND #$3F          isolate channel number
DDCE    A8          TAY
DDCF    B9 EC 00    LDA $00EC,Y
DDD2    29 01       AND #$01          isolate drive number
DDD4    85 70       STA $70
DDD6    AE 53 02    LDX $0253
DDD9    B5 E2       LDA $E2,X
DDDB    29 01       AND #$01          isolate drive number
DDDD    C5 70       CMP $70           same drive?
DDDF    D0 E1       BNE $DDC2         no
DDE1    B9 60 02    LDA $0260,Y       sector number in directory
DDE4    D5 D8       CMP $D8,X         same as file?
DDE6    D0 DA       BNE $DDC2         no
```

```
DDE8    B9 66 02    LDA $0266,Y
DDEB    D5 DD       CMP $DD,X      pointer same?
DDED    D0 D3       BNE $DDC2      no
DDEF    18          CLC
DDF0    60          RTS

******************************     write a block of a rel-file
DDF1    20 9E DF    JSR $DF9E      get buffer number
DDF4    50 06       BVC $DDFC      no rel-file?
DDF6    20 5E DE    JSR $DE5E      write block
DDF9    20 99 D5    JSR $D599      and verify
DDFC    60          RTS

******************************     write bytes for following track
DDFD    20 2B DE    JSR $DE2B      set buffer pointer
DE00    A5 80       LDA $80        track number
DE02    91 94       STA ($94),Y    in buffer
DE04    C8          INY
DE05    A5 81       LDA $81        sector number
DE07    91 94       STA ($94),Y    in buffer
DE09    4C 05 E1    JMP $E105      set rel-flag

******************************     get following track and sector #
DE0C    20 2B DE    JSR $DE2B      set buffer pointer
DE0F    B1 94       LDA ($94),Y    following track number
DE11    85 80       STA $80
DE13    C8          INY
DE14    B1 94       LDA ($94),Y    and get sector number
DE16    85 81       STA $81
DE18    RTS

******************************     following track for last block
DE19    20 2B DE    JSR $DE2B      set buffer pointer
DE1C    A9 00       LDA #$00       zero
DE1E    91 94       STA ($94),Y    as track number
DE20    C8          INY
DE21    A6 82       LDX $82        channel number
DE23    B5 C1       LDA $C1,X      pointer in block
DE25    AA          TAX
DE26    CA          DEX            minus 1
DE27    8A          TXA
DE28    91 94       STA ($94),Y    as pointer in block
DE2A    60          RTS

******************************     buffer pointer to zero
DE2B    20 93 DF    JSR $DF93      get buffer number
DE2E    0A          ASL A          times 2
DE2F    AA          TAX
DE30    B5 9A       LDA $9A,X      buffer pointer hi
DE32    85 95       STA $95
DE34    A9 00       LDA #$00
DE36    85 94       STA $94        buffer pointer lo
DE38    A0 00       LDY #$00
DE3A    60          RTS
```

```
********************************      get track and sector
DE3B    20 EB D0    JSR $D0EB         get channel number
DE3E    20 93 DF    JSR $DF93         get buffer number
DE41    85 F9       STA $F9           save
DE43    0A          ASL A             times 2
DE44    A8          TAY
DE45    B9 06 00    LDA $0006,Y       get track
DE48    85 80       STA $80
DE4A    B9 07 00    LDA $0007,Y       and sector # from disk controller
DE4D    85 81       STA $81
DE4F    60          RTS

********************************
DE50    A9 90       LDA #$90          command code for writing
DE52    8D 4D 02    STA $024D
DE55    D0 28       BNE $DE7F

DE57    A9 80       LDA #$80          command code for reading
DE59    8D 4D 02    STA $024D
DE5C    D0 21       BNE $DE7F
DE5E    A9 90       LDA #$90          command code for writing
DE60    8D 4D 02    STA $024D
DE63    D0 26       BNE $DE8B

DE65    A9 80       LDA #$80          command code for reading
DE67    8D 4D 02    STA $024D
DE6A    D0 1F       BNE $DE8B

DE6C    A9 90       LDA #$90          command code for writing
DE6E    8D 4D 02    STA $024D
DE71    D0 02       BNE $DE75

DE73    A9 80       LDA #$80          command code for reading
DE75    8D 4D 02    STA $024D
DE78    A6 82       LDX $82           channel number
DE7A    B5 CD       LDA $CD,X         side-sector buffer number
DE7C    AA          TAX
DE7D    10 13       BPL $DE92         buffer associated?
DE7F    20 D0 D6    JSR $D6D0         generate header for disk cont.
DE82    20 93 DF    JSR $DF93         get buffer number
DE85    AA          TAX
DE86    A5 7F       LDA $7F           drive number
DE88    9D 5B 02    STA $025B,X
DE8B    20 15 E1    JSR $E115         buffer number
DE8E    20 93 DF    JSR $DF93         get buffer number
DE91    AA          TAX
DE92    4C 06 D5    JMP $D506         write block

********************************      get following track & sector from
DE95    A9 00       LDA #$00          buffer
DE97    20 C8 D4    JSR $D4C8         buffer pointer to zero
DE9A    20 37 D1    JSR $D137         get byte
DE9D    85 80       STA $80           save as track
DE9F    20 37 D1    JSR $D137         get byte
DEA2    85 81       STA $81           as sector
```

```
DEA4    60          RTS

******************************   copy buffer contents
DEA5    48          PHA
DEA6    A9 00       LDA #$00
DEA8    85 6F       STA $6F
DEAA    85 71       STA $71
DEAC    B9 E0 FE    LDA $FEE0,Y      buffer address Y, hi
DEAF    85 70       STA $70
DFB1    BD E0 FE    LDA $FEE0,X      buffer address X, hi
DEB4    85 72       STA $72
DEB6    68          PLA
DEB7    A8          TAY
DEB8    88          DEY
DEB9    B1 6F       LDA ($6F),Y      copy contents of buffer Y
DEBB    91 71       STA ($71),Y      to buffer X
DEBD    88          DEY
DEBE    10 F9       BPL $DEB9
DEC0    60          RTS

******************************   erase buffer Y
DEC1    A8          TAY              buffer number
DEC2    B9 E0 FE    LDA $FEE0,Y      get hi-address
DEC5    85 70       STA $70
DEC7    A9 00       LDA #$00         lo-address
DEC9    85 6F       STA $6F
DECB    A8          TAY
DECC    91 6F       STA ($6F),Y      erase buffer
DECE    C8          INY
DECF    D0 FB       BNE $DECC
DED1    60          RTS

******************************   get side-sector number
DED2    A9 00       LDA #$00
DED4    20 DC DE    JSR $DEDC        buffer pointer to zero
DED7    A0 02       LDY #$02
DED9    B1 94       LDA ($94),Y      byte 2 contains the side-sector #
DEDB    60          RTS

******************************   set buffer ptr to side-sector
DEDC    85 94       STA $94          pointer lo
DEDE    A6 82       LDX $82          channel number
DEE0    B5 CD       LDA $CD,X        buffer number
DEE2    AA          TAX
DEE3    BD E0 FE    LDA $FEE0,X      buffer address hi
DEE6    85 95       STA $95          set
DEE8    60          RTS

******************************   buffer pointer for side-sector
DEE9    48          PHA              pointer in side-sector
DEEA    20 DC DE    JSR $DEDC        set buffer pointer
DEED    48          PHA
DEEE    8A          TXA              buffer number
DEEF    0A          ASL A            times 2
DEF0    AA          TAX
```

```
DEF1    68          PLA             buffer pointer hi
DEF2    95 9A       STA $9A,X
DEF4    68          PLA             buffer pointer lo
DEF5    95 99       STA $99,X
DEF7    60          RTS

******************************      get side-sector and buffer ptr
DEF8    20 66 DF    JSR $DF66       is side-sector in buffer
DEFB    30 0E       BMI $DF0B       no
DEFD    50 13       BVC $DF12       ok
DEFF    A6 82       LDX $82         channel number
DF01    B5 CD       LDA $CD,X       buffer number
DF03    20 1B DF    JSR $DF1B       read side-sector
DF06    20 66 DF    JSR $DF66       and check if in buffer
DF09    10 07       BPL $DF12       yes?
DF0B    20 CB E1    JSR $E1CB       get last side-sector
DF0E    2C CE FE    BIT $FECE       set V bit
DF11    60          RTS
DF12    A5 D6       LDA $D6         side-sector end pointer
DF14    20 E9 DE    JSR $DEE9       set pointer in side-sector
DF17    2C CD DE    BIT $FECD       erase V bit
DF1A    60          RTS

******************************      read side-sector
DF1B    85 F9       STA $F9         buffer number
DF1D    A9 80       LDA #$80        command code for reading
DF1F    D0 04       BNE $DF25

******************************      write side-sector
DF21    85 F9       STA $F9         buffer number
DF23    A9 90       LDA #$90        command code for writing
DF25    48          PHA
DF26    B5 EC       LDA $EC,X
DF28    29 01       AND #$01        isolate drive number
DF2A    85 7F       STA $7F
DF2C    68          PLA
DF2D    05 7F       ORA $7F         command code plus drive number
DF2F    8D 4D 02    STA $024D       save
DF32    B1 94       LDA ($94),Y     track number
DF34    85 80       STA $80
DF36    C8          INY
DF37    B1 94       LDA ($94),Y     sector number
DF39    85 81       STA $81
DF3B    A5 F9       LDA $F9         buffer number
DF3D    20 D3 D6    JSR $D6D3       transmit param to disk controller
DF40    A6 F9       LDX $F9         buffer number
DF42    4C 93 D5    JMP $D593       tranmit cmd to disk controller

******************************      set buffer pointer in side-sector
DF45    A6 82       LDX $82         channel number
DF47    B5 CD       LDA $CD,X       buffer number
DF49    4C EB D4    JMP $D4EB       set buffer pointer

******************************      calculate block # of a rel-file
DF4C    A9 78       LDA #$78        120 block ptrs per side-sector
```

```
DF4E    20 5C DF   JSR $DF5C      add to $70/$71
DF51    CA         DEX            side-sector number
DF52    10 F8      BPL $DF4C      next side-sector?
DF54    A5 72      LDA $72        pointer value in last block
DF56    4A         LSR A          divided by 2
DF57    20 5C DF   JSR $DF5C      add to previous sum
DF5A    A5 73      LDA $73        number of the side-sector block
DF5C    18         CLC
DF5D    65 70      ADC $70
DF5F    85 70      STA $70        add
DF61    90 02      BCC $DF65
DF63    E6 71      INC $71
DF65    60         RTS

******************************    verify side-sector in buffer
DF66    20 D2 DE   JSR $DED2      get side-sector number
DF69    C5 D5      CMP $D5        = number of necessary block?
DF6B    D0 0E      BNE $DF7B      no
DF6D    A4 D6      LDY $D6        pointer in side-sector
DF6F    B1 94      LDA ($94),Y    track number
DF71    F0 04      BEQ $DF77
DF73    2C CD FE   BIT $FECD      erase bits
DF76    60         RTS
DF77    2C CF FE   BIT $FECF      set N-bit
DF7A    60         RTS

DF7B    A5 D5      LDA $D5        side-sector number
DF7D    C9 06      CMP #$06       6 or greater?
DF7F    B0 0A      BCS $DF8B      yes
DF81    0A         ASL A
DF82    A8         TAY
DF83    A9 04      LDA #$04
DF85    85 94      STA $94
DF87    B1 94      LDA ($94),Y    track number
DF89    D0 04      BNE $DF8F
DF8B    2C D0 FE   BIT $FED0      set N and V bits
DF8E    60         RTS

DF8F    2C CE FE   BIT $FECE      set V bit
DF92    60         RTS

******************************    get buffer number
DF93    A6 82      LDX $82        channel number
DF95    B5 A7      LDA $A7,X      buffer number
DF97    10 02      BPL $DF9B
DF99    B5 AE      LDA $AE,X      buffer number from second table
DF9B    29 BF      AND #$BF       erase V bit
DF9D    60         RTS

DF9E    A6 82      LDX $82        channel number
DFA0    8E 57 02   STX $0257      save
DFA3    B5 A7      LDA $A7,X      get buffer number
DFA5    10 09      BPL $DFB0      buffer allocated
DFA7    8A         TXA
DFA8    18         CLC
```

```
DFA9   69 07      ADC #$07      increment number by 7
DFAB   8D 57 02   STA $0257     and save
DFAE   B5 AE      LDA $AE,X     buffer number from table 2
DFB0   85 70      STA $70
DFB2   29 1F      AND #$1F      erase the highest 3 bits
DFB4   24 70      BIT $70
DFB6   60         RTS

DFB7   AD 82      LDX $82       channel number
DFB9   B5 A7      LDA $A7,X     buffer number
DFBB   30 02      BMI $DFBF     buffer free?
DFBD   B5 AE      LDA $AE,X     buffer number from table 2
DFBF   C9 FF      CMP #$FF      free?
DFC1   60         RTS

DFC2   A6 82      LDX $82
DFC4   09 80      ORA #$80
DFC6   B4 A7      LDY $A7,X
DFC8   10 03      BPL $DFCD
DFCA   95 A7      STA $A7,X
DFCC   60         RTS
DFCD   95 AE      STA $AE,X
DFCF   60         RTS

*****************************  get next record in rel-file
DFD0   A9 20      LDA #$20
DFD2   20 9D DD   JSR $DD9D     erase bit 5
DFD5   A9 80      LDA #$80
DFD7   20 A6 DD   JSR $DDA6     test bit 7
DFDA   D0 41      BNE $E01D     set?
DFDC   A6 82      LDX $82       channel number
DFDE   F6 B5      INC $B5,X     increment record number
DFE0   D0 02      BNE $DFE4
DFE2   F6 BB      INC $BB,X     record number hi
DFE4   A6 82      LDX $82       channel number
DFE6   B5 C1      LDA $C1,X     write pointer
DFE8   F0 2E      BEQ $E018     zero?
DFEA   20 E8 D4   JSR $D4E8     set buffer pointer
DFED   A6 82      LDX $82       channel number
DFEF   D5 C1      CMP $C1,X     buffer ptr smaller than write ptr
DFF1   90 03      BCC $DFF6     yes
DFF3   20 3C E0   JSR $E03C     write block, read next block
DFF6   A6 82      LDX $82       channel number
DFF8   B5 C1      LDA $C1,X     write pointer
DFFA   20 C8 D4   JSR $D4C8     set buffer pointer = write ptr
DFFD   A1 99      LDA ($99),X   byte from buffer
DFFF   85 85      STA $85       put in output register
E001   A9 20      LDA #$20
E003   20 9D DD   JSR $DD9D     erase bit 5
E006   20 04 E3   JSR $E304     add record length to write ptr
E009   48         PHA           and save
E00A   90 28      BCC $E034     not yet in last block?
E00C   A9 00      LDA #$00
E00E   20 F6 D4   JSR $D4F6     get track number
E011   D0 21      BNE $E034     does block exist?
```

```
E013    68          PLA            pointer
E014    C9 02       CMP #$02       = 2
E016    F0 12       BEQ $E02A      yes
E018    A9 80       LDA #$80
E01A    20 97 DD    JSR $DD97      set bit 7
E01D    20 2F D1    JSR $D12F      get byte from buffer
E020    B5 99       LDA $99,X      buffer pointer
E022    99 44 02    STA $0244,Y    as end pointer
E025    A9 0D       LDA #$0D       CR
E027    85 85       STA $85        in output register
E029    60          RTS

E02A    20 35 E0    JSR $E035
E02D    A6 82       LDX $82        channel number
E02F    A9 00       LDA #$00
E031    95 C1       STA $C1,X      write pointer to zero
E033    60          RTS

E034    68          PLA
E035    A6 82       LDX $82        channel number
E037    95 C1       STA $C1,X      set write pointer
E039    4C 6E E1    JMP $E16E

******************************     write block and read next block
E03C    20 D3 D1    JSR $D1D3      get drive number
E03F    20 95 DE    JSR $DE95      get track and sector number
E042    20 9E DF    JSR $DF9E      get buffer number
E045    50 16       BVC $E05D      no rel-file?
E047    20 5E DE    JSR $DE5E      write block
E04A    20 1E CF    JSR $CF1E      change buffer
E04D    A9 02       LDA #$02
E04F    20 C8 D4    JSR $D4C8      buffer pointer to 2
E052    20 AB DD    JSR $DDAB      command code for writing?
E055    D0 24       BNE $E078      no
E057    20 57 DE    JSR $DE57      read block
E05A    4C 99 D5    JMP $D599      and verify

E05D    20 1E CF    JSR $CF1E      change buffer
E060    20 AB DD    JSR $DDAB      command code for writing?
E063    D0 06       BNE $E068      no
E065    20 57 DE    JSR $DE57      read block
E068    20 99 D5    JSR $D599      and verify
E06B    20 95 DE    JSR $DE95      get track and sector number
E06E    A5 80       LDA $80        track
E070    F0 09       BEQ $E07B      no following track
E072    20 1E CF    JSR $CF1E      change buffer
E075    20 57 DE    JSR $DE57      read block
E078    20 1E CF    JSR $CF1E      change buffer
E07B    60          RTS

******************************     write a byte in a record
E07C    20 05 E1    JSR $E105
E07F    20 93 DF    JSR $DF93      get buffer number
E082    0A          ASL A          times 2
E083    AA          TAX
```

```
E084    A5 85       LDA $85         data byte
E086    81 99       STA ($99,X)     write in buffer
E088    B4 99       LDY $99,X       buffer pointer
E08A    C8          INY             increment
E08B    D0 09       BNE $E096       not equal zero?
E08D    A4 82       LDY $82         channel number
E08F    B9 C1 00    LDA $00C1,Y     write pointer
E092    F0 0A       BEQ $E09E       equal zero?
E094    A0 02       LDY #$02        buffer pointer to 2
E096    98          TYA
E097    A5 82       LDY $82         channel number
E099    D9 C1 00    CMP $00C1,Y     buffer pointer = write pointer?
E09C    D0 05       BNE $E043       no
E09E    A9 20       LDA #$20
E0A0    4C 97 DD    JMP $DD97       set bit 5

E0A3    F6 99       INC $99,X       increment buffer pointer
E0A5    D0 03       BNE $E0AA       not zero?
E0A7    20 3C E0    JSR $E03C       else write block, read next one
E0AA    60          RTS

******************************      write byte in rel-file
E0AB    A9 A0       LDA #$A0
E0AD    20 A6 DD    JSR $DDA6       test bits 6 & 7
E0B0    D0 27       BNE $E0D9       set?
E0B2    A5 85       LDA $85         data byte
E0B4    20 7C E0    JSR $E07C       write in record
E0B7    A5 F8       LDA $F8         end?
E0B9    F0 0D       BEQ $E0C8       yes
E0BB    60          RTS

E0BC    A9 20       LDA #$20
E0BE    20 A6 DD    JSR $DDA6       test bit 5
E0C1    F0 05       BEQ $E0C8       not set
E0C3    A9 51       LDA #$51        51, 'overflow in record'
E0C5    8D 6C 02    STA $026C       set error flag
E0C8    20 F3 E0    JSR $E0F3       fill remainder with zeroes
E0CB    20 53 E1    JSR $E153
E0CE    AD 6C 02    LDA $026C       error flag set?
E0D1    F0 03       BEQ $E0D6       no
E0D3    4C C8 C1    JMP $C1C8       set error message

E0D6    4C BC E6    JMP $E6BC       error free execution
E0D9    29 80       AND #$80        bit 7 set?
E0DB    D0 05       BNE $E0E2       yes
E0DD    A5 F8       LDA $F8
E0DF    F0 DB       BEQ $E0BC       end?
E0E1    60          RTS

E0E2    A5 85       LDA $85         data byte
E0E4    48          PHA
E0E5    20 1C E3    JSR $E31C       expand side-sector
E0E8    68          PLA
E0E9    85 85       STA $85
E0EB    A9 80       LDA #$80
```

```
E0ED    20 9D DD    JSR $DD9D       erase bit 7
E0F0    4C B2 E0    JMP $E0B2       write byte in file

******************************      fill record with zeroes
E0F3    A9 20       LDA #$20
E0F5    20 A6 DD    JSR $DDA6       test bit 5
E0F8    D0 0A       BNE $E104       set?
E0FA    A9 00       LDA #$00
E0FC    85 85       STA $85         zero as data byte
E0FE    20 7C E0    JSR $E07C       write in record
E101    4C F3 E0    JMP $E0F3       until record full

E104    60          RTS

******************************      write buffer number in table
E105    A9 40       LDA #$40
E107    20 97 DD    JSR $DD97       set bit 6
E10A    20 9E DF    JSR $DF9E       get buffer number
E10D    09 40       ORA #$40        set bit 6
E10F    AE 57 02    LDX $0257       channel number + 7
E112    95 A7       STA $A7,X       write in table
E114    60          RTS

E115    20 9E DF    JSR $DF9E       get buffer number
E118    29 BF       AND #$BF        erase bit 6
E11A    AE 57 02    LDX $0257       channel number
E11D    95 A7       STA $A7,X       write in table
E11F    60          RTS

******************************      get byte from rel-file
E120    A9 80       LDA #$80
E122    20 A6 DD    JSR $DDA6       test bit 7
E125    D0 37       BNE $E15E       set?
E127    20 2F D1    JSR $D12F       get byte from buffer
E12A    B5 99       LDA $99,X       buffer pointer
E12C    D9 44 02    CMP $0244,Y     compare to end pointer
E12F    F0 22       BEQ $E135       equal?
E131    F6 99       INC $99,X       increment buffer pointer
E133    D0 06       BNE $E13B       not zero?
E135    20 3C E0    JSR $E03C       write block, read next one
E138    20 2F D1    JSR $D12F       get byte from buffer
E13B    A1 99       LDA ($99,X)
E13D    99 3E 02    STA $023E,Y     in output register
E140    A9 89       LDA #$89
E142    99 F2 00    STA $00F2,Y     set READ and WRITE flag
E145    B5 99       LDA $99,Y       buffer pointer
E147    D9 44 02    CMP $0244,Y     compare to end pointer
E14A    F0 01       BEQ $E14D       same?
E14C    60          RTS

E14D    A9 81       LDA #$81
E14F    99 F2 00    STA $00F2,Y     set flag for end
E152    60          RTS

E153    20 D0 DF    JSR $DFD0       find next record
```

```
E156    20 2F D1    JSR $D12F      get buffer and channel number
E159    A5 85       LDA $85        data byte
E15B    4C 3D E1    JMP $E13D      into output register

E15E    A6 82       LDX $82        channel number
E160    A9 0D       LDA #$0D       CR
E162    9D 3E 02    STA $023E,X    into output register
E165    A9 81       LDA #$81
E167    95 F2       STA $F2,X      set flag for end
E169    A9 50       LDA #$50
E16B    20 C8 C1    JSR $C1C8      50, 'record not present'

E16E    A6 82       LDX $82        channel number
E170    B5 C1       LDA $C1,X      write pointer
E172    85 87       STA $87        save
E174    C6 87       DEC $87
E176    C9 02       CMP #$02       equal 2?
E178    D0 04       BNE $E17E      no
E17A    A9 FF       LDA #$FF
E17C    85 87       STA $87
E17E    B5 C7       LDA $C7,X      record length
E180    85 88       STA $88
E182    20 E8 D4    JSR $D4E8      set buffer pointer
E185    A6 82       LDX $82        channel number
E187    C5 87       CMP $87        buffer pointer > write pointer?
E189    90 19       BCC $E1A4
E18B    F0 17       BEQ $E1A4      no
E18D    20 1E CF    JSR $CF1E      change buffer
E190    20 B2 E1    JSR $E1B2
E193    90 08       BCC $E19D
E195    A6 82       LDX $82        channel number
E197    9D 44 02    STA $0244,X
E19A    4C 1E CF    JMP $CF1E      change buffer

E19D    20 1E CF    JSR $CF1E      change buffer
E1A0    A9 FF       LDA #$FF
E1A2    85 87       STA $87
E1A4    20 B2 E1    JSR $E1B2
E1A7    B0 03       BCS $E1AC
E1A9    20 E8 D4    JSR $D4E8      set buffer pointer
E1AC    A6 82       LDX $82        channel number
E1AE    9D 44 02    STA $0244,X    end pointer
E1B1    60          RTS

E1B2    20 2B DE    JSR $DE2B      buffer pointer to zero
E1B5    A4 87       LDY $87
E1B7    B1 94       LDA ($94),Y    byte from buffer
E1B9    D0 0D       BNE $E1C8      not zero?
E1BB    88          DEY
E1BC    C0 02       CPY #$02
E1BE    90 04       BCC $E1C4
E1C0    C6 88       DEC $88
E1C2    D0 F3       BNE $E1B7
E1C4    C6 88       DEC $88
E1C6    18          CLC
```

```
E1C7    60          RTS

E1C8    98          TYA
E1C9    38          SEC
E1CA    60          RTS

******************************      get last side-sector
E1CB    20 D2 DE    JSR $DED2       get number of the side-sector
E1CE    85 D5       STA $D5         save
E1D0    A9 04       LDA #$04
E1D2    85 94       STA $94         pointer to side-sectors
E1D4    A0 0A       LDY #$0A
E1D6    D0 04       BNE $E1DC

E1D8    88          DEY
E1D9    88          DEY
E1DA    30 26       BMI $E202
E1DC    B1 94       LDA ($94),Y     track # of the previous block
E1DE    F0 F8       BEQ $E1D8
E1E0    98          TYA
E1E1    4A          LSR A           divide by 2
E1E2    C5 D5       CMP $D5         = number of the actual block?
E1E4    F0 09       BEQ $E1EF       yes
E1E6    85 D5       STA $D5         else save all numbers
E1E8    A6 82       LDX $82         channel number
E1EA    B5 CD       LDA $CD,X       buffer number
E1EC    20 1B DF    JSR $DF1B       read block
E1EF    A0 00       LDY #$00
E1F1    84 94       STY $94         buffer pointer
E1F3    B1 94       LDA ($94),Y     track number
E1F5    D0 0B       BNE $E202       another block?
E1F7    C8          INY
E1F8    B1 94       LDA ($94),Y     sector number = end pointer
E1FA    A8          TAY
E1FB    88          DEY
E1FC    84 D6       STY $D6         save end pointer
E1FE    98          TYA
E1FF    4C E9 DE    JMP $DEE9       set buffer pointer

E202    A9 67       #$67
E204    20 45 E6    JSR $E645       67, 'illegal track or sector'

******************************      P-command, 'Record'
E207    20 B3 C2    JSR $C2B3       verify lines
E20A    AD 01 02    LDA $0201       secondary address
E20D    85 83       STA $83
E20F    20 EB D0    JSR $D0EB       find channel number
E212    90 05       BCC $E219       found?
E214    A9 70       LDA #$70
E216    20 C8 C1    JSR $C1C8       70, 'no block'

E219    A9 A0       LDA #$A0
E21B    20 9D DD    JSR $DD9D       erase bits 6 & 7
E21E    20 25 D1    JSR $D125       verify if 'REL'-file
E221    F0 05       BEQ $E228       yes
```

```
E223    A9 64       LDA #$64
E225    20 C8 C1    JSR $C1C8     64, 'file type mismatch'

E228    B5 EC       LDA $EC,X
E22A    29 01       AND #$01
E22C    85 7F       STA $7F       drive number
E22E    AD 02 02    LDA $0202     record number lo
E231    95 B5       STA $B5,X
E233    AD 03 02    LDA $0203     record number hi
E236    95 BB       STA $BB,X
E238    A6 B2       LDA $82       channel number
E23A    A9 89       LDA #$89
E23C    95 F2       STA $F2,X     READ and WRITE flag
E23E    AD 04 02    LDA $0204     byte-pointer
E241    F0 10       BEQ $E253     zero?
E243    38          SEC
E244    E9 01       SBC #$01
E246    F0 0B       BEQ $E253
E248    D5 C7       CMP $C7,X     compare with record length
E24A    90 07       BCC $E253
E24C    A9 51       LDA #$51
E24E    8D 6C 02    STA $026C     51, 'overflow in record'
E251    A9 00       LDA #$00
E253    85 D4       STA $D4
E255    20 0E CE    JSR $CE0E     calculate pointer in rel-file
E258    20 F8 DE    JSR $DEF8     and read appropriate side-sector
E25B    50 08       BVC $E265     does block exist?
E25D    A9 80       LDA #$80
E25F    20 97 DD    JSR $DD97     set bit 7
E262    4C 5E E1    JMP $E15E     and 50, 'record not present'

E265    20 75 E2    JSR $E275
E268    A9 80       LDA #$80
E26A    20 A6 DD    JSR $DDA6     test bit 7
E26D    F0 03       BEQ $E272     not set
E26F    4C 5E E1    JMP $E15E     50, 'record not present'
E272    4C 94 C1    JMP $C194     done

E275    20 9C E2    JSR $E29C
E278    A5 D7       LDA $D7       pointer in rel-file
E27A    20 C8 D4    JSR $D4C8     set buffer pointer
E27D    A6 82       LDX $82       channel number
E27F    B5 C7       LDA $C7,X     record length
E281    38          SEC
E282    E5 D4       SBC $D4       minus position
E284    B0 03       BCS $E289     positive?
E286    4C 02 E2    JMP $E202     67, 'illegal track or sector'

E289    18          CLC
E28A    65 D7       ADC $D7       add pointer in data block
E28C    90 03       BCC $E291     no overflow
E28E    69 01       ADC #$01      plus 2
E290    38          SEC
E291    20 09 E0    JSR $E009     set pointer
E294    4C 38 E1    JMP $E138     get byte from buffer
```

```
E297   A9 51      LDA #$51
E299   20 C8 C1   JSR $C1C8      51, 'overflow in record'

E29C   A5 94      LDA $94        buffer pointer lo
E29E   85 89      STA $89
E2A0   A5 95      LDA $95        buffer pointer hi
E2A2   85 8A      STA $8A
E2A4   20 D0 E2   JSR $E2D0      compare track and sector
E2A7   D0 01      BNE $E2AA      not equal?
E2A9   60         RTS

E2AA   20 F1 DD   JSR $DDF1
E2AD   20 0C DE   JSR $DE0C
E2B0   A5 80      LDA $80        track
E2B2   F0 0E      BEQ $E2C2      no block following?
E2B4   20 D3 E2   JSR $E2D3      compare track and sector number
E2B7   D0 06      BNE $E2BF      not equal?
E2B9   20 1E CF   JSR $CF1E      change buffer
E2BC   4C DA D2   JMP $D2DA
E2BF   20 DA D2   JSR $D2DA
E2C2   A0 00      LDY #$00
E2C4   B1 89      LDA ($89),Y    track
E2C6   85 80      STA $80
E2C8   C8         INY
E2C9   B1 89      LDA ($89),Y    and sector of the next block
E2CB   85 81      STA $81
E2CD   4C AF D0   JMP $D0AF      read block

E2D0   20 3E DE   JSR $DE3E
E2D3   A0 00      LDY #$00
E2D5   B1 89      LDA ($89),Y    track number
E2D7   C5 80      CMP $80        compare
E2D9   F0 01      BEQ $E2DC
E2DB   60         RTS
E2DC   C8         INY
E2DD   B1 89      LDA ($89),Y    sector number
E2DF   C5 81      CMP $81        compare
E2E1   60         RTS

*******************************  subdivide records in data block
E2E2   20 2B DE   JSR $DE2B      set buffer pointer
E2E5   A0 02      LDY #$02
E2E7   A9 00      LDA #$00
E2E9   91 94      STA ($94),Y    erase buffer
E2EB   C8         INY
E2EC   D0 FB      BNE $E2E9
E2EE   20 04 E3   JSR $E304      set pointer to next record
E2F1   95 C1      STA $C1,X
E2F3   A8         TAY
E2F4   A9 FF      LDA #$FF
E2F6   91 94      STA ($94),Y    $FF as 1st character in record
E2F8   20 04 E3   JSR $E304      set pointer to next record
E2FB   90 F4      BCC $E2F1      done in this block?
E2FD   D0 04      BNE $E303      block full?
```

```
E2FF    A9 00       LDA #$00
E301    95 C1       STA $C1,X      write pointer to zero
E303    60          RTS

******************************     set pointer to next record
E304    A6 82       LDX $82        channel number
E306    B5 C1       LDA $C1,X      write pointer
E308    38          SEC
E309    F0 0D       BEQ $E318      equal zero?
E30B    18          CLC
E30C    75 C7       ADC $C7,X      add record length
E30E    90 0B       BCC $E31B      smaller than 256?
E310    D0 06       BNE $E318      equal 256?
E312    A9 02       LDA #$02
E314    2C CC FE    BIT $FECC
E317    60          RTS

E318    69 01       ADC #$01       add two
E31A    38          SEC
E31B    60          RTS

******************************     expand side-sector
E31C    20 D3 D1    JSR $D1D3      get drive number
E31F    20 CB E1    JSR $E1CB      get last side-sector
E322    20 9C E2    JSR $E29C
E325    20 7B CF    JSR $CF7B
E328    A5 D6       LDA $D6
E32A    85 87       STA $87
E32C    A5 D5       LDA $D5        side-sector number
E32E    85 86       STA $86
E330    A9 00       LDA #$00
E332    85 88       STA $88
E334    A9 00       LDA #$00
E336    85 D4       STA $D4
E338    20 0E CE    JSR $CE0E      calculate side-sector no. and ptr
E33B    20 4D EF    JSR $EF4D      number of free blocks
E33E    A4 82       LDY $82        channel number
E340    B6 C7       LDX $C7,Y      record length
E342    CA          DEX
E343    8A          TXA
E344    18          CLC
E345    65 D7       ADC $D7        plus pointer in data block
E347    90 0C       BCC $E355
E349    E6 D6       INC $D6
E34B    E6 D6       INC $D6        increment ptr to end by 2
E34D    D0 06       BNE $E355
E34F    E6 D5       INC $D5        increment side-sector number
E351    A9 10       LDA #$10
E353    85 D6       STA #D6        set pointer to 16
E355    A5 87       LDA $87
E357    18          CLC
E358    69 02       ADC #$02
E35A    20 E9 DE    JSR $DEE9      set buffer ptr for side-sector
E35D    A5 D5       LDA $D5        side-sector number
E35F    C9 06       CMP #$06
```

```
E361   90 05      BCC $E368     smaller than 6?
E363   A9 52      LDA #$52
E365   20 C8 C1   JSR $C1C8     52, 'file too large'
E368   A5 D6      LDA $D6       end pointer
E36A   38         SEC
E36B   E5 87      SBC $87       minus last end pointer
E36D   B0 03      BCS $E372
E36F   E9 0F      SBC #$0F      minus 16
E371   18         CLC
E372   85 72      STA $72
E374   A5 D5      LDA $D5       side-sector number
E376   E5 86      SBC $86       minus last side-sector number
E378   85 73      STA $73       save
E37A   A2 00      LDX #$00
E37C   86 70      STX $70       erase sum for calculation
E37E   86 71      STX $71
E380   AA         TAX
E381   20 51 DF   JSR $DF51     calculate block # of rel-file
E384   A5 71      LDA $71
E386   D0 07      BNE $E38F
E388   A6 70      LDX $70
E38A   CA         DEX
E38B   D0 02      BNE $E38F
E38D   E6 88      INC $88
E38F   CD 73 02   CMP $0273     block number of rel-file
E392   90 09      BCC $E39D     greater than free blocks on disk?
E394   D0 CD      BNE $E363     52, 'file too large'
E396   AD 72 02   LDA $0272
E399   C5 70      CMP $70
E39B   90 C6      BCC $E363     52, 'file too large'
E39D   A9 01      LDA #$01
E39F   20 F6 D4   JSR $D4F6     get byte from buffer
E3A2   18         CLC
E3A3   69 01      ADC #$01      plus 1
E3A5   A6 82      LDX $82
E3A7   95 C1      STA $C1,X     as write pointer
E3A9   20 1E F1   JSR $F11E     find free block in BAM
E3AC   20 FD DD   JSR $DDFD     track and sector in buffer
E3AF   A5 88      LDA $88
E3B1   D0 15      BNE $E3C8     only one block needed?
E3B3   20 5E DE   JSR $DE5E     write block
E3B6   20 1E CF   JSR $CF1E     change buffer
E3B9   20 D0 D6   JSR $D6D0     transmit param to disk controller
E3BC   20 1E F1   JSR $F11E     find free block in BAM
E3BF   20 FD DD   JSR $DDFD     track and sector in buffer
E3C2   20 E2 E2   JSR $E2E2     erase buffer
E3C5   4C D4 E3   JMP $E3D4

E3C8   20 1E CF   JSR $CF1E     change buffer
E3CB   20 D0 D6   JSR $D6D0     transmit param to disk controller
E3CE   20 E2 E2   JSR $E2E2     erase buffer
E3D1   20 19 DE   JSR $DE19     zero byte and end ptr in buffer
E3D4   20 5E DE   JSR $DE5E     write block
E3D7   20 0C DE   JSR $DE0C     get track and sector
E3DA   A5 80      LDA $80       track
```

```
E3DC    48          PHA
E3DD    A4 81       LDA $81         and sector
E3DF    48          PHA             save
E3E0    20 3E DE    JSR $DE3E       get track and sector from disk
E3E3    A5 81       LDA $81         controller
E3E5    48          PHA
E3E6    A5 80       LDA $80         save track and sector
E3E8    48          PHA
E3E9    20 45 DF    JSR $DF45       set buffer ptr for side-sector
E3EC    AA          TAX
E3ED    D0 0A       BNE $E3F9       pointer not zero?
E3EF    20 4E E4    JSR $E44E       write side-sector
E3F2    A9 10       LDA #$10
E3F4    20 E9 DE    JSR $DEE9       buffer pointer to 16
E3F7    E6 86       INC $86         increment side-sector number
E3F9    68          PLA
E3FA    20 8D DD    JSR $DD8D       track in side sector
E3FD    68          PLA
E3FE    20 8D DD    JSR $DD8D       sector in side-sector
E401    68          PLA
E402    85 81       STA $81         sector
E404    68          PLA
E405    85 80       STA $80         and get track back
E407    F0 0F       BEQ $E418       no more blocks?
E409    A5 86       LDA $86         side-sector number
E40B    C5 D5       CMP $D5         changed?
E40D    D0 A7       BNE $E3B6       yes
E40F    20 45 DF    JSR $DF45       set buffer ptr in side-sector
E412    C5 D6       CMP $D6         end pointer
E414    90 A0       BCC $E3B6       smaller?
E416    F0 B0       BEQ $E3C8       same
E418    20 45 DF    JSR $DF45       set buffer ptr in side-sector
E41B    48          PHA
E41C    A9 00       LDA #$00
E41E    20 DC DE    JSR $DEDC       buffer pointer to zero
E421    A9 00       LDA #$00
E423    A8          TAY
E424    91 94       STA ($94),Y     zero as track number
E426    C8          INY
E427    68          PLA             end pointer
E428    38          SEC
E429    E9 01       SBC #$01        minus one
E42B    91 94       STA ($94),Y     as sector
E42D    20 6C DE    JSR $DE6C       write block
E430    20 99 D5    JSR $D599       and verify
E433    20 F4 EE    JSR $EEF4       update BAM
E436    20 0E CE    JSR $CE0E       update pointer for rel-file
E439    20 1E CF    JSR $CF1E       change buffer
E43C    20 F8 DE    JSR $DEF8       right side-sector?
E43F    70 03       BVS $E444       no
E441    4C 75 E2    JMP $E275

E444    A9 80       LDA #$80
E446    20 97 DD    JSR $DD97       set bit 7
E449    A9 50       LDA #$50
```

```
E44B    20 C8 C1    JSR $C1C8       50, 'record not present'

******************************      write side-sector and allocate
                                    new one
E44E    20 1E F1    JSR $F11E       find free block in BAM
E451    20 1E CF    JSR $CF1E       change buffer
E454    20 F1 DD    JSR $DDF1       write block
E457    20 93 DF    JSR $DF93       get buffer number
E45A    48          PHA
E45B    20 C1 DE    JSR $DEC1       erase buffer
E45E    A6 82       LDX $82         channel number
E460    B5 CD       LDA $CD,X       buffer number
E462    A8          TAY
E463    68          PLA
E464    AA          TAX
E465    A9 10       LDA #$10        16 bytes of the side-sector
E467    20 A5 DE    JSR $DEA5       copy in buffer
E46A    A9 00       LDA #$00
E46C    20 DC DE    JSR $DEDC       buffer ptr to 0, old side-sector
E46F    A0 02       LDY #$02
E471    B1 94       LDA ($94),Y     side-sector number
E473    48          PHA
E474    A9 00       LDA #$00
E476    20 C8 D4    JSR $D4C8       buffer ptr to 0, new side-sector
E479    68          PLA
E47A    18          CLC
E47B    69 01       ADC #$01        increment side-sector number
E47D    91 94       STA ($94),Y     and in buffer
E47F    0A          ASL A           times 2
E480    69 04       ADC #$04        plus 4
E482    85 89       STA $89
E484    A8          TAY
E485    38          SEC
E486    E9 02       SBC #$02        minus 2
E488    85 8A       STA $8A         same pointer to old side-sector
E48A    A5 80       LDA $80         track
E48C    85 87       STA $87
E48E    91 94       STA ($94),Y     in buffer
E490    C8          INY
E491    A5 81       LDA $81         sector
E493    85 88       STA $88
E495    91 94       STA ($94),Y     in buffer
E497    A0 00       LDY #$00
E499    98          TYA
E49A    91 94       STA ($94),Y     zero in buffer
E49C    C8          INY
E49D    A9 11       LDA #$11        17
E49F    91 94       STA ($94),Y     number of bytes in block
E4A1    A9 10       LDA #$10        16
E4A3    20 C8 D4    JSR $D4C8       buffer pointer to 16
E4A6    20 50 DE    JSR $DE50       write block
E4A9    20 99 D5    JSR $D599       and verify
E4AC    A6 82       LDX $82         channel number
E4AE    B5 CD       LDA $CD,X       buffer number of the side-sector
E4B0    48          PHA
```

```
E4B1    20 9E DF    JSR $DF9E      get buffer number
E4B4    A6 82       LDX $82        channel number
E4B6    95 CD       STA $CD,X      write in table
E4B8    68          PLA
E4B9    AE 57 02    LDX $0257      channel number + 7
E4BC    95 A7       STA $A7,X      in table
E4BE    A9 00       LDA #$00
E4C0    20 C8 D4    JSR $D4C8      buffer pointer to zero
E4C3    A0 00       LDY #$00
E4C5    A5 80       LDA $80        track
E4C7    91 94       STA ($94),Y    in buffer
E4C9    C8          INY
E4CA    A5 81       LDA $81        sector
E4CC    91 94       STA ($94),Y    in buffer
E4CE    4C DE E4    JMP $E4DE

E4D1    20 93 DF    JSR $DF93      get buffer number
E4D4    A6 82       LDX $82        channel number
E4D6    20 1B DF    JSR $DF1B      read block
E4D9    A9 00       LDA #$00
E4DB    20 C8 D4    JSR $D4C8      buffer pointer to zero
EFDE    C6 8A       DEC $8A
E4E0    C6 8A       DEC $8A        counter for side-sector blocks
E4E2    A4 89       LDY $89
E4E4    A5 87       LDA $87        track number
E4E6    91 94       STA ($94),Y    in buffer
E4E8    C8          INY
E4E9    A5 88       LDA $88        sector number
E4EB    91 94       STA ($94),Y    in buffer
E4ED    20 5E DE    JSR $DE5E      write block
E4F0    20 99 D5    JSR $D599      and verify
E4F3    A4 8A       LDY $8A        counter for side-sector blocks
E4F5    C0 03       CPY #$03
E4F7    B0 D8       BCS $E4D1      greater than or equal to 3?
E4F9    4C 1E CF    JMP $CF1E      change buffer

*******************************    table of error messages
E4FC 00                            00
E4FD A0 4F CB                       ' oK'
E500 20 21 22 23 24 27             error numbers of 'read error'
E506 D2 45 41 44                   'Read'
E50A 89                            pointer to 'error'
E50B 52                            52
E50C 83                            pointer to 'file'
E50D 20 54 4F 4F 20 AC 4A 52 47    C5     ' too largE'
E517 50                            50
E518 8B 06                         pointer to 'record ' and 'not '
E51A 20 50 52 45 53 45 4E D4       ' presenT'
E522 51                            51
E523 CF 56 45 52 46 4C 4F 57 20    'Overflow in'
E52E 8B                            pointer to 'record'
E52F 25 28                         error numbers of 'write error'
E531 8A 89                         pointer to 'write' and 'error '
E533 26                            26
E534 8A                            pointer to 'write'
```

```
E535 20 50 52 4F 54 45 43 54 20 4F CE ' protect oN'
E540 29                               29
E541 88                               pointer to 'disk'
E542 20 49 85                         ' id'
E545 85                               pointer to ' mismatch'
E546 30 31 32 33 34                   error numbers for 'syntax error'
E54B D3 59 4E 54 41 58                'Syntax'
E551 89                               pointer to ' error'
E552 60                               60
E553 8A 03 84                          ptrs to 'write', 'file' & 'open'
E556 63                               63
E557 83                               pointer to 'file'
E558 20 45 58 49 53 54 D3             ' existS'
E55F 64                               64
E560 83                               pointer to 'file'
E561 20 54 59 50 45                   ' type'
E566 85                               pointer to 'mismatch'
E567 65                               65
E568 CE 4F 20 42 4C 4F 43 CB          'No block'
E570 66 67                            'illegal track or sector'
E572 C9 4C 4C 45 47 41 4C 20          'Illegal '
E57A 54 52 41 43 4B 20 4F 52          'track or'
E582 20 53 45 43 54 4F D2             'sectoR'
E589 61                               61
E58A 83 06 84                         pointer to 'file', 'not' & 'open'
E58D 39 62                            error nos. for 'file not found'
E590 83 06 87                          ptrs to 'file', 'not' & 'found'
E593 01                               01
E594 83                               pointer to 'file'
E594 53 20 53 43 52 41 54 43 48 45 C4  's scratcheD'
E59F 70                               70
E5A0 CE 4F 20 43 48 41 4E 4E 45 CC  'No channeL'
E5AA 71                               71
E5AB C4 49 52                         'Dir'
E5AE 89                               pointer to 'error'
E5AF 72                               72
E5B0 88                               pointer to 'disk'
E5B1 20 46 55 4C CC                   ' fulL'
E5B6 73                               73
E5B7 C3 42 4D 20 44 4F 53 20          'Cbm dos '
E5BF 56 32 2E 36 20 31 35 34 B1       'v2.6 1541'
E5C4 74                               74
E5C5 C4 42 49 56 45                   'Drive'
E5CA 06                               pointer to 'not'
E5CB 20 52 45 41 44 D9                ' readY'
E5D5 09
E5D6 C5 52 52 4F D2                   'ErroR'
E5DB 0A
E5DC D7 52 49 54 C5                   'WritE'
E5E1 03
E5E2 C6 49 4C C5                      'FilE'
E5E6 04
E6E7 CF 50 45 CE                      'OpeN'
E5EB 05
E5EC CD 49 53 4D 41 54 43 C8          'MismatcH'
```

```
E5F4 06
E5F5 CE 4F D4                         'NoT'
E5F8 07
E5F9 C6 4F 55 4E C4                   'FounD'
E5FE 08
E5FF C4 49 53 CB                      'DisK'
E603 0B
E604 D2 45 43 4F 52 C4                'RecorD'

********************************      prepare error number and message
E60A    48          PHA               save error code
E60B    86 F9       STX $F9           drive number
E60D    8A          TXA
E60E    0A          ASL A             times 2
E60F    AA          TAX               as pointer
E610    B5 06       LDA $06,X
E612    85 80       STA $80           get track
E614    B5 07       LDA $07,X
E616    85 81       STA $81           and sector number
E618    68          PLA               get error code back
E619    29 0F       AND #$0F          isolate bits 0-3
E61B    F0 08       BEQ $E625         zero, then 24, 'read error'
E61D    C9 0F       CMP #$0F          15?
E61F    D0 06       BNE $E627
E621    A9 74       LDA #$74
E623    D0 08       BNE $E62D         74, 'drive not ready'
E625    A9 06       LDA #$06          6
E627    09 20       ORA #$20          add $20
E629    AA          TAX
E62A    CA          DEX
E62B    CA          DEX               subtract two
E62C    8A          TXA
E62D    48          PHA               save error number
E62E    AD 2A 02    LDA $022A         number of the disk command
E631    C9 00       CMP #$00          OPEN or VALIDATE?
E633    D0 0F       BNE $E644         no
E635    A9 FF       LDA #$FF
E637    8D 2A 02    STA $022A
E63A    68          PLA               get error number back
E63B    20 C7 E6    JSR $E6C7         generate error message
E63E    20 42 D0    JSR $D042         load BAM
E641    4C 48 E6    JMP $E648         set error message

E644    68          PLA
E645    20 C7 E6    JSR $E6C7         set error message
E648    20 BD C1    JSR $C1BD         erase input buffer
E64B    A9 00       LDA #$00
E64D    8D F9 02    STA $02F9         erase error flag
E650    20 2C C1    JSR $C12C         turn LED off
E653    20 DA D4    JSR $D4DA         close channels 17 and 18
E656    A9 00       LDA #$00
E658    85 A3       STA $A3           input buffer pointer to zero
E65A    A2 45       LDX #$45
E65C    9A          TXS               initialize stack pointer
E65D    A5 84       LDA $84           secondary address
```

```
E65F    29 0F       AND #$0F
E661    85 83       STA $83
E663    C9 0F       CMP #$0F        15?
E665    F0 31       BEQ $E698       yes, command channel
E667    78          SEI
E668    A5 79       LDA $79         LISTEN active?
E66A    D0 1C       BNE $E688       yes
E66C    A5 7A       LDA $7A         TALK active?
E66E    D0 10       BNE $E680       yes
E670    A6 83       LDX $83         channel number
E672    BD 2B 02    LDA $022B,X     open channel to this second. addr
E675    C9 FF       CMP #$FF
E677    F0 1F       BEQ $E698       no
E679    29 0F       AND #$0F
E67B    85 82       STA $82         channel number
E67D    4C 8E E6    JMP $E68E

******************************      TALK
E680    20 EB D0    JSR $D0EB       open channel for reading
E683    20 4E EA    JSR $EA4E       accept byte
E686    D0 06       BNE $E68E

******************************      LISTEN
E688    20 07 D1    JSR $D107       open channel for writing
E68B    20 4E EA    JSR $EA4E       accept byte
E68E    20 25 D1    JSR $D125       verify file type
E691    C9 04       CMP #$04        file type REL?
E693    B0 03       BCS $E698       yes
E695    20 27 D2    JSR $D227       close channel
E698    4C E7 EB    JMP $EBE7

******************************      convert hex to decimal (2 bytes)
E69B    AA          TAX
E69C    A9 00       LDA #$00
E69E    F8          SED
E69F    E0 00       CPX #$00
F6A1    F0 07       BEQ $E6AA       convert hex to BCD
E6A3    18          CLC
E6A4    69 01       ADC #$01
A6A6    CA          DEX
E6A7    4C 9F E6    JMP $E69F
E6AA    D8          CLD

******************************      divide BCD number into two bytes
E6AB    AA          TAX
E6AC    4A          LSR A
E6AD    4A          LSR A           shift hi-nibble down
E6AE    4A          LSR A
E6AF    4A          LSR A
E6B0    20 B4 E6    JSR $E6B4       convert to ASCII
E6B3    8A          TXA
E6B4    29 0F       AND #$0F        erase top 4 bits
E6B6    09 30       ORA #$30        add '0'
E6B8    91 A5       STA ($A5),Y     write in buffer
E6BA    C8          INY             increment buffer pointer
```

```
E6BB   60          RTS

******************************        write 'ok' in buffer
E6BC   20 23 Cl    JSR $C123          erase error flag
E6BF   A9 00       LDA #$00           error number 0
E6Cl   A0 00       LDY #$00
E6C3   84 80       STY $80            track 0
E6C5   84 81       STY $81            sector 0

******************************        error message in buffer
E6C7   A0 00       LDY #$00           buffer pointer
E6C9   A2 D5       LDX #$D5
E6C8   86 A5       STX $A5            pointer $A5/$A6 TO $2D5
E6CD   A2 02       LDX #$02
E6CF   86 A6       STX $A6
E6Dl   20 AB E6    JSR $E6AB          error # to ASCII and in buffer
E6D4   A9 2C       LDA #$2C           ',' comma
E6D6   9A A5       STA ($A5),Y        write in buffer
ED68   C8          INY                increment buffer pointer
E6D9   AD D5 02    LDA $02D5          first digit of the disk status
E6DC   8D 43 02    STA $0243          in output register
E6DF   8A          TXA                error number in accumulator
E6E0   20 06 E7    JSR $E706          error message in buffer
E6E3   A9 2C       LDA #$2C           ',' comma
E6E5   91 A5       STA ($A5),Y        write in buffer
E6E7   C8          INY                and increment buffer pointer
E6E8   A5 80       LDA $80            track number
E6EA   20 9B E6    JSR $E69B          to ASCII and in buffer
E6ED   A9 2C       LDA #$2C           ',' comma
E6EF   91 A5       STA ($A5),Y        write in buffer
E6Fl   C8          INY                increment buffer pointer
E6F2   A5 81       LDA $81            sector
E6F4   20 9B E6    JSR $E69B          convert to ASCII and in buffer
E6F7   88          DEY
E6F8   98          TYA
E6F9   18          CLC
E6FA   69 D5       ADC #$D5
E6FC   8D 49 02    STA $0249          end pointer
E6FF   E6 A5       INC $A5
E701   A9 88       LDA #$88           set READ flag
E703   85 F7       STA $F7
E705   60          RTS

******************************        write error message to buffer
E706   AA          TAX                error code to X
E707   A5 86       LDA $86
E709   48          PHA                preserve pointer $86/$87
E70A   A5 87       LDA $87
E70C   48          PHA
E70D   A9 FC       LDA #$FC
E70F   85 86       STA #$E4           start of the error messages
E713   85 87       STA $87
E715   8A          TXA                error number in accumulator
E716   A2 00       LDX #$00
E718   Cl 86       CMP ($86,X)        compare with error no in table
```

```
E71A    F0 21       BEQ $E73D
E71C    48          PHA
E71D    20 75 E7    JSR $E775       bit 7 into carry and erase
E720    90 05       BCC $E727       not set?
E722    20 75 E7    JSR $E775       bit 7 into carry
E725    90 FB       BCC $E722       wait for character with bit 7 set
E727    A5 87       LDA $87
E729    C9 E6       CMP #$E6
E72B    90 08       BCC $E735       $E60A, check to end of table
E72D    D0 0A       BNE $E739
E72F    A0 0A       LDA #$0A
E731    C5 86       CMP $86
E733    90 04       BCC $E739
E735    68          PLA
E736    4C 18 E7    JMP $E718       no, continue
E739    68          PLA
E73A    4C 4D E7    JMP $E74D       done

E73D    20 67 E7    JSR $E767       get a character, bit 7 in carry
E740    90 FB       BCC $E73D       wait for character with bit 7 set
E742    20 54 E7    JSR $E754       and write in buffer
E745    20 67 E7    JST $E767       get next character
E748    90 F8       BCC $E742       wait for character with bit 7 set
E74A    20 54 E7    JSR $E754       put character in buffer
E74D    68          PLA
E74E    85 87       STA $87
E750    68          PLA             get pointer $86/$87 back
E751    85 86       STA $86
E753    60          RTS

******************************      get character and in buffer
E754    C9 20       CMP #$20        ' ' blank
E756    B0 0B       BCS $E763       greater, then write in buffer
E758    AA          TAX             save code
E759    A9 20       LDA #$20        blank
E75B    91 A5       STA ($A5),Y     write in buffer
E75D    C8          INY             increment buffer pointer
E75E    8A          TXA             code in accumulator
E75F    20 06 E7    JSR $E706       output previous text
E762    60          RTS
E763    91 A5       STA ($A5),Y     write character in buffer
E765    C8          INY             and increment pointer
E766    60          RTS

******************************      get a char of the error message
E767    E6 86       INC $86
E769    D0 02       BNE $E76D       increment pointer
E76B    E6 87       INC $87
E76D    A1 86       LDA ($86,X)     get character
E76F    0A          ASL A           bit 7 into carry
E770    A1 86       LDA ($86,X)     get character
E772    29 7F       AND #$7F        erase bit 7
E774    60          RTS

******************************      increment pointer
```

```
E775    20 6D E7   JSR $E76D      bit 7 into carry
E778    E6 86      INC $86
E77A    D0 02      BNE $E77E      increment pointer
E77C    E6 87      INC $87
E77E    60         RTS

******************************
E77F    60         RTS

******************************    check for AUTO-start
E780    AD 00 18   LDA $1800      read IEEE port
E783    AA         TAX
E784    29 04      AND #$04       isolate 'CLOCK IN' bit
E786    F0 F7      BEQ $E77F      not set, then done
E788    8A         TXA
E789    29 01      AND #$01       isolate 'DATA IN' bit
E78B    F0 F2      BEQ $E77F      not set, then done
E78D    58         CLI
E78E    AD 00 18   LDA $1800      load IEEE port
E791    29 05      AND #$05       test 'DATA IN' and 'CLOCK IN'
E793    F0 F9      BNE $E78E      wait until both set
E795    EE 78 02   INC $0278      file name
E798    EE 74 02   INC $0274      character in the input line
E79B    A9 2A      LDA #$2A       '*' as filename
E79D    8D 00 02   STA $0200      write in buffer
E7A0    4C A8 E7   JMP $E7A8

******************************    '&' - command
E7A3    A9 8D      LDA #$8D
E7A5    20 68 C2   JSR $C268      check command line to end
E7A8    20 58 F2   JSR $F258      (RTS)
E7AB    AD 78 02   LDA $0278      number of file names
E7AE    48         PHA            save
E7AF    A9 01      LDA #$01
E7B1    8D 78 02   STA $0278      file name
E7B4    A9 FF      LDA #$FF
E7B6    85 86      STA $86
E7B8    20 4F C4   JSR $C44F      find file
E7BB    AD 80 02   LDA $0280
E7BE    D0 05      BNE $E7C5      found?
E7C0    A9 39      LDA #$39
E7C2    20 C8 C1   JSR $C1C8      39, 'file not found'
E7C5    68         PLA
E7C6    8D 78 02   STA $0278      get number of file names back
E7C9    AD 80 02   LDA $0280
E7CC    85 80      STA $80        track
E7CE    AD 85 02   LDA $0285
E7D1    85 81      STA $81        and sector
E7D3    A9 03      LDA #$03       file type 'USR'
E7D5    20 77 D4   JSR $D477      buffer allocated, read 1st block
E7D8    A9 00      LDA #$00
E7DA    85 87      STA $87        erase checksum
E7DC    20 39 E8   JSR $E839      get byte from file
E7DF    85 88      STA $88        save as start address lo
E7E1    20 4B E8   JSR $E84B      form checksum
```

```
E7E4    20 39 E8    JSR $E839       get byte from file
E7E7    85 89       STA $89         as start address hi
E7E9    20 4B E8    JSR $E84B       form checksum
E7EC    A5 86       LDA $86
E7EE    F0 0A       BEQ $E7FA
E7F0    A5 88       LDA $88
E7F2    48          PHA             save program start address
E7F3    A5 89       LDA $89
E7F5    48          PHA
E7F6    A9 00       LDA #$00
E7F8    85 86       STA $86
E7FA    20 39 E8    JSR $E839       get byte from file
E7FD    85 8A       STA $8A         save as counter
E7FF    20 4B E8    JSR $E84B       form checksum
E802    20 39 E8    JSR $E839       get byte from file
E805    A0 00       LDY #$00
E807    91 88       STA ($88),Y     save as program bytes
E809    20 4B E8    JSR $E84B       form checksum
E80C    A5 88       LDA $88
E80E    18          CLC
E80F    69 01       ADC #$01
E811    85 88       STA $88         increment $88/$89
E813    90 02       BCC $E817
E815    E6 89       INC $89
E817    C6 8A       DEC $8A         decrement pointer
E819    D0 E7       BNE $E802
E81B    20 35 CA    JSR $CA35       get next byte
E81E    A5 85       LDA $85         data byte
E820    C5 87       CMP $87         equal to checksum?
E822    F0 08       BEQ $E82C       yes
E824    20 3E DE    JSR $DE3E       transmit param to disk controller
E827    A9 50       LDA #$50
E829    20 45 E6    JSR $E645       50, 'record not present'
E82C    A5 F8       LDA $F8         end?
E82E    D0 A8       BNE $E7D8       no, next data block
E830    68          PLA
E831    85 89       STA $89
E833    68          PLA             get program start address back
E834    85 88       STA $88
E836    6C 88 00    JMP ($0088)     and execute program
E839    20 35 CA    JSR $CA35       get byte from file
E83C    A5 F8       LDA $F8         end?
E83E    D0 08       BNE $E848       no
E840    20 3E DE    JSR $DE3E       transmit param to disk controller
E843    A9 51       LDA #$51
E845    20 45 E6    JSR $E645       51, 'overflow in record'
E848    A5 85       LDA $85         data byte
E84A    60          RTS

******************************      generate checksum
E84B    A8          CLC
E84C    65 87       ADC $87
E84E    69 00       ADC #$00
E850    85 87       STA $87
E852    60          RTS
```

```
*******************************   IRQ routine for serial bus
E853   AD 01 18   LDA $1801     read port A, erase IRQ flag
E856   A9 01      LDA #$01
E858   85 7C      STA $7C       set flag for 'ATN received'
E85A   60         RTS

*******************************   servicing the serial bus
E85B   78         SEI
E85C   A9 00      LDA #$00
E85E   85 7C      STA $7C       erase flag for 'ATN received'
E860   85 79      STA $79       erase flag for LISTEN
E862   85 7A      STA $7A       erase flag for TALK
E864   A2 45      LDX #$45
E866   9A         TXS           initialize stack pointer
E867   A9 80      LDA #$80
E869   85 F8      STA $F8       erase end flag
E86B   85 7D      STA $7D       erase EOI flag
E86D   20 B7 E9   JSR $E9B7     CLOCK OUT lo
E870   20 A5 E9   JSR $E9A5     DATA OUT, bit '0', hi
E873   AD 00 18   LDA $1800
E876   09 10      ORA #$10      switch data lines to input
E878   8D 00 18   STA $1800
E87B   AD 00 18   LDA $1800     read IEEE port
E87E   10 57      BPL $E8D7     EOI?
E880   29 04      AND #$04      CLOCK IN?
E882   D0 F7      BNE $E87B     no
E884   20 C9 E9   JSR $E9C9     get byte from bus
E887   C9 3F      CMP #$3F      unlisten?
E889   D0 06      BNE $E891     no
E88B   A9 00      LDA #$00
E88D   85 79      STA $79       reset flag for LISTEN
E88F   F0 71      BEQ $E902
E891   C9 5F      CMP #$5F      untalk?
E893   D0 06      BNE $E89B     no
E895   A9 00      LDA #$00
E897   85 7A      STA $7A       reset flag for TALK
E899   F0 67      BEQ $E902
E89B   C5 78      CMP $78       TALK address?
E89D   D0 0A      BNE $E8A9     no
E89F   A9 01      LDA #$01
E8A1   85 7A      STA $7A       set flag for TALK
E8A3   A9 00      LDA #$00
E8A5   85 79      STA $79       reset flag for LISTEN
E8A7   F0 29      BEQ $E8D2
E8A9   C5 77      CMP $77       LISTEN address?
E8AB   D0 0A      BNE $E8B7     no
E8AD   A9 01      LDA #$01
E8AF   85 79      STA $79       set flag for LISTEN
E8B1   A9 00      LDA #$00
E8B3   85 7A      STA $7A       reset flag for TALK
E8B5   F0 1B      BEQ $E8D2
E8B7   AA         TAX
E8B8   29 60      AND #$60
E8BA   C9 60      CMP #$60      set bit 5 and 6
```

```
E8BC    D0 3F      BNE $E8FD    no
E8BE    8A         TXA
E8BF    85 84      STA $84      byte is secondary address
E8C1    29 0F      AND #$0F
E8C3    85 83      STA $83      channel number
E8C5    A5 84      LDA $84
E8C7    29 F0      AND #$F0
E8C9    C9 E0      CMP #$E0     CLOSE?
E8CB    D0 35      BNE $E902
E8CD    58         CLI
E8CE    20 C0 DA   JSR $DAC0    CLOSE routine
E8D1    78         SEI
E8D2    2C 00 18   BIT $1800
E8D5    30 AD      BMI $E884
E8D7    A9 00      LDA #$00
E8D9    85 7D      STA $7D      set EOI
E8DB    AD 00 18   LDA $1800    IEEE port
E8DE    29 EF      AND #$EF     switch data lines to output
E8E0    8D 00 18   STA $1800
E8E3    A5 79      LDA $79      LISTEN active?
E8E5    F0 06      BEQ $E8ED    no
E8E7    20 2E EA   JSR $EA2E    receive data
E8EA    4C E7 EB   JMP $EBE7    to delay loop

E8ED    A5 7A      LDA $7A      TALK active?
E8EF    F0 09      BEQ $E8FA    no
E8F1    20 9C E9   JSR $E99C    DATA OUT, bit '1', lo
E8F4    20 AE E9   JSR $E9AE    CLOCK OUT hi
E8F7    20 09 E9   JSR $E909    send data
E8FA    4C 4E EA   JMP $EA4E    to delay loop
E8FD    A9 10      LDA #$10     either TALK or LISTEN,ignore byte
E8FF    8D 00 18   STA $1800    switch data lines to input
E902    2C 00 18   BIT $1800
E905    10 D0      BPL $E8D7
E907    30 F9      BMI $E902    wait for handshake

******************************  send data
E909    78         SEI
E90A    20 EB D0   JSR $D0EB    open channel for read
E90D    B0 06      BCS $E915    channel active
E90F    A6 82      LDX $82      channel number
E911    B5 F2      LDA $F2,X    set READ flag?
E913    30 01      BMI $E916    yes
E915    60         RTS
E916    20 59 EA   JSR $EA59    check EOI
E919    20 C0 E9   JSR $E9C0    read IEEE port
E91C    29 01      AND #$01     isolate data bit
E91E    08         PHP          and save
E91F    20 B7 E9   JSR $E9B7    CLOCK OUT lo
E922    28         PLP
E923    F0 12      BEQ $E937
E925    20 59 EA   JSR $EA59    check EOI
E928    20 C0 E9   JSR $E9C0    read IEEE port
E92B    29 01      AND #$01     isolate data bit
E92D    D0 F6      BNE $E925
```

```
E92F    A6 82       LDX $82        channel number
E931    B5 F2       LDA $F2,X
E933    29 08       AND #$08
E935    D0 14       BNE $E94B
E937    20 59 EA    JSR $EA59      check EOI
E93A    20 C0 E9    JSR $E9C0      read IEEE port
E93D    29 01       AND #$01       isolate data bit
E93F    D0 F6       BNE $E937
E941    20 59 EA    JSR $EA59      check EOI
E944    20 C0 E9    JSR $E9C0      read IEEE port
E947    29 01       AND #$01       isolate data bit
E949    F0 F6       BEQ $E941
E84B    20 AE E9    JSR $E9AE      CLOCK OUT hi
E94E    20 59 EA    JSR $EA59      check EOI
E951    20 C0 E9    JSR $E9C0      read IEEE port
E954    29 01       AND #$01       isolate data bit
E956    D0 F3       BNE $E94B
E958    A9 08       LDA #$08       counter to 8 bits for serial
E95A    85 98       STA $98        transmission
E95C    20 C0 E9    JSR $E9C0      read IEEE port
E95F    29 01       AND #$01       isolate data bit
E961    D0 36       BNE $E999
E963    A6 82       LDX $82
E965    BD 3E 02    LDA $023E,X
E968    6A          ROR A          lowest bit in carry
E969    9D 3E 02    STA $023E,X
E96C    B0 05       BCS $E973      set bit
E96E    20 A5 E9    JSR $E9A5      DATA OUT, output bit '0'
E971    D0 03       BNE $E976      absolute jump
E973    20 9C E9    JSR $E99C      DATA OUT, output bit '1'
E976    20 B7 E9    JSR $E9B7      set CLOCK OUT
E979    A5 23       LDA $23
E97B    D0 03       BNE $E980
E97D    20 F3 FE    JSR $FEF3      delay for serial bus
E980    20 FB FE    JSR $FEFB      set DATA OUT and CLOCK OUT
E983    C6 98       DEC $98        all bits output?
E985    D0 D5       BNE $E95C      no
E987    20 59 EA    JSR $EA59      check EOI
E98A    20 C0 E9    JSR $E9C0      read IEEE port
E98D    29 01       AND #$01       isolate data bit
E98F    F0 F6       BEQ $E987
E991    58          CLI
E992    20 AA D3    JSR $D3AA      get next data byte
E995    78          SEI
E996    4C 0F E9    JMP $E90F      and output

E999    4C 4E EA    JMP $EA4E      to delay loop

******************************     DATA OUT lo
E99C    AD 00 18    LDA $1800
E99F    29 FD       AND #$FD       output bit '1'
E9A1    8D 00 18    STA $1800
E9A4    60          RTS

******************************     DATA OUT hi
```

```
E9A5    AD 00 18    LDA $1800
E9A8    09 02       ORA #$02      output bit '0'
E9AA    8D 00 18    STA $1800
E9AD    60          RTS

******************************    CLOCK OUT hi
E9AE    AD 00 18    LDA $1800
E9B1    09 08       ORA #$08      set bit 3
E9B3    8D 00 18    STA $1800
E9B6    60          RTS

******************************    CLOCK OUT lo
E9B7    AD 00 18    LDA $1800
E9BA    29 F7       AND #$F7      erase bit 3
E9BC    8D 00 18    STA $1800
E9BF    60          RTS

******************************    read IEEE port
E9C0    AD 00 18    LDA $1800     read port
E9C3    CD 00 18    CMP $1800     wait for constants
E9C6    D0 F8       BNE $E9C0
E9C8    60          RTS

******************************
E9C9    A9 08       LDA #$08
E9CB    85 98       STA $98       bit counter for serial output
E9CD    20 59 EA    JSR $EA59     check EOI
E9D0    20 C0 E9    JSR $E9C0     read IEEE port
E9D3    29 04       AND #$04      CLOCK IN?
E9D5    D0 F6       BNE $E9CD     no, wait
E9D7    20 9C E9    JSR $E99C     DATA OUT, bit '1'
E9DA    A9 01       LDA #$01
E9DC    8D 05 18    STA $1805     set timer
E9DF    20 59 EA    JSR $EA59     check EOI
E9E2    AD 0D 18    LDA $180D
E9E5    29 40       AND #$40      timer run down?
E9E7    D0 09       BNE $E9F2     yes, EOI
E9E9    20 C0 E9    JSR $E9C0     read IEEE port
E9EC    29 04       AND #$04      CLOCK IN?
E9EE    F0 EF       BEQ $E9DF     no, wait
E9F0    D0 19       BNE $EA0B
E9F2    20 A5 E9    JSR $E9A5     DATA OUT bit '0' hi
E9F5    A2 0A       LDY #$0A      10
E9F7    CA          DEX           delay loop, approx 50 micro sec.
E9F8    D0 FD       BNE $E9F7
E9FA    20 9C E9    JSR $E99C     DATA OUT, bit '1', lo
E9FD    20 59 EA    JSR $EA59     check EOI
EA00    20 C0 E9    JSR $E9C0     read IEEE
EA03    29 04       AND #$04      CLOCK IN?
EA05    F0 F6       BEQ $E9FD     no, wait
EA07    A9 00       LDA #$00
EA09    85 F8       STA $F8       set EOI flag
EA0B    AD 00 18    LDA $1800     IEEE port
EA0E    49 01       EOR #$01      invert data byte
EA10    4A          LSR A
```

```
EA11    29 02       AND #$02
EA13    D0 F6       BNE $EA0B     CLOCK IN?
EA15    EA          NOP
EA16    EA          NOP
EA17    EA          NOP
EA18    66 85       ROR $85       prepare next bit
EA1A    20 59 EA    JSR $EA59     check EOI
EA1D    20 C0 E9    JSR $E9C0     read IEEE port
EA20    29 04       AND #$04      CLOCK IN?
EA22    F0 F6       BEQ $EA1A     no
EA24    C6 98       DEC $98       decrement bit counter
EA26    D0 E3       BNE $EA0B     all bits output?
EA28    20 A5 E9    JSR $E9A5     DATA OUT, bit '0', hi
EA2B    A5 85       LDA $85       load data byte again
EA2D    60          RTS

*******************************   accept data from serial bus
EA2E    78          SEI
EA2F    20 07 D1    JSR $D107     open channel for writing
EA32    B0 05       BCS $EA39     channel not active?
EA34    B5 F2       LDA $F2,X     WRITE flag
EA36    6A          ROR A
EA37    B0 0B       BCS $EA44     not set?
EA39    A5 84       LDA $84       secondary address
EA3B    29 F0       AND #$F0
EA3D    C9 F0       CMP #$F0      OPEN command?
EA3F    F0 03       BEQ $EA44     yes
EA41    4C 4E EA    JMP $EA4E     to wait loop

EA44    20 C9 E9    JSR $E9C9     get data byte from bus
EA47    58          CLI
EA48    20 B7 CF    JSR $CFB7     and write in buffer
EA4B    4C 2E EA    JMP $EA2E     to loop beginning

EA4E    A9 00       LDA #$00
EA50    8D 00 18    STA $1800     reset IEEE port
EA53    4C E7 EB    JMP $EBE7     to wait loop

EA56    4C 5B E8    JMP $EB58     to serial bus main loop

*******************************
EA59    A5 7D       LDA $7D       EOI received?
EA5B    F0 06       BEO $EA63     yes
EA5D    AD 00 18    LDA $1800     IEEE port
EA60    10 09       BPL $EA6B

EA62    60          RTS

EA63    AD 00 18    LDA $1800     IEEE port
EA66    10 FA       BPL $EA62
EA68    4C D7 E8    JMP $E8D7     set EOI, serve serial bus

*******************************   blink LED for hardware defects
EA6E    A2 00       LDX #$00      blink once, zero page
EA70    2C          .BYTE $2C
```

```
EA71   A5 6F      LDX $6F       blink X+1 times for RAM/ROM err
EA73   9A         TXS
EA74   BA         TSX
EA75   A9 08      LDA #$08      select LED bit in the port
EA77   0D 00 1C   ORA $1C00
EA7A   4C EA FE   JMP $FEEA     turn LED on, back to $EA7D
EA7D   98         TYA
EA7E   18         CLC
EA7F   69 01      ADC #$01
EA81   D0 FC      BNE $EA7F
EA83   88         DEY
EA84   D0 F8      BNE $EA7E
EA86   AD 00 1C   LDA $1C00
EA89   29 F7      AND #$F7      turn LED off
EA8B   8D 00 1C   STA $1C00
EA8E   98         TYA
EA8F   18         CLC
EA90   69 01      ADC #$01
EA92   D0 FC      BNE $EA90     delay loop
EA94   88         DEY
EA95   D0 F8      BNE $EA8F
EA97   CA         DEX
EA98   10 DB      BPL $EA75
EA9A   E0 FC      CPX #$FC
EA9C   D0 F0      BNE $EA8E     wait for delay
EA9E   F0 D4      BEQ $EA74     turn LED on again

******************************  RESET routine
EAA0   78         SEI
EAA1   D8         CLD
EAA2   A2 FF      LDX #$FF
EAA4   8E 03 18   STX $1803     port A to output
EAA7   E8         INX
EAA8   A0 00      LDY #$00
EAAA   A2 00      LDX #$00
EAAC   8A         TXA
EAAD   95 00      STA $00,X     erase zero page
EAAF   E8         INX
EAB0   D0 FA      BNE $EAAC
EAB2   8A         TXA
EAB3   D5 00      CMP $00,X     is byte erased?
EAB5   D0 B7      BNE $EA6E     no, then to error display (blink)
EAB7   F6 00      INC $00,X
EAB9   C8         INY
EABA   D0 FB      BNE $EAB7
EABC   D5 00      CMP $00,X
EABE   D0 AE      BNE $EA6E     error
EAC0   94 00      STY $00,X
EAC2   B5 00      LDA $00,X
EAC4   D0 A8      BNE $EA6E     error
EAC6   E8         INX
EAC7   D0 E9      BNE $EAB2
EAC9   E6 6F      INC $6F
EACB   86 76      STX $76
EACD   A9 00      LDA #$00
```

```
EACF    85 75       STA $75
EAD1    A8          TAY
EAD2    A2 20       LDX #$20        test 32 pages
EAD4    18          CLC
EAD5    C6 76       DEC $76
EAD7    71 75       ADC ($75),Y
EAD9    C8          INY
EADA    D0 FB       BNE $EAD7
EADC    CA          DEX
EADD    D0 F6       BNE $EAD5       test ROM
EADF    69 00       ADC #$00
EAE1    AA          TAX
EAE2    C5 76       CMP $76
EAE4    D0 39       BNE $EB1F       ROM error
EAE6    E0 C0       CPX #$C0
EAE8    D0 DF       BNE $EAC9
EAEA    A9 01       LDA #$01
EAEC    85 76       STA $76
EAEE    E6 6F       INC $6F
EAF0    A2 07       LDX #$07        test RAM, beginning at page 7
EAF2    98          TYA
EAF3    18          CLC
EAF4    65 76       ADC $76
EAF6    91 75       STA ($75),Y
EAF8    C8          INY
EAF9    D0 F7       BNE $EAF2
EAFB    E6 76       INC $76
EAFD    CA          DEX
EAFE    D0 F2       BNE $EAF2
EB00    A2 07       LDX #$07
EB02    C6 76       DEC $76
EB04    88          DEY
EB05    98          TYA
EB06    18          CLC
EB07    65 76       ADC $76
EB09    D1 75       CMP ($75),Y
EB0B    D0 12       BNE $EB1F       RAM error
EB0D    49 FF       EOR #$FF
EB0F    91 75       STA ($75),Y
EB11    51 75       EOR ($75),Y
EB13    91 75       STA ($75),Y
EB15    D0 08       BNE $EB1F       RAM error
EB17    98          TYA
EB18    D0 EA       BNE $EB04
EB1A    CA          DEX
EB1B    D0 E5       BNE $EB02       continue test
EB1D    F0 03       BEQ $EB22       ok
EB1F    4C 71 EA    JMP $EA71       to error display

EB22    A2 45       LDX #$45
EB24    9A          TXS             initialize stack pointer
EB25    AD 00 1C    LDA $1C00
EB28    29 F7       AND #$F7        turn LED off
EB2A    8D 00 1C    STA $1C00
EB2D    A9 01       LDA #$01
```

```
EB2F   8D 0C 18   STA $180C     CA1 (ATN IN) trigger on pos edge
EB32   A9 82      LDA #$82
EB34   8D 0D 18   STA $180D     interrupt possible through ATN IN
EB37   8D 0E 18   STA $180E
EB3A   AD 00 18   LDA $1800     read port B
EB3D   29 60      AND #$60      isolate bits 5 & 6 (device #)
EB3F   0A         ASL A
EB40   2A         ROL A
EB41   2A         ROL A         rotate to bit positions 0 & 1
EB42   2A         ROL A
EB43   09 48      ORA #$48      add offset from 8 + $40 for TALK
EB45   85 78      STA $78       device number for TALK (send)
EB47   49 60      EOR #$60      erase bit 6, set bit 5
EB49   85 77      STA $77       device number + $20 for LISTEN
EB4B   A2 00      LDX #$00
EB4D   A0 00      LDY #$00
EB4F   A9 00      LDA #$00
EB51   95 99      STA $99,X     low-byte of buffer address
EB53   E8         INX
EB54   B9 E0 FE   LDA $FEE0,Y   high byte of address from table
EB57   95 99      STA $99,X     save
EB59   E8         INX
EB5A   C8         INY
EB5B   C0 05      CPY #$05
EB5D   D0 F0      BNE $EB4F
EB5F   A9 00      LDA #$00
EB61   95 99      STA $99,X
EB63   E8         INX           ptr $A3/$A4 to $200, input buffer
EB64   A9 02      LDA #$02
EB66   95 99      STA $99,X
EB68   E8         INX
EB69   A9 D5      LDA #$D5
E86B   95 99      STA $99,X
EB6D   E8         INX           pointer $A5/$A6 to $2D5, error
EB6E   A9 02      LDA #$02      message pointer
EB70   95 99      STA $99,X
EB72   A9 FF      LDA #$FF
EB74   A2 12      LDX #$12
EB76   9D 2B 02   STA $022B,X   fill channel table with $FF
EB79   CA         DEX
EB7A   10 FA      BPL $EB76
EB7C   A2 05      LDX #$05
EB7E   95 A7      STA $A7,X     erase buffer table
EB80   95 AE      STA $AE,X
EB82   95 CD      STA $CD,X     erase side-sector table
EB84   CA         DEX
EB85   10 F7      BPL $EB7E
EB87   A9 05      LDA #$05      buffer 5
EB89   85 AB      STA $AB       associate with channel 4
EB8B   A9 06      LDA #$06      buffer 6
EB8D   85 AC      STA $AC       associate with channel 5
EB8F   A9 FF      LDA #$FF
EB91   85 AD      STA $AD
EB93   85 B4      STA $B4
EB95   A9 05      LDA #$05
```

```
EB97   8D 3B 02   STA $023B    channel 5 WRITE flag erased
EB9A   A9 84      LDA #$84
EB9C   8D 3A 02   STA $023A    channel 4 WRITE flag set
EB9F   A9 0F      LDA #$0F     initialize channel allocation reg
EBA1   8D 56 02   STA $0256    bit '1' equals channel free
EBA4   A9 01      LDA #$01
EBA6   85 F6      STA $F6      WRITE flag
EBA8   A9 88      LDA #$88
EBAA   85 F7      STA $F7      READ flag
EBAC   A9 F0      LDA #$E0     5 buffers free
EBAE   8D 4F 02   STA $024F    initialize buffer allocation reg
EBB1   A9 FF      LDA #$FF     $24F/$250, 16 bit
EBB3   8D 50 02   STA $0250
EBB6   A9 01      LDA #$01
EBB8   85 1C      STA $1C      flags for WRITE protect
EBBA   85 1D      STA $1D
EBBC   20 63 CB   JSR $CB63    set vector for U0
EBBF   20 FA CE   JSR $CEFA    initialize channel table
EBC2   20 59 F2   JSR $F259    intialization for disk controller
EBC5   A9 22      LDA #$22
EBC7   85 65      STA $65
EBC9   A9 EB      LDA #$EB     pointer $65/$66 to $EB22
EBCB   85 66      STA $66
EBCD   A9 0A      LDA #$0A
EBCF   85 69      STA $69      step width 10
EBD1   A9 05      LDA #$05     for sector assignment
EBD3   85 6A      STA $6A      5 read attempts
EBD5   A9 73      LDA #$73     prepare power-up message
EBD7   20 C1 E6   JSR $E6C1    73, 'cbm dos v2.6 1541'
EBDA   A9 1A      LDA #$1A     bit 1, 3 & 4 to exit
EBDC   8D 02 18   STA $1802    data direction of port B
EBDF   A9 00      LDA #$00
EBE1   8D 00 18   STA $1800    erase data register
EBE4   20 80 E7   JSR $E780    check for auto-start
EBE7   58         CLI
EBE8   AD 00 18   LDA $1800
EBEB   29 E5      AND #$E5     reset serial port
EBED   8D 00 18   STA $1800
EBF0   AD 55 02   LDA $0255    command flag set?
EBF3   F0 0A      BEQ $EBFF    no
EBF5   A9 00      LDA #$00
EBF7   8D 55 02   STA $0255    reset command flag
EBFA   85 67      STA $67
EBFC   20 46 C1   JSR $C146    analyze and execute command

********************************   wait loop
EBFF   58         CLI
EC00   A5 7C      LDA $7C      ATN signal discovered?
EC02   F0 03      BEQ $EC07    no
EC04   4C 5B E8   JMP $E85B    to IEEE routine
EC07   58         CLI
EC08   A9 0E      LDA #$0E     14
EC0A   85 72      STA $72      as secondary address
EC0C   A9 00      LDA #$00
EC0E   85 6F      STA $6F      job counter
```

```
EC10   85 70      STA $70
EC12   A6 72      LDX $72
EC14   BD 2B 02   LDA $022B,X    secondary address
EC17   C9 FF      CMP #$FF       channel associated?
EC19   F0 10      BEQ $EC2B      no
EC1B   26 3F      AND #$3F
EC1D   85 82      STA $82        channel number
EC1F   20 93 DF   JSR $DF93      get buffer number
EC22   AA         TAX
EC23   BD 5B 02   LDA $025B,X    drive number
EC26   29 01      AND #$01
EC28   AA         TAX
EC29   F6 6F      INC $6F,X      increment job counter
EC2B   C6 72      DEC $72        lo address
EC2D   10 E3      BPL $EC12      continue search
EC2F   A0 04      LDY #$04       buffer counter
EC31   B9 00 00   LDA $0000,Y    disk controller in action?
EC34   10 05      BPL $EC3B      no
EC36   29 01      AND #$01       isolate drive number
EC38   AA         TAX
EC39   F6 6F      INC $6F,X      increment job counter
EC3B   88         DEY
EC3C   10 F3      BPL $EC31      next buffer
EC3E   78         SEI
EC3F   AD 00 1C   LDA $1C00
EC42   29 F7      AND #$F7       erase LED bit
EC44   48         PHA
EC45   A5 7F      LDA $7F        drive number
EC47   85 86      STA $86
EC49   A9 00      LDA #$00
EC4B   85 7F      STA $7F        drive 0
EC4D   A5 6F      LDA $6F        job for drive 0?
EC4F   F0 0B      BEQ $EC5C      no
EC51   A5 1C      LDA $1C        write protect for drive 0?
EC53   F0 03      BEQ $EC58      no
EC55   20 13 D3   JSR $D313      close all channels to drive 0
EC58   68         PLA
EC59   09 08      ORA #$08       set LED bit
EC5B   48         PHA
EC5C   E6 7F      INC $7F        increment drive number
EC5E   A5 70      LDA $70        job for drive 1?
EC60   F0 0B      BEQ $EC6D      no
EC62   A5 1D      LDA $1D        write protect for drive 1?
EC64   F0 03      BEQ $EC69      no
EC66   20 13 D3   JSR $D313      close all channels to drive 1
EC69   68         PLA
EC6A   09 00      ORA #$00
EC6C   48         PHA
EC6D   A5 86      LDA $86
EC6F   85 7F      STA $7F        get drive number back
EC71   68         PLA            bit for LED
EC72   AE 6C 02   LDX $026C      interrupt counter
EC75   F0 21      BEQ $EC98      to zero?
EC77   AD 00 1C   LDA $1C00
EC7A   E0 80      CPX #$80
```

```
EC7C    D0 03       BNE $EC81
EC7E    4C 8B EC    JMP $EC8B
EC81    AE 05 18    LDX $1805       erase timer interrupt
EC84    30 12       BMI $EC98
EC86    A2 A0       LDX #$A0
EC88    8E 05 18    STX $1805       set timer
EC8B    CE 6C 02    DEC $026C       decrement counter
EC8E    D0 08       BNE $EC98       not yet zero?
EC90    4D 6D 02    EOR $026D
EC93    A2 10       LDX #$10
EC95    8E 6C 02    STX $026C       reset counter
EC98    8D 00 1C    STA $1C00       turn LED on/off
EC9B    4C FF EB    JMP $EBFF       back to wait loop

******************************      LOAD "$"
EC9E    A9 00       LDA #$00
ECA0    85 83       STA $83         secondary address 0
ECA2    A9 01       LDA #$01
ECA4    20 E2 D1    JSR $D1E2       find channel and buffer
ECA7    A9 00       LDA #$00
ECA9    20 C8 D4    JSR $D4C8       initialize buffer pointer
ECAC    A6 82       LDX $82         channel number
ECAE    A9 00       LDA #$00
ECB0    9D 44 02    STA $0244,X     pointer to end = zero
ECB3    20 93 DF    JSR $DF93       get buffer number
ECB6    AA          TAX
ECB7    A5 7F       LDA $7F         drive number
ECB9    9D 5B 02    STA $025B,X     bring in table
ECBC    A9 01       LDA #$01        1
ECBE    20 F1 CF    JSR $CFF1       write in buffer
ECC1    A9 04       LDA #$04        4, start address $0401
ECC3    20 F1 CF    JSR $CFF1       write in buffer
ECC6    A9 01       LDA #$01        2 times 1
ECC8    20 F1 CF    JSR $CFF1
ECCB    20 F1 CF    JSR $CFF1       write in buffer as link address
ECCE    AD 72 02    LDA $0272       drive number
ECD1    20 F1 CF    JSR $CFF1       write in buffer as line number
ECD4    A9 00       LDA #$00        line number hi
ECD6    20 F1 CF    JSR $CFF1       in buffer
ECD9    20 59 ED    JSR $ED59       directory entry in buffer
ECDC    20 93 DF    JSR $DF93       get buffer number
ECDF    0A          ASL A
ECE0    AA          TAX
ECE1    D6 99       DEC $99,X       decrement buffer pointer
ECE3    D6 99       DEC $99,X
ECE5    A9 00       LDA #$00
ECE7    20 F1 CF    JSR $CFF1       0 as line end in buffer
ECEA    A9 01       LDA #$01
ECEC    20 F1 CF    JSR $CFF1       2 times 1 as link address
ECEF    20 F1 CF    JSR $CFF1
ECF2    20 CE C6    JSR $C6CE       directory entry in buffer
ECF5    90 2C       BCC $ED23       another entry?
ECF7    AD 72 02    LDA $0272       block number lo
ECFA    20 F1 CF    JSR $CFF1       in buffer
ECFD    AD 73 02    LDA $0273       block number hi
```

```
ED00    20 F1 CF   JSR $CFF1      in buffer
ED03    20 59 ED   JSR $ED59      directory entry in buffer
ED06    A9 00      LDA #$00
ED08    20 F1 CF   JSR $CFF1      zero as end marker in buffer
ED0B    D0 DD      BNE $ECEA      buffer full? no
ED0D    20 93 DF   JSR $DF93      get buffer number
ED10    0A         ASL A
ED11    AA         TAX
ED12    A9 00      LDA #$00
ED14    95 99      STA $99,X      buffer pointer to zero
ED16    A9 88      LDA #$88       set READ flag
ED18    A4 82      LDY $82        channel number
ED1A    8D 54 02   STA $0254
ED1D    99 F2 00   STA $00F2,Y    flag for channel
ED20    A5 85      LDA $85        data byte
ED22    60         RTS

*******************************
ED23    AD 72 02   LDA $0272      block number lo
ED26    20 F1 CF   JSR $CFF1      write in buffer
ED29    AD 73 02   LDA $0273      block number hi
ED2C    20 F1 CF   JSR $CFF1      in buffer
ED2F    20 59 ED   JSR $ED59      'Blocks free.' in buffer
ED32    20 93 DF   JSR $DF93      get buffer number
ED35    0A         ASL A
ED36    AA         TAX
ED37    D6 99      DEC $99,X
ED39    D6 99      DEC $99,X      buffer pointer minus 2
ED3B    A9 00      LDA #$00
ED3D    20 F1 CF   JSR $CFF1
ED40    20 F1 CF   JSR $CFF1      three zeroes as program end
ED43    20 F1 CF   JSR $CFF1
ED46    20 93 DF   JSR $DF93      get buffer number
ED49    0A         ASL A          times 2
ED4A    A8         TAY
ED4B    B9 99 02   LDA $0099,Y    buffer pointer
ED4E    A6 82      LDX $82
ED50    9D 44 02   STA $0244,X    as end marker
ED53    DE 44 02   DEC $0244,X
ED56    4C 0D ED   JMP $ED0D

*******************************   transmit directory line
ED59    A0 00      LDY #$00
ED5B    B9 B1 02   LDA $02B1,Y    character from buffer
ED5E    20 F1 CF   JSR $CFF1      write in output buffer
ED61    C8         INY
ED62    C0 1B      CPY #$1B       27 characters?
ED64    D0 F5      BNE $ED5B
ED66    60         RTS

*******************************   get byte from buffer
ED67    20 37 D1   JSR $D137      get byte
ED6A    F0 01      BEQ $ED6D      buffer pointer zero?
ED6C    60         RTS
```

```
ED6D    85 85       STA $85         save data byte
ED6F    A4 82       LDY $82         channel number
ED71    B9 44 02    LDA $0244,Y     set end marker
ED74    F0 08       BEQ $ED7E       zero (LOAD $)?
ED76    A9 80       LDA #$80
ED78    99 F2 00    STA $00F2,Y     set READ flag
ED7B    A5 85       LDA $85         data byte
ED7D    60          RTS

ED7E    48          PHA
ED7F    20 EA EC    JSR $ECEA       create directory line in buffer
ED82    68          PLA
ED83    60          RTS

******************************      V command,   'collect'
ED84    20 D1 C1    JSR $C1D1       find drive number in input line
ED87    20 42 D0    JSR $D042       load BAM
ED8A    A9 40       LDA #$40
ED8C    8D F9 02    STA $02F9
ED8F    20 B7 EE    JSR $EEB7       create new BAM in buffer
ED92    A9 00       LDA #$00
ED94    8D 92 02    STA $0292
ED97    20 AC C5    JSR $C5AC       load directory, find 1st flag
ED9A    D0 3D       BNE $EDD9       found?
ED9C    A9 00       LDA #$00
ED9E    85 81       STA $81         sector 0
EDA0    AD 8E FE    LDA $FE85       18
EDA3    85 80       STA $80         track 18 for BAM
EDA5    20 E5 ED    JSR $EDE5       mark dir blocks as allocated
EDA8    A9 00       LDA #$00
EDAA    8D F9 02    STA $02F9
EDAD    20 FF EE    JSR $EEFF       write BAM back to disk
EDB0    4C 94 C1    JMP $C194       done, prepare disk status

******************************
EDB3    C8          INY
EDB4    B1 94       LDA ($94),Y     save track
ED86    48          PHA
EDB7    C8          INY
EDB8    B1 94       LDA ($94),Y     and sector
EDBA    48          PHA
EDBB    A0 13       LDA #$13        pointer to side-sector block
EDBD    B1 94       LDA ($94),Y
EDBF    F0 0A       BEQ $EDCB       no track following?
EDC1    85 80       STA $80         track and
EDC3    C8          INY
EDC4    B1 94       LDA ($94),Y
EDC6    85 81       STA $81         sector of 1st side-sector block
EDC8    20 E5 ED    JSR $EDE5       mark side-sector blocks as
EDCB    68          PLA             allocated
EDCC    85 81       STA $81
EDCE    68          PLA             get track and sector back
EDCF    85 80       STA $80
EDD1    20 E5 ED    JSR $EDE5       mark blocks of file as allocated
EDD4    20 04 C6    JSR $C604       read next entry in directory
```

```
EDD7    F0 C3       BEQ $ED9C       end of directory?
EDD9    A0 00       LDY #$00
EDDB    B1 94       LDA ($94),Y     file type
EDDD    30 D4       BMI $EDB3       bit 7 set, file closed?
EDDF    20 B6 C8    JSR $C8B6       file type to zero and write BAM
EDE2    4C D4 ED    JMP $EDD4

******************************      allocate file blocks in BAM
EDE5    20 5F D5    JSR $D55F       check track and sector number
EDE8    20 90 EF    JSR $EF90       allocate block in BAM
EDEB    20 75 D4    JSR $D475       read next block
EDEE    A9 00       LDA #$00
EDF0    20 C8 D4    JSR $D4C8       buffer pointer zero
EDF3    20 37 D1    JSR $D137       get byte from buffer
EDF6    85 80       STA $80         track
EDF8    20 37 D1    JSR $D137       get byte from buffer
EDFB    85 81       STA $81         sector
EDFD    A5 80       LDA $80         another block?
EDFF    D0 03       BNE $EE04       yes
EE01    4C 27 D2    JMP $D227       close channel

EE04    20 90 EF    JSR $EF90       allocate block in BAM
EE07    20 4D D4    JSR $D44D       read next block
EE0A    4C EE ED    JMP $EDEE       continue

******************************      N command, 'header'
EE0D    20 12 C3    JSR $C312       get drive number
EE10    A5 E2       LDA $E2         drive number
EE12    10 05       BPL $EE19       not clear?
EE14    A9 33       LDA #$33
EE16    4C C8 C1    JMP $C1C8       33, 'syntax error'
EE19    29 01       AND #$01
EE1B    85 7F       STA $7F         drive number
EE1D    20 00 C1    JSR $C100       turn LED on
EE20    A5 7F       LDA $7F         drive number
EE22    0A          ASL A           times 2
EE23    AA          TAX
EE24    AC 7B 02    LDY $027B       comma position
EE27    CC 74 02    CPY $0274       compare with end name
EE2A    F0 1A       BEQ $EE46       format without ID
EE2C    B9 00 02    LDA $0200,Y     first character of ID
EE2F    95 12       STA $12,X       save
EE31    B9 01 02    LDA $0201,Y     second character
EE34    95 13       STA $13,X
EE36    20 07 D3    JSR $D307       close all channels
EE39    A9 01       LDA #$01
EE3B    85 80       STA $80         track 1
EE3D    20 C6 C8    JSR $C8C6       format disk
EE40    20 05 F0    JSR $F005       erase buffer
EE43    4C 56 EE    JMP $EE56       continue as below

EE46    20 42 D0    JSR $D042       load BAM
EE49    A6 7F       LDX $7F         drive number
EE4B    BD 01 01    LDA $0101,X
EE4E    CD D5 FE    CMP $FED5       'A', marker for 1541 format
```

```
EE51    F0 03       BEQ $EE56       ok
EE53    4C 72 D5    JMP $D572       73, 'cbm dos v2.6 1541'

EE56    20 B7 EE    JSR $EEB7       create BAM
EE59    A5 F9       LDA $F9         buffer number
EE5B    A8          TAY
EE5C    0A          ASL A
EE5D    AA          TAX
EE5E    AD 88 FE    LDA $FE88       $90, start of disk name
EE61    95 99       STA $99,X       buffer pointer to name
EE63    AE 7A 02    LDX $027A
EE66    A9 1B       LDA #$1B        27
EE68    20 6E C6    JSR $C66E       write filenames in buffer
EE6B    A0 12       LDY #$12        position 18
EE6D    A6 7F       LDX $7F         drive number
EE6F    AD D5 FE    LDA $FED5       'A', 1541 format
EE72    9D 01 01    STA $0101,X
EE75    8A          TXA
EE76    0A          ASL A           times 2
EE77    AA          TAX
EE78    B5 12       LDA $12,X       ID, first character
EE7A    91 94       STA ($94),Y     in buffer
EE7C    C8          INY
EE7D    B5 13       LDA $13,X       and second character
EE7F    91 94       STA ($94),Y     in buffer
EE81    C8          INY
EE82    C8          INY
EE83    A9 32       LDA #$32        '2'
EE85    91 94       STA ($94),Y     in buffer
EE87    C8          INY
EE88    AD D5 FE    LDA $FED5       'A'  1541 format
EE8B    91 94       STA ($94),Y     in buffer
EE8D    A0 02       LDY #$02
EE8F    91 6D       STA ($6D),Y     and at position 2
EE91    AD 85 FE    LDA $FE85       18
EE94    85 80       STA $80         track number
EE96    20 93 EF    JSR $EF93       mark block as allocated
EE99    A9 01       LDA #$01        1
EE9B    85 81       STA $81         sector number
EE9D    20 93 EF    JSR $EF93       mark block as allocated
EEA0    20 FF EE    JSR $EEFF       write BAM
EEA3    20 05 F0    JSR $F005       pointer $6D/$6E to buffer, erase
                                              buffer
EEA6    A0 01       LDY #$01
EEA8    A9 FF       LDA #$FF
EEAA    9A 6D       STA ($6D),Y     track following is zero
EEAC    20 64 D4    JSR $D464       write BAM
EEAF    C6 81       DEC $81         decrement sector number, 0
EEB1    20 60 D4    JSR $D460       read block
EEB4    4C 94 C1    JMP $C194       prepare disk status

********************************    create BAM
EEB7    20 D1 F0    JSR $F0D1
EEBA    A0 00       LDY #$00
EEBC    A9 12       LDA #$12        18
EEBE    91 6D       STA ($6D),Y     pointer to directory track
```

```
EEC0    C8          INY
EEC1    98          TYA             1
EEC2    91 6D       STA ($6D),Y     pointer to directory sector
EEC4    C8          INY
EEC5    C8          INY
EEC6    C8          INY
EEC7    A9 00       LDA #$00
EEC9    85 6F       STA $6F
EECB    85 70       STA $70         3 bytes = 24 bits for sectors
EECD    85 71       STA $71
EECF    98          TYA             byte position
EED0    4A          LSR A
EED1    4A          LSR A           divided by 4 = track number
EED2    20 4B F2    JSR $F24B       get number of sectors
EED5    91 6D       STA ($6D),Y     and in BAM
EED7    C8          INY
EED8    AA          TAX
EED9    38          SEC
EEDA    26 6F       ROL $6F
EEDC    26 70       ROL $70         create bit model
EEDE    26 71       ROL $71
EEE0    CA          DEX
EEE1    D0 F6       BNE $EED9
EEE3    B5 6F       LDA $6F,X       3 bytes
EEE5    91 6D       STA ($6D),Y     the BAM in buffer
EEE7    C8          INY
EEE8    E8          INX
EEE9    E0 03       CPX #$03
EEEB    90 F6       BCC $EEE3
EEED    C0 90       CPY #$90        position 144?
EEEF    90 D6       BCC $EEC7       no, next track
EEF1    4C 75 D0    JMP $D075       calculate number of free blocks

******************************      write BAM if needed
EEF4    20 93 DF    JSR $DF93       get buffer number
EEF7    AA          TAX
EEF8    BD 5B 02    LDA $025B,X     command for disk controller
EEFB    29 01       AND #$01
EEFD    85 7F       STA $7F         isolate drive number
EEFF    A4 7F       LDY $7F
EF01    B9 51 02    LDA $0251,Y     BAM-changed flag set?
EF04    D0 01       BNE $EF07       yes
EF06    60          RTS

EF07    A9 00       LDA #$00
EF09    99 51 02    STA $0251,Y     reset BAM-changed flag
EF0C    20 3A EF    JSR $EF3A       set buffer pointer for BAM
EF0F    A5 7F       LDA $7F         drive number
EF11    0A          ASL A           times 2
EF12    48          PHA
EF13    20 A5 F0    JSR $F0A5       verify BAM entry
EF16    68          PLA
EF17    18          CLC
EF18    69 01       ADC #$01        increment track number
EF1A    20 A5 F0    JSR $F0A5       verify BAM entry
```

```
EF1D   A5 80      LDA $80        track
EF1F   48         PHA
EF20   A9 01      LDA #$01
EF22   85 80      STA $80        track 1
EF24   0A         ASL A
EF25   0A         ASL A          times 4
EF26   85 6D      STA $6D
EF28   20 20 F2   JSR $F220      verify BAM
EF2B   E6 80      INC $80        increment track number
EF2D   A5 80      LDA $80
EF2F   CD D7 FE   CMP $FED7      and compare with max val + 1 = 36
EF32   90 F0      BCC $EF24      ok, next track
EF34   68         PLA
EF35   85 80      STA $80        get track number back
EF37   4C 8A D5   JMP $D58A      write BAM to disk

*******************************  set buffer pointer for BAM
EF3A   20 0F F1   JSR $F10F      get 6 for drive 0
EF3D   AA         TAX
EF3E   20 DF F0   JSR $F0DF      allocate buffer
EF41   A6 F9      LDX $F9        buffer number
EF43   BD E0 FE   LDA $FEE0,X    buffer address, hi byte
EF46   85 6E      STA $6E
EF48   A9 00      LDA #$00       lo byte
EF4A   85 6D      STA $6D        pointer to $6D/$6E
EF4C   60         RTS

*******************************  get # of free blocks for dir
EF4D   A6 7F      LDX $7F        drive number
EF4F   BD FA 02   LDA $02FA,X    number of blocks, lo
EF52   8D 72 02   STA $0272
EF55   BD FC 02   LDA $02FC,X    number of blocks, hi
EF58   8D 73 02   STA $0273      in buffer for directory
EF5B   60         RTS

*******************************  mark block as free
EF5C   20 F1 EF   JSR $EFF1      set buffer pointer
EF5F   20 CF EF   JSR $EFCF      erase bit for sector in BAM
EF62   38         SEC
EF63   D0 22      BNE $EF87      block already free, then done
EF65   B1 6D      LDA ($6D),Y    bit model of BAM
EF67   1D E9 EF   ORA $EFE9      set bit X, marker for free
EF6A   91 6D      STA ($6D),Y
EF6C   20 88 EF   JSR $EF88      set flag for BAM changed
EF6F   A4 6F      LDY $6F
EF71   18         CLC
EF72   B1 6D      LDY ($6D),Y
EF74   69 01      ADC #$01       increment # of free blocks/track
EF76   91 6D      STA ($6D),Y
EF78   A5 80      LDA $80        track
EF7A   CD 85 FE   CMP $FE85      equal to 18?
EF7D   F0 3B      BEQ $EFBA      then skip
EF7F   FE FA 02   INC $02FA,X    inc # of free blocks in disk
EF82   D0 03      BNE $EF87
EF84   FE FC 02   INC $02FC,X    increment number of blocks hi
```

```
EF87    60          RTS

******************************   set flag for 'BAM changed'
EF88    A6 7F       LDX $7F      drive number
EF8A    A9 01       LDA #$01
EF8C    9D 51 02    STA $0251,X  flag = 1
EF8F    60          RTS

******************************   mark block as allocated
EF90    20 F1 EF    JSR $EFF1    set buffer pointer
EF93    20 CF EF    JSR $EFCF    erase bit for sector in BAM
EF96    F0 36       BEQ $EFCE    already allocated, then done
EF98    B1 6D       LDA ($6D),Y
EF9A    5D E9 EF    EOR $EFE9,X  erase bit for block
EF9D    91 6D       STA ($6D),Y
EF9F    20 88 EF    JSR $EF88    set flag for BAM changed
EFA2    A4 6F       LDA $6F
EFA4    B1 6D       LDA ($6D),Y
EFA6    38          SEC
EFA7    E9 01       SBC #$01     decrement # of blocks per track
EFA9    91 6D       STA ($6D),Y
EFAB    A5 80       LDA $80      track
EFAD    CD 85 FE    CMP $FE85    18?
EFB0    F0 0B       BEQ $EFBD
EFB2    BD FA 02    LDA $02FA,X  number of free blocks lo
EFB5    D0 03       BNE $EFBA
EFB7    DE FC 02    DEC $02FC,X  decrement number of free blocks
EFBA    DE FA 02    DEC $02FA,X
EFBD    BD FC 02    LDA $02FC,X  number of free blocks hi
EFC0    D0 0C       BNE $EFCE    more than 255 blocks free?
EFC2    BD FA 02    LDA $02FA,X  free blocks lo
EFC5    C9 03       CMP #$03
EFC7    B0 05       BCS $EFCE    smaller than 3?
EFC9    A9 72       LDA #$72
EFCB    20 C7 E6    JSR $E6C7    72, 'disk full'
EFCE    60          RTS

******************************   erase bit for sector in BAM entry
EFCF    20 11 F0    JSR $F011    find BAM field for this track
EFD2    98          TYA
EFD3    85 6F       STA $6F
EFD5    A5 81       LDA $81      sector
EFD7    4A          LSR A
EFD8    4A          LSR A        divide by 8
EFD9    4A          LSR A
EFDA    38          SEC
EFDB    65 6F       ADC $6F
EFDD    A8          TAY          byte number in BAM entry
EFDE    A5 81       LDA $81      sector number
EFE0    29 07       AND #$07
EFE2    AA          TAX          bit number in BAM entry
EFE3    B1 6D       LDA ($6D),Y  byte in BAM
EFE5    3D E9 EF    AND $EFE9,X  erase bit for corresponding
EFE8    60          RTS                 sector
```

```
******************************   powers of 2
EFE9    01 02 04 08 10 20 40 80

******************************   write BAM after change
EFF1    A9 FF       LDA #$FF
EFF3    2C F9 02    BIT $02F9
EFF6    F0 0C       BEQ $F004
EFF8    10 0A       BPL $F004
EFFA    70 08       BVS $F004
EFFC    A9 00       LDA #$00
EFFE    8D F9 02    STA $02F9    reset flag
F001    4C 8A D5    JMP $D58A    write block
F004    60          RTS

******************************   erase BAM buffer
F005    20 3A EF    JSR $EF3A    pointer $6D/$6E to BAM buffer
F008    A0 00       LDY #$00
F00A    98          TYA
F00B    91 6D       STA ($6D),Y  erase BAM buffer
F00D    C8          INY
F00E    D0 FB       BNE $F00B
F010    60          RTS

******************************
F011    A5 6F       LDA $6F
F013    48          PHA
F014    A5 70       LDA $70
F016    48          PHA
F017    A6 7F       LDX $7F      drive number
F019    B5 FF       LDA $FF,X
F01B    F0 05       BEQ $F022    drive zero?
F01D    A9 74       LDA #$74
F01F    20 48 E6    JSR $E648    'drive not ready'
F022    20 0F F1    JSR $F10F    get buffer number for BAM
F025    85 6F       STA $6F
F027    8A          TXA
F028    0A          ASL A
F029    85 70       STA $70
F02B    AA          TAX
F02C    A5 80       LDA $80      track
F02E    DD 9D 02    CMP $029D,X
F031    F0 0B       BEQ $F03E
F033    E8          INX
F034    86 70       STX $70
F036    DD 9D 02    CMP $029D,X
F039    F0 03       BEQ $F03E
F03B    20 5B F0    JSR $F05B
F03E    A5 70       LDA $70
F040    A6 7F       LDX $7F      drive number
F042    9D 9B 02    STA $029B,X
F045    0A          ASL A
F046    0A          ASL A        times 4
F047    18          CLC
F048    69 A1       ADC #$A1
F04A    85 6D       STA $6D
```

```
F04C    A9 02       LDA #$02
F04E    69 00       ADC #$00
F050    85 6E       STA $6E
F052    A0 00       LDY #$00
F054    58          PLA
F055    85 70       STA $70
F057    68          PLA
F058    85 6F       STA $6F
F05A    60          RTS

******************************
F05B    A6 6F       LDX $6F
F05D    20 DF F0    JSR $F0DF
F060    A5 7F       LDA $7F       drive number
F062    AA          TAX
F063    0A          ASL A
F064    1D 9B 02    ORA $029B,X
F067    49 01       EOR #$01
F069    29 03       AND #$03
F06B    85 70       STA $70
F06D    20 A5 F0    JSR $F0A5
F070    A5 F9       LDA $F9       buffer number
F072    0A          ASL A
F073    AA          TAX
F074    A5 80       LDA $80       track
F076    0A          ASL A
F077    0A          ASL A         times 4
F078    95 99       STA $99,X     equal pointer in BAM field
F07A    A5 70       LDA $70
F07C    0A          ASL A
F07D    0A          ASL A
F07E    A8          TAY
F07F    A1 99       LDA ($99,X)
F081    99 A1 02    STA $02A1,X
F084    A9 00       LDA #$00
F086    81 99       STA ($99,X)   zero in buffer
F088    F6 99       INC $99,X     increment buffer pointer
F08A    C8          INY
F08B    98          TYA
F08C    29 03       AND #$03
F08E    D0 EF       BNE $F07F
F090    A6 70       LDX $70
F092    A5 80       LDA $80       track
F094    9D 9D 02    STA $029D,X
F097    AD F9 02    LDA $02F9
F09A    D0 03       BNE $F09F
F09C    4C 8A D5    JMP $D58A     write block

F09F    09 80       ORA #$80
F0A1    8D F9 02    STA $02F9
F0A4    60          RTS

F0A5    A8          TAY
F0A6    B9 9D 02    LDA $029D,Y
F0A9    F0 25       BEO $F0D0
```

```
F0AB    48          PHA
F0AC    A9 00       LDA #$00
F0AE    99 9D 02    STA $029D,Y
F0B1    A5 F9       LDA $F9          buffer number
F0B3    0A          ASL A            times 2
F0B4    AA          TAX
F0B5    68          PLA
F0B6    0A          ASL A
F0B7    0A          ASL A
F0BB    95 99       STA $99,X
F0BA    98          TYA
F0BB    0A          ASL A
F0BC    0A          ASL A
F0BD    AB          TAY
F0BE    B9 A1 02    LDA $02A1,Y
F0C1    81 99       STA ($99,X)      write in buffer
F0C3    A9 00       LDA #$00
F0C5    99 A1 02    STA $02A1,Y
F0C8    F6 99       INC $99,X        increment buffer pointer
F0CA    C8          INY
F0CB    9B          TYA
F0CC    29 03       AND #$03
F0CE    D0 EE       BNE $F0BE
F0D0    60          RTS

F0D1    A5 7F       LDA $7F          drive number
F0D3    0A          ASL A
F0D4    AA          TAX
F0D5    A9 00       LDA #$00
F0D7    9D 9D 02    STA $029D,X
F0DA    E8          INX
F0DB    9D 9D 02    STA $029D,X
F0DE    60          RTS

F0DF    B5 A7       LDA $A7,X
F0E1    C9 FF       CMP #$FF
F0E3    D0 25       BNE $F10A
F0E5    8A          TXA
F0E6    48          PHA
F0E7    20 8E D2    JSR $D28E
F0EA    AA          TAX
F0EB    10 05       BPL $F0F2
F0ED    A9 70       LDA #$70
F0EF    20 C8 C1    JSR $C1C8        70, 'no channel'
F0F2    86 F9       STX $F9
F0F4    68          PLA
F0F5    A8          TAY
F0F6    8A          TXA
F0F7    09 80       ORA #$80
F0F9    99 A7 00    STA $00A7,Y
F0FC    0A          ASL A
F0FD    AA          TAX
F0FE    AD 85 FE    LDA $FE85        18, directory track
F101    95 06       STA $06,X        save
F103    A9 00       LDA #$00         0
```

```
F105    95 07       STA $07,X       as sector
F107    4C 86 D5    JMP $D586       write block

F10A    29 0F       AND #$0F
F10C    85 F9       STA $F9         buffer number
F10E    60          RTS

******************************      get buffer number for BAM
F10F    A9 06       LDA #$06
F111    A6 7F       LDX $7F         drive number
F113    D0 03       BNE $F118
F115    18          CLC
F116    69 07       ADC #$07        gives 13 for drive 0
F118    60          RTS

******************************      buffer number for BAM
F119    20 0F F1    JSR $F10F       get buffer number
F11C    AA          TAX
F11D    60          RTS

******************************      find and allocate free block
F11E    20 3E DE    JSR $DE3E       get track and sector number
F121    A9 03       LDA #$03
F123    85 6F       STA $6F         counter
F125    A9 01       LDA #$01
F127    0D F9 02    ORA $02F9
F12A    8D F9 02    STA $02F9
F12D    A5 6F       LDA $6F         save counter
F12F    48          PHA
F130    20 11 F0    JSR $F011       find BAM field for this track
F133    68          PLA
F134    85 6F       STA $6F         get counter back
F136    B1 6D       LDA ($6D),Y     number of free blocks in track
F138    D0 39       BNE $F173       blocks still free?
F13A    A5 80       LDA $80         track
F13C    CD 85 FE    CMP $FE85       18, directory track?
F13F    F0 19       BEQ $F15A       yes, 'disk full'
F141    90 1C       BCC $F15F       smaller, then next lower track
F143    E6 80       INC $80         increment track number
F145    A5 80       LDA $80
F147    CD D7 FE    CMP $FED7       36, highest track number plus one
F14A    D0 E1       BNE $F12D       no, continue searching this track
F14C    AE 85 FE    LDX $FE85       18, directory track
F14F    CA          DEX             decrement
F150    86 80       STX $80         save as track number
F152    A9 00       LDA #$00
F154    85 81       STA $81         begin with sector number zero
F156    C6 6F       DEC $6F         decrement counter
F158    D0 D3       BNE $F12D       not yet zero, then continue
F15A    A9 72       LDA #$72
F15C    20 C8 C1    JSR $C1C8       72, 'disk full'
F15F    C6 80       DEC $80         decrement track number
F161    D0 CA       BNE $F12D       not yet 0, continue in this track
F163    AE 85 FE    LDX $FE85       18, directory track
F166    E8          INX             increment
```

```
F167    86 80       STX $80        save as track number
F169    A9 00       LDA #$00
F16B    85 81       STA $81        begin with sector zero
F16D    C6 6F       DEC $6F        decrement counter
F16F    D0 BC       BNE $F12D      not yet zero, then continue
F171    F0 E7       BEQ $F15A      else 'disk full'

F173    A5 81       LDA $81        sector number
F175    18          CLC
F176    65 69       ADC $69        plus step width (10)
F178    85 81       STA $81        as new number
F17A    A5 80       LDA $80        track number
F17C    20 4B F2    JSR $F24B      get maximum sector number
F17F    8D 4E 02    STA $024E
F182    8D 4D 02    STA $024D      and save
F185    C5 81       CMP $81        greater than selected sector #?
F187    B0 0C       BCS $F195      yes
F189    38          SEC            else
F18A    A5 81       LDA $81        sector number
F18C    ED 4E 02    SBC $024E      minus maximum sector number
F18F    85 81       STA $81        save as new sector number
F191    F0 02       BEQ $F195      zero?
F193    C6 81       DEC $81        else decrement sector no. by one
F195    20 FA F1    JSR $F1FA      check BAM, find free sector
F198    F0 03       BEQ $F19D      not found?
F19A    4C 90 EF    JMP $EF90      allocate block in BAM
F19D    A9 00       LDA #$00
F19F    85 81       STA $81        sector zero
F1A1    20 FA F1    JSR $F1FA      find free sector
F1A4    D0 F4       BNE $F19A      found?
F1A6    4C F5 F1    JMP $F1F5      no, 'dir sector'

******************************     find free sector and allocate
F1A9    A9 01       LDA #$01
F1AB    0D F9 02    ORA $02F9
F1B1    A5 86       LDA $86
F1B3    48          PHA
F1B4    49 01       LDA #$01       track counter
F1B6    85 86       STA $86
F1B8    AD 85 FE    LDA $FE85      18, directory track
F1BB    38          SEC
F1BC    E5 86       SBC $86        minus counter
F1BE    85 80       STA $80        save as track number
F1C0    90 09       BCC $F1CB      result <= zero?
F1C2    F0 07       BEQ $F1CB      then try top half of dir
F1C4    20 11 F0    JSR $F011      find BAM field for this track
F1C7    B1 6D       LDA ($6D),Y    no. of free blocks in this track
F1C9    D0 1B       BNE $F1E6      free blocks exist
F1CB    AD 85 FE    LDA $FE85      18, directory track
F1CE    18          CLC
F1CF    65 86       ADC $86        plus counter
F1D1    85 80       STA $80        save as track number
F1D3    E6 86       INC $86        increment counter
F1D5    CD D7 FE    CMP $FED7      36, max track number plus one
F1D8    90 05       BCC $F1DF      smaller, then ok
```

```
F1DA   A9 67      LDA #$67
F1DC   20 45 E6   JSR $E645      67, 'illegal track or sector'
F1DF   20 11 F0   JSR $F011      find BAM field for this track
F1E2   B1 6D      LDA ($6D),Y    no. of free blocks in this track
F1E4   F0 D2      BEQ $F1BB      no more free blocks?
F1E6   68         PLA
F1E7   85 86      STA $86
F1E9   A9 00      LDA #$00
F1EB   85 81      STA $81        sector 0
F1ED   20 FA F1   JSR $F1FA      find free sector
F1F0   F0 03      BEQ $F1F5      not found?
F1F2   4C 90 EF   JMP $EF90      allocate block in BAM

F1F5   A9 71      LDA #$71
F1F7   20 45 E6   JSR $E645      71, 'dir error'

******************************   find free sectors in actual track
F1FA   20 11 F0   JSR $F011      find BAM field for this track
F1FD   98         TYA            points to # of free blocks
F1FE   48         PHA
F1FF   20 20 F2   JSR $F220      verify BAM
F202   A5 80      LDA $80        track
F204   20 4B F2   JSR $F24B      get max # of sectors of the track
F207   8D 4E 02   STA $024E      save
F20A   68         PLA
F20B   85 6F      STA $6F        save pointer
F20D   A5 81      LDA $81        compare sector
F20F   CD 4E 02   CMP $024E      with maximum number
F212   B0 09      BCS $F21D      greater than or equal to?
F214   20 D5 EF   JSR $EFD5      get bit number of sector
F217   D0 06      BNE $F21F      sector free?
F219   E6 81      INC $81        increment sector number
F21B   D0 F0      BNE $F20D      and check if free
F21D   A9 00      LDA #$00       no sectors free
F21F   60         RTS

******************************   verify no. of free blocks in BAM
F220   A5 6F      LDA $6F
F222   48         PHA
F223   A9 00      LDA #$00
F225   85 6F      STA $6F        counter to zero
F227   AC 86 FE   LDY $FE86      4, no. of bytes per track in BAM
F22A   88         DEY
F22B   A2 07      LDX #$07
F22D   B1 6D      LDA ($6D),Y
F22F   3D E9 EF   AND $EFE9,X    isolate bit
F232   F0 02      BEQ $F236
F234   E6 6F      INC $6F        increment counter of free sectors
F236   CA         DEX
F237   10 F4      BPL $F22D
F239   88         DEY
F23A   D0 EF      BNE $F22B
F23C   B1 6D      LDA ($6D),Y    compare with number on diskette
F23E   C5 6F      CMP $6F
F240   D0 04      BNE $F246      not equal, then error
```

```
F242    68          PLA
F243    85 6F       STA $6F
F245    60          RTS
F246    A9 71       LDA #$71
F248    20 45 E6    JSR $E645     71, 'dir error'

******************************    establish # of sectors per track
F24B    AE D6 FE    LDX $FED6     4 different values
F24E    DD D6 FE    CMP $FED6,X   track number
F251    CA          DEX
F252    B0 FA       BCS $F24E     not greater?
F254    BD D1 FE    LDA $FED1,X   get number of sectors
F257    60          RTS

F258    60          RTS

******************************    initialize disk controller
F259    A9 6F       LDA #$6F      bit 4 (write prot) & 7 (SYNC)
F25B    8D 02 1C    STA $1C02     data direction register port B
F25E    29 F0       AND #$F0
F260    8D 00 1C    STA $1C00     port B, control port
F263    AD 0C 1C    LDA $1C0C     PCR, control register
F266    29 FE       AND #$FE
F268    09 0E       ORA #$0E
F26A    09 E0       ORA #$E0
F26C    8D 0C 1C    STA $1C0C
F26F    A9 41       LDA #$41
F271    8D 0B 1C    STA $1C0B     timer 1 free running, enable
F274    A9 00       LDA #$00      port A latch
F276    8D 06 1C    STA $1C06     timer 1 lo latch
F279    A9 3A       LDA #$3A
F27B    8D 07 1C    STA $1C07     timer 1 hi latch
F27E    8D 05 1C    STA $1C05     timer 1 hi
F281    A9 7F       LDA #$7F
F283    8D 0E 1C    STA $1C0E     erase IRQs
F286    A9 C0       LDA #$C0
F288    8D 0D 1C    STA $1C0D
F28B    8D 0E 1C    STA $1C0E     IER, allow interrupts
F28E    A9 FF       LDA #$FF
F290    85 3E       STA $3E
F292    85 51       STA $51       track counter for formatting
F294    A9 08       LDA #$08      8
F296    85 39       STA $39       constants for block header
F298    A9 07       LDA #$07      7
F29A    85 47       STA $47       constants for data block
F29C    A9 05       LDA #$05
F29E    85 62       STA $62
F2A0    A9 FA       LDA #$FA      pointer $62/$63 to $FA05
F2A2    85 63       STA $63
F2A4    A9 C8       LDA #$C8      200
F2A6    85 64       STA $64
F2A8    A9 04       LDA #$04
F2AA    85 5E       STA $5E
F2AC    A9 04       LDA #$04
F2AE    85 6F       STA $6F
```

```
******************************   IRQ routine for disk controller
F2B0    BA          TSX
F2B1    86 49       STX $49          save stack pointer
F2B3    AD 04 1C    LDA $1C04
F2B6    AD 0C 1C    LDA $1C0C        erase interrupt flag from timer
F2B9    09 0E       ORA #$0E
F2BB    8D 0C 1C    STA $1C0C
F2BE    A0 05       LDY #$05
F2C0    B9 00 00    LDA $0000,Y      command for buffer Y?
F2C3    10 2E       BPL $F2F3        no
F2C5    C9 D0       CMP #$D0         exec. code for program in buffer
F2C7    D0 04       BNE $F2CD        no
F2C9    98          TYA
F2CA    4C 70 F3    JMP $F370        execute program in buffer
F2CD    29 01       AND #$01         isolate drive number
F2CF    F0 07       BEQ $F2D8        drive zero?
F2D1    84 3F       STY $3F
F2D3    A9 0F       LDA #$0F         else
F2D5    4C 69 F9    JMP $F969        74, 'drive not ready'

F2D8    AA          TAX
F2D9    85 3D       STA $3D
F2DB    C5 3E       CMP $3E          motor running?
F2DD    F0 0A       BEQ $F2E9        yes
F2DF    20 7E F9    JSR $F97E        turn drive motor on
F2E2    A5 3D       LDA $3D
F2E4    85 3E       STA $3E          set flag
F2E6    4C 9C F9    JMP $F99C        to job loop

F2E9    A5 20       LDA $20
F2EB    30 03       BMI $F2F0        head transport programmed?
F2ED    0A          ASL A
F2EE    10 09       BPL $F2F9
F2F0    4C 9C F9    JMP $F99C        to job loop

F2F3    88          DEY
F2F4    10 CA       BPL $F2C0        check next buffer
F2F6    4C 9C F9    JMP $F99C        to job loop

F2F9    A9 20       LDA #$20
F2FB    85 20       STA $20          program head transport
F2FD    A0 05       LDY #$05
F2FF    84 3F       STY $3F          initialize buffer counter
F301    20 93 F3    JSR $F393        set pointer in buffer
F304    30 1A       BMI $F320        command for buffer?
F306    C6 3F       DEC $3F          decrement counter
F308    10 F7       BPL $F301        check next buffer
F30A    A4 41       LDY $41          buffer number
F30C    20 95 F3    JSR $F395        set pointer in buffer
F30F    A5 42       LDA $42          track difference for last job
F311    85 4A       STA $4A          as counter for head transport
F313    06 4A       ASL $4A
F315    A9 60       LDA #$60         set flag for head transport
F317    85 20       STA $20
```

```
F319    B1 32       LDA ($32),Y    get track number from buffer
F31B    85 22       STA $22
F31D    4C 9C F9    JMP $F99C      to job loop
F320    29 01       AND #$01       isolate drive number
F322    C5 3D       CMP $3D        equal drive number of last job?
F324    D0 E0       BNE $F306      no
F326    A5 22       LDA $22        last track number
F328    F0 12       BEQ $F33C      equal zero?
F32A    38          SEC
F32B    F1 32       SBC ($32),Y    equal track number of this job?
F32D    F0 0D       BEQ $F33C      yes
F32F    49 FF       EOR #$FF
F331    85 42       STA $42
F333    E6 42       INC $42
F335    A5 3F       LDA $3F        drive number
F337    85 41       STA $41
F339    4C 06 F3    JMP $F306

E33C    A2 04       LDX #$04
F33E    B1 32       LDA ($32),Y    track number of the job
F340    85 40       STA $40        save
F342    DD D6 FE    CMP $FED6,X    compare with max track number
F345    CA          DEX
F346    B0 FA       BCS $F342      greater?
F348    8D D1 FE    LDA $FED1,X    get # of sectors per track
F34B    85 43       STA $43        and save
F34D    8A          TXA
F34E    0A          ASL A
F34F    0A          ASL A
F350    0A          ASL A
F351    0A          ASL A
F352    0A          ASL A
F353    85 44       STA $44        gives 0, 32, 64, 96
F355    AD 00 1C    LDA $1C00
F358    29 9F       AND #$9F
F35A    05 44       ORA $44        generate control byte for motor
F35C    8D 00 1C    STA $1C00
F35F    A6 3D       LDX $3D
F361    A5 45       LDA $45        command code
F363    C9 40       CMP #$40       position head?
F365    F0 15       BEQ $F37C      yes
F367    C9 60       CMP #$60       command code for prg execution?
F369    F0 03       BEQ $F36E      yes
F36B    4C B1 F3    JMP $F3B1      read block header

******************************     execute program in buffer
F36E    A5 3F       LDA $3F        buffer number
F370    18          CLC
F371    69 03       ADC #$03       plus 3
F373    85 31       STA $31
F375    A9 00       LDA #$00       equals address of buffer
F377    85 30       STA $30
F379    6C 30 00    JMP ($0030)    execute program in buffer

******************************     position head
```

```
F37C   A9 60      LDA #$60
F37E   85 20      STA $20       set flag for head transport
F380   AD 00 1C   LDA $1C00
F383   29 FC      AND #$FC      turn stepper motors on
F385   8D 00 1C   STA $1C00
F388   A9 A4      LDA #$A4      164
F38A   85 4A      STA $4A       step counter for head transport
F38C   A9 01      LDA #$01
F38E   85 22      STA $22       track number
F390   4C 69 F9   JMP $F969     ok

******************************  initialize pointer in buffer
F393   A4 3F      LDY $3F       buffer number
F395   B9 00 00   LDA $0000,Y   command code
F398   48         PHA           save
F399   10 10      BPL $F3AB
F39B   29 78      AND #$78      erase bits 0,1,2, and 7
F39D   85 45      STA $45
F39F   98         TYA           buffer number
F3A0   0A         ASL A         times two
F3A1   69 06      ADC #$06      plus 6
F3A3   85 32      STA $32       equals pointer to actual buffer
F3A5   98         TYA           buffer number
F3A6   18         CLC
F3A7   69 03      ADC #$03      plus 3
F3A9   85 31      STA $31       equals buffer address hi
F3AB   A0 00      LDY #$00
F3AD   84 30      STY $30       buffer address lo
F3AF   68         PLA           get command code back
F3B0   60         RTS

******************************  read block header, verify ID
F3B1   A2 5A      LDX #$5A      90
F3B3   86 4B      STX $4B       counter
F3B5   A2 00      LDX #$00
F3B7   A9 52      LDA #$52      82
F3B9   85 24      STA $24s
F3BB   20 56 F5   JSR $F556     wait for SYNC
F3BE   50 FE      BVC $F3BE     byte ready?
F3C0   B8         CLV
F3C1   AD 01 1C   LDA $1C01     data from read head
F3C4   C5 24      CMP $24
F3C6   D0 3F      BNE $F407     20, 'read error'
F3C8   50 FE      BVC $F3C8     byte ready?
F3CA   B8         CLV
F3CB   AD 01 1C   LDA $1C01     data byte from disk(block header)
F3CE   95 25      STA $25,X     save 7 bytes
F3D0   E8         INX
F3D1   E0 07      CPX #$07
F3D3   D0 F3      BNE $F3C8     continue reading
F3D5   20 97 F4   JSR $F497
F3D8   A0 04      LDY #$04      4 bytes plus parity
F3DA   A9 00      LDA #$00
F3DC   59 16 00   EOR $0016,Y   form checksum for header
F3DF   88         DEY
```

```
F3E0    10 FA       BPL $F3DC
F3E2    C9 00       CMP #$00       parity ok?
F3E4    D0 38       BNE $F41E      27, 'read error'
F3E6    A6 3E       LDX $3E        drive number
F3E8    A4 18       LDA $18        track number of header
F3EA    95 22       STA $22,X      use as actual track number
F3EC    A5 45       LDA $45
F3EE    C9 30       CMP #$30       code for 'preserve header'
F3F0    F0 1E       BEQ $F410      preserve header
F3F2    A5 3E       LDA $3E
F3F4    0A          ASL A
F3F5    A8          TAY
F3F6    B9 12 00    LDA $0012,Y
F3F9    C5 16       CMP $16        compare with ID1
F3FB    D0 1E       BNE $F41B
F3FD    B9 13 00    LDA $0013,Y
F400    C5 17       CMP $17        compare with ID2
F402    D0 17       BNE $F41B      <>, then 29, 'disk id mismatch'
F404    4C 23 F4    JMP $F423

F407    C6 4B       DEC $4B        decrement counter for attempts
F409    D0 B0       BNE $F3BB      and try again
F40B    A9 02       LDA #$02       else
F40D    20 69 F9    JSR $F969      20, 'read error'

******************************     preserve block header
F410    A5 16       LDA $16        ID1
F412    85 12       STA $12
F414    A5 17       LDA $17        and ID2
F416    85 13       STA $13        preserve
F418    A9 01       LDA #$01       ok
F41A    2C          .BYTE $2C
F41B    A9 0B       LDA #$0B       29, 'disk id mismatch'
F41D    2C          .BYTE $2C
F41E    A9 09       LDA #$09       27, 'write error'
F420    4C 69 F9    JMP $F969      done

******************************
F423    A9 7F       LDA #$7F
F425    85 4C       STA $4C
F427    A5 19       LDA $19
F429    18          CLC
F42A    69 02       ADC #$02
F42C    C5 43       CMP $43
F42E    90 02       BCC $F432
F430    E5 43       SBC $43
F432    85 4D       STA $4D
F434    A2 05       LDX #$05
F436    86 3F       STX $3F
F438    A2 FF       LDX #$FF
F43A    20 93 F3    JSR $F393      set buffer ptr for disk control.
F43D    10 44       BPL $F483
F43F    85 44       STA $44
F441    29 01       AND #$01
F443    C5 3E       CMP $3E
```

```
F445   D0 3C      BNE $F483
F447   A0 00      LDY #$00
F449   B1 32      LDA ($32),Y
F44B   C5 40      CMP $40
F44D   D0 34      BNE $F483
F44F   A5 45      LDA $45        command code
F451   C9 60      CMP #$60
F453   F0 0C      BEQ $F461
F455   A0 01      LDY #$01
F457   38         SEC
F458   B1 32      LDA ($32),Y
F45A   E5 4D      SBC $4D
F45C   10 03      BPL $F461
F45E   18         CLC
F45F   65 43      ADC $43
F461   C4 4C      CMP $4C
F463   B0 1E      BCS $F483
F465   48         PHA
F466   A5 45      LDA $45
F468   F0 14      BEQ $F47E
F46A   68         PLA
F46B   C9 09      CMP #$09
F46D   90 14      BCC $F483
F46F   C9 0C      CMP #$0C
F471   B0 10      BCS $F483
F473   85 4C      STA $4C
F475   A5 3F      LDA $3F
F477   AA         TAX
F478   69 03      ADC #$03
F47A   85 31      STA $31
F47C   D0 05      BNE $F483
F47E   68         PLA
F47F   C9 06      CMP #$06
F481   90 F0      BCC $F473
F483   C6 3F      DEC $3F
F485   10 B3      BPL $F43A
F487   8A         TXA
F488   10 03      BPL $F48D
F48A   4C 9C F9   JMP $F99C      to job loop

F48D   86 3F      STX $3F
F48F   20 93 F3   JSR $F393      get buffer number
F492   A5 45      LDA $45        command code
F494   4C CA F4   JMP $F4CA      continue checking

F497   A5 30      LDA $30
F499   48         PLA            save pointer $30/$31
F49A   A5 31      LDA $31
F49C   48         PHA
F49D   A9 24      LDA #$24
F49F   85 30      STA $30
F4A1   A9 00      LDA #$00       pointer $30/$31 to $24
F4A3   85 31      STA $31
F4A5   A9 00      LDA #$00
F4A7   85 34      STA $34
```

```
F4A9    20 E6 F7    JSR $F7E6
F4AC    A5 55       LDA $55
F4AE    85 18       STA $18
F4B0    A5 54       LDA $54
F4B2    85 19       STA $19
F4B4    A5 53       LDA $53
F4B6    85 1A       STA $1A
F4B8    20 E6 F7    JSR $F7E6
F4BB    A5 52       LDA $52
F4BD    85 17       STA $17
F4BF    A5 53       LDA $53
F4C1    85 16       STA $16
F4C3    68          PLA
F4C4    85 31       STA $31
F4C6    68          PLA              get pointer $30/$31 back
F4C7    85 30       STA $30
F4C9    60          RTS

********************************
F4CA    C9 00       CMP #$00         command code for 'read'?
F4CC    F0 03       BEQ $F4D1        yes
F4CE    4C 6E F5    JMP $F56E        continue checking command code

F4D1    20 0A F5    JSR $F50A        find beginning of data block
F4D4    50 FE       BVC $F4D4        byte ready?
F4D6    B8          CLV
F4D7    AD 01 1C    LDA $1C01        get data byte
F4DA    91 30       STA ($30),Y      and write in buffer
F4DC    C8          INY              256 times
F4DD    D0 F5       BNE $F4D4
F4DF    A0 BA       LDY #$BA
F4E1    50 FE       BVC $F4E1        byte ready?
F4E3    B8          CLV
F4E4    AD 01 1C    LDA $1C01        read bytes
F4E7    99 00 01    STA $0100,Y      from $1BA to $1FF
F4EA    C8          INY
F4EB    D0 F4       BNE $F4E1
F4ED    20 E0 F8    JSR $F8E0
F4F0    A5 38       LDA $38
F4F2    C5 47       CMP $47          equal 7, beginning of data block?
F4F4    F0 05       BEQ $F4FB        yes
F4F6    A9 04       LDA #$04         22, 'read error'
F4F8    4C 69 F9    JMP $F969        error termination

F4FB    20 E9 F5    JSR $F5E9        calculate parity of data block
F4FE    C5 3A       CMP $3A          agreement?
F500    F0 03       BEQ $F505        yes
F502    A9 05       LDA #$05         23, 'read error'
F504    2C          .BYTE $2C
F505    A9 01       LDA #$01         ok
F507    4C 69 F9    JMP $F969        prepare error message

********************************     find start of data block
F50A    20 10 F5    JSR $F510        read block header
F50D    4C 56 F5    JMP $F556        wait for SYNC
```

```
******************************    read block header
F510   A5 3D      LDA $3D         drive number
F512   0A         ASL A
F513   AA         TAX
F514   B5 12      LDA $12,X       ID1
F516   85 16      STA $16         save
F518   B5 13      LDA $13,X       ID2
F51A   85 17      STA $17         save
F51C   A0 00      LDY #$00
F51E   B1 32      LDA ($32),Y     get track and
F520   85 18      STA $18
F522   C8         INY
F523   B1 32      LDA ($32),Y     sector number from buffer
F525   85 19      STA $19
F527   A9 00      LDA #$00
F529   45 16      EOR $16
F52B   45 17      EOR $17         calculate parity for block header
F52D   45 18      EOR $18
F52F   45 19      EOR $19
F531   85 1A      STA $1A         and save
F533   20 34 F9   JSR $F934
F536   A2 5A      LDX #$5A        90 attempts
F538   20 56 F5   JSR $F556       wait for SYNC
F53B   A0 00      LDY #$00
F53D   50 FE      BVC $F35D       byte ready?
F53F   B8         CLV
F540   AD 01 1C   LDA $1C01       read data from block header
F543   D9 24 00   CMP $0024,Y     compare with saved data
F546   D0 06      BNE $F54E       not the same, try again
F548   C8         INY
F549   C0 08      CPY #$08        8 bytes read?
F54B   D0 F0      BNE $F53D       no
F54D   60         RTS

F54E   CA         DEX             decrement counter
F54F   D0 E7      BNE $F538       not yet zero?
F551   A9 02      LDA #$02
F553   4C 69 F9   JMP $F969       20, 'read error'

******************************    wait for SYNC
F556   A9 D0      LDA #$D0        208
F558   8D 05 18   STA $1805       start timer
F55B   A9 03      LDA #$03        error code
F55D   2C 05 18   BIT $1805
F560   10 F1      BPL $F553       timer run down, then 'read error'
F562   2C 00 1C   BIT $1C00       SYNC signal
F565   30 F6      BMI $F55D       not yet found?
F567   AD 10 1C   LDA $1C01       read byte
F56A   B8         CLV
F56B   A0 00      LDY #$00
F56D   60         RTS

******************************
F56E   C9 10      CMP #$10        command code for 'write'
```

```
F570   F0 03     BEQ $F575     yes
F572   4C 91 F6  JMP $F691     continue checking command code

******************************  write data block to disk
F575   20 E9 F5  JSR $F5E9     calculate parity for buffer
F57B   85 3A     STA $3A       and save
F57A   AD 00 1C  LDA $1C00     read port B
F57D   29 10     AND #$10      isolate bit for 'write protect'
F57F   D0 05     BNE $F586     not set, ok
F581   A9 08     LDA #$08
F583   4C 69 F9  JMP $F969     26, 'write protect'

F586   20 8F F7  JSR $F78F
F589   20 10 F5  JSR $F510     find block header
F58C   A2 09     LDX #$09
F58E   50 FE     BVC $F58E     byte ready?
F590   B8        CLV
F591   CA        DEX
F592   D0 FA     BNE $F58E
F594   A9 FF     LDA #$FF
F596   8D 03 1C  STA $1C03     port A (write/read head) to
F599   AD 0C 1C  LDA $1C0C     to output
F59C   29 1F     AND #$1F
F59E   09 C0     ORA #$C0      change PCR to output
F5A0   8D 0C 1C  STA $1C0C
F5A3   A9 FF     LDA #$FF
F5A5   A2 05     LDX #$05
F5A7   8D 01 1C  STA $1C01     write $FF to disk 5 times
F5AA   B8        CLV
F5AB   50 FE     BVC $F5AB     as SYNC characters
F5AD   B8        CLV
F5AE   CA        DEX
F5AF   D0 FA     BNE $F5AB
F5B1   A0 BB     LDY #$BB
F5B3   B9 00 01  LDA $0100,Y   bytes $1BB to $1FF to disk
F5B6   50 FE     BVC $F5B6
F5B8   B8        CLV
F5B9   8D 01 1C  STA $1C01
F5BC   C8        INY
F5BD   D0 F4     BNE $F5B3
F5BF   B1 30     LDA ($30),Y   write data buffer (256 bytes)
F5C1   50 FE     BVC $F5C1
F5C3   B8        CLV
F5C4   8D 01 1C  STA $1C01
F5C7   C8        INY
F5C8   D0 F5     BNE $F5BF
F5CA   50 FE     BVC $F5CA     byte ready?
F5CC   AD 0C 1C  LDA $1C0C
F5CF   09 E0     ORA #$E0      PCR to input again
F5D1   8D 0C 1C  STA $1C0C
F5D4   A9 00     LDA #$00
F5D6   8D 03 1C  LDA $1C03     port A (read/write head) to input
F5D9   20 F2 F5  JSR $F5F2
F5DC   A4 3F     LDY $3F
F5DE   B9 00 00  LDA $0000,Y
```

```
F5E1    49 30       EOR #$30        convert command code 'write'
F5E3    99 00 00    STA $0000,Y         to 'verify'
F5E6    4C B1 F3    JMP $F3B1

******************************      calculate parity for data buffer
F5E9    A9 00       LDA #$00
F5EB    A8          TAY
F5EC    51 30       EOR ($30),Y
F5EE    C8          INY
F5EF    D0 FB       BNE $F5EC
F5F1    60          RTS

F5F2    A9 00       LDA #$00
F5F4    85 2E       STA $2E
F5F6    85 30       STA $30
F5F8    85 4F       STA $4F
F5FA    A5 31       LDA $31
F5FC    85 4E       STA $4E
F5FE    A9 01       LDA #$01
F600    85 31       STA $31
F602    85 2F       STA $2F
F604    A9 BB       LDA #$BB
F606    85 34       STA $34
F608    85 36       STA $36
F60A    20 E6 F7    JSR $F7E6
F60D    A5 52       LDA $52
F60F    85 38       STA $38
F611    A4 36       LDY $36
F613    A5 53       LDA $53
F615    91 2E       STA ($2E),Y
F617    C8          INY
F618    A5 54       LDA $54
F61A    91 2E       STA ($2E),Y
F61C    C8          INY
F61D    A5 55       LDA $55
F61F    91 2E       STA ($2E),Y
F621    C8          INY
F622    84 36       STY $36
F624    20 E6 F7    JSR $F7E6
F627    A4 36       LDY $36
F629    A5 52       LDA $52
F62B    91 2E       STA ($2E),Y
F62D    C8          INY
F62E    A5 53       LDA $53
F630    91 2E       STA ($2E),Y
F632    C8          INY
F633    F0 0E       BEQ $F643
F635    A5 54       LDA $54
F637    91 2E       STA ($2E),Y
F639    C8          INY
F63A    A5 55       LDA $55
F63C    91 2E       STA ($2E),Y
F63E    C8          INY
F63F    84 36       STY $36
F641    D0 E1       BNE $F624
```

```
F643    A5 54       LDA $54
F645    91 30       STA ($30),Y
F647    C8          INY
F648    A5 55       LDA $55
F64A    91 30       STA ($30),Y
F64C    C8          INY
F64D    84 36       STY $36
F64F    20 E6 F7    JSR $F7E6
F652    A4 36       LDY $36
F654    A5 52       LDA $52
F656    91 30       STA ($30),Y
F658    C8          INY
F659    A5 53       LDA $53
F65B    91 30       STA ($30),Y
F65D    C8          INY
F65E    A5 54       LDA $54
F660    91 30       STA ($30),Y
F662    C8          INY
F663    A5 55       LDA $55
F665    91 30       STA ($30),Y
F667    C8          INY
F668    84 36       STY $36
F66A    C0 BB       CPY #$BB
F66C    90 E1       BCC $F64F
F66E    A9 45       LDA #$45
F670    85 2E       STA $2E
F672    A5 31       LDA $31
F674    85 2F       STA $2F
F676    A0 BA       LDY #$BA
F678    B1 30       LDA ($30),Y
F67A    91 2E       STA ($2E),Y
F67C    88          DEY
F67D    D0 F9       BNE $F678
F67F    B1 30       LDA ($30),Y
F681    91 2E       STA ($2E),Y
F683    A2 BB       LDX #$BB
F685    BD 00 01    LDA $0100,X
F688    91 30       STA ($30),Y
F68A    C8          INY
F68B    E8          INX
F68C    D0 F7       BNE $F685
F68E    86 50       STX $50
F690    60          RTS

*******************************
F691    C9 20       CMP #$20       command code for 'verify'?
F693    F0 03       BEQ $F698      yes
F695    4C CA F6    JMP $F6CA      continue checking command code

F698    20 E9 F5    JSR $F5E9      calculate parity for data buffer
F69B    85 3A       STA $3A        and save
F69D    20 8F F7    JSR $F78F
F6A0    20 0A F5    JSR $F50A      find start of data block
F6A3    A0 BB       LDY #$BB
F6A5    B9 00 01    LDA $0100,Y    data from buffer
```

```
F6A8   50 FE      BVC $F6A8      byte ready?
F6AA   B8         CLV
F6AB   4D 01 1C   EOR $1C01      compare with data from disk
F6AE   D0 15      BNE $F6C5      not equal, then error
F6B0   C8         INY
F6B1   D0 F2      BNE $F6A5
F6B3   B1 30      LDA ($30),Y    data from buffer
F6B5   50 FE      BVC $F6B5
F6B7   B8         CLV
F6B8   4D 01 1C   EOR $1C01      compare with data from disk
F6BB   D0 08      BNE $F6C5      not equal, then error
F6BD   C8         INY
F6BE   C0 FD      CPY #$FD
F6C0   D0 F1      BNE $F6B3
F6C2   4C 18 F4   JMP $F418      error free termination

F6C5   A9 07      LDA #$07
F6C7   4C 69 F9   JMP $F969      25, 'write error'

*******************************
F6CA   20 10 F5   JSR $F510      read block header
F6CD   4C 18 F4   JMP $F418      done

*******************************
F6D0   A9 00      LDA #$00
F6D2   85 57      STA $57
F6D4   85 5A      STA $5A
F6D6   A4 34      LDY $34
F6D8   A5 52      LDA $52
F6DA   29 F0      AND #$F0       isolate hi-nibble
F6DC   4A         LSR A
F6DD   4A         LSR A          and rotate to lower nibble
F6DE   4A         LSR A
F6DF   4A         LSR A
F6E0   AA         TAX            as index in table
F6E1   BD 7F F7   LDA $F77F,X
F6E4   0A         ASL A
F6E5   0A         ASL A          times 8
F6E6   0A         ASL A
F6E7   85 56      STA $56
F6E9   A5 52      LDA $52
F6EB   29 0F      AND #$0F       isolate lower nibble
F6ED   AA         TAX            as index in table
F6EE   BD 7F F7   LDA $F77F,X
F6F1   6A         ROR A
F6F2   66 57      ROR $57
F6F4   6A         ROR A
F6F5   66 57      ROR $57
F6F7   29 07      AND #$07
F6F9   05 56      ORA $56
F6FB   91 30      STA ($30),Y    in buffer
F6FD   C8         INY            increment buffer
F6FE   A5 53      LDA $53
F700   29 F0      AND #$F0       isolate upper nibble
F702   4A         LSR A
```

```
F703   4A         LSR A
F704   4A         LSR A           shift to upper nibble
F705   4A         LSR A
F706   AA         TAX             as index in table
F707   BD 7F F7   LDA $F77F,X
F70A   0A         ASL A
F70B   05 57      ORA $57
F70D   85 57      STA $57
F70F   A5 53      LDA $53
F711   29 0F      AND #$0F        lower nibble
F713   AA         TAX             as index
F714   BD 7F F7   LDA $F77F,X
F717   2A         ROL A
F718   2A         ROL A
F719   2A         ROL A
F71A   2A         ROL A
F71B   85 58      STA $58
F71D   2A         ROL A
F71E   29 01      AND #$01
F720   05 57      ORA $57
F722   91 30      STA ($30),Y     in buffer
F724   C8         INY             increment buffer
F725   A5 54      LDA $54
F727   29 F0      AND #$F0        isolate hi-nibble
F729   4A         LSR A
F72A   4A         LSR A
F72B   4A         LSR A
F72C   4A         LSR A
F72D   AA         TAX
F72E   BD 7F F7   LDA $F77F,X
F731   18         CLC
F732   6A         ROR A
F733   05 58      ORA $58
F735   91 30      STA ($30),Y     in buffer
F737   C8         INY             increment buffer pointer
F738   6A         ROR A
F739   29 80      AND #$80
F73B   85 59      STA $59
F73D   A5 54      LDA $54
F73F   29 0F      AND #$0F        lower nibble
F741   AA         TAX             as index
F742   BD 7F F7   LDA $F77F,X
F745   0A         ASL A
F746   0A         ASL A
F747   29 7C      AND #$7C
F749   05 59      ORA $59
F74B   85 59      STA $59
F74D   A5 55      LDA $55
F74F   29 F0      AND #$F0        isolate hi-nibble
F751   4A         LSR A
F752   4A         LSR A           shift to lower nibble
F753   4A         LSR A
F754   4A         LSR A
F755   AA         TAX             as index in table
F756   BD 7F F7   LDA $F77F,X
```

```
F759    6A          ROR A
F75A    66 5A       ROR $5A
F75C    6A          ROR A
F75D    66 5A       ROR $5A
F75F    6A          ROR A
F760    66 5A       ROR $5A
F762    29 03       AND #$03
F764    05 59       ORA $59
F766    91 30       STA ($30),Y    in buffer
F768    C8          INY            increment buffer pointer
F769    D0 04       BNE $F76F
F76B    A5 2F       LDA $2F
F76D    85 31       STA $31
F76F    A5 55       LDA $55
F771    29 0F       AND #$0F       lower nibble
F773    AA          TAX            as index
F774    BD 7F F7    LDA $F77F,X
F777    05 5A       ORA $5A
F779    91 30       STA ($30),Y    in buffer
F77B    C8          INY            increment buffer pointer
F77C    84 34       STY $34        and save
F77E    60          RTS

******************************
F77F 0A 0B 12 13 0E 0F 16 17
F787 09 19 1A 1B 0D 1D 1E 15

******************************
F78F    A9 00       LDA #$00
F791    85 30       STA $30
F793    85 2E       STA $2E
F795    85 36       STA $36
F797    A9 BB       LDA #$BB
F799    85 34       STA $34
F79B    85 50       STA $50
F79D    A5 31       LDA $31
F79F    85 2F       STA $2F
F7A1    A9 01       LDA #$01
F7A3    85 31       STA $31
F7A5    A5 47       LDA $47
F7A7    85 52       STA $52
F7A9    A4 36       LDY $36
F7AB    B1 2E       LDA ($2E),Y
F7AD    85 53       STA $53
F7AF    C8          INY
F7B0    B1 2E       LDA ($2E),Y
F7B2    85 54       STA $54
F7B4    C8          INY
F7B5    B1 2E       LDA ($2E),Y
F7B7    85 55       STA $55
F7B9    C8          INY
F7BA    84 36       STY $36
F7BC    20 D0 F6    JSR $F6D0
F7BF    A4 36       LDY $36
F7C1    B1 2E       LDA ($2E),Y
```

```
F7C3    85 52       STA $52
F7C5    C8          INY
F7C6    F0 11       BEQ $F7D9
F7C8    B1 2E       LDA ($2E),Y
F7CA    85 53       STA $53
F7CC    C8          INY
F7CD    B1 2E       LDA ($2E),Y
F7CF    85 54       STA $54
F7D1    C8          INY
F7D2    B1 2E       LDA ($2E),Y
F7D4    85 55       STA $55
F7D6    C8          INY
F7D7    D0 E1       BNE $F7BA
F7D9    A5 3A       LDA $3A
F7DB    85 53       STA $53
F7DD    A9 00       LDA #$00
F7DF    85 54       STA $54
F7E1    85 55       STA $55
F7E3    4C D0 F6    JMP $F6D0

F7E6    A4 34       LDY $34
F7E8    B1 30       LDA ($30),Y
F7EA    29 F8       AND #$F8
F7EC    4A          LSR A
F7ED    4A          LSR A
F7EE    4A          LSR A
F7EF    85 56       STA $56
F7F1    B1 30       LDA ($30),Y
F7F3    29 07       AND #$07
F7F5    0A          ASL A
F7F6    0A          ASL A
F7F7    85 57       STA $57
F7F9    C8          INY
F7FA    D0 06       BNE $F802
F7FC    A5 4E       LDA $4E
F7FE    85 31       STA $31
F800    A4 4F       LDY $4F
F802    B1 30       LDA ($30),Y
F804    29 C0       AND #$C0
F806    2A          ROL A
F807    2A          ROL A
F808    2A          ROL A
F809    05 57       ORA $57
F80B    85 57       STA $57
F80D    B1 30       LDA ($30),Y
F80F    29 3E       AND #$3E
F811    4A          LSR A
F812    85 58       STA $58
F814    B1 30       LDA ($30),Y
F816    29 01       AND #$01
F818    0A          ASL A
F819    0A          ASL A
F81A    0A          ASL A
F81B    0A          ASL A
F81C    85 59       STA $59
```

```
F81E    C8          INY
F81F    B1 30       LDA ($30),Y
F821    29 F0       AND #$F0
F823    4A          LSR A
F824    4A          LSR A
F825    4A          LSR A
F826    4A          LSR A
F827    05 59       ORA $59
F829    85 59       STA $59
F82B    B1 30       LDA ($30),Y
F82D    29 0F       AND #$0F
F82F    0A          ASL A
F830    85 5A       STA $5A
F832    C8          INY
F833    B1 30       LDA ($30),Y
F835    29 80       AND #$80
F837    18          CLC
F838    2A          ROL A
F839    2A          ROL A
F83A    29 01       AND #$01
F83C    05 5A       ORA $5A
F83E    85 5A       STA $5A
F840    B1 30       LDA ($30),Y
F842    29 7C       AND #$7C
F844    4A          LSR A
F845    4A          LSR A
F846    85 5B       STA $5B
F848    B1 30       LDA ($30),Y
F84A    29 03       AND #$03
F84C    0A          ASL A
F84D    0A          ASL A
F84E    0A          ASL A
F84F    85 5C       STA $5C
F851    C8          INY
F852    D0 06       BNE $F85A
F854    A5 4E       LDA $4E
F856    85 31       STA $31
F858    A4 4F       LDY $4F
F85A    B1 30       LDA ($30),Y
F85C    29 E0       AND #$E0
F85E    2A          ROL A
F85F    2A          ROL A
F860    2A          ROL A
F861    2A          ROL A
F862    05 5C       ORA $5C
F864    85 5C       STA $5C
F866    B1 30       LDA ($30),Y
F868    29 1F       AND #$1F
F86A    85 5D       STA $5D
F86C    C8          INY
F86D    84 34       STY $34
F86F    A6 56       LDX $56
F871    BD A0 F8    LDA $F8A0,X
F874    A6 57       LDX $57
F876    1D C0 F8    ORA $F8C0,X
```

```
F879    85 52       STA $52
F87B    A6 58       LDX $58
F87D    BD A0 F8    LDA $F8A0,X
F880    A6 59       LDX $59
F882    1D C0 F8    ORA $F8C0,X
F885    85 53       STA $53
F887    A6 5A       LDX $5A
F889    BD A0 F8    LDA $F8A0,X
F88C    A6 5B       LDX $5B
F88E    1D C0 F8    ORA $F8C0,X
F891    85 54       STA $54
F893    A6 5C       LDX $5C
F895    BD A0 F8    LDA $F8A0,X
F898    A6 5D       LDX $5D
F89A    1D C0 F8    ORA $F8C0,X
F89D    85 55       STA $55
F89F    60          RTS

******************************
F8A0 FF FF FF FF FF FF FF FF
F8A8 FF 80 00 10 FF C0 40 50
F8B0 FF FF 20 30 FF F0 60 70
F8B8 FF 90 A0 B0 FF D0 E0 FF

F8C0 FF FF FF FF FF FF FF FF
F8C8 FF 08 00 01 FF 0C 04 05
F8D0 FF FF 02 03 FF 0F 06 07
F8D8 FF 09 0A 0B FF 0D 0E FF

******************************
F8E0    A9 00       LDA #$00
F8E2    85 34       STA $34
F8E4    85 2E       STA $2E
F8E6    85 36       STA $36
F8E8    A9 01       LDA #$01
F8EA    85 4E       STA $4E
F8EC    A9 BA       LDA #$BA
F8EE    85 4F       STA $4F
F8F0    A5 31       LDA $31
F8F2    85 2F       STA $2F
F8F4    20 E6 F7    JSR $F7E6
F8F7    A5 52       LDA $52
F8F9    85 38       STA $38
F8FB    A4 36       LDY $36
F8FD    A5 53       LDA $53
F8FF    91 2E       STA ($2E),Y
F901    C8          INY
F902    A5 54       LDA $54
F904    91 2E       STA ($2E),Y
F906    C8          INY
F907    A5 55       LDA $55
F909    91 2E       STA ($2E),Y
F90B    C8          INY
F90C    84 36       STY $36
F90E    20 E6 F7    JSR $F7E6
```

```
F911    A4 36       LDY $36
F913    A5 52       LDA $52
F915    91 2E       STA ($2E),Y
F917    C8          INY
F918    F0 11       BEQ $F92B
F91A    A5 53       LDA $53
F91C    91 2E       STA ($2E),Y
F91E    C8          INY
F91F    A5 54       LDA $54
F921    91 2E       STA ($2E),Y
F923    C8          INY
F924    A5 55       LDA $55
F926    91 2E       STA ($2E),Y
F928    C8          INY
F929    D0 E1       BNE $F90C
F92B    A5 53       LDA $53
F92D    85 3A       STA $3A
F92F    A5 2F       LDA $2F
F931    85 31       STA $31
F933    60          RTS

F934    A5 31       LDA $31
F936    85 2F       STA $2F
F938    A9 00       LDA #$00
F93A    85 31       STA $31
F93C    A9 24       LDA #$24
F93E    85 34       STA $34
F940    A5 39       LDA $39
F942    85 52       STA $52
F944    A5 1A       LDA $1A
F946    85 53       STA $53
F948    A5 19       LDA $19
F94A    85 54       STA $54
F94C    A5 18       LDA $18
F94E    85 55       STA $55
F950    20 D0 F6    JSR $F6D0
F953    A5 17       LDA $17
F955    85 52       STA $52
F957    A5 16       LDA $16
F959    85 53       STA $53
F95B    A9 00       LDA #$00
F95D    85 54       STA $54
F95F    85 55       STA $55
F961    20 D0 F6    JSR $F6D0
F964    A5 2F       LDA $2F
F966    85 31       STA $31
F968    60          RTS

F969    A4 3F       LDY $3F
F96B    99 00 00    STA $0000,Y
F96E    A5 50       LDA $50
F970    F0 03       BEQ $F975
F972    20 F2 F5    JSR $F5F2
F975    20 8F F9    JSR $F98F
F978    A6 49       LDX $49         get stack pointer back
```

```
F97A   9A          TXS
F97B   4C BE F2    JMP $F2BE

F97E   A9 A0       LDA #$A0
F980   85 20       STA $20
F982   AD 00 1C    LDA $1C00
F985   09 04       ORA #$04        turn drive motor off
F987   8D 00 1C    STA $1C00
F98A   A9 3C       LDA $3C
F98C   85 48       STA $48
F98E   60          RTS

F98F   A6 3E       LDX $3E
F991   A5 20       LDA $20
F993   09 10       ORA #$10
F995   85 20       STA $20
F997   A9 FF       LDA #$FF
F999   85 48       STA $48
F99B   60          RTS

F99C   AD 07 1C    LDA $1C07
F99F   8D 05 1C    STA $1C05
F9A2   AD 00 1C    LDA $1C00
F9A5   29 10       AND #$10        write protect?
F9A7   C5 1E       CMP $1E
F9A9   85 1E       STA $1E
F9AB   F0 04       BEQ $F9B1
F9AD   A9 01       LDA #$01
F9AF   85 1C       STA $1C
F9B1   AD FE 02    LDA $02FE
F9B4   F0 15       BEQ $F9CB
F9B6   C9 02       CMP #$02
F9BB   D0 07       BNE $F9C1
F9BA   A9 00       LDA #$00
F9BC   8D FE 02    STA $02FE
F9BF   F0 0A       BEQ $F9CB
F9C1   85 4A       STA $4A
F9C3   A9 02       LDA #$02
F9C5   8D FE 02    STA $02FE
F9C8   4C 2E FA    JMP $FA2E

F9CB   A6 3E       LDX $3E
F9CD   30 07       BMI $F9D6
F9CF   A5 20       LDA $20
F9D1   A8          TAY
F9D2   C9 20       CMP #$20
F9D4   D0 03       BNE $F9D9
F9D6   4C BE FA    JMP $FABE

F9D9   C6 48       DEC $48
F9DB   D0 1D       BNE $F9FA
F9DD   98          TYA
F9DE   10 04       BPL $F9E4
F9E0   29 7F       AND #$7F
F9E2   85 20       STA $20
```

```
F9E4    29 10       AND #$10
F9E6    F0 12       BEQ $F9FA
F9E8    AD 00 1C    LDA $1C00
F9EB    29 FB       AND #$FB       drive motor on
F9ED    8D 00 1C    STA $1C00
F9F0    A9 FF       LDA #$FF
F9F2    85 3E       STA $3E
F9F4    A9 00       LDA #$00
F9F6    85 20       STA $20
F9F8    F0 DC       BEQ $F9D6
F9FA    98          TYA
F9FB    29 40       AND #$40
F9FD    D0 03       BNE $FA02
F9FF    4C BE FA    JMP $FABE

FA02    6C 62 00    JMP ($0062)

FA05    A5 4A       LDA #$4A
FA07    10 05       BPL $FA0E
FA09    49 FF       EOR #$FF
FA0B    18          CLC
FA0C    69 01       ADC #$01
FA0E    C5 64       CMP $64
FA10    B0 0A       BCS $FA1C
FA12    A9 3B       LDA #$3B
FA14    85 62       STA $62
FA16    A9 FA       LDA #$FA       pointer $62/$63 to $FA3B
FA18    85 63       STA $63
FA1A    D0 12       BNE $FA2E
FA1C    E5 5E       SBC $5E
FA1E    E5 5E       SBC $5E
FA20    85 61       STA $61
FA22    A5 5E       LDA $5E
FA24    85 60       STA $60
FA26    A9 7B       LDA #$7B
FA28    85 62       STA $62
FA2A    A9 FA       LDA #$FA       pointer $62/$63 to $FA7B
FA2C    85 63       STA $63
FA2E    A5 4A       LDA $4A        step counter for head transport
FA30    10 31       BPL $FA63
FA32    E6 4A       INC $4A        increment
FA34    AE 00 1C    LDX $1C00
FA37    CA          DEX
FA38    4C 69 FA    JMP $FA69

*******************************
FA3B    A5 4A       LDA $4A        step counter for head transport
FA3D    D0 EF       BNE $FA2E      not yet zero?
FA3F    A9 4E       LDA #$4E
FA41    85 62       STA $62
FA43    A9 FA       LDA #$FA       pointer $62/$63 to $FA4E
FA45    85 63       STA $63
FA47    A9 05       LDA #$05
FA49    85 60       STA $60        counter to 5
FA4B    4C BE FA    JMP $FABE
```

```
******************************
FA4E    C6 60       DEC $60       decrement counter
FA50    D0 6C       BNE $FABE     not yet zero?
FA52    A5 20       LDA $20
FA54    29 BF       AND #$BF      erase bit 6
FA56    85 20       STA $20
FA58    A9 05       LDA #$05
FA5A    85 62       STA $62
FA5C    A9 FA       LDA #$FA      pointer $62/$63 to FA05
FA5E    85 63       STA $63
FA60    4C BE FA    JMP $FABE

******************************
FA63    C6 4A       DEC $4A       step counter for head transport
FA65    AE 00 1C    LDX $1C00
FA68    E8          INX
FA69    8A          TXA
FA6A    29 03       AND #$03
FA6C    85 4B       STA $4B
FA6E    AD 00 1C    LDA $1C00
FA71    29 FC       AND #$FC
FA73    05 4B       ORA $4B       stepper motor off
FA75    8D 00 1C    STA $1C00
FA78    4C BE FA    JMP $FABE

******************************
FA7B    38          SEC
FA7C    AD 07 1C    LDA $1C07
FA7F    E5 5F       SBC $5F
FA81    8D 05 1C    STA $1C05
FA84    C6 60       DEC $60       decrement counter
FA86    D0 0C       BNE $FA94     not yet zero?
FA88    A5 5E       LDA $5E
FA8A    85 60       STA $60
FA8C    A9 97       STA #$97
FA8E    85 62       STA $62
FA90    A9 FA       LDA #$FA      pointer $62/$63 to $FA97
FA92    85 63       STA $63
FA94    4C 2E FA    JMP $FA2E

******************************
FA97    C6 61       DEC $61
FA99    D0 F9       BNE $FA94
FA9B    A9 A5       LDA #$A5
FA9D    85 62       STA $62
FA9F    A9 FA       LDA #$FA      pointer $62/$63 to $FAA5
FAA1    85 63       STA $63
FAA3    D0 EF       BNE $FA94

******************************
FAA5    AD 07 1C    LDA $1C07
FAA8    18          CLC
FAA9    65 5F       ADC $5F
FAAB    8D 05 1C    STA $1C05
```

```
FAAE    C6 60       DEC $60        decrement counter
FAB0    D0 E2       BNE $FA94      not yet zero?
FAB2    A9 4E       LDA #$4E
FAB4    85 62       STA $62
FAB6    A9 FA       LDA #$FA       pointer $62/$63 to $FA4E
FAB8    85 63       STA $63
FABA    A9 05       LDA #$05
FABC    85 60       STA $60        counter to 5
FABE    AD 0C 1C    LDA $1C0C
FAC1    29 FD       AND #$FD       erase bit 1
FAC3    8D 0C 1C    STA $1C0C
FAC6    60          RTS

******************************     formatting
FAC7    A5 51       LDA $51        track number
FAC9    10 2A       BPL $FAF5      fomatting already in progress
FACB    A6 3D       LDX $3D        drive number
FACD    A9 60       LDA #$60       flag for head transport
FACF    95 20       STA $20,X      set
FAD1    A9 01       LDA #$01
FAD3    95 22       STA $22,X      set destination track
FAD5    85 51       STA $51        running track # for format
FAD7    A9 A4       LDA #$A4       164
FAD9    85 4A       STA $4A        step counter for head transport
FADB    AD 00 1C    LDA $1C00
FADE    29 FC       AND #$FC       stepper motor on
FAE0    8D 00 1C    STA $1C00
FAE3    A9 0A       LDA #$0A       10
FAE5    8D 20 06    STA $0620      error counter
FAE8    A9 A0       LDA #$40       $621/$622 = 4000
FAEA    8D 21 06    STA $0621      initialize track capacity
FAED    A9 0F       LDA #$0F       4000 < capacity < 2*4000 bytes
FAEF    8D 22 06    STA $0622
FAF2    4C 9C F9    JMP $F99C      back in job loop

FAF5    A0 00       LDY #$00
FAF7    D1 32       CMP ($32),Y
FAF9    F0 05       BEQ $FB00
FAFB    91 32       STA ($32),Y
FAFD    4C 9C F9    JMP $F99C      to job loop

FB00    AD 00 1C    LDA $1C00
FB03    29 10       AND #$10       write protect?
FB05    D0 05       BNE $FB0C      no
FB07    A9 08       LDA #$08
FB09    4C D3 FD    JMP $FDD3      26, 'write protect on'

FB0C    20 A3 FD    JSR $FDA3      write $FF to disk 10240 times
FB0F    20 C3 FD    JSR $FDC3      code ($621/$622) times to disk
FB12    A9 55       LDA #$55       $55
FB14    8D 01 1C    STA $1C01      to write head
FB17    20 C3 FD    JSR $FDC3      and ($621/$622) times to disk
FB1A    20 00 FE    JSR $FE00      switch to read
FB1D    20 56 F5    JSR $F556      set timer, find $FF (SYNC)
FB20    A9 40       LDA #$40
```

```
FB22   0D 0B 18    ORA $180B     timer 1 free running
FB25   8D 0B 18    STA $180B
FB28   A9 62       LDA #$62      98 cycles, about 0.1 ms
FB2A   8D 06 18    STA $1806
FB2D   A9 00       LDA #$00
FB2F   8D 07 18    STA $1807
FB32   8D 05 18    STA $1805     start timer
FB35   A0 00       LDY #$00      counter to zero
FB37   A2 00       LDX #$00
FB39   2C 00 1C    BIT $1C00     SYNC found?
FB3C   30 FB       BMI $FB39     no, wait
FB3E   2C 00 1C    BIT $1C00     SYNC found?
FB41   10 FB       BPL $FB3E     wait for SYNC
FB43   AD 04 18    LDA $1804     reset interrupt flag timer
FB46   2C 00 1C    BIT $1C00     SYNC found?
FB49   10 11       BPL $FB5C     not SYNC ($55)?
FB4B   AD 0D 18    LDA $180D     interrupt flag register
FB4E   0A          ASL A         shift timer flag
FB4F   10 F5       BPL $FB46     timer not run down yet?
FB51   E8          INX           increment counter
FB52   D0 EF       BNE $FB43
FB54   C8          INY           increment hi-byte of counter
FB55   D0 EC       BNE $FB43
FB57   A9 02       LDA #$02      overflow, then error
FB59   4C D3 FD    JMP $FDD3     20, 'read error'

FB5C   86 71       STX $71
FB5E   84 72       STY $72
FB60   A2 00       LDX #$00
FB62   A0 00       LDY #$00      counter to zero again
FB64   AD 04 18    LDA $1804     reset timer 1 interrupt flag
FB67   2C 00 1C    BIT $1C00     SYNC found?
FB6A   30 11       BMI $FB7D     yes
FB6C   AD 0D 18    LDA $180D     interrupt-flag register
FB6F   0A          ASL A         timer flag to bit 7
FB70   10 F5       BPL $FB67     no, wait until timer run down
FB72   E8          INX
FB73   D0 EF       BNE $FB64     increment counter
FB75   C8          INY
FB76   D0 EC       BNE $FB64
FB78   A9 02       LDA #$02      overflow, then error
FB7A   4C D3 FD    JMP $FDD3     20, 'read error'

FB7D   38          SEC
FB7E   8A          TXA
FB7F   E5 71       SBC $71       difference between counter
FB81   AA          TAX
FB82   85 70       STA $70
FB84   98          TYA           and value for $FF-storage
FB85   E5 72       SBC $72
FB87   A8          TAY           bring to $70/$71
FB88   85 71       STA $71
FB8A   10 0B       BPL $FB97     difference positive?
FB8C   49 FF       EOR #$FF
FB8E   A8          TAY
```

```
FB8F   8A          TXA
FB90   49 FF       EOR #$FF     calculate abs. val of difference
FB92   AA          TAX
FB93   E8          INX
FB94   D0 01       BNE $FB97
FB96   C8          INY
FB97   98          TYA
FB98   D0 04       BNE $FB9E
FB9A   E0 04       CPX #$04     difference less than 4 * 0.1 ms
FB9C   90 18       BCC $FBB6    yes
FB9E   06 70       ASL $70
FBA0   26 71       ROL $71      double difference
FBA2   18          CLC
FBA3   A5 70       LDA $70
FBA5   6D 21 06    ADC $0621
F8A8   8D 21 06    STA $0621    add to 4000
FBAB   A5 71       LDA $71
FBAD   6D 22 06    ADC $0622
FBB0   8D 22 06    STA $0622
FBB3   4C 0C FB    JMP $FB0C    repeat until diff < 4 * 0.1 ms

FBB6   A2 00       LDX #$00
FBB8   A0 00       LDY #$00     counter to zero
FBBA   B8          CLV
FBBB   AD 00 1C    LDA $1C00    SYNC?
FBBE   10 0E       BPL $FBCE    no
FBC0   50 59       BVC $FBBB    byte ready?
FBC2   B8          CLV
FBC3   E8          INX
FBC4   D0 F5       BNE $FBBB    increment counter
FBC6   C8          INY
FBC7   D0 F2       BNE $FBBB
FBC9   A9 03       LDA #$03     overflow, then error
FBCB   4C D3 FD    JMP $FDD3    21, read error

FBCE   8A          TXA
FBCF   0A          ASL A        double counter
FBD0   8D 25 06    STA $0625
FBD3   98          TYA
FBD4   2A          ROL A        and to $624/$625 as track cap.
FBD5   8D 24 06    STA $0624
FBD8   A9 BF       LDA #$BF
FBDA   2D 0B 18    AND $180B
FBDD   8D 0B 18    STA $180B
FBE0   A9 66       LDA #$66     102
FBE2   8D 26 06    STA $0626
FBE5   A6 43       LDX $43      number of sectors in this track
FBE7   A0 00       LDY #$00
FBE9   98          TYA
FBEA   18          CLC
FBEB   6D 26 06    ADC $0626
FBEE   90 01       BCC $FBF1
FBF0   C8          INY
FBF1   C8          INY
FBF2   CA          DEX
```

```
FBF3    D0 F5       BNE $FBEA      calculate # of bytes
FBF5    49 FF       EOR #$FF
FBF7    38          SEC
FBF8    69 00       ADC #$00
FBFA    18          CLC
FBFB    6D 25 06    ADC $0625
FBFE    B0 03       BCS $FC03
FC00    CE 24 06    DEC $0624
FC03    AA          TAX
FC04    98          TYA
FC05    49 FF       EOR #$FF
FC07    38          SEC
FC08    69 00       ADC #$00
FC0A    18          CLC
FC0B    6D 24 06    ADC $0624      result in A/X
FC0E    10 05       BPL $FC15
FC10    A9 04       LDA #$04
FC12    4C D3 FD    JMP $FDD3      22, 'read error'

FC15    A8          TAY
FC16    8A          TXA
FC17    A2 00       LDX #$00
FC19    38          SEC            total divided by number
FC1A    E5 43       SBC $43        of sectors ($43)
FC1C    B0 03       BCS $FC21
FC1E    88          DEY
FC1F    30 03       BMI $FC24
FC21    E8          INX
FC22    D0 F5       BNE $FC19
FC24    8E 26 06    STX $0626      compare no. of bytes per interval
FC27    E0 04       CPX #$04       with minimum value
FC29    B0 05       BCS $FC30      ok
FC2B    A9 05       LDA #$05
FC2D    4C D3 FD    JMP $FDD3      23, 'read error'
FC30    18          CLC            remainder of division
FC31    65 43       ADC $43        plus number of sectors
FC33    8D 27 06    STA $0627      save
FC36    A9 00       LDA #$00
FC38    8D 28 06    STA $0628      counter for sectors
FC3B    A0 00       LDY #$00       counter lo
FC3D    A6 3D       LDX $3D        drive number
FC3F    A5 39       LDA $39        constant 8, marker for header
FC41    99 00 03    STA $0300,Y    in buffer
FC44    C8          INY
FC45    C8          INY
FC46    AD 28 06    LDA $0628      sector number
FC49    99 00 03    STA $0300,Y    in buffer
FC4C    C8          INY
FC4D    A5 51       LDA $51        track number
FC4F    99 00 03    STA $0300,Y    in buffer
FC52    C8          INY
FC53    B5 13       LDA $13,X      ID 2
FC55    99 00 03    STA $0300,Y    in buffer
FC58    C8          INY
FC59    B5 12       LDA $12,X      ID 1
```

```
FC5B   99 00 03   STA $0300,Y    in buffer
FC5E   C8         INY
FC5F   A9 0F      LDA #$0F       15
FC61   99 00 03   STA $0300,Y    in buffer
FC64   C8         INY
FC65   99 00 03   STA $0300,Y    15 in buffer
FC68   C8         INY
FC69   A9 00      LDA #$00
FC6B   59 FA 02   EOR $02FA,Y
FC6E   59 FB 02   EOR $02FB,Y
FC71   59 FC 02   EOR $02FC,Y    generate checksum
FC74   59 FD 02   EOR $02FD,Y
FC77   99 F9 02   STA $02F9,Y
FC7A   EE 28 06   INC $0628      increment counter
FC7D   AD 28 06   LDA $0628      counter
FC80   C5 43      CMP $43        compare with no. of sectors
FC82   90 BB      BCC $FC3F      smaller, then continue
FC84   98         TYA
FC85   48         PHA
FC86   E8         INX
FC87   8A         TXA
FC88   9D 00 05   STA $0500,X
FC8B   E8         INX
FC8C   D0 FA      BNE $FC88
FC8E   A9 03      LDA #$03       buffer pointer to $300
FC90   85 31      STA $31
FC92   20 30 FE   JSR $FE30
FC95   68         PLA
FC96   A8         TAY
FC97   88         DEY
FC98   20 E5 FD   JSR $FDE5      copy buffer data
FC9B   20 F5 FD   JSR $FDF5      copy data in buffer
FC9E   A9 05      LDA #$05
FCA0   85 31      STA $31        buffer pointer to $500
FCA2   20 E9 F5   JSR $F5E9      calculate parity for data buffer
FCA5   85 3A      STA $3A        and save
FCA7   20 8F F7   JSR $F78F
FCAA   A9 00      LDA #$00
FCAC   85 32      STA $32
FCAE   20 0E FE   JSR $FE0E
FCB1   A9 FF      LDA #$FF
FCB3   8D 01 1C   STA $1C01      to write head
FCB6   A2 05      LDX #$05       write $FF 5 times
FCB8   50 FE      BVC $FCB8      byte ready
FCBA   B8         CLV
FCBB   CA         DEX
FCBC   D0 FA      BNE $FCB8
FCBE   A2 0A      LDX #$0A       10 times
FCC0   A4 32      LDY $32        buffer pointer
FCC2   50 FE      BVC $FCC2      byte ready?
FCC4   B8         CLV
FCC5   B9 00 03   LDA $0300,Y    data from buffer
FCC8   8D 01 1C   STA $1C01      write
FCCB   C8         INY
FCCC   CA         DEX            10 data written?
```

```
FCCD   D0 F3      BNE $FCC2
FCCF   A2 09      LDX #$09      9 times
FCD1   50 FE      BVC $FCD1     byte ready?
FCD3   B8         CLV
FCD4   A9 55      LDA #$55      $55
FCD6   8D 01 1C   STA $1C01     write
FCD9   CA         DEX
FCDA   D0 F5      BNE $FCD1     9 times?
FCDC   A9 FF      LDA #$FF      $FF
FCDE   A2 05      LDX #$05      5 times
FCE0   50 FE      BVC $FCE0     byte ready?
FCE2   B8         CLV
FCE3   8D 01 1C   STA $1C01     to write head
FCE6   CA         DEX
FCE7   D0 F7      BNE $FCE0
FCE9   A2 BB      LDX #$BB
FCEB   50 FE      BVC $FCEB
FCED   B8         CLV
FCEE   BD 00 01   LDA $0100,X   area $1BB to $1FF
FCF1   8D 01 1C   STA $1C01     save
FCF4   E8         INX
FCF5   D0 F4      BNE $FCEB
FCF7   A0 00      LDY #$00
FCF9   50 FE      BVC $FCF9     byte ready?
FCFB   B8         CLV
FCFC   B1 30      LDA ($30),Y   256 bytes of data
FCFE   8D 01 1C   STA $1C01     write byte to disk
FD01   C8         INY
FD02   D0 F5      BNE $FCF9
FD04   A9 55      LDA #$55      $55
FD06   AE 26 06   LDX $0626     ($626) times
FD09   50 FE      BVC $FD09
FD0B   B8         CLV
FD0C   8D 01 1C   STA $1C01     write
FD0F   CA         DEX
FD10   D0 F7      BNE $FD09
FD12   A5 32      LDA $32
FD14   18         CLC
FD15   69 0A      ADC #$0A      plus 10
FD17   85 32      STA $32
FD19   CE 28 06   DEC $0628     decrement sector number
FD1C   D0 93      BNE $FCB1
FD1E   50 FE      BVC $FD1E     byte ready?
FD20   B8         CLV
FD21   50 FE      BVC $FD21     byte ready?
FD23   B8         CLV
FD24   20 00 FE   JSR $FE00     switch to reading
FD27   A9 C8      LDA #$C8      200
FD29   8D 23 06   STA $0623
FD2C   A9 00      LDA #$00
FD2E   85 30      STA $30
FD30   A9 03      LDA #$03      buffer pointer to $200
FD32   85 31      STA $31
FD34   A5 43      LDA $43       number of sectors per track
FD36   8D 28 06   STA $0628
```

```
FD39    20 56 F5    JSR $F556      wait for SYNC
FD3C    A2 0A       LDX #$0A       10 data
FD3E    A0 00       LDY #$00
FD40    50 FE       BVC $FD40      byte ready?
FD42    B8          CLV
FD43    AD 01 1C    LDA $1C01      read byte
FD46    D1 30       CMP ($30),Y    compare with data in buffer
FD48    D0 0E       BNE $FD58      not equal, error
FD4A    C8          INY
FD4B    CA          DEX
FD4C    D0 F2       BNE $FD40
FD4E    18          CLC
FD4F    A5 30       LDA $30
FD51    69 0A       ADC #$0A       increment pointer by 10
FD53    85 30       STA $30
FD55    4C 62 FD    JMP $FD62

FD58    CE 23 06    DEC $0623      decrement counter for attempts
FD5B    D0 CF       BNE $FD2C      not yet zero?
FD5D    A9 06       LDA #$06       else error
FD5F    4C D3 FD    JMP $FDD3      24, 'read error'

FD62    20 56 F5    JSR $F556      wait for SYNC
FD65    A0 BB       LDY #$BB
FD67    50 FE       BVC $FD67      byte ready?
FD69    B8          CLV
FD6A    AD 01 1C    LDA $1C01      read byte
FD6D    D9 00 01    CMP $0100,Y    compare with buffer contents
FD70    D0 E6       BNE $FD58      not equal, error
FD72    C8          INY
FD73    D0 F2       BNE $FD67      next byte
FD75    A2 FC       LDX #$FC
FD77    50 FE       BVC $FD77      byte ready?
FD79    B8          CLV
FD7A    AD 01 1C    LDA $1C01      read byte
FD7D    D9 00 05    CMP $0500,Y    compare with buffer contents
FD80    D0 D6       BNE $FD58      not equal, then error
FD82    C8          INY
FD83    CA          DEX            next byte
FD84    D0 F1       BNE $FD77
FD86    CE 28 06    DEC $0628      decrement sector counter
FD89    D0 AE       BNE $FD39      not yet zero?
FD8B    E6 51       INC $51        increment track number
FD8D    A5 51       LDA $51
FD8F    C9 24       CMP #$24       compare with 36, highest trk# +1
FD91    B0 03       BCS $FD96      greater, then formatting done
FD93    4C 9C F9    JMP $F99C      continue

FD96    A9 FF       LDA #$FF
FD98    85 51       STA $51        track number to $FF
FD9A    A9 00       LDA #$00
FD9C    85 50       STA $50
FD9E    A9 01       LDA #$01
FDA0    4C 69 F9    JMP $F969      ok
```

```
******************************     write $FF 10240 times
FDA3    AD 0C 1C    LDA $1C0C
FDA6    29 1F       AND #$1F        switch PCR to writing
FDA8    09 C0       ORA #$C0
FDAA    8D 0C 1C    STA $1C0C
FDAD    A9 FF       LDA #$FF
FDAF    8D 03 1C    STA $1C03       port A(read/write head) to output
FDB2    8D 01 1C    STA $1C01       write $FF to disk
FDB5    A2 28       LDX #$28        40
FDB7    A0 00       LDY #$00
FDB9    50 FE       BVC $FDB9       byte ready?
FDBB    B8          CLV
FDBC    88          DEY
FDBD    D0 FA       BNE $FD89
FDBF    CA          DEX
FDC0    D0 F7       BNE $FD89
FDC2    60          RTS

******************************     read/write ($621/$622) times
FDC3    AE 21 06    LDX $0621
FDC6    AC 22 06    LDY $0622
FDC9    50 FE       BVC $FDC9       byte ready?
FDCB    B8          CLV
FDCC    CA          DEX
FDCD    D0 FA       BNE $FDC9
FDCF    88          DEY
FDD0    10 F7       BPL $FDC9
FDD2    60          RTS

******************************     attempt counter for formatting
FDD3    CE 20 06    DEC $0620       decrement number of attempts
FDD6    F0 03       BEQ $FDDB       zero, then error
FDD8    4C 9C F9    JMP $F99C       continue

FDDB    A0 FF       LDY #$FF
FDDD    84 51       STY $51         flag for end of formatting
FDDF    C8          INY
FDE0    84 50       STY $50
FDE2    4C 69 F9    JMP $F969       error termination

******************************
FDE5    B9 00 03    LDA $0300,Y
FDE8    99 45 03    STA $0345,Y
FDEB    88          DEY             copy buffer contents
FDEC    D0 F7       BNE $FDE5
FDEE    AD 00 03    LDA $0300
FDF1    8D 45 03    STA $0345
FDF4    60          RTS

******************************
FDF5    A0 44       LDY #$44
FDF7    B9 BB 01    LDA $01BB,Y     $1BB to $1FF
FDFA    91 30       STA ($30),Y     write in buffer $30/$31
FDFC    88          DEY
FDFD    10 F8       BPL $FDF7
```

```
FDFF    60          RTS

******************************    switch to reading
FE00    AD 0C 1C    LDA $1C0C
FE03    09 E0       ORA #$E0      switch PCR to reading
FE05    8D 0C 1C    STA $1C0C
FE08    A9 00       LDA #$00
FE0A    8D 03 1C    STA $1C03     port A to input
FE0D    60          RTS

******************************    write $55 10240 times
FE0E    AD 0C 1C    LDA $1C0C
FE11    29 1F       AND #$1F
FE13    09 C0       ORA #$C0      switch PCR to writing
FE15    8D 0C 1C    STA $1C0C
FE18    A9 FF       LDA #$FF
FE1A    8D 03 1C    STA $1C03     port A to output (write head)
FE1D    A9 55       LDA #$55      %01010101
FE1F    8D 01 1C    STA $1C01     to port A (write head)
FE22    A2 28       LDX #$28
FE24    A0 00       LDY #$00
FE26    50 FE       BVC $FE26     byte ready for write electronics
FE28    B8          CLV
FE29    88          DEY
FE2A    D0 FA       BNE $FE26     10240 times
FE2C    CA          DEX
FE2D    D0 F7       BNE $FE26
FE2F    60          RTS

******************************
FE30    A9 00       LDA #$00
FE32    85 30       STA $30
FE34    85 2E       STA $2E
FE36    85 36       STA $36
FE38    A9 BB       LDA #$BB
FE3A    85 34       STA $34
FE3C    A5 31       LDA $31
FE3E    85 2F       STA $2F
FE40    A9 01       LDA #$01
FE42    85 31       STA $31
FE44    A4 36       LDY $36
FE46    B1 2E       LDA ($2E),Y
FE48    85 52       STA $52
FE4A    C8          INY
FE4B    B1 2E       LDA ($2E),Y
FE4D    85 53       STA $53
FE4F    C8          INY
FE50    B1 2E       LDA ($2E),Y
FE52    85 54       STA $54
FE54    C8          INY
FE55    B1 2E       LDA ($2E),Y
FE57    85 55       STA $55
FE59    C8          INY
FE5A    F0 08       BEQ $FE64
FE5C    84 36       STY $36
```

```
FE5E   02 D0 F6   JSR $F6D0
FE61   4C 44 FE

FE64   4C D0 F6   JMP $F6D0

******************************  interrupt routine
FE67   48         PHA
FE68   8A         TXA
FE69   48         PHA             save registera
FE6A   98         TYA
FE6B   48         PHA
FE6C   AD 0D 18   LDA $180D       interrupt from serial bus
FE6F   29 02      AND #$02
FE71   F0 03      BEQ $FE76       no
FE73   20 53 E8   JSR $E853       serve serial bus
FE76   AD 0D 1C   LDA $1C0D       interrupt from timer 1?
FE79   0A         ASL A
FE7A   10 03      BPL $FE7F       no
FE7C   20 B0 F2   JSR $F2B0       IRQ routine for disk controller
FE7F   68         PLA
FE80   A8         TAY
FE81   68         PLA             get register back
FE82   AA         TAX
FE83   68         PLA
FE84   40         RTI

******************************  constants for disk format
FE85 12                           18, track for BAM and directory
FE86 04                           start of BAM at position 4
FE87 04                           4 bytes in BAM for each track
FE88 90                           $90 = 144, end of BAM, disk name

******************************  table of command words
FE89 56 49 44 4D 42 55            'V', 'I', 'D', 'M', 'B', 'U'
FE8F 50 26 43 52 53 4E            'P', '&', 'C', 'R', 'S', 'N'

******************************  lo-bytes of command addresses
FE95 84 05 C1 F8 1B 5C
FE9F 07 A3 F0 88 23 0D

******************************  hi-bytes of command addresses
FEA1 ED D0 C8 CA CC CB
FEA7 E2 E7 C8 CA C8 EE

******************************
FEAD 51 DD 1C 9E 1C               bytes for syntax check

******************************  file control methods
FEB2 52 57 41 4D                  'R', 'W', 'A', 'M'

******************************  file types
FEB6 44 53 50 55 4C               'D', 'S', 'P', 'U', 'L'

******************************  names of file types
FEBB 44 53 50 55 52          1st letters 'D', 'S', 'P', 'U', 'R'
```

```
FEC0 45 45 52 53 45         2nd letters 'E', 'E', 'R', 'S', 'E'
FEC5 4C 51 47 52 4C         3rd letters 'L', 'Q', 'G', 'R', 'L'

********************************
FECA 08 00 00

********************************
FECD 3F 7F BF FF                 masks for bit command

********************************  number of sectors per track
FED1 11 12 13 15                 17, 18, 19, 21

********************************  contants for disk format
FED5 4A                          'A' marker for 1541 format
FED6 04                          4 track numbers
FED7 24                          36, highest track number + 1
FED8 1F 19 12                    31, 25, 18 tracks with change of
                                 number of sectors

********************************
FEDB 01 FF FF 01 00              control bytes for head position

********************************  addresses of buffers
FEE0 03 04 05 06 07              high bytes

********************************
FEE5 07 0E

********************************  for UI command
FEE7   6C 65 00   JMP ($0065)

********************************  for diagnostic routine
FEEA   8D 00 1C   STA $1C00      turn LED on
FEED   8D 02 1C   STA $1C02      port to output
FEF0   4C 7D EA   JMP $EA7D      back to diagnostic routine

********************************  delay loop for serial bus
FEF3   8A         TXA
FEF4   A2 05      LDX #$05
FEF6   CA         DEX            about 40 microseconds
FEF7   D0 FD      BNE $FEF6
FEF9   AA         TAX
FEFA   60         RTS

********************************  data output to serial bus
FEFB   20 AE E9   JSR $E9AE      CLOCK OUT hi
FEFE   4C 9C E9   JMP $E99C      DATA OUT lo

********************************  UI vector
FF01   AD 02 02   LDA $0202
FF04   C9 2D      CMP #$2D       '-'
FF06   F0 05      BEQ $FF0D
FF08   38         SEC
FF09   E9 2B      SBC #$2B       '+'
FF0B   D0 DA      BNE $FEE7      indirect jump over ($65)
```

```
FF0D   85 23       STA $23
FF0F   60          RTS

******************************
FF10 AA ...
FFE1 ... AA

******************************
FFE2 52 53 52 AA
FFE6 C6 C8 8F F9

******************************  USER vectors
FFEA 5F CD                      UA, U1, $CD5F
FFEC 97 CD                      UB, U2, $CD97
FFEE 00 05                      UC, U3, $0500
FFF0 03 05                      UD, U4, $0503
FFF2 06 05                      UE, U5, $0506
FFF4 09 05                      UF, U6, $0509
FFF6 0C 05                      UG, U7, $050C
FFF8 0F 05                      UH, U8, $050F
FFFA 01 FF                      UI, U9, $FF01
                            (NMI vector not used)

******************************  hardware vectors
FFFC 0A EA                      $EAA0   RESET and UJ (U:) vector
FFFE 67 FE                      $FE67   IRQ vector
```

Chapter 4: Programs and Tips for the 1541 Disk Drive

4.1 Utility Programs

4.1.1 Displaying all File Parameters

The directory contains several important pieces of information about each file. Some information is not kept in the directory, such as the starting address of a program.

These and other file parameters can be easily found and displayed by the following program. The number and kind of file parameters are naturally dependent on the file type. A relative file, for instance, has no starting address. The following table presents the parameters displayed by this program.

PARAMETER	FILE TYPE				
	DEL	SEQ	PRG	USR	REL
File closed?	X	X	X	X	X
File protected?	X	X	X	X	X
Allocated blocks	X	X	X	X	X
Side-sector blocks					X
Data blocks					X
Records					X
Start address			X		
Free blocks, disk	X	X	X	X	X
Allocated bl. disk	X	X	X	X	X

This program is documented in detail so that the serious programmer can get a good overview of the file parameters. In addition, the variables used by the program are explained.

Variables used in the program:

Numerical Variables

T - Track of the actual block of the file entry in the directory
S - Sector of the actual block of the file entry in the directory
FL - Flag, set if the file name read from the diskette does not agree with the searched-for file
TY - File type of the given file (byte 0 of the entry)

FT - nybble of the file type (bits 0-3), contains the actual file type
LB - Low byte of the starting address
HB - High byte of the starting address
BL - Number of allocated blocks in the file
RL - Record length of a relative file
DT - Track of the first data block of a program file, which contains the starting address
DS - Sector of the first data block of a program file
SA - Starting address of a program file
BF - Number of free blocks on a disk
BA - Number of allocated blocks on a disk
BS - Number of side-sector blocks in a relative file
RC - Number of records in a relative file

String Variables

F$ - Name of the file to search for
FF$- Contains the actual file name from the directory
FT$- File type
CL$- Indicates whether the file is closed or not (contains "YES" or "NO")
PR$- Indicates whether the file is protected or not (contains "YES" or "NO")
RE$- contains CHR$(18), REVERSE ON
RA$- contains CHR$(146), REVERSE OFF

Program Documentation:

110 Set the color code of the screen
120 - 200 Program heading
210 - 230 Asks if the names should be listed out. Sets flag FL to 1 and executes the routine at 280-490.
250 - 270 Input the filename. Asks for new input if the filename if greater than 16 characters.
280 - 490 Reads the file name from the directory and either displays it (FL=1) or compares it to the desired filename.
500 - 530 Reads byte 0 (file type) of the file entry of the desired file and stores it in TY. Also, the right half-byte is stored in FT.
540 - 590 Checks the file type and saves the text in FT$, and checks for invalid file type.
600 - 610 Checks bit 7 of the file type byte (file closed?) and saves the result in CL$.
620 - 630 Checks bit 6 of the file type byte (file protected?) and saves the result in PR$.
640 - 690 Reads the number of allocated blocks in the file from bytes 28 and 29 of the file entry and saves it in BL.

700 - 730 If it is relative file, the record length is read from byte 21 and saved in RL
740 - 880 If it is a program file, the starting address of the file is taken from the first data block and stored in SA.
890 - 980 Free blocks on the disk are calculated by reading the first byte of the track-marked BAM section and added to BF. The allocated blocks are calculated by BA = 664 - BF
990 -1020 Here the number of side-sector blocks (BS) of a relative file is calculated with the help of the record length (RL) and the number of allocated blocks in the file (RC).
1040-1230 Here the data can be sent to the screen or the printer as one chooses. The file parameters are shown in REVERSE.
1240-1280 The parameters of another file can be output.

The program is written for a CBM 64. In spite of this, it can be run without major changes on a VIC 20. Only line 110, where the color of the screen is set, need be changed for the VIC 20.

BASIC Listing of the Program:

```
100 CLR
110 POKE 53280,2:POKE53281,2:PRINTCHR$(158);CHR$(147);
120 PRINT TAB(6);"==========================="
130 PRINT TAB(6);"DISPLAY ALL FILE PARAMETERS"
140 PRINT TAB(6);"==========================="
150 PRINT:PRINT
160 PRINT"WITH THIS PROGRAM, ALL PARAMETERS OF A"
170 PRINT"FILE CAN BE OUTPUT TO THE SCREEN OR TO"
180 PRINT"A PRINTER AT YOUR OPTION."
200 PRINT:PRINT
210 PRINT"LIST FILENAMES (Y/N)?"
220 GETX$:IFX$<>"Y"ANDX$<>"N"THEN220
230 IF X$="Y"THENFL=1:GOSUB280
240 FL=0
250 INPUT"NAME OF THE FILE: ";F$
260 IFLEN(F$)<=16THEN280
270 PRINT"FILENAME TOO LONG!":GOTO250
280 OPEN 15,8,15,"I0":OPEN2,8,2,"#"
290 T=18:S=1
300 PRINT#15,"B-R";2;0;T;S
310 PRINT#15,"B-P";2;0
320 GET#2,X$:IFX$=""THENX$=CHR$(0)
325 T=ASC(X$)
330 GETX$:IFX$=""THENX$=CHR$(0)
340 S=ASC(X$)
350 FORX=0TO7
360 PRINT#15,"B-P";2;X*32+5
370 FF$=""
380 FORY=0TO15
390 GET#2,X$:IFX$=""THENX$=CHR$(0)
```

```
400 IF ASC(X$)=160THEN430
410 FF$=FF$+X$
420 NEXT Y
430 IFF$=FF$THEN490
440 IFFLTHENPRINTFF$
450 NEXT X
460 IF T=0 THEN 480
470 GOTO 300
480 CLOSE2:CLOSE15
485 IFFL=0THENPRINT"FILENAME NOT FOUND!":GOTO210
490 IFFLTHENRETURN
500 PRINT#15,"B-P";2;X*32+2
510 GET#2,X$:IFX$=""THENX$=CHR$(0)
520 TY=ASC(X$)
530 FT=TYAND15
540 IFFT=0THENFT$="DELETED"
550 IFFT=1THENFT$="SEQUENTIAL"
560 IFFT=2THENFT$="PROGRAM"
570 IFFT=3THENFT$="USER"
580 IFFT=4THENFT$="RELATIVE"
590 IFFT>4THENPRINT"INVALID FILE TYPE!":GOTO200
600 IFTYAND128THENCL$="YES":GOTO620
610 CL$="NO"
620 IFTYAND64THENPR$="YES":GOTO640
630 PR$="NO"
640 PRINT#15,"B-P";2;X*32+30
650 GET#2,X$:IFX$=""THENX$=CHR$(0)
660 LB=ASC(X$)
670 GET#2,X$:IFX$=""THENX$=CHR$(0)
680 HB=ASC(X$)*256
690 BL=LB+HB
700 IFFT<>4THEN740
710 PRINT#15,"B-P";2;X*32+23
720 GET#2,X$:IFX$=""THENX$=CHR$(0)
730 RL=ASC(X$)
740 IFFT<>2THEN890
750 PRINT#15,"B-P";2;X*32+3
760 GET#2,X$:IFX$=""THENX$=CHR$(0)
770 DT=ASC(X$)
780 GET#2,X$:IFX$=""THENX$=CHR$(0)
790 DS=ASC(X$)
800 OPEN3,8,3,"#"
810 PRINT#15,"B-R";3;0;DT;DS
820 PRINT#15,"B-P";3;2
830 GET#3,X$:IFX$=""THENX$=CHR$(0)
840 LB=ASC(X$)
850 GET#3,X$:IFX$=""THENX$=CHR$(0)
860 HB=ASC(X$)*256
870 SA=LB+HB
880 CLOSE3
890 PRINT#15,"B-R";2;0;18;0
900 BF=0
910 FORI=4TO140STEP4
920 IFI=72THEN960
930 PRINT#15,"B-P";2;I
```

```
940 GET#2,X$:IFX$=""THENX$=CHR$(0)
950 BF=ASC(X$)+BF
960 NEXT
980 BA=664-BF
990 IFFT<>4THEN1040
1010 BS=BL/121:IFBS<>INT(BS)THENBS=INT(BS+1)
1020 RC=INT(((BL-BS)*254)/RL)
1040 PRINTCHR$(147);"SCREEN OR PRINTER (S/P)?"
1050 GETX$:IFX$<>"S"ANDX$<>"P"THEN1050
1060 RE$=CHR$(18):RA$=CHR$(146)
1070 IFX$="S"THENOPEN1,3:PRINT#1,CHR$(147)
1080 IFX$="P"THENOPEN1,4
1090 PRINT#1,"FILE PARAMETERS       ";RE$;F$;RO$
1100 PRINT#1,"-----------------------------------"
1110 PRINT#1,"FILE TYPE:            ";RE$;FT$;RA$:PRINT#1
1120 PRINT#1,"FILE CLOSED:          ";RE$;CL$;RA$:PRINT#1
1130 PRINT#1,"FILE PROTECTED:       ";RE$;PR$;RA$:PRINT#1
1140 PRINT#1,"ALLOCATED BLOCKS:     ";RE$;BL;RA$:PRINT#1
1150 IFFT<>4THEN1200
1160 PRINT#1,"RECORD LENGTH:        ";RE$;RL;RA$:PRINT#1
1170 PRINT#1,"SIDE-SECTOR BLOCKS:   ";RE$;BS;RA$:PRINT#1
1180 PRINT#1,"DATA BLOCKS:          ";RE$;BL-BS;RA$:PRINT#1
1190 PRINT#1,"RECORDS:              ";RE$;RC;RA$:PRINT#1
1200 IFFT=2THENPRINT#1,"START ADDRESS:                     ";
     RE$;SA;RA$:PRINT#1
1210 PRINT#1,"FREE BLOCKS (DISK):   ";RE$;BF;RA$:PRINT#1
1220 PRINT#1,"ALLOCATED BLOCKS (D):";RE$;BA;RA$:PRINT#1
1230 CLOSE1
1240 PRINT"MORE (Y/N)?"
1250 CLOSE2:CLOSE15
1260 GETX$:IFX$<>"Y"ANDX$<>"N"THEN1260
1270 IFX$="Y"THEN100
```

4.1.2 Scratch-protect Files – File Protect

As already mentioned, it is possible to protect files on the VIC-1541 diskette and save this information in the directory. A file's type is contained in byte 0 of the file entry. Bit 6 denotes a protected file. If this bit is set to 1, the file can no longer be deleted with the **SCRATCH** command. But because the DOS has no command to set this bit an alternative way must be used to protect a file.

With the following program, you can:

* display all files on the disk
* protect files
* unprotect files
* erase files

This program can delete protected files as well as unprotected files. If you wish to delete a protected file, you must confirm it. This program is also documented with a variable usage and descriptions so that you can use these techniques in your own programs.

List of Variables:

DF	-	Flag, set in the routine "read/search file" if the desired filename is found
FL	-	Set if the routine "read/search file" is only to be used for listing files
FT	-	Variable for storing the filetype
T	-	Track of the actual block of the file entry
S	-	Sector of the actual block of the file entry
TT	-	Track, in which the file entry block of the desired file is found
SS	-	Sector, in which the file entry block of the desired file is found
FF$	-	last filename read from the directory
F$	-	filename to search for

Program Documentation:

100			Set the screen color
110	-	230	Program header and option menu
240	-	260	Read the menu choice and call the appropriate subroutine
270			Back to the option menu
280	-	350	Subprogram "list all files"
		310	Erase screen
		320	Set flag FL to list files in the subroutine "read/search file"
		350	Reset the flag and jump back
360	-	600	Subroutine "protect file"
		390	Call subroutine "input filename"
		400	Call the subroutine "read/search file"
410	-	450	Test if the file is found
460	-	480	Read file type and store in FT
490	-	500	Test if the file is already protected
		510	Protect file (bit 6 to 1)
520	-	550	Transfer the file type to the buffer and write the block to disk
		560	Close the channel
570	-	600	Message "File protected" and jump back
610	-	850	Subroutine "unprotect file"
		640	Call subroutine "input filename"
		650	Call subroutine "read/search file"
660	-	700	Test if file is found
710	-	730	Read file type and store in FT
740	-	750	Test if the file is already unprotected
		760	Unprotect the file (bit 6 to 0)
770	-	800	Transfer the file type to the buffer and write the block to the disk
		810	Close the file
820	-	850	End the subroutine

860 -1170 Subroutine "erase a file"
890 Call the subroutine "input filename"
900 Call the subroutine "read/search file"
910 - 950 Test if the file is found
960 - 980 Read the file type and save in FT
990 Test if the file is protected
1000-1030 Indicate that the file is protected, with the possibility to erase it anyway
1040-1060 Ask if the file should really be erased
1070 Bit 6 set back, if protected
1080-1110 Transfer the file type to the buffer and write the block to the disk
1120 Initialize the diskette
1130 Erase the file
1140-1170 End the subroutine
1190-1560 Subroutine "read/search file"
1220 Open the command and data channels
1230-1240 Read directory and set buffer pointer
1250-1320 Test if the disk contains a write protect. For this purpose, the directory is written back to the disk unchanged (line 1250). If the disk has a write protect tab on it, the error message 26, WRITE PROTECT ON will occur.
1330 Initial values for the track and sector variables are set
1340-1350 Read the file entry block and position the buffer pointer to the first byte
1360-1390 Read the address of the next file entry block
1400-1530 Loop to read filenames. The names are then either listed on the screen or compared to the desired filename, based on the value of flag FL
1540-1560 If the variable T (track) contains zero, no more file entry blocks follow and the subroutine ends.

BASIC Listing of the Program:

```
100 POKE 53280,2:POKE53281,2:PRINTCHR$(158);CHR$(147);
110 PRINTTAB(8);"======================="
120 PRINTTAB(8);"ERASE AND PROTECT FILES"
130 PRINTTAB(8);"======================="
140 PRINT:PRINT
150 PRINT"WITH THIS PROGRAM, FILES CAN BE"
160 PRINT"PROTECTED, ERASED, AND UNPROTECTED"
180 PRINT:PRINT
190 PRINTTAB(6);" -1- LIST ALL FILES":PRINT
200 PRINTTAB(6);" -2- PROTECT A FILE":PRINT
210 PRINTTAB(6);" -3- UNPROTECT A FILE":PRINT
220 PRINTTAB(6);" -4- ERASE A FILE":PRINT
230 PRINTTAB(6);" -5- END THE PROGRAM":PRINT
240 GETX$:IFX$=""ORVAL(X$)<1ORVAL(X$)>5THEN240
250 IFVAL(X$)=5THENEND
260 ONVAL(X$)GOSUB280,360,610,860
270 GOTO 100
280 REM -------------
290 REM LIST ALL FILES
```

```
300 REM --------------
310 PRINTCHR$(147)
320 FL=1:GOSUB1190
330 PRINT:PRINT"RETURN FOR MORE"
340 INPUTX$
350 FL=0:RETURN
360 REM --------------
370 REM PROTECT A FILE
380 REM --------------
390 GOSUB1580
400 GOSUB1190
410 IFDF=1THEN460
420 PRINT"FILE NOT FOUND!":PRINT
430 PRINT"RETURN FOR MORE"
440 INPUTX$:CLOSE2:CLOSE15
450 RETURN
460 PRINT#15,"B-P";2;X*32+2
470 GET#2,X$:IFX$=""THENX$=CHR$(0)
480 FT=ASC(X$)
490 IF(FT AND 64)=0 THEN 510
500 PRINT"FILE IS ALREADY PROTECTED!":PRINT:GOTO430
510 FT=(FT OR 64)
520 PRINT#15,"B-P";2;X*32+2
530 PRINT#2,CHR$(FT);
540 PRINT#15,"B-P";2;0
550 PRINT#15,"U2";2;0;TT;SS
560 CLOSE2:CLOSE15
570 PRINT"FILE PROTECTED."
580 PRINT"RETURN FOR MORE"
590 INPUTX$
600 CLOSE2:CLOSE15:RETURN
610 REM ----------------
620 REM UNPROTECT A FILE
630 REM ----------------
640 GOSUB1580
650 GOSUB1190
660 IFDF=1THEN710
670 PRINT"FILE NOT FOUND!":PRINT
680 PRINT"RETURN FOR MORE"
690 INPUTX$:CLOSE2:CLOSE15
700 RETURN
710 PRINT#15,"B-P";2;X*32+2
720 GET#2,X$:IFX$=""THENX$=CHR$(0)
730 FT=ASC(X$)
740 IF (FT AND 64)=64THEN760
750 PRINT"FILE IS ALREADY UNPROTECTED!":PRINT:GOTO680
760 FT=(FTAND255-64)
770 PRINT#15,"B-P";2;X*32+2
780 PRINT#2,CHR$(FT);
790 PRINT#15,"B-P";2;0
800 PRINT#15,"U2";2;0;TT;SS
810 CLOSE2:CLOSE15
820 PRINT"FILE UNPROTECTED."
830 PRINT"RETURN FOR MORE"
840 INPUTX$
```

```
850 RETURN
860 REM ------------
870 REM ERASE A FILE
880 REM ------------
890 GOSUB1580
900 GOSUB1190
910 IFDF=1THEN960
920 PRINT"FILE NOT FOUND!":PRINT
930 PRINT"RETURN FOR MORE"
940 INPUTX$:CLOSE2:CLOSE15
950 RETURN
960 PRINT#15,"B-P";2;X*32+2
970 GET#2,X$:IFX$=""THENX$=CHR$(0)
980 FT=ASC(X$)
990 IF(FT AND 64)=0THEN1040
1000 PRINT"WARNING! FILE IS PROTECTED!"
1010 PRINT"UNPROTECT AND ERASE (Y/N)?"
1020 GETX$:IFX$<>"Y"ANDX$<>"N"THEN1020
1030 IFX$="N"THEN1170
1040 PRINT"ARE YOU SURE (Y/N)?"
1050 GETX$:IFX$<>"Y"ANDX$<>"N"THEN1050
1060 IFX$="N"THEN1170
1070 FT=(FT AND 255-64)
1080 PRINT#15,"B-P";2;X*32+2
1090 PRINT#2,CHR$(FT);
1100 PRINT#15,"B-P";2;0
1110 PRINT#15,"U2";2;0;TT;SS
1120 PRINT#15,"I0"
1130 PRINT#15,"S:"+F$
1140 PRINT"FILE ERASED."
1150 PRINT"RETURN FOR MORE"
1160 INPUTX$
1170 CLOSE2:CLOSE15:RETURN
1180 REM
1190 REM ------------------
1200 REM READ / SEARCH FILE
1210 REM ------------------
1220 OPEN15,8,15,"I0":OPEN2,8,2,"#"
1230 PRINT#15,"B-R";2;0;18;0
1240 PRINT#15,"B-P";2;0
1250 PRINT#15,"U2";2;0;18;0
1260 INPUT#15,X1$
1270 IF VAL(X1$)<>26 THEN 1330
1280 PRINT"PLEASE REMOVE THE WRITE PROTECT TAB FROM"
1290 PRINT"THE DISKETTE BEFORE USING THIS PROGRAM."
1300 PRINT"RETURN FOR MORE"
1310 INPUTX$
1320 CLOSE2:CLOSE15:RETURN
1330 T=18:S=1:TT=18:SS=1
1340 PRINT#15,"B-R";2;0;T;S
1345 TT=T:SS=S
1350 PRINT#15,"B-P";2;0
1360 GET#2,X$:IFX$=""THENX$=CHR$(0)
1370 T=ASC(X$)
1380 GET#2,X$:IFX$=""THENX$=CHR$(0)
```

```
1390 S=ASC(X$)
1400 FORX=0TO7
1410 PRINT#15,"B-P";2;X*32+2
1420 GET#2,X$:IFX$=""THENX$=CHR$(0)
1430 IFASC(X$)=0THEN1530
1440 PRINT#15,"B-P";2;X*32+5
1450 FF$=""
1460 FORY=0TO15
1470 GET#2,X$:IFX$=""THENX$=CHR$(0)
1480 IFASC(X$)=160THEN1500
1490 FF$=FF$+X$
1500 NEXTY
1510 IFFLTHENPRINTFF$:GOTO1530
1520 IFF$=FF$THENDF=1:GOTO1570
1530 NEXTX
1540 IFT<>0THEN1340
1550 CLOSE2:CLOSE15
1560 IFFL=0THENPRINT"FILENAME NOT FOUND!":FORI=1TO2000:
     NEXT
1570 RETURN
1580 REM --------------
1590 REM INPUT FILENAME
1600 REM --------------
1610 PRINT:PRINT
1620 INPUT"FILENAME:";F$
1630 IFLEN(F$)<=16THEN1650
1640 PRINT"FILENAME TOO LONG!":GOTO1620
1650 DF=0:FL=0
1660 RETURN
```

This utility program was written for the CBM 64. This version can also be run on the VIC 20. Only line 100 which sets the screen color on the CBM 64 need be changed or ignored. If you value perfect video output, lines 110-230 can also be changed to accommodate the VIC 20's smaller screen size.

4.1.3 Backup Program - Copying a Diskette

The VIC 1541 disk drive does not allow disks to be duplicated since it is a single drive, as the double drives permit with the **COPY** or **BACKUP** commands of BASIC 4.0. With the 1541, each program to be copied must be transferred through the computer.

Here's an example of how you might copy a diskette using a single disk drive:

First, the BAM as well as the names and IDs of the disk to be copied are read into the computer. From the information in the BAM, you can determine which blocks of the original diskette are used. In order to save time, only the allocated blocks are copied. Then a direct access file is opened and the first 169 (as many as will fit in the memory of the Commodore 64) allocated blocks are read. Then the user is asked to put a new diskette in the drive. The new diskette is then formatted with the name and ID of the original diskette. Now the previously read blocks are written to the diskette. The next 169 blocks of the original diskette are read into memory and written out to the destination diskette. This ends after four disk swaps, at which time the entire diskette will have been copied.

The program is written in BASIC except for the portion which reads and writes the direct access file. This part is written in machine language which is considerably faster than a GET# loop in BASIC. Because of the nature of the program, the number of diskette changes is dependent on the free storage in the computer. A VIC 20 with a 16K expansion requires 11 changes of original and destination diskettes.

Here is a time comparison between this program and duplication on a double drive with the same capacity. Our program requires about 20 minutes, while the CBM 4040 does it in about 3 minutes.

Duplicating a diskette with this program is quite simple. You need only follow the messages on the screen to insert the original or destination diskette. The program does the rest for you.

```
100 REM  BACKUP PROGRAM C64 - VIC 1541
110 REM
120 POKE56,23:CLR:GOSUB640
130 OPEN1,8,15
140 DIM B%(35,23),S%(35),Z(7),A$(1)
150 A$(0)="DESTINATION":A$(1)="ORIGINAL":R=1
160 AD=23*256:GOSUB590
170 POKE250,0:POKE251,AD/256
180 GOSUB530:GOSUB290
190 PRINTNS"BLOCKS TO COPY":PRINT
200 T=1:S=0
210 FORI=1TO4:TT=T:SS=S:R=1:IFI=1THEN240
220 IFR=0ANDI=1THENGOSUB450:GOTO240
230 GOSUB590
240 POKE251,AD/256:FORJ=1TO169
250 IFB%(T,S)=0THENGOSUB570
260 S=S+1:IFS=S%(T)THENT=T+1:S=0:IFT=36THENJ=169
270 NEXT:IFRTHENR=0:T=TT:S=SS:GOTO220
280 NEXT:GOTO510
290 T=18:S=0:GOSUB570
300 NS=0:FORT=1TO35:S=0
310 NS=NS+S%(T)-PEEK(AD+4*T)
320 FORJ=1TO3
330 B=PEEK(AD+4*T+J)
340 FORI=0TO7
```

```
340 FORI=0TO7
350 B%(T,S)=B AND Z(I):S=S+1
360 NEXT I,J
370 FOR S=S%(T)TO23
380 B%(T,S)=-1 : NEXT S,T
390 FOR I=0TO15
400 A=PEEK(AD+144+I)
410 IFA<>160THENN$=N$+CHR$(A)
420 NEXT
430 I$=CHR$(PEEK(AD+162))+CHR$(PEEK(AD+163))
440 PRINTN$,I$:RETURN
450 PRINT"PLEASE INSERT NEW DISKETTE"
460 PRINT"AND PRESS RETURN":PRINT:POKE198,0:CLOSE2
470 GETA$:IFA$<>CHR$(13)THEN470
480 PRINT#1,"N0:"N$","I$
490 INPUT#1,A,B$,C,D:IFATHENPRINTA","B$","C","D:END
500 GOTO630
510 CLOSE2:CLOSE1:END
520 REM SECTORS PER TRACK
530 FORT=1TO35
540 S%(T)=21:IFT>17THENS%(T)=19:IFT>24THENS%(T)=18:
    IFT>30THENS%(T)=17
550 NEXT
560 FORI=0TO7:Z(I)=2↑I:NEXT:RETURN
570 IFRTHENPRINT#1,"U1 2 0"T;S:SYSIN:RETURN
580 PRINT#1,"B-P 2 0":SYSOUT:PRINT#1,"U2 2 0"T;S:RETURN
590 CLOSE2:PRINT"PLEASE INSERT "A$(R)" DISKETTE."
600 PRINT"AND PRESS RETURN":PRINT:POKE198,0
610 GETA$:IFA$<>CHR$(13)THEN610
620 PRINT#1,"I0"
630 OPEN2,8,2,"#":RETURN
640 FOR I = 828 TO 873 : REM READ MACHINE LANG. PROGRAM
650 READ X : POKE I,X : S=S+X : NEXT
660 DATA 162,  2, 32,198,255,160,  0, 32,207,255,145,250
670 DATA 200,208,248,230,251, 32,204,255, 96,198,  1,162
680 DATA   2, 32,201,255,160,  0,177,250, 32,210,255,200
690 DATA 208,248,230,251, 32,204,255,230,  1, 96
700 IF S<>7312 THEN PRINT "ERROR IN DATA!!":END
710 IN=828:OUT=849:RETURN
```

4.1.4 Copying Individual Files to another Diskette

The following program permits you to copy individual files from one diskette to another. The files can be programs (PRG), sequential files (SEQ) or user files (USR). Relative files cannot be copied with this program; these can be copied with a BASIC program that reads all data records into a string array and then writes them back again into a new file.

In the first pass, the program reads the complete file into the memory of the Commodore 64. Then the destination

Next the complete file is written on the second disk. The computer has 49 Kbytes for data storage; you can handle up to 196 blocks on the diskette.

For reasons of speed, the reading and writing of the data is performed by a machine language program, which is stored in DATA statements.

The program is suited for copying sequential files as already mentioned, as well as programs of all kinds; the start address (of a machine language program) is not relevant.

```
100 REM  FILE COPIER PROGRAM  C64
110 REM
120 POKE 56,12 : CLR
130 GOSUB 1000
140 INPUT"FILENAME  ";N$
150 PRINT"FILE TYPE ";
160 GETT$:IFT$<>"S"ANDT$<>"P"ANDT$<>"U"THEN160
170 PRINTT$:PRINT
180 PRINT"PLEASE INSERT ORIGINAL DISK"
190 PRINT"AND PRESS A KEY":PRINT
200 GETA$:IFA$=""THEN200
210 OPEN 2,8,2,N$+","+T$
220 POKE 3,0:POKE 4,12:SYS 866
230 CLOSE 2
240 PRINT"PLEASE INSERT DESTINATION DISK"
250 PRINT"AND PRESS A KEY":PRINT
260 GETA$:IFA$=""THEN260
270 OPEN 2,8,2,N$+","+T$+",W"
280 POKE 3,0:POKE 4,12:SYS 828
290 CLOSE 2 : END
1000 FOR I = 828 TO 898
1010 READ X : POKE I,X : S=S+X : NEXT
1020 DATA 162,  2, 32,201,255,198,  1,160,  0, 56,165,  3
1030 DATA 229,  5,165,  4,229,  6,176, 13,177,  3, 32,210
1040 DATA 255,230,  3,208,236,230,  4,208,232,230,  1, 76
1050 DATA 204,255,162,  2, 32,198,255,160,  0, 32,207,255
1060 DATA 145,  3,230,  3,208,  2,230,  4, 36,144, 80,241
1070 DATA 165,  3,133,  5,165,  4,133,  6, 76,204,255
1080 IF S<>8634 THEN PRINT "ERROR IN DATA !!":END
1090 RETURN
```

4.1.5 Reading the directory from within a program

Sometimes applications programs store user data in a file under a desired name. If you want to use this file again, but you cannot remember the file name, then you have a problem. If this happens, you must exit the program, search for the name in the directory, reload the program and start again. To avoid this, you can include a directory listing routine in your program. If you forget the filename, you can display the directory with a function key, for example, without the need to leave the program. Here is a sample of such a routine:

```
100 PRINTCHR$(147);
110 OPEN15,8,15,"I0":OPEN2,8,2,"#"
120 T=18:S=1
130 PRINT#15,"B-R";2;0;T;S
140 PRINT#15,"B-P";2;0
150 GET#2,X$:IFX$=""THENX$=CHR$(0)
160 T=ASC(X$)
170 GET#2,X$:IFX$=""THENX$=CHR$(0)
180 S=ASC(X$)
190 FORX=0TO7
200 PRINT#15,"B-P";2;X*32+5
210 FF$=""
220 FORY=0TO15
230 GET#2,X$:IFX$=""THENX$=CHR$(0)
240 IFASC(X$)=160THEN270
250 FF$=FF$+X$
260 NEXTY
270 IFA=0THENA=1:PRINTFF$;:GOTO290
280 A=0:PRINTTAB(20);FF$
290 NEXTX
300 IFT<>0THEN130
310 CLOSE1:CLOSE2
320 PRINT"RETURN FOR MORE"
330 INPUTX$
340 END:REM  IF SUBROUTINE, THEN RETURN HERE
```

In order to select the filename, the directory is printed on the screen. Should this program be used as a subroutine (called with GOSUB) line 340 must contain RETURN instead of END.

We used this routine in the utility programs in sections 4.1.1 and 4.1.2.

4.2 The Utility Programs on the TEST/DEMO Disk

There are many 1541 owners that know little about the programs contained on the Test/Demo disk. The main reason is that these programs are largely undocumented. The following descriptions of these programs should help you:

4.2.1 DOS 5.1

The DOS 5.1 simplifies the operation of the VIC-1541 DOS. It can run on the VIC-20 or Commodore 64. To load DOS 5.1 on the VIC-20, give the commands

```
LOAD"VIC-20 WEDGE",8
RUN
```

This is the loader for DOS 5.1 for the VIC 20.

If you want to use it on the Commodore 64, give the commands:

```
LOAD"C-64 WEDGE",8
RUN
```

This loads DOS 5.1 into the CBM 64.

What does this DOS 5.1 offer? It allows you to send convenient commands to the 1541 disk drive. If, for example, you want to display the directory on the screen, you use the DOS 5.1 command @$ or >$. This does not erase the program in memory.

The individual commands of the DOS 5.1

Command	Function
@$ or >$	Display the directory
@V or >V	Same function as "VALIDATE"
@C:... or >C:...	Copy files (COPY)
©file or /file	Load program
@ or >	Read and display error message
@N:... or >N:...	Format a diskette
@I or >I	Intitialize the disk
@R:... or >R:...	Rename a file (RENAME)
@S:... or >S:...	Erase a file (SCRATCH)
@#n or >#n	Change disk device to n

4.2.2 COPY/ALL

With the program **COPY/ALL** files can be copied between disk drives with different addresses. A drive must be changed from device address 8 with the program **DISK ADDR CHANGE** before this can occur. After starting the program, the message:

```
disk copy all           jim butterfield

from unit? 8
```

appears on the screen. Here you give the device address of the disk drive from which you wish to get the files. If this address is 8, just press RETURN. After this you give the corresponding drive number of this unit (always 0 for single drives). In this manner you also give the device address of the destination drive. Once this has occurred, the program asks

```
want to new the output disk
?n
```

You are being asked if the destination diskette should be formatted. You answer with 'y' (yes) or 'n' (no).
Then you can choose the files you want to copy with the wildcard (*). If all files are supposed to be copied, just give the asterisk.
Now the program gives the message

```
hold down 'y' or 'n' key to select
```

The program displays the files on the original disk, which you can select with the 'y' key (yes) or 'n' (no). The files by which you pressed 'y' will be copied.
If, during the copying process, asterisks (***) appear behind the files, it means that an error has occurred.
If there is not enough room on the destination disk, "*** output disk full" and "do you have a new one" appears. The remaining files can be put on another formatted diskette. To do this, answer 'y' when ready.

At the the conclusion of the copying process, the number of free blocks on the destination disk is displayed.

4.1.3 DISK ADDR CHANGE

With this program, the device address of a disk drive can be changed through software. After starting the program, turn all drives off except for the one you wish to change. Now enter the old and new device addresses.

After this, the address is changed and the other drive can be turned back on.

The following drives can be changed with this program:

```
2031  DOS V2.6
2040  DOS V1.1
4040  DOS V2.1
4040  DOS V2.7
8050  DOS V2.5
8050  DOS V2.7
8250  DOS V2.7
```

4.2.4 DIR

This is a small help program with the following possibilites:

d - display the directory on the screen

> - With this character, a disk command can be given in shortened form (for example, >N:TEST,KN to format a diskette)

q - exit the program

s - display the error channel

These possibilities are also found in DOS 5.1, along with other commands.

4.2.5 VIEW BAM

With this utility program you can view the usage of diskette blocks on the screen. This table displays the sectors in columns and the tracks in rows. Crosses indicate free blocks and reverse crosses indicate allocated blocks. 'n/a' means that these blocks do not exist on the track.

After outputting the table, the diskette name and the number of free blocks is displayed.

4.2.6 CHECK DISK

The utility program **CHECK DISK** tests every block on the diskette by writing to and reading from it. The current block and the total number of tested blocks is displayed on the screen.

4.2.7 DISPLAY T&S

If you are interested in the construction of the individual blocks of the disk and want to display these on the screen, this utility program will help you. After starting the program you give the desired track and sector. This will then be sent to the printer or screen. The DISK-MONITOR contained in this book is a easier to use, because it allows you to change blocks and save them again.

4.2.8 PERFORMANCE TEST

This program makes it possible to test the mechanics of the VIC-1541 disk drive. To accomplish this, all the access commands are executed, in the following order:

1. Disk is formatted
2. A file is opened for reading
3. Data are written to this file
4. The file is closed again
5. This file is opened for reading
6. The data are read
7. The file is closed again
8. The file is erased
9. Track 35 is written
10. Track 1 is written
11. Track 35 is read
12. Track 1 is read

After each access of the disk the error channel is displayed. In this manner, it can be established which access of the disk is not executed properly.

When using this program, use only diskettes containing no important data because the entire diskette is erased during the testing.

4.3 BASIC-Expansion and Programs for easy Use of the 1541

4.3.1 Input strings of desired length from the disk

Reading data from the disk with the INPUT# statement has one major disadvantage - only data items having fewer than 88 characters can be read. This is because the input buffer of the computer is limited. In addition, not all characters can be read with the INPUT# statement. If a record contains a comma or colon, BASIC views it as a separating character and the remainder of the input is assigned to the next variable. If the INPUT# statement has only one variable, the remainder is ignored and the next INPUT# statement continues reading past the next carriage return (CHR$(13)). The alternative, to read the input with a GET# statement but results in much slower input.

To avoid these disadvantages, we can use a small machine language routine.

We will change the INPUT# statement, so that we can specify the number of characters to be read. To distinguish it from the normal INPUT# statement, we name the command INPUT*. The syntax looks like this:

```
INPUT* lfn, len, var
```

Lfn is the logical file number of the previously OPENed file, len is the number of characters to be read, and var is the string variable into which the characters are to be read. A program excerpt might look like this:

```
100 OPEN 2,8,2,"FILE"
110 INPUT* 2,100,A$
```

This reads a string of 100 characters from the opened file into A$. This procedure is especially suited for relative files, because a complete record can be read with one command after positioning the record pointer. The partitioning of record into fields can be accomplished with the MID$ function. An elegant method of creating records is described in the next section.

With this procedure it is no longer necessary to end a record with a carriage return. You can especially make use of the maximum record length with relative files:

```
100 OPEN 1,8,15
110 OPEN 2,8,2, "REL-FILE,L,"+CHR$(20)
120 PRINT#1, "P"+CHR$(10)+CHR$(0)+CHR$(1)
130 PRINT#2, "12345678901234567890";
140 PRINT#1, "P"+CHR$(10)+CHR$(0)+CHR$(1)
```

```
150 INPUT* 2,20,A$
160 PRINT A$

12345678901234567890
```

Here is the assembler listing for the machine language program. It resides in the cassette buffer just like a loader program in BASIC for the Commodore 64 and VIC 20.

```
033C                 ;
                     ; INPUT* LFN,LEN,A$
                     ;
033C                 INPUT      EQU  $85
033C                 STAR       EQU  $AC
033C                 BASVEC     EQU  $308
033C                 CHRGET     EQU  $73
033C                 CHRGOT     EQU  CHRGET + 6
                     ;
033C                 ; C64 VERSION
033C                 ;
033C                 CHKIN      EQU  $E11E
033C                 BASIN      EQU  $E112
033C                 CHKCOM     EQU  $AEFD
033C                 INTER      EQU  $A7AE
033C                 EXECOLD    EQU  $A7E7
033C                 INPUTOLD   EQU  $ABBF
033C                 FINDVAR    EQU  $B08B
033C                 STRRES     EQU  $B475
033C                 FRESTR     EQU  $B6A3
033C                 GETBYT     EQU  $B79E
                     ;
                     ; VIC 20 VERSION
                     ;
033C                 CHKIN      EQU  $E11B
033C                 BASIN      EQU  $E10F
033C                 CHKCOM     EQU  $CEFD
033C                 INTER      EQU  $C7AE
033C                 EXECOLD    EQU  $C7E7
033C                 INPUTOLD   EQU  $CBBF
033C                 FINDVAR    EQU  $D08B
033C                 STRRES     EQU  $D475
033C                 FRESTR     EQU  $D6A3
033C                 GETBYT     EQU  $D79E
                     ;
                     ; COMMON LABELS
                     ;
033C                 VARADR     EQU  $49
033C                 CLRCH      EQU  $FFCC
033C                 PARA       EQU  $61
                     ;
033C                            ORG  828
033C A9 47           INIT       LDA  #<TEST
033E A0 03                      LDY  #>TEST
0340 8D 08 03                   STA  BASVEC
0343 8C 09 03                   STY  BASVEC+1
```

```
580:    0346 60                 RTS
                          ;
600:    0347 20 73 00 TEST      JSR  CHRGET
610:    034A C9 85              CMP  #INPUT
620:    034C F0 06              BEQ  FOUND
630:    034E 20 79 00           JSR  CHRGOT
640:    0351 4C E7 A7           JMP  EXECOLD   ; TO THE OLD
                                                 ROUTINE
650:    0354 20 73 00 FOUND     JSR  CHRGET
660:    0357 C9 AC              CMP  #STAR     ; NEW INPUT
                                                 ROUTINE
670:    0359 F0 06              BEQ  OKSTAR
680:    035B 20 BF AB           JSR  INPUTOLD
680:    035E 4C AE A7           JMP  INTER
690:    0361 20 9B B7 OKSTAR    JSR  GETBYT-3  ; GET FILE
                                                 NUMBER
700:    0364 20 1E E1           JSR  CHKIN
710:    0367 20 FD AE           JSR  CHKCOM
720:    036A 20 9E B7           JSR  GETBYT    ; LENGTH
730:    036D 8A                 TXA
730:    036E 48                 PHA            ; NOTICE
740:    036F 20 FD AE           JSR  CHKCOM
750:    0372 20 8B B0           JSR  FINDVAR   ; SEARCH FOR
                                                 VARIABLE
760:    0375 85 49              STA  VARADR
760:    0377 84 4A              STY  VARADR+1
770:    0379 20 A3 B6           JSR  FRESTR
780:    037C 68                 PLA            ; LENGTH
790:    037D 20 75 B4           JSR  STRRES    ; RESERVE PLACE
                                                 FOR STRING
800:    0380 A0 02              LDY  #2
810:    0382 B9 61 00 STORE     LDA  PARA,Y
820:    0385 91 49              STA  (VARADR),Y
830:    0387 88                 DEY
840:    0388 10 F8              BPL  STORE
850:    038A C8                 INY            ; Y=0
860:    038B 20 12 E1 FETCH     JSR  BASIN
870:    038E 91 62              STA  (PARA+1),Y
880:    0390 C8                 INY
890:    0391 C4 61              CPY  PARA
900:    0393 D0 F6              BNE  FETCH
910:    0395 20 CC FF           JSR  CLRCH
910:    0398 4C AE A7           JMP  INTER     ;TO INTERPRETER
                                                LOOP
```

Here are the BASIC programs for entering the machine language program for the INPUT* statement.

INPUT* , 64 Version

```
100 FOR I = 828 TO 922
110 READ X : POKE I,X : S=S+X : NEXT
120 DATA 169, 71,160,  3,141,  8,  3,140,  9,  3, 96, 32
```

```
130 DATA 115,  0,201,133,240,  6, 32,121,  0, 76,231,167
140 DATA  32,115,  0,201,172,240,  6, 32,191,171, 76,174
150 DATA 167, 32,155,183, 32, 30,225, 32,253,174, 32,158
160 DATA 183,138, 72, 32,253,174, 32,139,176,133, 73,132
170 DATA  74, 32,163,182,104, 32,117,180,160,  2,185, 97
180 DATA   0,145, 73,136, 16,248,200, 32, 18,225,145, 98
190 DATA 200,196, 97,208,246, 32,204,255, 76,174,167
200 IF S <> 11096 THEN PRINT "ERROR IN DATA !!" : END
210 SYS 828 : PRINT "OK."
```

INPUT* , VIC 20 VERSION

```
100 FOR I = 828 TO 922
110 READ X : POKE I,X : S=S+X : NEXT
120 DATA 169, 71,160,  3,141,  8,  3,140,  9,  3, 96, 32
130 DATA 115,  0,201,133,240,  6, 32,121,  0, 76,231,199
140 DATA  32,115,  0,201,172,240,  6, 32,191,203, 76,174
150 DATA 199, 32,155,215, 32, 27,225, 32,253,206, 32,158
160 DATA 215,138, 72, 32,253,206, 32,139,208,133, 73,132
170 DATA  74, 32,163,214,104, 32,117,212,160,  2,185, 97
180 DATA   0,145, 73,136, 16,248,200, 32, 15,225,145, 98
190 DATA 200,196, 97,208,246, 32,204,255, 76,174,199
200 IF S <> 11442 THEN PRINT "ERROR IN DATA !!" : END
210 SYS 828 : PRINT "OK."
```

4.3.2 Easy Preparation of Data Records

If you have worked with relative files before, you know that a definite record length must be established. This record is usually divided into several fields which likewise begin at a definite position within the record, and have a set length.

If you create a new record, for example, a separate INPUT statement is generally used for each field. Before the complete record can be written, it must be assembled properly. Each field must be checked for proper length. If it is longer than then the planned length of the corresponding data field, the remainder must be truncated to the proper length. Here are two new BASIC commands that are excellently suited for this task. These new commands are written in machine language and are initialized with a SYS command. You can then use them as any other BASIC commands.

The first command has the name !STR$ and serves to create a string with the length of the data record.

```
A$ = !STR$(100," ")
```

creates a string with 100 blanks and puts it in the variable A$.

The next command places our data field in the previously created string. For example, if you want to assign the variable N$ containing the last name as a field of 25 characters at position 1 in the string A$, our new command looks like this:

```
MID$ (A$,1,25) = N$
```

Here the MID$ command is used as a so-called pseudo-variable on the left side of the assignment statement. What happens here is as follows:

The variable N$ replaces the first 25 characters of A$. If the variable N$ is longer than 25 characters, only the first 25 characters are replaced and the rest are disregarded. If N$ is shorter than 25 characters, only as many characters are replaced as N$ contains. The original characters in A$ remain (blanks, in our case). That is exactly as we wanted. Now we can program the following:

```
200 INPUT "LAST NAME      "; L$
210 INPUT "FIRST NAME     "; F$
220 INPUT "STREET         "; S$
230 INPUT "CITY           "; C$
240 INPUT "STATE          "; T$
250 INPUT "ZIP CODE       "; Z$
260 A$ = !STR$ (92, " ")
270 MID$ (A$,1,25)  = L$
280 MID$ (A$,26,20) = F$
290 MID$ (A$,46,20) = S$
300 MID$ (A$,66,15) = C$
310 MID$ (A$,81,2)  = T$
320 MID$ (A$,83,9)  = Z$
330 PRINT#2, A$
```

Here is the machine language program for the Commodore 64

```
C800                    ORG   $C800
C800        CHKOPEN     EQU   $AEFA
C800        CHKCLOSE    EQU   $AEF7
C800        CHKCOM      EQU   $AEFD
C800        FRMEVL      EQU   $AD9E
C800        CHKSTR      EQU   $AD8F
C800        FRESTR      EQU   $B6A3
C800        YFAC        EQU   $B3A2
C800        CHRGET      EQU   $73
C800        CHRGOT      EQU   CHRGET+6
C800        GETBYT      EQU   $B79B
C800        INTEGER     EQU   $B1AA
C800        DESCRPT     EQU   $64
C800        STRADR      EQU   $62
C800        ADR2        EQU   $FB
```

```
232:    C800              ADR1      EQU   $FB+2
233:    C800              LEN1      EQU   3
234:    C800              LEN2      EQU   4
235:    C800              NUMBER    EQU   5
236:    C800              START     EQU   6
237:    C800              TYPFLAG   EQU   13
238:    C800              STRCODE   EQU   $C4
240:    C800              ILLQUAN   EQU   $B248
241:    C800              SYNTAX    EQU   $AF08
242:    C800              POSCODE   EQU   $B9
243:    C800              VECTOR    EQU   $30A
245:    C800              TEMP      EQU   LEN1
248:    C800 A9 0D                  LDA   #<TESTIN
248:    C802 A0 C8                  LDY   #>TESTIN
248:    C804 8D 0A 03               STA   VECTOR
248:    C807 8C 0B 03               STY   VECTOR+1
248:    C80A 4C 6B C8               JMP   MIDSTR
250:    C80D A9 00        TESTIN    LDA   #0
250:    C80F 85 0D                  STA   TYPFLAG
250:    C811 20 73 00               JSR   CHRGET
251:    C814 C9 21                  CMP   #"!"
251:    C816 F0 06                  BEQ   TEST2
251:    C818 20 79 00               JSR   CHRGOT
251:    C81B 4C 8D AE               JMP   $AE8D
252:    C81E 20 73 00     TEST2     JSR   CHRGET
252:    C821 C9 C4                  CMP   #STRCODE
252:    C823 F0 03                  BEQ   STRING
253:    C825 4C 08 AF               JMP   SYNTAX
                          ;
                          ; STRING$ FUNCTION
                          ;
900:    C828 20 73 00     STRING    JSR   CHRGET
900:    C82B 20 FA AE               JSR   CHKOPEN      ;OPEN PAREN
910:    C82E 20 9E B7               JSR   GETBYT+3
920:    C831 8A                     TXA
920:    C832 48                     PHA                ;NOTICE LENGTH
930:    C833 20 FD AE               JSR   CHKCOM
940:    C836 20 9E AD               JSR   FRMEVL
950:    C839 24 0D                  BIT   TYPFLAG
960:    C83B 30 0C                  BMI   STR          ;STRING
970:    C83D 20 AA B1               JSR   INTEGER
980:    C840 A5 64                  LDA   DESCRPT      ;HIGH BYTE
990:    C842 D0 24                  BNE   ILL          ; >255
1000:   C844 A5 65                  LDA   DESCRPT+1    ; LOW BYTE,
                                                         LENGTH
1010:   C846 4C 52 C8               JMP   STR2
1020:   C849 20 82 B7     STR       JSR   $B782        ;SETSTR
                                                        TYPFLAG TO
                                                        NUMERIC
1030:   C84C F0 1A                  BEQ   ILL          ;LENGTH 0
1040:   C84E A0 00                  LDY   #0
1050:   C850 B1 22                  LDA   ($22),Y      ;FIRST CHAR
1060:   C852 85 03        STR2      STA   TEMP
1070:   C854 68                     PLA                ;LENGTH
1080:   C855 20 7D B4               JSR   $B47D        ;FRESTR
```

```
C858 A8                      TAY
C859 F0 07                   BEQ  STR3
C85B A5 03                   LDA  TEMP
C85D 88          LOOP        DEY
C85E 91 62                   STA  (STRADR),Y ; CREATE
                                                 STRING
C860 D0 FB                   BNE  LOOP
C862 20 CA B4    STR3        JSR  $B4CA      ;BRING STRING
                                         IN DESCRIPTOR STACK
C865 4C F7 AE                JMP  CHKCLOSE
C868 4C 48 B2    ILL         JMP  ILLQUAN
                  ;
                  ; MID$(STRINGVAR,POS,LEN) = STRING EXP
                  ; MID$(STRINGVAR,POS) = STRING EXP
                  ;
C86B             MIDCODE     EQU  $CA
C86B             EXECUT      EQU  $308 ;VECTOR FOR
                                   STATEMENT EXECUTE
C86B             EXECOLD     EQU  $A7E7
C86B             VARNAM      EQU  $45
C86B             VARADR      EQU  $49
C86B             DESCRPT     EQU  $64
C86B             TESTSTR     EQU  $AD8F
C86B             GETVAR      EQU  $B08B
C86B             SETSTR      EQU  $AA52
C86B             TEST        EQU  $AEFF
C86B             GETBYT      EQU  $B79E
0003                         ORG  3
0004             LENGTH      DST  1
0005             POSITION    DST  1
0007             VARSTR      DST  2
0007             COMP        EQU  $B2
0007             POINT2      EQU  $50
                  ;
C86B A9 76       MIDSTR      LDA  #<MIDTEST
C86D A0 C8                   LDY  #>MIDTEST
C86F 8D 08 03                STA  EXECUT
C872 8C 09 03                STY  EXECUT+1
C875 60                      RTS
C876 20 73 00    MIDTEST     JSR  CHRGET
C879 C9 CA                   CMP  #MIDCODE   ;CODE FOR MID$
C87B F0 06                   BEQ  MID        ;? YES
C87D 20 79 00                JSR  CHRGOT
C880 4C E7 A7                JMP  EXECOLD    ;EXECUTE
                                         NORMAL STATEMENT
C883 20 73 00    MID         JSR  CHRGET     ;NEXT CHAR
C886 20 FA AE                JSR  CHKOPEN    ;OPEN PAREN
C889 20 8B B0                JSR  GETVAR     ;GET VAR
C88C 85 64                   STA  DESCRPT
C88E 84 65                   STY  DESCRPT+1
C890 85 49                   STA  VARADR
C892 84 4A                   STY  VARADR+1
C894 20 A3 B6                JSR  FRESTR
C897 A0 00                   LDY  #0
C899 B1 64                   LDA  (DESCRPT),Y
```

```
545:    C89B 48                     PHA               ;LENGTH
545:    C89C F0 2E                  BEQ   ILL
550:    C89E 20 52 AA               JSR   SETSTR      ;PUT STRING IN
                                                       RAM
560:    C8A1 A0 01                  LDY   #1
560:    C8A3 B1 49                  LDA   (VARADR),Y
560:    C8A5 85 05                  STA   VARSTR      ;VAR ADDR
570:    C8A7 C8                     INY
570:    C8A8 B1 49                  LDA   (VARADR),Y
570:    C8AA 85 06                  STA   VARSTR+1
600:    C8AC 20 FD AE               JSR   CHKCOM
610:    C8AF 20 9E B7               JSR   GETBYT      ;GET POS
620:    C8B2 8A                     TXA
630:    C8B3 F0 17                  BEQ   ILL
650:    C8B5 CA                     DEX
650:    C8B6 86 04                  STX   POSITION
660:    C8B8 20 79 00               JSR   CHRGOT
660:    C8BB C9 29                  CMP   #")"        ;END OF
                                                   EXPRESSION?
665:    C8BD D0 04                  BNE   NEXT
665:    C8BF A9 FF                  LDA   #$FF        ;MAX LENGTH
665:    C8C1 D0 0C                  BNE   STORE
670:    C8C3 20 FD AE NEXT          JSR   CHKCOM
670:    C8C6 20 9E B7               JSR   GETBYT      ;GET LEN
680:    C8C9 8A                     TXA
690:    C8CA D0 03                  BNE   *+5
700:    C8CC 4C 48 B2 ILL           JMP   ILLQUAN
710:    C8CF 85 03    STORE         STA   LENGTH
715:    C8D1 68                     PLA
715:    C8D2 38                     SEC
715:    C8D3 E5 04                  SBC   POSITION
717:    C8D5 C5 03                  CMP   LENGTH
717:    C8D7 B0 02                  BCS   OK
717:    C8D9 85 03                  STA   LENGTH
720:    C8DB 20 F7 AE OK            JSR   CHKCLOSE    ;CLOSE PAREN
730:    C8DE A9 B2                  LDA   #COMP
770:    C8E0 20 FF AE               JSR   TEST
780:    C8E3 20 9E AD               JSR   FRMEVL      ;GET EXP
790:    C8E6 20 A3 B6               JSR   FRESTR
800:    C8E9 A0 02                  LDY   #2
800:    C8EB B1 64                  LDA   (DESCRPT),Y
800:    C8ED 85 51                  STA   POINT2+1
800:    C8EF 88                     DEY
800:    C8F0 B1 64                  LDA   (DESCRPT),Y
800:    C8F2 85 50                  STA   POINT2
810:    C8F4 88                     DEY
810:    C8F5 B1 64                  LDA   (DESCRPT),Y
820:    C8F7 F0 D3                  BEQ   ILL         ;0 THEN ERROR
840:    C8F9 C5 03                  CMP   LENGTH
850:    C8FB B0 02                  BCS   OK1
860:    C8FD 85 03                  STA   LENGTH
870:    C8FF A5 05    OK1           LDA   VARSTR
880:    C901 18                     CLC
880:    C902 65 04                  ADC   POSITION
910:    C904 85 05                  STA   VARSTR
```

```
910:    C906 90 02              BCC  *+4
920:    C908 E6 06              INC  VARSTR+1
940:    C90A A4 03              LDY  LENGTH
950:    C90C 88        LOOP     DEY
950:    C90D B1 50              LDA  (POINT1),Y ;TRANSFER
                                          CHARS FROM STRING
960:    C90F 91 05              STA  (VARSTR),Y ;EXP TO VAR
970:    C911 C0 00              CPY  #0
970:    C913 D0 F7              BNE  LOOP
980:    C915 4C AE A7           JMP  $A7AE   ;TO INTERPRETER
                                             LOOP
```

For those who have no monitor or assembler for the Commodore 64, we have written a loader program in BASIC.

```
100 FOR I = 51200 TO 51479
110 READ X : POKE I,X : S=S+X : NEXT
120 DATA 169, 13,160,200,141, 10,  3,140, 11,  3, 76,107
130 DATA 200,169,  0,133, 13, 32,115,  0,201, 33,240,  6
140 DATA  32,121,  0, 76,141,174, 32,115,  0,201,196,240
150 DATA   3, 76,  8,175, 32,115,  0, 32,250,174, 32,158
160 DATA 183,138, 72, 32,253,174, 32,158,173, 36, 13, 48
170 DATA  12, 32,170,177,165,100,208, 36,165,101, 76, 82
180 DATA 200, 32,130,183,240, 26,160,  0,177, 34,133,  3
190 DATA 104, 32,125,180,168,240,  7,165,  3,136,145, 98
200 DATA 208,251, 32,202,180, 76,247,174, 76, 72,178,169
210 DATA 118,160,200,141,  8,  3,140,  9,  3, 96, 32,115
220 DATA   0,201,202,240,  6, 32,121,  0, 76,231,167, 32
230 DATA 115,  0, 32,250,174, 32,139,176,133,100,132,101
240 DATA 133, 73,132, 74, 32,163,182,160,  0,177,100, 72
250 DATA 240, 46, 32, 82,170,160,  1,177, 73,133,  5,200
260 DATA 177, 73,133,  6, 32,253,174, 32,158,183,138,240
270 DATA  23,202,134,  4, 32,121,  0,201, 41,208,  4,169
280 DATA 255,208, 12, 32,253,174, 32,158,183,138,208,  3
290 DATA  76, 72,178,133,  3,104, 56,229,  4,197,  3,176
300 DATA   2,133,  3, 32,247,174,169,178, 32,255,174, 32
310 DATA 158,173, 32,163,182,160,  2,177,100,133, 81,136
320 DATA 177,100,133, 80,136,177,100,240,211,197,  3,176
330 DATA   2,133,  3,165,  5, 24,101,  4,133,  5,144,  2
340 DATA 230,  6,164,  3,136,177, 80,145,  5,192,  0,208
350 DATA 247, 76,174,167
360 IF S <> 31128 THEN PRINT "ERROR IN DATA !!" : END
370 SYS 51200 : PRINT "OK."
```

4.3.3 Spooling - Printing Directly from the Disk

If you have a printer connected to your computer in addition to the disk drive, you can use a special characteristic of the the serial bus.

It is possible to send files directly from disk to the printer, without the need to transfer it byte by byte with the computer. For example, if you have text saved as a sequential file, and you want to print it on the printer, the following program allows you to do so:

```
100 OPEN 1,4 : REM PRINTER
110 OPEN 2,8,2, "0:TEST" : REM TEXT FILE
120 GET#2, A$ : IF ST = 64 THEN 140
130 PRINT#1, A$; : GOTO 120
140 CLOSE 1 : CLOSE 2
150 END
```

Characters are sent from the disk to the printer until the end of file is recognized. Then the two files are closed and the program ended.

The following is done when spooling:

First both files are opened again. Then a command to receive data (Listen) is sent to the printer, while the disk drive receives the command to send data (Talk). Data are sent automatically from the disk to the printer until the end of file is reached. During this time, the computer can be used without interferring with the transfer of data. Only the use of peripheral devices is not possible during this time.

In practice, this is done with a small machine language program. When you want to start printing, you call the program and give the name of the file which you want to send.

SYS 828, "TEXT"

OPENs the file **TEXT** on the diskette and sends it to the printer. As soon as the transfer is begun, the computer responds with **READY.** again and you can use it, as long as no attempt is made to access the serial bus. You can prove that the computer is no longer needed for transfer by pulling out the bus cable to the disk, so that the diskette is connected only to the printer. When the spooling is done, the disk file is still open (the red LED is still lit). You can CLOSE the file and turn the printer off and then back on, and give the SYS command without a filename (the cable to the disk must be attached, of course).

SYS 828

With same command you can stop a transfer in progress. The machine language program in the form of a loader program for the Commodore 64 and the VIC 20 is found at the end.

Here are some hints for use:

We have successfully used the printer spooling with a Commodore 64 and a VIC 20 with a printer such as the the VIC

1525. Attempts using an Epson printer with a VIC interface as well as the VIC 1526 did not succeed. The serial bus, in contrast with the parallel IEEE bus, appears to be capable of spooling only with limitations. This is why it is necessary to turn the printer off after spooling, because it still blocks the bus. We would be happy if you would inform us of your experience with other printers.

```
                                ;
                                ; 1541 - 64 SPOOL
                                ;
110:   033C               CHRGOT    EQU  $79
130:   033C               LISTEN    EQU  $FFB1
140:   033C               ATNRES    EQU  $EDBE      ;ATN HI
142:   033C               CLOCK     EQU  $EE85      ;CLOCK HI
144:   033C               DATA      EQU  $EE97      ;DATA HI
160:   033C               CLOSE     EQU  $FFC3
170:   033C               CLALL     EQU  $FFE7
175:   033C               SETFIL    EQU  $FFBA
180:   033C               GETNAME   EQU  $E254      ;GET FILENAME
190:   033C               OPEN      EQU  $FFC0
200:   033C               CHKIN     EQU  $FFC6
202:   033C               UNTALK    EQU  $FFAB
204:   033C               UNLISTEN  EQU  $FFAE
230:   033C               FNLEN     EQU  $B7
240:   033C               INDEV     EQU  $99        ;INPUT DEVICE
260:   033C               NMBFLS    EQU  $98        ;NO. OF FILES
280:   033C               ERROR     EQU  $AF08      ;SYNTAX ERROR
                                ;
300:   033C                         ORG  828
310:   033C 20 79 00                JSR  CHRGOT     ;MORE CHARS
320:   033F F0 33                   BEQ  OFF        ;SPOOL DONE
330:   0341 20 E7 FF                JSR  CLALL
340:   0344 20 54 E2                JSR  GETNAME
350:   0347 A6 B7                   LDX  FNLEN
360:   0349 F0 38                   BEQ  SYNTAX
370:   034B A9 02                   LDA  #2
380:   034D A2 08                   LDX  #8
390:   034F A0 02                   LDY  #2
400:   0351 20 BA FF                JSR  SETFIL
410:   0354 20 C0 FF                JSR  OPEN       ;OPEN FILE
411:   0357 A9 04                   LDA  #4
412:   0359 20 B1 FF                JSR  LISTEN     ;PRINTER
413:   035C 20 BE ED                JSR  ATNRES
420:   035F A2 02                   LDX  #2
430:   0361 20 C6 FF                JSR  CHKIN      ;DISK
435:   0364 20 BE ED                JSR  ATNRES
435:   0367 20 85 EE                JSR  CLOCK
435:   036A 20 97 EE                JSR  DATA
510:   036D A9 00                   LDA  #0
520:   036F 85 99                   STA  INDEV
530:   0371 85 98                   STA  NMBFLS
540:   0373 60                      RTS
550:   0374 A9 01         OFF       LDA  #1
560:   0376 85 98                   STA  NMBFLS
```

```
570:    0378 20 AE FF             JSR   UNLISTEN
580:    037B 20 AB FF             JSR   UNTALK
620:    037E A9 02                LDA   #2
630:    0380 4C C3 FF             JMP   CLOSE
640:    0383 4C 08 AF SYNTAX      JMP   ERROR
```

Here is the BASIC loader program for the Commodore 64.

```
100 FOR I = 828 TO 901
110 READ X : POKE I,X : S=S+X : NEXT
120 DATA  32,121,  0,240, 51, 32,231,255, 32, 84,226
130 DATA 166,183,240, 56,169,  2,162,  8,160,  2, 32
140 DATA 186,255, 32,192,255,169,  4, 32,177,255, 32
150 DATA 190,237,162,  2, 32,198,255, 32,190,237, 32
160 DATA 133,238, 32,151,238,169,  0,133,153,133,152
170 DATA  96,169,  1,133,152, 32,174,255, 32,171,255
180 DATA 169,  2, 76,195,255, 76,  8,175
190 IF S <> 9598 THEN PRINT "ERROR IN DATA !!" : END
200 PRINT "OK."
```

For the VIC 20, use the following program:

```
100 FOR I = 828 TO 901
110 READ X : POKE I,X : S=S+X : NEXT
120 DATA  32,121,  0,240, 51, 32,231,255, 32, 81,226
130 DATA 166,183,240, 56,169,  2,162,  8,160,  2, 32
140 DATA 186,255, 32,192,255,169,  4, 32,177,255, 32
150 DATA 197,238,162,  2, 32,198,255, 32,197,238, 32
160 DATA 132,239, 32,160,228,169,  0,133,153,133,152
170 DATA  96,169,  1,133,152, 32,174,255, 32,171,255
180 DATA 169,  2, 76,195,255, 76,  8,207
190 IF S <> 9648 THEN PRINT "ERROR IN DATA !!" : END
200 PRINT "OK."
```

4.4 Overlay Technique and Chaining Machine Language Programs

A proven programming technique involves the creation of a menu program which then loads and executes other programs based on the user's choice. There are two variations: preserving or clearing the old variables in the chained program.

It is possible to pass the old variables if the calling program is as large or larger than the chained program. If a program is chained from another program, the pointer to the end of the previous program remains intact, and the new program loads over the old.

In this example, we would get the following result:

```
100 REM PROGRAM 1
110 REM THIS PROGRAM IS LARGER THAN THE SECOND
120 A = 1000
130 LOAD "PROGRAM 2",8

100 REM PROGRAM 2
110 PRINT A

1000
```

If the chained program is larger than the original program, part of the variables are overwritten and contain meaningless values. Moreover, when the variables that the program destroyed are assigned new values, part of the program is also destroyed.

There are two characteristics of passing variables from the previous program that should be noted - for strings and for functions.

Any string variables that are defined as constants enclosed in quotes in the first program, will have a problem. The string variable pointer points to the actual text in the program. If, for example, a string is defined in the first program with the following assignment

```
100 A$ = "TEXT"
```

the variable pointer points to the actual text within line number 100. When chaining, the next program does not change this pointer. New text is now at the original location, so the variable has unpredictable contents. We can easily work around this, however. We need only ensure that the text is copied from the program into string storage where text variables are normally stored. You can do this as follows:

```
100 A$ = "TEXT" + ""
```

By concatenating an empty string, you force the contents of the variable to be copied to the string storage area.

Similar considerations apply to function definitions, because here also the pointer points to the definition within the program. Here you must define the function again in the second program, for example:

```
100 DEF FN A(X) = 0.5 * EXP (-X*X)
```

If you want to chain a program, you can continue to use the old variables provided the second program is not longer than the first. If the chained program is longer, and we do not want to preserve the old variables, there is a trick we can use.

We need only set the end-of-program pointer to the end of the new program immediately after loading. This can be done with two POKE commands:

```
POKE 45, PEEK(174) : POKE 46, PEEK (175) : CLR
```

The CLR command is absolutely necessary. This line should be the first line in the chained program. This allows us to chain a large program without transfer of variables. Another, not so elegant method involves writing the load command in the keyboard buffer so the program will automatically be loaded in the direct mode. To do this, we write the LOAD and RUN commands on the screen and fill the keyboard buffer with 'HOME' and carriage returns. An END statement must come after this in the program. The control system then gets the contents of the keyboard buffer in the direct mode and reads the LOAD and RUN commands that control the loading and execution of the program. Because this occurs in the direct mode, the end address of the program is automatically set, the variables are erased and the program is started with the RUN. The disadvantage of this method is that since the LOAD command must appear on the video screen, any display will be destroyed. In practice it looks like this:

```
1000 PRINT CHR$(147)"LOAD"CHR$(34)"PROGRAM 2"CHR$(34)",8"
1010 PRINT : PRINT : PRINT : PRINT
1020 PRINT "RUN"
1030 POKE 631,19 : POKE 632,13 : POKE 633,13
1040 POKE 634,13 : POKE 635,13 : POKE 636,13
1050 POKE 198,6  : END
```

You can see that this procedure is more complicated than the previous one; it is only mentioned for the sake of completeness. With the first procedure, only the LOAD command need be programmed in line 1000:

```
1000 LOAD "PROGRAM 2",8
```

There is another technique for chaining machine language programs.

If a machine language program is to be used from a BASIC program, it must usually be loaded at the beginning of the BASIC program. You must take note of two things:

First of all, you must make sure that the machine language program loads to a specific place in memory. If you load a program without additional parameters, the control system treats it as a BASIC program and loads it at the starting address of the BASIC RAM, generally at 2049 (Commodore 64). Machine language programs can only be run, however, when they are loaded at the address for which they were written. This absolute loading can be accomplished by adding the secondary address 1:

```
LOAD "MACH-PRG",8,1
```

But remember that when loading a program from within another program, BASIC attempts to RUN the program from the beginning. This leads to an endless loop when loading machine language programs, because the operating system thinks that a new BASIC program has been chained:

```
100 LOAD "MACH-PRG",8,1
```

Here we can make use of the fact that the variables are preserved when chaining. If we program the following, we have reached our goal:

```
100 IF A=0 THEN A=1 : LOAD "MACH-PRG",8,1
110 ...
```

When the program is started with RUN, A has the value zero and the assignment after the THEN is executed, A contains the value 1 and the machine language program is then LOADed. When the program begins again after LOADing the program **MACH-PRG**, A has the value 1 so the next line is executed.

The procedure is similar if you have several machine language programs to load.

```
100 IF A=0 THEN A=1 : LOAD "PROG 1",8,1
110 IF A=1 THEN A=2 : LOAD "PROG 2",8,1
120 IF A=2 THEN A=3 : LOAD "PROG 3",8,1
130 ....
```

The first time through, PROG 1 will be loaded, the next time, PROG 2, and so on. Once all the programs are loaded, execution continues with line 130.

4.5 Merge - Appending BASIC Programs

Certainly you have thought about the possibility of combining two separate BASIC programs into one. Without further details this is not possible, because loading the second program would overwrite the first. With the knowledge of how BASIC programs are stored in memory and on the diskette, you can develop a simple procedure to accomplish this task.

BASIC programs are stored in memory as follows:

```
NL NH      pointer to the next program line, lo hi
LL LH      line number, lo hi
XX YY ZZ    ..... tokenized BASIC statements
00         end-of-line marker
```

At the end of the program are two additional zero bytes:

```
00  00     a total of 3 zero bytes
```

Programs are also saved in this format. Where the program starts and ends lies in two pointers in page zero:

```
PRINT PEEK(43) + 256 * PEEK(44)
```

gives the start of BASIC, 2049 for the Commodore 64,

```
PRINT PEEK(45) + 256 * PEEK(46)
```

points to the byte behind the three zero bytes.

Because a program is always loaded at the start of BASIC, contained in the pointer at 43/44, one can cause a second program to load at the end of the first. In practice, we must proceed as follows:

First we load the first program into memory.

LOAD "PROGRAM 1",8

Now get the value of the ending address of the program.

```
A = PEEK(45) + 256 * PEEK(46)
```

This value is decremented by two so that the two zero bytes at the end of the program are known.

```
A = A - 2
```

Now, note the original value of the start of BASIC.

```
PRINT PEEK(43), PEEK(44)
```

Next, set the start of BASIC to this value.

```
POKE, A AND 255 : POKE 44, A / 256
```

Now, LOAD the second program.

```
LOAD "PROGRAM 2",8
```

If you set the start of BASIC back to the original value, 1 and 8 for the Commodore 64 (as shown above with the PRINT commands), you have the complete program in memory and can view it with LIST or save it with SAVE.

```
POKE 43,1 : POKE 44,8
```

The following should be noted when using this method:

The appended program may contain only line numbers that are greater than the largest line number of the first program. Otherwise these line numbers can never be accessed with GOTO or GOSUB and the proper program order cannot be guaranteed.

This procedure is especially well suited for constructing a subroutine library for often used routines, so they need not be typed in each time. It will work out best if you reserve specific line numbers for the subroutines, such as 20000-25000, 25000-30000, and so on. If you want to merge several programs in this manner, you must first load the program with smallest line numbers, and then the program with the next highest numbers, etc.

4.6 Disk Monitor for the Commodore 64 and VIC 20

In this section we present a very useful tool for working with your disk drive, allowing you to load, display, modify, and save desired blocks on the diskette.

For reasons of speed, the program is written entirely in machine language. The following commands are supported:

* Read a block from the disk
* Write a block to the disk
* Display a block on the screen
* Edit a block on the screen
* Send disk commands
* Display disk error messages
* Return to BASIC

The program announces its execution (automatically by the BASIC load program) with

```
DISK-MONITOR V1.0
>
```

and waits for your input. If you enter '@', the error message from the disk will be displayed, for example

```
00, ok,00,00
```

If you want to send a command to the disk, enter an '@' followed by the command.
You can initialize a diskette with

```
>@I
```

You can send complete disk commands in this manner, that you would otherwise send with

```
OPEN 15,8,15
PRINT# 15,"command"
CLOSE 15
```

For example, you can erase files, format disks, and so on.

The most important function of the disk monitor is the direct access of any block on the diskette. For this, you use the commands R and W. R stands for READ and reads a desired block, W stands for WRITE and writes a block to the disk. You need only specify the track and sector you want to read. These must be given in hexadecimal, exactly as the output is given on the screen. If, for example, you want to read track 18, sector 1 (the first directory block), enter the following command:

```
>R 12 01
```

Each input must be given as a two-digit hex number, separated from each other with a blank.

In order to display the block, use the command **M**. We receive the following output:

```
DISK-MONITOR V1.0
>M
>:00   12 04 82 11 01 47 52 41   .....GRA
>:08   46 49 4B 20 41 49 44 2E   FIX AID.
>:10   53 52 43 A0 A0 00 00 00   SRC   ...
>:18   00 00 00 00 00 00 15 00   ........
>:20   00 00 82 13 00 48 50 4C   .....HPL
>:28   4F 54 2E 53 52 43 A0 A0   OT.SRC
>:30   A0 A0 A0 A0 A0 00 00 00        ...
>:38   00 00 00 00 00 00 05 00   ........
>:40   00 00 82 13 03 56 50 4C   .....VPL
>:48   4F 54 2E 53 52 43 A0 A0   OT.SRC
>:50   A0 A0 A0 A0 A0 00 00 00        ...
>:58   00 00 00 00 00 00 09 00   ........
>:60   00 00 82 13 09 4D 45 4D   .....MEM
>:68   2E 53 52 43 A0 A0 A0 A0   .SRC
>:70   A0 A0 A0 A0 A0 00 00 00        ...
>:78   00 00 00 00 00 00 06 00   ........
>:80   00 00 82 13 08 4D 45 4D   .....MEM
>:88   2E 4F 42 4A A0 A0 A0 A0   .OBJ
  etc.
```

Let's take a closer look at the output. The first hex number after the colon gives the address of the following 8 bytes in the block, 00 indicates the first byte in the block (the numbering goes from 00 to FF (0-255)). 8 bytes follow the address (4 on the VIC 20). In the right half are the corresponding ASCII characters. If the code is not printable ($00 to $1F and $80 to $9F), a period is printed. When you give the command **M**, as above, the entire block is displayed. Because the block does not fit on the screen completely, it is possible to display only part of it. You can give an address range that you would like to display. If you only want to see the first half, enter:

```
>M 00 7F
```

The second half with:

```
>M 80 FF
```

With the VIC 20, you can view quarters of the block. If you now wish to change some data, you simply move the cursor to the corresponding place, overwrite the appropriate byte, and press RETURN. The new value is now stored and the right half is updated with the proper ASCII character.

To write the modified block back to the diskette, you use the command W. Here also you must give the track and sector numbers in hexadecimal.

>W 12 01

writes the block back to track 18, sector 1, from where we had read the block previously.

If you want to get back to BASIC, enter **X** and the computer will respond with **READY.**. If you then want to use the disk monitor again, you need not load it again. Just type SYS 49152 for the C64 or SYS 6690 for the VIC 20.

A warning:

Be sure to make a copy of any diskette that you work with in this way. Should you make an error when editing or writing a block, you can destroy important information on the disk so that it can no longer be used in the normal manner. You should make it a rule to only work with a copy.

Here you find an assembler listing of the program. After this are the BASIC loader programs for the Commodore 64 and VIC 20.

```
                         ;
                         ; disk monitor vic 20 / cbm 64
                         ;
190:   C000             PROMPT    EQU  ">"
200:   C000             NCMDS     EQU  6          ;NUMBER OF
                                                   COMMANDS
210:   C000             INPUT     EQU  $FFCF
220:   C000             TALK      EQU  $FFB4
230:   C000             SECTALK   EQU  $FF96
240:   C000             IEEEIN    EQU  $FFA5
250:   C000             UNTALK    EQU  $FFAB
260:   C000             LISTEN    EQU  $FFB1
270:   C000             SECLIST   EQU  $FF93
280:   C000             IEEEOUT   EQU  $FFA8
290:   C000             UNLIST    EQU  $FFAE
300:   C000             WRITE     EQU  $FFD2
310:   C000             OPEN      EQU  $FFC0
320:   C000             CLOSE     EQU  $FFC3
330:   C000             SETPAR    EQU  $FFBA
340:   C000             SETNAM    EQU  $FFBD
350:   C000             CHKIN     EQU  $FFC6
360:   C000             CKOUT     EQU  $FFC9
370:   C000             CLRCH     EQU  $FFCC
380:   C000             CR        EQU  13
390:   C000             QUOTE     EQU  $22
400:   C000             QUOTFLG   EQU  $D4
410:   0200                       ORG  $200       ;BASIC INPUT
                                                    BUFFER
420:   0201             SAVX      BYT  0
430:   0202             WRAP      BYT  0
440:   0203             BAD       BYT  0
```

```
450:   0204            FROM      BYT  0
460:   0205            TO        BYT  0
470:   0205            STATUS    EQU  $90
480:   0205            SA        EQU  $B9         ;SECONDARY
                                                   ADDRESS
490:   0205            FA        EQU  $BA         ;DEVICE #
500:   0205            FNADR     EQU  $BB         ;FILENAME ADR
510:   0205            FNLEN     EQU  $B7         ;LEN OF
                                                   FILENAME
520:   0205            TMPC      EQU  $97
610:   C000            COUNT     EQU  8    ;# OF BYTES PER LINE
620:   C000            READY     EQU  $E37B       ;$E467 FOR VIC
630:   C000 A2 00      INIT      LDX  #0
640:   C002 BD 85 C2   MSGOUT    LDA  MESSAGE,X
650:   C005 20 D2 FF             JSR  WRITE
660:   C008 E8                   INX
670:   C009 E0 12                CPX  #ASCDMP-MESSAGE
680:   C00B D0 F5                BNE  MSGOUT
690:   C00D A2 0D      START     LDX  #CR
700:   C00F A9 3E                LDA  #PROMPT
710:   C011 20 EB C0             JSR  WRTWHR
710:   C014 A9 00                LDA  #0
710:   C016 8D 01 02             STA  WRAP
720:   C019 20 33 C1   ST1       JSR  RDOC ;READ INPUT LINE
730:   C01C C9 3E                CMP  #PROMPT
740:   C01E F0 F9                BEQ  ST1
750:   C020 C9 20                CMP  #" " ;READ OVER BLANK
760:   C022 F0 F5                BEQ  ST1
770:   C024 A2 05      S0        LDX  #NCMDS-1 ;COMPARE WITH
                                                COMMAND TABLE
780:   C026 DD 6A C0   S1        CMP  CMDS,X
790:   C029 D0 0C                BNE  S2
800:   C02B 8E 00 02             STX  SAVX ;# OF CMDS IN TABLE
840:   C02E BD 70 C0             LDA  ADRH,X
850:   C031 48                   PHA              ;JUMP ADDR TO
                                                   STACK
860:   C032 BD 76 C0             LDA  ADRL,X
870:   C035 48                   PHA
880:   C036 60                   RTS
890:   C037 CA         S2        DEX
900:   C038 10 EC                BPL  S1   ;LOOP OF ALL CMDS
910:   C03A 4C 0D C0             JMP  START
                        ;
                        ; SUBROUTINE TO DISPLAY
                        ; THE DISK CONTENTS
960:   C03D 85 97      DM        STA  TMPC
970:   C03F 20 62 C0   DM1       JSR  SPACE
980:   C042 B9 E0 C2             LDA  BUFFER,Y    ;GET BYTE FROM
                                                   BUFFER
990:   C045 20 DC C0             JSR  WROB
1000:  C048 C8                   INY
1000:  C049 D0 03                BNE  DM2
1000:  C04B EE 01 02             INC  WRAP
1010:  C04E C6 97      DM2       DEC  TMPC
1020:  C050 D0 ED                BNE  DM1
```

```
C052 60                     RTS
                  ; READ BYTES AND WRITE TO MEMORY
C053 20 FE C0 BYT           JSR  RDOB
C056 90 03                  BCC  BY3         ;BLANK?
C058 99 E0 C2               STA  BUFFER,Y    ;WRITE BYTE IN
                                              BUFFER
C05B C8       BY3           INY
C05C C6 97                  DEC  TMPC
C05E 60                     RTS
C05F 20 62 C0 SPAC2         JSR  SPACE
C062 A9 20    SPACE         LDA  #" "
C064 2C                     BYT  $2C
C065 A9 0D    CRLF          LDA  #CR
C067 4C D2 FF               JMP  WRITE
                  ;
                  ; COMMAND AND ADDRESS TABLE
C06A 3A       CMDS          ASC  ':'  ;EDIT MEM CONTENTS
C06B 57                     ASC  'W'  ;WRITE BLOCK
C06C 52                     ASC  'R'  ;READ BLOCK
C06D 4D                     ASC  'M'  ;DISLPAY BYTES
C06E 40                     ASC  '@'  ;DISK COMMAND
C06F 58                     ASC  'X'  ;EXIT
C070 C0       ADRH          EQU  >ALTM-1
C071 C1                     EQU  >DIRECT-1
C072 C1                     EQU  >DIRECT-1
C073 C0                     EQU  >DSPLYM-1
C074 C1                     EQU  >DISK-1
C075 E3                     EQU  >READY-1
C076 C0       ADRL          EQU  <ALTM-1
C077 90                     EQU  <DIRECT-1
C078 90                     EQU  <DIRECT-1
C079 7B                     EQU  <DSPLYM-1
C07A 3E                     EQU  <DISK-1
C07B 7A                     EQU  <READY-1
C07C A0 00    DSPLYM        LDY  #0
C07E 8C 03 02               STY  FROM
C081 88                     DEY
C082 8C 04 02               STY  TO
C085 20 CF FF               JSR  INPUT
C088 C9 0D                  CMP  #CR
C08A F0 17                  BEQ  DSP1
C08C 20 FE C0               JSR  RDOB        ;READ START
                                              ADDRESS
C08F 90 12                  BCC  DSP1
C091 8D 03 02               STA  FROM
C094 20 CF FF               JSR  INPUT
C097 C9 0D                  CMP  #CR
C099 F0 08                  BEQ  DSP1
C09B 20 FE C0               JSR  RDOB        ;READ END ADR
C09E 90 03                  BCC  DSP1
C0A0 8D 04 02               STA  TO
C0A3 AC 03 02 DSP1          LDY  TO
C0A6 20 C6 C2 DSP2          JSR  TESTEND
C0A9 20 D6 C2               JSR  ALTRIT
C0AC 98                     TYA
```

```
1480:   C0AD 20 DC C0          JSR   WROB       ;ADDRESS
1490:   C0B0 20 62 C0          JSR   SPACE      ;OMIT FOR VIC
1500:   C0B3 A9 08             LDA   #COUNT     ;8 OR 4
1510:   C0B5 20 3D C0          JSR   DM         ;DISPLAY
1520:   C0B8 20 97 C2          JSR   ASCDMP     ;ASCII DUMP
1530:   C0BB 4C A6 C0          JMP   DSP2       ;ABS JUMP
1550:   C0BE 4C 0D C0 BEQS1    JMP   START
                         ;EDIT MEMORY; READ ADDRESS AND DATA
1570:   C0C1 20 FE C0 ALTM     JSR   RDOB       ;READ ADDR
1580:   C0C4 90 F8             BCC   BEQS1
1590:   C0C6 A8                TAY
1600:   C0C7 A9 08             LDA   #COUNT     ;# OF BYTES
1610:   C0C9 85 97             STA   TMPC
1610:   C0CB 20 33 C1          JSR   RDOC       ;OMIT FOR VIC
1620:   C0CE 20 33 C1 A5       JSR   RDOC
1620:   C0D1 20 53 C0          JSR   BYT
1630:   C0D4 D0 F8             BNE   A5
1640:   C0D6 20 97 C2          JSR   ASCDMP
1650:   C0D9 4C 0D C0          JMP   START
                         ;
                         ;WRITE BYTE AS HEX NUMBER
1710:   C0DC 48       WROB     PHA
1720:   C0DD 4A                LSR   A
1730:   C0DE 4A                LSR   A
1740:   C0DF 4A                LSR   A
1750:   C0E0 4A                LSR   A
1760:   C0E1 20 F4 C0          JSR   ASCII      ;CONVERT TO
                                                 ASCII
1770:   C0E4 AA                TAX
1780:   C0E5 68                PLA
1790:   C0E6 29 0F             AND   #$0F
1800:   C0E8 20 F4 C0          JSR   ASCII
                         ; WRITE CHARACTERS IN X AND A
1820:   C0EB 48       WRTWHR   PHA
1830:   C0EC 8A                TXA
1840:   C0ED 20 D2 FF          JSR   WRITE
1850:   C0F0 68                PLA
1860:   C0F1 4C D2 FF          JMP   WRITE
1870:   C0F4 18       ASCII    CLC
1880:   C0F5 69 F6             ADC   #$F6
1890:   C0F7 90 02             BCC   ASC1
1900:   C0F9 69 06             ADC   #6
1910:   C0FB 69 3A    ASC1     ADC   #$3A
1920:   C0FD 60                RTS
                         ; READ HEX BYTE AND PUT IN A
1950:   C0FE A9 00    RDOB     LDA   #0
1960:   C100 8D 02 02          STA   BAD  ;READ NEXT CHAR
1970:   C103 20 33 C1          JSR   RDOC
1980:   C106 C9 20    RDOB1    CMP   #'
1990:   C108 D0 09             BNE   RDOB2
2000:   C10A 20 33 C1          JSR   RDOC ;READ NEXT CHAR
2010:   C10D C9 20             CMP   #'
2020:   C10F D0 0F             BNE   RDOB3
2030:   C111 18                CLC        ;CY=0
2040:   C112 60                RTS
```

```
C113 20 28 C1 RDOB2     JSR  HEXIT
C116 0A                 ASL  A
C117 0A                 ASL  A
C118 0A                 ASL  A
C119 0A                 ASL  A
C11A 8D 02 02           STA  BAD
C11D 20 33 C1           JSR  RDOC
C120 20 28 C1 RDOB3     JSR  HEXIT
C123 0D 02 02           ORA  BAD
C126 38                 SEC        ;CY=1
C127 60                 RTS
C128 C9 3A    HEXIT     CMP  #$3A
C12A 08                 PHP
C12B 29 0F              AND  #$0F
C12D 28                 PLP
C12E 90 02              BCC  HEX09       ;0-9
C130 69 08              ADC  #8          ;PLUS 9 (C-1)
C132 60       HEX09     RTS
C133 20 CF FF RDOC      JSR  INPUT       ;READ CHAR
C136 C9 0D              CMP  #CR         ;CR?
C138 D0 F8              BNE  HEX09       ;NO, RETURN
C13A 68                 PLA
C13B 68                 PLA
C13C 4C 0D C0           JMP  START
              ;
              ;
              ; DOS SUPPORT
C13F 20 CF FF DISK      JSR  INPUT
C142 C9 0D              CMP  #CR
C144 D0 27              BNE  DSKCMD      ;DISK COMMAND
C146 A9 00              LDA  #0
C148 85 90              STA  STATUS      ;ERASE STATUS
C14A 20 65 C0           JSR  CRLF
C14D A9 08              LDA  #8
C14F 85 BA              STA  FA          ;DISK ADDR
C151 20 B4 FF           JSR  TALK
C154 A9 6F              LDA  #15+$60     ;SA 15
C156 85 B9              STA  SA
C158 20 96 FF           JSR  SECTALK     ;SEC ADDR
C15B 20 A5 FF ERRIN     JSR  IEEEIN
C15E 24 90              BIT  STATUS
C160 70 05              BVS  ENDDSK
C162 20 D2 FF           JSR  WRITE
C165 D0 F4              BNE  ERRIN
C167 20 AB FF ENDDSK    JSR  UNTALK
C16A 4C 0D C0           JMP  START
C16D C9 24    DSKCMD    CMP  #'$
C16F F0 1D              BEQ  ERR1        ;CATALOG
C171 48                 PHA
C172 A9 08              LDA  #8
C174 85 BA              STA  FA
C176 20 B1 FF           JSR  LISTEN
C179 A9 6F              LDA  #15+$60
C17B 85 B9              STA  SA
C17D 20 93 FF           JSR  SECLIST
```

```
2560:  C180 68                    PLA
2570:  C181 20 A8 FF CMDOUT       JSR  IEEEOUT
2580:  C184 20 CF FF              JSR  INPUT
2590:  C187 C9 0D                 CMP  #CR
2600:  C189 D0 F6                 BNE  CMDOUT
2610:  C18B 20 AE FF              JSR  UNLIST
2630:  C18E 4C 0D C0 ERR1         JMP  START
2640:  C191 20 33 C1 DIRECT       JSR  RDOC
2640:  C194 20 FE C0              JSR  RDOB       ;READ TRACK
2650:  C197 90 F5                 BCC  ERR1
2660:  C199 8D 27 C2              STA  TRACK
2670:  C19C 20 33 C1              JSR  RDOC
2670:  C19F 20 FE C0              JSR  RDOB
2680:  C1A2 90 EA                 BCC  ERR1
2690:  C1A4 8D 2A C2              STA  SECTOR
2690:  C1A7 20 49 C2              JSR  OPNDIR
2690:  C1AA AD 00 02              LDA  SAVX
2690:  C1AD C9 01                 CMP  #1
2690:  C1AF F0 1E                 BEQ  DIRWRITE
2700:  C1B1 A9 31                 LDA  #'1
2710:  C1B3 20 ED C1              JSR  SENDCMD    ;SEND BLOCK
                                                   READ COMMAND
2720:  C1B6 A2 0D                 LDX  #13
2730:  C1B8 20 C6 FF              JSR  CHKIN
2740:  C1BB A2 00                 LDX  #0
2750:  C1BD 20 CF FF DIRIN        JSR  INPUT
2760:  C1C0 9D E0 C2              STA  BUFFER,X
2770:  C1C3 E8                    INX
2770:  C1C4 D0 F7                 BNE  DIRIN
2780:  C1C6 20 CC FF              JSR  CLRCH
2790:  C1C9 20 6E C2 ENDDIR       JSR  CLSDIR
2790:  C1CC 4C 0D C0              JMP  START
2800:  C1CF 20 2C C2 DIRWRITE     JSR  BUFPNT     ;SET BUFFER
                                                   POINTER
2810:  C1D2 A2 0D                 LDX  #13
2820:  C1D4 20 C9 FF              JSR  CKOUT
2830:  C1D7 A2 00                 LDX  #0
2840:  C1D9 BD E0 C2 DIROUT       LDA  BUFFER,X
2850:  C1DC 20 D2 FF              JSR  WRITE
2860:  C1DF E8                    INX
2860:  C1E0 D0 F7                 BNE  DIROUT
2870:  C1E2 20 CC FF              JSR  CLRCH
2880:  C1E5 A9 32                 LDA  #'2
2890:  C1E7 20 ED C1              JSR  SENDCMD    ;SEND BLOCK
                                           WRITE COMMAND
2900:  C1EA 4C C9 C1              JMP  ENDDIR
2910:  C1ED 8D 20 C2 SENDCMD      STA  CMDSTR+1
2910:  C1F0 A2 0F                 LDX  #15
2920:  C1F2 AD 27 C2              LDA  TRACK
2920:  C1F5 20 78 C2              JSR  NUMBASC
2920:  C1F8 8E 27 C2              STX  TRACK
2920:  C1FB 8D 28 C2              STA  TRACK+1
2930:  C1FE AD 2A C2              LDA  SECTOR
2930:  C201 20 78 C2              JSR  NUMBASC
2930:  C204 8E 2A C2              STX  SECTOR
```

```
2930:  C207 8D 2B C2              STA  SECTOR+1
2940:  C20A A2 0F                 LDX  #15
2940:  C20C 20 C9 FF              JSR  CKOUT
2950:  C20F A2 00                 LDX  #0
2960:  C211 BD 1F C1  COMDOUT     LDA  CMDSTR,X
2970:  C214 20 D2 FF              JSR  WRITE
2980:  C217 E8                    INX
2980:  C218 E0 0D                 CPX  #BUFPNT-CMDSTR
2990:  C21A D0 F5                 BNE  COMDOUT
3000:  C21C 4C CC FF              JMP  CLRCH
3010:  C21F 55 31 3A  CMDSTR      ASC  'U1:13 0 '
            31 33 20
            30 20
3020:  C227 00 00 20  TRACK       BYT  0,0,$20
3030:  C22A 00 00     SECTOR      BYT  0,0
3040:  C22C A2 0F     BUFPNT      LDX  #15
3050:  C22E 20 C9 FF              JSR  CKOUT
3060:  C231 A2 00                 LDX  #0
3070:  C233 BD 41 C2  PNTOUT      LDA  BUFTXT,X
3080:  C236 20 D2 FF              JSR  WRITE
3090:  C239 E8                    INX
3090:  C23A E0 08                 CPX  #OPNDIR-BUFTXT
3100:  C23C D0 F5                 BNE  PNTOUT
3110:  C23E 4C CC FF              JMP  CLRCH
3120:  C241 42 2D 50  BUFTXT      ASC  'B-P 13 0'
            20 31 33
            20 30
3130:  C249 A9 0F     OPNDIR      LDA  #15
3130:  C24B A8                    TAY
3140:  C24C A2 08                 LDX  #8
3150:  C24E 20 BA FF              JSR  SETPAR
3160:  C251 A9 00                 LDA  #0
3170:  C253 20 BD FF              JSR  SETNAM
3180:  C256 20 C0 FF              JSR  OPEN
3190:  C259 A9 0D                 LDA  #13
3190:  C25B A8                    TAY
3200:  C25C A2 08                 LDX  #8
3210:  C25E 20 BA FF              JSR  SETPAR
3220:  C261 A9 01                 LDA  #1
3230:  C263 A2 6D                 LDX  #<DADR
3240:  C265 A0 C2                 LDY  #>DADR
3250:  C267 20 BD FF              JSR  SETNAM
3260:  C26A 4C C0 FF              JMP  OPEN
3270:  C26D 23        DADR        .BYT '#
3280:  C26E A9 0D     CLSDIR      LDA  #13
3290:  C270 20 C3 FF              JSR  CLOSE
3300:  C273 A9 0F                 LDA  #15
3310:  C275 4C C3 FF              JMP  CLOSE
3230:  C278 A2 30     NUMBASC     LDX  #'0          ;HEX # TO AS
3330:  C27A 38                    SEC
3340:  C27B E9 0A     NUMB1       SBC  #10
3350:  C27D 90 03                 BCC  NUMB2
3360:  C27F E8                    INX
3370:  C280 B0 F9                 BCS  NUMB1
3380:  C282 69 3A     NUMB2       ADC  #$3B         ;'9' + 1
```

```
3390:  C284 60                   RTS
3400:  C285 0D         MESSAGE   EQU  CR
3410:  C286 44 49 53             ASC  'DISK-MONITOR V1.0'
            4B 2D 4D
            4F 4E 49
            54 4F 52
            20 56 31
            2E 30
3430:  C297 98         ASCDMP    TYA
3440:  C298 38                   SEC
3440:  C299 E9 08                SBC  #COUNT
3440:  C29B A8                   TAY
3450:  C29C 20 62 C0             JSR  SPACE
3460:  C29F A9 12                LDA  #18        ;RVS ON
3470:  C2A1 20 D2 FF             JSR  WRITE
3480:  C2A4 A2 08                LDX  #COUNT
3490:  C2A6 B9 E0 C2 AC2         LDA  BUFFER,Y
3500:  C2A9 29 7F                AND  #$7F
3510:  C2AB C9 20                CMP  #'
3520:  C2AD B0 04                BCS  AC3
3530:  C2AF A9 2E                LDA  #'.
3540:  C2B1 D0 03                BNE  AC4
3550:  C2B3 B9 E0 C2 AC3         LDA  BUFFER,Y
3560:  C2B6 20 D2 FF AC4         JSR  WRITE
3570:  C2B9 A9 00                LDA  #0
3570:  C2BB 85 D4                STA  QUOTFLG
3580:  C3BD C8                   INY
3580:  C2BE CA                   DEX
3590:  C2BF D0 E5                BNE  AC2
3600:  C2C1 A9 92                LDA  #146       ;RVS OFF
3610:  C2C3 4C D2 FF             JMP  WRITE
3620:  C2C6 AD 01 02 TESTEND     LDA  WRAP
3620:  C2C9 D0 06                BNE  ENDEND
3630:  C2CB CC 04 02             CPY  TO
3640:  C2CE B0 01                BCS  ENDEND
3650:  C2D0 60                   RTS
3660:  C2D1 68         ENDEND    PLA
3660:  C2D2 68                   PLA
3660:  C2D3 4C 0D C0             JMP  START
3670:  C2D6 20 65 C0 ALTRIT      JSR  CRLF
3680:  C2D9 A9 3A                LDA  #':
3690:  C2DB A2 3E                LDX  #PROMPT
3700:  C2DD 4C EB C0             JMP  WRTWHR
3730:  C2E0            BUFFER    DST  256   ;256 BYTE BUFFER
                                                  FOR BLOCK
```

Here is the BASIC program for entering the disk monitor if you do not have an assembler.

DISK-MONITOR, C64 VERSION

```
100 FOR I = 49152 TO 49887
110 READ X : POKE I,X : S=S+X : NEXT
120 DATA 162,  0,189,133,194, 32,210,255,232,224, 18,208
130 DATA 245,162, 13,169, 62, 32,235,192,169,  0,141,  1
140 DATA   2, 32, 51,193,201, 62,240,249,201, 32,240,245
150 DATA 162,  5,221,106,192,208, 12,142,  0,  2,189,112
160 DATA 192, 72,189,118,192, 72, 96,202, 16,236, 76, 13
170 DATA 192,133,151, 32, 98,192,185,224,194, 32,220,192
180 DATA 200,208,  3,238,  1,  2,198,151,208,237, 96, 32
190 DATA 254,192,144,  3,153,224,194,200,198,151, 96, 32
200 DATA  98,192,169, 32, 44,169, 13, 76,210,255, 58, 87
210 DATA  82, 77, 64, 88,192,193,193,192,193,227,192,144
220 DATA 144,123, 62,122,160,  0,140,  3,  2,136,140,  4
230 DATA   2, 32,207,255,201, 13,240, 23, 32,254,192,144
240 DATA  18,141,  3,  2, 32,207,255,201, 13,240,  8, 32
250 DATA 254,192,144,  3,141,  4,  2,172,  3,  2, 32,198
260 DATA 194, 32,214,194,152, 32,220,192, 32, 98,192,169
270 DATA   8, 32, 61,192, 32,151,194, 76,166,192, 76, 13
280 DATA 192, 32,254,192,144,248,168,169,  8,133,151, 32
290 DATA  51,193, 32, 51,193, 32, 83,192,208,248, 32,151
300 DATA 194, 76, 13,192, 72, 74, 74, 74, 74, 32,244,192
310 DATA 170,104, 41, 15, 32,244,192, 72,138, 32,210,255
320 DATA 104, 76,210,255, 24,105,246,144,  2,105,  6,105
330 DATA  58, 96,169,  0,141,  2,  2, 32, 51,193,201, 32
340 DATA 208,  9, 32, 51,193,201, 32,208, 15, 24, 96, 32
350 DATA  40,193, 10, 10, 10, 10,141,  2,  2, 32, 51,193
360 DATA  32, 40,193, 13,  2,  2, 56, 96,201, 58,  8, 41
370 DATA  15, 40,144,  2,105,  8, 96, 32,207,255,201, 13
380 DATA 208,248,104,104, 76, 13,192, 32,207,255,201, 13
390 DATA 208, 39,169,  0,133,144, 32,101,192,169,  8,133
400 DATA 186, 32,180,255,169,111,133,185, 32,150,255, 32
410 DATA 165,255, 36,144,112,  5, 32,210,255,208,244, 32
420 DATA 171,255, 76, 13,192,201, 36,240, 29, 72,169,  8
430 DATA 133,186, 32,177,255,169,111,133,185, 32,147,255
440 DATA 104, 32,168,255, 32,207,255,201, 13,208,246, 32
450 DATA 174,255, 76, 13,192, 32, 51,193, 32,254,192,144
460 DATA 245,141, 39,194, 32, 51,193, 32,254,192,144,234
470 DATA 141, 42,194, 32, 73,194,173,  0,  2,201,  1,240
480 DATA  30,169, 49, 32,237,193,162, 13, 32,198,255,162
490 DATA   0, 32,207,255,157,224,194,232,208,247, 32,204
500 DATA 255, 32,110,194, 76, 13,192, 32, 44,194,162, 13
510 DATA  32,201,255,162,  0,189,224,194, 32,210,255,232
520 DATA 208,247, 32,204,255,169, 50, 32,237,193, 76,201
530 DATA 193,141, 32,194,162, 15,173, 39,194, 32,120,194
540 DATA 142, 39,194,141, 40,194,173, 42,194, 32,120,194
550 DATA 142, 42,194,141, 43,194,162, 15, 32,201,255,162
560 DATA   0,189, 31,194, 32,210,255,232,224, 13,208,245
570 DATA  76,204,255, 85, 49, 58, 49, 51, 32, 48, 32,  0
580 DATA   0, 32,  0,  0,162, 15, 32,201,255,162,  0,189
590 DATA  65,194, 32,210,255,232,224,  8,208,245, 76,204
600 DATA 255, 66, 45, 80, 32, 49, 51, 32, 48,169, 15,168
610 DATA 162,  8, 32,186,255,169,  0, 32,189,255, 32,192
```

```
620 DATA 255,169, 13,168,162,  8, 32,186,255,169,  1,162
630 DATA 109,160,194, 32,189,255, 76,192,255, 35,169, 13
640 DATA  32,195,255,169, 15, 76,195,255,162, 48, 56,233
650 DATA  10,144,  3,232,176,249,105, 58, 96, 13, 68, 73
660 DATA  83, 75, 45, 77, 79, 78, 73, 84, 79, 82, 32, 86
670 DATA  49, 46, 48,152, 56,233,  8,168, 32, 98,192,169
680 DATA  18, 32,210,255,162,  8,185,224,194, 41,127,201
690 DATA  32,176,  4,169, 46,208,  3,185,224,194, 32,210
700 DATA 255,169,  0,133,212,200,202,208,229,169,146, 76
710 DATA 210,255,173,  1,  2,208,  6,204,  4,  2,176,  1
720 DATA  96,104,104, 76, 13,192, 32,101,192,169, 58,162
730 DATA  62, 76,235,192
740 IF S <> 90444 THEN PRINT "ERROR IN DATA !!" : END
750 SYS 49152
```

DISK-MONITOR, VIC 20 VERSION

In order to allow this program to be run on the VIC 20, it was split into two parts. Enter each program separately, saving the first under the name "DOS LOADER.1" and second under "DOS LOADER.2". To load the disk monitor, load the first program and start it with RUN. If all data are correct, the second program will automatically be loaded and the disk monitor started.

```
100 POKE 55, 6690 AND 255 : POKE 56, 6690 / 256 : CLR
105 FOR I = 6690 TO 7056 : REM DOS LOADER.1
110 READ X : POKE I,X : S=S+X : NEXT
120 DATA 162,  0,189,164, 28, 32,210,255,232,224, 18,208
130 DATA 245,162, 13,169, 62, 32,  7, 27,169,  0,141,  1
140 DATA   2, 32, 79, 27,201, 62,240,249,201, 32,240,245
150 DATA 162,  5,221,140, 26,208, 12,142,  0,  2,189,146
160 DATA  26, 72,189,152, 26, 72, 96,202, 16,236, 76, 47
170 DATA  26,133,151, 32,132, 26,185,  0, 29, 32,248, 26
180 DATA 200,208,  3,238,  1,  2,198,151,208,237, 96, 32
190 DATA  26, 27,144,  3,153,  0, 29,200,198,151, 96, 32
200 DATA 132, 26,169, 32, 44,169, 13, 76,210,255, 58, 87
210 DATA  82, 77, 64, 88, 26, 27, 27, 26, 27,228,223,175
220 DATA 175,157, 90,102,160,  0,140,  3,  2,136,140,  4
230 DATA   2, 32,207,255,201, 13,240, 23, 32, 26, 27,144
240 DATA  18,141,  3,  2, 32,207,255,201, 13,240,  8, 32
250 DATA  26, 27,144,  3,141,  4,  2,172,  3,  2, 32,229
260 DATA  28, 32,245, 28,152, 32,248, 26,169,  4, 32, 95
270 DATA  26, 32,182, 28, 76,200, 26, 76, 47, 26, 32, 26
280 DATA  27,144,248,168,169,  4,133,151, 32, 79, 27, 32
290 DATA 117, 26,208,248, 32,182, 28, 76, 47, 26, 72, 74
300 DATA  74, 74, 74, 32, 16, 27,170,104, 41, 15, 32, 16
310 DATA  27, 72,138, 32,210,255,104, 76,210,255, 24,105
320 DATA 246,144,  2,105,  6,105, 58, 96,169,  0,141,  2
330 DATA   2, 32, 79, 27,201, 32,208,  9, 32, 79, 27,201
340 DATA  32,208, 15, 24, 96, 32, 68, 27, 10, 10, 10, 10
350 DATA 141,  2,  2, 32, 79, 27, 32, 68, 27, 13,  2,  2
360 DATA  56, 96,201, 58,  8, 41, 15, 40,144,  2,105,  8
```

```
370 DATA  96, 32,207,255,201, 13,208,248,104,104, 76, 47
380 DATA  26, 32,207,255,201, 13,208, 39,169,  0,133,144
390 DATA  32,135, 26,169,  8,133,186, 32,180,255,169,111
400 DATA 133,185, 32,150,255, 32,165,255, 36,144,112,  5
410 DATA  32,210,255,208,244, 32,171,255, 76, 47, 26,201
420 DATA  36,240, 29, 72,169,  8,133
430 IF S <> 35614 THEN PRINT "ERROR IN DATA !!" : END
440 LOAD "DOS LOADER.2",8
```

```
100 CLR : FOR I = 7057 TO 7422 : REM DOS LOADER.2
110 READ X : POKE I,X : S=S+X : NEXT
120 DATA 186, 32,177,255,169,111,133,185, 32,147,255,104
130 DATA  32,168,255, 32,207,255,201, 13,208,246, 32,174
140 DATA 255, 76, 47, 26, 76, 47, 26, 32, 79, 27, 32, 26
150 DATA  27,144,245,141, 70, 28, 32, 79, 27, 32, 26, 27
160 DATA 144,234,141, 73, 28, 32,104, 28,173,  0,  2,201
170 DATA   1,240, 30,169, 49, 32, 12, 28,162, 13, 32,198
180 DATA 255,162,  0, 32,207,255,157,  0, 29,232,208,247
190 DATA  32,204,255, 32,141, 28, 76, 47, 26, 32, 75, 28
200 DATA 162, 13, 32,201,255,162,  0,189,  0, 29, 32,210
210 DATA 255,232,208,247, 32,204,255,169, 50, 32, 12, 28
220 DATA  76,232, 27,141, 63, 28,162, 15,173, 70, 28, 32
230 DATA 151, 28,142, 70, 28,141, 71, 28,173, 73, 28, 32
240 DATA 151, 28,142, 73, 28,141, 74, 28,162, 15, 32,201
250 DATA 255,162,  0,189, 62, 28, 32,210,255,232,224, 13
260 DATA 208,245, 76,204,255, 85, 49, 58, 49, 51, 32, 48
270 DATA  32,  0,  0, 32,  0,  0,162, 15, 32,201,255,162
280 DATA   0,189, 96, 28, 32,210,255,232,224,  8,208,245
290 DATA  76,204,255, 66, 45, 80, 32, 49, 51, 32, 48,169
300 DATA  15,168,162,  8, 32,186,255,169,  0, 32,189,255
310 DATA  32,192,255,169, 13,168,162,  8, 32,186,255,169
320 DATA   1,162,140,160, 28, 32,189,255, 76,192,255, 35
330 DATA 169, 13, 32,195,255,169, 15, 76,195,255,162, 48
340 DATA  56,233, 10,144,  3,232,176,249,105, 58, 96, 13
350 DATA  68, 73, 83, 75, 45, 77, 79, 78, 73, 84, 79, 82
360 DATA  32, 86, 49, 46, 48,152, 56,233,  4,168, 32,132
370 DATA  26,169, 18, 32,210,255,162,  4,185,  0, 29, 41
380 DATA 127,201, 32,176,  4,169, 46,208,  3,185,  0, 29
390 DATA  32,210,255,169,  0,133,212,200,202,208,229,169
400 DATA 146, 76,210,255,173,  1,  2,208,  6,204,  4,  2
410 DATA 176,  1, 96,104,104, 76, 47, 26, 32,135, 26,169
420 DATA  58,162, 62, 76,  7, 27
430 IF S <> 39496 THEN PRINT "ERROR IN DATA !!" : END
440 SYS 6690
```

Chapter 5: The Larger CBM Disks

5.1 IEEE-Bus and Serial Bus

Standard Commodore 64's and VIC 20's have a serial bus over which they communicate with peripheral devices such as the VIC 1541 disk drive as well as printers and plotters.

The principle of the bus makes it possible to chain peripherals. Each device has its own device address over which one can communicate with it. The standard address of the disk is 8, a printer is usually 4. The device address is identical to the primary address in the OPEN command. For instance,

```
OPEN 1,4
```

opens a channel to the printer. In order to open several disk files at once, another address, the secondary address, serves to distinguish them. The disk has 16 secondary addresses at its disposal, from 0 to 15. Three secondary addresses are reserved, while the other 13 can be freely used:

Secondary address 0 is used for loading programs.

Secondary address 1 is used for saving programs.

Secondary address 15 is the command and error channel.

The secondary addresses from 2 to 14 can be used for opening files as desired.

The transfer of information between the Commodore 64 and the VIC 1541 occurs serially over this bus. Serial means that the the data is sent a bit at a time over just one wire. Data within the computer and disk drive are stored and manipulated in 8 bit groups called bytes. When a byte is sent serially, each individual bit must be sent over the data line. In order that the sender and receiver can stay in step, a so-called 'handshake' line is needed. If we look at the pin-out of the serial bus, we find 6 wires:

Pin	Function
1	SRQ IN
2	ground
3	ATN
4	CLCK
5	DATA
6	RESET

If the computer wants to send data to the disk drive, the

ATN (attention) line is set. When this signal is high, all peripherals on the bus stop their work and read the next byte. The data is sent bit-wise over the DATA line. So that the receivers know when the next bit comes, a signal is also sent along the CLCK (clock) line. This transmitted byte is the device address. If this value does not correspond with the device address of a receiving peripheral, the rest of the data is ignored. If, however, the device is addressed, a secondary address may be transmitted. Along with the device address (0 to 31), the device is informed by means of the other three bits whether it is supposed to receive data (LISTEN) or send data (TALK). Following this, data is sent from the computer or from the addressed device.

The RESET line resets all attached devices when the computer is turned on. Over the SRQ IN (service request) line, peripheral devices can inform the bus controller (in our case, the computer), if data is ready, for example. However, this line is not checked by the control system in the Commodore computers.

If one wants to attach several disk drives to the same computer, each must have a different peripheral address. If this is done only occasionally, the program **DISK ADDR CHANGE** can be used, as described in section 4.2.3. The new address (9 for example), remains only until the device is turned off. If the change should be permanent, it can be changed with DIP switches in the drive.

The principle of transfer of data over the IEEE 488 bus is similar to the serial bus function. The important difference is that the data is transmitted over 8 data lines in parallel, not serial. In addition, more handshake lines are needed, so the IEEE bus requires a 24-line cable. The main advantage of the IEEE 488 bus is its ability to transmit a byte at a time, resulting in a higher rate of transfer. Measurements indicate that the IEEE-bus is about 5 times faster than the serial bus: 1.8 Kbyte/second vs. 0.4 Kbyte/second. Loading a 10K program with the VIC 1541 takes about 25 seconds; on the identical 2031, it takes less than 6. This reason alone is enough to warrant outfitting your computer with an IEEE bus.

At the same time, it is possible to use all the other peripherals that the large CBM computers can access.

5.2 Comparison of all CBM Disk Drives

In the following table you find the technical data of all CBM disk drives compared.

The Technical Data of all Commodore Disk Drives

Model	1541	2031	4040	8050	8250
DOS version(s)	2.6	2.6	2.1/ 2.7	2.5/ 2.7	2.7
Drives	1	1	2	2	2
Heads per drive	1	1	1	1	2
Storage capacity	170 K	170 K	340 K	1.05 M	2.12 M
Sequential files	168 K	168 K	168 K	521 K	1.05 M
Relative files	167 K	167 K	167 K	183 K/ 518 K	1,04 M
Buffer storage (KB)	2	2	4	4	4
Tracks	35	35	35	77	77
Sectors per track	17-21	17-21	17-21	23-29	23-29
Bytes per block	256	256	256	256	256
Free blocks	664	664	1328	4104	8266
Directory and BAM (track)	18	18	18	38/39	38/39
Directory entries	144	144	144	224	224
Transfer rate (KB/s)					
internal	40	40	40	40	40
over ser./IEEE bus	0.4	1.8	1.8	1.8	1.8
Access time (ms)					
Track to track	30	30	30	5	5
Average time	360	360	360	125	125
Revolutions/minute	300	300	300	300	300

Overview of the "large" CBM drives

The VIC 1541 disk drive has the smallest storage capacity of the CBM disks, but it is also the only drive that can be connected directly to the Commodore 64 and VIC 20 over the serial bus.

The functions, construction, and operation are identical to those of the CBM 2031 drive. The only difference from the VIC 1541 is the parallel IEEE bus instead of the serial bus.

This results in an increase in the transfer rate to the computer of a factor of 5. To connect a Commodore 64 or VIC 20, one needs an IEEE interface, as with all other CBM drives. The storage format of the 2031 is compatible to the 1541; both have 170K per disk. Diskettes can be written with one device and read with the other. This is true for the next drive in the line, the CBM 4040. The 4040 is a double drive with 170K per drive.

The advantage of a double drive lies not only in the increased storage capacity, but also in the ability to transfer data from drive to drive. It is possible to copy complete programs and files using the existing 1541 command.

```
OPEN 1,8,15, "C1:TEST=0:TEST"  or

COPY "TEST",D0 TO "TEST",D1
```

copies the file **TEST** from drive 0 to drive 1 with the same name. In this manner one can concatenate several files on different drives. The most important capability of double drives is the ability to duplicate entire diskettes. This is accomplished by a command from the computer; the drive automatically formats the disk and then makes a track by track copy from one drive to the other. The command to do this is worded:

```
OPEN 1,8,15, "D1=0"  or

BACKUP D0 TO D1
```

The process takes less than 3 minutes on the 4040; during this time the computer may be used since the disk drive performs the entire operation by itself.

The two other CBM drives, the CBM 8050 and the CBM 8250 operate in double density (77 tracks). Disks written with the 1541 or 4040 are not compatible with the 8050/8250. Programs and data can be copied with the **COPY/ALL** program, which transfers from one format to another. This is the reason these drives have greater storage capacity: 1 MB for the 8050 and 2 MB for the 8250. The doubled capacity of the 8250 comes about because both sides of the disk are used (double-sided); it has two reads/write heads per drive. In order to be able to use the whole capacity for relative files (see section 3.4), a so-called 'super side-sector' was introduced, which contains pointers to 127 groups of 6 side-sector blocks each. Through this, a relative file can (theoretically) hold 23 MB of data. These drives can be connected to a Commodore 64 or VIC 20 over an IEEE bus, so that these computers can also access several megabytes.

An additional advantage of the large CBM drives is their larger buffer storage. It is possible to have more files open simultaneously than on the VIC 1541. Up to 5 sequential files or 3 relative files may be open at any one time, as well as combinations of the two, of course.

With the 8050/8250 format, tracks 38 and 39 are used for the BAM and directory. The disk name and format marker are in track 39 sector 0.

```
>:00  26 00 43 00 00 00 43 42  &.C...CB
>:08  4E 20 38 30 35 30 A0 A0  M 8050
>:10  A0 A0 A0 A0 A0 A0 A0 A0
>:18  30 31 A0 32 43 A0 A0 A0  01 2C
```

The track/sector pointer to the first BAM block (track 38 sector 0) is in bytes 0 and 1. Byte 2 contains the format marker 'C'. Bytes 3 through 5 are unused. The disk name is in 6 to 21, filled with shifted spaces, in our case **CBM 8050.** Bytes 24 and 25 contain the id '01', while bytes 26 and 27 contain the DOS format **2C.**

The BAM no longer occupies just one block, but is dispersed over track 38; sectors 0 and 3 are used in the 8050, the 8250 used sectors 6 and 9 in addition. Because more sectors are use per track, the BAM entry for each track has been enlarged to 5 bytes. The first byte still contains the number of free sectors per track and the following bytes contain the bit model of the free and allocated sectors (0 = sector allocated, 1 = sector free). Here we have the contents of track 38 sector 0

```
>:00  26 03 43 00 01 33 1D FF
>:08  FF FF 1F 1D FF FF FF 1F
>:10  1D FF FF FF 1F 1D FF FF
>:18  FF 1F 1D FF FF FF 1F 1D
>:20  FF FF FF 1F 1D FF FF FF
>:28  1F 1D FF FF FF 1F 1D FF
>:30  FF FF 1F 1D FF FF FF 1F
>:38  1D FF FF FF 1F 1D FF FF
>:40  FF 1F 1D FF FF FF 1F 1D
>:48  FF FF FF 1F 1D FF FF FF
>:50  1F 1D FF FF FF 1F 1D FF
>:58  FF FF 1F 1D FF FF FF 1F
>:60  1D FF FF FF 1F 1D FF FF
>:68  FF 1F 1D FF FF FF 1F 1D
>:70  FF FF FF 1F 1D FF FF FF
>:78  1F 1D FF FF FF 1F 1D FF
>:80  FF FF 1F 1D FF FF FF 1F
>:88  1D FF FF FF 1F 1D FF FF
>:90  FF 1F 1D FF FF FF 1F 1D
>:98  FF FF FF 1F 1D FF FF FF
>:A0  1F 1D FF FF FF 1F 1D FF
>:A8  FF FF 1F 18 FC F3 EF 1F
>:B0  00 00 00 00 00 00 00 00
>:B8  00 00 00 00 00 00 00 0F
>:C0  F4 93 46 1A 18 6C FB FF
>:C8  1F 00 00 00 00 00 00 00
```

```
>:D0   00 00 00 00 00 00 00 00
>:D8   05 00 00 4D 04 1B FF FF
>:E0   FF 07 1B FF FF FF 07 1B
>:E8   FF FF FF 07 1B FF FF FF
>:F0   07 1B FF FF FF 07 1B FF
>:F8   FF FF 07 1B FF FF FF 07
```

Bytes 0 and 1 point to the next BAM block, track 38 sector 3. Byte 2 contains the format marker 'C' again. The track numbers belonging to this BAM section are in bytes 4 and 5; here tracks 1 through 51. At position 6 we find the 5 byte entry for each track. The next BAM block is constructed similarly. The last BAM block always points to the first directory block: track 39 sector 1.

Four BAM blocks are needed for the 8250: track 38 sector 0 contains the tracks 1 to 51, track 38 sector 3 contains 52 to 100, track 38 sector 6 contains track 101 through 150 and track 38 sector 9 pertains to tracks 151 to 154.

The directory track, track 39, contains 28 free blocks; up to 28*8=224 directory entries can be stored, in contrast to 144 for the 1541/4040. The construction of the directory is alike for all formats. The following table illustrates the track/sector layout:

	1541 / 4040	8050 / 8250	
Tracks	1 - 17 : 0 - 20	1 - 39 : 0 - 28	sectors
	18- 24 : 0 - 18	40 - 53 : 0 - 26	
	25- 30 : 0 - 17	54 - 64 : 0 - 24	
	31- 35 : 0 - 16	65 - 77 : 0 - 22	
		8250 only	
		78 -116 : 0 - 28	
		117 -130 : 0 - 26	
		131 -141 : 0 - 24	
		142 -154 : 0 - 22	
Blocks	683	2083 : 4186	
Free blocks	664	2052 : 4133	

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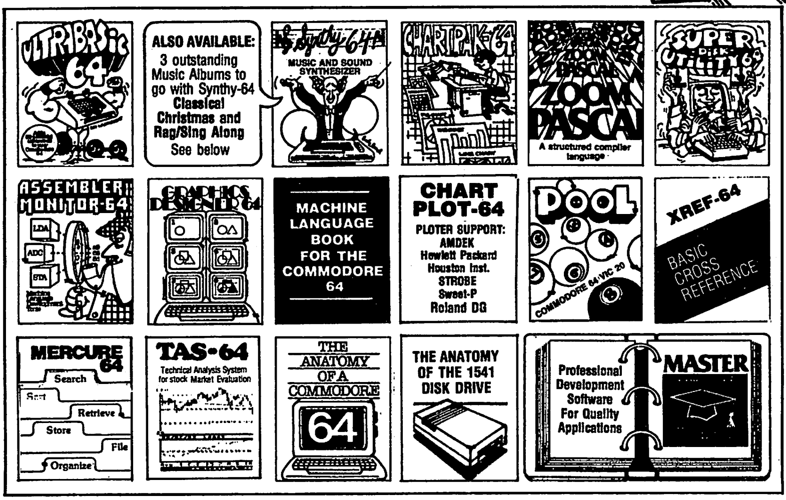

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