

# Restoring and Demonstrating 1960s Vintage Computers at the Computer History Museum

Robert Garner

IBM 1401 Restoration Project Lead Volunteer



Making IT Work Conference  
Computer Conservation Society  
London, May 22, 2017

# THE COMPUTER HISTORY MUSEUM

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The world's leading institution exploring the history of the computing revolution and its ongoing worldwide impact on the human experience.



- **Collections and Exhibitions:** >109,000 computing artifacts and 834 oral histories. Hosts 200,000 visitors annually.
- **Specialized Programs & Events:** Speaker series (CHM Live!) and events with prominent tech leaders.
- **Educational Outreach:** Educational programming reaching 18,000 students annually.
- **Innovation and Entrepreneurship Center:** Engages and cultivates new audiences with innovators and change makers.
- **Young Professionals:** Next Gen Advisory Board events, large social media reach.

# Exhibitions



**R | EVOLUTION**

The First 2000 Years of Computing

Exhibitions showcase the Museum's unique and large collection, and engage new audiences with technology and stories in a venue dedicated to innovation.

## ***Revolution***

- Chronicles the evolution and impact of computing from the abacus to smart phone
- 25,000 square feet in 19 galleries
- Features >1,000 artifacts and videos
- Engages audiences through docent-led tours and technology demonstrations

## ***Make Software: Change the World!***

- An interactive exhibit that explores the impact software makes on everyday lives

# Speaker Series: CHM Live!



CHM Live! is a multi-media program with a world-wide distribution on the web, regional and national public radio & television.

Past speakers include:

- Ed Catmull. *Pres., Pixar & Walt Disney*
- Marissa Mayer, *CEO, Yahoo!*
- Elon Musk, *CEO, Tesla Motors, SpaceX*
- Sheryl Sandberg, *COO, Facebook*
- Eric Schmidt, *Chairman, Google*
- Mark Zuckerberg, *CEO, Facebook*



# Education



## **Design\_CODE\_Build**

Interactive events for “underrepresented in high-tech” middle school students, introducing basic concepts behind coding to excite students about pursuing STEM in their education and future careers.

## **Talking to the Future**

High school students engage with innovative entrepreneurs and tech industry leaders through design challenges, interactive demos and speaker panels, and inspiring activities designed for collaboration.

## **School Group Visits**

11,000 students annually visit the museum for free school visits to participate in interactive workshops related to STEM disciplines.

# Vintage restorations and live demos



## **DEC PDP-1 Demo Lab**

Showcases SpaceWar! video game on eerie CRT, music synthesis.  
Demos: first and third Saturdays of month



## **IBM 1401 Demo Lab**

Showcases the lively line printer, punched-card equipment, keypunches, tape drives.  
Demos: Wednesday afternoons and Saturday mornings



## **IBM 350 1<sup>st</sup> Disk Drive Demo**

Showcases operational 50-platter disk and access arm. Located in Revolution exhibit.  
Demos: Wednesday afternoons



# RESTORATION

(1998 – 2000)

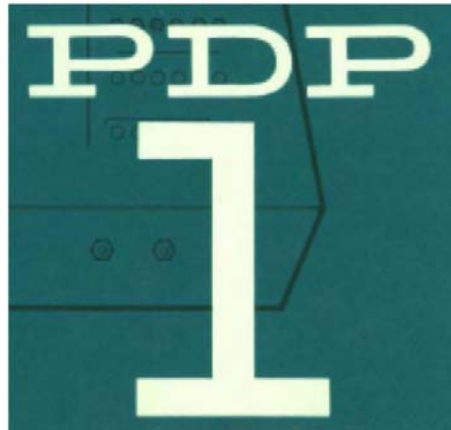
No longer demo'd

# IBM 1620 restoration





**digital equipment corporation**



**RESTORATION & DEMOS**

(2003 – 2006, ongoing)

# DEC PDP-1 restoration



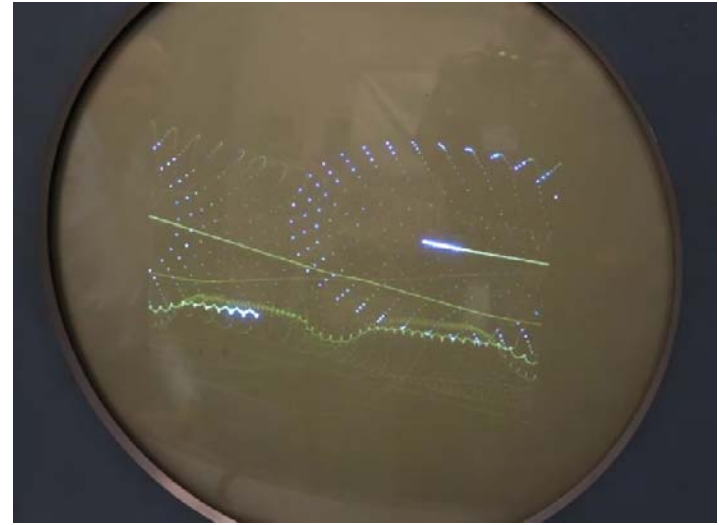
# PDP-1 demos



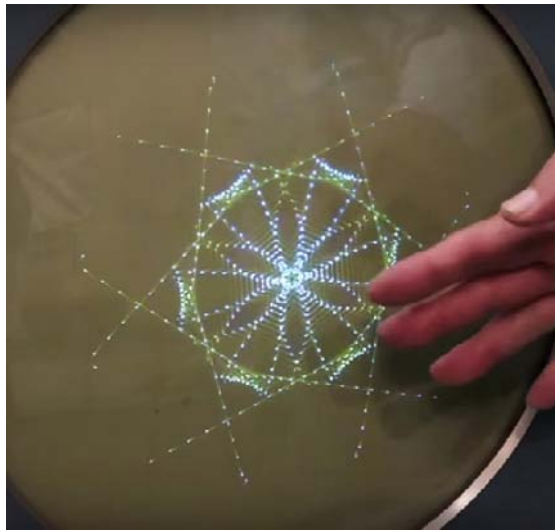
# PDP-1 demos with CRT display



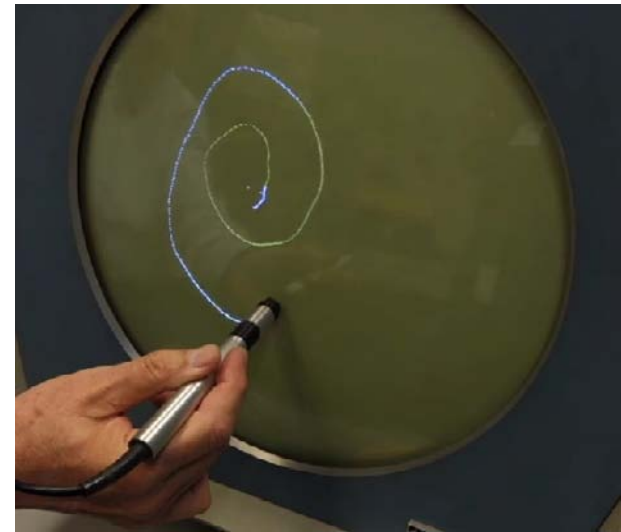
Spacewar!



Minskytron



Snowflake



Light Pen

# PDP-1 special visitors



Bill Gates



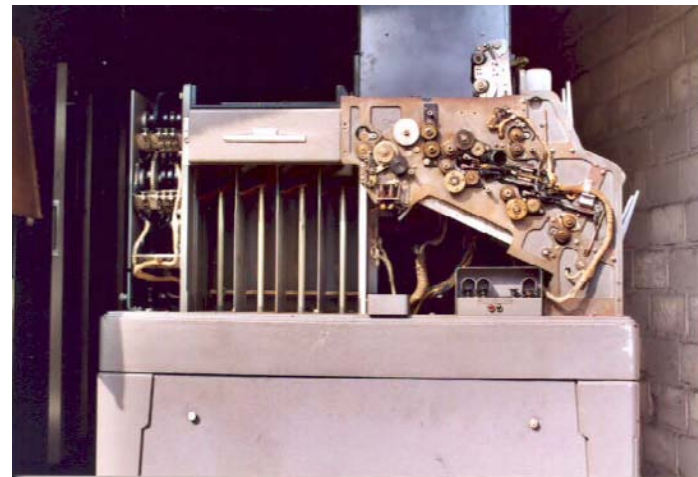
Gordon Bell



# TWO RESTORATIONS

(2004 – 2009, ongoing)

# DE 1401, Hamm, Germany (2004)



# How to find a restoration team?

## **An IBM 1401 Needs Help**

The Computer History Museum in Mountain View is looking for volunteers to help restore an historic IBM 1401 Data Processing System it has just acquired. Needed are retired IBM Field or Customer Engineers who serviced vintage IBM systems from the early 60's. Anyone who is interested in bringing this system back on-line, helping with programming, or becoming a Museum visitor docent would be welcome. Experience in mechanical systems (gearing, etc.) would be priceless.

The Museum's new 1401 was last operational in Germany in the 1980's. It was carefully stowed away by it's lifelong customer engineer, who will travel to the Museum to help bring it back to life.

URL for the Computer History Museum is ([www.computerhistory.org](http://www.computerhistory.org).)

Phone: (650) 810-1010

Location: 1401 Shoreline Blvd, at the intersection of Highway 101 in Mountain View.

### **Contact:**

**Robert Garner**

**(408) 927-1739**

**[robarn@us.ibm.com](mailto:robarn@us.ibm.com)**



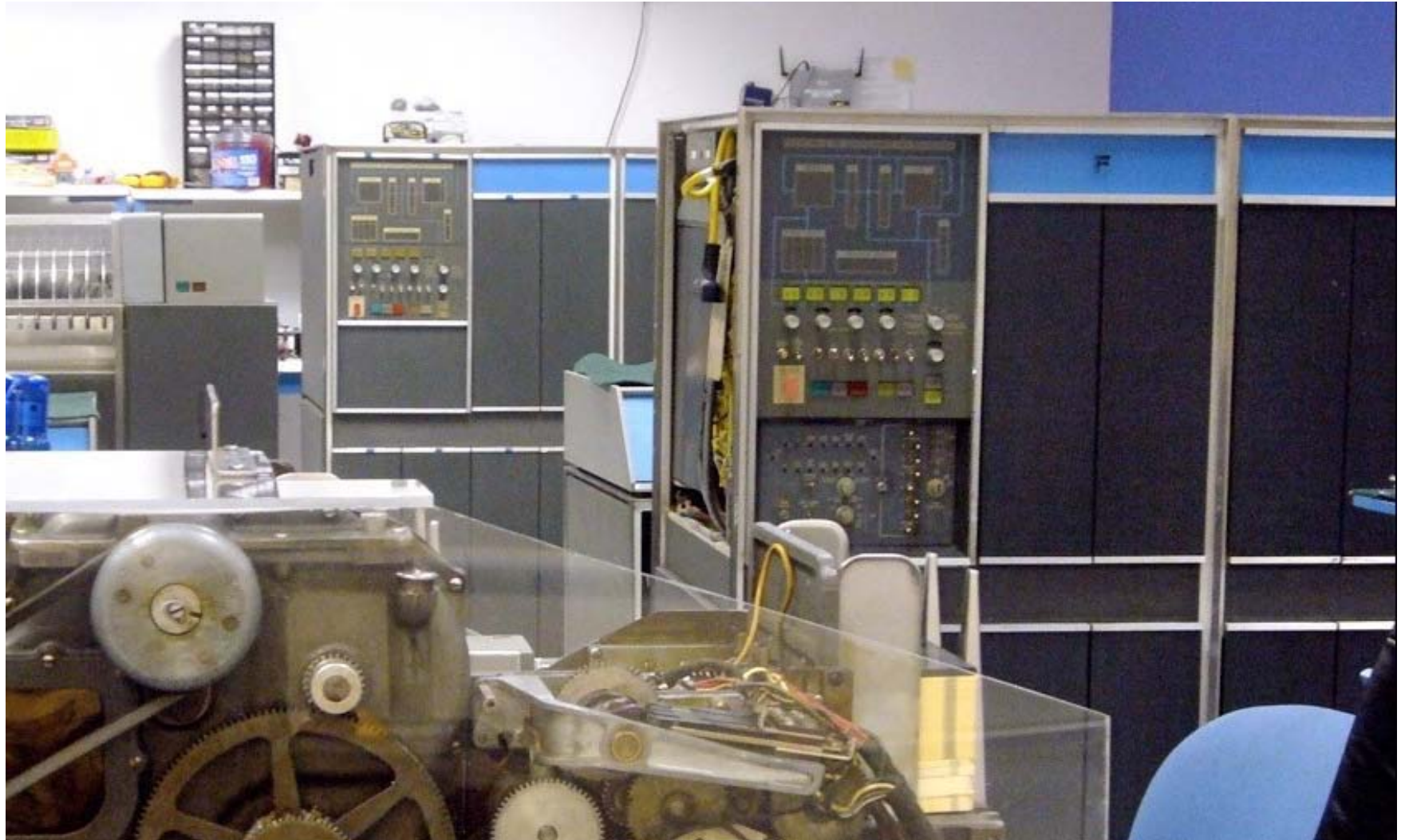
# Early restoration team (2004)



# CT 1401, Darien, Connecticut (2008)



# Two 1401s! (2008)



# 1401 restoration lab (2009)



# 1401 full volunteer team (2013)



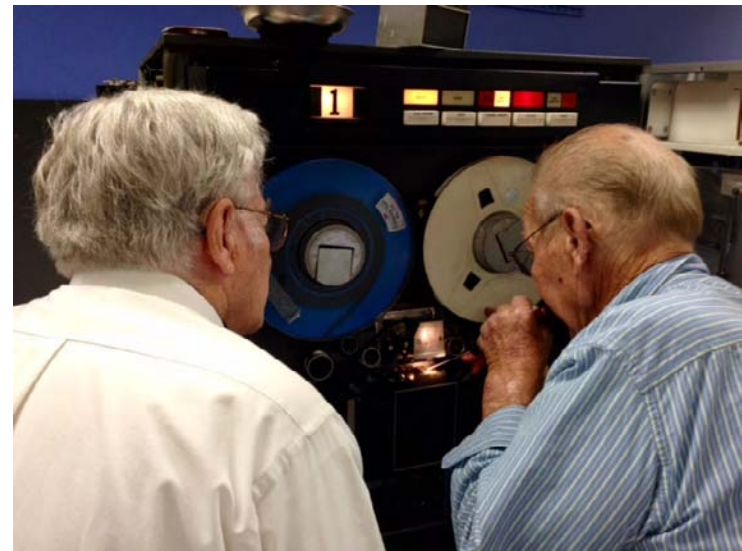
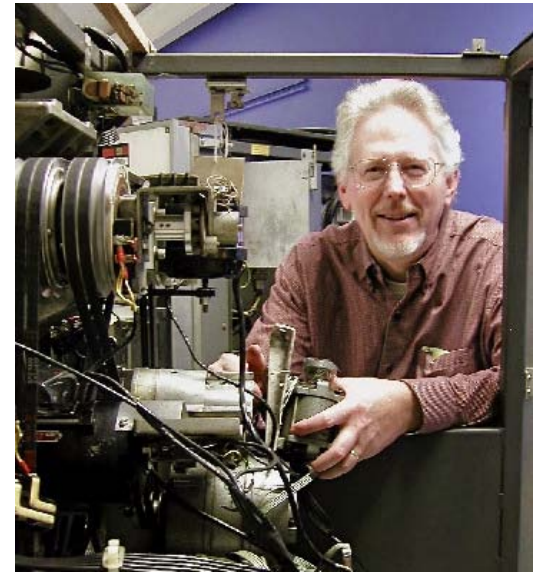
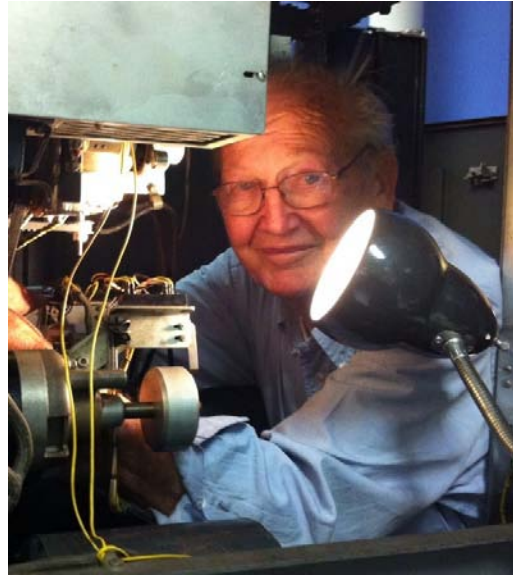
George Ahearn Ron Williams Bart Cotton Frank King Judith Heammerle Bob Erickson Glen Lea Stan Paddock Dave Lion Joe Preston Bill Flora Ron Crane Douglas Martin  
Bill Newman Ed Thelen Robert Garner Bill Worthington Don Luke

## 1401 Oral History Panel (2015)

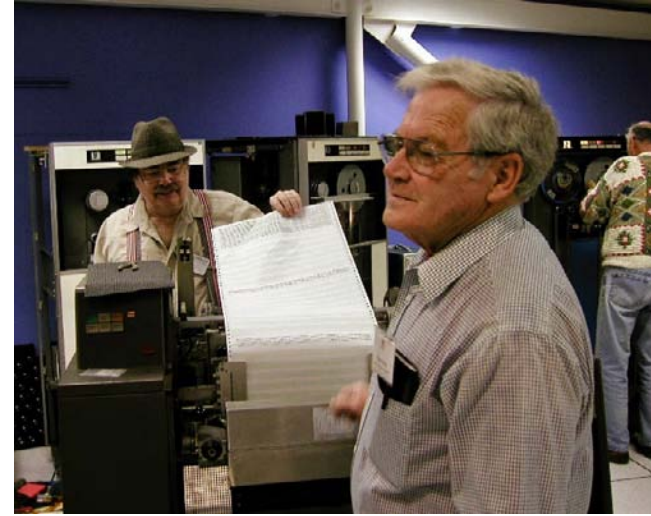


Bill Flora George Ahearn Frank King Allen Palmer Ed Thelen Iggy Menendez

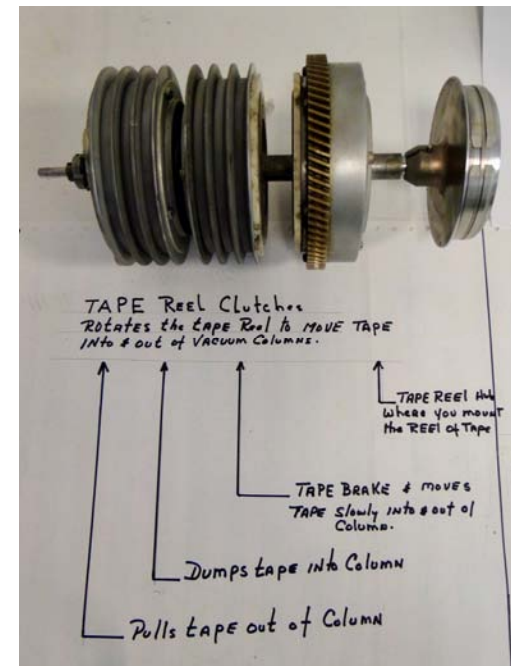
# 20,000+ volunteer hours



# 20,000+ volunteer hours



# DE 729 tape drive refurbishment

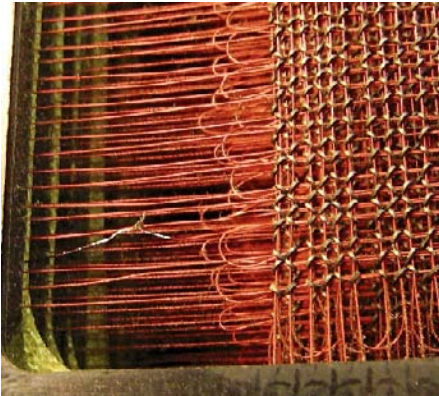




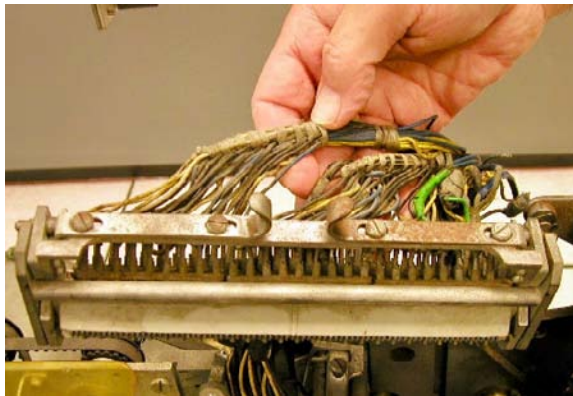
# IBM 1402 (finiky) mechanicals



# 1401 faulty components & corrosion



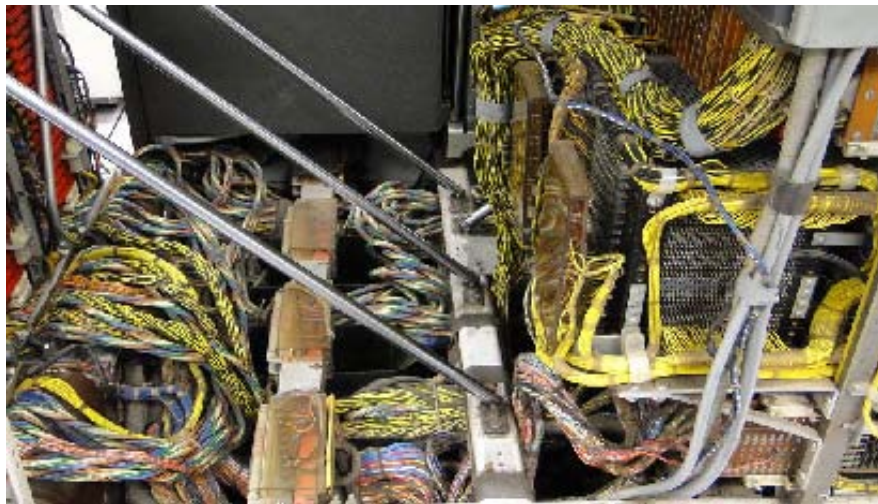
One broken core wire



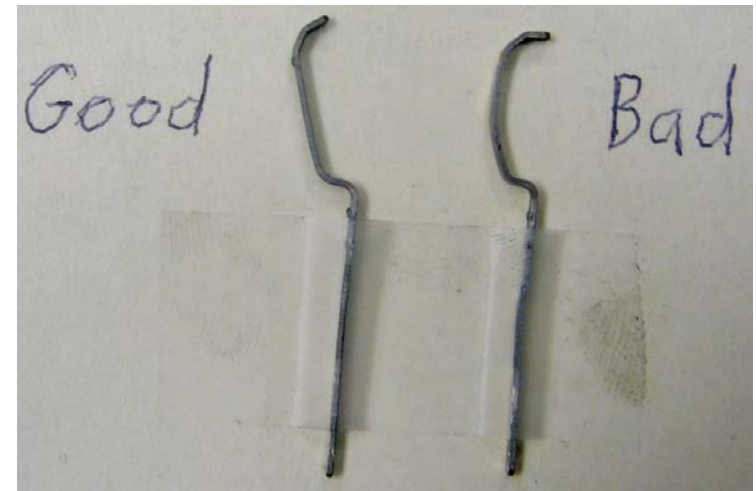
Corroded 1402 brush block



Several leaky capacitors

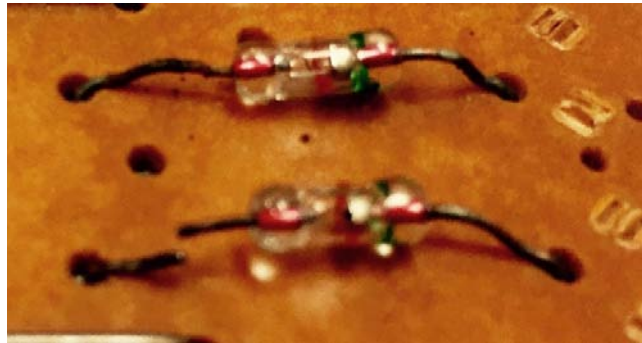


NO wiring or wire-wrap problems!



One faulty backplane connector

# DE 1401 corroded “solid state” devices



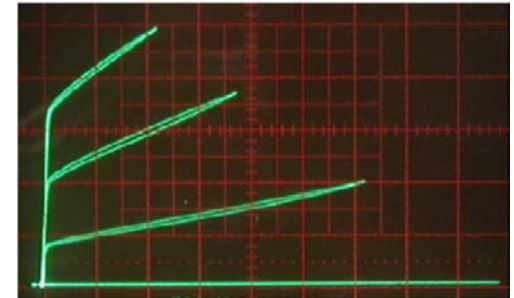
Rusted germanium diode leads



Loopy

I-V traces

OK



Bizarre “loopy” I-V germanium alloy-junction transistors (surface state contamination)



Rusted transistor caps & leads

DE 1401: 117 faulty SMS cards

CT 1401: 30 faulty SMS cards

Given 3000 SMS cards per 1401:

Average annual failure rate =

1 per 2000 per year (0.05%)

# 1401 replacement parts & supplies



400,000 (un)punched cards

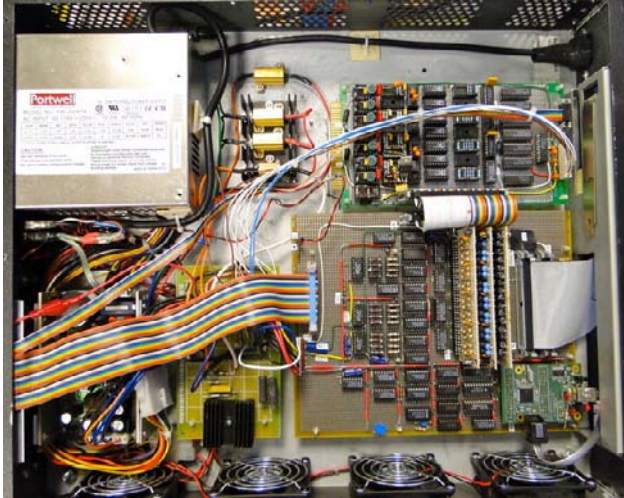


New-old-stock germanium transistors



Spare SMS printed-circuit cards

# Custom 729 tape drive emulator



# 1401 programming group (2012)



Ed Thelen - BIG PRINT

Ron Mak - ROPE

Van Snyder - Simulator  
& AutoCoder in ROPE

George Bill  
Ahearn Newman

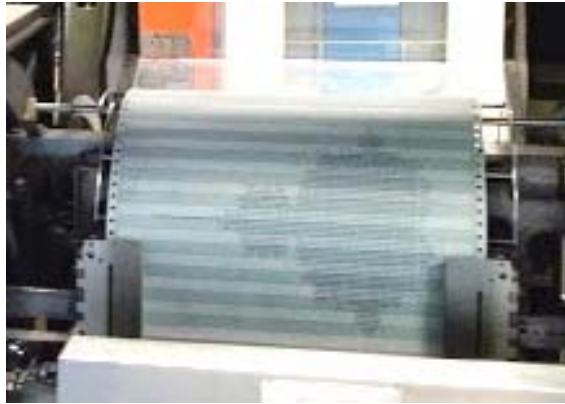
Bob Feretich  
tape emulator

# 1401 Development & Simulation Environment (ROPE)

The screenshot displays the ROPE/1401 simulation environment with the following components:

- EXEC: powers2v2**: Main code editor showing assembly instructions for calculating powers of 2. Comments include: "PRINT THE POWERS OF 2 UP TO 130 DIGITS. COMPUTE THE NUMBERS INSIDE THE PRINT AREA (LOCATIONS 201-332). START WITH THE WORD MARK OVER THE LEAST SIGNIFICANT DIGIT AND MOVE IT LEFT ONE DIGIT EACH TIME AFTER AN OVERFLOW AND PREPEND A '1' AS THE NEW MOST SIGNIFICANT DIGIT. PRINT EACH NUMBER WITHOUT LEADING ZEROES." Instructions include ORG, X1, START, CS, MOVEM, CW, MCW, SBR, C, BE, and SW.
- PRINTOUT: powers2v2**: Printer output window displaying a long sequence of digits representing the powers of 2, starting with 480981520952081045071765624224562232065397860164239095208531909697964083434718092213655548692006303809402830848...
- MEMORY: 0 - 399**: Memory view window showing a memory dump with addresses from 0 to 399. It includes a search bar and checkboxes for "Show" and "Auto update".
- CONSOLE**: Console window showing logic status (OVFL0, B=A, B#A, B>A, B<A), error messages (A, B), and sense switches (A, B, C, D, F, G).
- Simulator messages**: A message box at the bottom left indicating "Step expired, IS: 373 (SWM 1,4)".
- Control Panel**: A set of buttons at the bottom for "Kill simulator", "Runtime data...", "Continue program", "Single step", "Slower", "Memory...", "Simulator options...", "Show all", "Quit program", "Auto step", "Faster", "Timers...", and "Console..."

# 1401 modern programs



Mandelbrot Set



Ray tracing

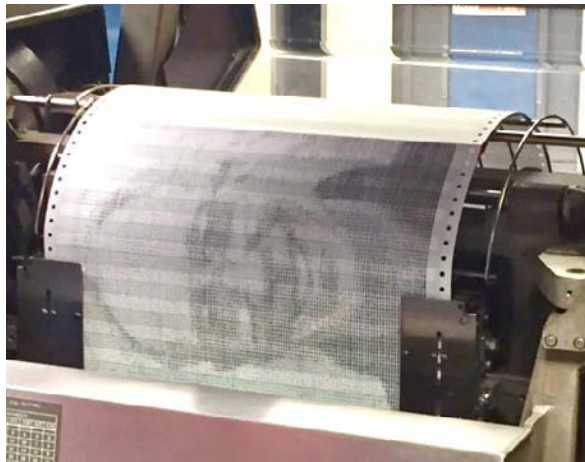
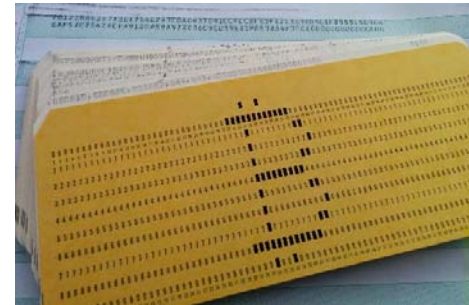


Photo-to-1403 overprinting



Bitcoin mining

At 80 seconds per double SHA-256 hash, a 1401 would require about  $10^{14}$  years and  $10^{18}$  US dollars of electricity to mine a single block of transactions, for a return of \$ 6,000.



# Bob Erickson (92)



**IBM 1401**

**DEMONSTRATIONS**

# Demo Lab corridor



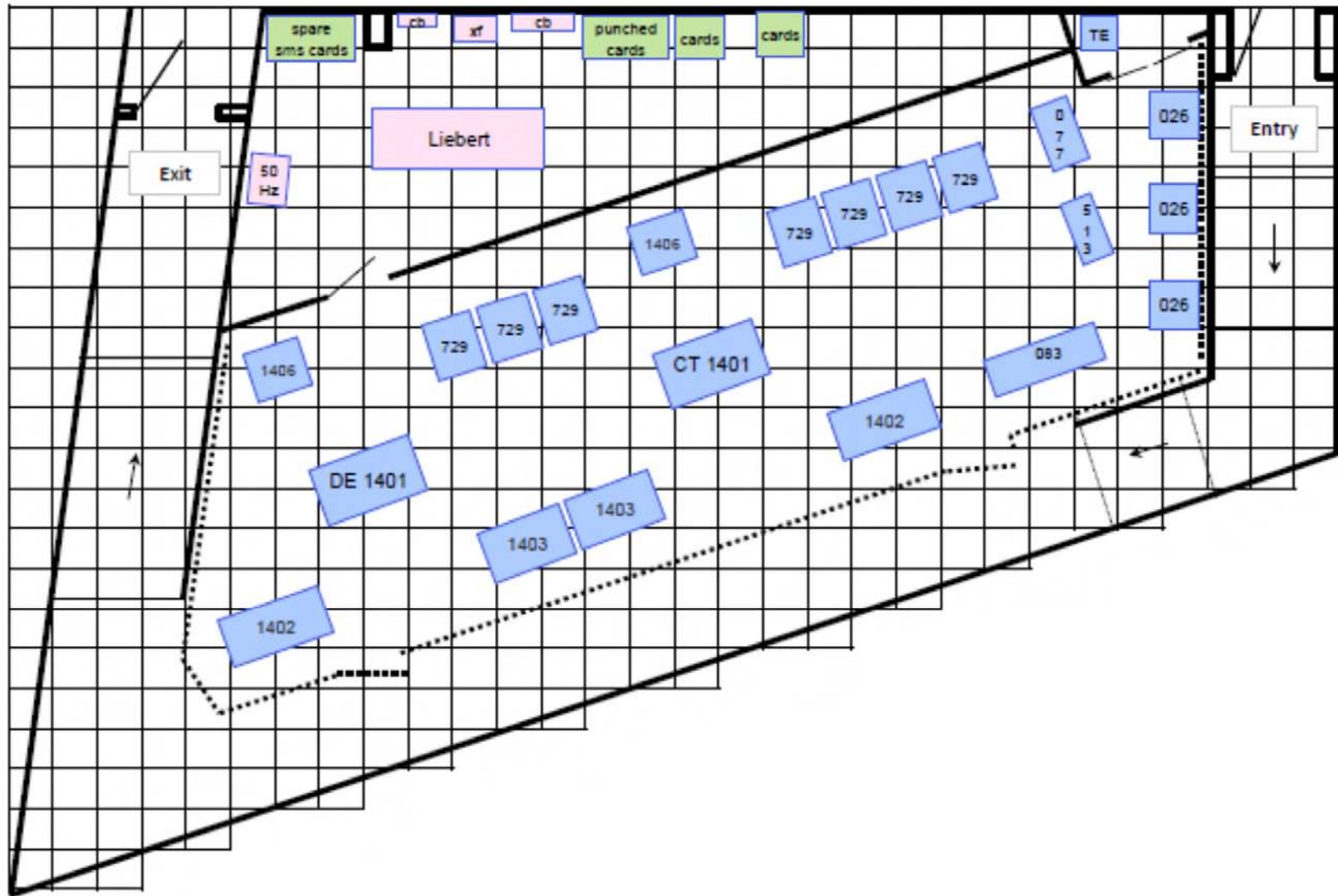
# IBM 1401 vintage showroom (1960s)



# IBM 1401 Demo Lab (2011)



# 1401 Demo Lab – floorplan



# 1401 Demo Lab – signage


## THE IBM 1401: DAWN OF A NEW ERA

The IBM 1401 Data Processing System was introduced in 1959. Its impact was dramatic. By the mid-1960s, nearly half the computers in the world were IBM 1401s.


In the early 1960s, the population was expanding and institutions from every corner of society were automating.

The 1401 was the perfect solution for businesses. It was relatively inexpensive, simple yet powerful, and easily expandable. For small businesses, the 1401 provided a way forward from punched card mechanical processing to modern, electronic computing.


The last IBM 1401 was delivered in 1971, marking 12 years of service, a very long time for a computer system and a testament to the vision of its designers.




**LIFE magazine cover, 1959**  
LIFE magazine featured the 1401 on October 5, 1959, in that magazine's first issue. The cover, which cost of course to advertise, had been 48 million perfect copies to get 1,500 sets of magnetic tape.



**1401 assembly line, Redshift, NY, early 1960s**  
The IBM 1401 was the first computer to exceed 10,000 jobs.



**1401 programming 1960s, 1961**  
The first large-scale program for computing in small business came, replacing programs, a task which required programming. The related program allows instructions to be kept in the computer's memory, a much faster and better solution. All companies using one a shared program.



## THE IBM 1401 RESTORATION AT THE COMPUTER HISTORY MUSEUM

Bringing computer systems back to life requires an almost magical mix of experience, technical ability, dedication... and a little luck.

It took five years and over 20,000 hours for the CHM 1401 restoration team to bring back to life two complete 1960s-era IBM 1401 computer systems.

Both 1401s suffered from corrosion, including rusted transistors, which the team toiled long hours to discover and repair. The team refurbished worn-out mechanical components such as clutches and bearings, replaced belts, lubricated rolling parts, and designed electronics to emulate a magnetic-tape drive...thousands of steps in all.

The restoration project is an ongoing odyssey and labor of love: unraveling technical mysteries, sharing tales, and learning, maintaining and demonstrating these living time travel machines.



Restoration team member Bob Erickson works on the challenging task of repairing the machine's core memory unit. Bob was an IBM customer engineer from 1941 to 1984.

Courtesy of Robert Garner



A core group of the restoration team are former IBM customer engineers, who had kept 1401s running in their heyday, joined now by new volunteers learning how to keep the 1401 running today and into the future. Restoration team (l to r): George Ahearn, Ron Williams, Bart Cotton, Frank King, Bill Newman, Judith Heammerle, Ed Thelen, Bob Erickson, Glen Lea, Robert Garner, Stan Paddock, Bill Worthington, Dave Lion, Joe Preston, Bill Flora, Ron Crane and Douglas Martin. Not shown: Bob Feretich, Jim Hunt, Don Luke, Ron Mak, Allen Palmer, Grant Saviers and Sam Spigren.

Courtesy of Robert Garner

# 1401 Demo Lab – entrance wall





# 1401 Demo Lab – entrance



# 1401 demos



# 1401 demos



# 1401 demos



# 1401 demo – school field trip days



# 1401 demo – high school students



# 1401 demos – college CS students



# 1401 demo – special guest



Chuck Branscomb, directed development of 1401 (1957-60)



# 1401 demos – punched cards, props, ...



# IBM 026 keypunches



# IBM 001 hand keypunch



# 'Young Professionals' 1960s retro event



# 1401 ongoing maintenance

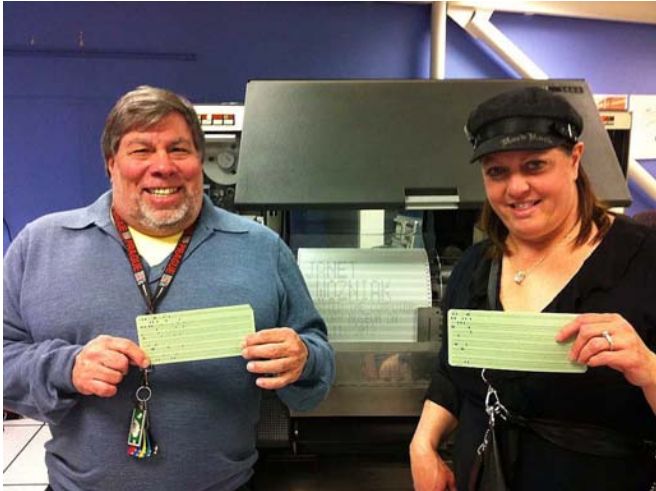


# 1401 ongoing maintenance



(Maker Faire, 2017)

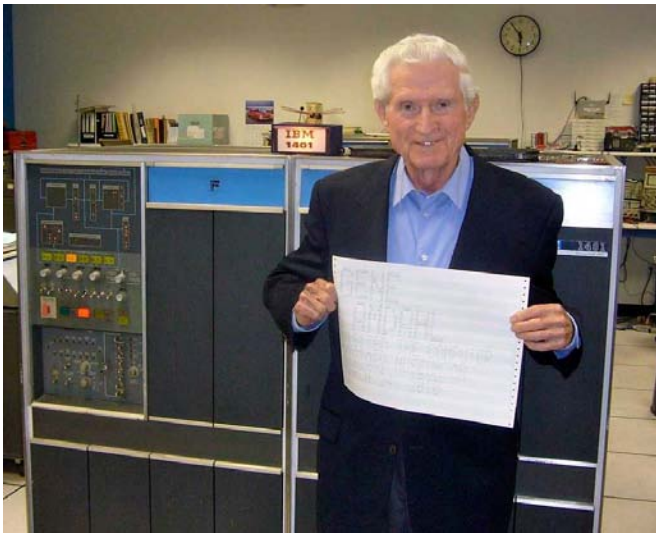
# 1401 special visitors



Steve & Janet Wozniak



Bob Metcalfe



Gene Amdahl



Doug Englebart

# Restoration Guidelines

- Safety first
  - Two people must be present when equipment is open and energized.
  - CPR and first-aid training
- Historical integrity & authenticity
- Reversible alterations
- Record/log restoration actions
- Restoration policy:
  - Objectives, criteria, logistics, liaison



# Ingredients for success

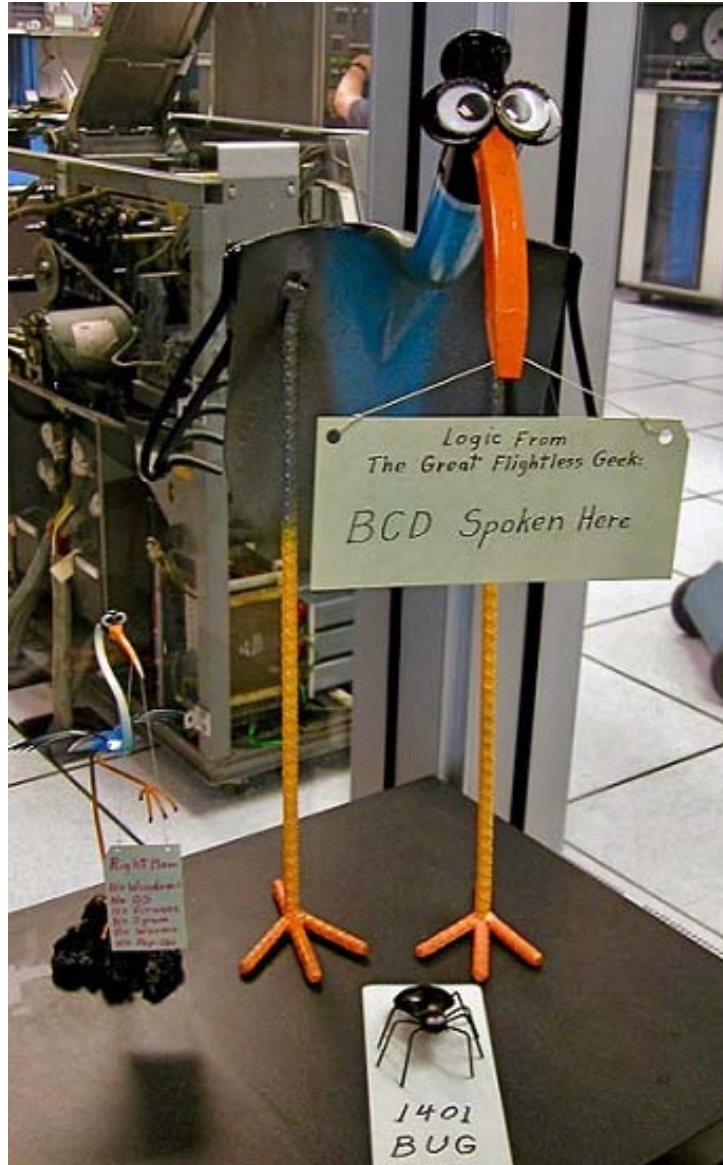
- Compelling demo!
- Pool of volunteers
- Light-hearted temperament & comradery
- Engaged museum liaison
- Two systems – if possible
- Workshop – nearby
- Web scribe and documentarian
- Demo training – lead & assistant

# Measured pace

*“Unlike normal high-tech endeavors, where the longer it takes the less valuable the product, with computer artifact restoration projects, the longer it takes the more valuable the outcome.”*

– R. Garner

# Light-hearted temperament



# Comradery



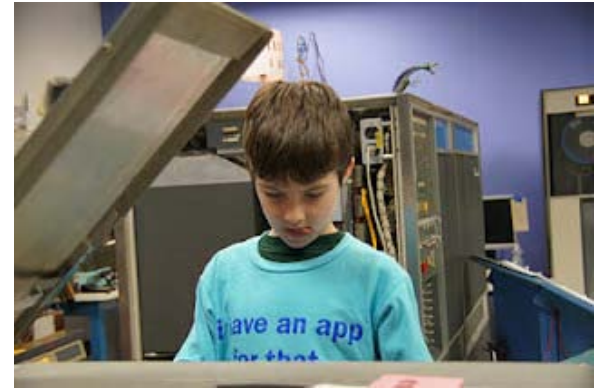
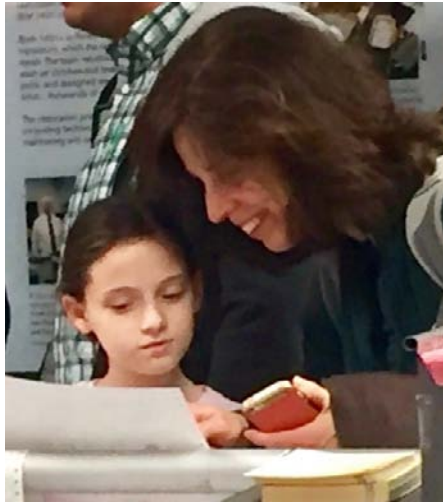
# Restoration workshop



# Why restore vintage computers?

- Deepens museum's presentation and interpretation of computing history
- Enriches visitors' experience
- Bolsters museum's educational mission
- Illustrates the fundamentals of computers
- Creates authentic "time-machine" experience
- Seeing how far technology changed in fifty years, visitors may contemplate what computing will be like in the next half century.

# Why demo vintage computers?



# Why demo vintage computers?

