Chapter 20. Meeting 20, Languages: The Early History of Music Programming and Digital Synthesis

20.1. Announcements

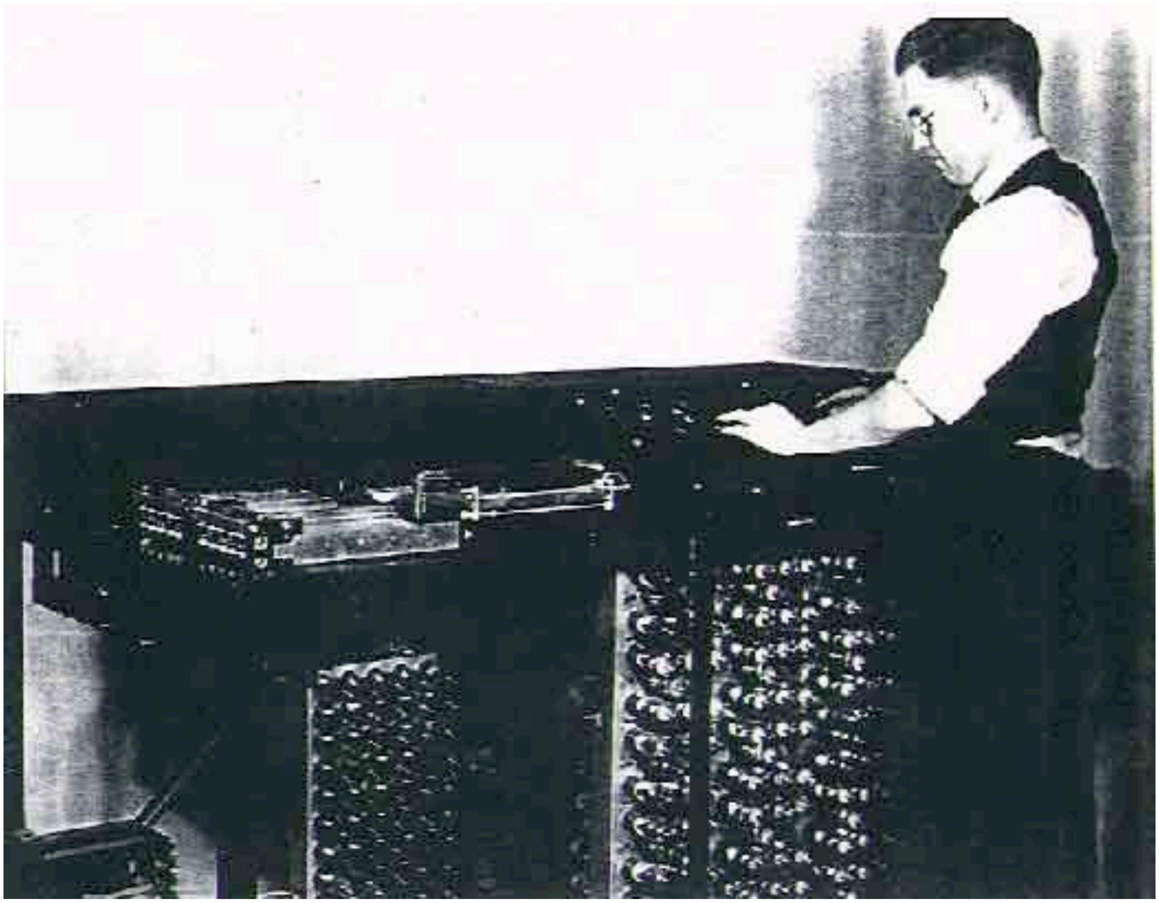
- Music Technology Case Study Final Draft due Tuesday, 24 November

20.2. Quiz

- 10 Minutes

20.3. The Early Computer: History

- 1942 to 1946: Atanasoff-Berry Computer, the Colossus, the Harvard Mark I, and the Electrical Numerical Integrator And Calculator (ENIAC)
- 1942: Atanasoff-Berry Computer



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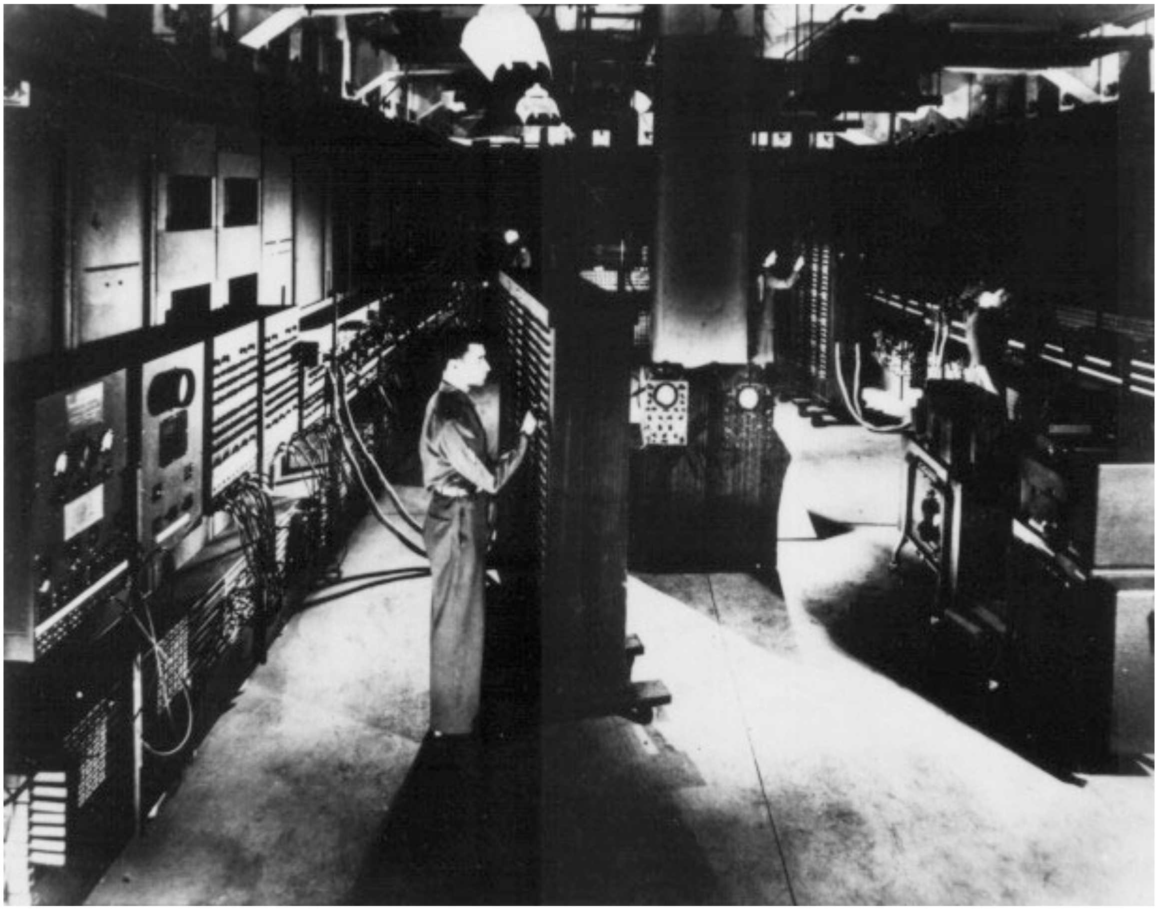
- 1946: ENIAC unveiled at University of Pennsylvania



Source: US Army

- Diverse and incomplete computers

Defining characteristics of five first operative digital computers

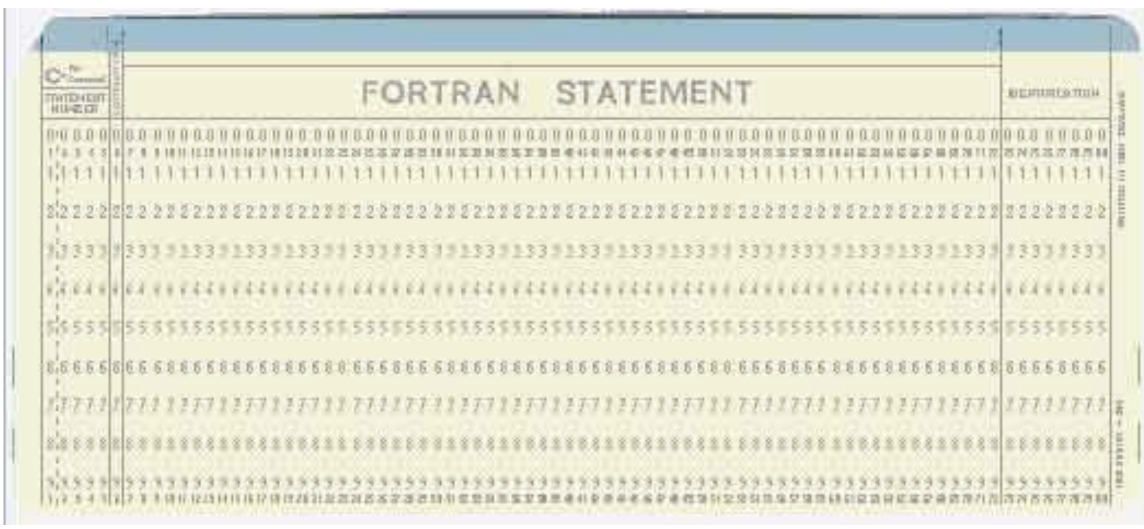
Computer	Nation	Shown working	Digital	Binary	Electronic	Programmable	Turing complete
Zuse Z3	Germany	May 1941	Yes	Yes	No	By punched film stock	Yes (1998)
Atanasoff-Berry Computer	USA	Summer 1941	Yes	Yes	Yes	No	No
Colossus computer	UK	1943	Yes	Yes	Yes	Partially, by rewiring	No
Harvard Mark I/IBM ASCC	USA	1944	Yes	No	No	By punched paper tape	No
ENIAC	USA	1944	Yes	No	Yes	Partially, by rewiring	Yes
		1948	Yes	No	Yes	By Function Table ROM	Yes

20.4. The Early Computer: Interface

- Punchcards
- 1960s: card printed for Bell Labs, for the GE 600

Courtesy of Douglas W. Jones. Used with permission.

- Fortran cards



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20.5. The Jacquard Loom

- 1801: Joseph Jacquard invents a way of storing and recalling loom operations

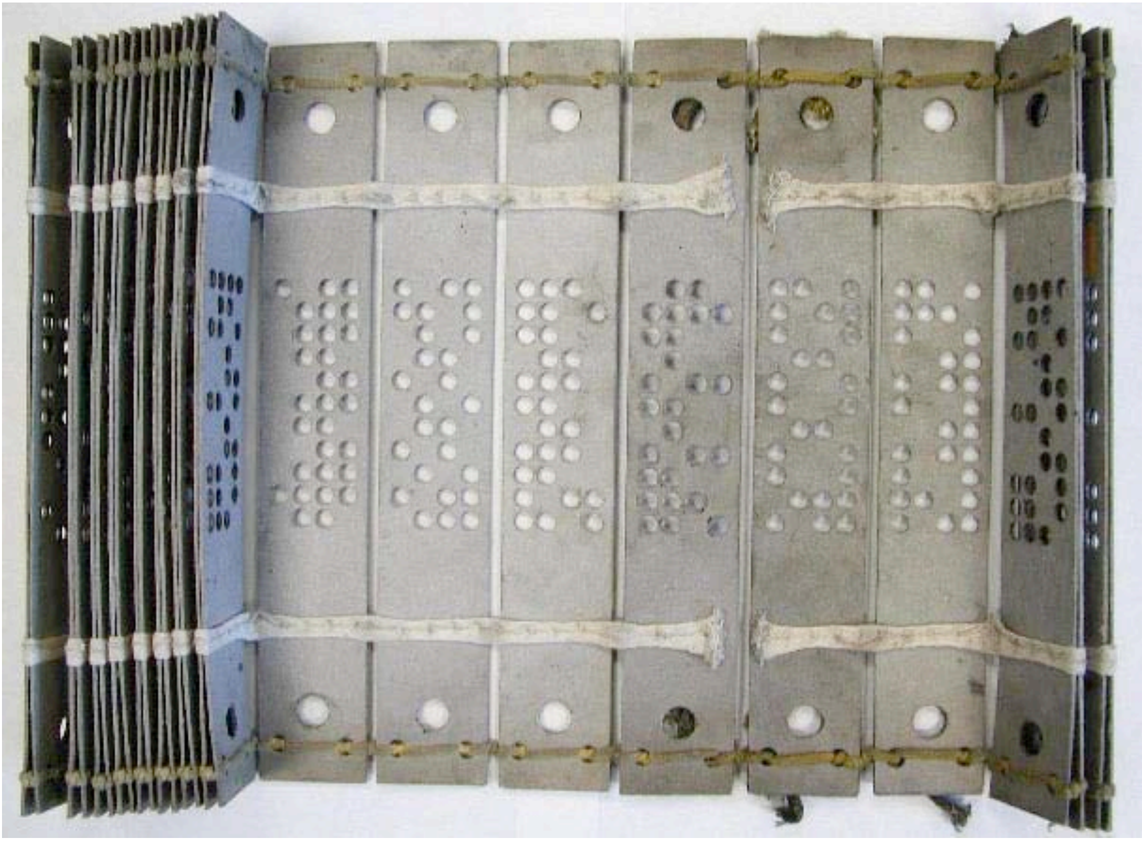


Photo courtesy of Douglas W. Jones at the University of Iowa.

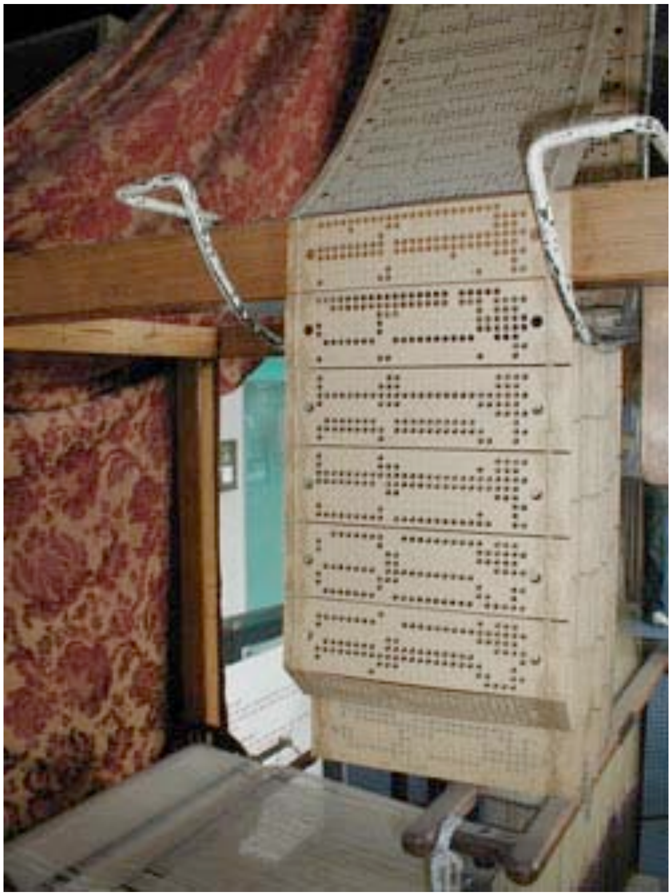


Photo by George H. Williams, from Wikipedia (public domain).

- Multiple cards could be strung together
- Based on technologies of numerous inventors from the 1700s, including the automata of Jacques Vaucanson (Riskin 2003)

20.6. Computer Languages: Then and Now

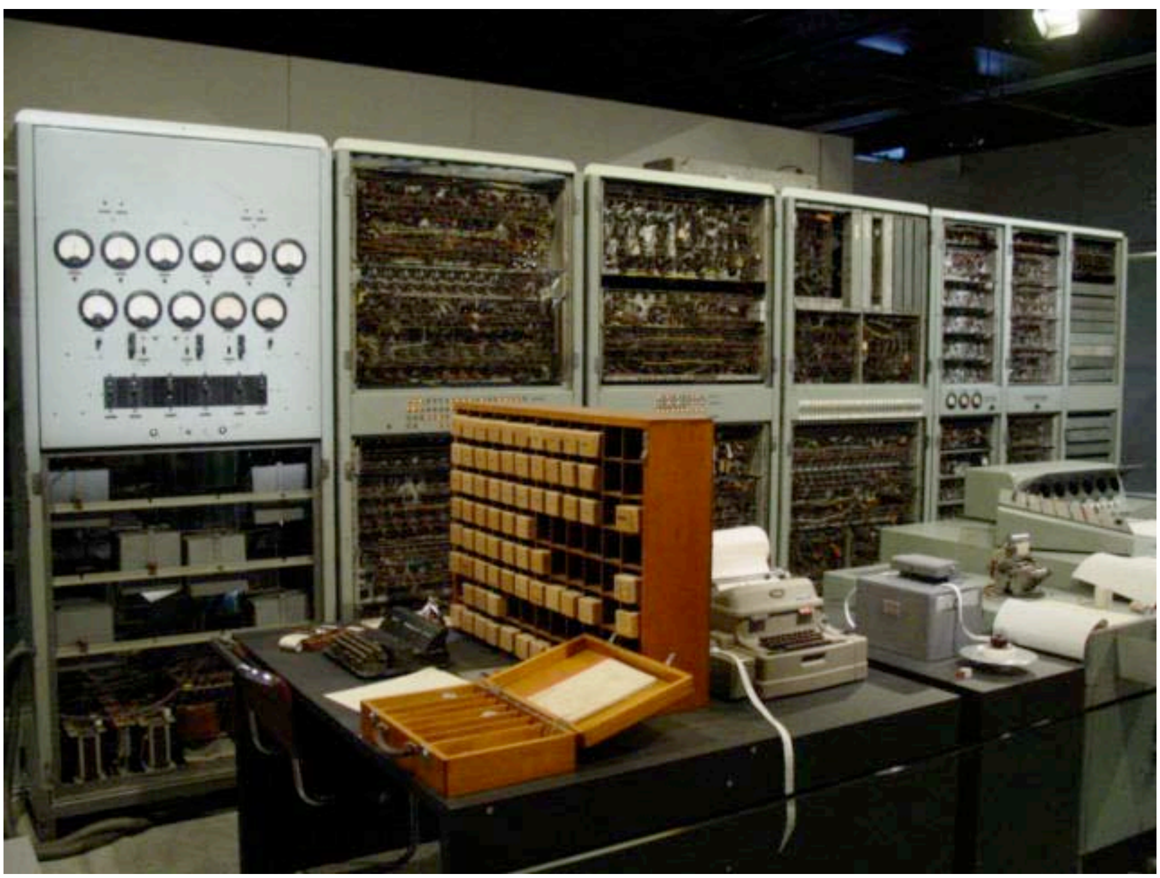
- Low-level languages are closer to machine representation; high-level languages are closer to human abstractions
- Low Level
    - Machine code: direct binary instruction
    - Assembly: mnemonics to machine codes
- High-Level: FORTRAN
    - 1954: John Backus at IBM design FORmula TRANslator System
    - 1958: Fortran II

    - 1977: ANSI Fortran

- High-Level: C
    - 1972: Dennis Ritchie at Bell Laboratories
    - Based on B
- Very High-Level: Lisp, Perl, Python, Ruby
    - 1958: Lisp by John McCarthy
    - 1987: Perl by Larry Wall
    - 1990: Python by Guido van Rossum
    - 1995: Ruby by Yukihiro "Matz" Matsumoto

20.7. The Earliest Computer Sounds: CSIRAC

- late 1940s: The Australian Council for Scientific Industrial Research develop the (CSIR) Mk 1 computer, later CSIRAC (Council for Scientific and Industrial Research Automatic Computer)



- 1951: CSIR programmed by Geoff Hill to play simple melodies with a pulse-wave through its integrated loudspeaker
- CSIRAC Performance: .001 Mhz speed, less than 768 bytes of RAM, consumed 30,000 watts of power, and weighed 7,000 Kg
- Listen: Reconstruction of CSIRAC music, *Colonel Bogey*

- Listen: Reconstruction of CSIRAC music, *In Cellar Cool*, with simulated machine noise

20.8. The Earliest Computer Sounds: The Ferranti Mark 1 and MIRACLE

- Recently original recordings of early computers have been released
- 1951: Christopher Strachey, under guidance from Alan Turing, writes a program for Ferranti Mark 1 at the University of Manchester (Fildes 2008)

  Listen: Christopher Strachey. "God Save the King" and more (BBC News website)

- 1955: David Caplin and Dietrich Prinz write a program to generate and synthesize the Mozart Dice Game on a Ferranti Mark 1* (MIRACLE) at Shell laboratories in Amsterdam (Ariza 2009b)

Listening: Mozart "Dice Game" on the Ferranti Mark 1.

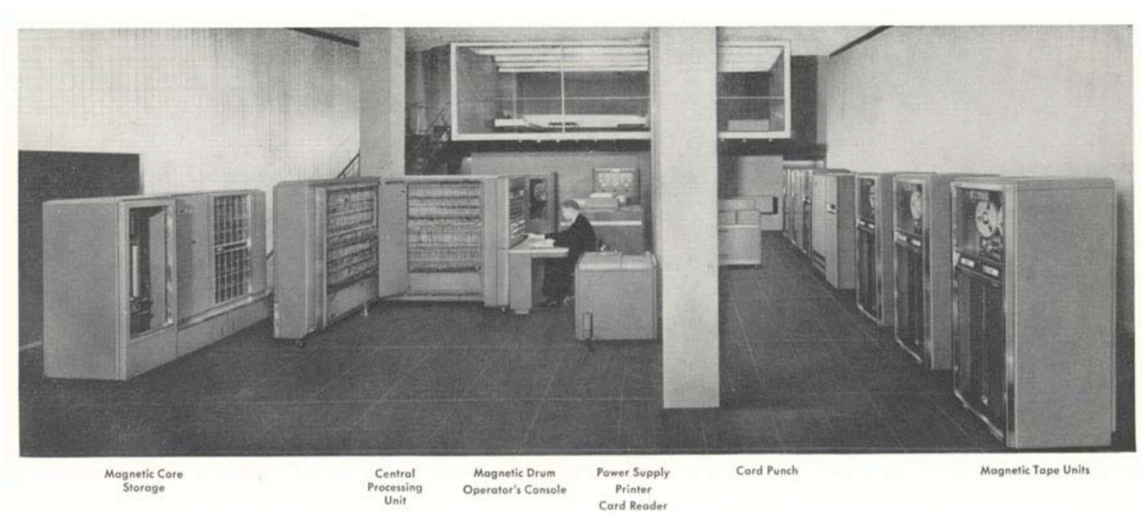
20.9. 1950s: The First Synthesis Language

- Max Mathews, working at the acoustics research department Bell Laboratories in New Jersey, conducted experiments in analog to digital conversion (ADC) and digital to analog conversion (DAC)
- 1957: Music I is used on an IBM 704 to render compositions by Newman Guttman

Listening: *The Silver Scale* (1957): frequently cited as the first piece of computer music

- IBM 704, released in 1954, was the first mass-produced computer with core memory and floating-point arithmetic

Photo: Lawrence Livermore National Laboratory



IBM 704 ELECTRONIC DATA-PROCESSING MACHINES

- Music 1: one voice, one waveform (triangle), square envelope, and control only of pitch, loudness, and decay

- The IBM 704 was in NYC; output has to be taken to a 12 bit DAC at Bell Labs in New Jersey (1980, p. 15)
- Mathews: "... as far as I know there were no attempts to perform music with a computer" (1980, p. 16)

  "Music I sounded terrible and was very limited" (1980, p. 16)
- 1958: Music II: adds four voices and 16 stored waveforms
- Moves to IBM 7094

20.10. 1950s: Early Concepts of Music N

- 1960: Music III: solidified fundamental concepts
- Unit generator: modular building blocks of sound processing similar to the components of a modular synthesizer

  Mathews: "I wanted to give the musician a great deal of power and generality in making the musical sounds, but at the same time I wanted as simple a program as possible" (1980, p. 16)

  Mathews: "I wouldn't say that I copied the analog synthesizer building blocks; I think we actually developed them fairly simultaneously" (1980, p. 16)
- Wavetables: stored tables of frequently used data (often waveforms) retained and reused for efficiency
- Two code files (then punch cards) required to produce sounds
  - Orchestra: synthesis definitions of instruments with specified parametric inputs
  - Score: a collection of event instructions providing all parameters to instruments defined in the Orchestra

20.11. Listening: Tenney

- James Tenney: student of Lejaren Hiller at the University of Illinois
- Mathews: "to my mind, the most interesting music he did at the Laboratories involved the use of random noises of various sorts." (1980, p. 17)
- Employed randomness as a sound source and as a compositional strategy (Mathews and Pierce 1987, p. 534)
- Listen: James Tenney, *Analog #1: Noise Study*, 1961

20.12. 1960s: Distribution

- Lack of portable, hardware independent languages led to new versions of Music-N for each machine
- 1962: Music IV: Mathews and Joan Miller complete on IBM 7094 computer

- Early 1960s Max Mathews distributes Music IV to universities with computers
- Leads to MUSIC 4B (Hubert Howe and Godfrey Winham), MUSIC 4BF, in Fortran, and MUSIC 360, developed for the IBM 360, written by Barry Vercoe

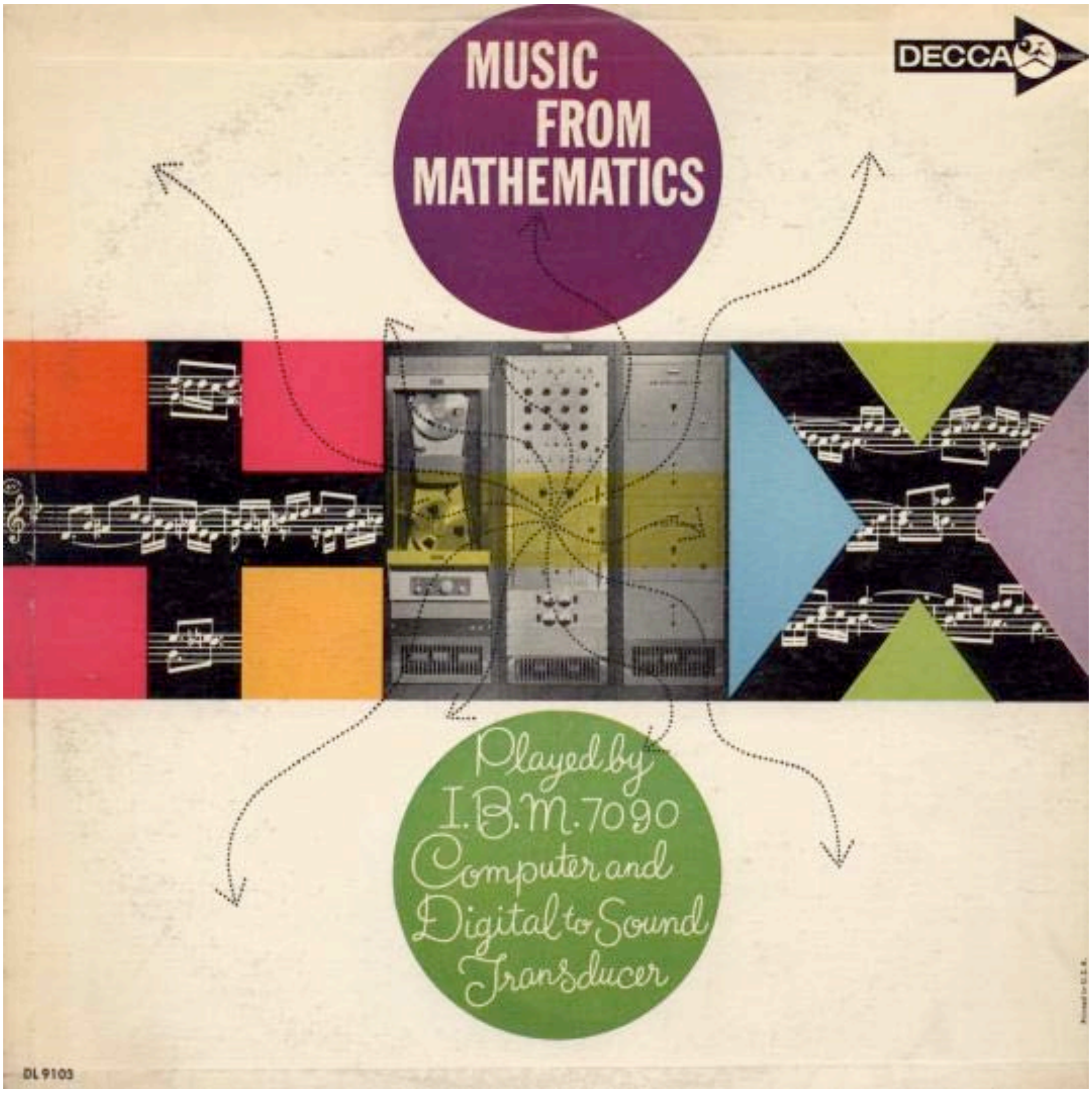
- 1967-1968: Mathews completes Music V, written in FORTRAN with inner loops of unit generators coded in machine language (1980, p. 17)
- Music V: source code distributed as boxes of 3500 punch cards (Chadabe 1997, p. 114)

20.13. 1960s: Working Methods

- Music V was a multi-pass batch program
- IBM 7094 was used to generate digital audio samples that were stored on magnetic tape
- IBM 1620 was used to convert samples into analog audio signals
- Rendering audio and DA conversion would take up to two weeks

20.14. Music from Mathematics

- Album released on Decca Records in 1962 with early computer music by Mathews, J.R. Pierece, David Lewin, James Tenney, and others.



20.15. Listening: Jean-Claude Risset

- Risset visits Bell Labs in 1964, works with Mathews
- Had researched timbre analysis methods and held a Ph.D. in physics
- 1969: Works with sounds entirely synthesized with a computer at Bell Labs using Music V
- Used of additive and FM synthesis techniques
- Listen: Jean-Claude Risset: "Mutations," 1969

20.16. 1970s: Music 11 and Control Rate Signals

- 1973: Vercoe, at MIT, releases Music 11 for the Digital Equipment PDP-11
- Optimized performance by introducing control rate signals (k-rate) separate from audio rate signals (a-rate)

20.17. Listening: Barry Vercoe

- Composition for Viola and Computer
- All digital parts produced with Music 11
- Listen: Vercoe: “Synapse” 1976

20.18. Listening: James Dashow

- Completed at MIT with Music 11
- Listen: Dashow: “In Winter Shine” 1983

20.19. 1980s: Portability

- Machine specific low-level code quickly became obsolete

- Machine independent languages, such as C, offered greatest portability
- 1985: Vercoe translates Music 11 into C, called Csound
- 1990: Vercoe demonstrates real-time Csound
- Csound is ported to all platforms and is modern Music-N

20.20. Reading: Roads: Interview with Max Mathews

- Roads, C. 1980. "Interview with Max Mathews." *Computer Music Journal* 4(4): 15-22.
- Mathews states that "the only answer I could see was not to make the instruments myself -- not to impose my taste and ideas about instruments or the musicians -- but rather to make a set of fairly universal building blocks and give the musician both the task and the freedom to put these together into his or her instruments" (1980, p. 16); is this goal possible?
- Mathews states that "The reaction amongst all but a handful of people was a combination of skepticism, fear, and complete lack of comprehension" (1980); what motivated these responses, and how were these responses different based on established musical roles?
- What does Mathews later work with GROOVE, the Sequential Drum, and electric violins suggest about his interests after Music V?

20.21. Listening: Spiegel

- Laurie Spiegel: worked at Bell Labs from 1973 to 1979
- Worked with Mathews on the GROOVE system
- Appalachian Grove composed with the GROOVE system
- Listen: Laurie Spiegel, *Appalachian Grove I*, 1974

- *Improvisation on a "Concerto Generator"*, realized on the Alles synthesizer with interactive control software written in C for the DEC PDP-11

YouTube (http://www.youtube.com/watch?v=fWKDsfARXMc)