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MI & S: Basic Issues & Training
CINE-GT 2920
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29 November 2012

The Jones Buffer[1]

Dave Jones

Dave Jones has been a working video artist and engineer since the early 1970s, involved with artists and organizations including Shirley Clark, VideoFreex, and the Experimental Television Center. After spending the early 1970s touring Europe with his multi-media performance group VideoHeads, Jones went on to work for the Experimental Television Center and found his own video tool company, Designlab, in 1985. Jones is well-known for utilizing concepts from analog audio synthesis in his video tool designs. His most prominent creations include the Jones digitizer, sequencer, colorizer, keyer, and frame buffer. This research paper focuses on the Jones frame buffer, or FB-1 model, the culmination of years of experimentation combining concepts used in the digitizer, sequencer, colorizer, and keyer. [2]

Trajectory of Development

In 1974 Dave Jones began development on analog-to-digital and digital-to-analog converters, circuits that would transform an analog video signal into

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[1] **Much of the technical and chronological information throughout this paper is paraphrased from two e-mail interviews between Dave Jones and myself. The ability to receive responses to specific questions has enabled me to offer a detailed description and analysis of this device. It should be noted that many of the technical descriptions are necessarily informed by my ongoing correspondence with Dave, and as such are primarily attributed to him. . I have specifically cited Jones' interviews and additional primary sources when directly quoting or closely paraphrasing. I have pieced together and organized a chronology of events based on the entirety of my primary and secondary sources.**

[2] Jones, David. "Dave Jones Bio." *Dave Jones Design,* 2007.

digital bits and subsequently back into analog form. [Fig. 1] The resulting processed image displayed a rudimentary rendering of the original video comprised of 16 levels of gradation from black to white. These grey levels represented the luminance of the original video signal expressed in lower resolution digital pixels.

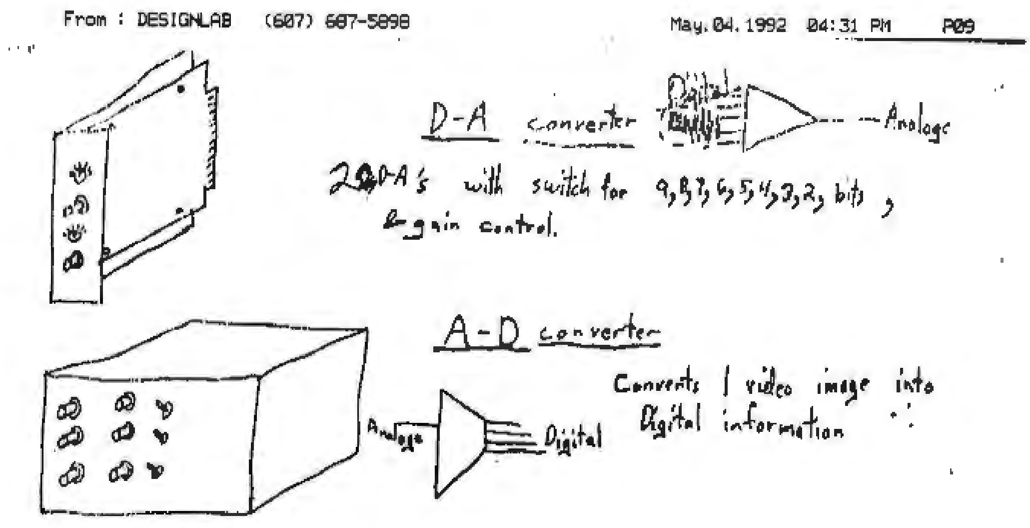

Fig. 1 Hand drawn images of Dave Jones' Digital-to-Analog & Analog-to-Digital converters[3]

In early 1975, Jones added a digital memory board to his analog-to-digital/digital-to-analog converter, creating a device capable of caching pixels on several periodic scan lines of video. This pixelizer, "line buffer" as Jones named it, would repeat a given scan line of pixels several times before sampling the video signal again and repeating that scan line correspondingly. The resulting frame displayed a more pixelated version of the original high-resolution digital picture, giving the image the appearance of being stretched down the frame.[4]

[3] Jones, David. "Dave Jones Resume: 1980." Fax to Woody & Steina Vasulka. (4 May 1992).
[4] Jones, David. "Re: Frame buffer information." E-mail message, 16 Oct. 2012.

This "line buffer" device also had oscillator input, allowing the size of the pixels to be adjusted themselves.

The evolution continued into April of 1977, when Jones purchased several surplus IBM integrated circuits from an electronic parts store in Kingston, New York. His take that day included several memory chips each capable of holding 4096 bits of data. Jones used these memory chips to built a circuit that would connect with his analog-to digital/digital-to-analog converters, "[soldering] four of the memory chips on top of each other, with a pair of pins on each chip sticking out sideways, in order to run all of the signals from chip to chip."[5] The result was a 64 x 64 resolution frame buffer capable of storing one low-resolution still image. [Fig. 2 & Fig. 3] The 1992 "Eigenwelt der Apparate-Welt" issue of *Ars Electronica* gives a straightforward description of the 1977 still frame buffer:

> "The 64 by 64 frame buffer [stored] images as a pattern of 64 horizontal by 64 vertical squares, with a choice of 16 grey levels per square. The cost of memory and analog to digital conversion limited the number of grey levels and resolution. These limitations yielded a video image meshed into a charming box-like grid of intensity that is frozen or held under front panel control. A 4 bit, 16 level video-speed Analog to Digital Converter, samples the monochrome video input. This is fed to a 4K by 4 bit static Random Access Memory (RAM), where it is held on command by a front panel push button, locked to the vertical interval. The output of the frame buffer memory passes to the output Digital to Analog converter, changing the video signal back to its analog form. When running "live" the image bypasses the frame buffer memory, passing straight to output. When "frozen," the image is pulled from the frame buffer, showing the last stored picture. A horizontally/vertically locked address counter supplies the timing for the memory." [6]

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[5] Ibid.

[6] Schier, Jeff; Vasulka, Woody. Ed., Dunn, David and Weibel, Peter. "David Jones: Jones Frame Buffer (Spatial and Intensity Digitizer), 1977." *Ars Electronica*: 1.

Artist Gary Hill—at the time Jones' roommate in Barrytown, New York—was the first video maker to experiment with the 64 x 64 still frame buffer. Though he had originally commissioned Jones to build a video colorizer, Hill soon discovered that he was more intrigued by the memory capabilities of this fledgling frame buffer prototype. He recalls arriving home one evening to find an image that would transform the direction of his artwork:

> "One day I came home and Dave was gone. He had left the equipment on, and there was this digitally stored image on the screen of him smiling and waving. Suddenly colorizing seem superficial, next to having access and control over the architecture of the frame in real time."[7]

Both Jones and Hill remember this anecdote as the pivotal moment when they realized the significance of his creation. Hill began building reproductions of Jones' 64 x 64 frame buffer circuit boards, continuing to use them in his work throughout the late 1970s.

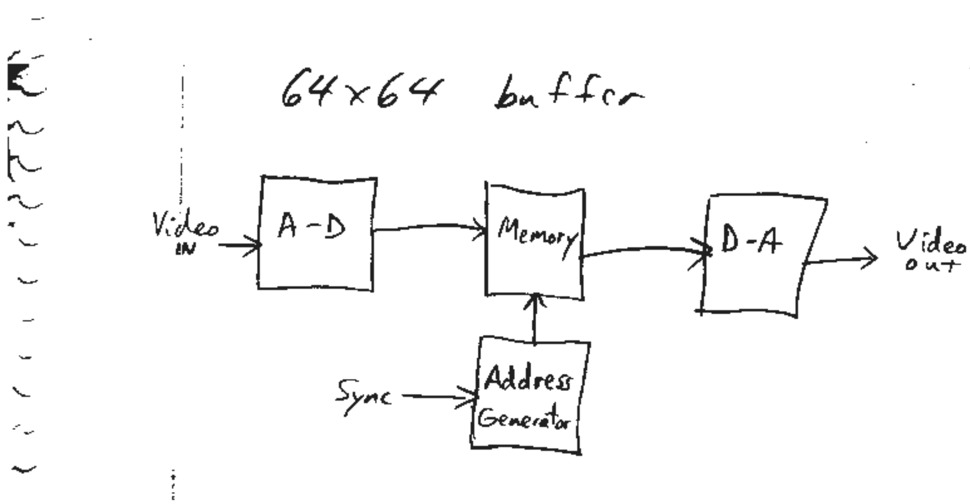

Fig. 2 Flow diagram of the 64 x 64 frame buffer hand drawn by Dave Jones [1992][8]

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[7] Furlong, Lucinda. "A Manner of Speaking: An Interview with Gary Hill." *Afterimage. Visual Studies Workshop.* 10.8 (1983): n. pag.
[8] Jones, David. "Dave Jones Resume: 1980." Fax to Woody & Steina Vasulka. (4 May 1992).

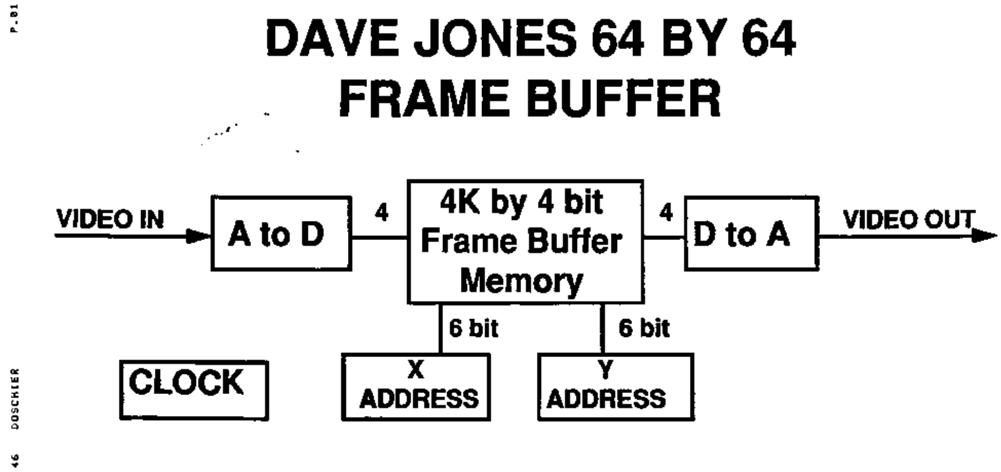

Fig. 3 Flow diagram of 64 x 64 frame buffer [1992][9]

Gary Hill was not the only artist inspired by Jones' creation. In 1979, Jones was back in Binghamton, New York at the Experimental Television Center when video artist Peer Bode approached him about building another frame buffer for his own work. Determined to improve upon his last design, Jones purchased several dynamic RAM chips, which stored more memory than the 4096 bit IBM chips he had used for the initial buffer. Jones and Bode constructed a 256 x 256 buffer, a higher resolution version of the frame buffer prototype. This frame buffer "had a variable oscillator for the horizontal oscillator, which made variable width vertical columns in the image"; by altering this variable oscillator, a user could manipulate the horizontal resolution of the image being stored in the memory.[10] Additionally, this buffer version included a built in keyer-like feature. This keyer enabled the user to control the storage of the images in the memory chip, resulting in the ability to essentially superimpose a live image on top of previously

[9] Ibid.
[10] Jones, David. "Re: Frame buffer information." E-mail message, 16 Oct. 2012.

stored images. This created an effect neither of the creators had previously encountered: a “memory trail” in which the live image seemed to smear across the monitor.[11]

By 1980, this device had developed into the early iteration of the Jones Buffer, offering the same real-time digitization and selective storage/keyer capabilities of its predecessor, but with the added potential to interface with the Cromemco Z-80[12] computer system. When operating in conjunction with the Z-80, the frame buffer could store and playback up to 16 pages of still images, creating the illusion of animation through sequencing multiple consecutive frames.[13] [Fig. 4]

Fig. 4 “Jones Frame Buffer.” *ETC Studio System Manual.* 1980

[11] Ibid.
[12] Dave Jones also refers to this as the S-100 Cromemco.
[13] Bode, Peer; Brewster, Richard; Hocking, Sherry Miller; Rudolph, Hank, and Schlanger, Matthew. “Jones Frame Buffer.” *ETC Studio System Manual.* 1980: n. pag.

The years between 1981 and 1983 were spent undertaking research to further develop and improve upon this version of the Jones Buffer. With grant funding provided by the Experimental Television Center, Jones was able to have printed circuit boards etched for the final iteration of the frame buffer in 1983-84. Marketed as the FB-1 model, this frame buffer had the ability to store and retrieve 32 frames of video image, and featuring voltage control inputs for extensive image manipulation and the possibility to interface the device with custom computer software. During this period the Jones Buffer was still operating with software for the Cromemco Z-80 computer system, "one of the only commercially available "low-cost" digital devices, which incorporated concepts of video, and recordable signal output" at that time.[14] However, Jones switched computer systems around 1986 when the Experimental Television Center acquired a Commodore AMIGA 1000 computer, noting this system in the official FB-1 operation manual published by his company, Designlab.

[14] "Cromemco in the ETC Studio." *Video History Project: Resources – Tool Description.* Experimental Television Center, 2011.

FB-1 Model: Design & Function

Fig. 5 “Jones Frame Buffer.” ETC *Video History Project: Early Media Instruments.* Experimental Television Center, 2010 DVD.

The FB-1 model shared similarities with its immediate predecessor: it had 256x256 resolution, could store and retrieve a sequence of still images, and had a built in keyer. But Jones had spent several years improving on his designs, and the FB-1 featured many novel functions: the memory was now capable of storing and retrieving 32 frames of video image when paired with the AMIGA 1000 [Fig. 6]; the “BufPalette” software allowed the user to change the speed of the storage and playback, pause and alternate the directional order of the sequence, and “colorize” the gray levels with an RGB slider, an effect Jones referred to as “pseudo-color”; key clip capabilities were extended with an additional external keying option; but the most important improvement was the addition of control voltage inputs.[15]

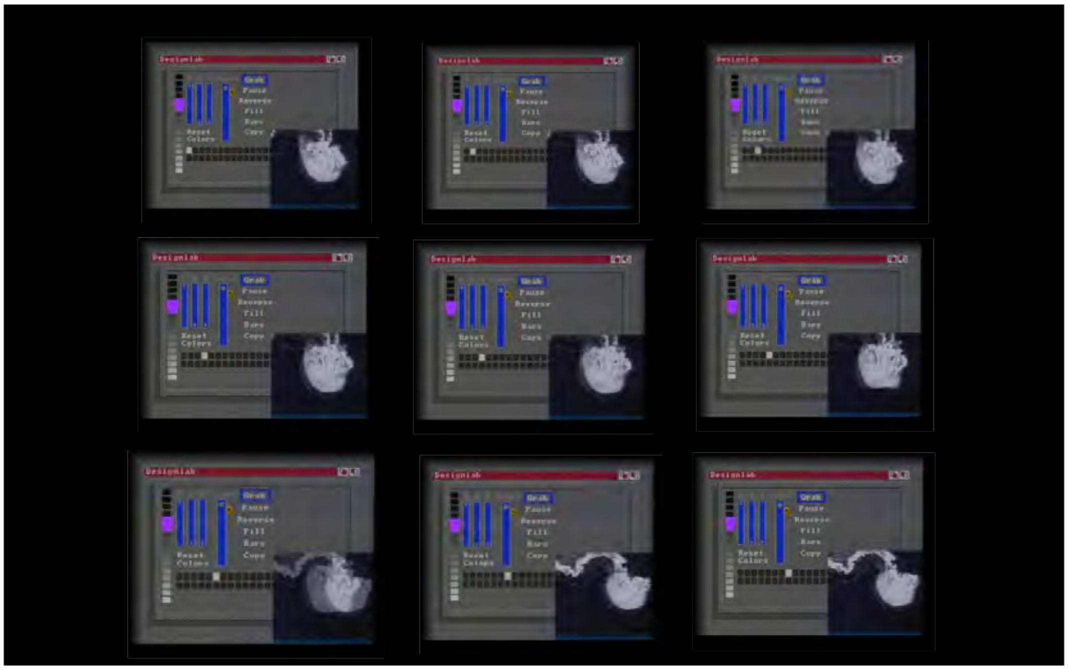

Fig. 6 “Jones Frame Buffer.” ETC *Video History Project: Early Media Instruments.* Experimental Television Center, 2010 DVD.

The implementation of voltage control manipulation is the primary feature that sets the Jones Buffer apart from other frame buffers of the time. Inspired by the electronic audio community, Jones began applying voltage control concepts used primarily in analog audio synthesizers to his video synthesizer designs, “[adding] incredible power to the video machines since now you could turn any, or all, of the knobs at once.”[16] In his 1978 article “Voltage Control and the Analog Synthesizer”, Richard Brewster explains that adjusting the gain automatically via the voltage control inputs can be advantageous in comparison to the manual alternative by allowing “variations which are smoother and quicker than is

[15] Jones, David. FB-1 User Guide. Owego, NY: *Designlab*, n.d.
[16] Jones, David. “Dave Jones Design History.” *Dave Jones Design,* 2007.

possible by hand", "increased precision", and "step-like movement."[17]

The control panel of the FB-1 featured three knobs with adjoining voltage control inputs labeled "Contrast", "Brightness", and "Key Clip". [Fig. 5] Both the knobs and the inputs use voltage to control and manipulate the analog video signal before it is digitized: when an external control voltage source, such as an oscillator, remote control panel, or computer is plugged into the input on the frame buffer, that voltage interacts with the original knob voltage allowing more complex manipulations to occur.[18] In short, Jones' use of voltage control in the frame buffer design broadens the scope of the potential image manipulation.

The "Brightness" and "Contrast" knobs are relatively self-explanatory, and their corresponding voltage control inputs adjust the size and bias of the main video signal. Patching an oscillator into the voltage control input beneath the "Brightness" knob on the frame buffer causes horizontal bands to flow down the video image. As the frequency of the wave is increased, the bands multiply in number, and as the frequency is decreased, the nature of the shapes within the image content begin to be more visibly warped by the oscillation. The "Contrast" knob and voltage control input have decidedly more subtle effects, softening the edges of the forms within the video. In both cases, the nature of the effect is determined by the gain, frequency, and shape of the wave itself [sine, square, sawtooth, square, pulse]. [Figs. 7 & 8]

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[17] Brewster, Richard. "Voltage Control and the Analog Synthesizer." *ETC Studio System Manual.* 1978: n. pag.
[18] Jones, David. FB-1 User Guide. Owego, NY: *Designlab*, n.d.

Fig. 7 “Jones Frame Buffer.” ETC *Video History Project: Early Media Instruments.* Experimental Television Center, 2010 DVD.

Fig. 8 “Jones Frame Buffer.” ETC *Video History Project: Early Media Instruments.* Experimental Television Center, 2010 DVD.

The built in keying function allows the live image to play over the stored image in real time. The 32 frames of memory are constantly resampled as the live image plays across it, compounding the individual frames with each pass.

Images are built up on top of each other leaving what Jones refers to as a "memory trail" in their wake. Using the AMIGA 1000 software, the user can pause on an individual frame, allowing the stored samplings from the live image to build up exclusively on the chosen frame. This will interrupt a fluid animation sequence, but creates more complex graphical imagery. [Fig. 9 & 10]

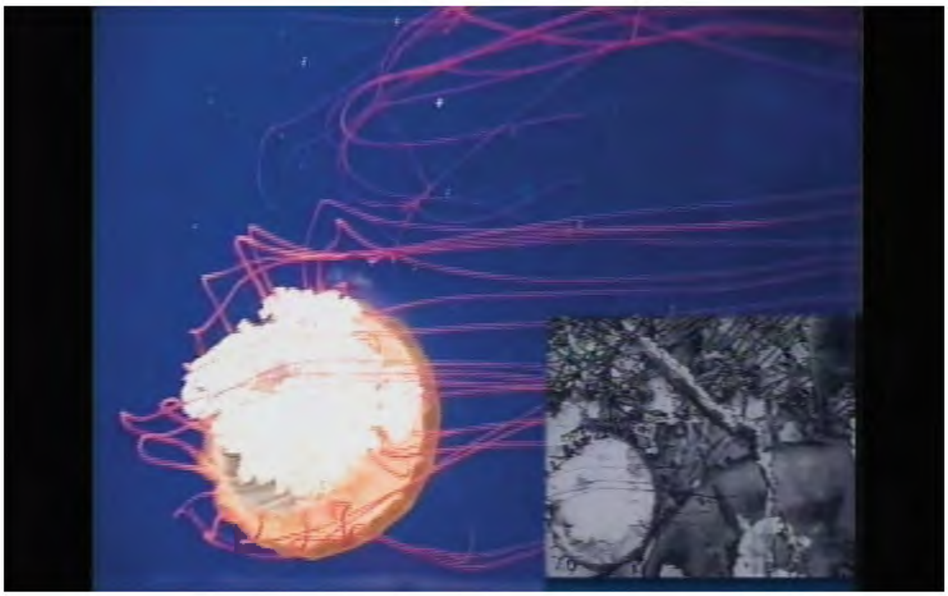

Fig. 9 "Jones Frame Buffer." ETC *Video History Project: Early Media Instruments.* Experimental Television Center, 2010 DVD.

Fig. 10 "Jones Frame Buffer." ETC *Video History Project: Early Media Instruments.* Experimental Television Center, 2010 DVD.

Additionally, the software allows the image to be digitally colorized by choosing individual gray levels from the sidebar 16 level spectrum and assigning a computer generated "pseudo-color" using RGB labeled sliders.[19] Each gray level can take on a different color determined by the varying degree of Red, Green, and Blue set by the sliders. There are "4096 colors and grays to choose from, but only sixteen can be seen at once". [20] [Fig. 11]

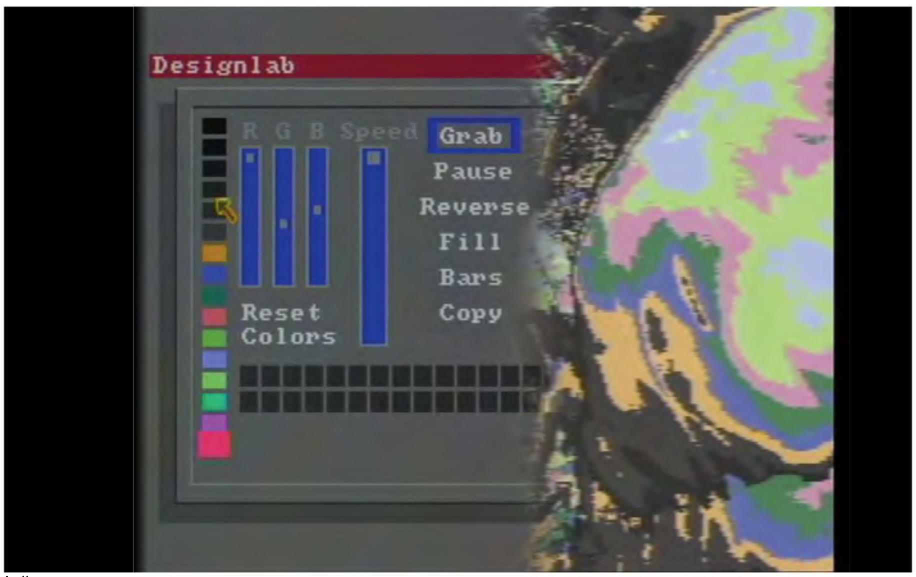

Fig. 11 "Jones Frame Buffer." ETC *Video History Project: Early Media Instruments.* Experimental Television Center, 2010 DVD.

The "Key Clip" knob and voltage control input affect the second video input, allowing the user to select gray levels within the image and to choose whether the light parts or dark parts of the 16 gray levels will be stored. Jones describes the operational flow of this process:

> "The clip control works on the analog video that goes into the second video input of the buffer, which is the "clip" video input. That second image is fed into an analog "comparator" which compares the video signal with a DC voltage set by

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[19] "Jones Frame Buffer." ETC *Video History Project: Early Media Instruments.* Experimental Television Center, 2010 DVD.
[20] Jones, David. FB-1 User Guide. Owego, NY: *Designlab*, n.d.

> the knob or a moving control voltage fed into the control voltage input. The comparator circuit then compares the video against that voltage and creates a single bit digital signal which is positive when the video is brighter than the knob or control voltage, and is negative when the video is below that level."[21]

In other words, light or dark parts of the image are stored or not stored in accordance with their relationship to the voltage being input into the system. This is regulated by four switches on the panel labeled: Key On, Key Off, Key Normal, and Key Reverse. When the Key Off + Key Normal switches are activated, the monitor shows only the stored frames. When the Key Off + Key Reverse switches are activated, only the live images plays back on the screen. When the Key On + Key Normal switch are activated, the light parts of the main image are stored, whereas when the Key Reverse is activated in Key On mode, the dark parts are stored. [Fig. 12]

Fig. 12 "Jones Frame Buffer." ETC *Video History Project: Early Media Instruments.* Experimental Television Center, 2010 DVD.

[21] Jones, David. "Re: Follow Up Questions on the Jones Buffer." E-mail message, 24 Nov. 2012.

In addition to these keying features, the FB-1 model also allows an external keying processing from a second live video source. During external keying, a “key edge” is set by defining the shape of a light object against a black background. The key edge determines where the live image and stored image will be played back; the user can choose to play the stored image inside or outside of the key edge, while the key edge itself is stored and played back simultaneously. The key edge can also be used as a solitary fill image, able to be manipulated further using voltage control. [Figs. 13 & 14]

Fig. 13 “Jones Frame Buffer.” ETC *Video History Project: Early Media Instruments.* Experimental Television Center, 2010 DVD.

Fig. 14 “Jones Frame Buffer.” ETC *Video History Project: Early Media Instruments.* Experimental Television Center, 2010 DVD.

Specifications and Modifications

The final FB-1 model of the Jones buffer was a versatile system with the potential to be customized and expanded for each individual user. It could be used in conjunction with a computer, a remote controlled panel provided by Designlab, or as a stand-alone single-frame unit.[22] It was possible to expand the number of frames available and add up to four inputs/outputs with additional memory boards, and to add a digital colorizer, but the standard system featured two inputs, one output, 16 frames of black and white video at 256 x 256 resolution, and four standard sync signals.[23] The number and type of sync

[22] Jones, David. FB-1 User Guide. Owego, NY: *Designlab*, n.d.
[23] Ibid.

signals varied according to the number and type of expansions added to the system.

Additional expansions are offered in the FB-1 Manual, published c. 1986, and include features including:

> "1. True Color Input/Output: Lets you grab true color images.
> 2. Frame Repositioner: Move the frame up & down, or side to side.
> 3. Formula Processor: Miniature image processor.
> 4. Buffer I/O: Multi function expansion board that includes:
> -Resolution control: 12 resolutions, 64x64 to 256x512.
> -Sketching: Draw lines, dots, etc. in the buffer.
> -Archive: Save images on your computer's disk.
> -Animation: Retrieve pieces of images from disk in long sequences."[24]

According to Jones, the fourth expansion option was the only one that was ever created. The Buffer I/O was an additional board that provided the computer with access to the buffer circuitry. The resolution control was primarily used with customized software and allowed the user to add more frames by reducing the resolution. The sketching allowed the user to generate graphics by "drawing" pixels on the buffer memory. Jones notes that these two features were rarely implemented. The archive feature saved the buffer's stored images onto the computer's disk drive, allowing a user to retrieve sequences of images later, often to be printed off. Finally, the animation feature worked in conjunction with the archive, allowing sequences stored on the computer's disk drive to be retrieved and played back any time. This feature also allowed a user to create new

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[24] Ibid.

images or manipulate stored images in computer paint programs and later play them back in a designated sequence.[25]

Presentation and Preservation

The FB-1/Jones Buffer was used as an in-house production tool at the Experimental Television Center and sold to individual consumers for at-home use. Though the consumer market sometimes used the device in a performative context, the FB-1/Jones Buffer was primarily used in production and post-production work. Implementing a standard video-output, it was possible to record directly to video tape, to run the processed video directly to a monitor, or to run the video signal through additional processing tools before recording a physical copy.[26]

Aside from direct tape recording, there were two interrelated methods for saving content produced using the buffer, both involving the AMIGA 1000 software. The “Archive” expansion later added to FB-1 buffer models allowed a user to save still frames or sequences of frames onto the computer’s disk memory for future retrieval and processing. The user also had the option to literally print out still frames using a custom software designed by Jones called, “FinePrint”. This software was designed for a “dot matrix” printer using ink ribbons that were nearly used up. Originally created to simulate images using patterns composed of black dots and white blanks, Jones reimagined the

[25] Ibid.
[26] Jones, David. “Re: Follow Up Questions on the Jones Buffer.” E-mail message, 24 Nov. 2012.

potential output of these printers using the worn out ink ribbons to produce light grays instead of blacks. Using an additive process[27], the faded ink ribbons would "build up true levels of gray on the paper" by completing multiple passes across a page. [28] This enabled a user to print out simulations of the 16 levels of gray digitized images created in the frame buffer. According to Jones, several thousand copies of this software were sold, and several prominent video artists, including Peer Bode, Connie Coleman, and Alan Powell, produced images using this software that "were hung on the walls of galleries like paintings or etchings".[29]

The preservation issues encountered by the FB-1/Jones Buffer extend in two directions, pertaining to form and content. In relation to form, the primary preservation issues concern the idea of authenticity and the integrity of the "original". From the mid 1980s onwards, Jones was developing customized software for various computer systems to be paired with the frame buffer, an exercise that effectively extinguishes, or at the very least reduces, the chance of computer obsolescence. It would certainly be possible to design improved software today that could interface with the analog aspects of the frame buffer. Furthermore, the general types of electronic parts and memory chips used in the construction of the machine are not obsolete, meaning that the circuitry could be emulated with newer parts that could even be more effective as

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[27] Hocking, Ralph. The Arnot Museum. "G.R.I.D – Works." (1986): n. pag.
[28] Jones, David. "Re: Follow Up Questions on the Jones Buffer." E-mail message, 24 Nov. 2012.
[29] Ibid.

long as original schematics are available. The issue at stake is the importance of authenticity in reconstructing a machine: the Cromemco Z80 and the AMIGA 1000 have been out of production for decades, and it is likely that many of the specific circuitry components are no longer made, even if there are near identical versions available. Many of the original characteristics produced by this early software and hardware might be lost in contemporary emulation, even potentially undesirable flaws such as slight delays in the “real-time” image. These idiosyncrasies represent the authenticity of the original device, and the inability to access the hardware and software native to this apparatus means modern copies could only exist as representative facsimiles.

The other preservation issue related to the buffer concerns the content produced using the device. Clearly any content that is recorded onto magnetic tape will face preservation issues intrinsic to that format. Due to natural material decay and playback obsolescence, this content must be migrated to secondary formats. It is without question that content is necessarily degraded each time it is transferred, but an even more prominent quality issue arises in proper exhibition/playback of these outdated video recordings. Video content was made to be exhibited on cathode ray tube monitors which are quickly approaching obsolescence. Because the original image quality of video is not properly represented on flat-screened televisions, content of this era will suffer from poor exhibitive integrity.

Additionally, much of the content produced on the FB-1/Jones Buffer was saved onto obsolete computer disk drives, most of which would be exceptionally difficult to access in present times. This “archived” content is subject not only to format/playback obsolescence, but also to the proper operation of the computer’s memory itself, which could potentially fail and erase these “saved” images.

A DVD produced by the Experimental Television Center released in 2010 includes a recorded demonstration of a fully-operational FB-1 model frame buffer from 2005. The original FB-1 hardware and AMIGA software are used in this demo, indicating that some care has been taken to preserve the integrity of this device at the ETC center. Still, many video artists created content using this device at ETC and at home, and it is primarily this work that is most at risk.

Conclusions

Jones continued designing image processing tools for video and installation artists throughout the 1990s, in addition to industrial engineering work and computer software development projects.[30] Though his image processing work in the 1970s and early 1980s revolved around a “”system” concept”, or “a collection of video processing and control voltage processing devices […] tied together with a central patch panel”, his later designs took on a modular approach.[31] By developing individual modules that had the same image processing functions as his previous “system” designs, “the central patch [was]

[30] Jones, David. “Dave Jones Bio.” *Dave Jones Design,* 2007.
[31] Jones, David. “Video Synth Concept.” *Jones Video,* n.d

eliminated, and the user [could] build their own system with whatever combination of modules they enjoy the most".[32] This user/consumer-geared approach to system design continues to be implemented by contemporary image processing companies such as LZX Industries, which produces individual modules modeled after various influential 1970s/80s designs.[33] Jones himself continues to create video processing devices and is slated to release new modules in 2013.

[32] Ibid.
[33] *LZX Industries.* LZX Industries, 2010. Web. 19 Dec. 2012.

Annotated Bibliography

Bode, Peer. "Curriculum Vitae." ***Peerbode.com.,*** **n.d. Web. 6 Oct. 2012**

A summary of the person history and artistic works of video artist Peer Bode. Bode assisted in the manufacturing of the Jones Buffer and has used this device to create video artworks. This curriculum vitae provides information on the influence of the Jones Buffer on well-known content and contributes context for this device's main user groups and user environments.

Bode, Peer; Brewster, Richard; Hocking, Sherry Miller; Rudolph, Hank, and Schlanger, Matthew. "Jones Frame Buffer." ***ETC Studio System Manual.*** **1980: n. pag.** ***Experimental Television Center.*** **Web. 6 Oct. 2012.**

A basic summary of the operational information for the Jones Buffer. Provides a simplified description of the core mechanisms and functioning of this device. Additionally, this summary provides historical context within the trajectory of the buffer development based on the technological description given.

Brewster, Richard. "Voltage Control and the Analog Synthesizer." ***ETC Studio System Manual.*** **1978: n. pag.** ***Experimental Television Center.*** **Web. 28 Nov. 2012.**

A detailed but straightforward article on the functioning and use of voltage control in the analog synthesizer systems used at ETC. This source helped develop my understanding of the fundamental principle of voltage control, as applied to video image processing.

Furlong, Lucinda. "A Manner of Speaking: An Interview with Gary Hill." ***Afterimage. Visual Studies Workshop.*** **10.8 (1983): n. pag.** ***Experimental Television Center.*** **Web. 6 Oct. 2012**

An in depth interview with video artist Gary Hill regarding his work and his time spent working at the Experimental Television Center. Gary comments on his professional relationship with Jones Buffer designer, David Jones, at ETC and provides a brief history of the creation of the Jones Buffer. The segment of the interview featuring the Jones Buffer provides context for its incarnation, main user group appeal, and associated content.

Hocking, Ralph. The Arnot Museum. "G.R.I.D – Works." (1986): n. pag. Retrieved from *Experimental Television Center.* Web.

A description of Ralph Hocking's person artistic practices, including a brief explanation of the dot matrix printer device he developed alongside Dave Jones. I used this article to develop my understanding of the functionality of the dot matrix printer. This source also demonstrates the influence Jones and his innovative designs had on other video artists at the time.

Hocking, Sherry Mill. "The Evolution of Thinking Machines." *The Squealer, Squeaky Wheel/Buffalo Media Resources, Inc.* 1.15 (2004): n. pag. Retrieved from *Experimental Television Center*. Web. 6 Oct. 2012.

This source provides a lengthy and detailed chronology of tool/apparatus design at the Experimental Television Center from 1972 – 2003. Many of Dave Jones' creations are featured in this piece and it was immensely helpful in recreating as accurate a timeline as possible. Using a variety of primary sources, such as current interviews with Jones and articles/resumes/fliers created by him ranging from the 1970s-1990s, can pose a number of difficulties when attempting to understand the occurrence of events. There were many dates that differed slightly between source documents, so having this ETC source helped provide additional and less subjective context.

Jones, David. "Re: Frame buffer information." Message to the creator. 16 Oct. 2012. E-mail.

A personal interview with Jones Buffer creator, David Jones, conducted via e-mail. Jones responded with detailed information on the development of the frame buffer, the impetus for and context of its creation, associated artists involved with the design and construction, and operational information.

----- "Re: Follow Up Questions on the Jones Buffer." Message to the creator. 24 Nov. 2012. E-mail.

A second personal interview with creator David Jones, conducted via e-mail. Jones provided more specific information regarding the process of manipulating of the analog signal, particularly regarding the keying effects. The description of how keying and the key clip feature function within the circuit itself were vital to my understanding of this machine. Additionally, Jones described the subsequent features developed for the frame buffer as listed in the FB-1 manual. Finally, Jones explained the contexts in which his device was often used, naming several of the primary artists who benefited from his creations.

----- "Dave Jones Resume: 1980." Fax to Woody & Steina Vasulka. (4 May 1992). PDF.

A typed, professional resume created by Dave Jones detailing the trajectory of his career and accomplishments. This resume aided in forming a chronology of events and developments for the frame buffer as well as providing background information on the creator.

----- "Subject: History." Fax to Woody and Steina Vasulka. (4 May 1992). PDF.

A personal 12-page fax sent to Woody & Steina Vasulka in 1992. It featured a handwritten "current" resume, the resume from 1980 (above), as well as hand-drawn diagrams and descriptions of several technological creations including the 64x64 frame buffer. The fax also included information about Gary Hill's involvement in the development of the frame buffer as limited: though Gary Hill built several 64x64 buffers based on Jones' design, the conception, design, and original construction were exclusively Jones' work.

----- "This is a 6 Page Flier I sent out June 1976." Fax to Woody and Steina Vasulka. (4 May 1992). PDF.

A hand-drawn flier of equipment developed by Dave Jones sent to potential customers in 1976. The flier included images of the analog-to-digital and digital-to-analog converters used in the frame buffer.

----- FB-1 User Guide. Owego, NY: *Designlab*, n.d. PDF file.

An in-depth user manual for the final frame buffer design. Describes the controls found on the stand-alone device and their operation as well as the capabilities of the device when combined with the Amiga computer system and accompanying customized software. Additional information is provided regarding the actual functioning of the frame buffer design, including basic configuration/operation schematics.

----- "Video Synth Concept." *Jones Video,* n.d. Web. 6 Oct. 2012

This source provided context for the trajectory of Jones' design career. Specifically, this article detailed Jones' shift from "systems" based image processing design to module-based synthesizer design, describing the technical and practical choices for changing directions. Additionally, this source gave detailed technical descriptions of Jones' use of sync generators and output amps, the two consistent core features of Jones' systems.

----- "Dave Jones Design History." *Dave Jones Design,* 2007. Web. 6 Oct. 2012.

This source is one of Dave Jones' professional websites, and this particular page provides a very brief description of his design history. I used this source primarily for information on Jones' use of control voltage in his designs.

----- "Dave Jones Bio." *Dave Jones Design,* 2007. Web. 6 Oct. 2012.

This source is one of Dave Jones' professional websites, and this particular page provides a brief professional biography. This source was useful in providing a basic description of Jones' background for my introduction.

***LZX Industries.* LZX Industries, 2010. Web. 19 Dec. 2012.**

This source is simply the website for a contemporary design and manufacturing company, producing image processing modules for video synthesizer systems. This company has been highly influenced by the video artists and engineers of the 1970s and 1980s, including Dave Jones. I used this source as an example of the modern influence of the frame buffer.

Schier, Jeff; Vasulka, Woody. Ed., Dunn, David and Weibel, Peter. "David Jones: Jones Frame Buffer (Spatial and Intensity Digitizer), 1977." ***Eigenwelt der Apparate-Welt.*** **Spec. Issue of** ***Ars Electronica.*** **(1992). Web. 6 Oct. 2012.**

This article appeared in a special issue of *Ars Electronica* from 1992, focused on video art and experimental electronics surrounding the Experimental Television Center and many associated artist/engineers. This particular piece provided a brief but detailed biography of Dave Jones and detailed the functioning of his early 64 x 64 frame buffer design.

Schlanger, Matthew. "Jones Frame Buffer Prototype." ***Experimental Television Center.*** **2011. Web. 6 Oct. 2012.**

A brief description of the creation of the Jones Buffer prototype from a designer and video artist who aided in the initial construction. This article describes the differences between the prototype and the most updated model and provides photographs of the initial design.

"Cromemco in the ETC Studio." ***Video History Project: Resources – Tool Description.*** **Experimental Television Center, 2011. Web. 24 Nov. 2012**

A brief article from the Video History Project at ETC detailing the basic design and functioning of the Cromemco computer system widely used at ETC in the late 1970s/early 1980s. I used this source as a reference for the chronology of technological development at ETC.

"Jones Frame Buffer." ETC ***Video History Project: Early Media Instruments.*** **Dem. David Jones. Doc. Pamela Susan Hawkins and Hank Rudolph. Feat. Carolyn Tennant. (13 July 2005). Experimental Television Center, 2010. DVD.**

A demonstration of the most up-to-date model of the Jones Buffer conducted by the creator, exploring all of the features and capabilities of the instrument. An extremely helpful visual aid to accompany the user manual.