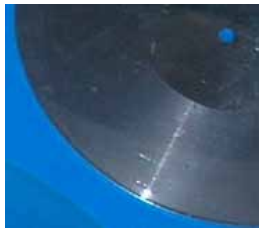




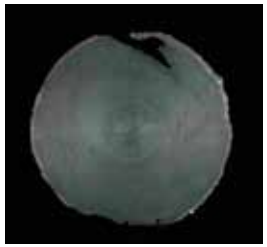
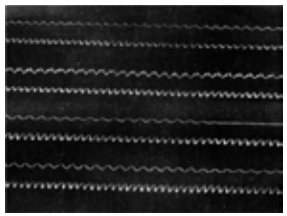
Optical Scanning Applied to Recorded Sound Preservation and Access


Carl Haber

Lawrence Berkeley National Lab






Collaboration and Support

Lawrence Berkeley National Lab
The Library of Congress
The Smithsonian Institution
Univ. of Appl. Sciences, Fribourg, Switzerland

INSTITUTE of Museum and Library SERVICES

Smithsonian Institution

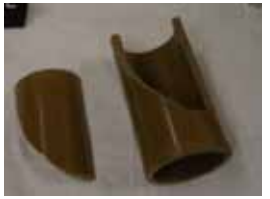
THE ANDREW W. MELLON FOUNDATION

John Simon Guggenheim Memorial Foundation
Fellowships to Assist Research and Artistic Creation

The 1st 90 years of sound recording is dominated by mechanical carriers.

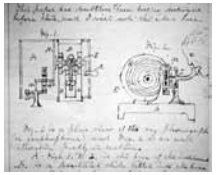
~10 million grooved recordings in US collections (x 2 worldwide?)

Some of the media are in delicate or damaged condition, the formats are diverse, and in some cases obsolete.



The development is rich in heroic invention and innovation.

- Scott 1860 Phonautograph
- Edison 1877 Tin foil
- Bell early 1880's Wax, light
- Berliner late 1880's commercial disc



- Technology
- Ethnography
- Folk culture
- The Arts
- Politics

The collections capture a broad sweep of history.

Non-Contact Restoration of Sound Recordings

•Apply modern optical measurements techniques, data acquisition, control, and processing to the goal of digitizing sound recordings non-invasively and generally.

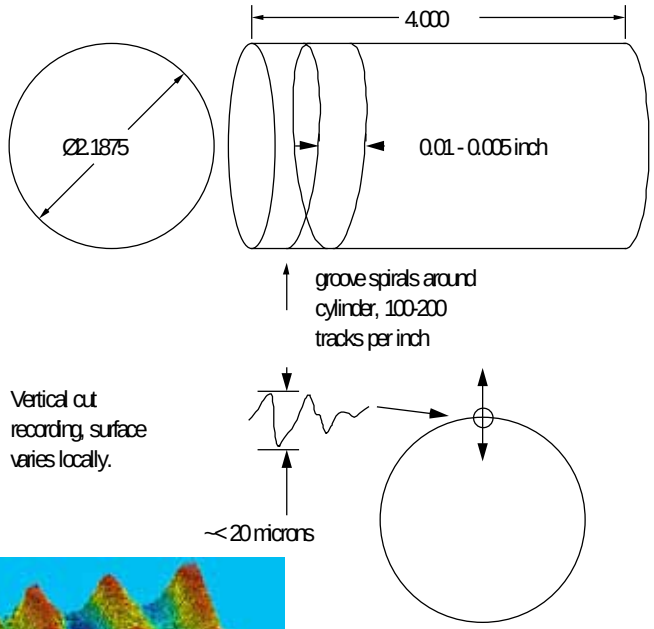
- Preservation: restore or stabilize delicate or damaged media
- Access: mass digitization of diverse media, automation
- Condition assessment
- Obsolete and historic formats and legacy playback systems

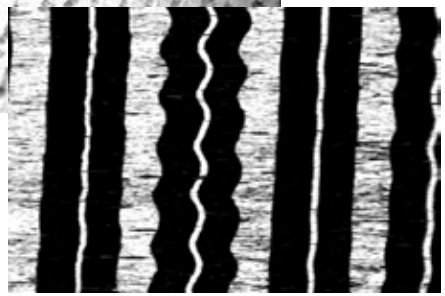
- Many technical demonstrations and developments with a variety of media
- Through collaboration with major collections attempt to bring this technology into broad application.
- Have now restored many early experimental, ethnographic, and commercial sound recordings using this approach.

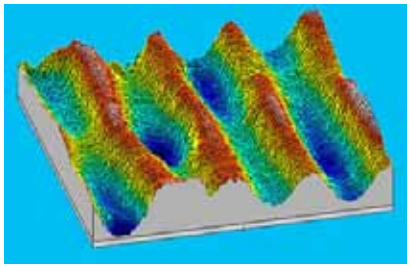
Mechanical Recording Principles

Cylinder: groove varies in depth (Vertical Cut)

Disc: groove moves from side to side (Lateral Cut)



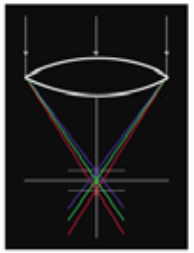


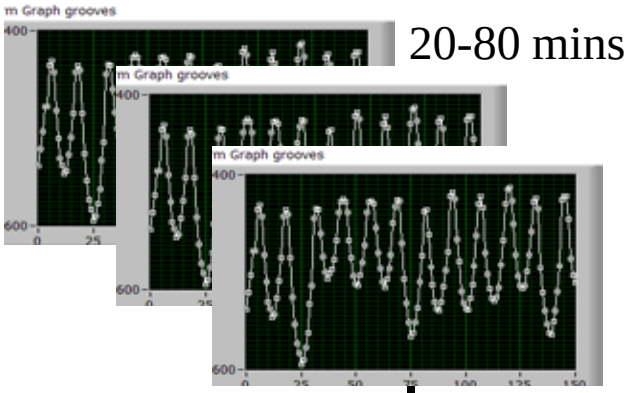


Audio is encoded in micron scale features which are >100 meters long

Basic Optical Process

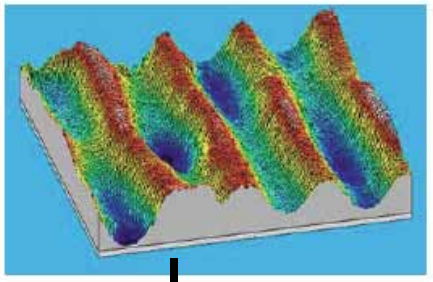
High resolution optical probe…creates a series of depth/intensity profiles of the surface





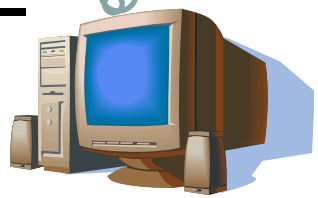
20-80 mins

These are merged into a surface map

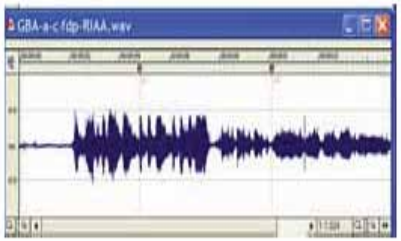


Map is archived

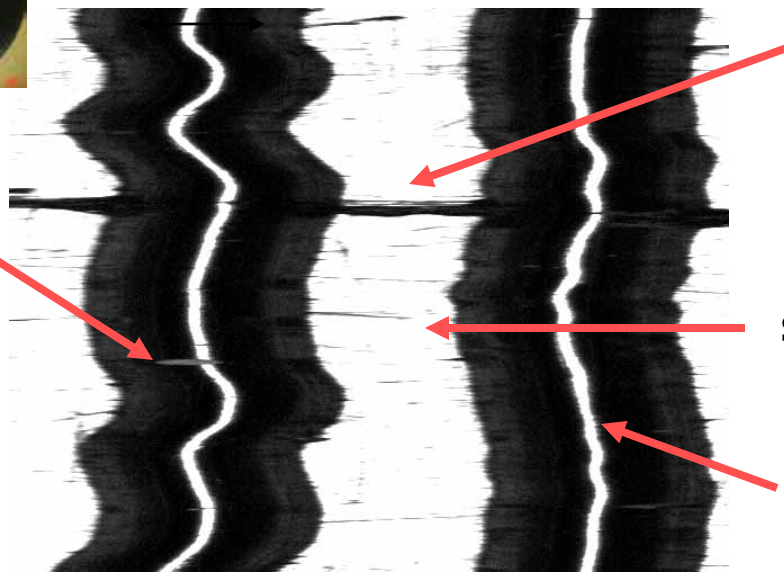
Calculate the motion of a virtual needle, apply optional restoration

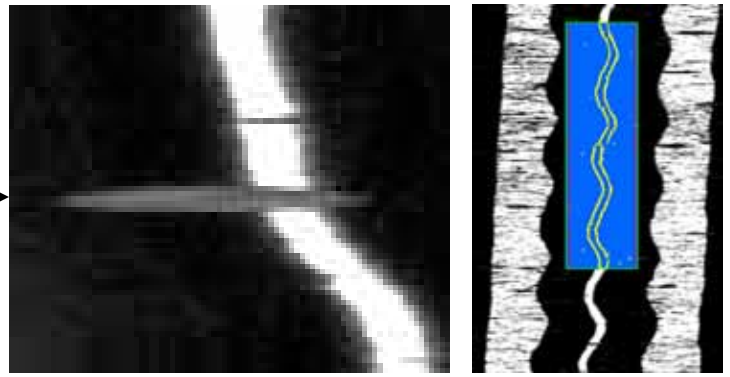


Create audio waveform

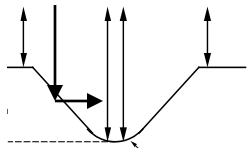


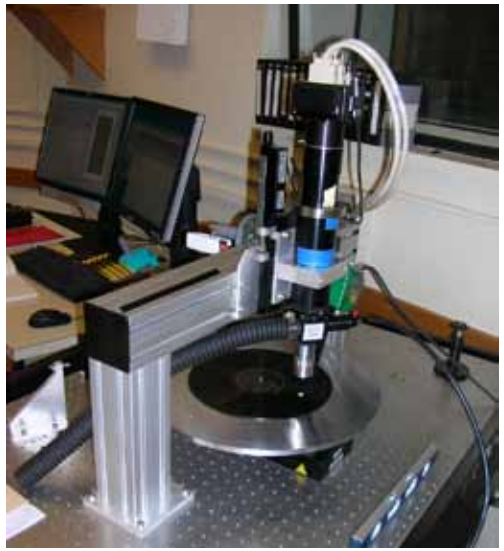
2D Imaging: Line Scan Camera “IRENE”





Coaxial illumination



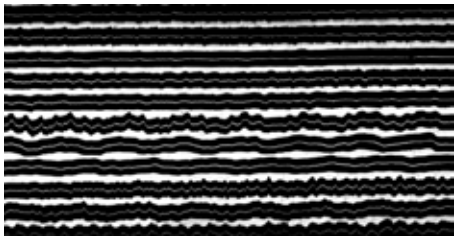


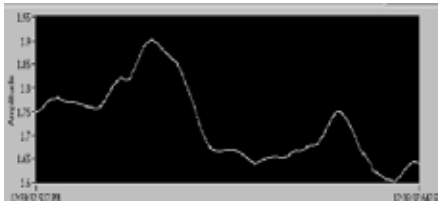
“IRENE”

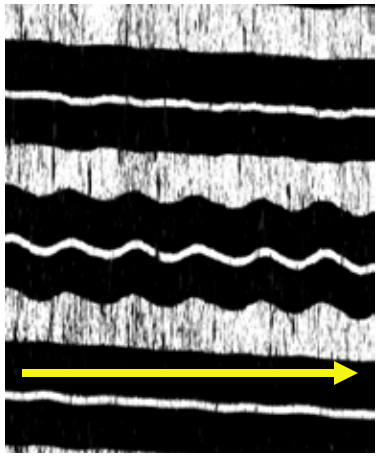
- Suitable for disc with lateral groove
- Require 1 pixel = ~ 1 micron on the disc surface
- High resolution = narrow depth of field, 10 – 20 microns
- High speed cameras allow near “real-time” imaging
- Extract groove information from high contrast edge transitions

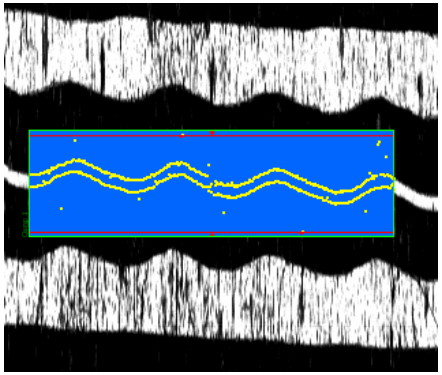
I.R.E.N.E

Line scan



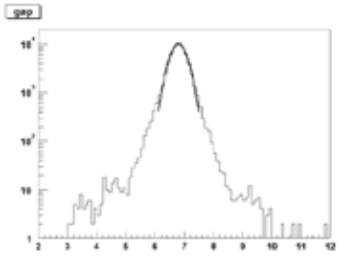




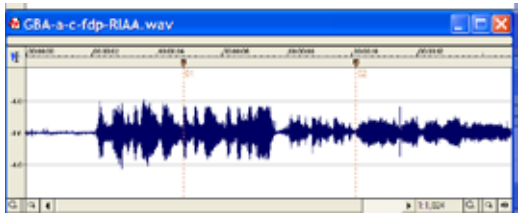


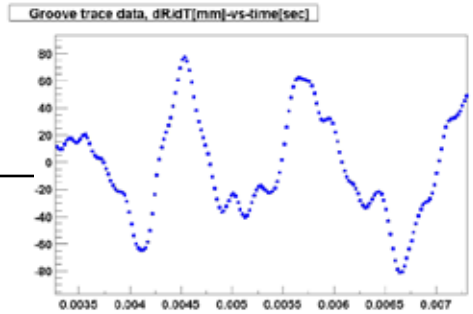
Time
Pixels = 104 KHz

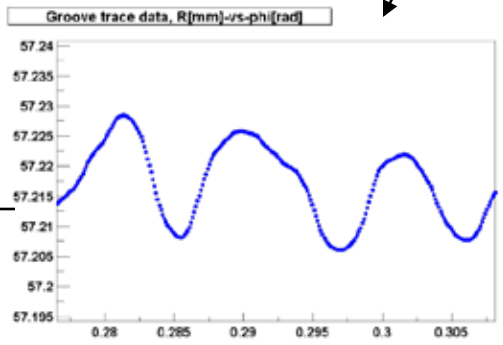
Width across
groove bottom



Measure slope
at each point
(stylus velocity)



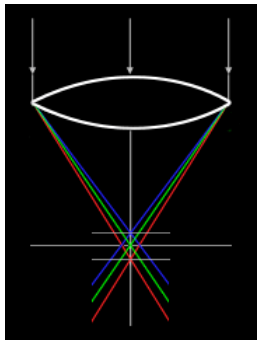


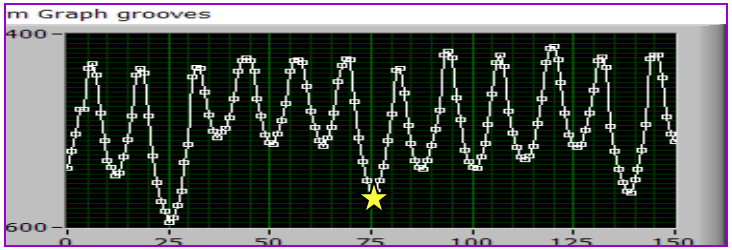


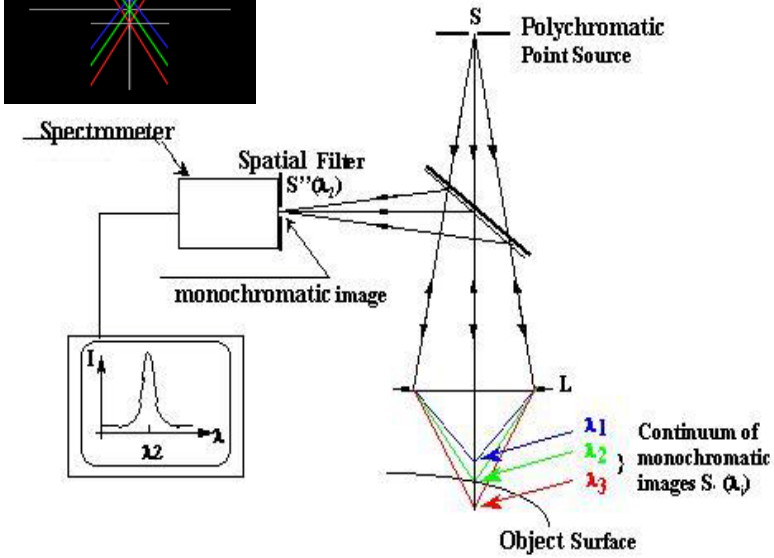
Average
Filter using width cut

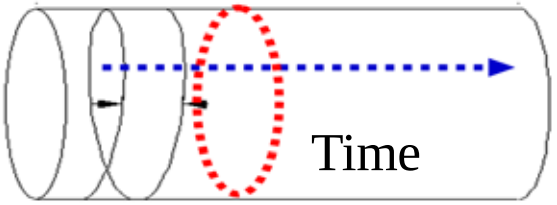
3D Imaging: Confocal Scanning Probe

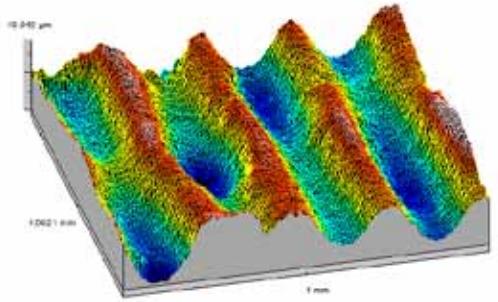
Required for cylinder with vertical groove modulation.









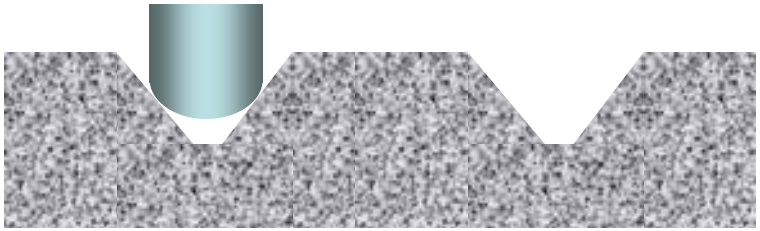


Collects 180 point line at up to 1.8 KHz/line scan time ~ 30 minutes

Redundancy

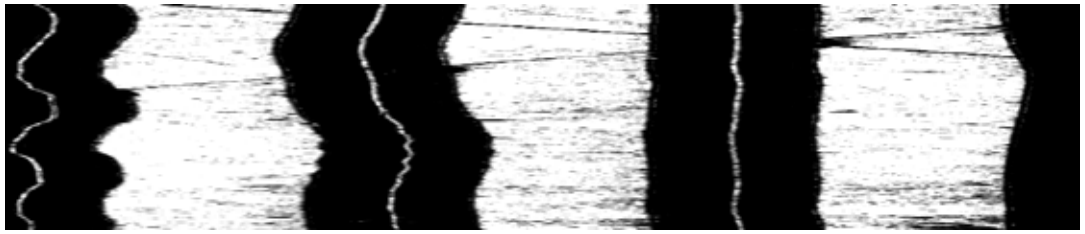
Audio stored in entire profile, signal averaging

Stylus



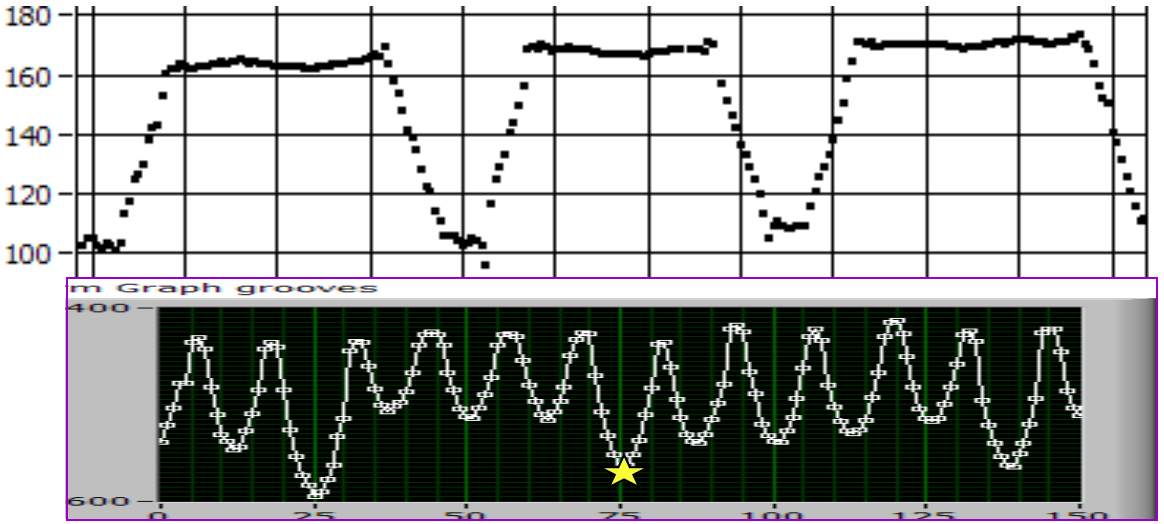
Stylus comes into contact at 2 points

2D



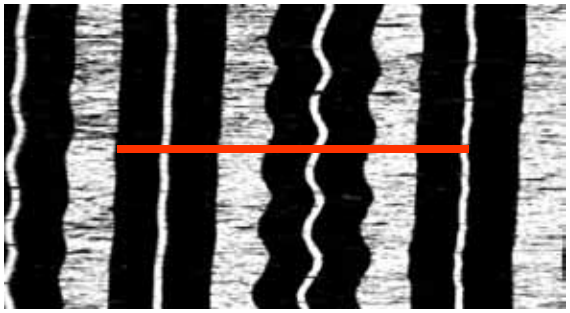
Measure the groove bottom with 2 points/slice

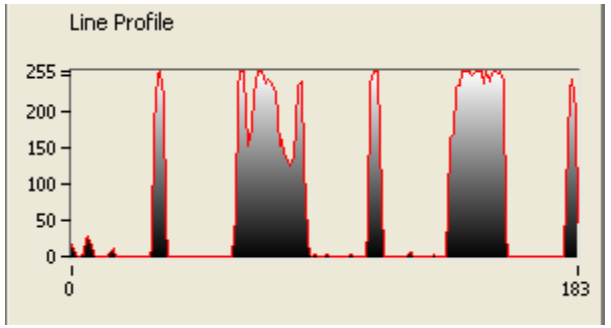
3D

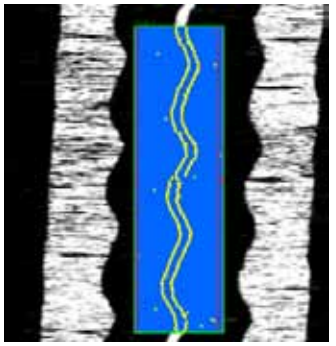


Measure the entire groove with ~30 points/slice

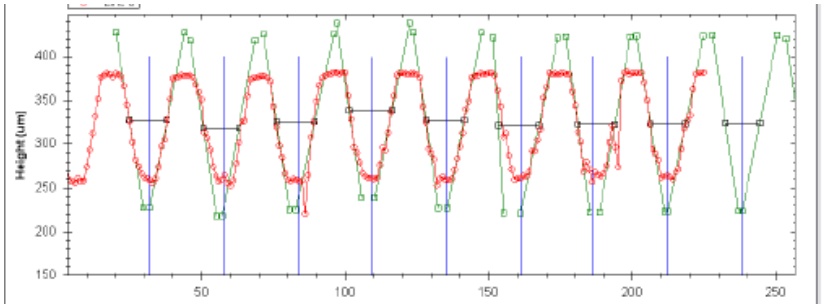
Image Analysis

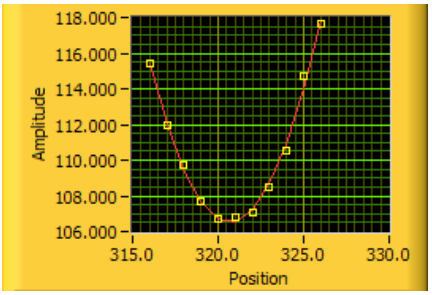






Edge detection





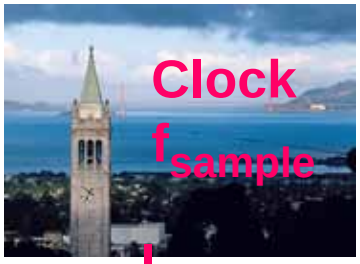
Surface parameterized by functions

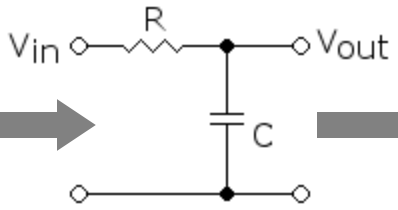
- Feature extraction and measurement
  - Importance of characteristics and algorithms
  - Control of data quality: DOF, focus, intensity, bad points
- Measured characteristics of features provide a natural noise detection and removal tool

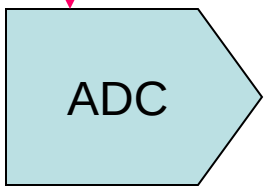
Digitization

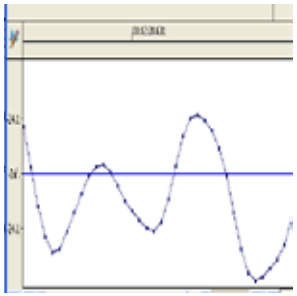
Analog waveform

Low-pass filter
$f_0 < f_{sample}/2$

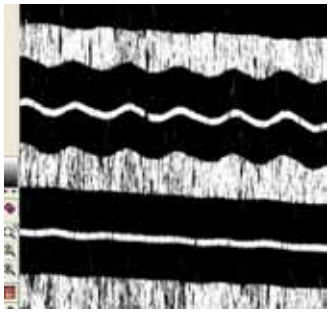








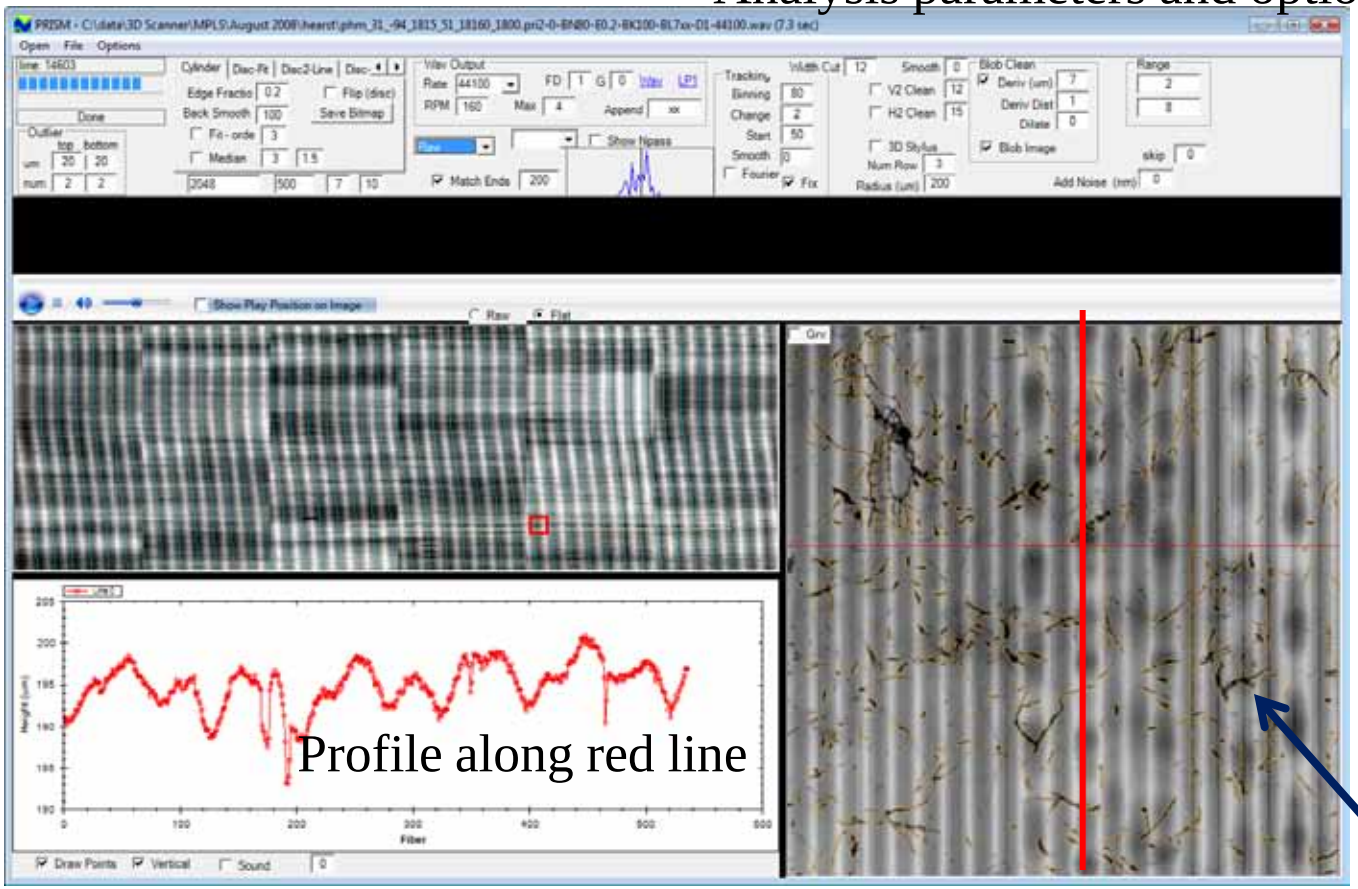
Commercial CD: 16 bits, 44.1 KHz
Archive spec: 24 bits, 96 KHz



Pixel: 100-400 KHz

Analysis Software Example

Analysis parameters and options



Overview of full data set

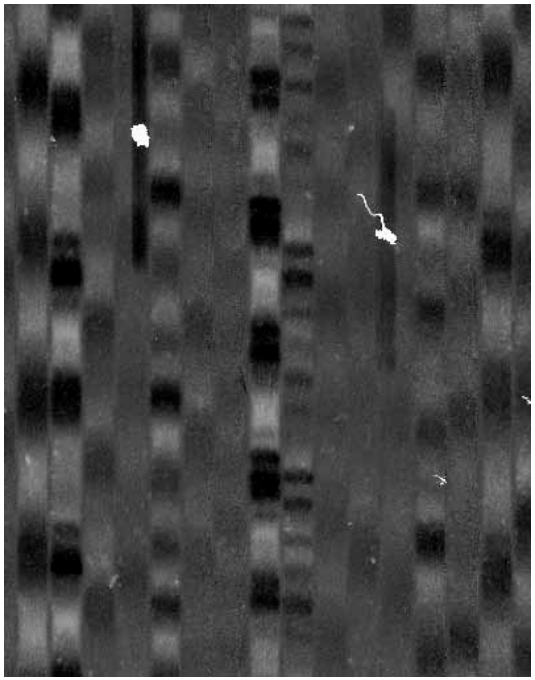
Zoomed in view

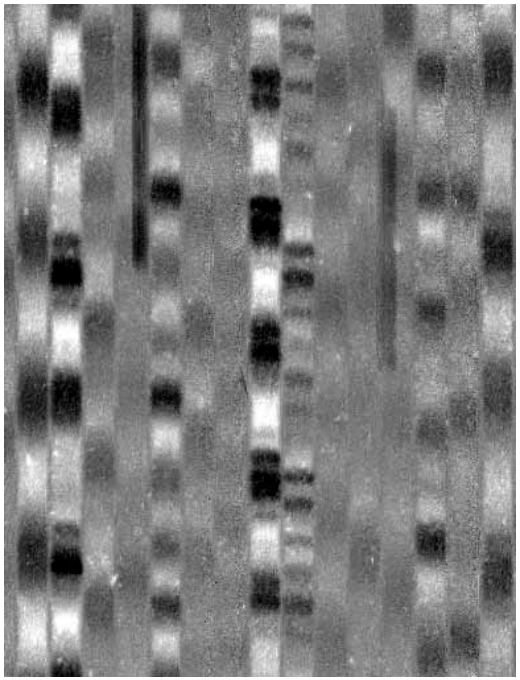
Depth image, black is deepest

Surface damage

The analysis packages “PRISM” and “RENE” include powerful tools and options for access to data and image processing to remove defects and damage.

Example of Dust Removal



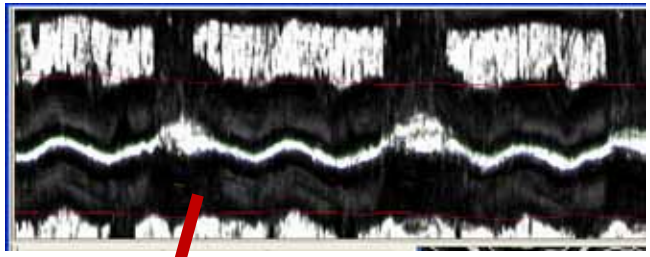


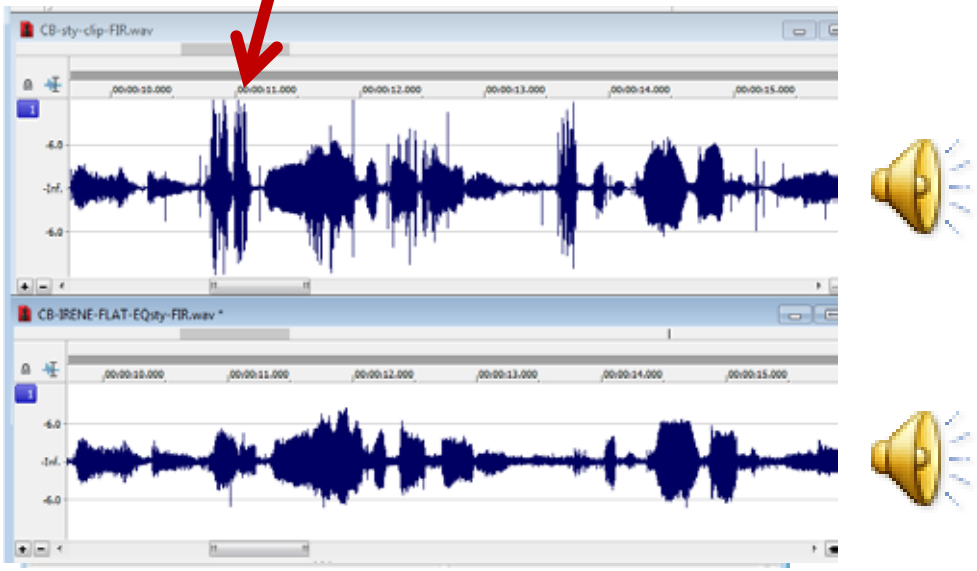
Dust particles appear WHITE because they are above the surface

Examples of Distortion Recovery

Chattanooga Blues, Ida Cox, 1923, Paramount 12063

Acoustic recording, heavily worn, cracked,
with significant stylus damage and distortion





Double Check Stomp

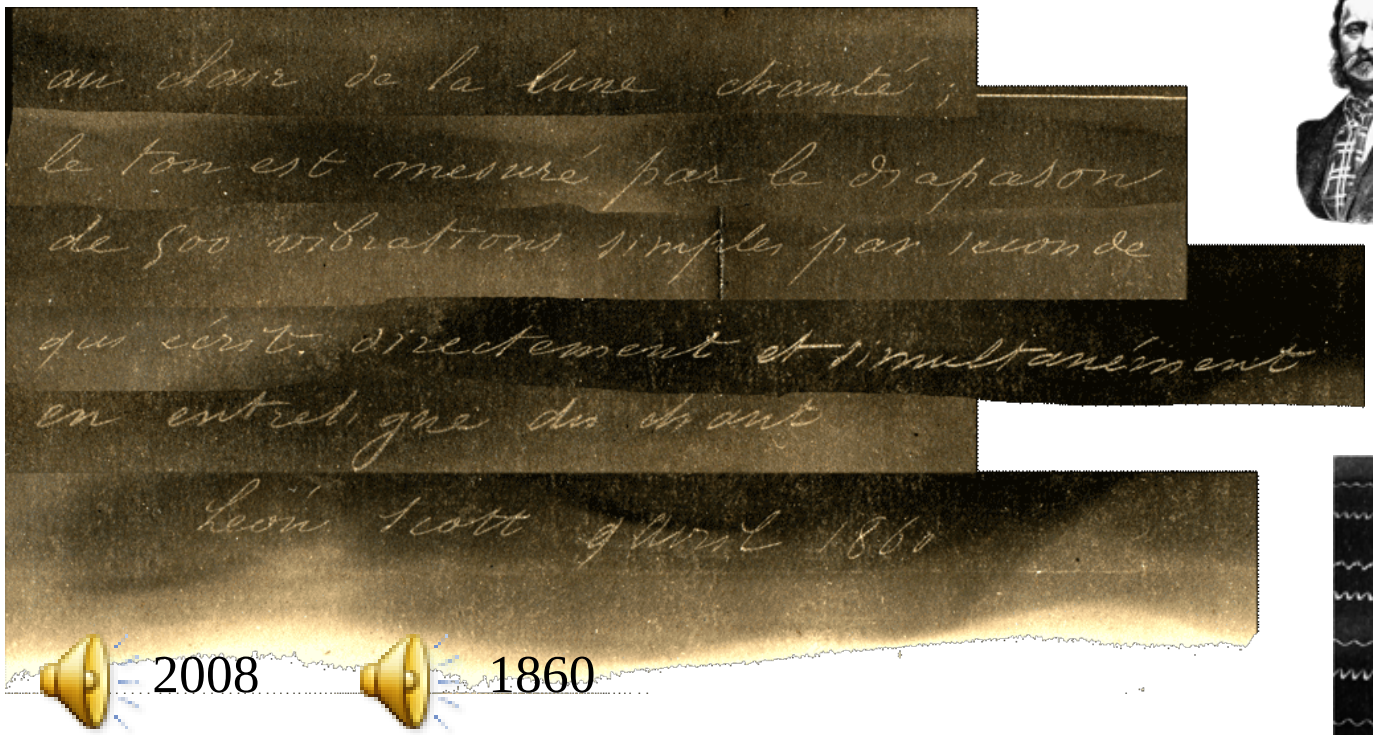
Duke Ellington, 1930

Comparison: Shellac disc in good condition, disc cleaned before stylus transfer, IRENE transfer before cleaning

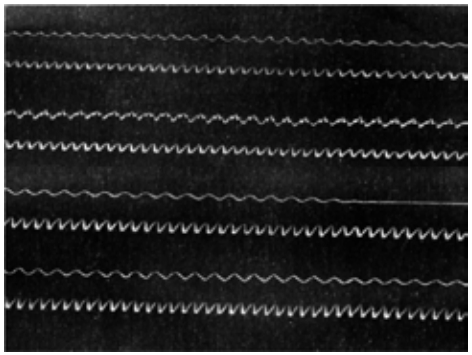
Stylus, optimized, cleaned

IRENE
Not cleaned

In 1860, French inventor Edourd Leon Scott records sound on paper traces.
Scott's original tracings were located, digitized, and processed as 2D optical scans

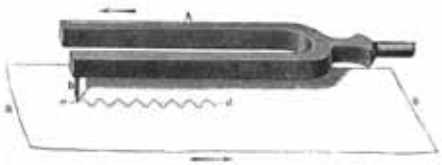


17 years
Before
Edison



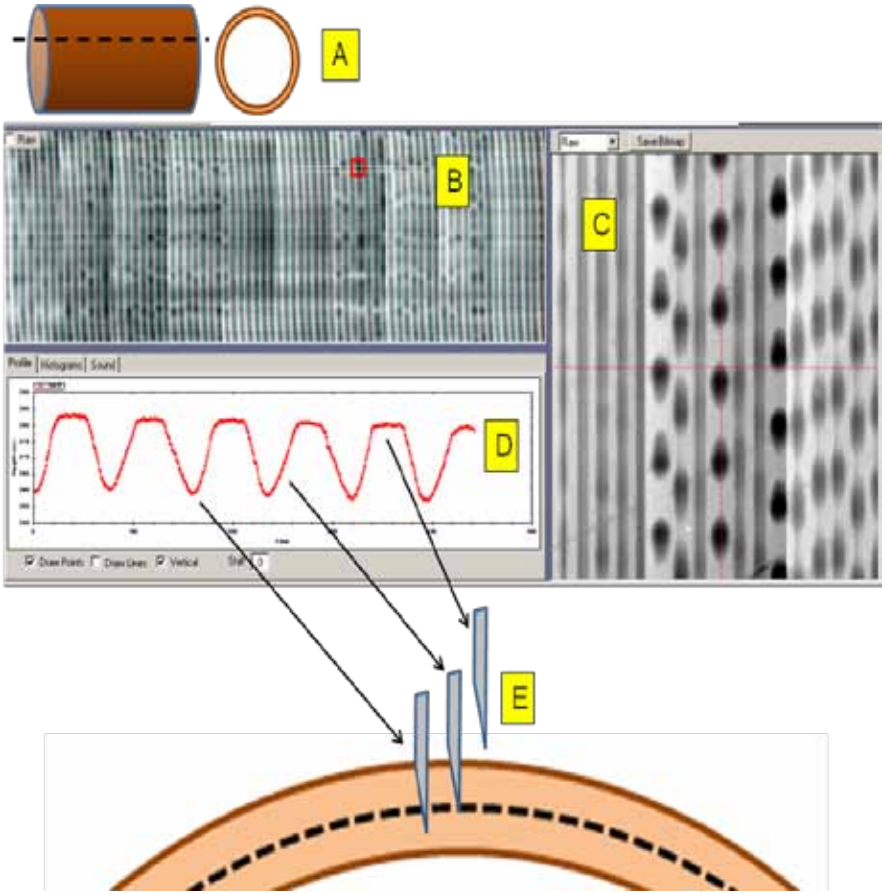
"Au Clair de la Lune" ["By the Light of the Moon"] sung;
"…the pitch is measured by the tuning fork of 500 simple vibrations per second which writes directly and simultaneously in interlinear space of the song"

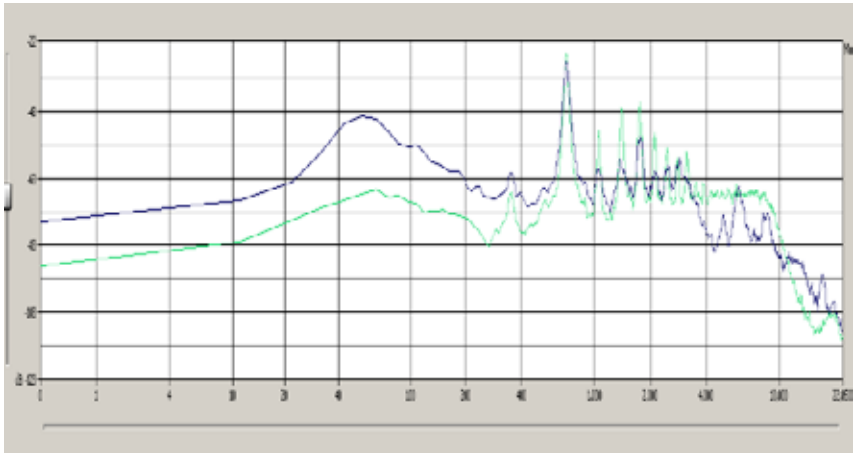
(French Patent Office)



Léon Scott 9 April 1860

F.Boas,1930, Vancouver Is.; Distortion Effect





Stylus version (black)

3D version (blue)

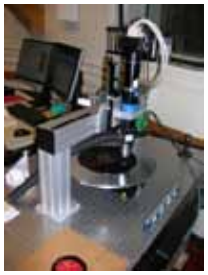
Since optical scanning is free from the real-time dynamic effects inherent in stylus playback certain types of distortion can be reduced

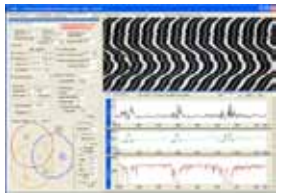
U. of Indiana, ATM

Projects and Collaboration

- Concept was tested 2002-2003 leading to interest and support from the Library of Congress and others.
- IRENE: a fast 2D scanner, installed at LC in 2006 (NEH)
- 3D: a fast 3D scanner for cylinders and discs 2008-9 (IMLS)
  - Preservation and restoration of early and damaged recordings
- Connecting to Collections: 2010-12 (IMLS)
  - Migration of technology into use at multiple collection sites
    - Evaluate a production scale system at the Library of Congress
    - Construct a “portable” version for R.Muthiah Library, Chennai, India
  - Special Studies: extend and advance tool set
    - Early experimental recordings: Smithsonian NMAH
    - Damaged broken, unplayable, or rare recordings: Edison NHS, Univ. of Applied Science, Fribourg, Switzerland, Al discs
    - Wax field recorded and dictation cylinders: Phoebe Hearst Museum
    - Cylinder molds and disc stampers: Berlin Phonogramm Archive

Production Scale System at LC Packard Campus
600 sides scanned in late 2011 and 2012





IRE #

Condition data

Warped?

in/out?

autoPOS'N

autoFOCUS

Image quality

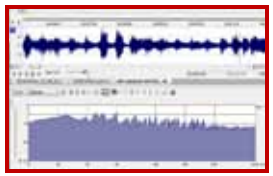
Scan

RENE

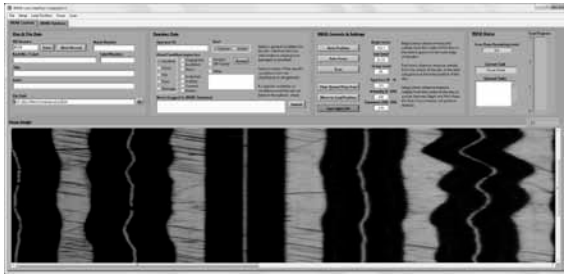
New images?

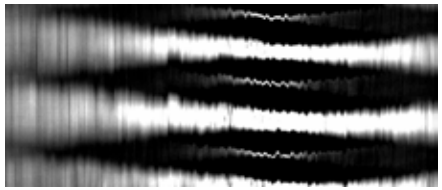
Process

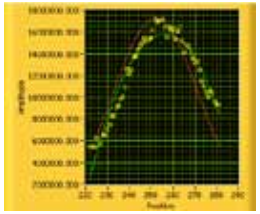
Resample



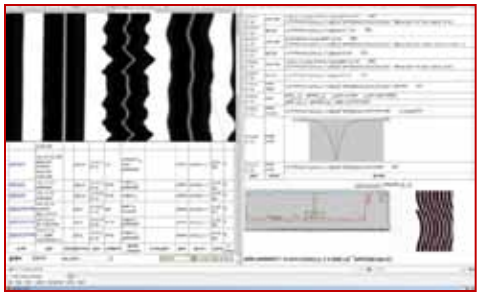
WAV







Results database



IRENE User Interface for Production Scanning

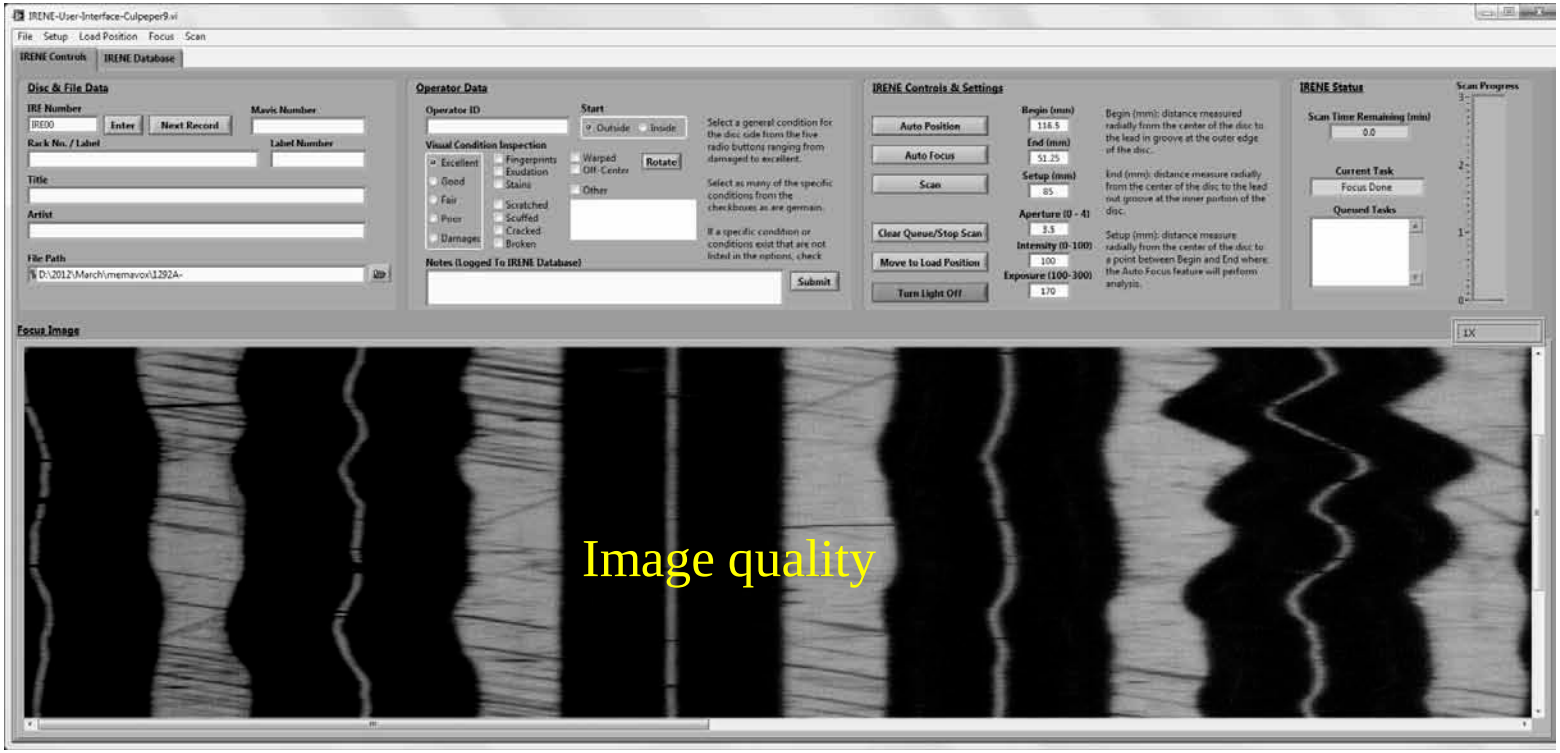
- Developed in collaboration with the Library of Congress
- 3rd generation run control interface for 2D disc scanning

Disc data entry
Links automatically to database and index file

Operator quality and comments entry

Minimal run commands and settings

Scan status, progress bar, and task queue



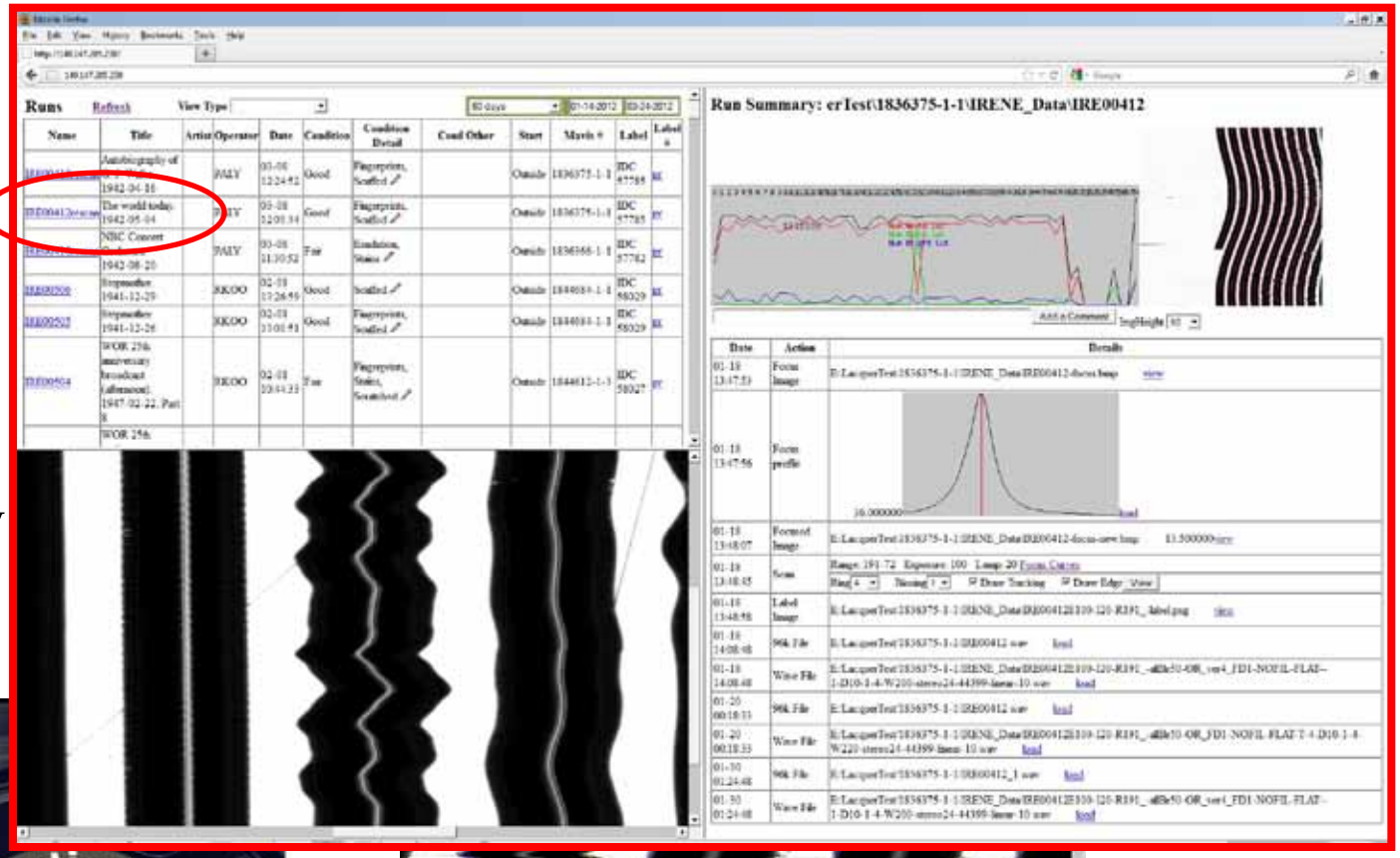
IRENE Database for Production Scanning

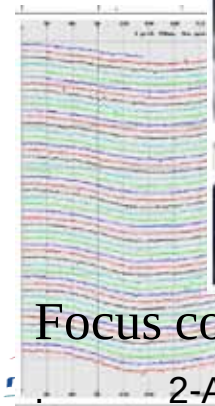
IRE00412
The World Today
1942-05-94

Audio

Initial focus quality

Label shot





Focus control

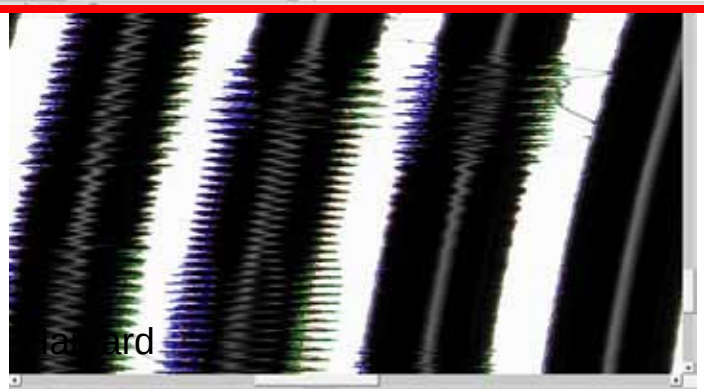
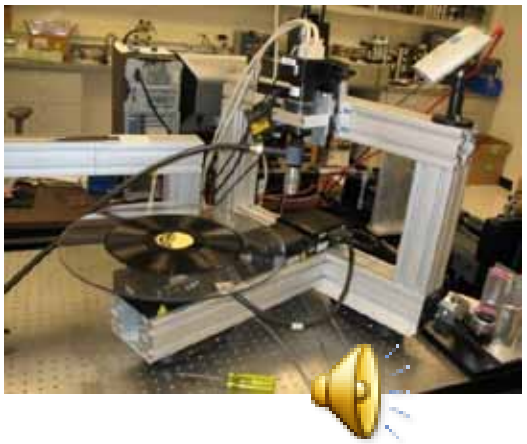


Image analysis

Portable System

- Native scanning system utilizes heavy vibration isolation, various expensive components.
- A more portable, less expensive variation is attractive for a variety of needs.
- Target was R.Muthiah Research Library, Chennai, through U. of Chicago South Asia Library collaboration (large early 20th Century disc collection)
- Evaluated a large variety of technical options, complete redesign of isolation which resulted in an improved isolation for the 2D scanner
- Software and control tightly coupled to Culpeper project



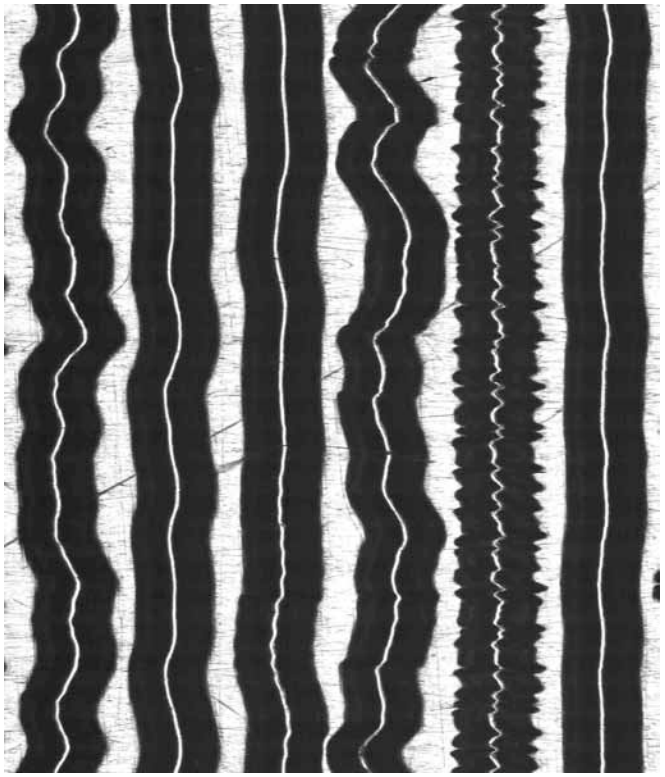
Aluminum Discs

- The use of Aluminum discs for sound recording began in the 1930's.
- Grooves were engraved or embossed in the soft metal
- Grooves were typically very shallow as compared with shellac or lacquer
- They were meant to be played back with "fiber" stylus so as to not score or damage the surface

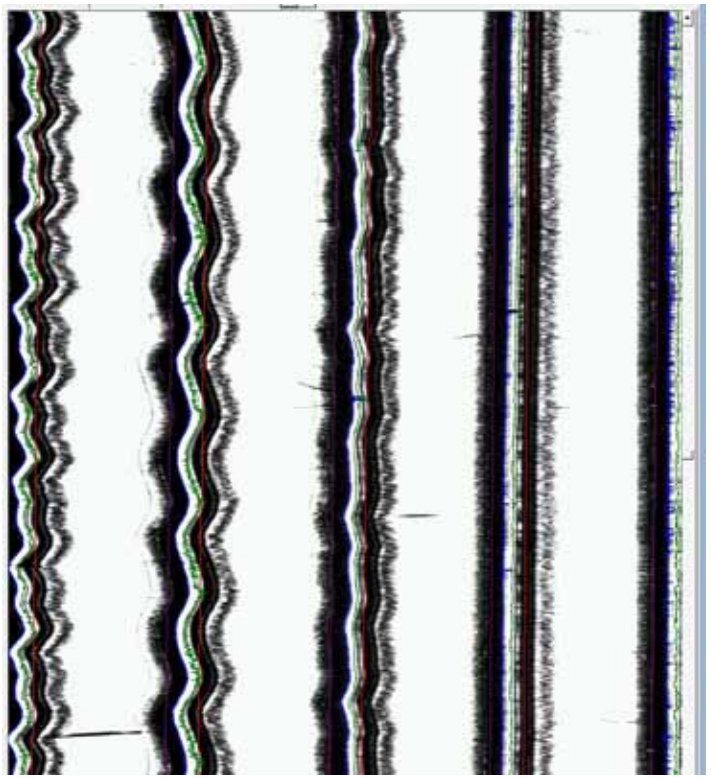
Optical Scans of Aluminum Discs

- Al discs have been studied with both 2D and 3D imaging.
- The results have been quite variable and it appears that the cutting process may not have been uniform.
- Among the most challenging media encountered
- Condition assessment across a collection would be very appropriate.
- Such discs may benefit from an approach which combines complementary features of 2D and 3D imaging. This represents a future development.

2D Imaging

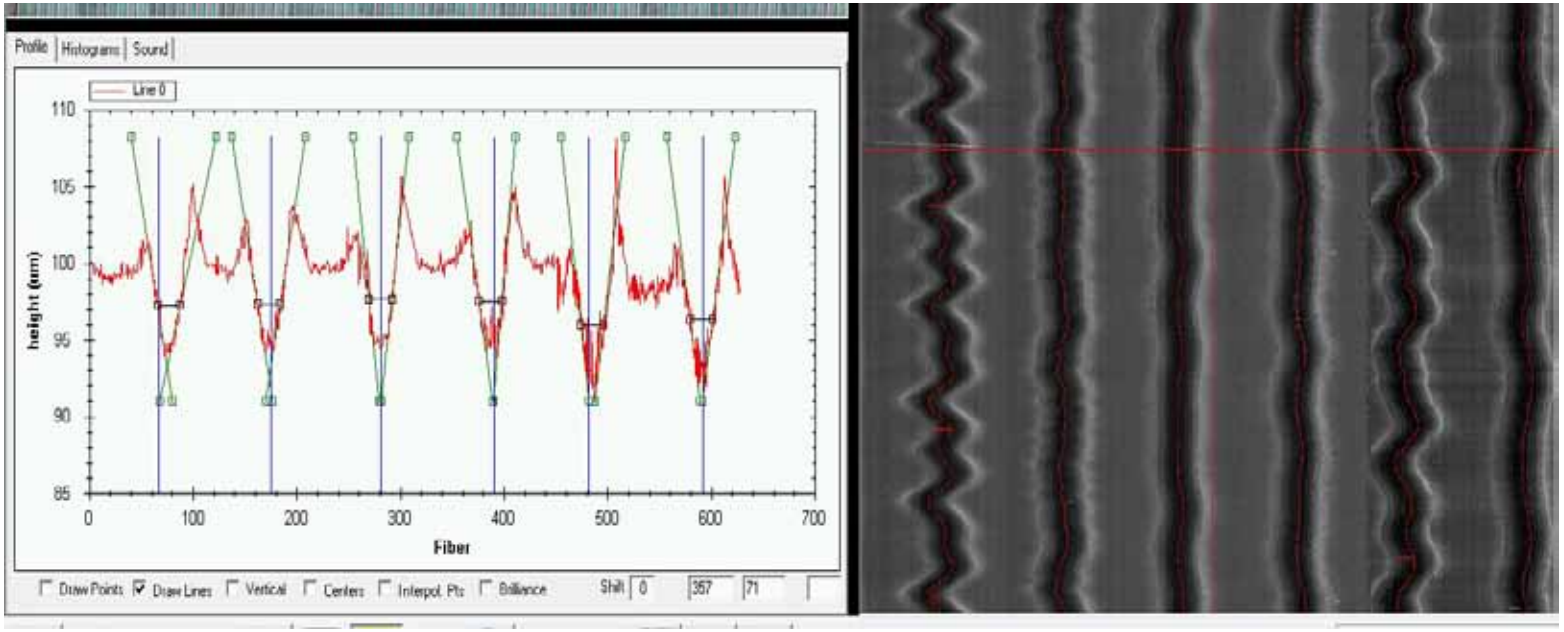


Typical image from commercial shellac pressed disc



Al disc (71/69) from Parry collection

3D Imaging

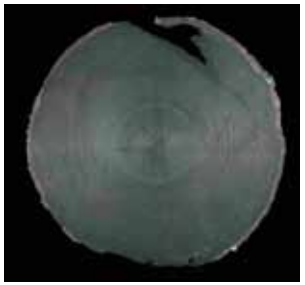
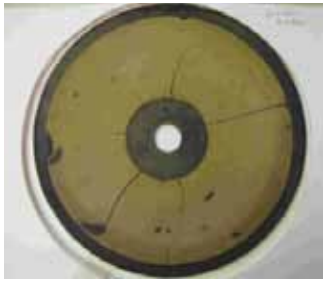


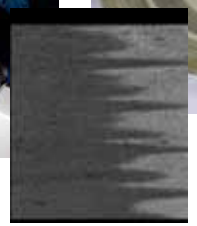
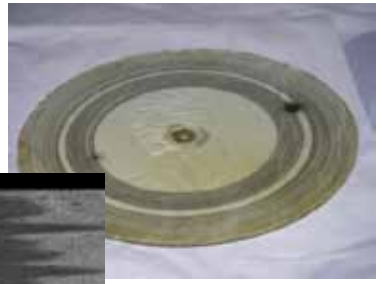
4579 4981


Grooves are very shallow (~5 microns)
Significant extruded material present
Very sensitive to how/what data is used
Results obtained from 4579/4981
No usable audio yet from 69/71

Smithsonian Volta Lab. Coll.

- In 1880 Alexander Graham Bell established the Volta Laboratory at 1221 Connecticut Avenue, Washington, D.C., to conduct research on sound recording and other topics.
- He formed an association with chemist (and cousin) Chichester Bell and instrument builder Charles Sumner Tainter.
- The associates experimented with an astounding variety of materials and formats. They produced numerous patents before settling on the wax cylinder as a recording medium of choice.
- Most of the experimental materials and notes are now in the collections of the Smithsonian Institution (>200 recordings).

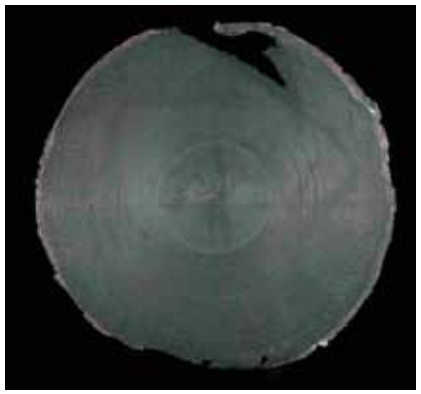



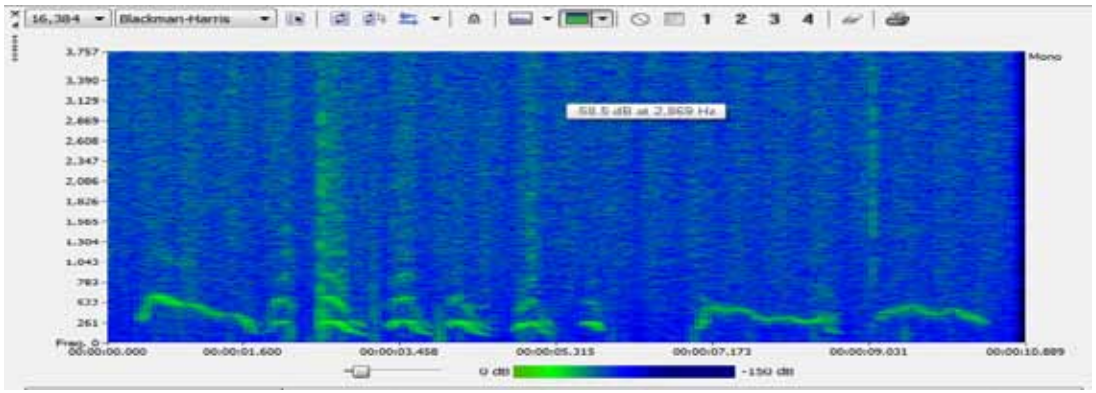
Electroformed Copper Stamper (1881)

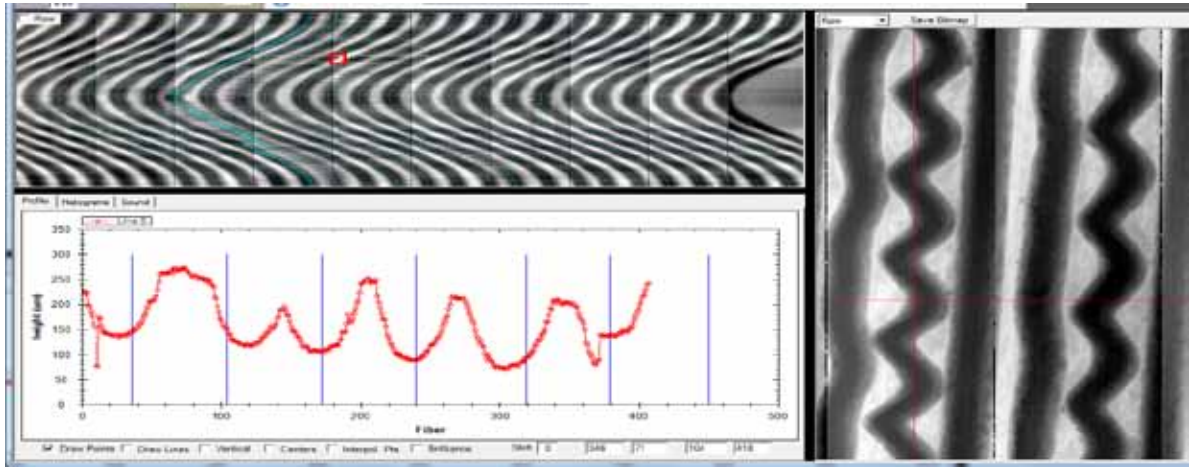
prob. earliest example of a lateral cut disc record!

Restored in 2011 using 3D optical scan

Trrrrrr 1 2 3 4 5 6 trrrr trrrrr





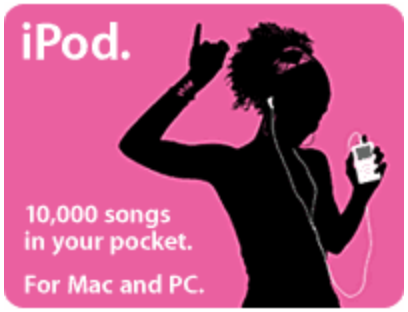


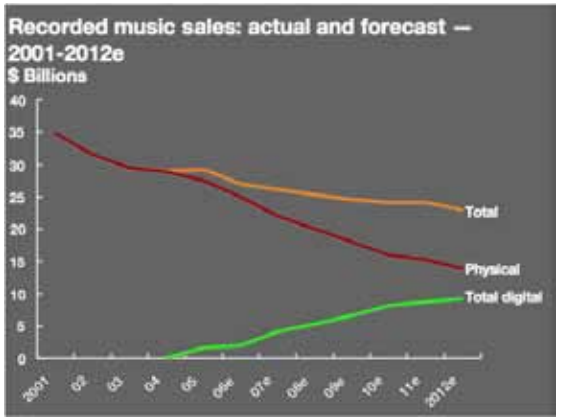
Accompanying Notes

Charles Sumner Tainter, Home Notes Oct. 17, 1881

"Our object is to use the copper electro-type for the purpose of forming records or phonograms in other substances by stamping, or printing, and to use these stamped copies for reproducing the sounds originally recorded in the composition.

In this way a piece of music, for instance, can be recorded once, and any number of copies made from this original record, and the music reproduced from any each of the copies."

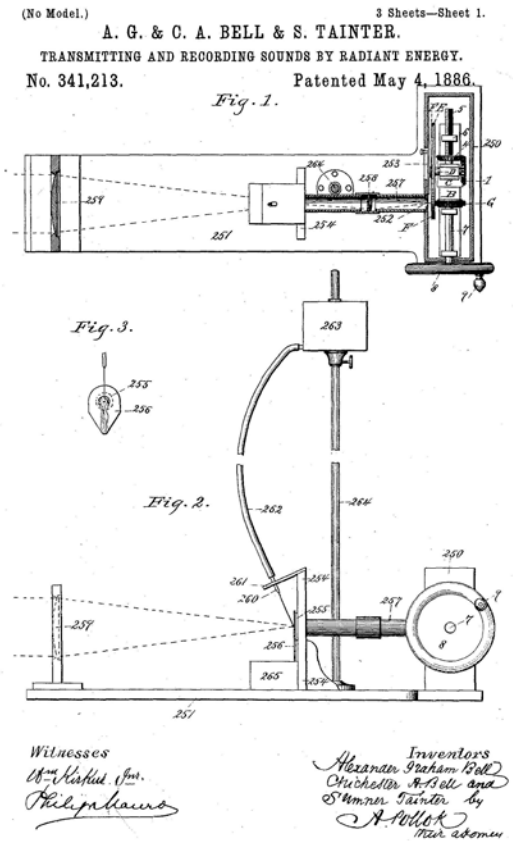




Optical Sound Recorder (1885)

Variable density

Discussed in Patent 341213


(No Model.) 3 Sheets—Sheet 1.

A. G. & C. A. BELL & S. TAINTER.

TRANSMITTING AND RECORDING SOUNDS BY RADIANT ENERGY.

No. 341,213. Patented May 4, 1886.

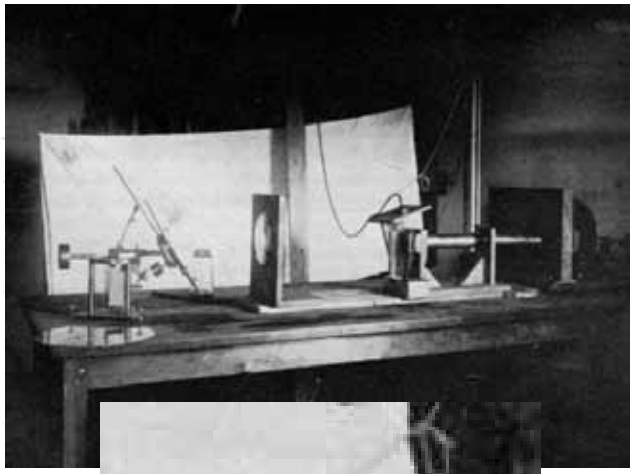
Fig. 1.

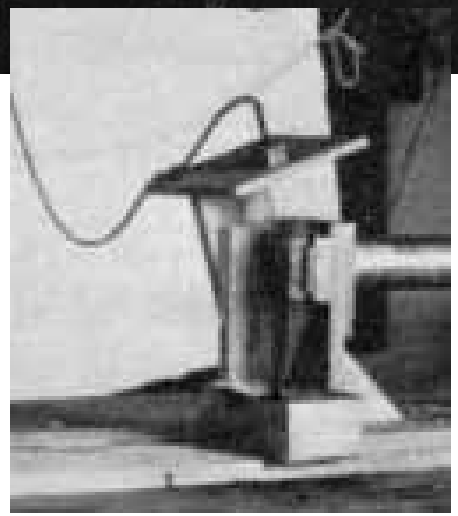
Fig. 3.

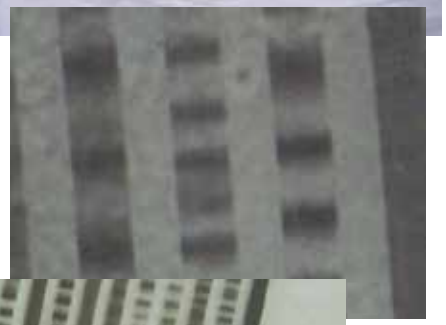
Fig. 2.

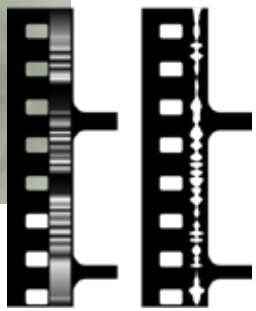
Witnesses

Inventors









…H G Rogers

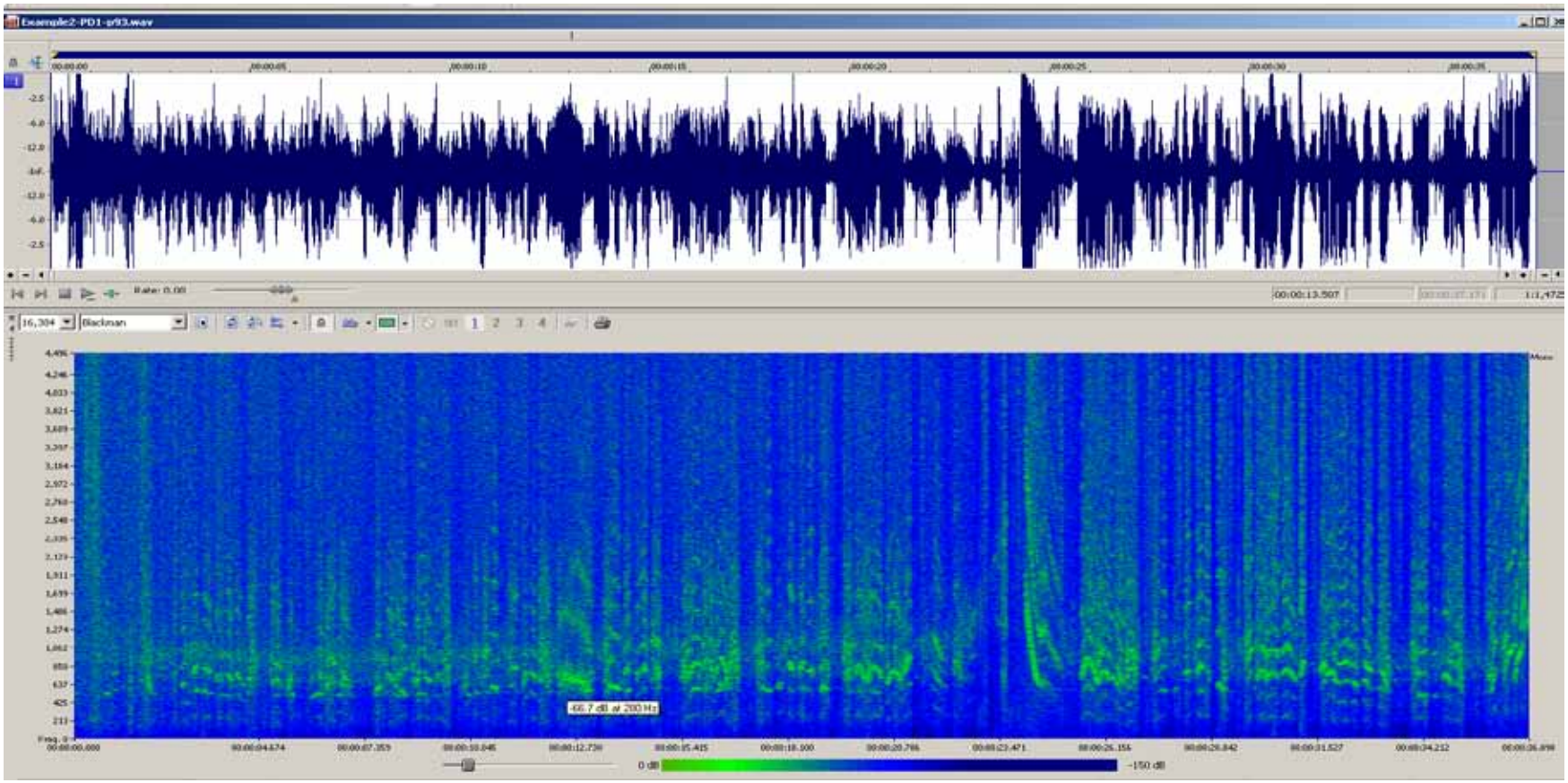
It's the 11th day of March 1885

Trrr..?who put in the pipe ??

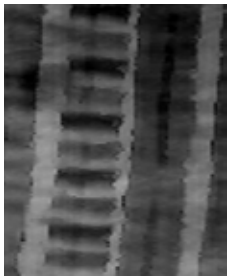
Mary had a little lamb and its fleece was white as snow. Everywhere that Mary went..oh no!

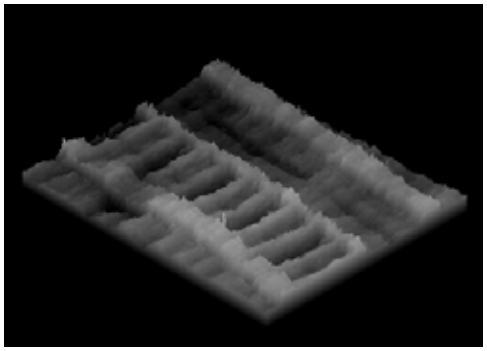
Trrr.. Mary had a little…

How's that for high? Trrr…



Edison Talking Doll ~1887 (ENHS)
"Twinkle twinkle little star…."



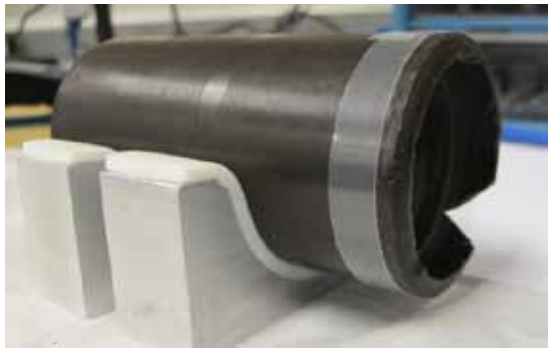
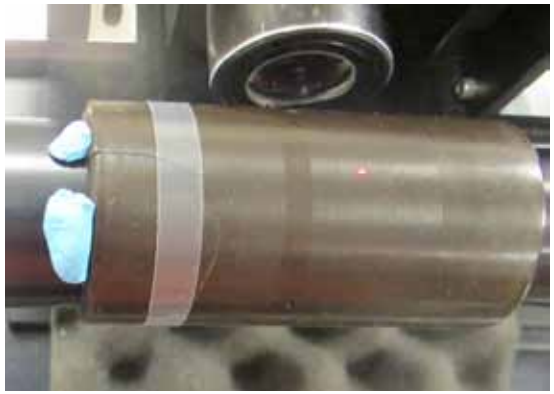


- This item was an experimental prototype for product sold by Edison some years later
- It is believed to be the first known recording of a woman and the first recording made for commercial purposes
- The product was a flop and Edison referred to the dolls as "little monsters", he had the remainder buried.
- One site notes, "a complete disaster, terrifying children and costing their parents nearly a month's pay."

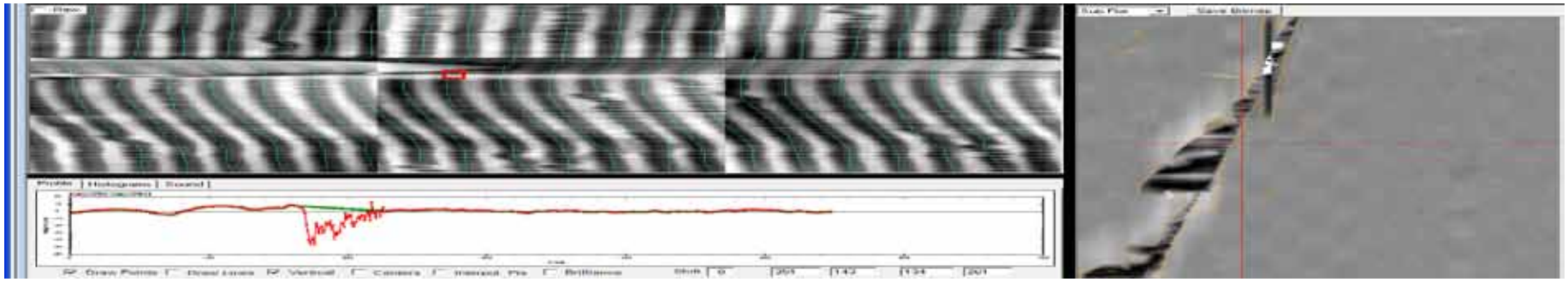
Field Recordings Pilot Study

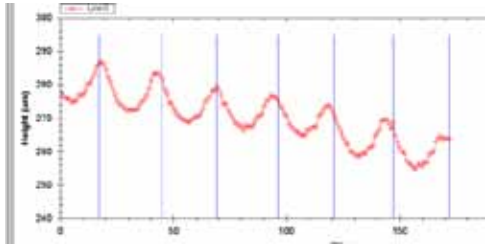
- Working with 2 collections
  - Have scanned 60 of 100 planned items from UCB Hearst Museum representing a survey of Native Californian materials (~1900-1914)
  - Have scanned ~20 items from Indiana Univ. recorded by Franz Boas on Vancouver Island in 1930, including a broken cylinder.
- Create improved access to these materials
- Measure and develop a project workflow (20/week)
- Correlate/synchronize with motion pictures?
- Sept 2011 talk at “Century of Ishi” conf. Maryrose Barrios

Broken Wax Cylinder

- Temporarily constrain pieces on the mandrel with plastic straps and (re-useable) putty, shift strap, scan in segments



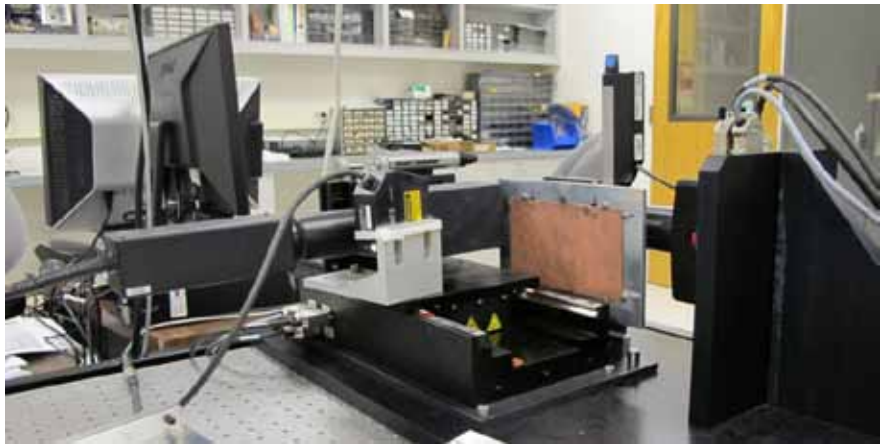


Galvano Study

- Berlin Phonogramm Archive, large scale conversion of field recordings to galvanos as a means for preservation and access
- Alternative process is wax casting.
- Earlier attempts to scan with 2D video not successful
- Proposal to make a thin probe to fit inside galvano
- Proof of principle using sacrificial sample

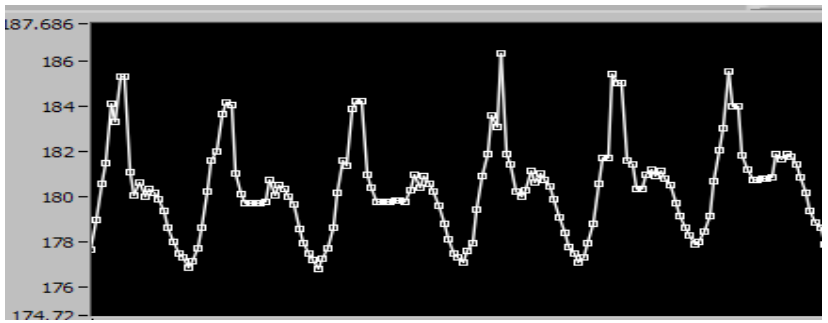
Stylus

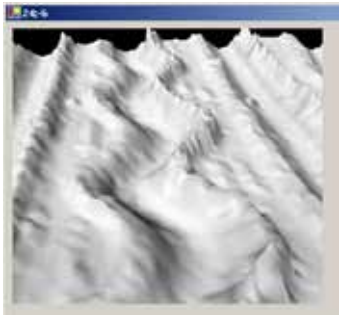
3D

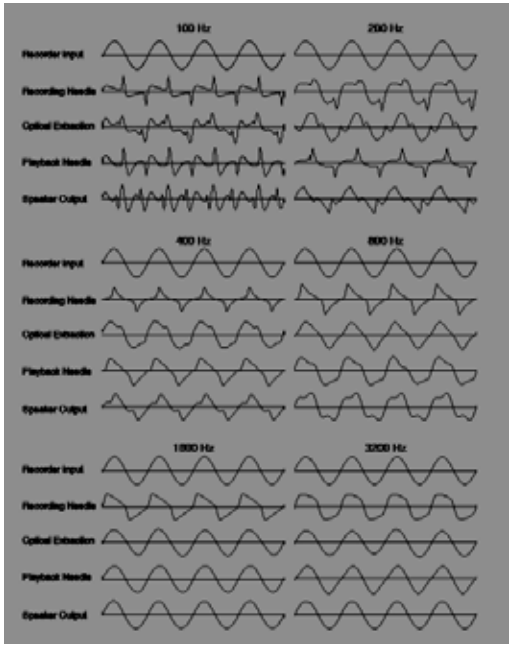


Plastic Dictation Belts

- Dictation, telephone and radio monitoring 1940's-1970's
  - US Presidential phone conversations
- Groove is embossed, lateral modulation, shallow
- Never meant as an archival medium, poor storage

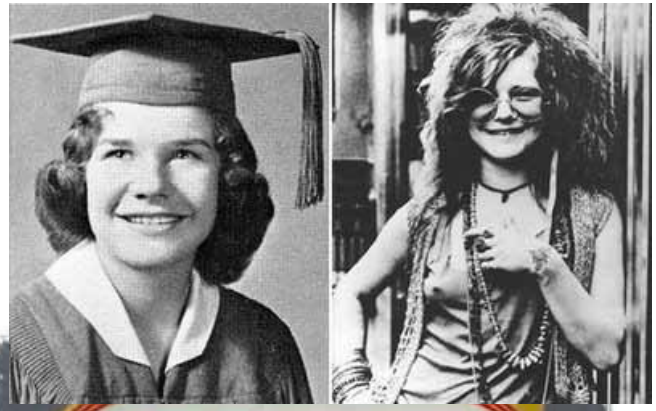






Personal Recordings

- Greetings, mementos, 1940's – 1960's
- Mostly in private collections
- Typically on delicate or unstable media

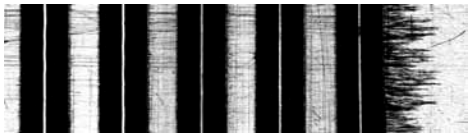


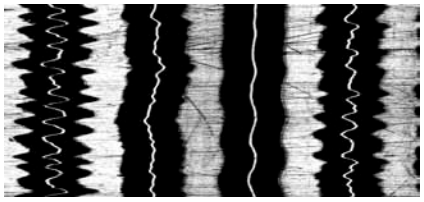
Future Directions: A New Toolkit

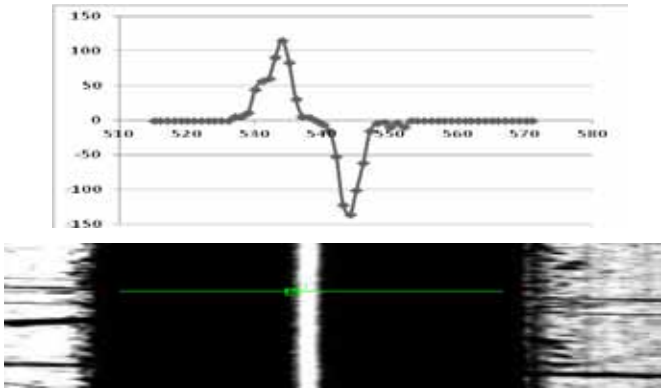
- Lessons learned from small production runs
  - Generally want to provide users with more “handles” to deal with challenging cases
  - Broken and damage media are an important component, need better tools for both automatic and user driven corrections
- The 2D production system at NAVCC uses automatic focus and start/stop determination
  - Extend this to other parameters which effect data collection
  - Extend this to 3D scanning
- Parameters which determine audio extraction could be optimized by an adaptive pre-processing stage.
  - Use inherent features of the data to self calibrate

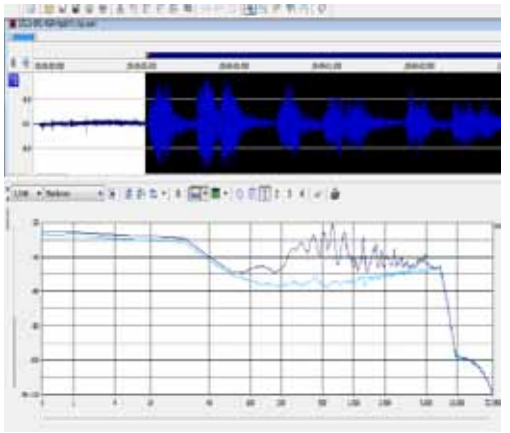
Adaptive and Self Calibrating Methods

- Most data sets contain quiet lead in/out portions
- Try to identify and analyze these first, minimize noise by varying parameters or algorithms and using these sections as a test sample. Different approaches for 2D and 3D.





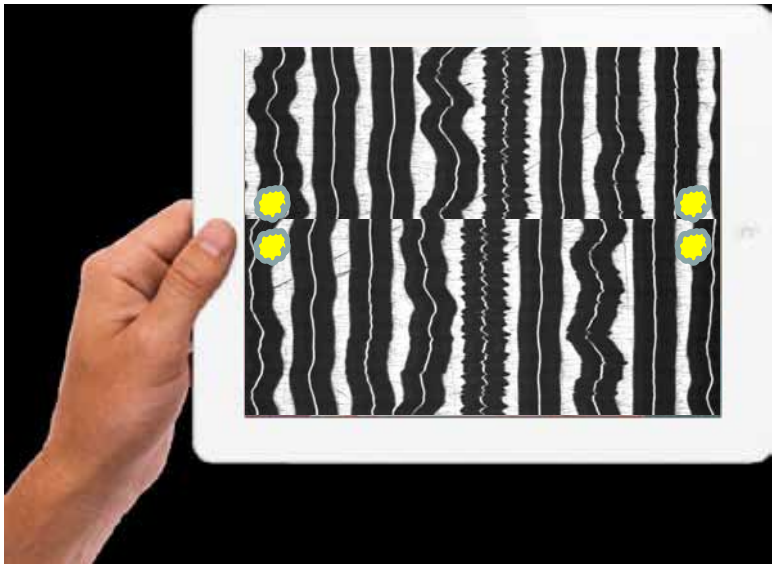




Concepts for a Tablet Interface

Tracking the groove

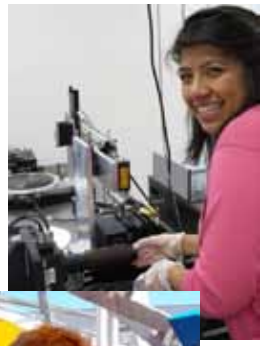
Re-align broken disc



- Experience of special studies and production indicates that there may be cases where increased user access to the data would be an advantage.
- If a large number of systems come into use it may be more efficient to provide such a toolkit than to tweek the automatic software in response to every special case which arises

Collaboration, Sociology, and Outreach

- Strong collaborative response from collections communities, large and small.
- Have found the community to be very open to new ideas and engaging
- For scientists, an amazing opportunity to study the earliest attempts to record information(!)
- ~25 students from STEM fields have contributed and been exposed to the impact that they can have on historical preservation.
- Many opportunities to share STEM methods with new communities and the public.



Gypsy Fortune Teller
cracked wax cylinder, circa 1906

Montana State Hist. Commission

- You will soon go to a ball or large gathering and meet a new friend.
- A sincere friend seeks to help you in matters of importance to you.
- Your troubles can be avoided by changing your attitude towards them.
- You will have unexpected good fortune in a letter.
- The first years of your life will be the unhappiest.
- You will be married three times, each time more happily.
- A person who has made trouble for you in the past will become your friend.

Conclusions

- Optical methods have been shown to be effective in preserving and creating digital access to sound recordings.
- Methods are being put into use and evaluated as part of archival workflow.
- A portable system has been developed.
- A variety of special applications have been investigated.
- The flexibility and format independence of optical scanning make it an effective tool to study the early history of sound recording.
- Many opportunities for outreach and novel STEM education
- For more information: http://irene.lbl.gov/

Backup Slides

Jack London Dictation Cylinder
(J L State Park)

December 2, 1915

Dear Max Ehrmann:

Just a rush letter, ere I sail for Hawaii. I merely want to tell you that everything concerning California prisons in the Star Rover is true. Ed. Morell is a real man, and Ed. Morell is his real name. He had a fifty year sentence, and he spent five years of it in solitary, as I have described. Two years ago Jake Oppenheimer was executed in California for assault and battery. I can only repeat, that what I have described is true of California up to the year 1913. I do not know what has happened in California since that date.

If you ever read a book of mine entitled The Road, in which I give some few of my experiences, you will notice that in the Erie County penitentiary at Buffalo, New York, I have slipped by without describing much of the worst that I found obtaining there. What I found there was unprintable, and almost unthinkable.

I am still curious to know how my handling of the Christ situation in Jerusalem will strike you.

IRENE Production Scale Evaluation

- 2D IRENE scanner and s/w installed at LC Packard Campus, Culpeper, Va. facility
- 5 LC staff were trained to operate the system
- 200 shellac discs (400 sides) scanned (time duration: up to 12 discs/day)
- 100 lacquer discs scanned
- "I" (user interface) redesign, added:
  - feature to pull in catalog data, identity confirmation
  - operator technical data fields for visual disc condition assessment
  - disc spin feature to help identify warped discs (laser superior to direct inspection),
- Encountered focus issues on lacquer discs, modified laser optics to address this
- Added variable camera aperture to allow for larger focus depth with warped discs
- Imaging largely successful, operators able to choose basic settings with little trouble
- Image analysis
  - certain like sets of discs from particular record labels consistently converted to audio well and other sets consistently converted poorly, conclusion: adjustments to the analysis algorithm rectified some of these issues, study of problems continues.
  - Identified a number of s/w interference issues, multiple processes, shared resource,
- Next steps: iterate on analysis aspects, re-process
- Analysis and report

Collections

- This is a list of potential sites/collections which have either expressed interest in the technology or we have worked with already
- The Library of Congress
- Harvard University: Milman Parry Collection ~3K aluminum discs
- Indiana University Archive of Traditional Music, major collection of early cylinders, discs
- UC Berkeley P. Hearst Museum, 3K Native American field recorded cylinders
- Edison National Historic Site: all the Edison cylinder and vertical disc production and development
- Smithsonian: Volta Lab + early sound collection, ~400 unique items, + all the other SI holdings
- Canadian Bell National Historic site – wax cylinders
- Moscow Conservatory of Music: ~80 years of classical music
- Berlin Phonogramm Archive: >10K cylinders/galvano's (connection to other European archives)
- R. Muthiah Research Library, Chennai, India
- EMI Archives, Abbey Road, UK, with University of Chicago
- Small institutions – Schenectady Museum, ND State Archive,…

Technology

- 2D and 3D approaches have run in parallel
- Clear now that they compliment each other, better to have both available together
- New data taking and optimization strategies then open up.
- New optical probes can include both 3D and 2D imaging in the same “head”
- Clearly an interesting direction for R&D

History

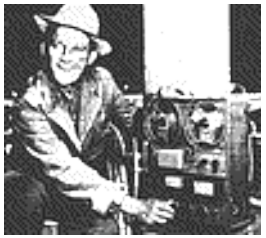
- 1853 Leon Scott: *Phonoautograph* paper recorder
- 1877 Thomas Edison invents sound reproduction on tin foil *Phonograph*

- 1880-5 Bell(s) and Tainter, Volta Lab research into audio formats, finally introduce wax cylinder
- 1887 Emile Berliner invents disc *Gramophone*
- 1925 Western Electric *Orthophonic* (electrical) system

end of the "**Acoustic Era**"

Discos fonográficos Pathé
Caras y Caretas (7/7/1906)

- 1929 Edison production ends, lacquer transcription disc introduced
- 1947 Magnetic tape in production use, Ampex 200A
- 1948 33 1/3 rpm LP introduced
- 1958 Stereophonic LP on sale, uses 45/45 system



- 1963 Cassette magnetic tapes

- 1982 Compact Disc (*CD*)

end of the "**Analog Era**"

- 2001 Apple *IPOD*

- Late 2000's Massive online access to digital sound files

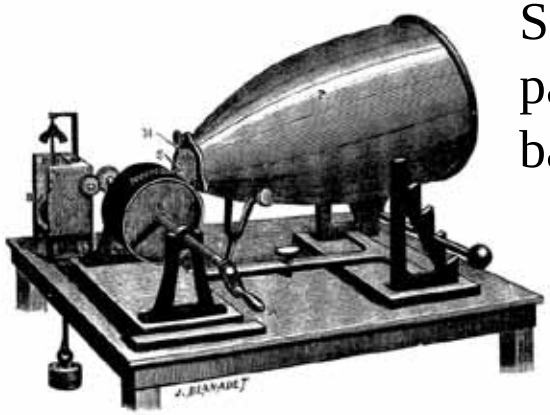
Window on Invention and History

- The format independence of optical scanning make it a useful tool to study recorded sound and the history of invention
- 1860 Leon Scott Phonoautograms: the 1st recordings
- (1877 Edison foils): the first reproductions
- 1881-1886 Volta Lab: most of the practical aspects unveiled
- 1887 Edison Talking Doll: the 1st commercial recording
- Late 1880's Berliner Discs: the commercial disc format
- 1900's consumable cylinders: recordings becomes a tool for ethnographic research, a novelty, and an industry
- 1910's – 1950's shellac, lacquer, and aluminum discs
- 1960's Plastic dictation belts

Earliest Inventions

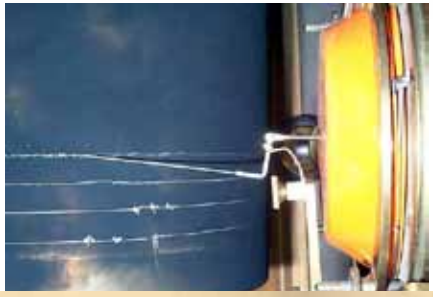
Phonautograph
Leon Scott
1853

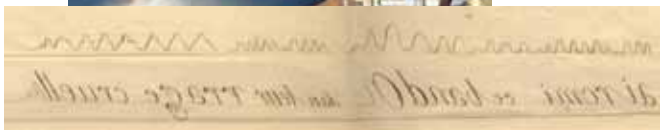
Phonograph
Tom Edison
1877



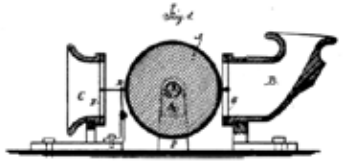
Scott enscribed sound on paper and could not play it back

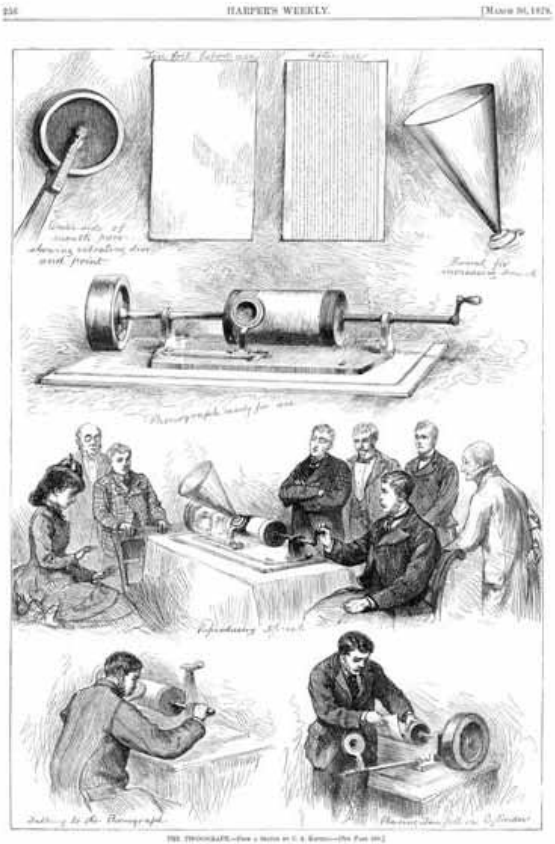
Edison embossed sound on foil and was therefore the first to reproduce it.

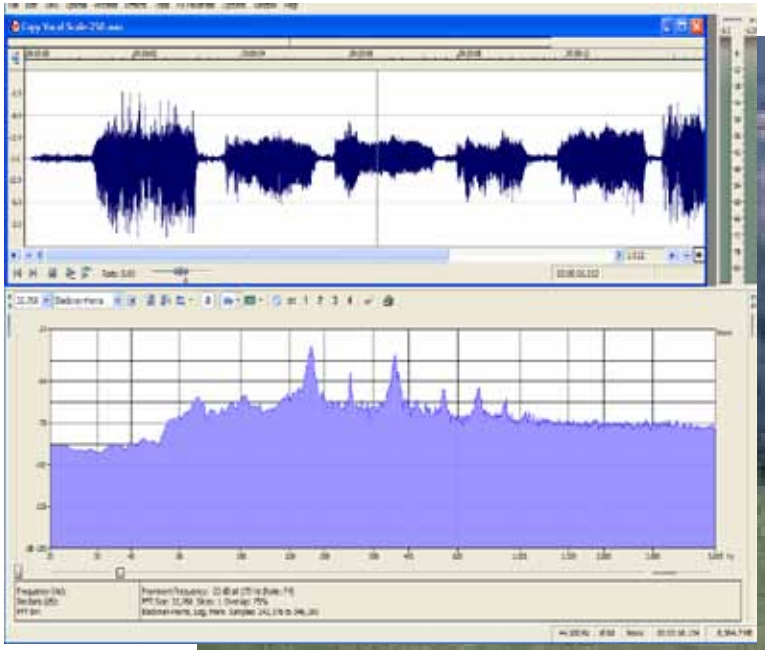


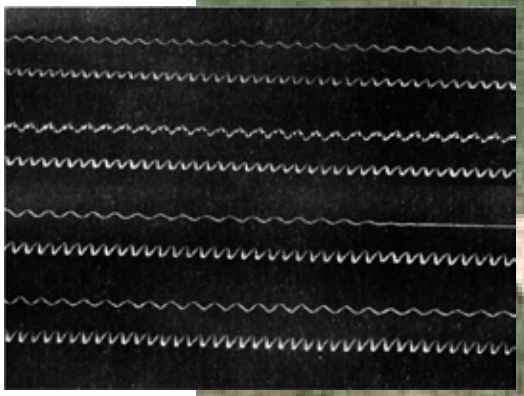


T. A. EDISON.
Phonograph or Speaking Machine.
No. 200,521. Patented Feb. 19, 1878.





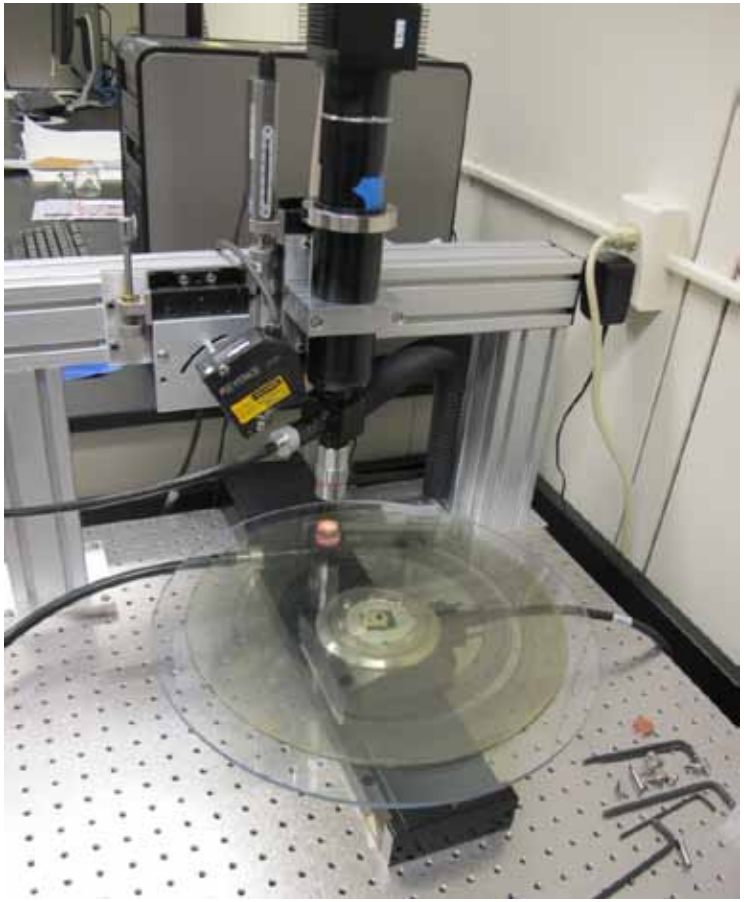




2nd example of a sound recording in history w/ 250 Hz tuning fork crosstalk

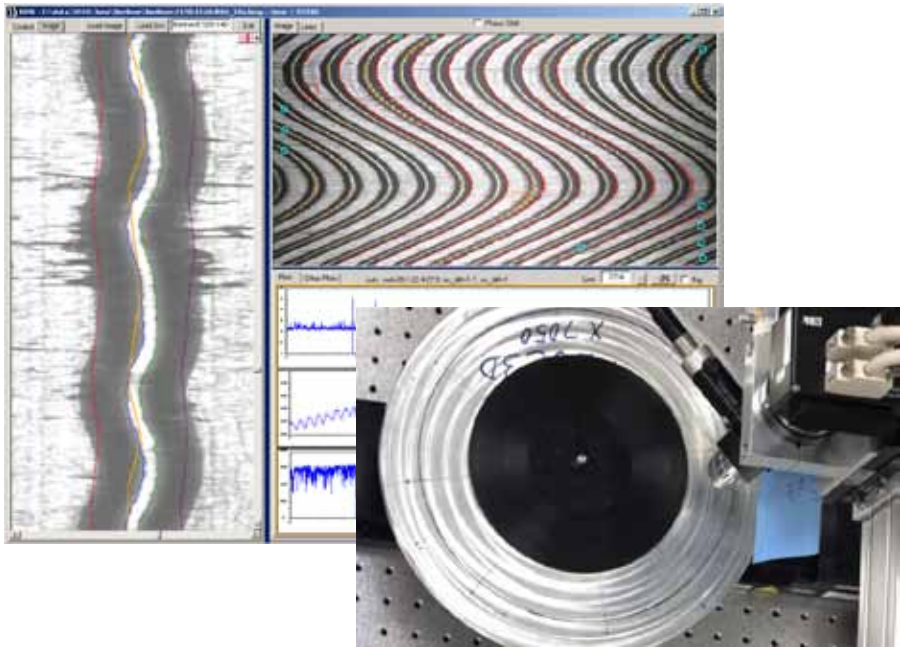
Do Re Mi Fa So La Ti# Do

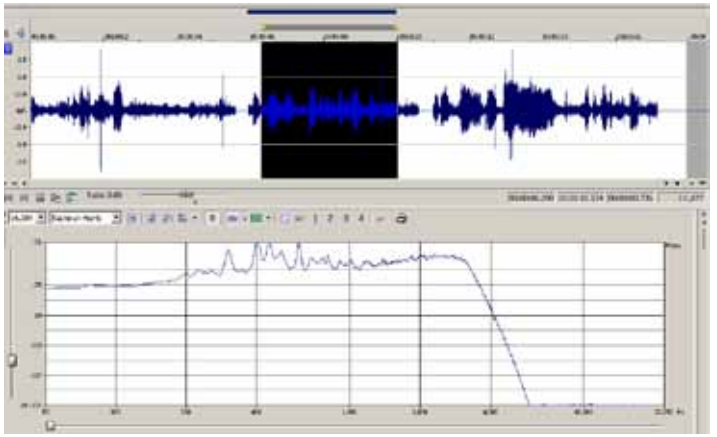
Measurement Process (2011)



Berliner Discs

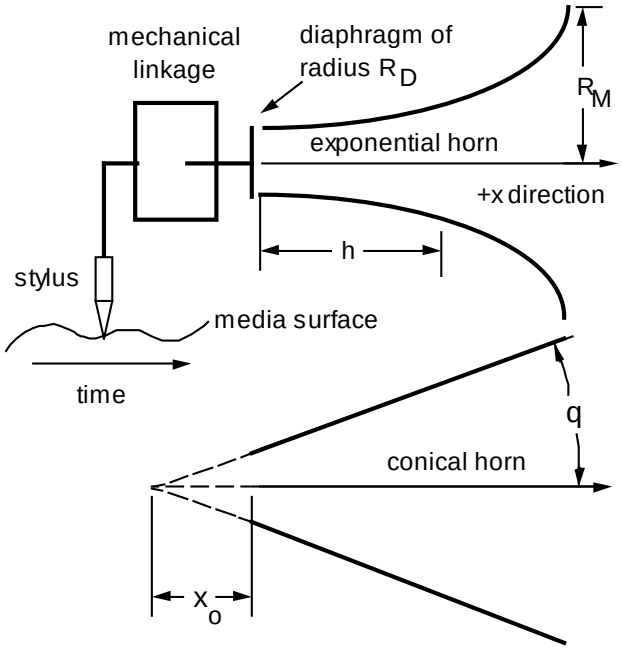
- Very early commercial disc production
- Significant collections at the LoC and EMI Archives (UK)
- Small study done with 3D and 2D imaging

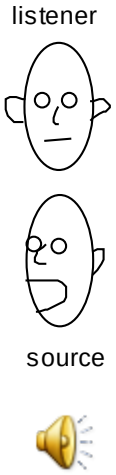


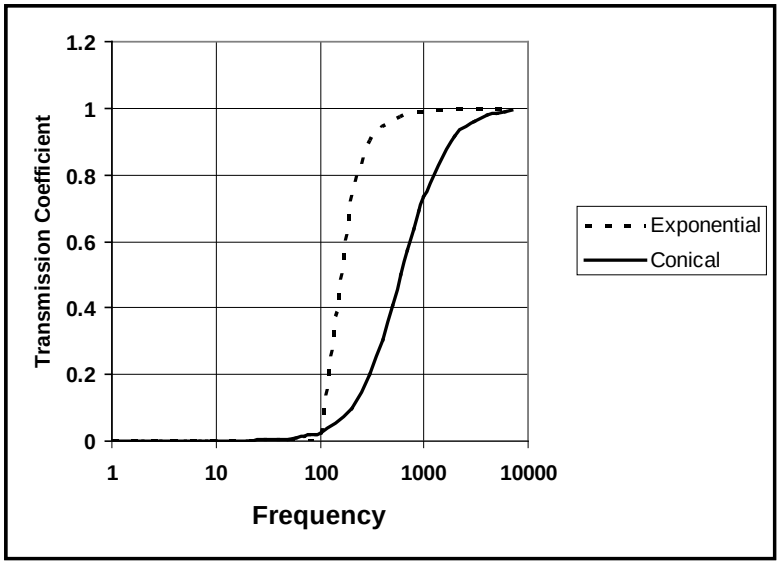


Note: offensive content

Optical + EQ + filter



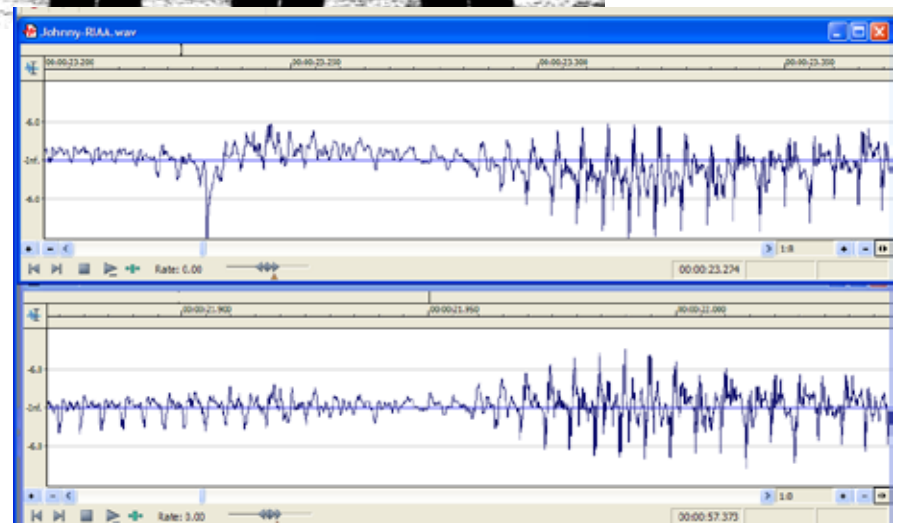




Response of horn and diaphragm at low frequency can modify response and deviations from “constant velocity” characteristic.

“Johnny”: Les Paul and Mary Ford

1953 recording, shellac 78 rpm disc is worn and scratched, distorted

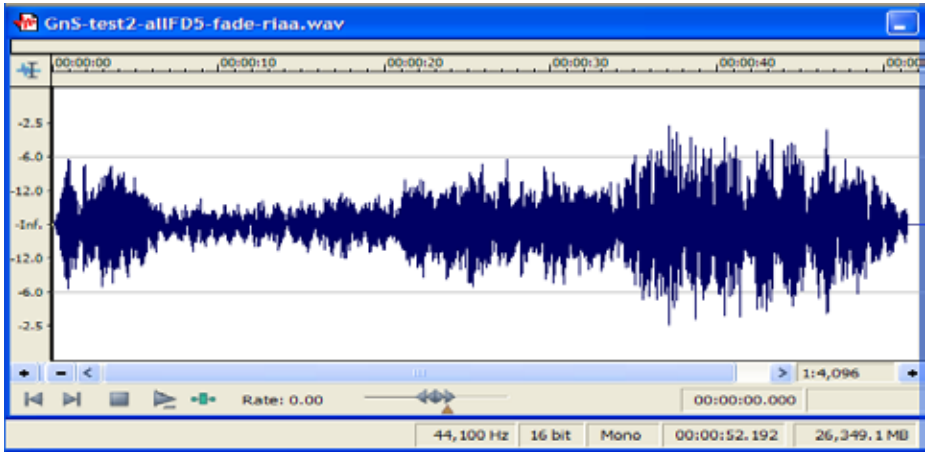


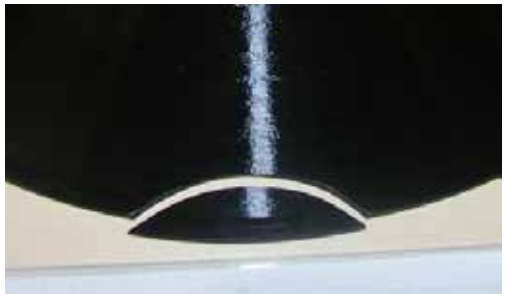
Stylus version has a clear skip due to scratch

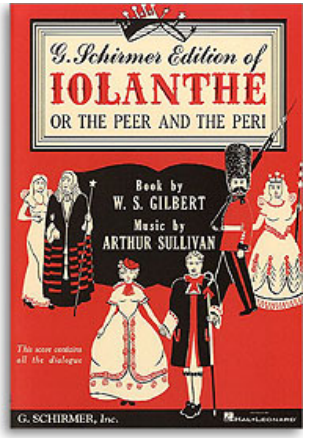
IRENE

Broken Record

Gilbert and Sullivan “Iolanthe” 1930 Victor 9708







Rare Lacquer Transcription Discs

Typically these are one-of-a-kind and considered delicate. Archivists may prefer a non-invasive approach to playback and/or evaluation.

78 rpm acetate
Theos Bernard, interview,
1930's (UCB)


U.S. Tibetan Scholar Is Missing
In Punjab After a Tribal Attack

Theos Bernard, Author, Feared Dead by Wife Who Reports Incident in New Delhi

NEW DELHI, Oct. 20 (AP)—An American student of Tibetan culture has been missing since mid-September on a trip to a Tibetan monastery and may be dead, his wife today reported.

Mrs. Theos Bernard, 40, of New York and Santa Barbara, Calif., son of G. Bernard of Northridge, Calif.

Interviewed here, Mrs. Bernard said shepherds had told of seeing Lahouli tribesmen attack her husband's party and kill his Moslem servants. That was in the Himalaya Mountains of northern India, she said, between Sept. 12 and Sept. 16.

Mrs. Bernard said she had learned that her husband then was short of food and she feared that he might also have lost his heavy clothing to the raiders.

Mr. Bernard set out Aug. 20 from the out-of-the-way Kulu Valley of the northern Punjab. Six days after that, she said, Hindu-Moslem rioting broke out in the valley and she herself had to flee 126 miles on foot southward to Simla. She passed through New Delhi today on her way to Calcutta, where she said she would await word of her husband.

Theos Bernard

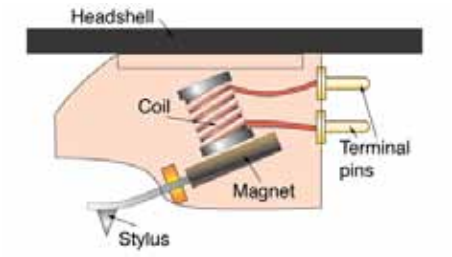
Oriental Philosophy from Colum-

78 rpm nitrate on glass
Label: Howard Hughes,
Collier Award 1939 (Lakeland Mus.)

78 rpm acetate on metal
1940's studio test
Mutt Carey and the NY'rs (LoC)

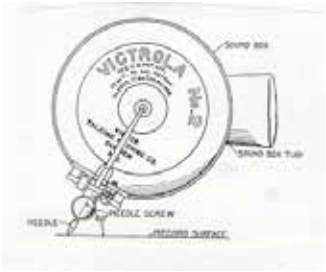
What is the relationship between "groove" and sound?

Electro-magnetic case

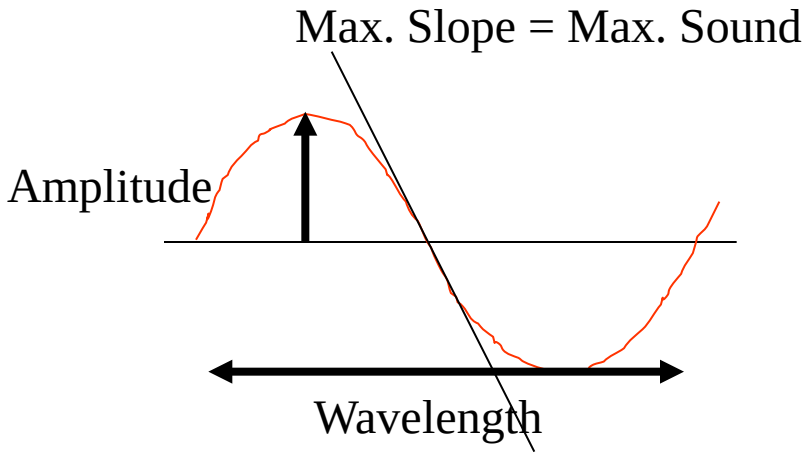


induction

Acoustic case



Diaphragm is over-damped to provide flat response



Sound = Stylus Velocity

$$A_p = \frac{v_p}{2\pi f}$$

("constant velocity condition")