

# A Tale of Two Cartridges

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## *Final Cartridge III vs. Action Replay Mk. IV*

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### Review by Noel Nyman

The Final Cartridge III, \$54.99

Action Replay Mk. IV, \$59.99

(prices in U.S. dollars)

Both cartridges distributed by Datel Computers, 3430 E. Tropicana Ave., Unit #67, Las Vegas, NV 89121

These cartridges are aimed at different audiences. The FC-III is billed as "a powerful 64K ROM-based operating system for the C64 and C128." The emphasis is on "keep it simple" for the beginner, while giving all users extra features such as a notepad and calculator available as 'windows.'

The Mk. IV is advertised in full page, four colour magazine ads as "the ultimate backup cartridge." The drawings show a futuristic space vehicle cartridge "docking" at the C64 expansion port.

In spite of the differences in marketing, the cartridges have much in common (see the comparison chart accompanying this review).

### Final Cartridge III

The FC-III comes in a box nearly the size of the C64 itself, slickly printed with color pictures of various computer screens and descriptions of features. A carrying handle is provided, in case you find the need to tote a two by three inch cartridge around in a eight by twelve inch box.

The large box is necessary for the documentation, which should win an award for originality of format. The pages measure about eight by twelve. They are loose in the box, and punched with two holes on the eight inch side. Metal tabs are provided to hold the pages together.

Each piece of paper has four document pages printed on it. If folded in half, the collated pages would make an average sized booklet. Unfortunately, if you did that with the FC-III docs, the page numbers would be scattered all over the place.

The documentation is clear and easy to read, though occasionally brief. Some commands described are not mentioned in the summaries, which makes looking them up difficult. There are a few awkward phrases, typical of manuals translated from one language to another (FC-III originates in the Netherlands). Some of the diagrams do not correspond to the actual screen displays. More on this later.

The cartridge is the usual black shell with a few surprises added. There are two square switch buttons identified as "reset" and "freeze." A small red LED lights when the FC-III is active and goes off when the cartridge is 'killed.'

On power-up, you see a menu bar across the top of the screen in place of the usual start-up screen. This bar controls several pull-down menus which, in turn, control the cartridge options.

You select one of the bar options by 'pointing' at it and 'clicking.' The pointer on the FC-III is a coloured arrow. You move the arrow using a mouse, a joystick, or the function keys. Once you've pointed at an item, you select it by 'clicking' ...pressing the mouse button, the joystick fire button, or the Commodore logo key on the keyboard.

The choice of the function keys instead of the cursor keys to move the pointer is frustrating. I kept hitting the cursor keys out of habit. I often overshot my target when using a joystick. The pointer speed and acceleration can be changed. But it can't be slowed enough to let joystick novices such as me operate efficiently.

### Windows arrive

FC-III brings 'windows' to the C64, common in other computer operating systems such as the Amiga and Macintosh. A window is a box that appears on the screen, and is used to perform an operating system function. If other information is already on the screen, the current or active window overlaps it. You can move windows around and display several at one time, although only one will be active. When you've finished with the function controlled by a window, the window disappears and whatever screen information was under it is restored.

### Cartridge comparison chart

	MK-IV	FC-III
Window driven		*
Clock/alarm		*
Calculator		*
Notepad		*
<b>Printing</b>		
Low -res screen		*
High -res screen:	*	*
"negative" print	*	*
change size		*
print sideways		*
print sprites		*(1)
<b>Disk operations</b>		
Fast load	*(2)	*
Fast save	*	*
Fast format	*	*
"Wedge" commands	*	*(3)
File copy	*	
Disk copy	*	
<b>Freeze</b>		
Backup memory	*	*
View sprites in memory	*	
Save sprites	*	*(4)
Change sprites	*(5)	
Disable collision det	*	*
Swap joystick ports		*
Add "autofire"		*
Save screen to disk	*	
Poke memory	*(6)	*(6)
Modify text	*	

#### Notes

(1) In some games, sprites definitions are changed part way down the screen using a "raster interrupt" routine. Depending on the raster location at the moment of freezing, some sprites may not appear on the hard copy.

(2) The MK-IV offers two fast loading routines; see text.

(3) Some of the standard wedge commands are available in the FC-III by using unusual syntax. Sending DOS commands from BASIC follows the Simons' BASIC syntax. For example, to see a disk directory, you type: DOS "\$

(4) The FC-III can save any portion of memory with the MLmonitor. But, the user must identify the starting and ending addresses for the sprite.

(5) Limited sprite editing: flip, erase, mirror, and reverse.

(6) "Pokes" or parameter changes can also be made through the ML mon-

The advantage of windows is that a computer novice can operate the system quickly. No need to learn complex commands like **load "\$", 8** to view a disk directory, for example.

The disadvantage of windows for the experienced user is that you have to use the pointer to access everything, even if you know faster methods. Another disadvantage unique to FC-III windows is that they are only available in the 'desktop' mode. You can't call the window functions from a BASIC program or in direct mode from the BASIC screen. When you exit to 'desktop' from BASIC, you lose anything in BASIC memory.

Instead of icons (little drawings that somewhat resemble the options they represent), the FC-III uses mostly 'gadgets,' small blocks with real words inside them.

To read a disk directory, you point to the "utilities" option on the menu bar and hold the 'clicker' button or logo key. Five options are displayed, including "disk." Move the pointer down until the disk option is highlighted. Releasing the clicker causes the Disk Operations window to appear on the screen.

The window, which takes up about half the screen, is filled with gadgets. The largest one is the window's top border, a series of horizontal lines. By pointing at this gadget, holding the clicker, and moving the pointer, you can 'drag' the window to any location on the screen. This is typical of windows as used on other computers.

There are three DIR gadgets, each with an '8' and '9' gadget. To get a directory from drive 8, point to and click on the '8' gadget for one of the DIR's. The '8' will be highlighted. Then point to the DIR and click. A new window will appear, with the disk name and the first ten directory entries listed. Two arrow icons let you scroll up and down through the directory.

At the bottom of the new window are two additional gadgets, SORT and READ. The SORT gadget is not mentioned in the documentation, and the diagram of the directory window does not show it. If you click on SORT, the READ gadget is replaced by LINE. The files' listing order doesn't change.

If you select a file name by pointing/clicking on it, then click on LINE, you'll be given the option of adding a line above the selected file name. Now, when you click on SORT again you'll be asked if you want to write the directory back to the disk. When I tried that, all the windows vanished, the computer locked up, and I had to reset with the cartridge switch. Perhaps there is a way to sort the directory with the undocumented SORT gadget, but I couldn't find one.

The READ gadget is used to re-read the directory when you change disks. An alternative is to change disks, then call up a second window using a different directory window. The second window will overlap the previous windows.

The "exchange" icon (a bright square overlapping a dark square) is used to exchange the top, 'active' window with the last active window. The window now on top becomes the current window (usually, see the exception below). Or, if the option you want on an inactive window is visible, clicking on it will sometimes make its window active and initiate the action.

The "de-select" icon (a bright square with a dot in it), is used to remove a window from the screen. This does not remove it from memory, however. If you re-activate the window the old information re-appears in it.

This may be an advantage... keeping old directory listings handy in memory for future reference. But for most of us, it adds another point/click sequence on the READ gadget unnecessarily. The only way to completely initialize the windows is to exit to BASIC, then return via the DESKTOP command, or reset the cartridge.

## More disk operations

From the Disk Operations window, you can execute many common disk commands, as well as a few new ones. "Fast format" takes about 28 seconds. It gives you a prompt window, reminding you that this command will wipe out existing data, with the option to abort. Again, the pointer must be moved and clicked to either continue or abort the format.

When you select fast format, the name of the last disk read appears in the "from" window. If you don't select that window and type in a new disk name and ID, the disk will be formatted using the name and ID of the last disk you read.

"Empty" performs a 'short New,' which reformats the directory to 'erase' all disk files. You can also rename and scratch files, validate or rename the disk, and read the disk status. For most of these commands, you'll need to select the appropriate gadget, then select the DO gadget to perform the command.

RUNning a file can be more complex. First, you select the file to be RUN by pointing/clicking. Then you click on the RUN gadget and the DO gadget. FC-III will pop up a new window reminding you that you'll leave the desktop. If you click on the RUN gadget in the new window, FC-III will switch to BASIC mode and LOAD and RUN the file.

As a challenge, FC-III does not identify the file types in the directory. This makes it easy to try to RUN sequential files. The system doesn't check for this possibility (assuming that you've memorized all your disks' file types, I guess), and will try to RUN the sequential file. The user is left with a flashing light on the disk drive and a "?FILE NOT FOUND ERROR" message on the BASIC screen. Very cryptic indeed for the novice, who will be frustrated by the fact that the file obviously *is* there in the directory window!

Also, if you have several directory windows, you can highlight a file in any of them for the RUN command. But, you'll get a "no file selected" message if the DIR window you've used isn't the active one in the Disk Operations window.

## Other FC-III window options

Another window lets you set a system clock in either 12 or 24 hour format and add an alarm as well. The docs don't tell you that you can't set the alarm unless you've already selected alarm mode in the clock pull-down menu.

A simple calculator window is also available. It does four-function math with a memory. Fortunately, you can enter numbers from the keyboard rather than by pointing/clicking their gadgets, although that works too. The calculator does not include square root, per cent, or memory +/- as shown in the picture on the front of the FC-III box.

### LOAD COMPARISON TIMES

	no cart	FC-III	Mk. IV Turbo	Warp
Flight Simulator, to Miags field (size in blocks)	3:35	0:30 (196)	0:24 (199)	0:12 (211)
Disk Maintenance, to main menu (size in blocks)	1:08	0:19 (138)	0:16 (133)	0:08 (141)
Easy Script, to document in place (size in blocks)	0:57	0:16 (88)	0:11 (67)	0:07 (71)
BASIC program that loads data (size in blocks)	1:49 (145)	0:17 (107)	0:12 (101)	0:07 (106)

Another window lets you change some of the desktop preferences, such as screen colours, pointer device port, and pointer speed. The BASIC preferences window lets you add a keyboard click, key repeat, defeat cursor blink, change the default device, and use the numeric keypad on a C128 in C64 mode. There appears to be no way to save the new preferences for future sessions. They have to be changed to your liking

each time the computer is turned on. With all the pointing and clicking required, I soon settled for the default values.

The Notepad option removes windows and gives the user a blank screen with a new set of pull down menus. Text can be entered and edited using the regular cursor keys. You can control the line and character spacing, and select bold and proportional print, and wordwrap. The text is not limited to a single screen, and the resulting file can be SAVED to disk or tape and recalled later in Notepad mode. It can also be printed.

The FC-III supports Commodore, RS-232 serial, and Centronics parallel printers. The latter two types require a special cable "available from your dealer." That may be true in Europe, but here, the few local Commodore dealers knew nothing about any special cable. But it is available mail order for \$20 US.

I tested the cartridge with a Star Micronics SG-10 and a Micro-Graphix MW-350 interface set for Commodore emulation. This combination usually works well as a 'Commodore' printer. The result was a plain vanilla printout of the text... no proportional spacing. The text did word-wrap properly, in 80 columns rather than the 64 columns used for the screen display. The printer locked up when I tried printing in bold.

The Notepad text files are stored as PRG types in PET ASCII. The various options such as proportional print and line spacing, are screen options only and are not SAVED with the text. Text files from other sources can be brought into the Notepad, provided the file is type PRG. Since the first two bytes of a program file are the load address, Notepad automatically removes them. If your file was originally a sequential type, the first two text characters will be discarded instead. There's no way to view a disk directory from Notepad mode.

### FC-III BASIC additions

The FC-III adds several features to BASIC. LIST scrolls up as well as down. A Shift-L in a REM normally defeats LISTING. Shift-L with the FC-III in place LISTS as OFF, so the balance of the program will LIST properly. The OFF command is documented as part of the TRACE OFF and BAR OFF options. But, used by itself, it appears to be equivalent to KILL, which disables the cartridge.

Also handy are the DUMP command, which displays the values of all simple variables, and the ARRAY command which does the same for arrays, including string arrays. The DUMP command has trouble with DEF FN's. It confuses them with integers and uses the bytes that point to the definition address (low/high order) as an integer value (high/low order).

The MEM command shows the total BASIC bytes available, and how many are used by program, variables, arrays, strings, and how many are free. Although the documentation claims that FC-III adds "24K bytes extra memory in BASIC," the MEM command reveals only the standard 38,911 bytes available.

TRACE displays each line of BASIC at the top of the screen as it's executed. TRACE can be slowed to a viewable speed using the CTRL key, although this will interfere with INPUT commands. TRACE uses address 682 as a flag. Any non-zero value here will cause TRACE to be active. Some machine language programs are stored in this area, and their presence may trigger TRACE mode at inappropriate times.

AUTO also uses low memory. Location 681 contains 64 when auto is active. Locations 820/821 hold the last line number used and locations 822/823 hold the increment.

Programmers using FC-III should avoid locations 679-767 and 820-827 since other cartridge functions may use these memory areas.

PACK and UNPACK are the most curious BASIC add-ons. PACK changes BASIC so it lists as:

```
1987 SYS 2061
```

The command moves the entire BASIC program up in memory, and adds a machine code routine to the beginning of the program. When RUN, the SYS command copies the BASIC program back to the normal starting location, changes a few vectors, and RUNS the program. Machine language programmers may want to examine the code used to do this, since it must overwrite itself to move BASIC back down.

The program is simply put back in BASIC space to RUN. If RUN/STOP is used, the entire program can be LISTED normally. This makes UNPACK unnecessary.

MON enters a machine language monitor with all the usual commands. Added commands allow editing memory as sprites

or text characters, and viewing common memory areas as RAM or ROM. The monitor can operate on memory in the disk drive as well as the computer.

BAR allows displaying a menu bar at the top of the screen. This can only be done with a joystick or mouse button. The menu bar shows the definitions FC-III gives the function keys. There appears to be no way to change these. Other options include switching to the monitor, the desktop, or the freezer menu.

Two pull-down menu options list the added BASIC commands, including some not documented. HELP doesn't generate any errors, but doesn't seem to do anything either. REPLACE is more interesting. It uses the syntax

```
REPLACE old,new
```

where "old" and "new" can be any variable name, BASIC command, or text in quotes. Any lines changed are listed as REPLACE executes.

BAR OFF disables the BAR for programs that object to its presence.

### Disk commands

The 'dos' command is used as a "wedge", acting like the ">" or "@ " character normally used. Giving the command 'DOS' by itself will read the error channel.

```
dos ``command''
```

sends the command to the disk drive. For example, DOS "\$" reads and displays the disk directory to the screen.

DLOAD and DSAVE perform disk LOAD and SAVE with no need for a ",8" after them. DLOAD is *not* the same as its C128 (or BASIC 4.0) namesake. It performs a BLOAD instead, placing the program at its original location address. Two similar commands are DVERIFY and DAPPEND. All of the 'D' commands can be entered as 'D' followed by the next letter shifted.

APPEND (or DAPPEND) is used to add a program from disk to the program in memory. The usual stipulation is that the second program must have higher line numbers than the last line of the first program. To 'avoid' this situation, FC-III includes the ORDER command, which moves lower line numbers from the appended program into numerical sequence with the original program lines.

This creates a sort of merge. If the new lines make sense when executed with the old, the program will RUN. If both programs have the same line number, the new line is placed in sequence ahead of the old one. But, the old line is still retained in memory, and continues to execute. Editing, GOTO and GOSUB will see only the first, or newly added, line. This makes for strange and sloppy BASIC.

## The Action Replay Mk. IV

In contrast to the slick packaging of the FC-III, the Mk. IV came via mail order in a plastic bag inside a plain brown cardboard box. The cartridge shell is red plastic, with no labels of any sort. Two round black switches stick out the back at the right.

The documentation is a saddle-stitched booklet, using good quality typewriter printing. The instructions cover three versions of the cartridge.

At power-up, you see a four-option menu. Selection is done with the function keys, and there are no windows. F1 fills memory with a known value. This aids in making frozen copies. F3 creates a 'normal reset', disabling the Mk. IV for software that won't load with the cartridge active.

F5 calls up a utilities menu that executes DOS commands. The format routine takes only 13 seconds. The menu also accesses a full disk copier and a file copier. The latter looks remarkably like Jim Butterfield's "Copy-All." This menu also saves a special fast loader program to disk (more later).

The only exit from this menu is to "Fastload," the same as the final option of the first menu.

### Mk. IV BASIC mode

Except for an added message and a change to white text, the Fastload screen looks like the standard C64 screen. No windows, no notepad, no calculator.

You do have the usual disk wedge commands with the usual '@' syntax. @\$ displays the directory, for example. The wedge uses the 'last device accessed' memory location 186, which can confuse it after printing; the @\$ command will try valiantly to get a directory from the printer. A @8 sets things right again.

The '/' entered in front of a file name will load the program. This is often done after listing a directory. As with the Epyx FastLoad cartridge, if the file is larger than nine blocks, you must space over the remaining digits.

```
/5 "FILE" PRG
```

will try to load a file named "5."

BOOT will load a program, then SYS to the starting address of that program. MERGE is a true merge, rather than APPEND, which is also supported.

The line numbers of the program being MERGED from disk can be changed as part of the MERGE command.

The AUTO command has a small bug. If you edit a logical line that ends with a number, and the number wraps to the start of the next physical line, AUTO turns off.

My favorite is LINESAVE, which has the syntax:

```
LINESAVE "filename",8,startline-endline
```

and SAVES a part of the BASIC program in memory.

COPY and BACKUP activate the built-in file and disk copying routines.

The Mk. IV has some of the BASIC commands found in the FC-III (see the comparison chart), although the FC-III is the clear winner in BASIC additions.

The machine language monitor is virtually identical with the monitor in the FC-III, but does not directly edit sprites or text characters. It does display memory as CBM screen codes, as well as PET ASCII text, hex values, or assembly code. It will also display and allow changes to the I/O registers.

### To freeze or not to freeze

'Freezing' is a technique for halting a program in progress. A copy of the frozen computer memory can be saved. If that memory 'snapshot' can be successfully reloaded, the program will continue from the point at which it was halted. See "How They Work" at the end of this article for the technical explanation of how this is done.

I first saw this as strictly a 'pirate' technique. Since the program is fully loaded when halted, all the copy protection on the disk is bypassed. The memory snapshot can be copied with any file copier and passed around freely.

But there are legitimate uses for freezing. Most frozen copies take less time to load than the originals. Many commercial programs are incompatible with fast loading routines, and with them the improvement can be dramatic. Since the copy protection isn't used by the frozen copy, there's none of the head banging found on older commercial programs.

If you use several options of the same program, you can freeze a version of each, after loading the necessary overlays, or selecting menu options. If you're a game player, you can freeze the game just before taking on the next adversary. If you lose, you needn't fight your way back through the lower levels again.

*Transactor* does not condone theft of software by any method. Use of freezing cartridges on any programs you don't own is unethical. But legitimate owners of programs should know about all the options they have for making the best use of their software. We're not telling the pirates anything new here. They already know all about freezing programs.

### Freezing with the FC-III

The FC-III freezer menu can be accessed from pull down menus or by pressing the "freeze" button on the cartridge. The

latter may be the only option if a program won't load with the cartridge active. In that case, you use the KILL option to disable the cartridge, turning the red LED off.

The freezer bar controls pull down menus to back-up the program in memory, change some game options, change screen/border colors, and print screen dumps. To freeze, just select "disk" or "tape" from the backup menu. Only the joystick or mouse will point/click on the freeze menus.

The frozen memory is saved to disk as two separate files, "FC" and "-FC." You can rename these files later. There's no message given about file size before the save starts. You should use a reasonably empty disk since frozen memory often takes 150 disk blocks or more.

You're returned to the desktop menu bar with no option to resume the frozen program.

### Freezing with the Mk. IV

The freezer menu is accessed by the freeze switch. The switches aren't labeled, and if you push "reset" instead, you'll have to start over. From this menu, you can enter the monitor, get a disk directory, do some interesting sprite manipulations, save or print the hi-res screen, or back up the program.

Before the backup is saved, you're given several DOS options, including "directory" and "format." You're also told the size of the file to be saved and given three save formats: standard, turbo, and Warp\*25. Files saved using "turbo" are standard DOS files with an optimized "interleave," the number of sectors skipped between two consecutive program sectors on the disk. Files saved in this way will load a bit faster with the Mk. IV or its fastload routine. They will load without the cartridge also, but more slowly.

The Warp\*25 uses non-DOS techniques to save files. They can be re-loaded very fast with the Mk. IV in place, or with a special loader program that's saved into the directory track on the disk using a special menu option. The Warp\*25 files are larger than turbo files. They require consecutive tracks on a disk, so may report a "disk full" error when many free blocks remain. The Warp\*25 files load much faster than any others. In fact, Warp\*25 may be the Mk. IV's best feature. See the loading times comparison chart.

### Hi-res screen options

The Mk. IV allows you to freeze the program, then save the current hi-res screen in one of six software formats: Blazing Paddles, Koala, Advanced Art Studio, Artist 64, Vidcom 64, and Image System. Only multi-colour hi-res screens can be saved.

Freezing may occur while the "raster" (the part of the video system that 'paints' the image on the screen) is mid-screen, resulting in strange images. The screen can be viewed with the

F7 key before the save. You can restart the program and 'jog' through a picture to try for a better image. Stationary hi-res screens are easy to capture. Sprites will *not* appear on the saved image.

The FC-III does not have a screen save option. You can view the captured hi-res screen for printing purposes. Sprites are visible on the FC-III captured screen, although the presence of some moving sprites will depend on the raster location.

You can select among printer types, print density, the size of the finished product, and sideways printing. With my printer/interface, the various density options produced the same output. Size can be increased both vertically and horizontally. The default values are both '1,' which produces an output about three by five inches. Increasing the horizontal value to '2' makes the hard copy twice as wide - a bit wider than a nine inch printer can reproduce. You can make a full size '2' by '2' image by specifying the "sideways" option.

In the larger sizes, picture elements become larger and the gray scale hatching detail increases. The hard copy always starts with a corner of the screen. So it is difficult to get a large scale hard copy of objects in the center. You can enter the freeze mode to print low resolution screens with the same options.

You are returned to the desktop menu bar after printing, with no option to restart the program.

### Gaming options

Both cartridges offer several features of interest to game players. Both will disable sprite collision detection. This may allow you to survive unscathed in some games, although both manuals caution that many games do not use the built-in C64 sprite detection systems. Both cartridges make the machine language monitor available in freeze mode, so changes can be made in the program. The Mk. IV makes this easier with a POKE mode.

The FC-III adds an 'autofire' feature to the joystick fire button. It also will 'swap' joystick ports in case you start with your joystick in the wrong place. Actually, this command changes the keyboard scan too, with fascinating results on programs such as Flight Simulator.

The Mk. IV will search for and replace PET ASCII text in memory. I was able to change "player" to "sucker" in Beach-Head without the need to hunt for the text with the ML monitor. It will not change hi-res text, of course.

A real plus for the Mk. IV is its sprite mode during freeze. Memory can be displayed as sprite images, either hires or multi-color. The sprites can be saved to disk individually, and loaded back into memory. They can be wiped out, inverted, mirror imaged, or flipped. The sprite address is displayed, facilitating the use of the ML monitor to save a range of sprites.

I extracted the rotating gun from Raid on Bungeling Bay for use in my own BASIC program. Then, I replaced the gunboat sprites with tiny Jump Men. This is great fun. But it would be more useful if the Mk. IV included a sprite editor.

### Compatibility

Frozen FC-III programs use a fast loader routine which conflicts with the Mk. IV. The turbo or standard Mk. IV frozen programs can be loaded with the FC-III.

The Mk. IV claims to be compatible with the 1541, 1541C, 1571, and 1581 disk drives and the C64, C128, and C128D. The FC-III works with the C64 and C128. No list of disk drives is provided. I tested only the 1541.

The Mk. IV command prompts and menus are printed in white. The SX-64 background screen color is also white. So, using the Mk. IV with the portable becomes more of a challenge. You can change the text color from some modes. The FC-III prints in text color, so all messages are visible. But the hires windows and menus are very hard to read on the built-in monitor.

### Final comparison

So, which cartridge should you buy? If your goal is a simpler operating system, the FC-III is the clear choice. The window environment provides a (dare I say it) "user friendly" atmosphere, free of arcane commands. Experienced users will quickly skip to the BASIC command screen instead.

The FC-III is also the best for screen dumps to the printer, both for options and its ability to display sprites.

The Mk. IV gives game players more options, and wins the fast loading race hands down. If windows don't interest you, the Mk. IV is the better value.

### CAPSULE COMPARISON (zero to three stars)

	FC-III	Mk.IV
Features		
BASIC commands :	***	*
ML monitor :	***	***
Screen dumps :	***	*
Screen saves :	-	***
Gaming :	*	**
Disk operations :	**	***
Freezer operation :	***	***
Windows :	**	-
Ease of Use (beginner) :	***	**
Ease of Use (experienced user) :	*	***
Overall rating :	**	**

### How They Work

The memory in the C64 and C128 is shared by several systems. The MPU (Micro Processor Unit) stores information in memory for use as program data and for screen display. The VIC (Video Interface Chip) looks at memory also to get the information to create a screen display.

Only one device at a time can access memory. The VIC chip has priority, and uses a technique called DMA (Direct Memory Access) to assert its rights to RAM (Random Access or read/write Memory). When the VIC chip activates a special DMA circuit, the MPU is put on hold until DMA is released.

The DMA line is also available at the cartridge or expansion port. Freezer cartridges produce their own DMA signal when the freeze button is pressed. This halts the MPU.

A new processor inside the cartridge takes over. This second MPU has its own operating system in ROM inside the cartridge. It usually has some RAM in there also.

The cartridge MPU can read the keyboard, joysticks, disk drives, and make changes in the regular computer memory. On command, it makes an image or 'snapshot' of the computer RAM on disk or tape.

You can examine the innards of either cartridge easily with the aid of a small Phillips screwdriver. The usual snap tabs are missing from the shells, and the cartridges come apart easily. The FC-III is a complex system of integrated circuits. The Mk. IV is simple by comparison, owing largely to the custom SMT (Surface Mounted Technology) MPU/ROM chip mounted on the underside of the board.

Be careful in handling either exposed board. Both use MOS chips, which can be easily damaged by improper handling. Also, note that the switches in both units are simply soldered to the circuit board with no other mechanical support. Push gently on those switches. Heavy use may break the solder joints or the boards themselves. The exposed long metal sections of the Mk. IV switch may be more susceptible to damage than the black buttons of the FC-III.