# John McCarthy

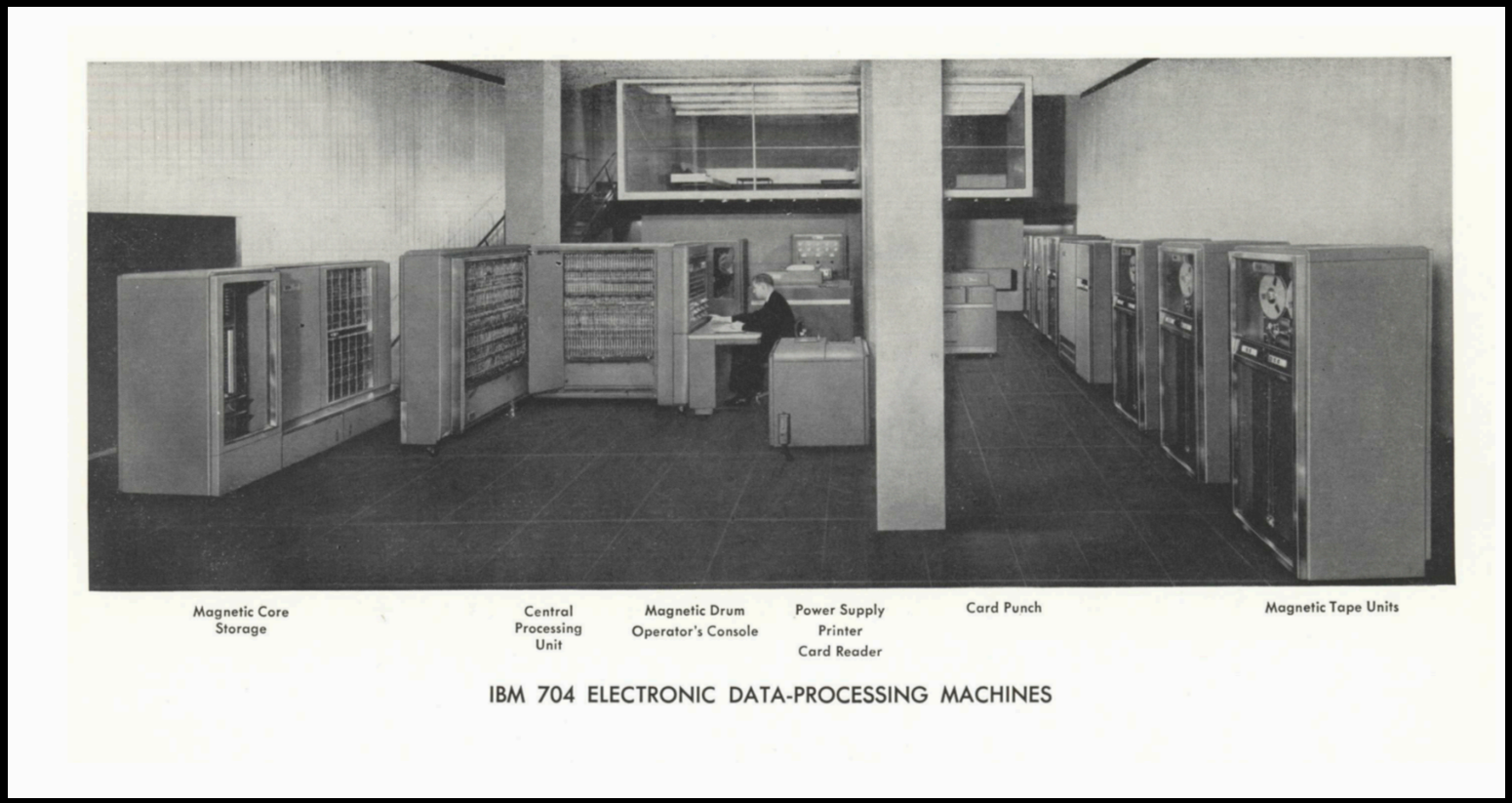
# Recursive Functions of Symbolic Expressions and their Computation by Machine

## AIM-008 March 13, 1959

```
eval[e] = [
first[e] = NULL → [null[eval[first[rest[e]]]] → T; 1 → F]
first[e] = ATOM → [atom[eval[first[rest[e]]]] → T; 1 → F]
first[e] = EQ → eval[first[rest[e]]] = eval[first[rest[rest[e]]]] → T;
      1 → F]
first[e] = QUOTE → first[rest[e]];
first[e] = FIRST → first[eval[first[rest[e]]]];
first[e] = REST → rest[eval[first[rest[e]]]];
first[e] = COMBINE → combine[eval[first[rest[e]]];eval[first[rest[rest
      [e]]]]];
first[e] = COND → evcon[rest[e]];
first[first[e]] = LAMBDA → evlam[first[rest[first[e]]];first[rest[rest
      [first[e]]]];rest[e]];
first[first[e]] = LABEL → eval[combine[subst[first[e];first[rest
      [first[e]]];first[rest[rest[first[e]]]];rest[e]]]]
where; evcon[c] = [eval[first[first[c]]] = 1 → eval[first[rest[first[c]]]];
            T → evcon[rest[c]]]
```

# Первый Лисп

**Стив Рассел пишет версию под IBM 704**



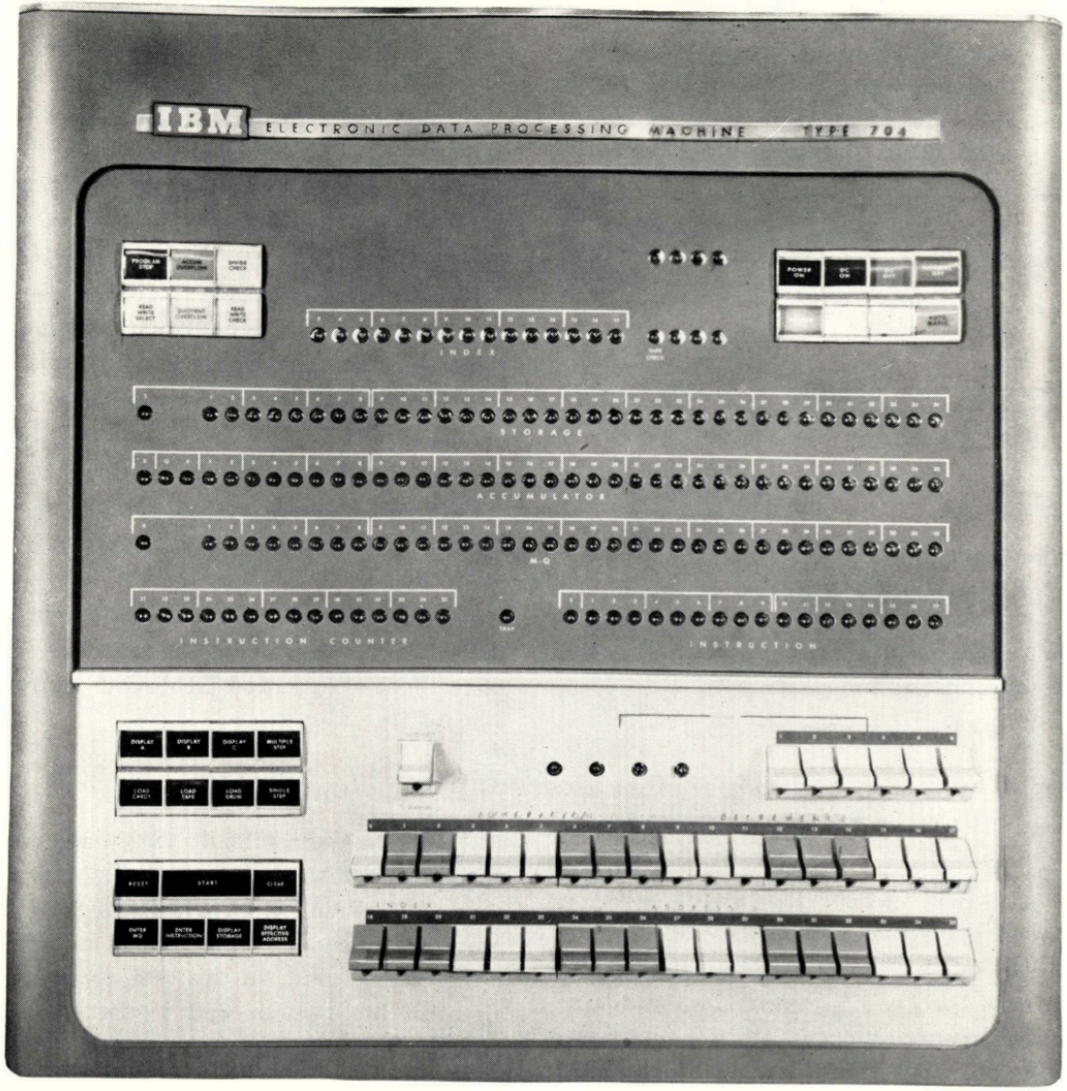
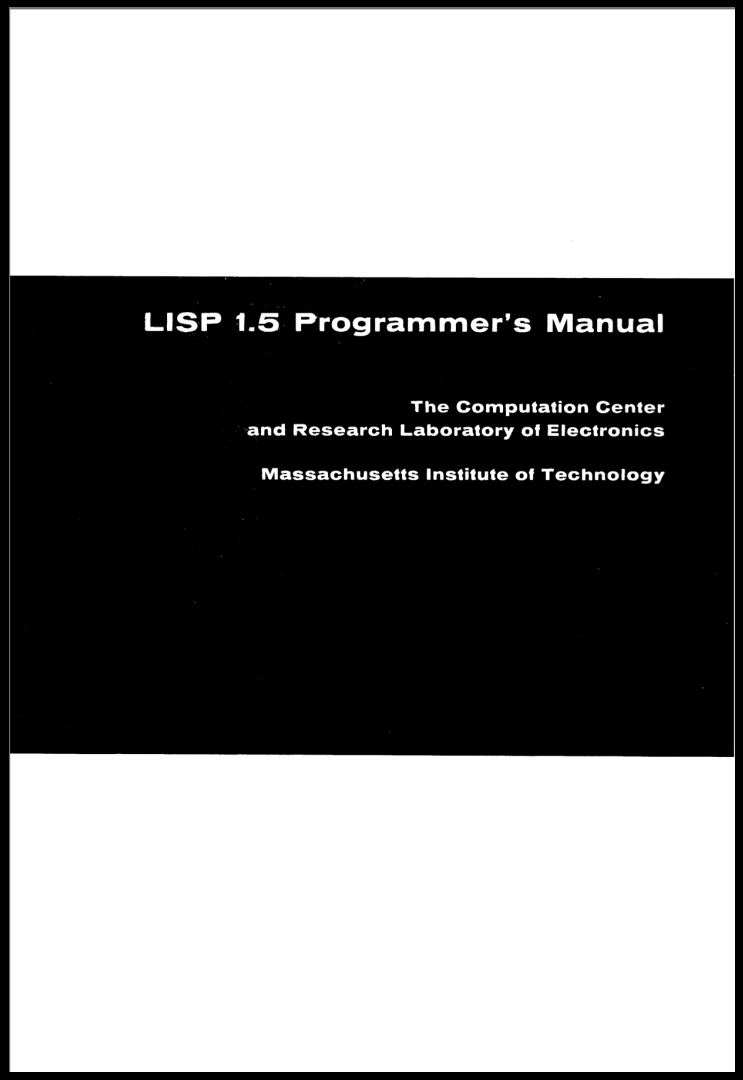

IBM
ELECTRONIC DATA PROCESSING MACHINE
TYPE 704
INDEX
STORAGE
ACCUMULATOR
M-Q
INSTRUCTION COUNTER
INSTRUCTION
RESET
START
CLEAR

FIGURE 12

# LISP 1.5


LISP 1.5 Programmer's Manual
The Computation Center
and Research Laboratory of Electronics
Massachusetts Institute of Technology

# Джозеф Ликлайдер

- «Симбиоз человека и комьютера» 1960
- «Межгалактическая компьютерная сеть» >>

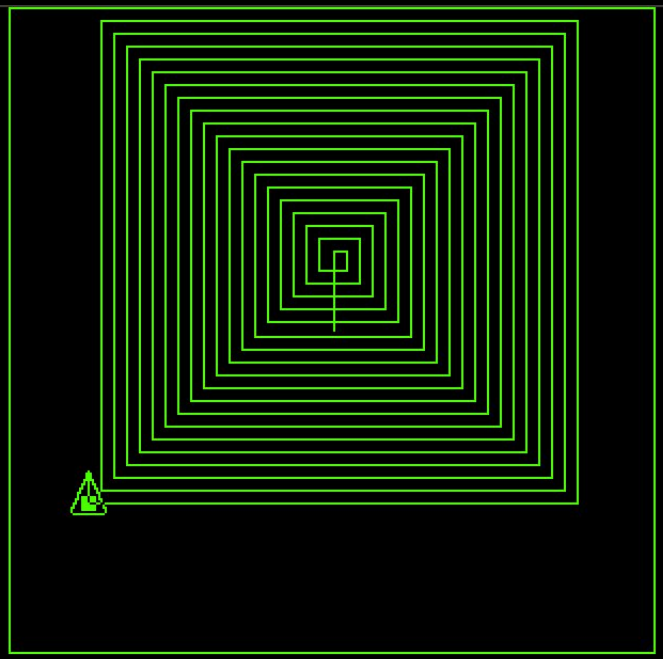
  Стандартные компоненты, доступные всем, итп

# Project MAC

- MAC Mathematic and Computation, Multiple Access Computer, Machine Aided Cognition, Man and Machine
- Марвин Минский, Джон Маккарти, Джозеф Ликлайдер, Ричард Гринблатт, ...
- Компьютерное зрение, механическое движение, язык
- ARPANET

# MACLISP

- 1964
- PDP-10



```
>30 spiral :n + 10
;CONTINUING EVALUATION

;YOU HAVE RUN OUT OF LIST SPACE. MORE?:
y
; OK. (19832 WORDS)
;ERROR IN LINE 10 OF SPIRAL: FORWARD :N
;TURTLE MOVED OFF THE TOP OF THE SCREEN

##MORE##
```

The LISP language is used widely in the artificial intelligence research community, and is rapidly gaining adherents outside this group. Most serious LISP usage has historically been on the DEC PDP-10 computer, and both "major" implementations (InterLisp at BBN/XEROX and Maclisp at M.I.T.) were originally done on the PDP-10. Our personal experience has largely been with the Maclisp dialect of LISP, which was originally written in 1965.

Over the years, dramatic changes have taken place in the Maclisp implementation. At a certain point, however, modification and reimplementation of a language on a given machine can no longer efficiently gloss over basic problems in the architecture of the computer system. We, and many others, believe this is now the case on the PDP-10 and similar time-shared computer systems.

# CONS

"Knight machine"

**CURRENT STATUS (August 1977)**

The original prototype CONS machine was designed and built somewhat more than two years ago. It had no memory and no I/O capability, and remained pretty much on the back burner while software was developed with a simulator on the PDP-10 (the simulator executed the Lisp machine macro instruction set, a function now performed by CONS microcode.) Microprogramming got under way a little over a year ago, and in the beginning of 1977 the machine got memory, a disk, and a terminal.

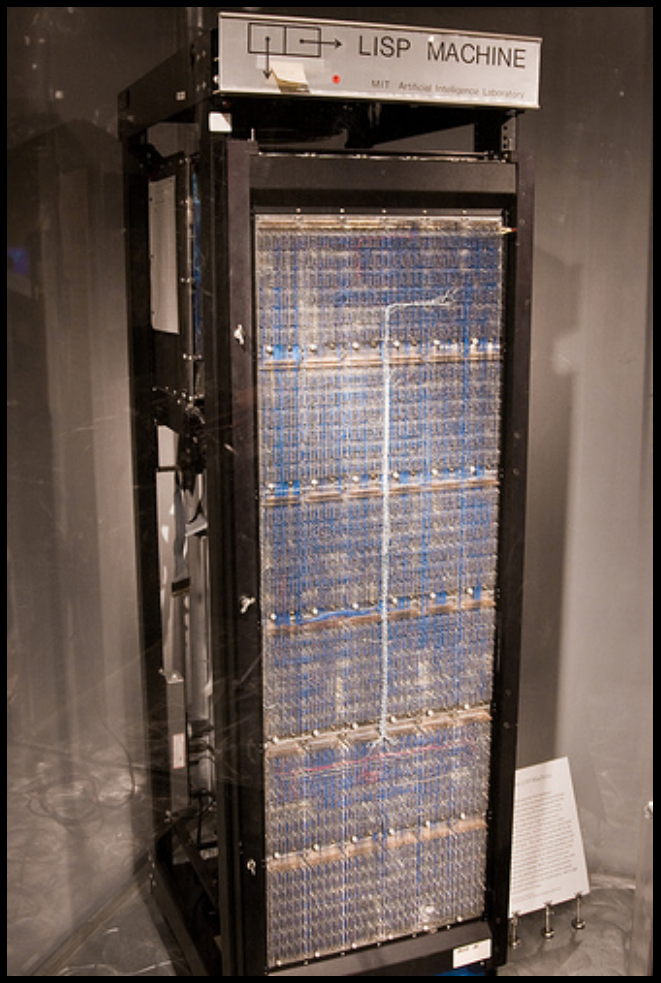
AIM-444

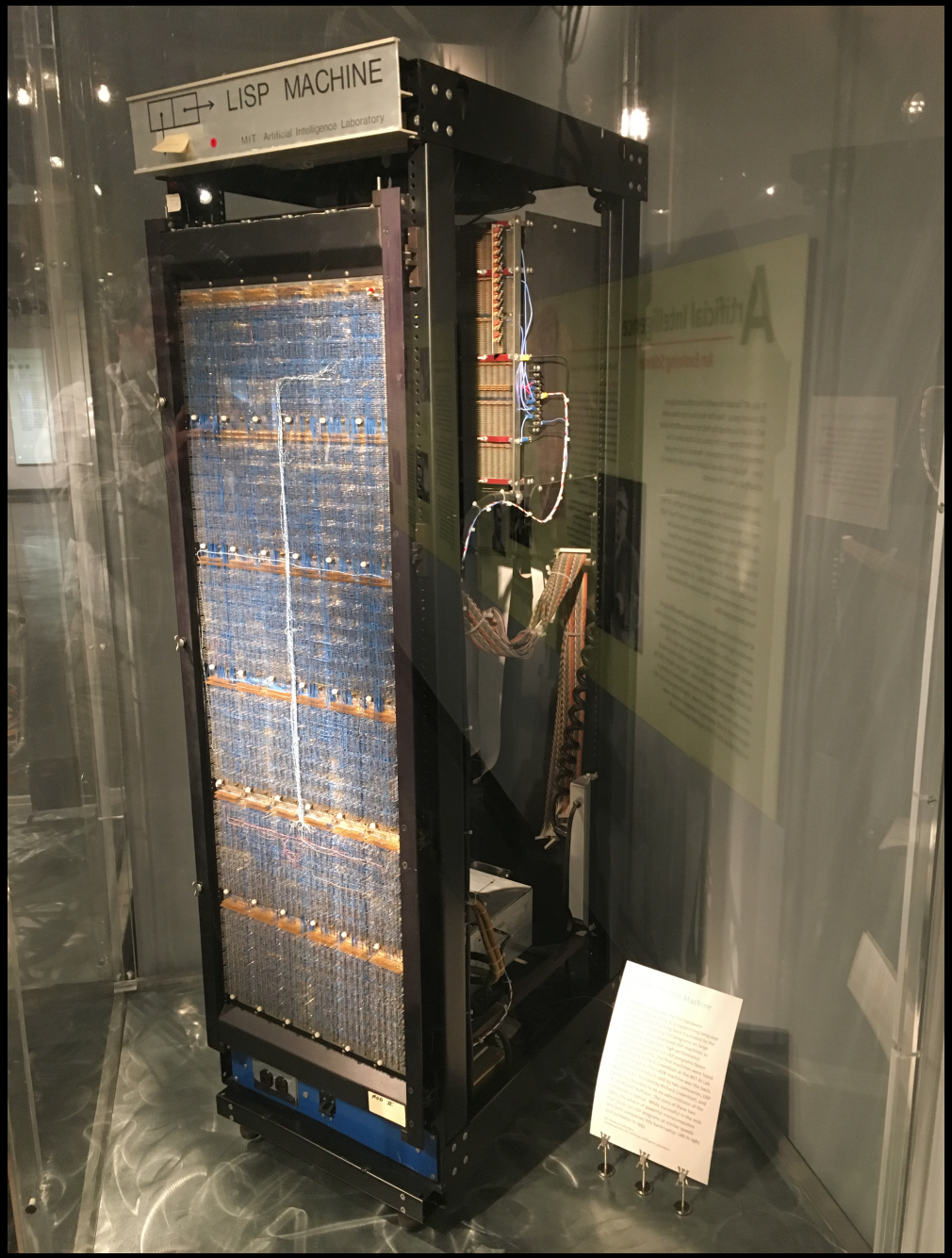
# Так зачем лисп машины?

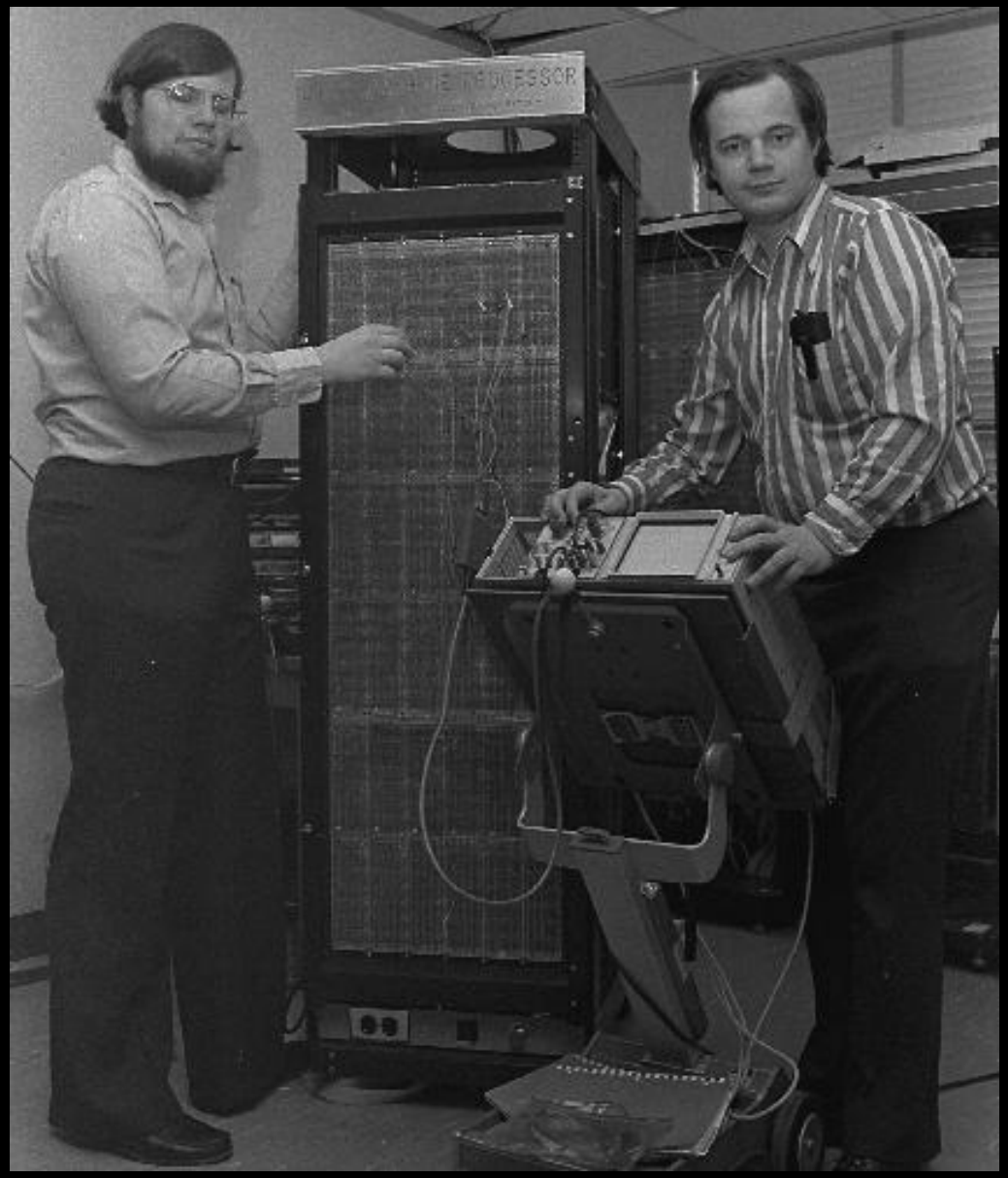
- Fast call/return
- Memory efficient lists
- Garbage collector
- Dynamic type checking (tagged memory, hardware)
- Больше памяти!!1

# CADR

- 32-bit, 1k RAM, 16k microcode
  24-bit virtual addresses, etc.
- Монтаж накруткой
- Малое количество ИС
- 25 машин, $50000 каждая
- CHAOS




LISP MACHINE
MIT Artificial Intelligence Laboratory



# «Инерпретатор микрокода»

- ALU
- BYTE
- JUMP
- DISPATCH

**ALU** The destination receives the result of a boolean or arithmetic operation performed on the two sources.

**BYTE** The destination receives the result of a byte extraction, byte deposit, or selective field substitution from one source to the other. The byte so manipulated can be of any non-zero width.

**JUMP** A transfer of control occurs, conditional on the value of any bit accessible to the M bus, or on a variety of ALU and other internal conditions such as pending interrupts and page faults.

**DISPATCH** A transfer of control occurs to a location determined by a word from the dispatch memory selected by a byte of up to seven bits extracted from the M bus.

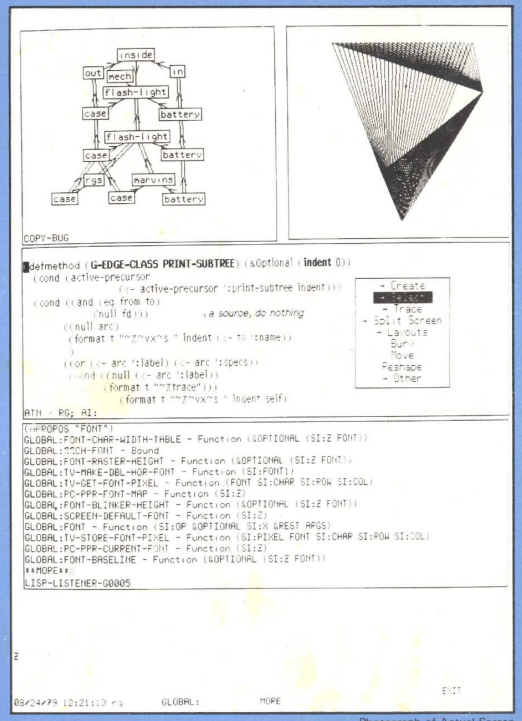
# CHINUAL


DAVID MOON
RICHARD M. STALLMAN
DANIEL WEINREB
LISP
ACHINE
ANUAL


BREAK
ESC
CLEAR
TAB
ALT
FORM
VT
RUB OUT
SHIFT LOCK
TOP
SHIFT
META
CTRL
BS
CALL
RETURN
LINE
BACK NEXT
SHIFT
TOP
CTRL
META

# Symbolics, LMI

- 1979
- Пилим бабло
- Russel Noftsker vs Richard Greenblatt
- GNU




Photograph of Actual Screen

## Applications

LISP machines have been used extensively in the following areas:

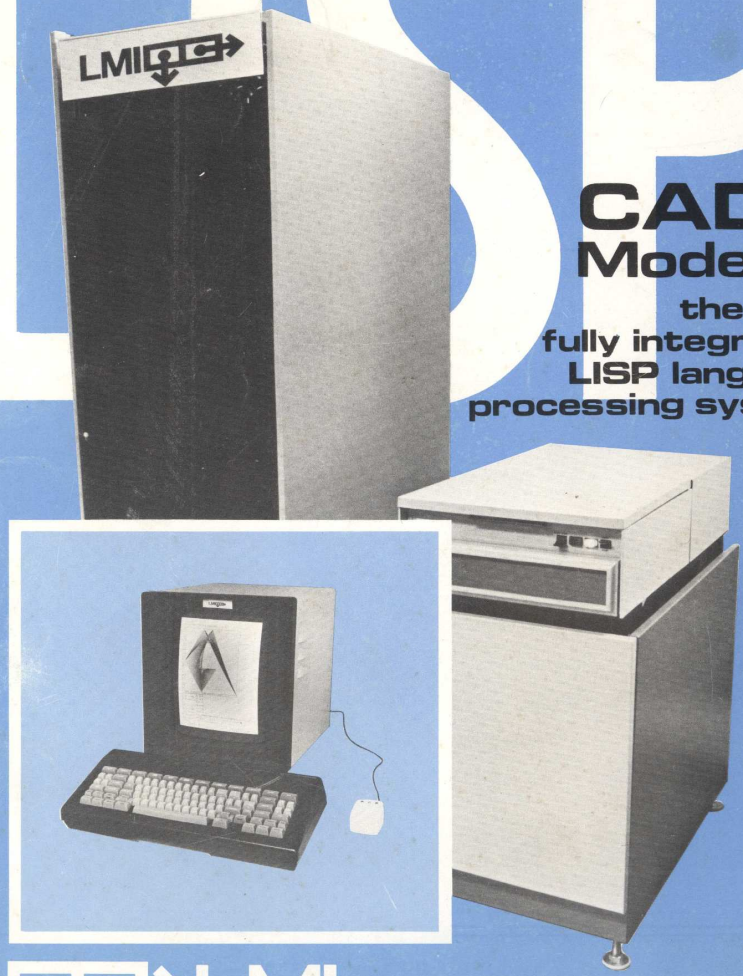
- Natural Language Comprehension
- Integrated Circuit Design
- Symbolic Mathematics
- Human Factors Engineering
- Image Perception Processing
- Physical Simulation

LMI
3916 Sepulveda Blvd.
Culver City, Ca. 90230
(213) 390-3642

# LISP

## CADR Model A

### the first fully integrated LISP language processing system



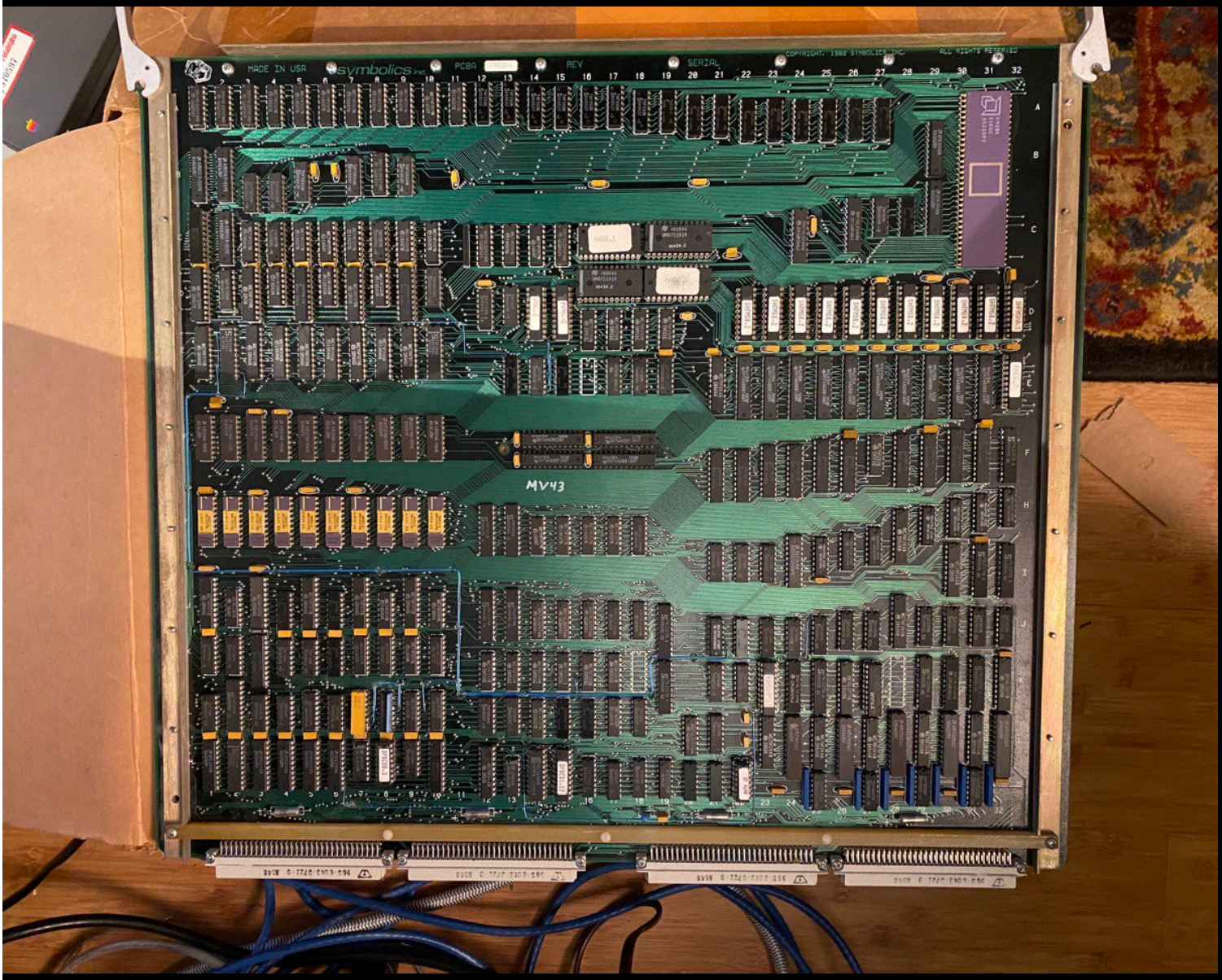

LMI LISP MACHINE, INC. · Los Angeles · Cambridge

# Symbolics 3600


- CADR + PAL

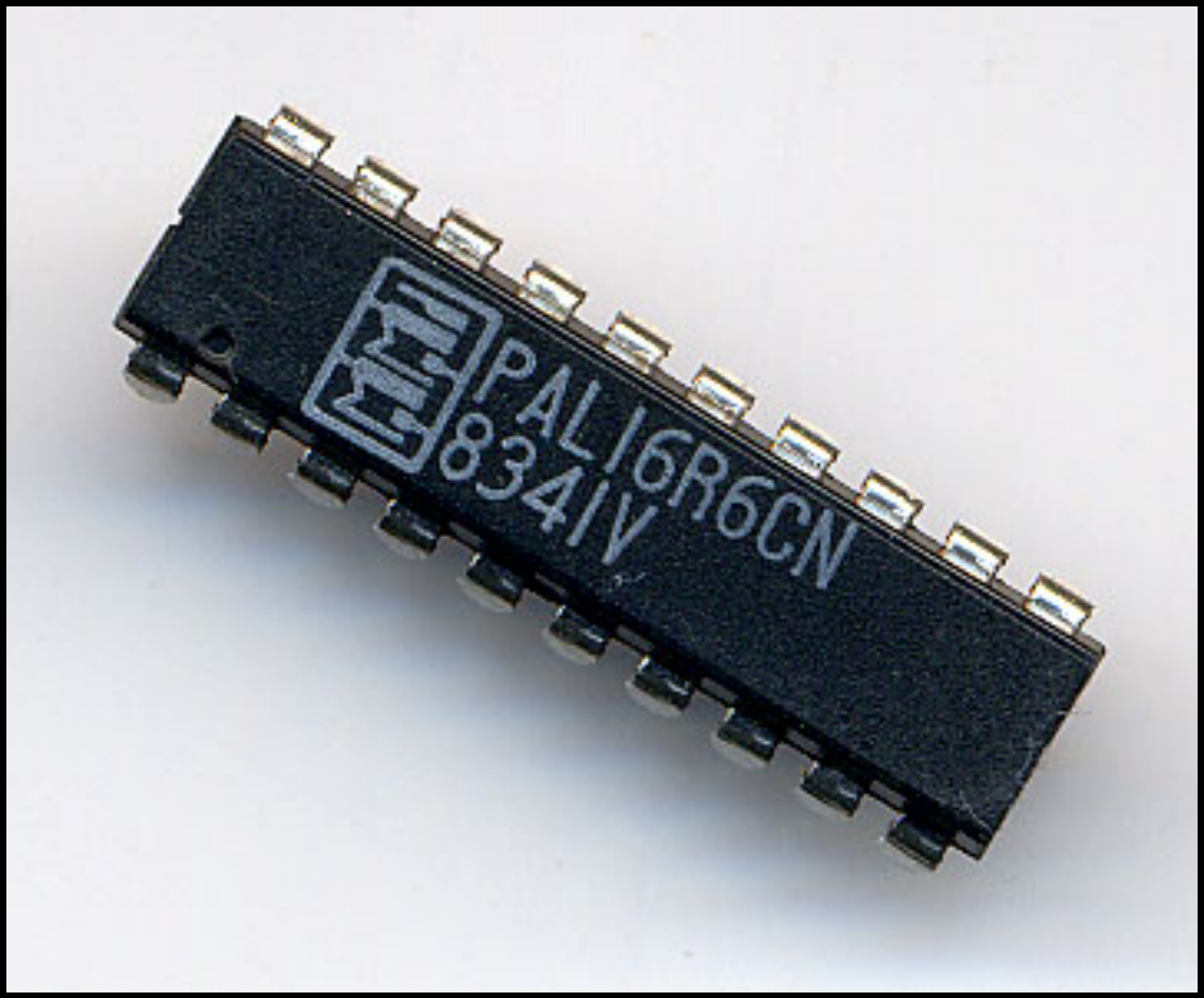

symbolics
symbolics 3640
fuck computers

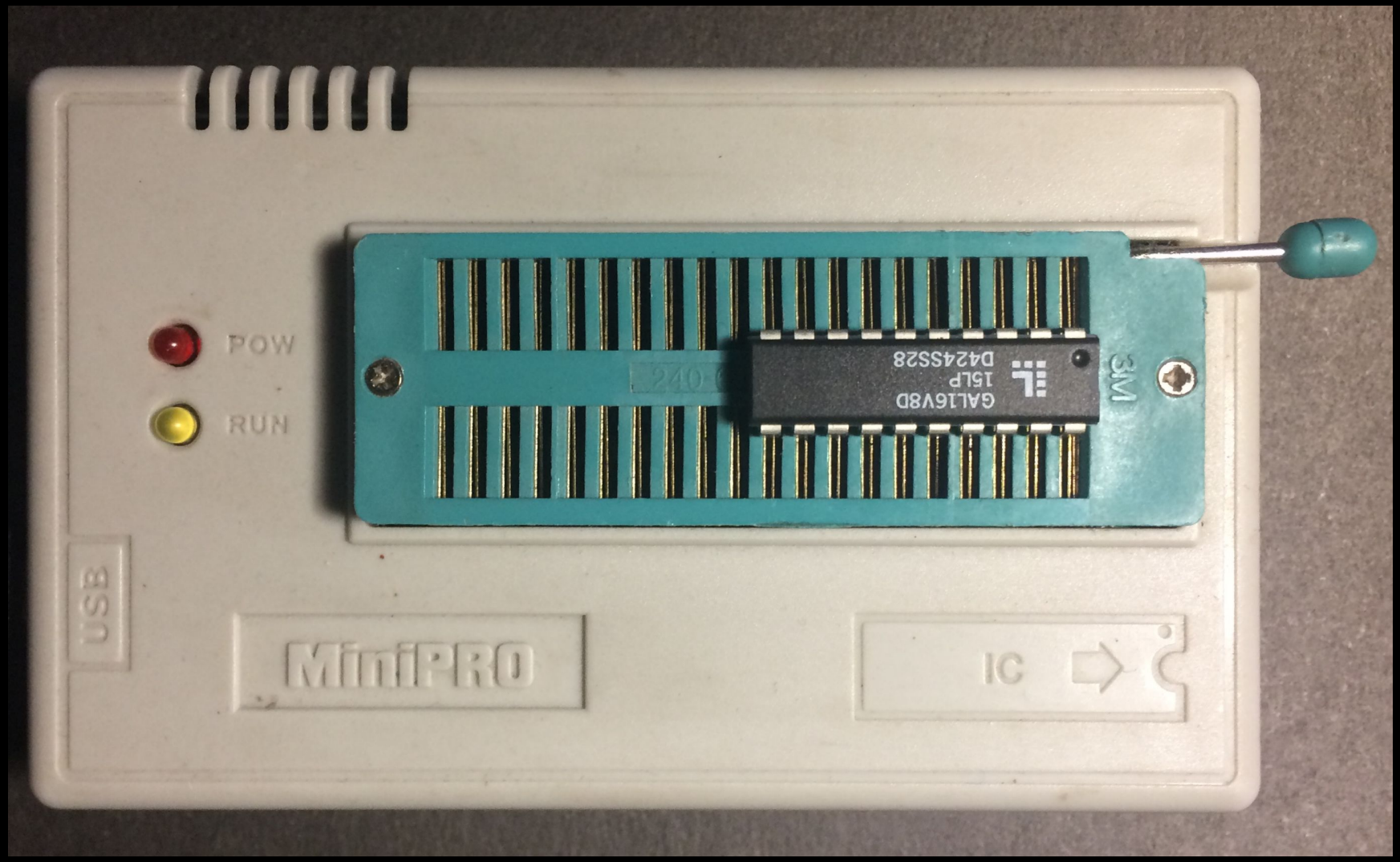

RUN
FAULT
RESET
POWER
MEM
MEM
MEM
I/O
FE
MC
SQ
DP
FPA
DP


MADE IN USA
symbolics inc.
PCBA
REV
SERIAL
COPYRIGHT, 1982 SYMBOLICS INC.
ALL RIGHTS RESERVED
MV43


symbolics XL1200
FU
TEL

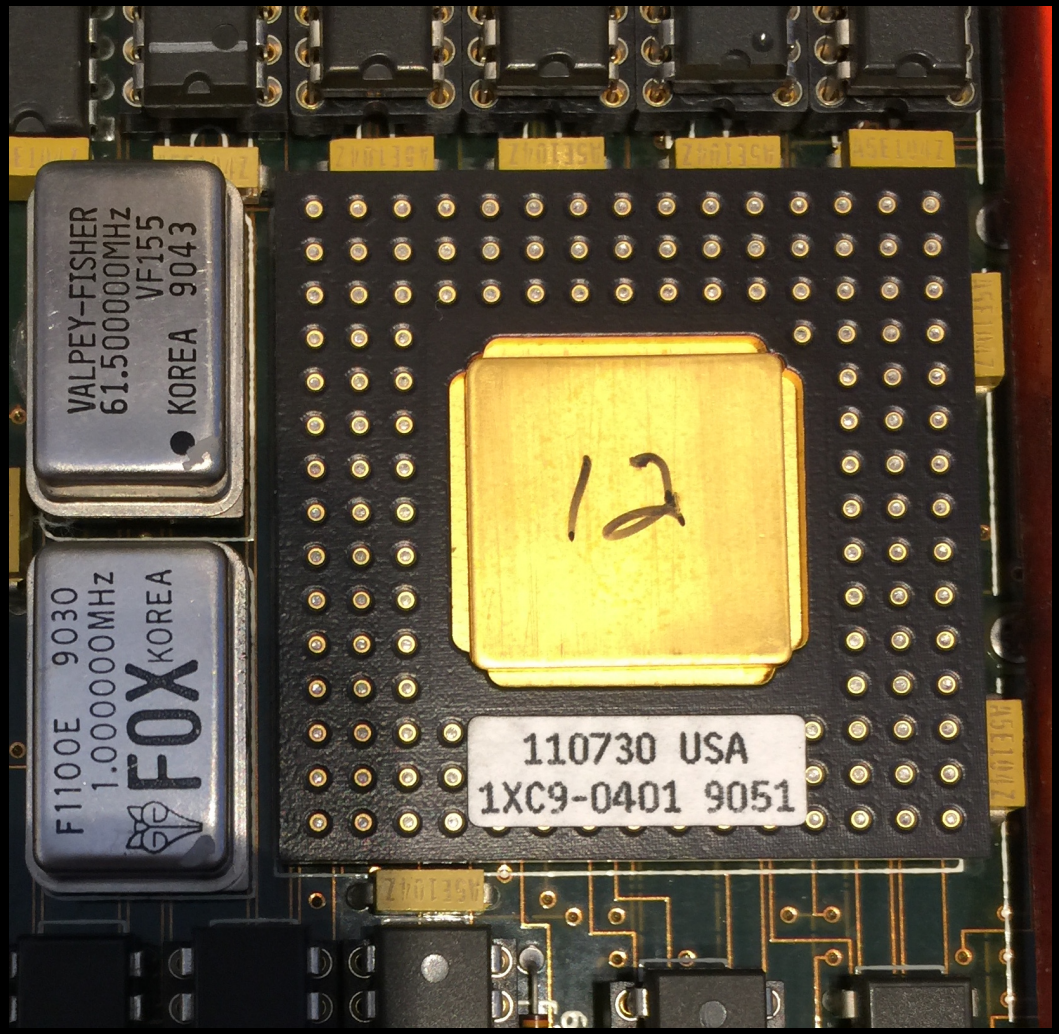
# Programmable Array Logic




POW
RUN
USB
MiniPRO
IC
GAL16V8D
15LP
D424SS28
3M

# XL1200, MacIvory

- CADR + PAL
  + VLSI (Ivory)

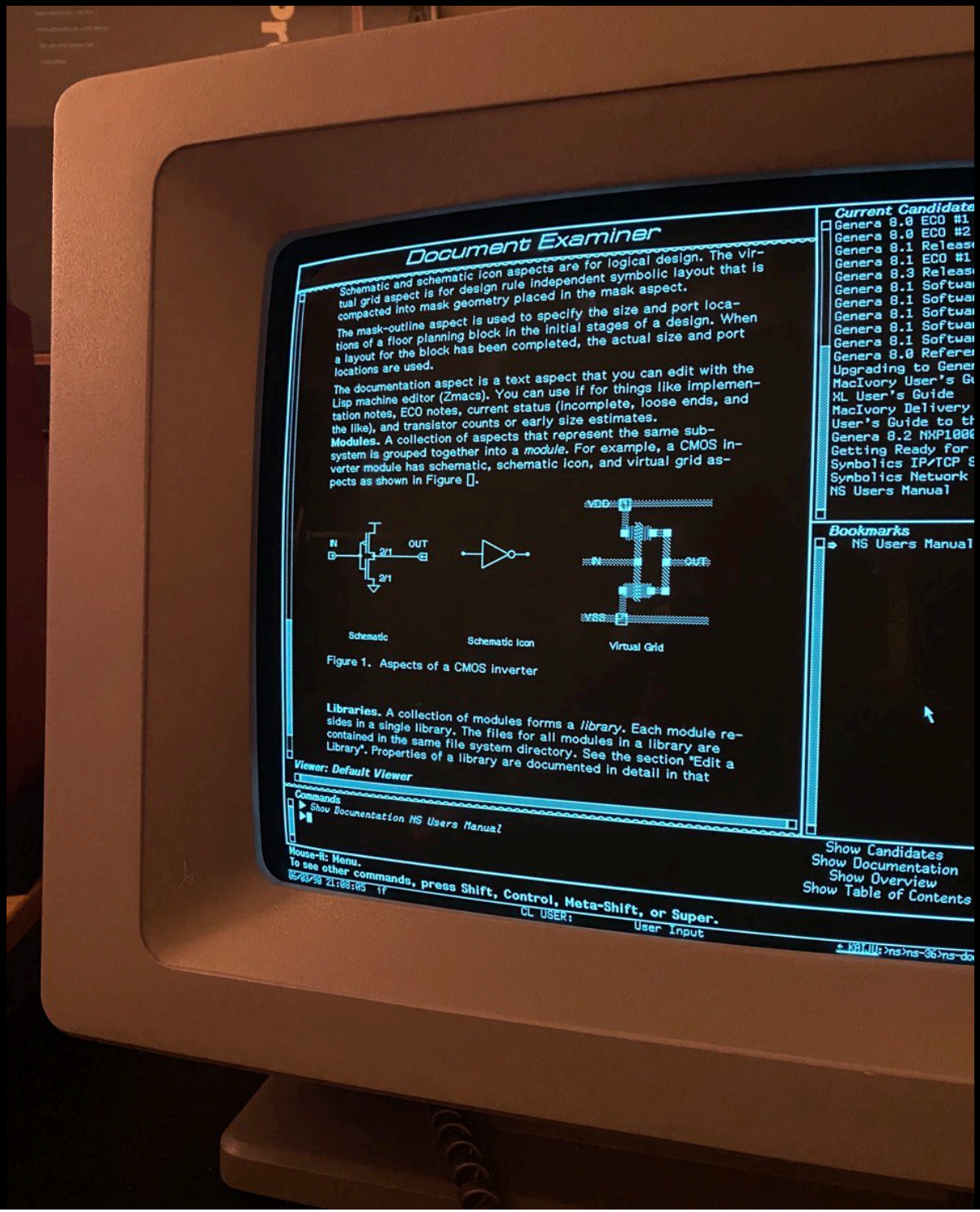


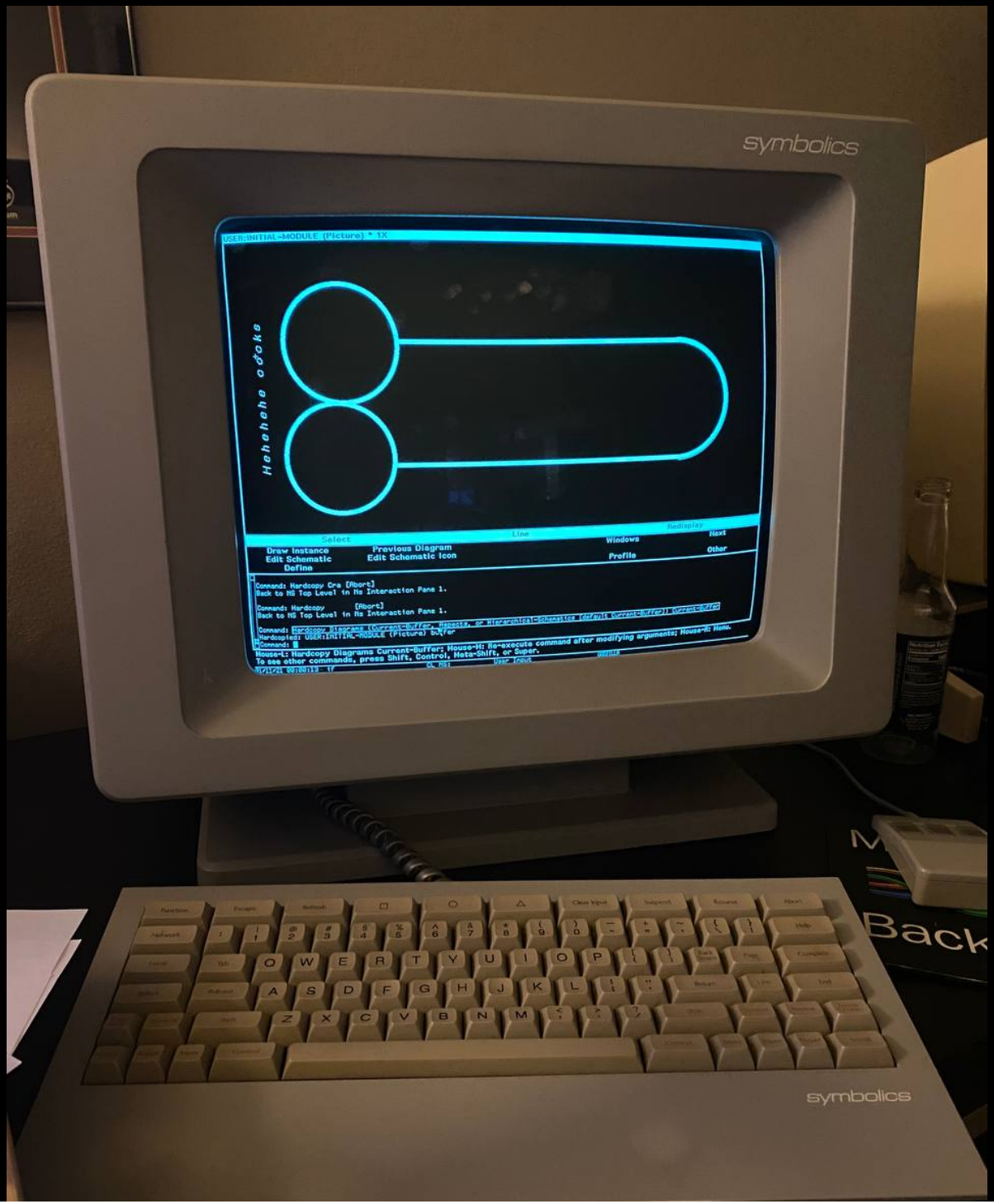
# 3. VLSI Implementation

Ivory was designed using a highly integrated proprietary VLSI design system called NS [5], which is implemented on the Symbolics 3600 Lisp machine. This provides a highly interactive design and simulation environment and in addition, a symbolic layout methodology that allows the complete chip data base to be designed in a process independent manner. The current design is electrically optimized for a 2u/1.6u double level metal CMOS process, although the data base may be retargetted to 1.2u and 1.0u processes to decrease cost and increase speed. The layout density in all styles of layout is comparable to orthogonal geometry hand designs. The design contains approximately 390,000 transistor sites with 255,000 placements. A total elapsed time of 10 months was needed to progress from architecture specification to the first tape-out.

A two phase clock is employed which is routed throughout the chip. Registers and latches use nMOS pass transistors with restoring inverters as the basic storage device. An extra synchronization clock is used to generate memory timing signals.

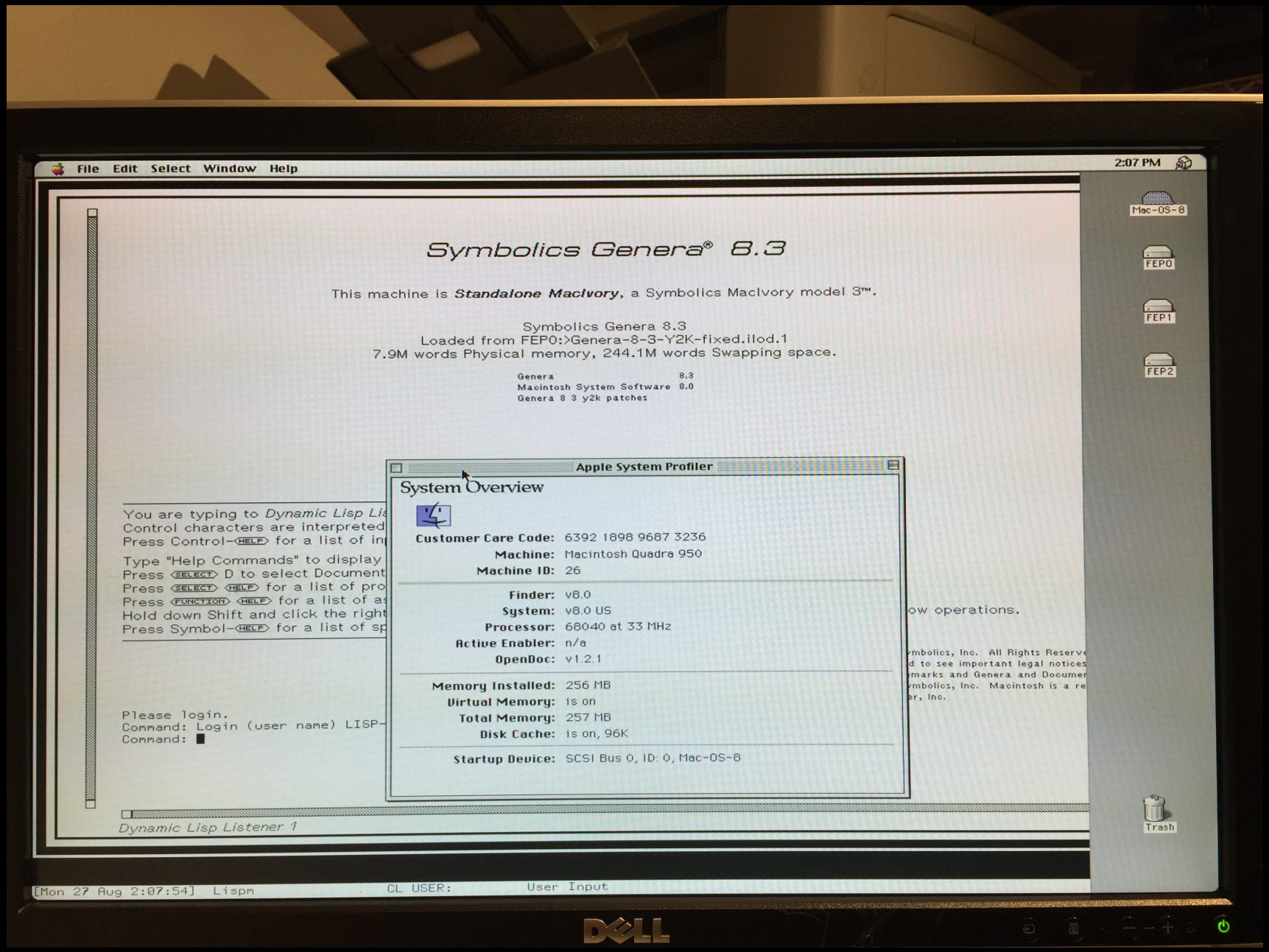
In line with the ability to retarget the design using the symbolic layout tools and the sheer impossibility of hand optimizing 390,000 transistors, the circuit design of the chip was kept fairly simple. The majority of logic in the design is static - either fully complementary CMOS logic gates, pseudo nMOS gates for high fan-in NOR gates or nMOS pass transistor logic for selected muxes. Dynamic gates are only used in the microcode ROM, instruction decoder and the RAMs. The RAMs are implemented using a standard 6 transistor static cell, while the CAMs in the design use a 10 transistor static cell. All control logic is in the form of static, fully complementary standard cells. The symbolic layout for control modules was automatically generated using a standard cell place and route system. A standard cell library, memory library and data-path library is used for most of the designs in the chip. Customization of logic and circuits is kept to a minimum to ensure uniformity of


Document Examiner
Schematic and schematic icon aspects are for logical design. The virtual grid aspect is for design rule independent symbolic layout that is compacted into mask geometry placed in the mask aspect.
The mask-outline aspect is used to specify the size and port locations of a floor planning block in the initial stages of a design. When a layout for the block has been completed, the actual size and port locations are used.
The documentation aspect is a text aspect that you can edit with the Lisp machine editor (Zmacs). You can use if for things like implementation notes, ECO notes, current status (incomplete, loose ends, and the like), and transistor counts or early size estimates.
Modules. A collection of aspects that represent the same subsystem is grouped together into a module. For example, a CMOS inverter module has schematic, schematic icon, and virtual grid aspects as shown in Figure [].
IN
OUT
2/1
2/1
VDD
VSS
IN
OUT
Schematic
Schematic Icon
Virtual Grid
Figure 1. Aspects of a CMOS inverter
Libraries. A collection of modules forms a library. Each module resides in a single library. The files for all modules in a library are contained in the same file system directory. See the section "Edit a Library". Properties of a library are documented in detail in that
Viewer: Default Viewer
Commands
Show Documentation NS Users Manual
Current Candidate
Genera 8.0 ECO #1
Genera 8.0 ECO #2
Genera 8.1 Releas
Genera 8.1 ECO #1
Genera 8.3 Releas
Genera 8.1 Softwa
Genera 8.1 Softwa
Genera 8.1 Softwa
Genera 8.1 Softwa
Genera 8.1 Softwa
Genera 8.0 Refere
Upgrading to Gene
MacIvory User's G
XL User's Guide
MacIvory Delivery
User's Guide to th
Genera 8.2 NXP100
Getting Ready for
Symbolics IP/TCP S
Symbolics Network
NS Users Manual
Bookmarks
NS Users Manual
Show Candidates
Show Documentation
Show Overview
Show Table of Contents
Mouse-R: Menu.
To see other commands, press Shift, Control, Meta-Shift, or Super.
CL USER:
User Input


symbolics
USER:INITIAL-MODULE (Picture) * 1X
Hehehehe cake
Select
Line
Redisplay
Draw Instance
Edit Schematic
Define
Previous Diagram
Edit Schematic Icon
Windows
Next
Profile
Other
Command: Hardcopy Cra [Abort]
Back to NS Top Level in Ns Interaction Pane 1.
Command: Hardcopy [Abort]
Back to NS Top Level in Ns Interaction Pane 1.
Hardcopied: USER:INITIAL-MODULE (Picture) Color
Commands:
House-L: Hardcopy Diagrams Current-Buffer; House-H: Re-execute command after modifying arguments; House-H: Hema.
To see other commands, press Shift, Control, Meta-Shift, or Super.
symbolics


XL1201


MAC IVORY
MODEL 2
(PROCESSOR BOARD)
DO NOT
TOUCH!
WEITEK
115826-A
115827-A
115828-A
115687-C
115690-A
115691-C
115692-B
SYMBOLICS INC
MACIVORY PROCESSOR


File Edit Select Window Help
2:07 PM
Mac-OS-8
FEP0
FEP1
FEP2
Trash
Symbolics Genera® 8.3
This machine is Standalone MacIvory, a Symbolics MacIvory model 3™.
Symbolics Genera 8.3
Loaded from FEP0:>Genera-8-3-Y2K-fixed.ilod.1
7.9M words Physical memory, 244.1M words Swapping space.
Genera 8.3
Macintosh System Software 8.0
Genera 8 3 y2k patches
Apple System Profiler
System Overview
Customer Care Code: 6392 1898 9687 3236
Machine: Macintosh Quadra 950
Machine ID: 26
Finder: v8.0
System: v8.0 US
Processor: 68040 at 33 MHz
Active Enabler: n/a
OpenDoc: v1.2.1
Memory Installed: 256 MB
Virtual Memory: is on
Total Memory: 257 MB
Disk Cache: is on, 96K
Startup Device: SCSI Bus 0, ID: 0, Mac-OS-8
You are typing to Dynamic Lisp Li
Control characters are interpreted
Press Control-HELP for a list of in
Type "Help Commands" to display
Press SELECT D to select Document
Press SELECT HELP for a list of pro
Press FUNCTION HELP for a list of as
Hold down Shift and click the right
Press Symbol-HELP for a list of sp
ow operations.
mbolics, Inc. All Rights Reserve
d to see important legal notices
marks and Genera and Documer
mbolics, Inc. Macintosh is a re
er, Inc.
Please login.
Command: Login (user name) LISP-
Command:
Dynamic Lisp Listener 1
[Mon 27 Aug 2:07:54] Lispm CL USER: User Input
DELL