Chapter 3. Meeting 3, Recording: The History of Analog Audio

3.1. Announcements

• Check course notes for reading and listening discussion leaders
• Quiz next Tuesday

3.2. A History of Analog Recorded Mediums

• From the helix, to the spiral, to the line
• A reduction in dimensionality
• A trend towards facilitating non-linearity

3.3. What is Analog

• Something that is analogous to something else
• A direct, continuous, sonic transduction
• The earliest methods of storing and transporting sound were all analog

3.4. Sending Messages: Telegraphy

• tele (far) + graph (write)
• Transmission of messages using optics, radio, or other mediums
• Electrical telegraph (telegraphs): foundation of modern communication systems
• 1837: Samuel Morse (1791-1872) patents electrical telegraph
INTERNATIONAL MORSE CODE

1. A dash is equal to three dots.
2. The space between parts of the same letter is equal to one dot.
3. The space between two letters is equal to three dots.
4. The space between two words is equal to five dots.

A  • •
B  • • • •
C  • • • •
D  • • •
E  •
F  • • • •
G  • • •
H  • • • •
I  •
J  • • • • •
K  • • •
L  • • • •
M  • • • •
N  • •
O  • • • • •
P  • • • • •
Q  • • • • •
R  • • • •
S  • • • •
T

U  • • • • •
V  • • • • •
W  • • • •
X  • • • •
Y  • • • • •
Z  • • • • •

Source: Wikimedia.

• 1866: first trans-atlantic cable
• 1891 international telegraph lines, the Victorian internet (Standage 2007)
3.5. Sending Sonic Messages: Bell

- Alexander Graham Bell (1847-1922)
- Desire to transmit the sound of the human voice by telegraph
- Desire to reduce traffic on telegraph lines by accommodating multiple signals at different frequencies (acoustic telegraphy)
- Initially called the device the harmonic telegraph: transmit sound through analog wave-forms in electronic currents
- 10 March 1876: through prototype told his assistant: “Mr. Watson, come here”
- 1876: Bell files patent application for telephone: “the method of, and apparatus for, transmitting vocal or other sounds telegraphically … by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sound.”
- Early designs used “microphones” filled with fluid that responded to changes in air pressure and created an analogous voltage
- 1877: Bell Telephone Company was created
- 1879: Began using an improved microphone
3.6. Sending Sonic Messages: Gray and Meucci

- Antonio Meucci (1909-1896)
- Created, tested, demonstrated, and filed for patents on telephone models prior to Bell’s work, as early as 1857
- Had failed to file patent before Bell’s patent (filed a patent caveat in 1871)
- Elisha Gray: presents a similar telephone at Philadelphia Exhibition
- Files patent on the same day as Bell: 14 February 1876

3.7. Sound Analysis to Sound Recording: Phonoautograph

- Édouard-Léon Scott: Parisian typesetter and inventor
- 1857: Leon Scott builds phonoautograph, tracing waveform on smoked paper
Figure 12.2  Rudolf Koenig’s version of the Phonoautograph for recording images of sound waveforms. (a) Apparatus. (b) Recordings.

Courtesy of MIT Press. Used with permission.

- Did not conceive of recording sound for playback, but for study and analysis
- Possibly the earliest recordings from 1860 (Rosen 2008)
1860 phonautograms by Édouard-Léon Scott de Martinville, restored by FirstSounds.org.
"Au Clair de la Lune."

3.8. Recording Sonic Messages: Vertical Cuts in Tin

- Thomas Alva Edison (1847-1931)
- First prototype of the phonograph tested in 1877
- Hand crank to turn a cylinder covered in tin
- Hill and dale vertical cuts
• Produced a helical trace around the cylinder

• Original 1877 Edison model

Source: U.S. National Park Service
• A refined production model
• Mechanical recording and mechanical playback

3.9. Tracks on Wax

• 1888 first commercial phonographs in production
• Replaced tin with a wax coating
• Four inch cylinder could record between 3 and 4 minutes
• Hand cranks soon replaced with spring-wound mechanisms

3.10. The Voice of Edison

• Earliest known recording of Edison
• Recorded on an Edison yellow paraffin cylinder in 1888
• Audio: Thomas A. Edison: “Around the world on the phonograph,” 1888
• Extensive archive of early recordings by Edison:
  http://www.nps.gov/edis/photosmultimedia/the-recording-archives.htm
3.11. Recorded Sound: A Commercial Endeavor

- Edison desired that the phonograph be used for business: “... I don't want the phonograph sold for amusement purposes, it is not a toy. I want it sold for business purposes only” (Brady 1999, p. 22).
- Wanted to lease machines to businesses
- Marketed applications included creating audio albums of voices of the dead
- Advertisement from Harpers, 1898
THE
EDISON
NEW STANDARD
PHONOGRAPHER.

Price $20 Complete

Produces the same results as the other famous models of the GENUINE EDISON PHONOGRAPHER, using the same records and the same reproducer. Simplest, most durable, and cheapest talking-machine.

EDISON NEW STANDARD, $20.00.
" Home Phonograph, 30.00.
" Spring Motor " 75.00.
" Electric " 75.00.

ALL GENUINE PHONOGRAPHERS bear
this signature:

THOMAS A EDISON

MARK

Catalogue No. 3 free from the NATIONAL PHONOGRAPHER CO., St. James Building, Broadway & 26th St., New York.
Edison records 50 cents each, $5.00 per dozen.

Source: U.S. Library of Congress
• Eventually accepts home use, but still not for music

- 1887: Emile Berliner (1851-1929) introduces the disc-based Gramophone

- 1888: Emile Berliner publishes “Etching The Human Voice”
MEMBERS OF THE FRANKLIN INSTITUTE, LADIES AND GENTLEMEN.—The last year in the first century of the history of the United States was a remarkable one in the history of science.

There appeared about that period something in the drift of scientific discussions, which, even to the mind of an observant amateur, foretold the coming of important events.

The dispute of Religion versus Science was once more at its height; prominent daily papers commenced to issue weekly discussions on scientific topics; series of scientific books in attractive popular form were eagerly bought by the cultured classes; popular lectures on scientific subjects were sure of commanding enthusiastic audiences; the great works on evolution had just commenced to take root outside of the small circle of logical minds from which they had emanated, and which had fostered them. Scientific periodicals were expectantly scanned for new information, and the minds of both professionals and amateurs were on the qui vive.

Add to this the general excitement prevailing on account of the forthcoming centennial celebration with its crowning event, so dear to this nation of inventors, the world’s exhibition, and even those who did not at the time experience the effects of an atmosphere pregnant with scientific ozone, can, in their minds, conjure up the pulsating, swaying, and turbulent sea of scientific research of that period. Science evidently was in labor.

The year 1876 came, and when the jubilee was at its very height, and when this great City of Philadelphia was one surging mass of patriots filling the air with the sounds of millions of shouts, a still small voice, hardly audible, and coming from a
• First discs were made of acid-etched zinc

• Later discs made of glass, plastics, other materials.

• Transduced waveform into lateral, rather than vertical, cuts
• 1895: Commercial pre-recorded discs were available for sale

• Still using mechanical recording and mechanical playback

• 1901: Eldridge Johnson, along with Berliner, incorporate Victor Talking Machine Company, merging Berliner’s Berliner Gramophone and Johnson’s Consolidated Talking Machine Company

3.13. The Cylinder and the Disc

• The cylinder permitted recording, at home or in the office

• The disc was cheap to reproduce, and was primarily for distribution of pre-recorded material

• Between 1890 and 1910 pre-recorded programs on discs out-sell recordable blank cylinders

• By 1913: Edison is the last manufacturer to stop selling cylinders


• Nipper: 1884-1895

• Painting by his owner, Mark Barraud, renamed “His Master’s Voice”
• Painting bought by The Gramophone Company (became EMI) in 1899, and replaced the phonograph with a gramophone

• Used in advertising in 1900

• Berliner buys rights in 1902 for Victor Talking Machine Company (later RCA Victor)

3.15. The Age of the Disc

• 1910s onward the disc is the medium of recorded sound

• Edison reluctantly creates and sells disc-based players

3.16. Analog Recording from 1890 to 1920s

• Social issues

  • Edison Realism Test: a formalized, marketing procedure to encourage listeners to imagine performance while listening

  • Illustrated song machine and the projecting phonograph: attempts to restore visual element with graphical mechanizations

  • 1903 Rosenfield Illustrated song machine
• Personification and anthropomorphism: Talking Machines

• Technical issues
  • Record entire ensemble with one horn, mechanically
  • Some instruments and singers recorded better than others
3.17. Reading: Katz


- Vibrato [vibrato.pd]
• What stages of a change in vibrato performance does Katz document?

• What reasons, other than recording, does Katz state others have offered?

• What are the three reasons Katz sees the increase in vibrato as “a response to the exigencies of sound recording”

• How else might recording be seen as a catalyst rather than a tool of preservation?

• The idiomatic of new mediums: “necessity ... may sometimes be the mother of aesthetics”

3.18. Electrification of Sound

• Phonographs and gramophones: mechanical recording, mechanical playback

• late 1920s: innovations in microphones led to electrical recording

• 1930s: electrical playback and amplification
3.19. The Fidelity of Recorded Audio

- 1890s to 1920s (1925)
  - Narrow frequency response: best 200 and 2k Hertz
  - Very low dynamic range
  - Poor signal to noise ratio
- 1930s
  - Frequency response from 100 to 4.5k
  - Dynamic range of 30 dB
  - Wagner: Ride of the Valkyries, from Die Valkyrie, 1921, American symphony Orchestra, Edison Diamond Disc [samplePlayer:pd]
  - Audio: local
  - Wagner: Ride of the Valkyries, from Die Valkyrie, 1988, Cincinnati Pops Orchestra
  - Audio: local

3.20. Disc Formats

- 78 RPM discs
  - 1900 to 1925 discs recorded between 74 and 82 rpm
  - 78 rpm based on a 3600 rpm motor with 46:1 gear ratio: 78.26 rpm
  - Covered in shellac: Asian beetle juice
  - Available in 10 inch (3 minutes) and 12 inch (4-6 minutes) formats
- 33.33333 RPM discs
  - Columbia Records (owned by CBS): June 1948 releases Long Playing Record
  - Use of more-narrow grooves (microgroove)
  - Use of vinyl offered better sound quality
• 12 inch diameter, 30 minutes or more per side

• 45 RPM discs
  • RCA Victor introduces in 1949, 7 months after LP
  • 7 inch diameter, 4 minutes per side
  • Designed to have uniform size, easy distribution, automatic changers (jukebox)
  • Became known as “singles”: one tune per side
  • The B or flip side offered a bonus track
  • Extended Play (EP) 45s achieved 7 minutes per side
  • Early model manufactured by RCA

• RCA advertisement
GREATEST MUSICAL ADVANCE IN 50 YEARS

New RCA Victor System
OF RECORDED MUSIC

The modern, inexpensive way to enjoy music in the home

The new RCA Victor system has more advantages, offers more enjoyment than any other system ever devised. From the new compact player to the distortion-free 7-in. record, it marks an impressive milestone in RCA Victor’s lifetime goal—to make the pleasures of recorded music a reality in every home.

WORLD’S FASTEST CHANGER

Lightning fast! This changer plays up to ten of the 7-in., 45 rpm records like the new RCA Victor record . . . the first record distortion-free over its entire playing surface. These non-breakable records can play just as long as ordinary 12-in. discs . . . cost far less.

The new changer is the easiest to operate. Slip up to ten records on the spindle . . . push one button and enjoy over 50 minutes of just the music you want. It is the safest operating player ever. No chipping of center hole. No more “spindle-seeking” while loading.

COLLECT RECORDS AT LESS COST

Yet, with all its advantages, the new RCA Victor system costs far less. Smaller size and fewer parts naturally mean greater savings. No wonder this amazing new system has been acclaimed the modern, inexpensive way to enjoy music in the home.

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3.21. The Expansion of the Music Business

- 1927: 104 million discs sold
- From 1934 to 1939: 6,000 to 152,000 record players produced (Magoun 2002, p. 149)
- Marketed to middle class for consumer usage
- 1930s: gramophones packaged with radios

3.22. Reading: Magoun


- What were some of the motivations for the 45-RPM disc?
- What audience, and what music, was associated with the 45-RPM disc?
- Was fidelity and sound quality a driving force in product design? Is it today?
- What other entertainment was competing with record sales?

3.23. Stereo

- By recording two channels (sometimes called tracks), sound could be panned left and right
- Increase sense of space in recorded sound
- 1958: first stereo records issues

3.24. Aural Transduction to Magnetic Flux

- Magnetic wire recording in 1898: Valdemar Poulsen
- Magnetic tape in 1928: Furtz Pfleumer (Germany)
  - Wire was difficult to record, cut, and splice
  - Cellulose acetate coated in iron oxide
  - Permitted splicing with adhesive tape
- How it works
Figure by MIT OpenCourseWare.
3.25. Early Magnetic Recording Devices

- 1930s: Magnetophone (AEG, Germany)
- 1940s: Commercially developed in the late 1940s by American Jack Mullin with Bing Crosby
- Reel to reel audio tape recording machines spread in 1950s with companies like Ampex

• 1940s: Guitarist Les Paul (1915-) experiments with adding and bouncing tracks in direct to wax disk recording

• 1948: produced “Lover (When You're Near Me)” album with this technique, combining up to 8 guitars

• Modifies an Ampex Model 300 mono tape recorder to record multiple individual tracks
FOR
Critical TAPE RECORDING
to 40,000 cycles

Tape recording is superior to all other re-
production methods and “AMPEXED TAPE”
has the greatest fidelity and range now possi-
ble. Simplified operation plus sure results make
AMPEX unexcelled for all critical recording uses.
Dual tape speeds with automatic speed and equali-
zation change is but one of many exclusive AMPEX
features.

Unequaled for
TELEMETERSING • BROADCASTING • RESEARCH

STANDARD OF
THE GREAT
RADIO SHOWS

Simultaneous
• ERASE
• RECORD
• PLAY BACK

MODEL 300
Price $1575
(f.o.b. San Carlos)
Meter Control
Panel $114 Extra

AMPEX ELECTRIC CORP., San Carlos, California
Without obligation please send 16-page illustrated
booklet containing technical specifications of Ampex
Magnetic Tape Recorders.

NAME__________________________

ADDRESS_____________________

CITY_________________________STATE________

Our need is for:
□ Laboratory Research
□ Multi-Channel Recording
□ Recording-Broadcasting
□ Telemetering
□ Industrial Recording
□ Aerophysical Research

AMPEX ELECTRIC CORPORATION
SAN CARLOS, CALIFORNIA
DEALERS IN PRINCIPAL CITIES
• By 1953 develops first 8 track recorder
• Employed recording at different speed to transpose guitar part on playback
• Les Paul and his wife Mary

3.27. Listening
• Les Paul, “Lover,” 1948

3.28. Music in Your Pocket: The Cassette
• 1962: Philips releases compact cassette

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• 45 minutes per side
• Initially had less quality than larger formats
• Improved frequency response from 30-18000 Hertz

• 1963 to 1968: 9000 to 2.4 million players sold

• Affordable home recording

• Double cassette decks: easy copying

• Home Taping is Killing Music: 1980s anti-copyright infringement campaign by British Phonographic Industry (similar to RIAA)

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3.29. Reading: Millard: Tape Recording and Music Making

• How did tape recording relate to the Edison cylinder?

• Who were the early adopters of tape recording devices, and what did they do with them?

• What new techniques were possible with tape recording?

• What musical genres were particularly influenced by the cassette, and why?

3.30. Reading: Collins


• Creative applications of tape heads and tape
3.31. Tape Cartridges and Stereo 8

• The 8-track cartridge
• 1964 to 1982-1988
• An endless tape loop: one continuous piece of tape
• Self winding, and could not rewind

• Four tracks: two pairs of stereo tracks side by side
• 1965: Ford puts 8-tracks in cars
• Tape head alignment was a regular problem