Volunteer Newsletter

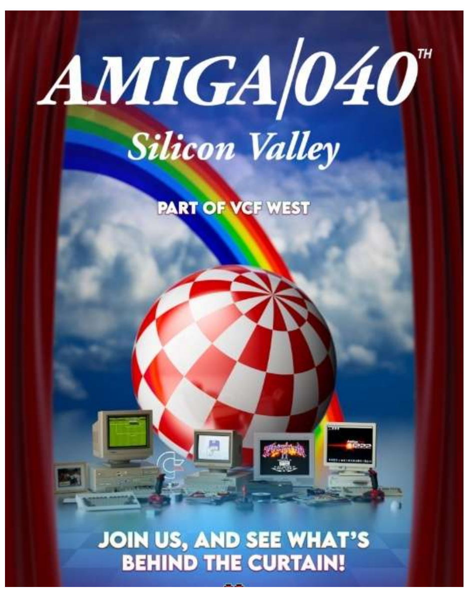
August 2025

Broken Records – Vintage Computer Festival

CHM partnered with VCF West again this year for an unbelievable record-setting weekend. Hosting this popular event that featured an extraordinary showcase of historical computers, from pristine originals to ingenious modern hacks and hands-on demos of historical systems from the 1960s through the 1990s, our goal was to increase attendance by 10% over 2024. Instead, we achieved a 65% increase… and set three records:

- Single Day Ticketing Sales: Doubled
- Single Day Store Sales: Nearly Doubled
- Best of all - Single Day Attendance: 2,265 visitors!

Thanks to all of you who participated and volunteered! We are looking forward to doing it again next year!



Vintage Computer Festival History

By Curtis Jones, RAMAC Demonstrator

When Janelle asked me to write something about the Vintage Computer Festival at the museum this first weekend of August, I decided to write about the VCF going back to its inception. But I discovered that my first VCF was VCF 4.0 in 2000.

https://vcfed.org/events/archives-show-summaries/vcf-west-archives/

Still, there is a much earlier connection - before the VCFs. VCF 4.0 was located at "Parkside Hall" in downtown San Jose, and one of the speakers was Jim Warren who was behind the West Coast Computer Faires. I asked him if he remembered where it was located. He looked around, and his face lit up. The second West Coast Computer Faire was at what was then called the "new" Convention Center. New name, but the same place.

It took some poking around the Web to see where the VCF really began – Sellam Ismael's VCF 1.0 at the Alameda County Fairgrounds in 1997. It is mentioned in the program for this year's VCF. Sellam gave an informative history of the VCF at the VCF SoCal in 2024.

https://www.youtube.com/watch?v=jEhfqquGA1I

VCFs have spread around the world. Sellam mentions Europe in 2000. He discussed providing directions for running a VCF to Evan Koblenz for VCF East. The archives show the first two VCF East shows were in Massachusetts, and in 2006 the VCF East arrived at the InfoAge Center in Wall New Jersey (very much worth a visit!).

https://vcfed.org/events/archives-show-summaries/vcf-east-archives/

It was in 2015 that organizers of the various VCFs organized the Vintage Computer Federation. https://vcfed.org/. Most of the officers have been coming to VCF West for the past few years and put real work into setting up and running the event.

The VCF came to the Computer History Museum in 2002. The archives record it being held at "Moffett Federal Airfield, Mountain View, California." The notice I sent to the APL Bay Area Users' Group states, "Moffett Training & Conference Center." I think of it as the officers' club, and it is just a block or so away from the Quonset huts where the museum's collection was exhibited.

In 2003, CHM moved to 1401 N. Shoreline Boulevard, and the "new" building accommodated the VCF nicely. The exhibits were in what is now the auditorium and talks took place in what is currently the museum store and the classroom overlooking the parking lot. The museum staff was very actively involved in making things run smoothly. Sellam speaks highly of the museum's help at 1:01 in his talk.

(https://www.youtube.com/watch?v=jEhfqquGA1I)

The connection between the VCF and the museum got even closer this year. We all noticed that we paid our admission to the VCF at the museum's front desk! I sure saw that for the museum's staff it was "all hands on deck." I especially appreciated the help at the front of house since it gave me more time at the VCF itself!

The usual suspects from the Vintage Computer Federation were here tending to business. We all saw Jeff Brace and Corey Cohen at the desks for badge distribution and consignment. Many of us might not have noticed Corey's name or that it shows up in most articles about auctions of Apple 1s. Erik Klein and his family were working away without a lot of notice that Erik is the president of the Vintage Computer Federation. Many of us know Erik since he has been around the museum for years. New, at least to me, were this year's showrunners Zack and Michelle Hardesty.

But what we are really interested in are the exhibits and talks.

Overall:	https://vcfed.org/events/vintage-computer-festival-west/
Exhibits:	https://vcfed.org/events/vintage-computer-festival-west/vcf-west-exhibits/
Talks:	https://vcfed.org/events/vintage-computer-festival-west/vcf-west-speakers/

This year's VCF focused on the 41 years since the Commodore Amiga was introduced at the 1984 CES. I was most impressed that Reece Pollak brought a CDC 160-A computer from the System Source Computer Museum in Hunt Valley, Maryland and demonstrated it in operation. We have Seymour Cray's experimental circuit in the supercomputer gallery and a 160-A in the minicomputer gallery. Beyond that there was much more to explore. The exhibitor numbers were up to 68 according to the map!

VCF offered so many talks that the Orientation Theater was used in addition to the Hahn Auditorium. Videos of the talks will be posted under VCF 2025 at:

https://vcfed.org/vcf-west-2025-videos/ or

https://vcfed.org/events/archives-show-summaries/vcf-west-archives/ under VCF West 2025.

The museum itself was surely a major attraction with extra docent-led tours and demonstrations offered. The RAMAC demo was well attended, and the 1401 Demonstration Team welcomed large crowds up to 5:00 each day!

At the awards ceremony Zack Hardesty said there were about 3500 visitors heartily exceeding previous attendance records. Looking forward to what next year will offer!

Data Storage: Hard Disk Drives

By Bruno Marchon, Chair of the Storage SIG and RAMAC Demonstrator

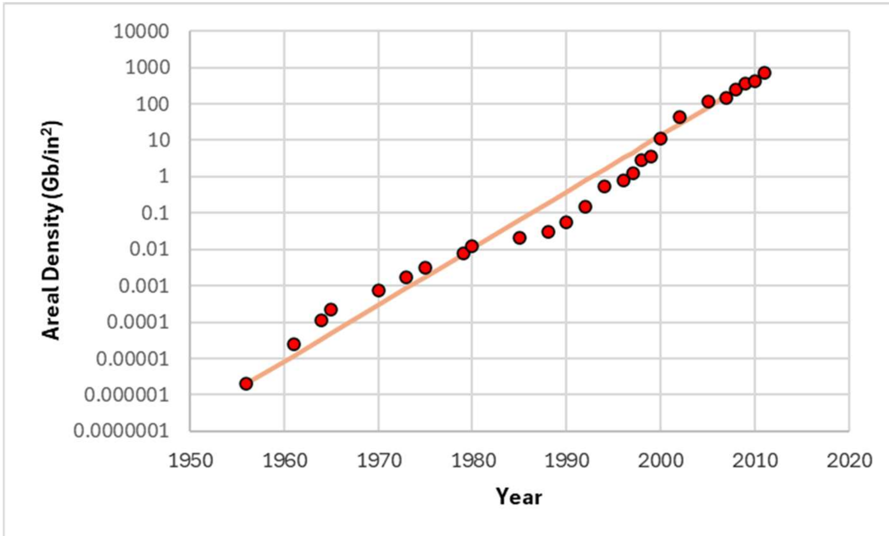
The Birth of HDDs

Even if hard disk drives (HDD) today are no longer part of the home computing environment, it is important to stress that most of the data in the cloud still resides on rigid spinning magnetic disks. The birthdate of HDDs is 1956, when IBM first commercialized the Model 350, aka RAMAC, the very first disk drive, capable of storage a whopping 5 million characters with an average access time of less than one second (Figure 1). The Ramac was a huge advance over punched cards, the storage of choice at the time.

Left: Period photo of an IBM 350 (Ramac). Right: A restored Ramac on display at CHM

<u>Historical Growth of Storage Density</u>

A good proxy for technological advances in HDDs is the Areal Density (AD), typically measured as the number of bits that can be stored for every square inch of disk surface. Historical AD growth has mirrored Moore's law from its inception until ~2011, with an average growth rate of 43% per year, i.e., roughly doubling every two years (Figure 2). It is interesting to note that AD growth in the 1980's has lagged the historical trend but made that up in the 1990's when AD growth peaked at about 100%, roughly doubling every year. In this timeframe, storage density grew an astonishing 9 orders of magnitude. To put this growth in perspective, the bit dimension in the RAMAC was about the size of an elongated grain of sand (1.3x0.25mm), whereas today, it would be the size of just a few hundred organic molecules (40x10nm).



Growth of HDD Areal Density. The solid line is a 43%/annum fit to the data

<u>Form Factor Evolution</u>

The IBM Ramac had a stack of fifty 24in diameter disks, but it was not the largest disk drive ever made. The record belongs to the ca. 1961 Bryant Model 2, with 39in magnesium disks (Figure 3). With advances in areal density, HDDs became smaller, with disk diameter shrinking to 14”, 8”, 5.25”, 3.5” and 2.5” inch, the latter becoming widespread in laptop computers in the early 2000s. Before the advent of flash storage for portable computing, there was a push for further HDD miniaturization, with offerings at 1.8,” 1.3,” 1.0,” and even 0.85” (Figure 4). However, these form factors were short-lived as flash memory became the storage of choice for laptops, cameras, phones etc… Today, nearly all HDD sold are in the 3.5” form factor

Left: The 205MB 39” Bryant Model 2. Right: A Bryant disk from my collection

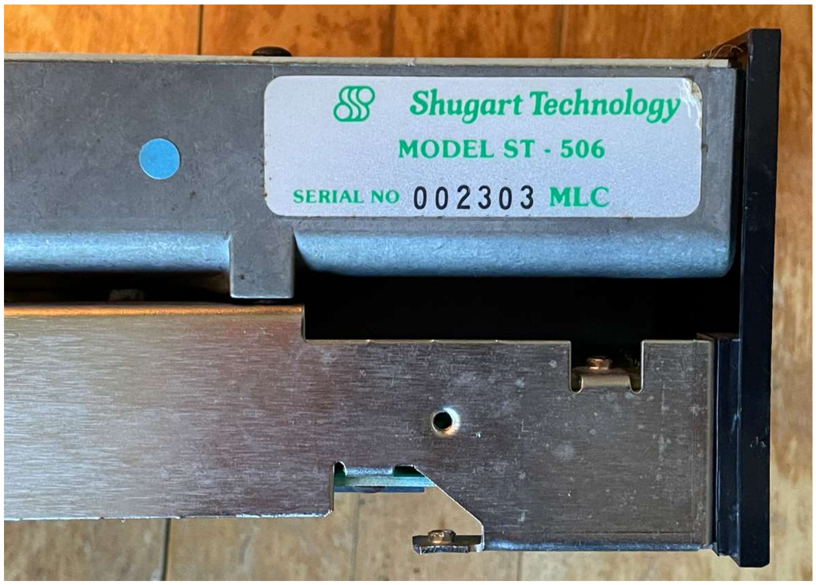
Small form factor HDDs from my collection (15GB Toshiba 1.8", 20MB HP 1.3", 340MB IBM 1.0", and 4GB Toshiba 0.85")

Collecting Vintage Hard Drives

I spent 27 years of my career in HDD companies (Seagate, IBM, Hitachi), and being a serial collector, I started amassing disk drives starting in the 1990s. I specialize in 5.25", full height early MFM drives used in early IBM PCs, as well as 3.5" full height SCSI drives mostly from compact Macintosh of the mid-80s. I also recently started collecting microdrives (1" form factor and below), and the advantage of these small drives is that my whole collection of about 50 different drives fits in just a small binder! I like powering up and testing my vintage HDDs. Most of them (~80%) work straight away, even after having spent nearly 40 years in storage. A few HDDs (~10%) need some more tinkering. By far the most common failure mode is stiction, either from the head parked on the disk, or from the actuator stuck to the "crash stop." A short-term fix is simply to open the enclosure and force-move the disk or the actuator. Interestingly, these vintage HDDs seem fairly robust against short excursions to non-filtered air.

I enjoy doing a bit of digital archeology and exploring the type of files that still reside on them. Most of the time, I see just a handful of letters, accounting spreadsheets and a few games. It is amazing to see how much money people were then willing to spend on a personal computer (about a month's salary) for so little apparent use.

My rarest item is a 5.25" MFM *Shugart Technology* ST-506 (Figure 5). Al Shugart had founded *Shugart Associates* in 1973, making mostly floppy drives (8" and 5.25"). After selling the company to Xerox, he went on to start *Shugart Technology* in 1979, making 5.25" HDDs. However, he quickly had to change the name to *Seagate Technology*, as Xerox claimed the rights to the *Shugart* trademark. Very few HDDs were made with the early *Shugart Technology* label, and I was lucky to find one many years ago at "Weird Stuff," a now-defunct Sunnyvale store that sold vintage computing parts.



An ultra-rare 5MB "Shugart Technology" ST-506

WANTED

For Mischief and Mayhem in the Museum

Offense:
Leaving multiple jars of chads on Dag's desk – without explanation, remorse, or a recycling plan.

Suspect Profile:

- Likely possesses a suspiciously deep knowledge of vintage computing.
- Enjoys practical jokes at the expense of fellow CHM volunteers and staff.
- May be seen carrying additional jars, bags, or boxes of chads.

Alias:

- *The Chadminator*
- *The Hanging Menace*
- *The Punch Card Phantom*

Reward:
Dag's eternal gratitude and a reprieve from future lectures on proper disposal of computing debris.

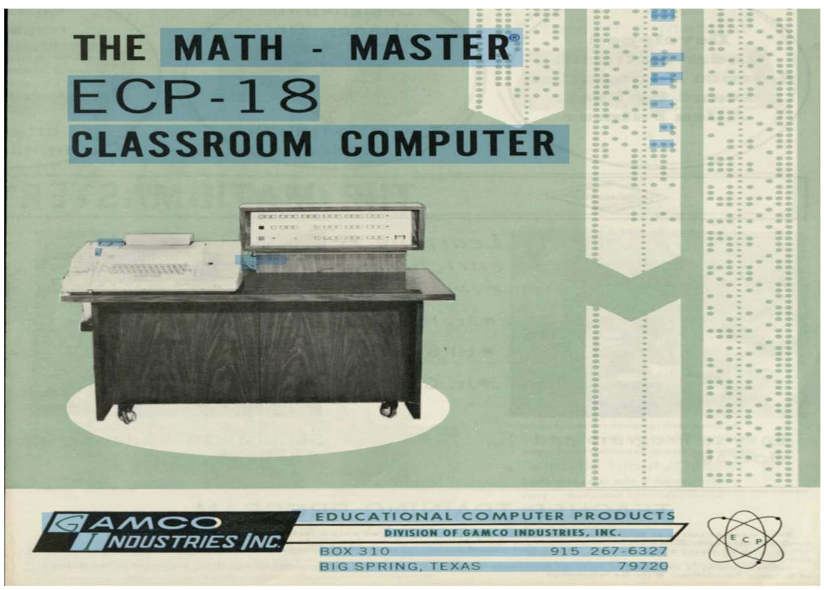
Warning:
This perpetrator may strike again. Be on the lookout for stray jars.

Do you recognize these jars?

Spotlight on Docent Trainee, Juanita Mah

In elementary school I thought my strength was writing. My dream was to write the next Nancy Drew novel, and I was proud of the essays, short stories, and poems that got praise from readers. It wasn't until middle school that I discovered that I was good at math. My math teachers made "new math," algebra, and the slide rule fun to learn, and I became an enthusiastic competitor at local math competitions.

So, when a summer course called Computer Math was offered in 1969 — just before my senior year of high school—I jumped at the chance to learn another kind of math. It turned out to be a computer programming course using the Math-Master ECP-18. According to a brochure in the CHM's archive, the ECP-18 was developed under a National Science Foundation grant by Dr. Allen Fulmer, a professor at Oregon College of Education.



The Math - Master ECP-18 Classroom Computer, 1967, acquisition no. X6818.2013

Our model came with 2048 words of memory, each 18 bits long. Input could be entered using a display panel, a teletype keyboard or paper tape reader; output was returned on the display panel or paper tape punch. The brochure listed a printer, but I don't recall ours having one.

The ECP-18 had three registers: the accumulator, an instruction register, and an instruction counter. That summer, we used the registers to code and debug our programs.

We manually entered our programs bit by bit by pressing accumulator buttons and watching the “ones” light up on the registers while stepping through the program one instruction at a time.

We also learned FORTRAN programming. Our teacher, who was taking a programming course at San Diego State (a 120-mile drive) on weekends, was learning right along with us. We wrote our programs on FORTRAN coding sheets, carefully checking our program for errors before turning them in on Fridays. She submitted them to a key punch operator in San Diego, and we received our results the following Monday. Needless to say, turnaround time was very slow!

In those days, few people had the chance to work directly with a computer. The fun of being able to interact directly with a computer and the thrill of that aha moment when my code finally ran successfully convinced me that I wanted to be a computer programmer. That summer marked the start of my journey into computer science that eventually led me to the program at UC Berkeley.

Juanita Mah

La Salle University Train at Home Matchbook

References:
1. ECP-18 sales brochure from the CHM archive: https://archive.computerhistory.org/resources/access/text/2021/07/102776364-05-01-acc.pdf
2. Judy Allen Memoir: https://lookingthroughwater.wordpress.com/2012/05/31/memoor-chapter-six-metamorphosis/
3. Arvid Lonseth Memoir: https://lookingthroughwater.wordpress.com/2012/05/31/memoir-chapter-five-arvid-lonseth/

Volunteer Benefits: Reserving Free Tickets

Share the CHM Experience with Those Who Matter Most!

As a valued member of the Computer History Museum team, you can share your ticketing perks with family, friends, neighbors, and even your postal worker. What better way to spread the fun than by inviting your loved ones to enjoy unique experiences at CHM!

Instructions for reserving tickets:

1. Go to the [General Admission]() page and click on the **"Member Login"** in the upper right corner.
2. Sign-in using the email address you use for V4S and enter the code that it sent to your email.
3. Once signed in, **Select** General Admission tickets and your desired date. Add tickets to your cart. Your volunteer discount will be automatically applied and will make up to 4 tickets free.
4. Click **Proceed to Checkout** to advance payment information. A donation request will appear, but it is **optional**—it is appreciated but not required.
5. Accept the terms and conditions, then click **Complete Order**.
6. An email with your tickets will be sent to your email address. Feel free to forward it to family, friends, or anyone you wish.
7. Have your guests bring the email or show the QR code at the front desk when they arrive.

What you need to know:

- Important: You must be signed into the portal using the same email address you use to log into V4S. If the discount is not being applied correctly, please confirm you are using the correct email.
- You can reserve up to **4 free tickets** at a time, but there is **no limit on the number of tickets** you can reserve throughout the year.

The Computer

By Claude.ai in the style of Edgar Allan Poe

Submitted by Jim Hollenhorst, Docent Trainee

Once upon a midnight dreary, while I pondered, weak and weary,
Over many a quaint and curious volume of forgotten lore—
While I nodded, nearly napping, suddenly there came a tapping,
As of someone gently rapping, rapping at my chamber door.
“Tis some visitor,” I muttered, “tapping at my chamber door—
Only this and nothing more.”

But the sound was calculation, whirring gears in combination,
Babbage's engine, first creation of the computational shore—
Then came Turing, mind so keen, with his theoretical machine,
Breaking codes that intervened in the midst of global war.
Logic gates and circuits gleaming, switching on and off in war—
Binary and nothing more.

Then the vacuum tubes were glowing, ENIAC’s power ever growing,
Room-sized monsters, current flowing through each cathode’s heated core—
Soon transistors, small and nimble, made the giants seem so simple,
Silicon wafers, clean and ripple-free, replaced what came before.
Microchips on circuit boards replaced what came before—
Progress forevermore.

Then came personal computers, desktops for the daily commuters,
Apple, IBM, and suitors vying for the retail floor—
Networks linking every station, spawning global information,
Internet’s vast congregation, data flowing shore to shore.
The World Wide Web connecting every distant shore—
Knowledge by the score.

Now the smartphones that we carry hold more power than we’d tarry
To imagine—processors merry, dancing through each software chore—
Cloud computing, AI learning, quantum bits are slowly turning
All our notions, overturning what we thought possible before.
The future knocks upon tomorrow’s door—
Computing evermore.

History Repeats Itself?

By Gallery Interpreter Atsushi Yamazaki

A short phrase in a company history book caught my eye in May 2025. It stated, “Rittor Music Inc. is famous for standardizing MIDI together with Yamaha and Roland. MIDI completely transformed the music industry from analog recording to digital recording. Rittor Music also had the power to change the world.” Mr. Ryuichi Sasaki, a founder of Rittor Music Inc., donated the Yamaha DX7 to CHM in 2019. I contacted Mr. Sasaki and Mr. Akihiko Nakashima about “the hidden history of the Yamaha DX7, MIDI and Rittor Music in the 1980s.” I wrote the story below based on my interview and their documents.

Ryuich Sakamoto playing Yamaha DX7

Hidden history of Yamaha DX7 launch in 1983

Rittor Music Inc. (founded by Ryuichi Sasaki in 1978), a Tokyo-based publisher and software manufacturer which published Japan’s first Keyboard Magazine and music collection software, was approached by Yamaha in 1982 to develop a demo program playing the new DX7 connected to a personal computer at the launch of the DX Series the following year. “When we developed and tested the prototype MIDI interface board in a PC-98 and connected the prototype DX7, everything was still prototype including the software. So, we had a lot of trouble figuring out what was wrong and who to turn to for help,” said Mr. Nakashima.

Rittor Music completed a MIDI interface board for NEC’s PC-8001with software, and performed PC+DX7 demos successfully at the nationwide DX7 launch events in the spring of 1983. In the same year, Rittor Music released a MIDI music collection with performance software for NEC’s PC-98 and also developed a MIDI interface for the Apple-II. Rittor Music promoted MIDI technology with musical sensibility, and published special journals, magazines, instructional books, software development tools, and planning support to evangelize MIDI for music fans to compose, play, and record music in the everyday life of professional and ordinary people. As one of the few global standards originating in

Japan, MIDI created a global electronic music industry. Standardization efforts were conducted in English with the world's leading musical instrument manufacturers (Yamaha, Roland, Korg, Casio, Sequential Circuits, etc.). Rittor Music played a key role in facilitating the industry, including editing the MIDI 1.0 specification, formulating the Standard MIDI File, publishing the MIDI Bible I & II - which detailed the standard - and founding the Musical Electronics Industry Association.

This is a hidden history of Yamaha DX7 and MIDI in 1980's. Yamaha, the world's largest music instrument company, collaborated with a small but talented company for the successful launch of DX7. The media in 1980's were books, magazines, and CD publications by Rittor Music. MIDI, a global standard, was the biggest player for the evolution of the digital music industry and changed the world of music.

The Birth of "Hatsune Miku" in 2007

Hatsune Miku officially code-named
CV01, is a Vocaloid software voicebank

In 2006, Yamaha's Mr. Kenmochi introduced VOCALOID2 to Mr. Sasaki of Crypton Future Media in Sapporo, a company of about 25 employees with whom he had previously tested the music software, Daisy. They began developing a new software service. Sasaki wanted to create the image of female androids, Hatsune Miku, in Japanese SF culture and the illustrations in anime and manga. VOCALOID2 has a high-pitched synthesized voice and uses Yamaha technology, and he decided to use the Yamaha DX7 as a motif. The DX7 was known for its metallic and high-pitched electronic sounds. The slightly unusual blue green of Hatsune Miku's image was also chosen to match the DX7's color. "If the DX7 hadn't been the motif, the character's appearance might have been completely different," says Sasaki. When Hatsune Miku was released, there wasn't much content available on YouTube or Nico Nico Douga. Amateurs who uploaded anime songs, people who had written lyrics and melodies hoping to have a singer sing them someday, and other subculture enthusiasts began uploading their works, thinking, "I heard that having Hatsune Miku sing would be a hot topic. So why not release it?" A wide range of users began to appear. As they considered how to handle Hatsune Miku's copyright and how to create rules and etiquette for the secondary, tertiary, quaternary, and quintessential creative works created using Hatsune Miku, they decided to release the original Hatsune Miku copyright in the form of a license, similar to an open-source license, stating, "Feel free to use it under these conditions." The chain of Hatsune Miku creations spread across the internet in the form of a chain of empathy and a chain of thanks.

This is another example of Yamaha collaborating with a small but talented company to produce “Hatsune Miku” in 2007. The media in 2000’s was the internet and YouTube. With the Open Source license for Hatsune Miku and their secondary creative works generating a chain of empathy and thanks.

History repeats itself? Yamaha repeats itself?

Sources:

- “Rittor Music and MIDI” by Yasuhiko Nakashima May 10, 2025.
- Impress Group 30-Year History Published by Impress Holdings Co., Ltd. April 1, 2022.
- Keyboard Magazine, December 1983. https://www.rittormusic.co.jp/backnumber/km/km198312.html.
- MIDI Bible, Volume 1 (by Yasuhiko Nakashima), MIDI Bible II.
- https://www.tjf.or.jp/clicknippon/ja/mywayyourway/11/post-29.php.
- https://sg.wantedly.com/companies/crypton/post_articles/540884.
- https://performingarts.jpf.go.jp/article/7116/.
- https://www.youtube.com/watch?v=UiSPiIwnWoY&list=RDUiSPiIwnWoY&start_radio=1.
- https://logmi.jp/main/social_economy/271875.

Japanese High School Students Visiting CHM

The Man-Machine Interface that Helped Revolutionize Computing – the Digital Equipment Corporation Type 30 Precision CRT Display

By Joe Fredrick with Mike Cheponis, and Abilio Marques

The Digital Equipment Corporation (DEC) Type 30 Precision CRT Display was introduced in 1960 as part of the Programmed Data Processor -1 (PDP-1) system. The Type 30 consisted of a round 16-inch diameter monochrome cathode ray tube (CRT) display with all driver & interface electronics and power supplies packaged in a standalone desk-like unit. The Type 30's various versions: 30E, 30G, and 30H optionally included a Type 32 light pen pointing device, similar in function to a modern-day tablet stylus or pen.

The Type 30's lineage traces to MIT's Whirlwind project at the Servomechanisms Laboratory in the late 1940s–early 1950s, and then through the TX-0/TX-2 display and light-pen work at the newly formed MIT Lincoln Laboratory (est. 1951). That experience—carried into DEC by Ben Gurley—led to the PDP-1's Type 30 display, using a random-position, point-plotting, "point scope" technology, in contrast to later vector and raster display technologies.

Whirlwind's design and its CRT display and light pen human interfaces significantly influenced the design of MIT's TX-0 and TX-2 experimental computers. These influences extended beyond the boundaries of academic and research laboratories when they were commercialized by DEC and embodied in the Type 30. Today we give little thought to the graphical displays on our laptops, smart phones, smart watches, and electric vehicles and to their associated mouse / touchscreen pointing devices, but in the late 50s and early 60s these human interface devices were truly revolutionary.

Architecture

The heart of the Type 30 is the monochrome display tube. It is of the type commonly used in the 1940s and late 1950s to display radar data in air traffic applications. DEC's Type 30 uses a 16ADP7A CRT with P7 "cascade" phosphor that emits a quick blue flash (tens of microseconds, ZnS:Ag) followed by a fading yellow-green afterglow (~0.4 s to 10%, ZnCdS:Cu) for each plotted point -- the classic blue dot with a green tail that viewers see. Such behavior is highly desirable in radar applications where the radar antenna sweeps the entire horizon only about once per second. This behavior is favored in PDP-1 applications because it allows time for the program to perform other tasks between display refreshes.

The design of the Type 30 is straight forward. It is a X-Y (Cartesian coordinate, in engineering speak) point-plotting display in contrast to today's raster scan or vector drawing technologies. The Type 30 does not incorporate screen memory or automatic refresh, both common in modern computer display subsystems. For PDP-1 applications that use the Type 30 display, the user's program must refresh (rewrite) every point on the display for it to be persistently visible to observers for more than a few hundred milliseconds. In general, the user's program interacts with the Type 30 display by setting the X- and Y-addresses of the desired point and then by executing a command to illuminate the point at that address on the screen. In practice, a programmer sets the X-address by loading the left-right X-coordinate into the PDP-1's accumulator register and sets the Y-address by loading the up-down Y-coordinate into the PDP-1's I/O register and then executes a display-one-point (dpy) instruction to illuminate the specified point with one of eight intensity levels. This process typically takes about 50 microseconds, resulting in a maximum 'writing rate' of approximately 20,000 points per second, far below today's video game graphics refresh rates.

The display, though physically large at 16-inch diameter, limits the user area to a center square 9-3/8 inches by 9-3/8 inches. Within this area the resolution is 1024 by 1024 discrete points / pixels each approximately 0.030 inches in diameter (about 33 per inch).

Restoration Effort

The Computer History Museum's PDP-1 system was restored to operating condition by a team of volunteers[i] back in 2003-2005. A critical part of the restoration effort was the identification and digitization (scanning & reproduction) of historical PDP-1 system documentation from MIT and DEC, held in the Computer History Museum's archives. Al Kossow, a curator at the time, made available to the team numerous manuals, electrical schematics, and software paper tapes[ii]. The engineering part of the restoration effort was focused on testing and repairing the electronics and electromechanical elements of the processor, console typewriter, paper tape reader & punch as well as the Type 30 display and its associated light pen. Another, equally significant part of the restoration effort was the study and duplication of the museum's collection of vintage PDP-1 software. That software, embodied in listings and punched on paper tape included DEC system test & diagnostic programs as well as utilities and applications. One part of the paper tape collection led Peter Samson to recreate his Music Player program. Another part of the collection included tapes of Spacewar!, the iconic interactive computer shoot-em-up game, developed at MIT in 1962 mostly by Steve Russell, Martin Graetz, and Wayne Wiitanen with additional collaborators and contributors. These and a few other graphics programs: Minskytron, Snowflake and Munching Squares, form part of the regularly scheduled public PDP-1 Demonstrations that have taken place over the past 20 years at the CHM.

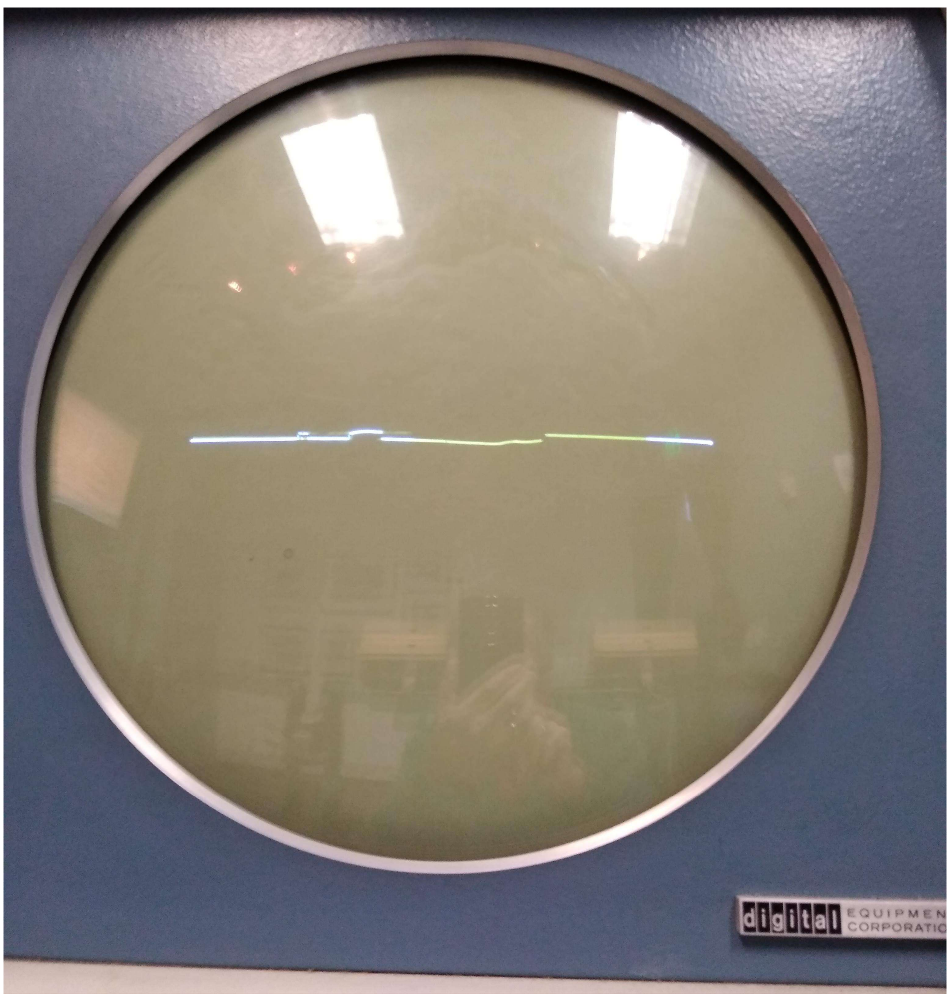
Display Anomalies and A Wrinkle in Space

Within several years after the system restoration was completed, the Type 30 Display started requiring periodic attention to keep it operating. In the Fall of 2019, the Deflection Amp module's cooling fan failed and required replacement. The CRT's Type 770 (+10 Kv) power supply failed in April 2023 during the start of a public demo, due to high leakage on a pair of output filter capacitors that caused the CRT to go dark. The capacitors were replaced later, in May 2023, with new ones to restore operation.

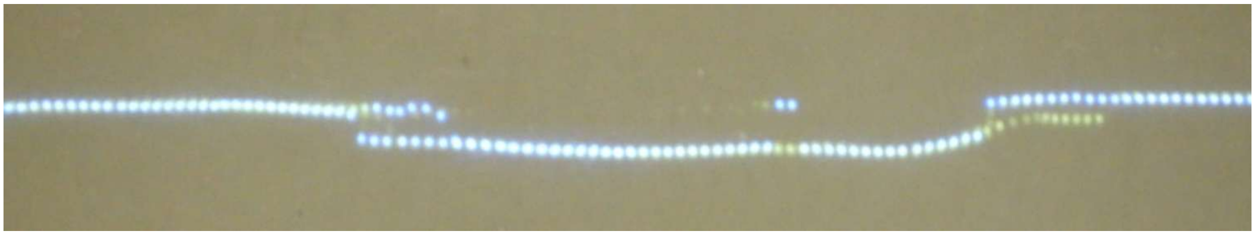
Additional failures have occurred more recently. For example, the PDP-1 demonstrators began to observe graphic display anomalies as early as February 2024. While demonstrating Spacewar! the team observed the fragmentation of the spaceships into multiple parts and a shadowed outline of the ships on other occasions. The immediate reaction was to restart Spacewar! and, if that failed to correct the problem, then reload the program from paper tape into another memory bank. These actions sometimes 'fixed' the problem and suggested that the display anomaly might be caused by a core memory failure. Subsequent investigation and memory testing with the DEC diagnostic programs showed no evidence of memory failure at the time.

Then on 30 March 2024 at the start of a Spacewar! tournament, the display's Type 722 (+10V, -3V and -15V) power supply failed, sending some smoke into the demo room. The failure was traced to a degraded capacitor connected to the supply's ferro-resonant transformer. The 60-year-old capacitor simply wore out. It was replaced with a new one in mid-April 2024.

A discontinuity or wrinkle in the lower portion of the display field showed up more often during demonstrations in the Summer of 2024 while running the Munching Squares and Spacewar! programs. It was soon referred to as the 'glitch.' This became the puzzle that members of the maintenance team began working on in earnest beginning in September 2024. Here is a classic photo of a horizontal line glitch: a test program generated a straight-line segment, but the display exhibits a glitch in certain address ranges.



Close up, the glitch looks like these photos. The display should be a straight line!



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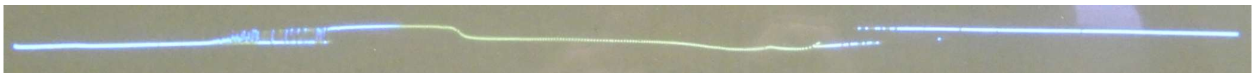


And you can find a video of the glitch in action here.

https://drive.google.com/file/d/1bwMWN6dvLWoVK6tWP6_wYQP0MJZlShJs/view?usp=sharing.

Investigation and Repair

An interdisciplinary approach evolved to determine the root cause of the glitch, starting with the fact that the glitch was frustratingly elusive. It did not regularly or consistently occur with the suite of PDP-1 Demo programs. The maintenance team[iii] considered several possible areas of the system to investigate: intermittent failures of the PDP-1's core memory, intermittent failures of the PDP-1's I/O interface (to the Type 30 Display), and intermittent failures in the digital logic and/or analog portions of the Type 30 Display itself.

Initially the glitch seemed to affect the horizontal lines of displayed images causing vertical deviations, but later investigations demonstrated a loose interaction between purely X and purely Y elements. These two clues, though insufficient to immediately identify a single, simple root cause, did help to validate the repairs that were later implemented. After trying a few 'quick' logic-module swaps without resolving the issue, a more systematic approach was taken to examine, test, and verify the proper function of each relevant part of the system.

The glitch seemed to be somewhat temperature dependent, warmer room temperatures loosely correlated with its appearance. Early investigations suggested that loading the Spacewar! program in another core memory bank of the PDP-1, relocating it from bank 2 to bank 0, sometimes made the glitch disappear (at least for a while). Core memory bank 0 benefits from temperature compensation of its read/write & inhibit drive currents, while banks 1 and 2 simply follow along. The team tested each of the PDP-1's core memory banks but found no failures, so attention turned to possible corruption of the X and Y addresses as they were transferred to- and held in- the Type 30's X and Y address registers, while executing a display-one-point (dpy) command.

In order to force the elusive glitch to consistently appear, several team members[iv] wrote custom test programs to generate and display individual horizontal, vertical and diagonal lines. The PDP-1 console's Test Word input switches controlled the start & stop addresses of the line, in real time, and allowed the operator to dynamically explore the X / Y address ranges where glitches occurred. The isolated lines offered simple images without the extra display clutter associated with the other demonstration programs. With these test programs (crosshair.asm, raster.asm and lins4.asm) in our toolbox we were able to force the glitch nearly any time we wished and allowed us to probe the Type 30's data path logic signals – the goal of every engineer debugging a system.

The loose interaction between the X and Y addresses of a glitch was puzzling, considering that most of the X and Y axis data paths are separated in the Type 30's architecture. The Type 30 is an X-Y address, Cartesian coordinate, point-plotting display. The data path consists of an X-channel and a Y-channel, each separately but simultaneously controlling the corresponding position of the CRT's electron beam: X-channel controls left-right positioning and the Y-channel controls up-down positioning.

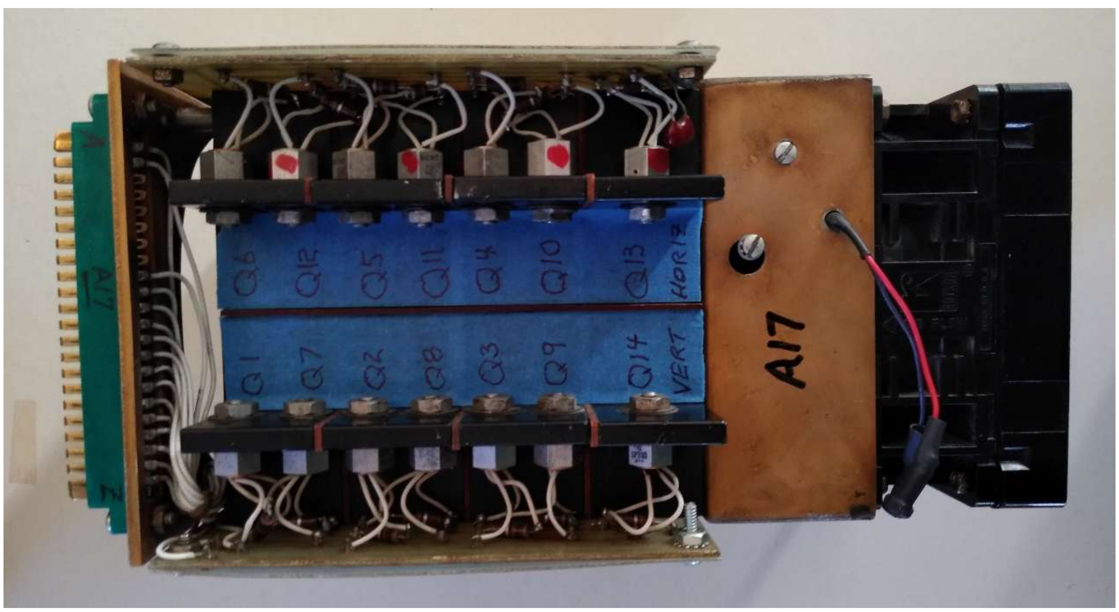
Both the X and Y data paths consist of digital logic elements (data registers, transfer gates, and level shifters) and analog elements (digital-to-analog converters, signal amplifiers, CRT deflection yoke). To narrow the scope of the investigation, the maintenance team focused on the digital portions of the data paths. Using modern-day logic analyzers and oscilloscopes, the 10-bit X and 10-bit Y addresses from the PDP-1 test programs were traced and probed along their respective data paths. No obvious digital logic module or component defects were identified among the digital elements, so the team's attention turned to investigating the analog portions of the X and Y signal paths.

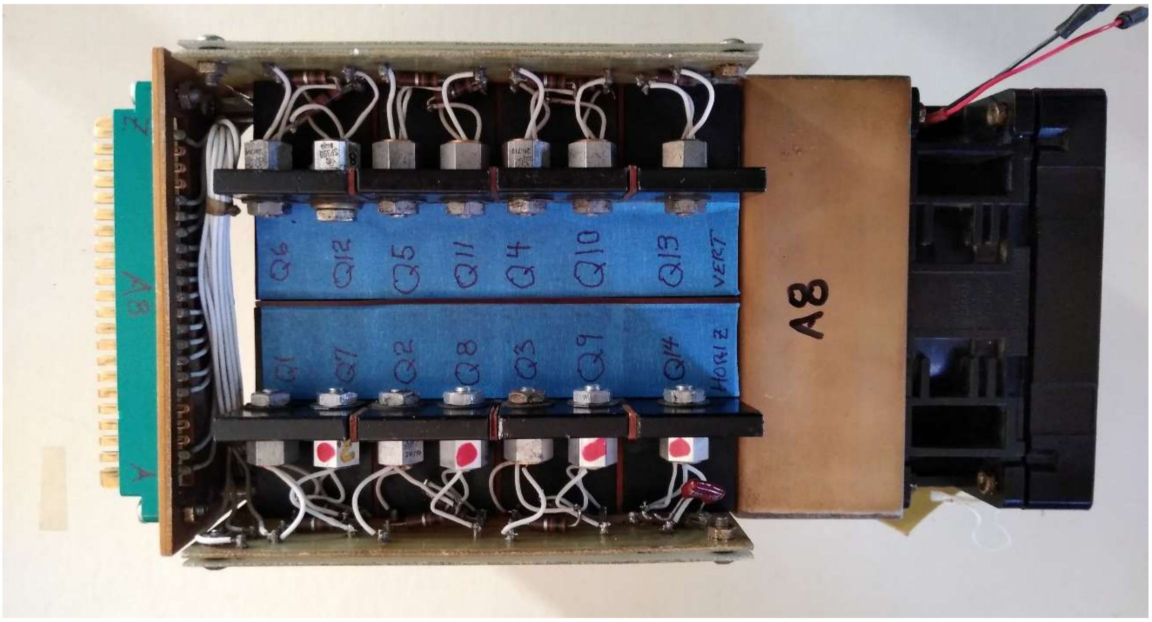
The analog elements of the signal paths include separate X and Y digital-to-analog (D/A) converters, separate X and Y Display Preamps to process the DAC outputs and the Deflection Amp power stage to boost the signal and drive the CRT deflection yoke' up, down, left and right coils. The D/A converts the digital bits representing the X (and Y) address value into a corresponding analog value. The resulting analog voltage drives the X (and Y) Display Preamp which in turn drives the Deflection Amp. The Deflection Amp transforms the differential X (and Y) analog voltage from the preamp into corresponding X left and right (and Y up and down) analog currents which flow through the CRT magnetic deflection yoke's coils. The magnetic fields, which surround the yoke's coils, position the beam to the intended X-Y point on the screen.

The design and performance characteristics of the Display Preamp module are briefly described in the Type 30 technical documentation. The team did not want to test these modules in a live system or immediately jump into bench-testing these modules, for fear of damaging them, without a greater understanding of the Display Preamp circuit's behavior and performance limits. Members of the team, with the help of Dr. Frank M. Caimi, leveraged modern day circuit simulation tools to investigate how individual component failures would affect the preamp's performance – this as a possible clue to the root cause of the glitch.

Bench probing and measurement of each Display Preamp module’s transistors and diodes identified several out-of-spec components. Each marginal component was replaced with a new-old-stock device. In total 7 transistors and 5 Zener diodes among the four Display Preamp modules tested were replaced. A custom test jig was designed and constructed to allow the team to observe and adjust each Display Preamp module’s behavior on-the-bench when subjected to simulated realistic drive conditions. This technique of testing the module, removed from the system, allowed us to pre-set the adjustment trim-pots on the module to ‘safe & conservative’ settings. The Type 30’s technical documentation contains several warnings with respect to making adjustments to set the displayed image’s up/down, left-right positions and the overall size of the image in a live system. We did as much as possible to pre-set these adjustments on the bench to protect the artifact, before adjusting them in the live system.

Having thoroughly tested and refurbished the Display Preamps, the team turned its attention to the quad channel Deflection Amp that generates the right-left and up-down drive currents. This module, with four groups of seven transistors each (one driver, with six in parallel), is key to the function of the Type 30 Display. It is both a wonder of 1960’s thermal and electrical engineering and a terror to work on. It is not a module designed to be repaired easily! Here are the two sides of the pre-refurbished Deflection Amp module showing all 28 transistors that comprise the four groups.





Extreme caution was used to bench test each transistor (all 28) and their matching base-drive resistors (all 28) with the objective of finding any defective parts. Numerous transistors exhibited bad performance, all 28 of the resistors were out-of-spec and many transistors exhibited marginal low gain & high leakage values – indicative of device aging and wear out. In all, 17 of the 28 transistors and all 28 resistors were replaced. All removed parts were tagged & bagged and new parts were identified with red nail polish.

We mentioned above that 'the glitch appearance seemed to be loosely correlated with elevated room temperature.' Physical examination of the Deflection Amp module revealed that some transistors had rather poor thermal bonding to the underlying heatsink. As a precaution to future thermal degradation of the transistors, modern-day thermal bonding paste was applied to each transistor and its stud-mounting nut suitably torqued for improved thermal performance.

<u>Of Sails and Cooler Breezes</u>

Along the way of investigating and diagnosing the display glitch the team observed that when the PDP-1 Demo room became unusually warm, the glitch seemed to appear sooner than in a cooler room. A simple experiment with the room fan seemed to confirm this observation. Thus began another effort to examine the performance of the three Muffin® cooling fans in the Type 30 Display. Over the past few years each of these fans have failed due to age or weak air flow and were replaced with modern day equivalent units. One such fan forced room air through the Deflection Amp's heatsink assembly to cool the transistors. Initially the Deflection Amp's fan was replaced with a fan with similar specifications, however this proved to be poor choice because the high-density of fins in the heatsink assembly present a high resistance to air flow. In order to evaluate alternative fans, a simple homebrew wind tunnel was constructed and with a calibrated air flow meter. A high-performance fan was identified by this process and installed in the Deflection Amp module. Subsequent testing showed that the temperature of the exit-side of the Deflection Amp's heatsink assembly measured about 28 C (82 F about 10 degrees above room temperature) after a period of Type 30 operation with the new fan and improved thermal mounting of the transistors.

The Type 30's fan Sail Switch failed during fan testing. The sail switch monitors the air flow through the Deflection Amp's heatsink. The sail switch controls the power-on/off sequencing of the Type 30 Display and is a critical element in safely powering it up and down. Repositioning the Deflection Amp's cooling fan by moving it away from the front side of the heatsink assembly by one-half inch and closing off some seams to prevent escape air flow seemed to improve the operation of the sail switch. It now functions as expected.

Is it Fixed Yet?

As of this writing, August 2025, the major glitch seems to have disappeared or significantly shrunk in size[v]. However, we note that there are still some transistors in the Deflection Amp that fail to fully meet specification with respect to gain and leakage current. Such degraded components will continue to affect the display's performance until the team can acquire a sufficient quantity of fully 'good' transistors to replace all of them. Our challenge is the scarcity of 60-year-old New Old Stock 2N1719 (or 2N2994) stud-mount transistors. We have searched far-and-wide with human- and AI-powered tools, with limited success.

The debugging and repair effort was a long slog, with many clues and some false tracks along the way but the team is pleased to have a (hopefully) improved Type 30 Display which will continue to amaze and inform the museum's visitors for years to come.

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[1] The early restoration team included (alphabetical): Lyle Bickley, Mike Cheponis, R. Tim Coslet, Joe Fredrick, Peter Jennings, Al Kossow, Dr. Bob Lash, Steve Russell, Peter Samson, Rafael Skodlar, Eric Smith, and Ken Sumrall. Later PDP-1 volunteers included: Kora, Joe Lynch, Abilio Marques, and Diane Zingale.

[ii] A broad collection of scanned and preserved original computer documents (manuals, engineering drawings & software) is available online at Al Kossow's https://bitsavers.org/, including many for the PDP-1.

[iii] (alphabetical): Mike Cheponis, Joe Fredrick, Abilio Marques, Peter Samson, and Diane Zingale.

[iv] (alphabetical): Mike Cheponis, Abilio Marques, and Peter Samson.

[v] An example of Munching Squares, after the display was 'fixed'. https://drive.google.com/file/d/1B1b-snZ_yHPCJLIAUkHLoWaLhEc46dSp/view?usp=sharing

And one of Spacewar! after the display was 'fixed'. https://drive.google.com/file/d/1A-1zm0hCvS80cXnu5sbFYKWFaZCNxiL_/view?usp=sharing