

## **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

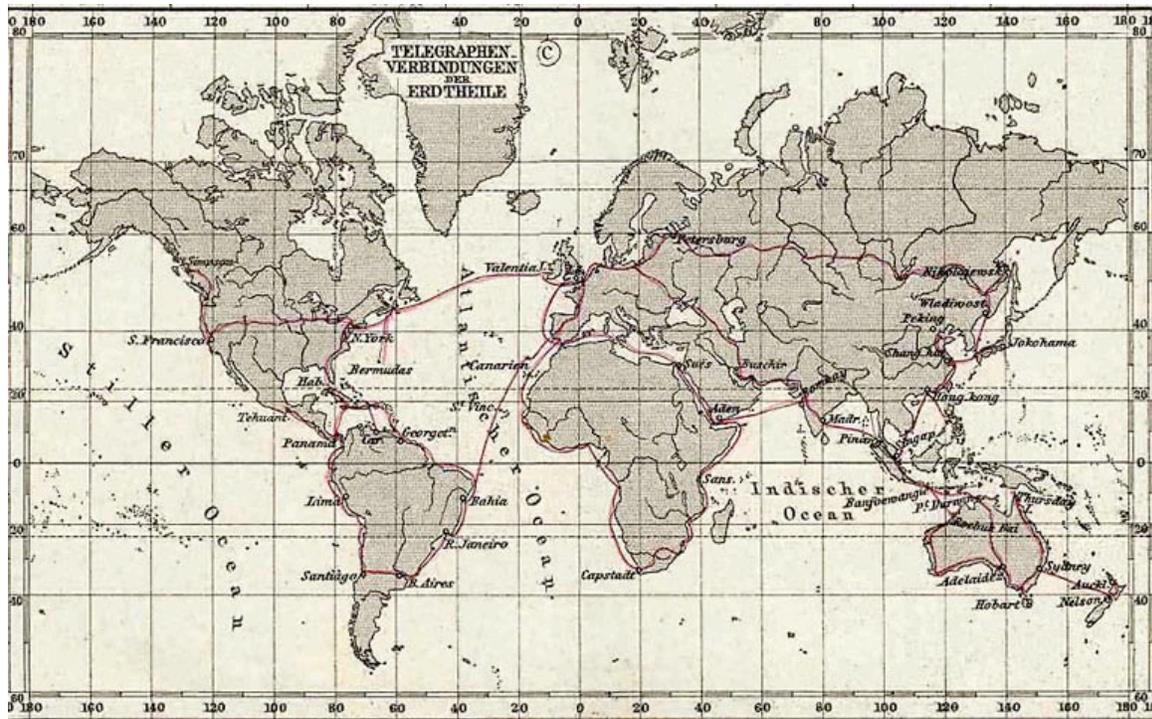
1. A dash is equal to three dots.
2. The space between parts of the same letter is equal to one dot.
3. The space between two letters is equal to three dots.
4. The space between two words is equal to five dots.

A	• —	U	• • —
B	— • • •	V	• • • —
C	— • — •	W	• — —
D	— • •	X	— • • —
E	•	Y	— • — —
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K	— • —	1	• — — — —
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N	— •	4	• • • • —
O	— — —	5	• • • • •
P	• — — •	6	— • • • •
Q	— — • —	7	— — • • •
R	• — •	8	— — — • •
S	• • •	9	— — — — •
T	—	0	— — — — —

Source: [Wikimedia](#).

From Snodgrass, R. T., and V. F. Camp. *Radio Receiving for Beginners*.  
New York, NY: MacMillan, 1922.

- 1866: first trans-atlantic cable
- 1891 international telegraph lines, the Victorian internet (Standage 2007)



Source: [Wikipedia](#)

### 3.5. Sending Sonic Messages: Bell

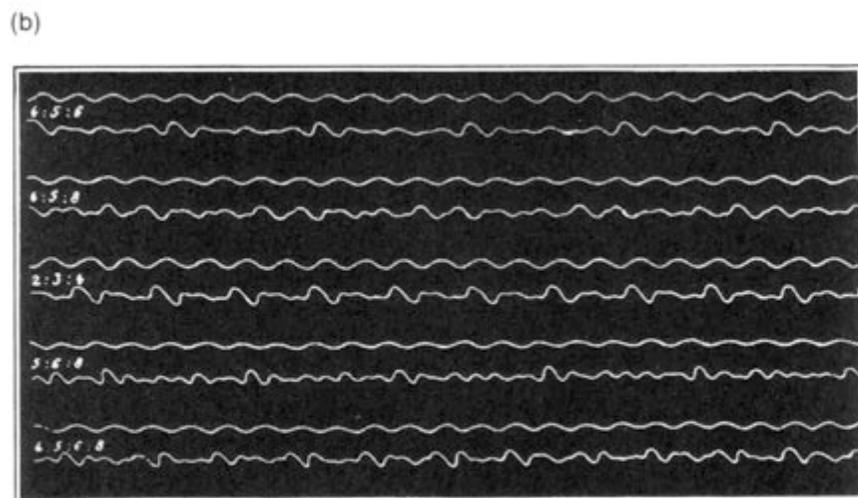
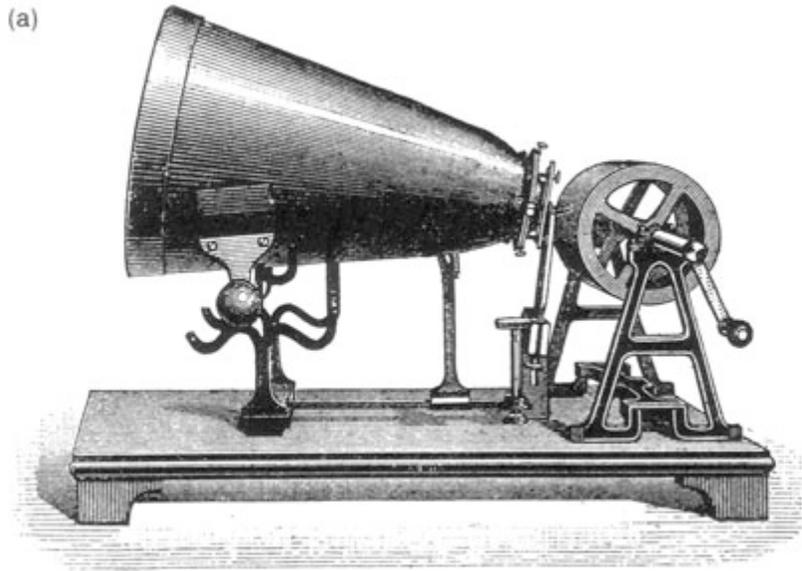
- Alexander Graham Bell (1847-1922)
- Desire to transmit the sound of the human voice by telegraph
- Desire to reduce traffic on telegraph lines by accommodating multiple signals at different frequencies (acoustic telegraphy)
- Initially called the device the harmonic telegraph: transmit sound through 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 (1809-1896)
- 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**

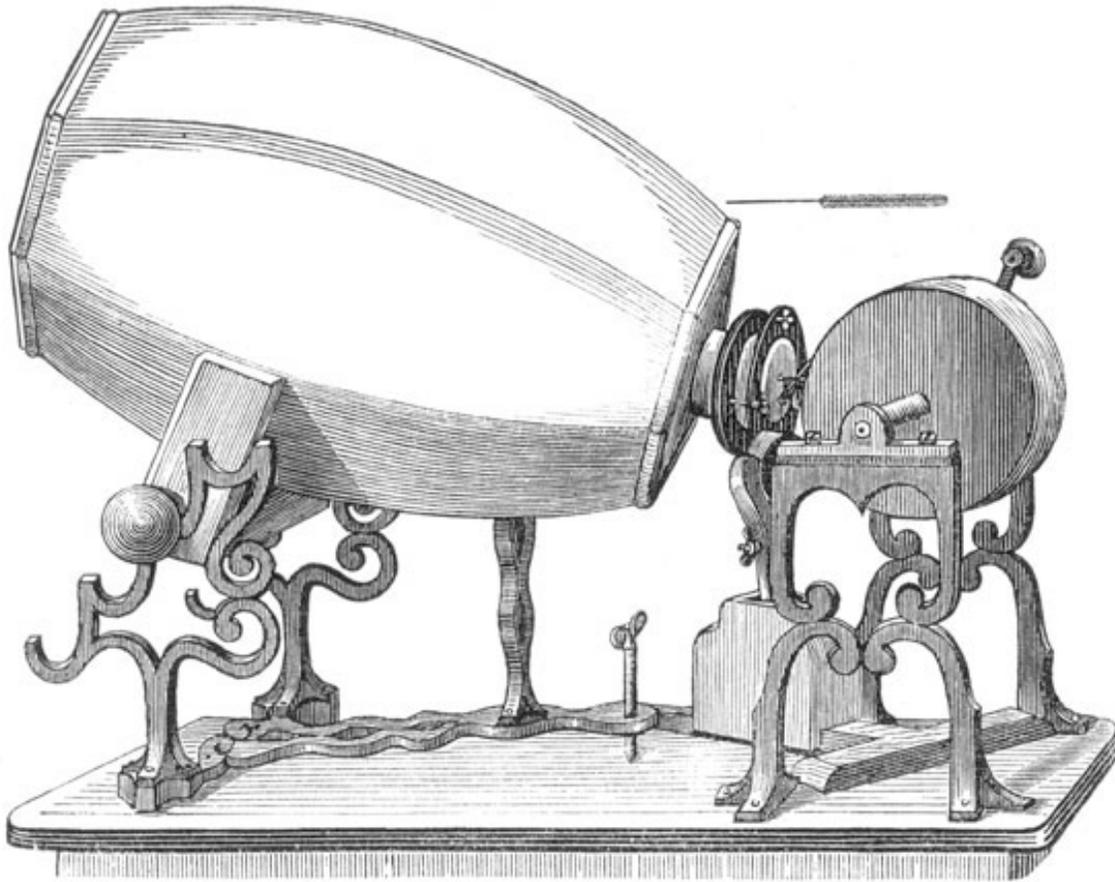
- Édouard-Léon Scott: Parisian typesetter and inventor
- 1857: Leon Scott builds phonoautograph, tracing waveform on smoked paper



**Figure 12.2** Rudolf Koenig's version of the Phonoautograph for recording images of sound waveforms. (a) Apparatus. (b) Recordings.

Source: Roads, C. *The Computer Music Tutorial*. Cambridge, MA: MIT Press, 1996.  
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)



Courtesy of FirstSounds.org. Source: Franz Josef Pisko, *Die neuere Apparate der Akustik* (Vienna, 1865).

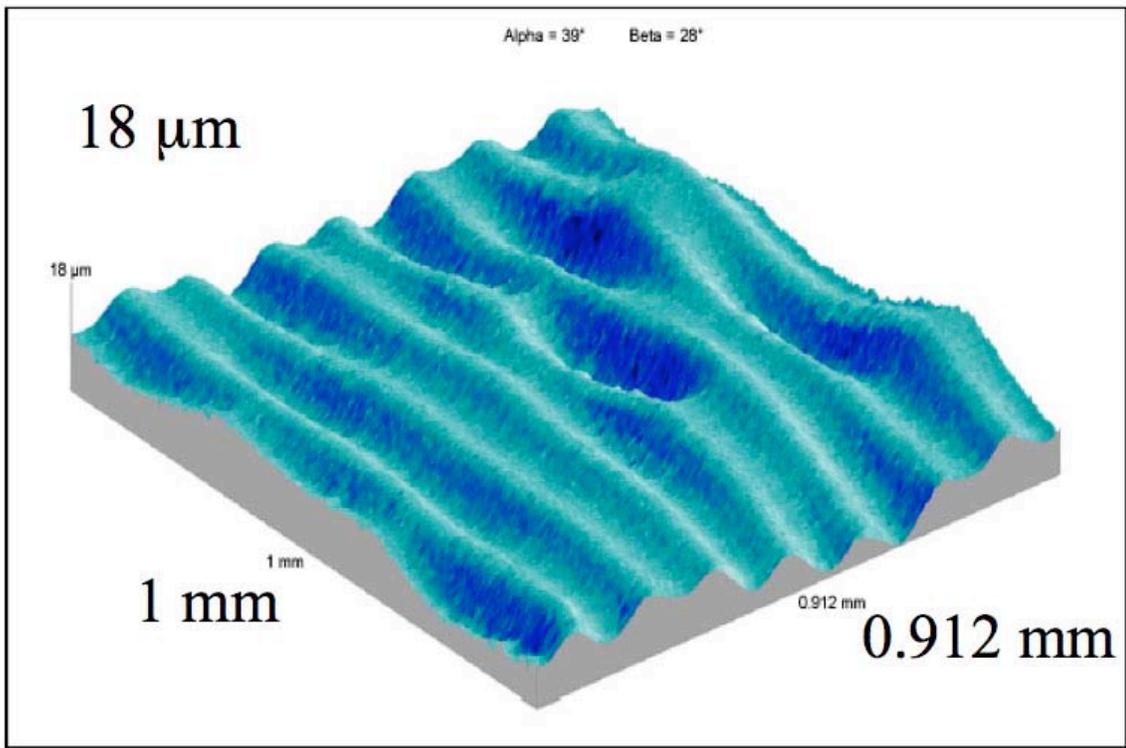
Recording reconstructed from scanned imprint:

1860 phonautograms by Édouard-Léon Scott de Martinville, restored by FirstSounds.org.  
"Au Clair de la Lune."

Courtesy of FirstSounds.org. Source: Franz Josef Pisko, *Die neuere Apparate der Akustik* (Vienna, 1865).

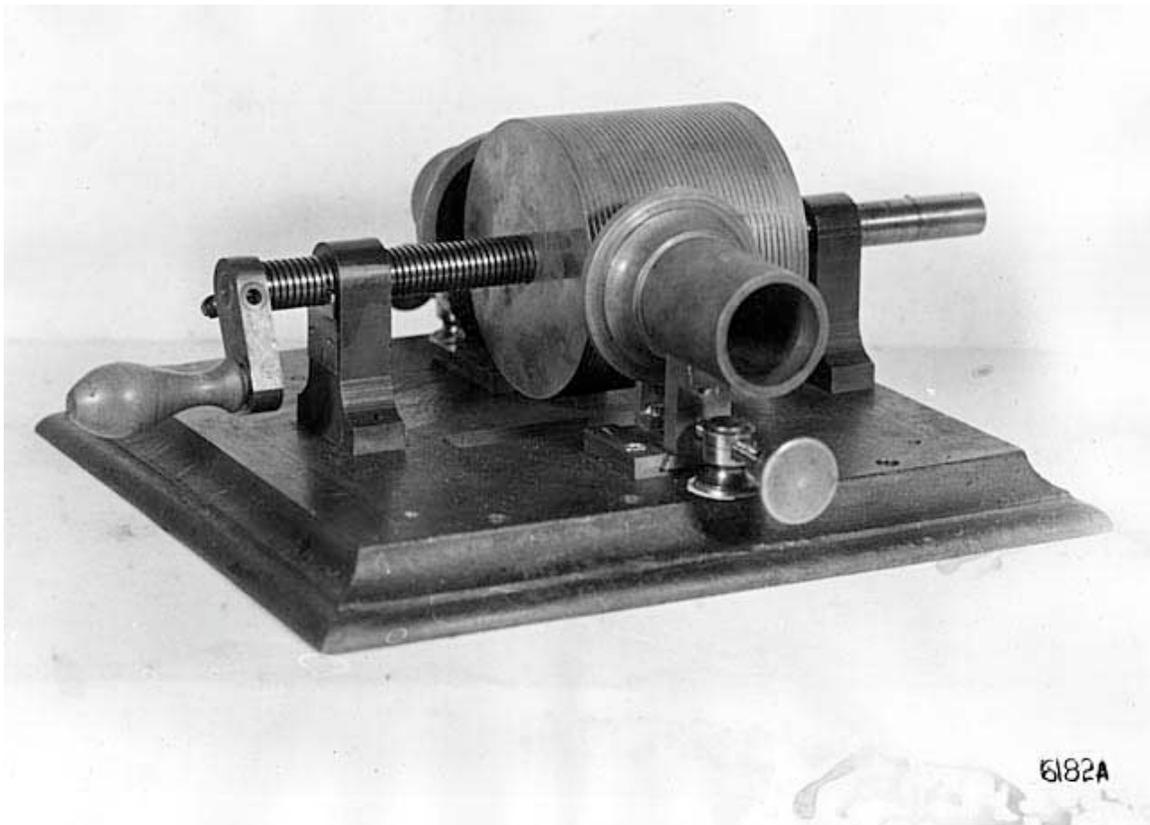
### 3.8. Recording Sonic Messages: Vertical Cuts in Tin

- 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



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- Produced a helical trace around the cylinder
- Original 1877 Edison model



Source: U.S. National Park Service

- A refined production model



Source: U.S. Library of Congress

- 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**

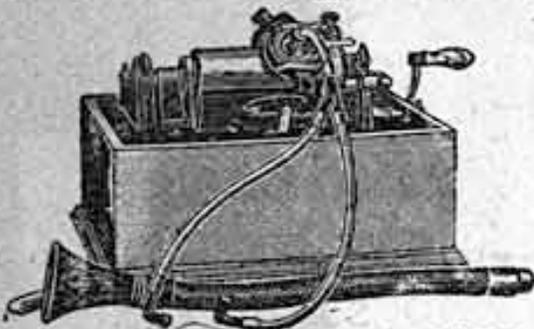
- Edison desired that the phonograph be used for business: “... I don't want the phonograph sold for amusement purposes, it is not a toy. I want it sold for business purposes only” (Brady 1999, p. 22).
- Wanted to lease machines to businesses
- Marketed applications included creating audio albums of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

# THE EDISON

## NEW STANDARD

### PHONOGRAPH.

PRICE \$20 COMPLETE



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

ALL GENUINE PHONOGRAPHS bear  
this signature:

TRADE  
*Thomas A Edison*  
MARK

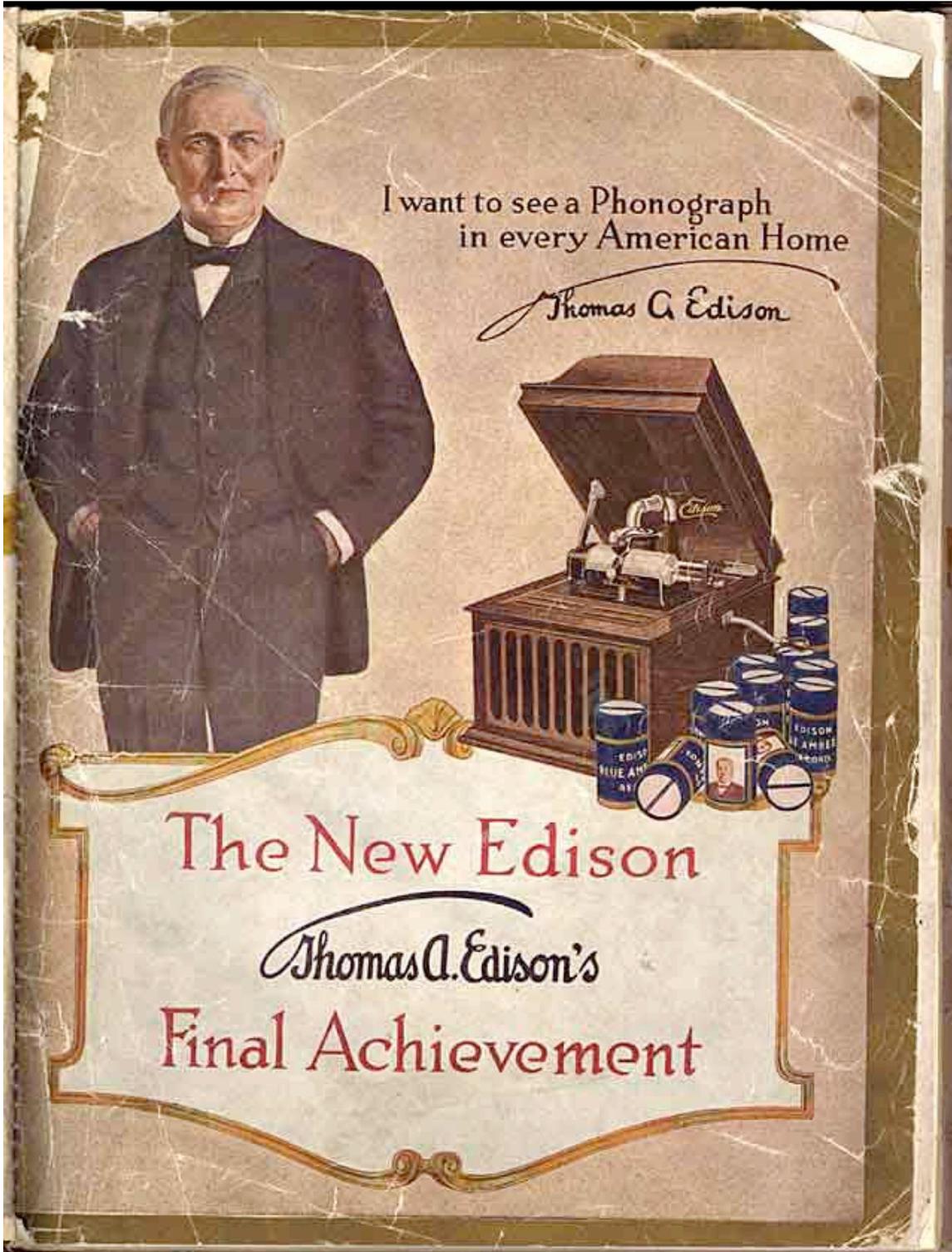
*Catalogue No. 3 free from the*

**NATIONAL PHONOGRAPH CO.,**  
St. James Building, Broadway & 26th St., New York.

Edison records 50 cents each, \$5.00 per dozen.

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

- Eventually accepts home use, but still not for music



Source: U.S. Library of Congress

### 3.12. A Spiral not a Helix: The Innovation of the Disc

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



Source: U.S. Library of Congress

- 1888: Emile Berliner publishes “Etching The Human Voice”

Copy from which I read the  
paper May 16/88.

The text was changed here and there for  
publication

THE GRAMOPHONE.

ETCHING THE HUMAN VOICE.

BY EMILE BERLINER.

in  
Journal of  
the F. I.

[To be read at the Stated Meeting, Wednesday, May 16, 1888.]

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.

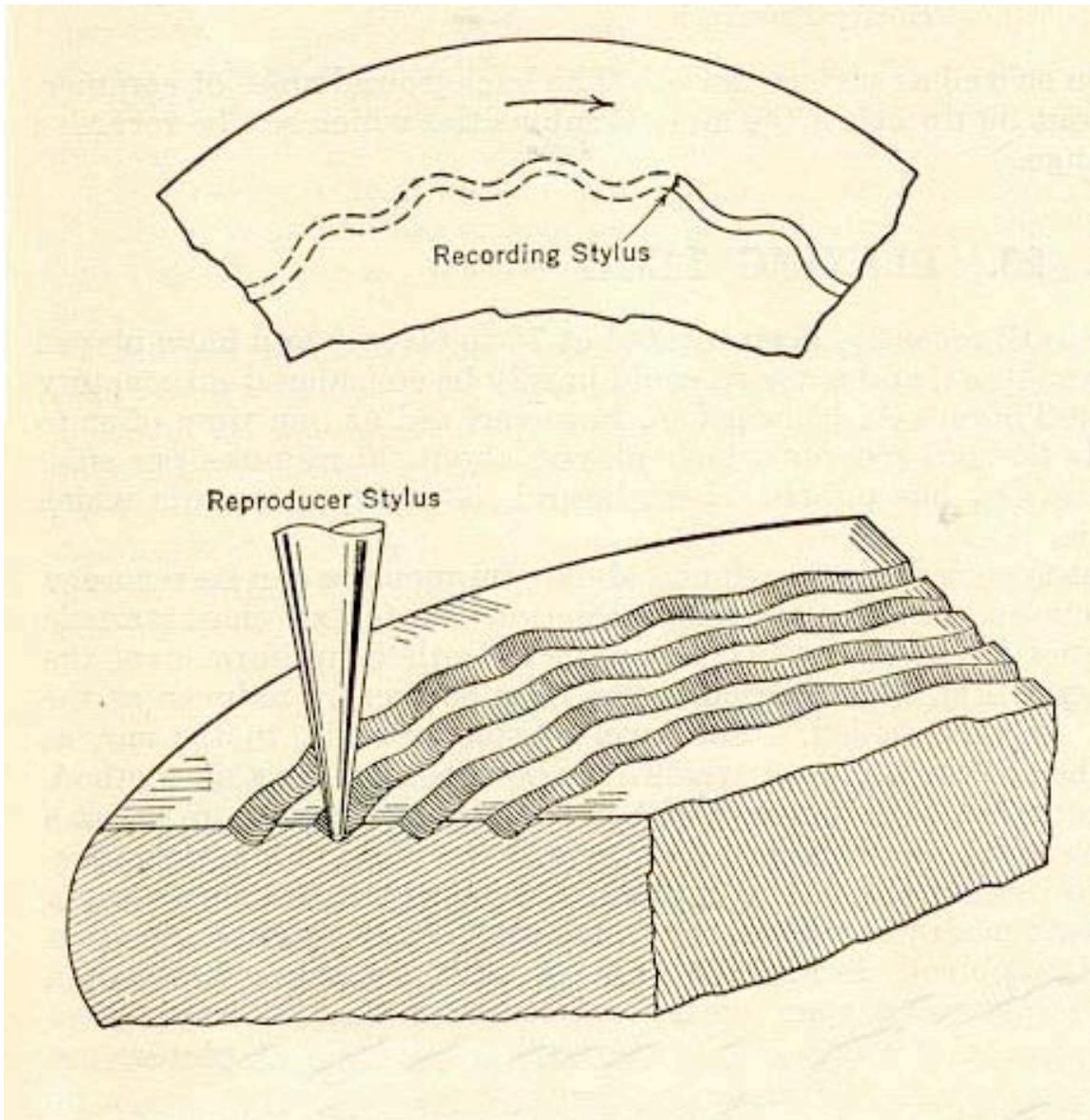
There appeared about that period something in the drift of scientific discussions, which, even to the mind of an observant amateur, foretold the coming of important events.

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*.

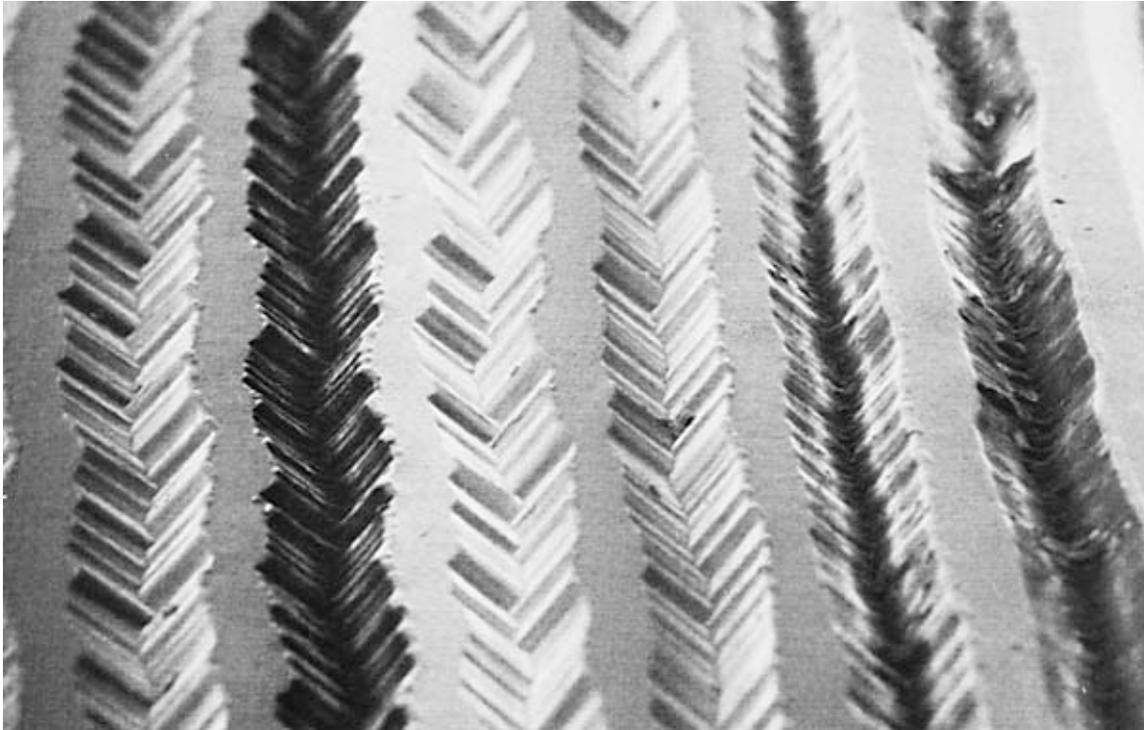
Add to this the general excitement prevailing on account of the forthcoming centennial celebration with its crowning event, so dear to this nation of inventors, the world's exhibition, and even those who did not at the time experience the effects of an atmosphere pregnant with scientific ozone, can, 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



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- 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

### **3.14. Recorded Sound: A Commercial Mascot**

- 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

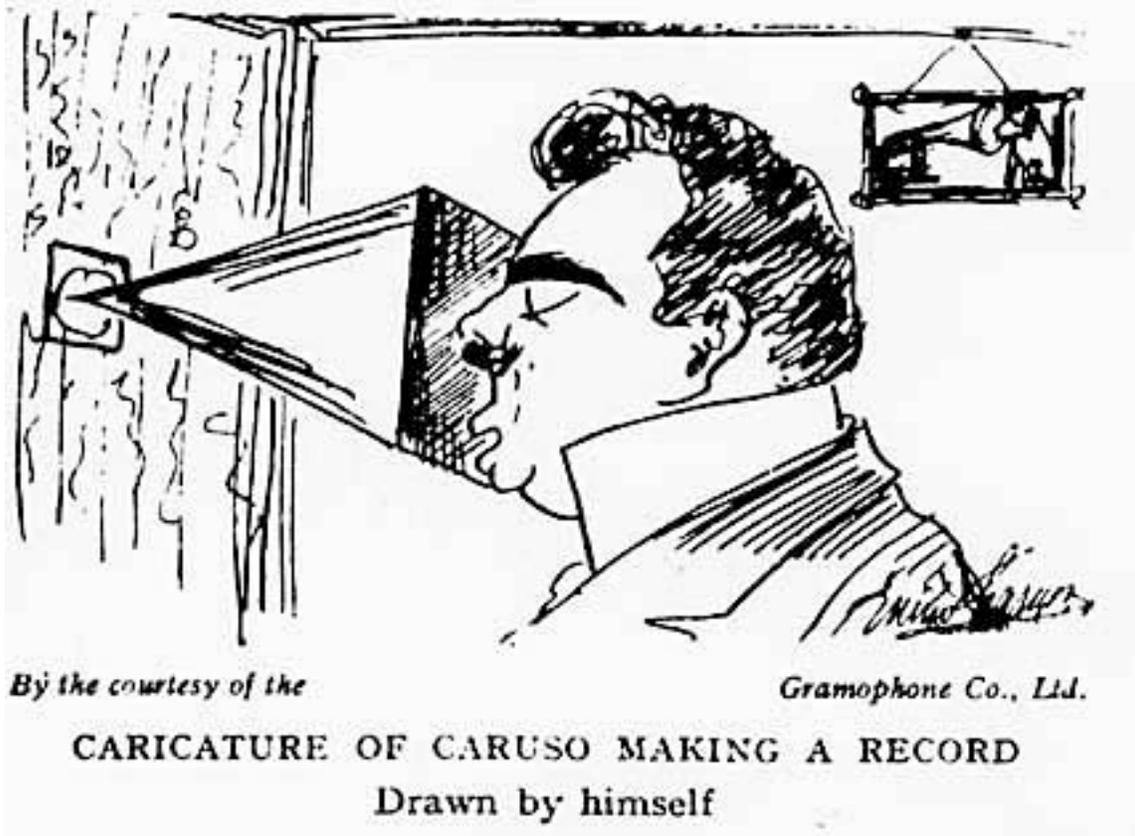
### **3.16. Analog Recording from 1890 to 1920s**

- 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



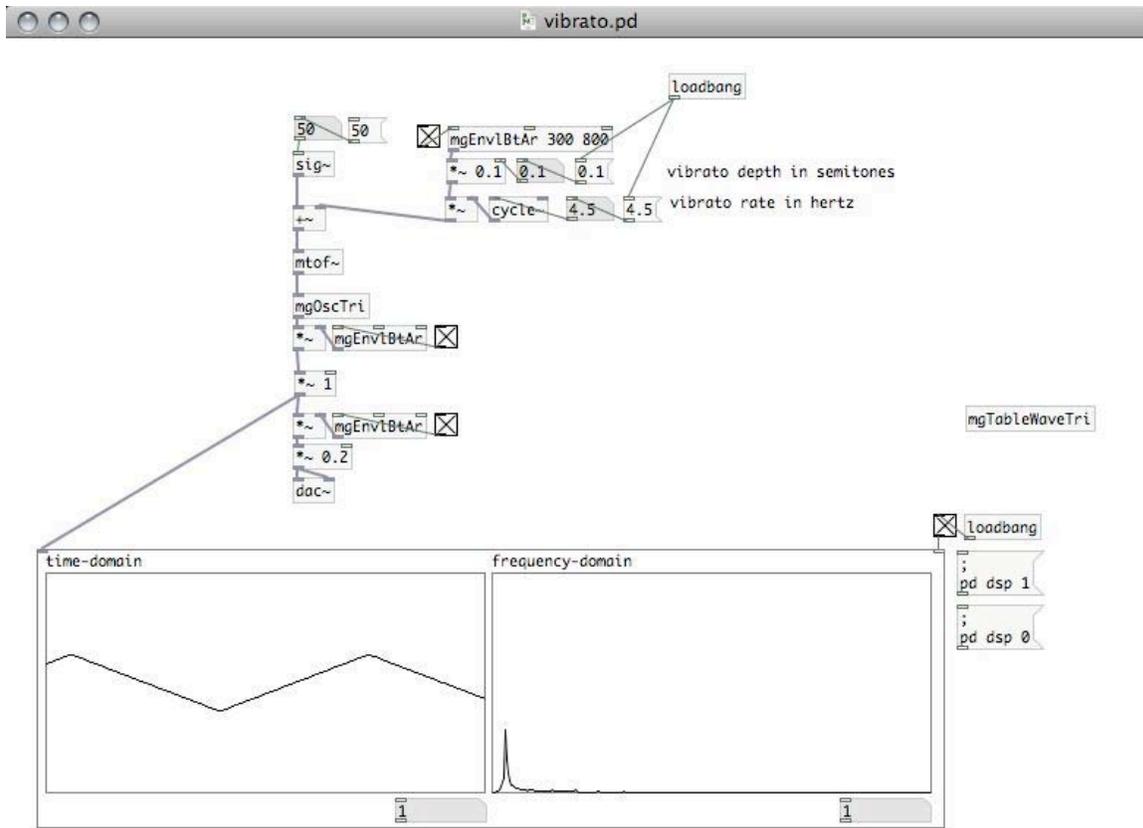
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- Personification and anthropomorphism: Talking Machines
- Technical issues
  - Record entire ensemble with one horn, mechanically
  - Some instruments and singers recorded better than others



### 3.17. Reading: Katz

- Katz, M. 2002. "Aesthetics out of Exigency: Violin Vibrato and the Phonograph." In *Music and Technology in the Twentieth Century*. H. Braun, ed. Baltimore: The Johns Hopkins University Press. 174-185.
- Vibrato [vibrato.pdf]



- 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
- 33.333333 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



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- 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-inch 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-inch, 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-inch 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 *surest* 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.



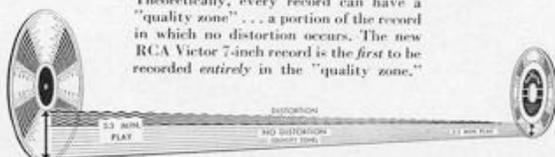
**Model 9-JY** • Now you can enjoy the advantages and savings of the new RCA Victor system at an unbelievably low cost. Model 9-JY can be easily attached to your present instrument, regardless of make or model. Even in this small attachment, surface noise is virtually eliminated. Plays up to 10 of the new records.



**Model 9-W-103** • A modern console featuring the new RCA Victor system. AM-FM radio, "Golden Throat" tone system. Storage for 24 albums or 189 singles. And new records fit ordinary bookshelves. Lovely walnut, mahogany or lined oak finish. A great achievement in styling, performance and price.



**Model 9-W-105** • A must for music lovers who already have collections of 10- and 12-inch records. Two changers, AM-FM radio, "Golden Throat" tone system. Plays standard 10- and 12-inch records as well as the low-cost, distortion-free 7-inch records. Ample record storage space in the lovely, Period cabinet.



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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

- Magoun, A. B. 2002. "The Origins of the 45-RPM Record at RCA Victor, 1939-1948." In *Music and Technology in the Twentieth Century*. H. Braun, ed. Baltimore: The Johns Hopkins University Press. 148-157.
- 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: Fritz Pfleumer (Germany)
  - Wire was difficult to record, cut, and splice
  - Cellulose acetate coated in iron oxide
  - Permitted splicing with adhesive tape
- How it works

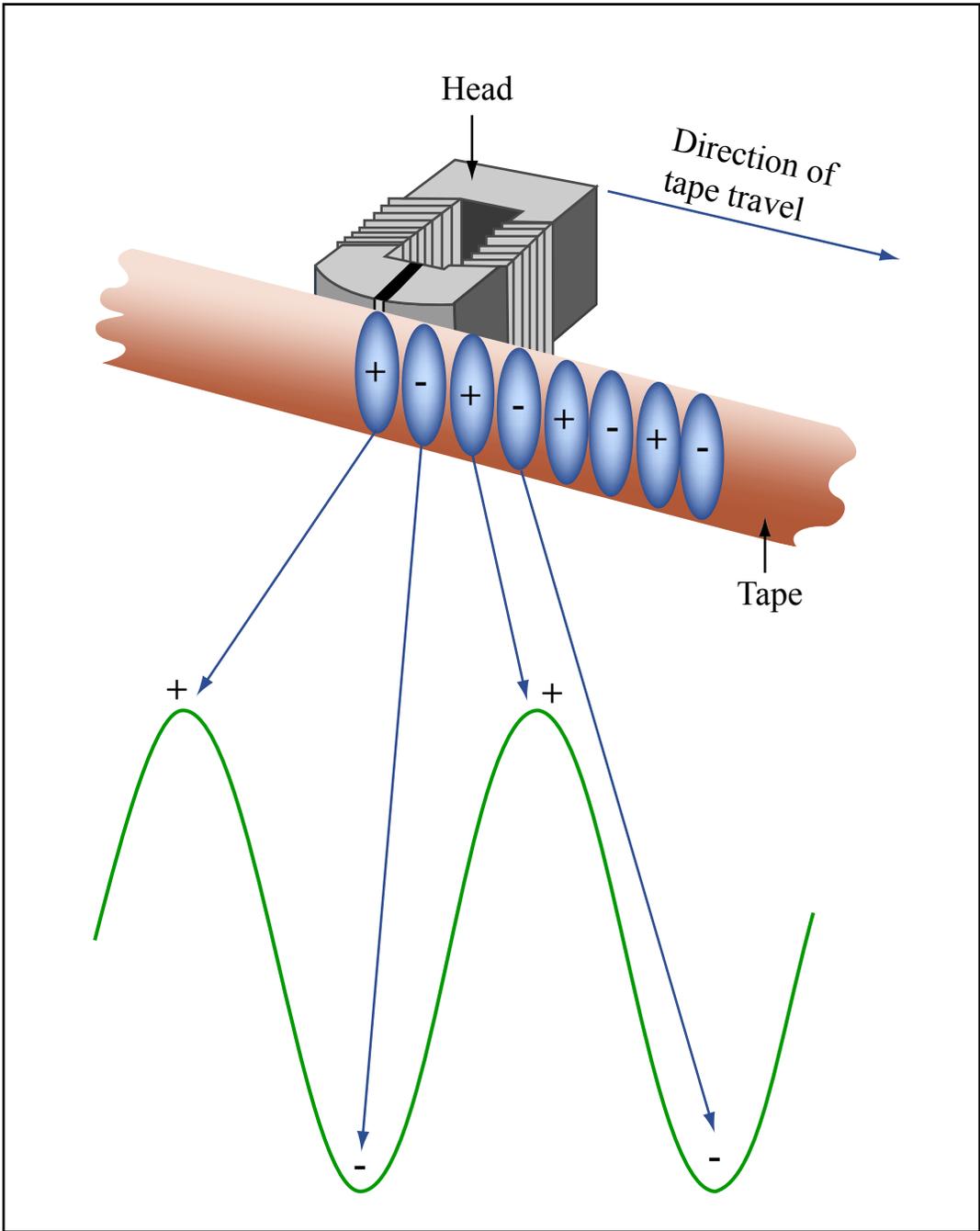


Figure by MIT OpenCourseWare.

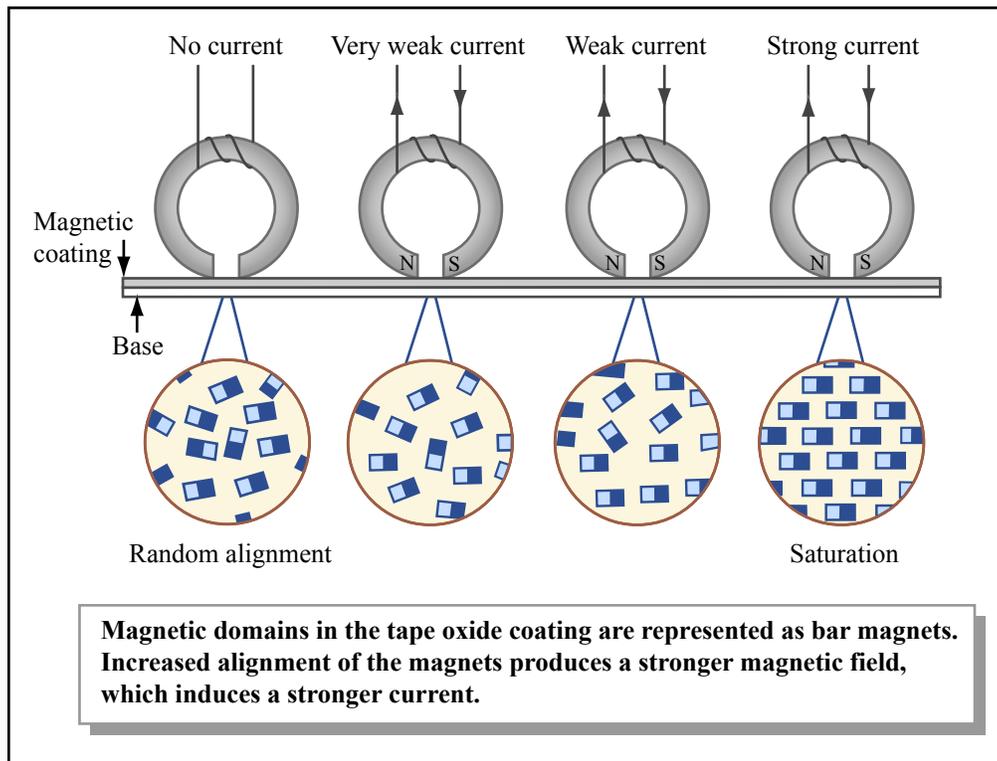


Figure by MIT OpenCourseWare.

### 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

*The BEST BUY in* **Recorders!**  
 Complete PUSH-BUTTON CONTROL

- CUT TAPE COSTS IN HALF
- OUTPERFORMS EVERYTHING IN ITS PRICE CLASS
- HIGHEST QUALITY & RESPONSE EVER BUILT INTO A PORTABLE

15,000 cps at 15 & 7½ inches per second

**AMPEX**  
 AMPEX ELECTRIC CORPORATION  
 Redwood City, California

*Advanced Series 400-A*  
 Write for Bulletin A-211

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**AMPEX**  
301

**The portable recorder  
you specified**

*now the famous  
Ampex portable fits your  
professional recording  
needs exactly*

**Low Impedance Output** . . . . .  
All lines, 150 volts, balanced or unbalanced, linear impedance or program level.

**Low Impedance Input** . . . . .  
accommodates high or low impedance microphones. Low impedance inputs are secured by necessary plug-in transformer.

**Instantaneous Starting** . . . . .  
controls to fully play within less than one-tenth of a second.

**Illuminating Record Safety Button** . . . . .  
prevents accidental erasure or accidental retrace.

**Saddle Tan Case** . . . . .  
Handcarried in case of rugged construction for extra portability and safety.

**HIGHEST QUALITY IN THE SMALLEST PACKAGE**

**Superb Fidelity** - Program recorded at 15,000 rpm, or 7 1/2 in/sec. Down to speed for 4 cps at 15,000 - 5 cps down at 10,000. Speed-tape ratio over 55 db. Filter and equalizer. 30 db E.P.P. 1 Separate magnetic tape playback heads.

**Accurate Timing** - Precision motor drive. Timing accuracy within 20 microseconds in 30 second playback.

**Accurate Detection** - Double auto bias. "Loop search" if missing. Large scale meter measures program level. Control is automatic when record is played back.

**Dependable Service** - This portable has been tested in equivalent of more than 10 years of normal broadcasting usage. "Field" availability for maintenance.

The 301 really fits in - it's the smallest portable performance for its size and weight. It's the professional choice for mobile work.

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- Tape permitted multitrack recording
- Pioneered by Les Paul, developed as early as 1954

### 3.26. Analog Audio Multitracks: Les Paul

- 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 reproduction methods and "AMPEXED TAPE" has the greatest fidelity and range now possible. Simplified operation plus sure results make AMPEX unexcelled for all critical recording uses. Dual tape speeds with automatic speed and equalization change is but one of many exclusive AMPEX features.

*Unequaled for*

**TELEMETERING • BROADCASTING • RESEARCH**

# AMPEX

**STANDARD OF  
THE GREAT  
RADIO SHOWS**

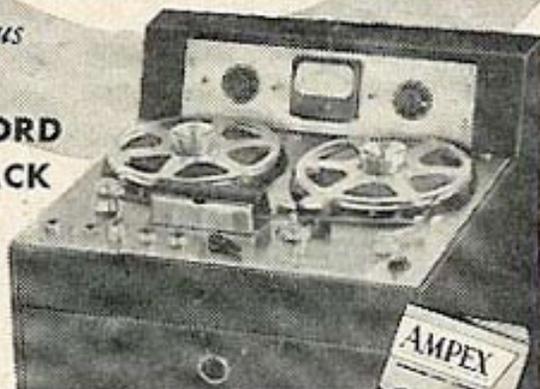
*Simultaneous*

- 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 Ampeg Magnetic Tape Recorders.*

NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_

CITY \_\_\_\_\_ STATE \_\_\_\_\_

**Our need is for:**

- |  |  |
|--|--|
| <input type="checkbox"/> Laboratory Research     | <input type="checkbox"/> Telemetry             |
| <input type="checkbox"/> Multi-Channel Recording | <input type="checkbox"/> Industrial Recording  |
| <input type="checkbox"/> Recording-Broadcasting  | <input type="checkbox"/> Aerophysical Research |

**AMPEX ELECTRIC CORPORATION**  
SAN CARLOS, CALIFORNIA  
**DEALERS IN PRINCIPAL CITIES**

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- 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)

**HOME TAPING IS  
KILLING MUSIC**



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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**

- Collins, N. 2009. *Handmade Electronic Music: The Art of Hardware Hacking*. 2nd ed. New York: Routledge.
- 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



Source: [Wikipedia](#)

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

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21M.380 Music and Technology (Contemporary History and Aesthetics)  
Fall 2009

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