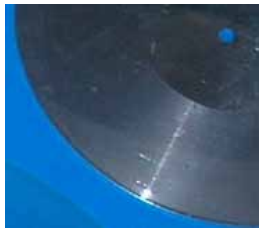




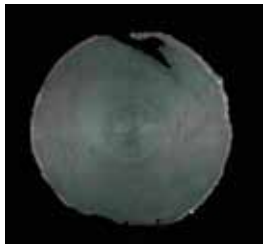
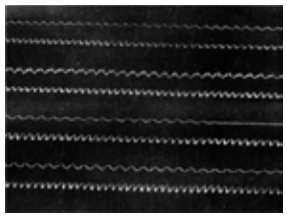
Advancing Optical Scanning of Mechanical Sound Carriers: Connecting to Collections and Collaborations


Carl Haber

Lawrence Berkeley National Lab



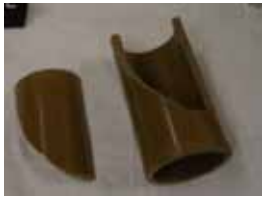



The 1st 90 years of sound recording is dominated by mechanical carriers.

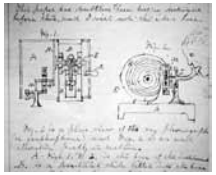
~10 million grooved recordings in US collections (x 2 worldwide?)

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.

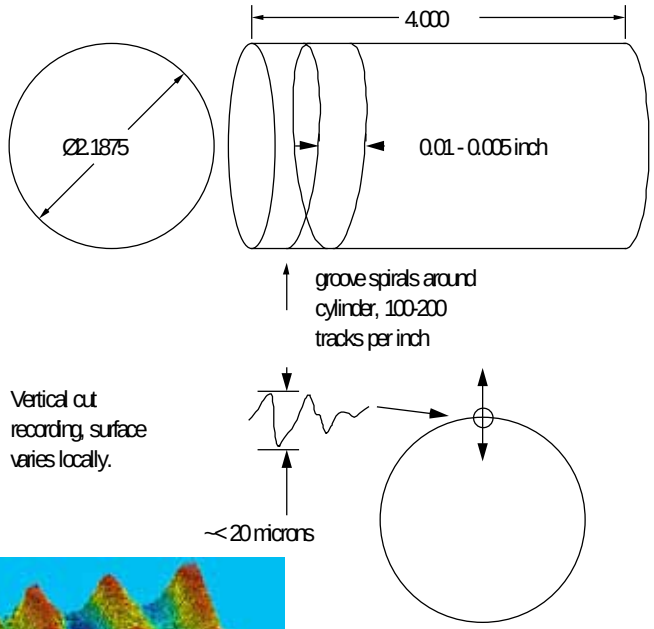
- Preservation: restore or stabilize delicate or damaged media
- Access: mass digitization of diverse media, automation
- Condition assessment
- Obsolete and historic formats and legacy playback systems

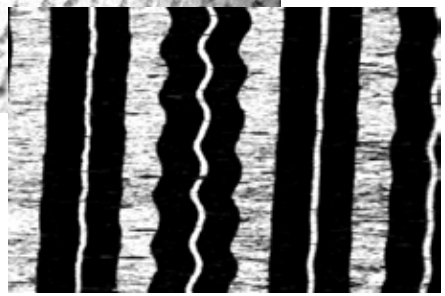
- IMLS is supporting the development of this technology – today's status report
- Through collaboration with major collections attempt to bring this technology into broad application.
- Have now restored many early experimental, ethnographic, and commercial sound recordings using this approach.

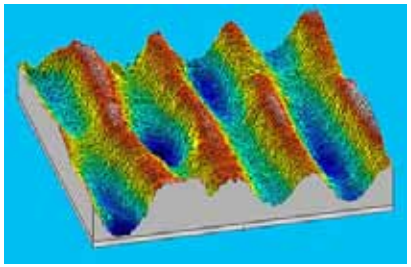
Mechanical Recording Principles

Cylinder: groove varies in depth (Vertical Cut)

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



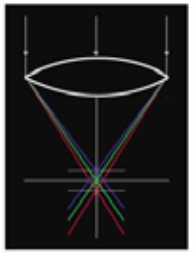


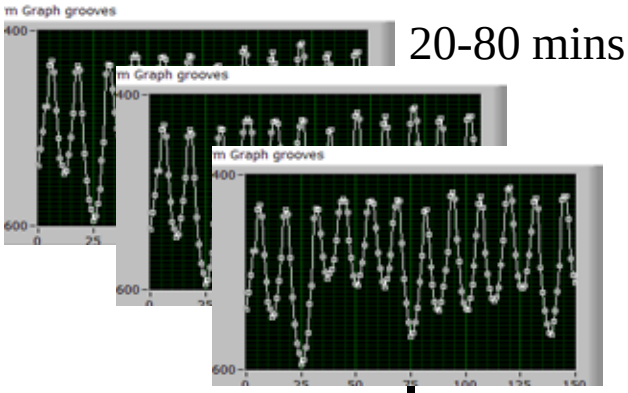


Audio is encoded in micron scale features which are >100 meters long

Basic Optical Process

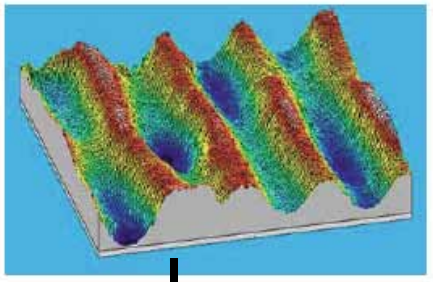
High resolution optical probe…creates a series of depth/intensity profiles of the surface





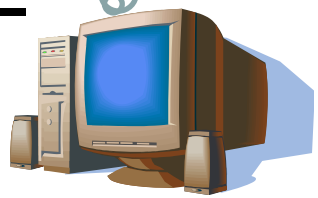
20-80 mins

These are merged into a surface map

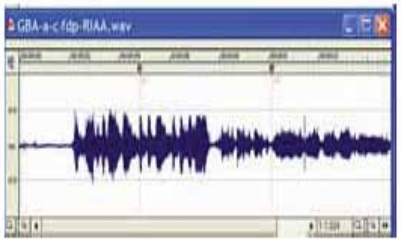


Map is archived

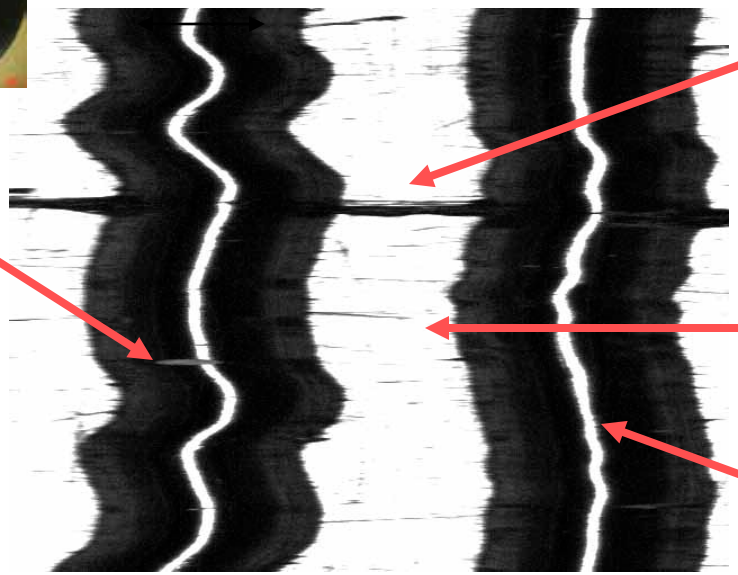
Calculate the motion of a virtual needle, apply optional restoration

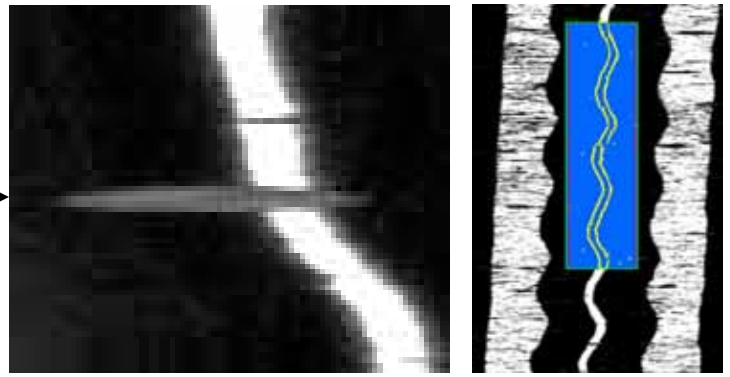


Create audio waveform

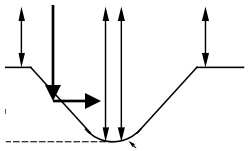


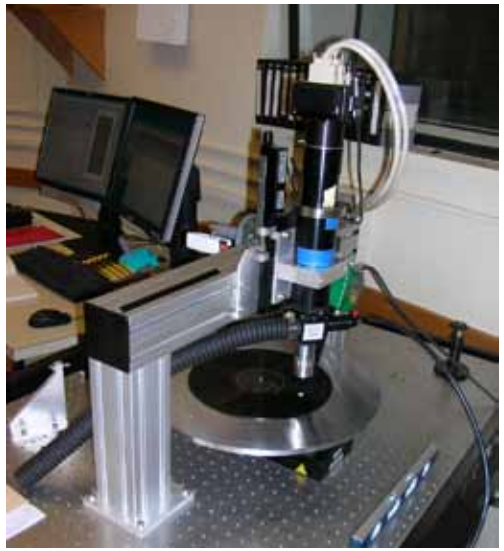
2D Imaging: Line Scan Camera “IRENE”





Coaxial illumination



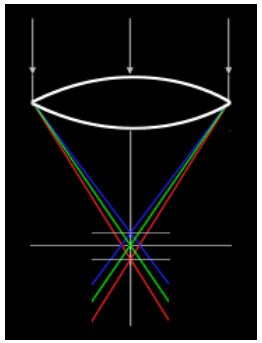


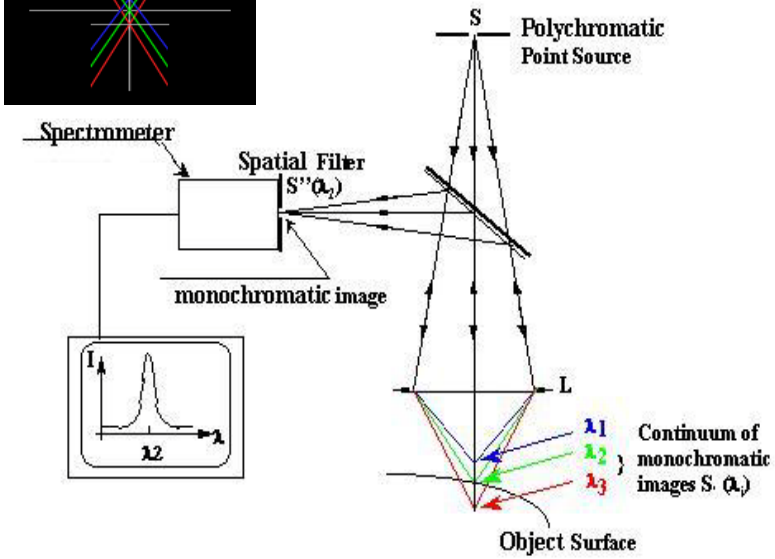
“IRENE”

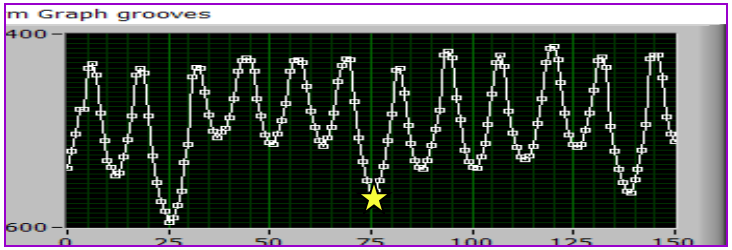
- Suitable for disc with lateral groove
- Require 1 pixel = ~ 1 micron on the disc surface
- High resolution = narrow depth of field, 10 – 20 microns
- High speed cameras allow near “real-time” imaging
- Extract groove information from high contrast edge transitions

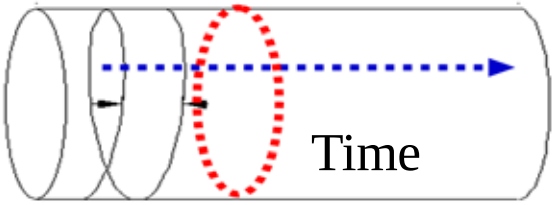
3D Imaging: Confocal Scanning Probe

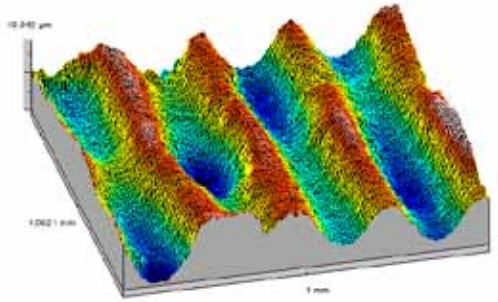
Required for cylinder with vertical groove modulation.







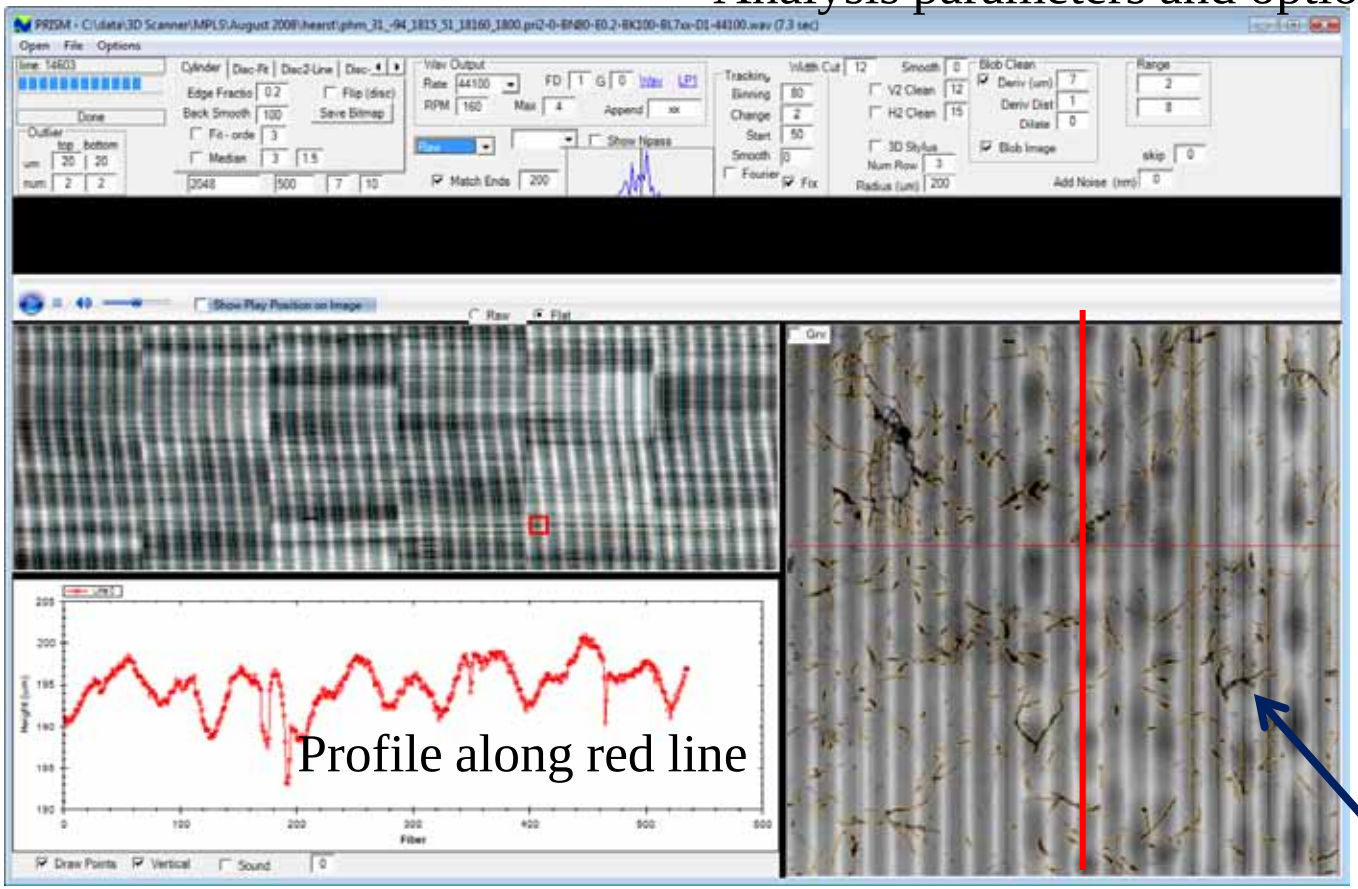




Collects 180 point line at up to 1.8 KHz/line
scan time ~ 30 minutes

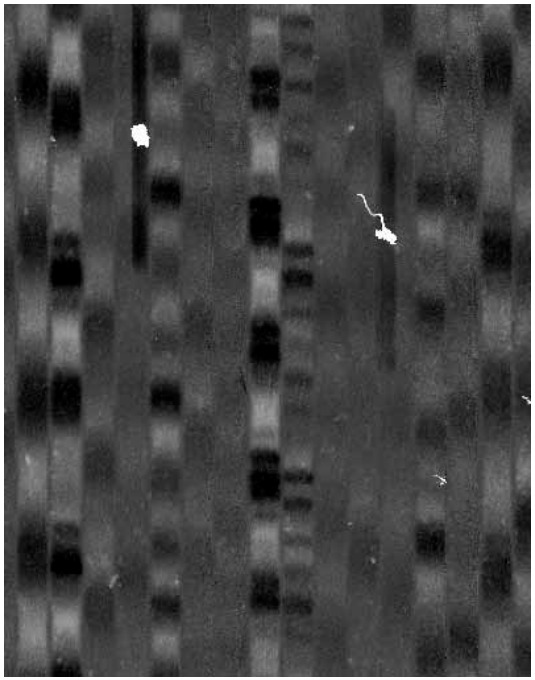
Analysis Software Example

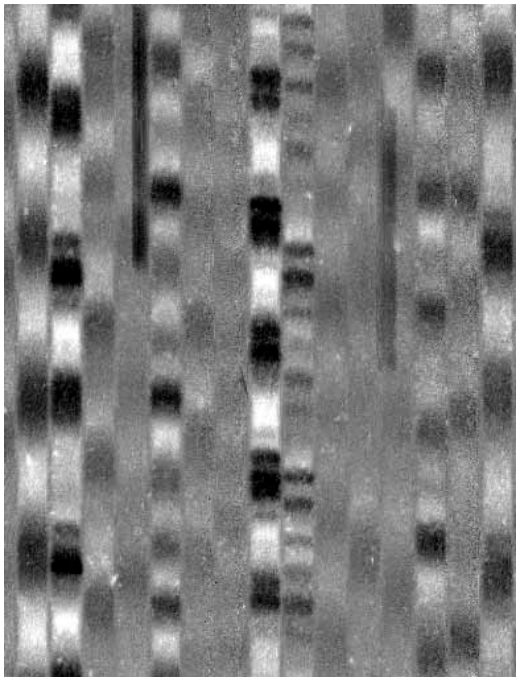
Analysis parameters and options



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



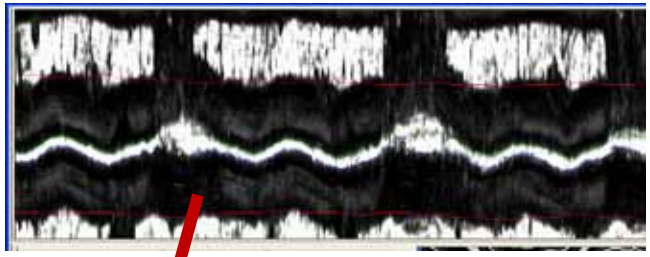


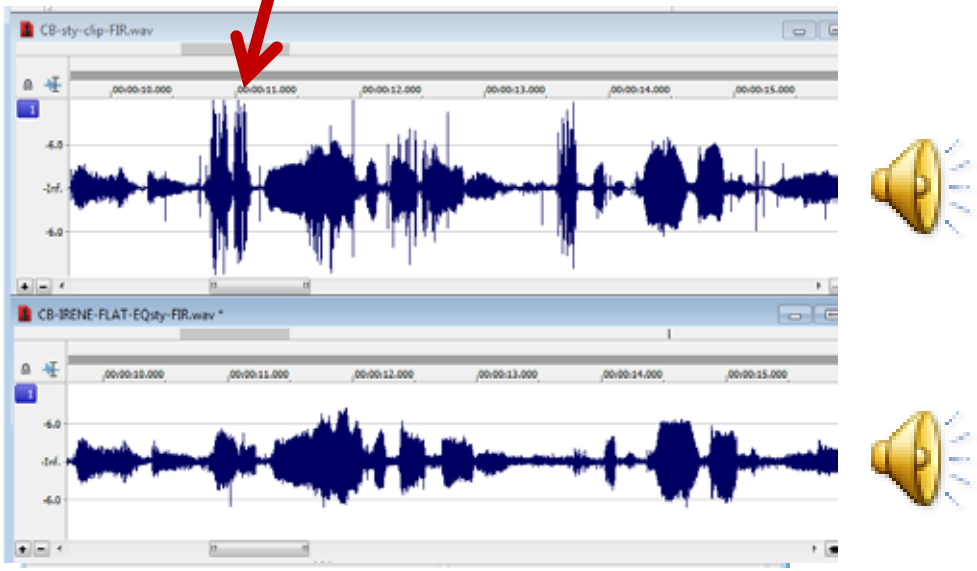
Dust particles appear WHITE because they are above the surface

Examples of Distortion Recovery

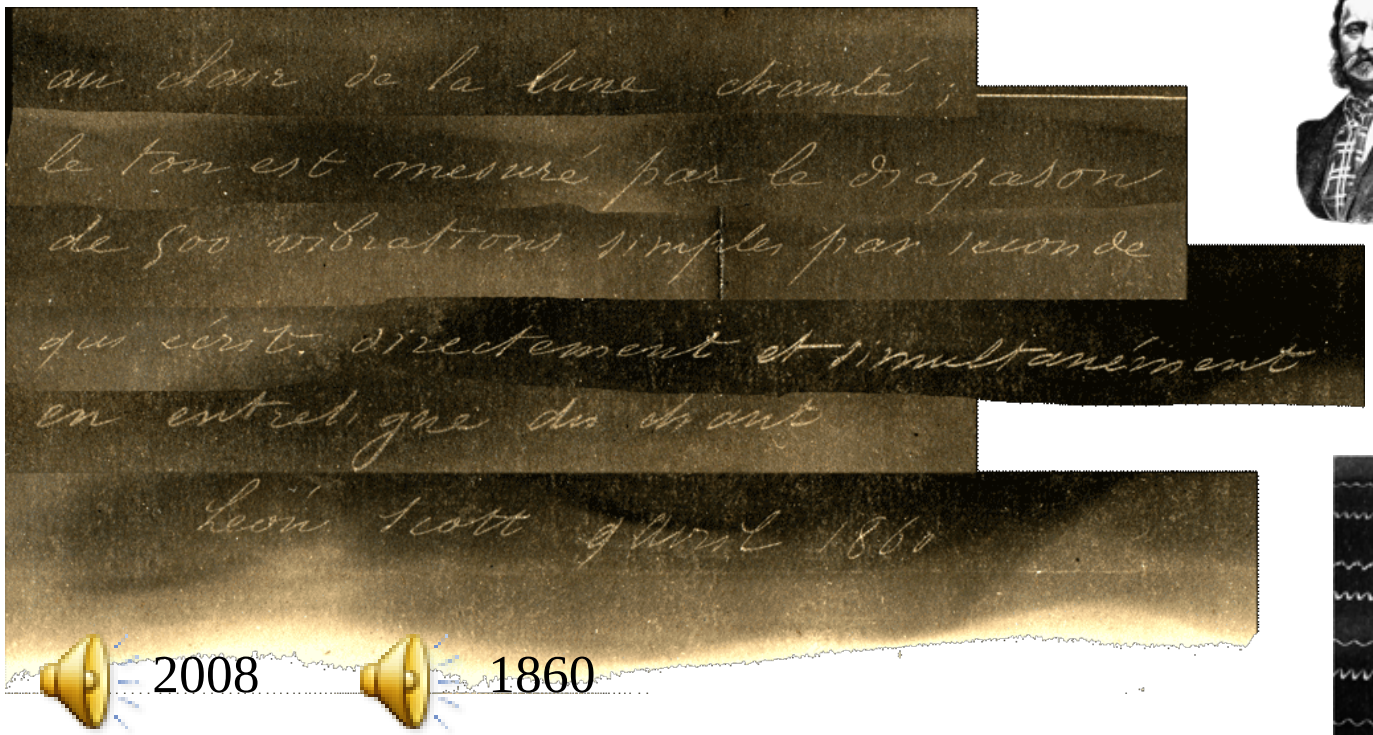
Chattanooga Blues, Ida Cox, 1923, Paramount 12063

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

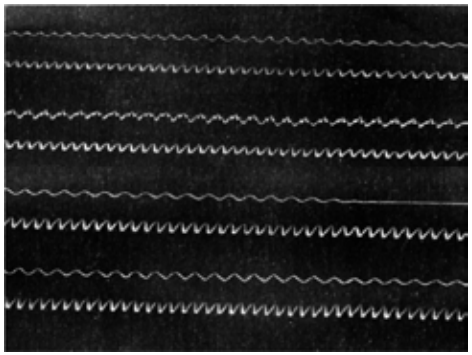




In 1860, French inventor Edourd Leon Scott records sound on paper traces.
Scott's original tracings were located, digitized, and processed as 2D optical scans

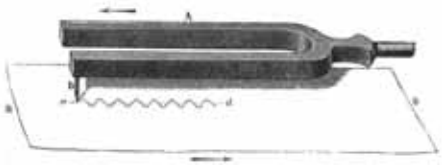


17 years
Before
Edison



"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)

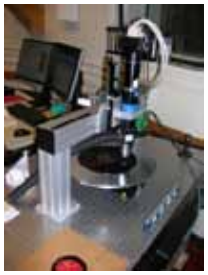


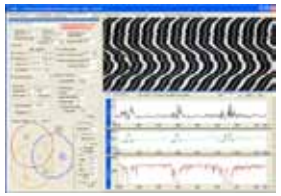
Léon Scott 9 April 1860

Projects and Collaboration

- Concept was tested 2002-2003 leading to interest and support from the Library of Congress and others.
- 3D: a fast 3D scanner for cylinders and discs 2008-9 (IMLS)
  - Preservation and restoration of early and damaged recordings
  - Benefit from recent improvements in 3D probe technology
- 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
    - Wax field recorded and dictation cylinders: Phoebe Hearst Museum
    - Cylinder molds and disc stampers: Berlin Phonogramm Archive

Production Scale System at LC Packard Campus





IRE #

Condition data

Warped?

in/out?

autoPOS'N

autoFOCUS

Image quality

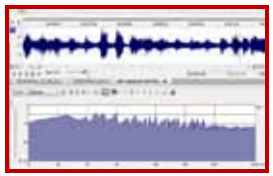
Scan

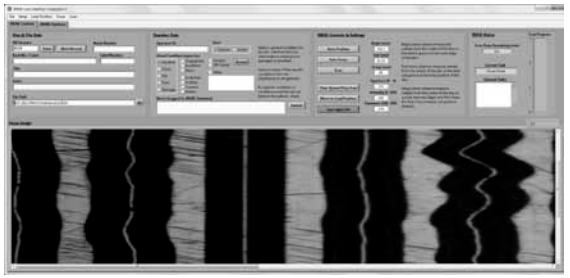
RENE

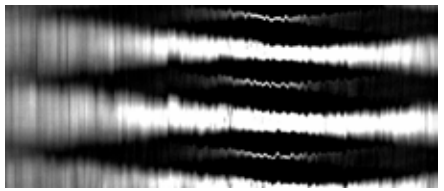
New images?

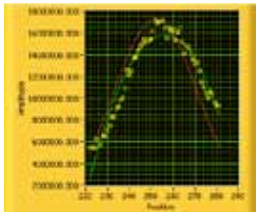
Process

Resample

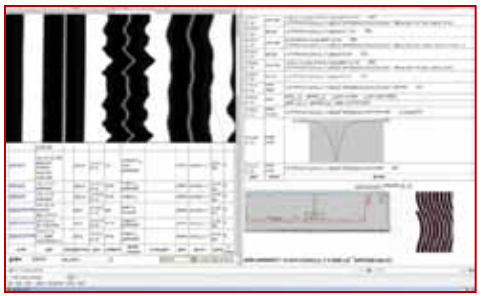








Results database



IRENE User Interface for Production Scanning

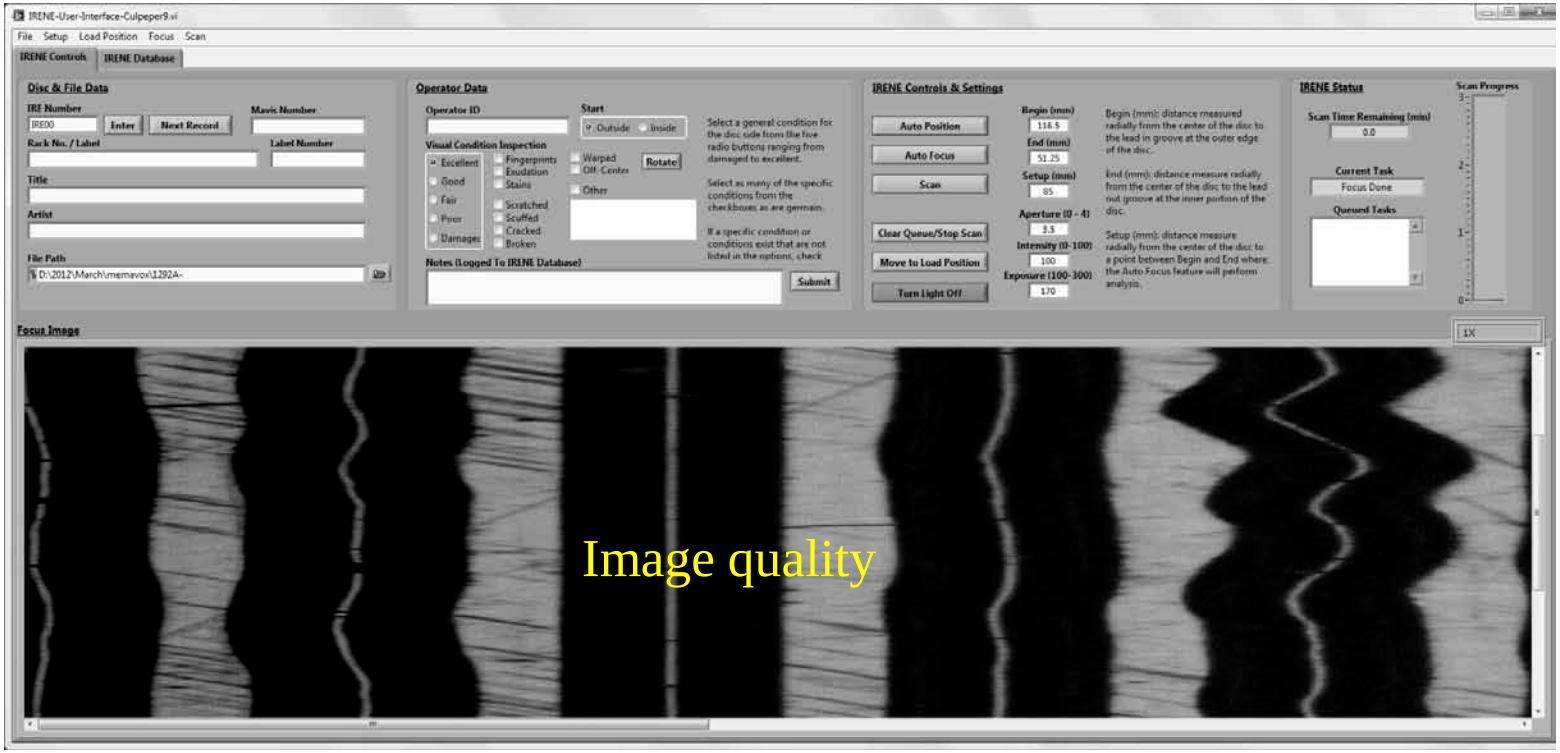
- Developed in collaboration with the Library of Congress
- 3rd generation run control interface for 2D disc scanning

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

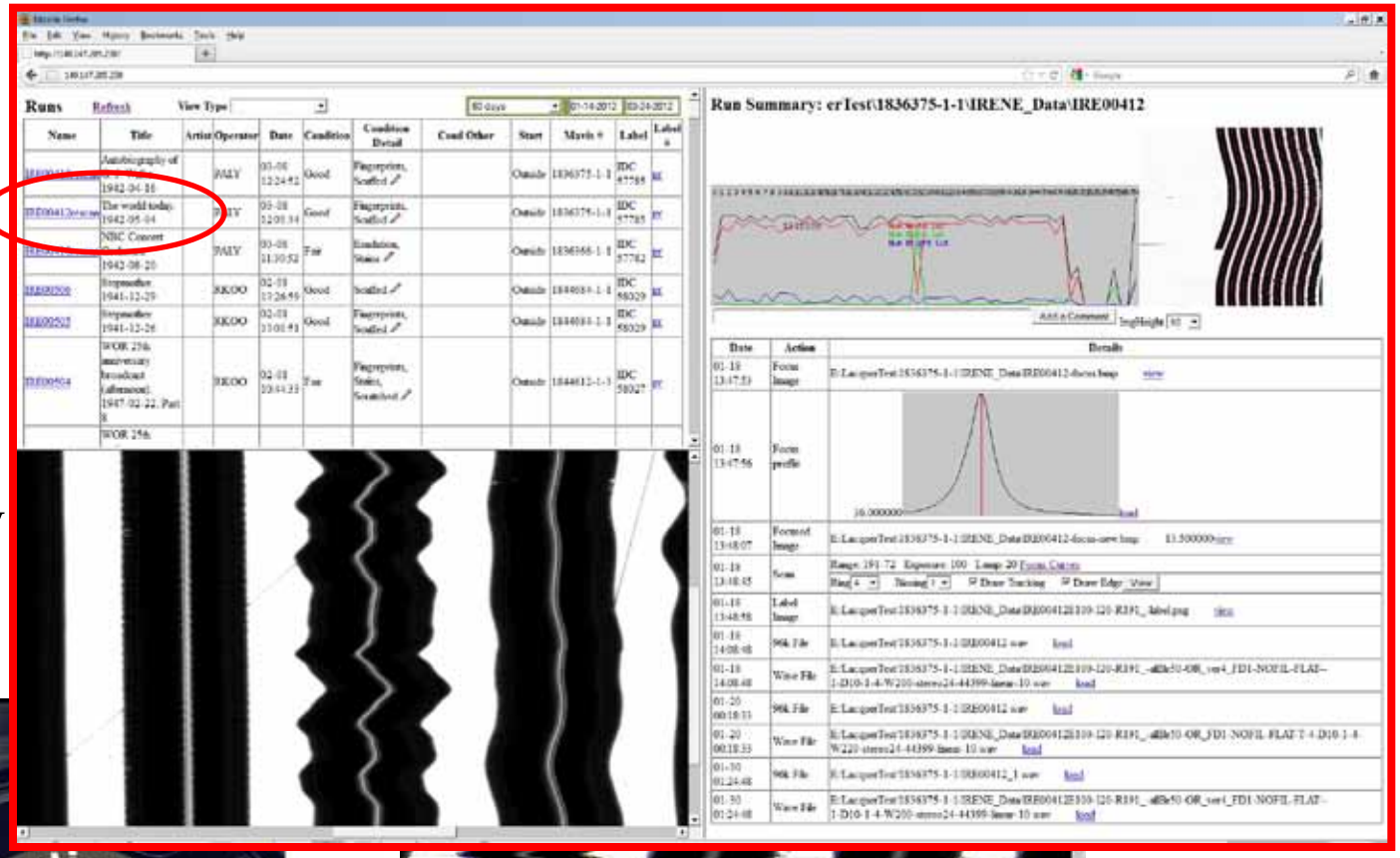


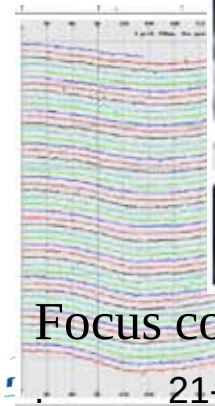
IRENE Database for Production Scanning

IRE00412
The World Today
1942-05-94

Initial focus quality

Label shot





Focus control

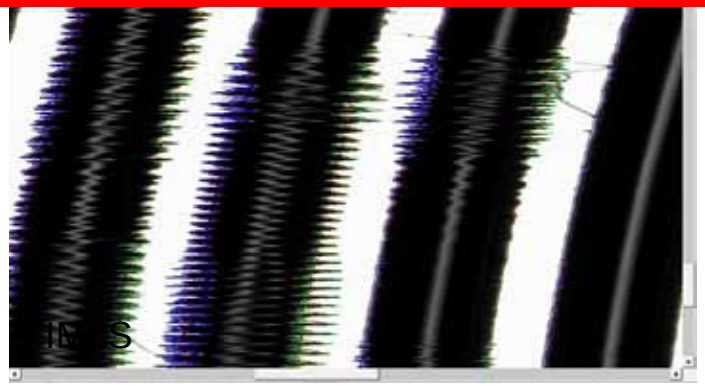


Image analysis

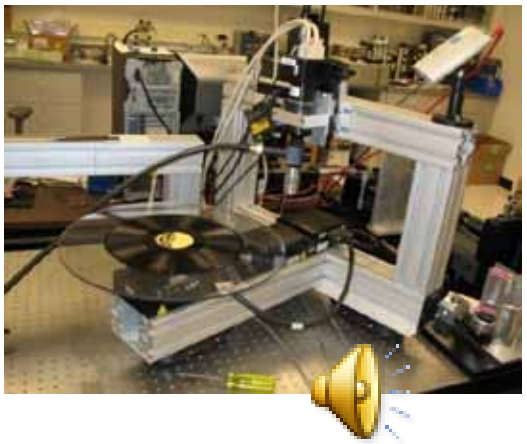
Audio

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

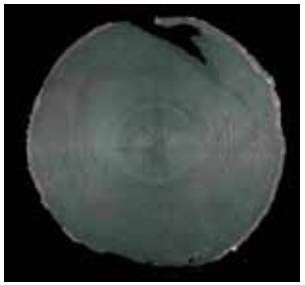
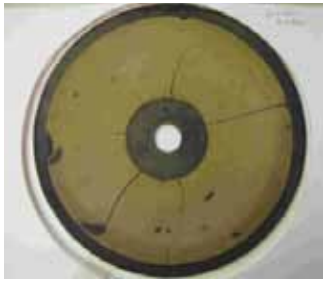
Portable System

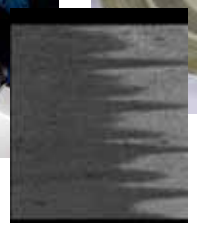
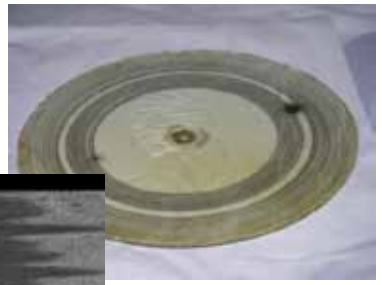
- Native scanning system utilizes heavy vibration isolation, various expensive components.
- A more portable, less expensive variation is attractive for a variety of needs.
- Target was R.Muthiah Research Library, Chennai, through U. of Chicago South Asia Library collaboration (large early 20th Century 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



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).

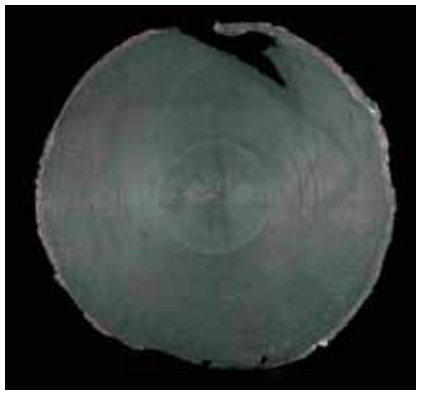



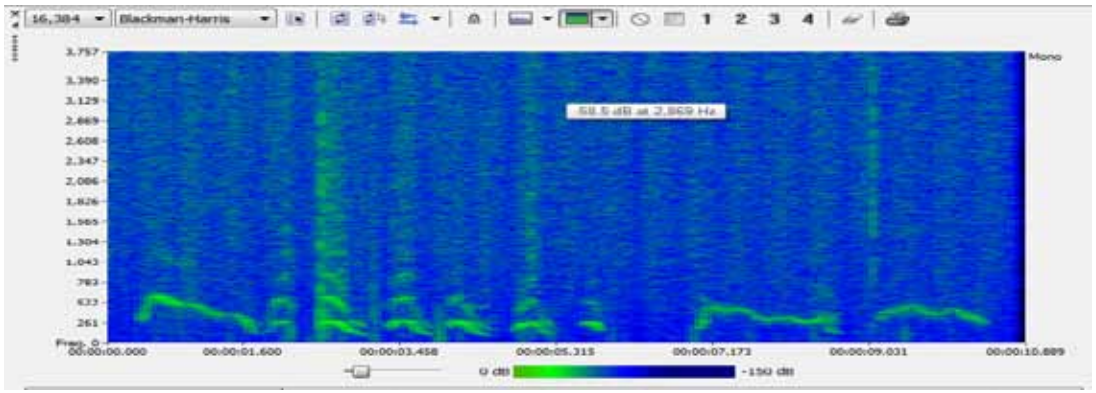
Electroformed Copper Stamper (1881)

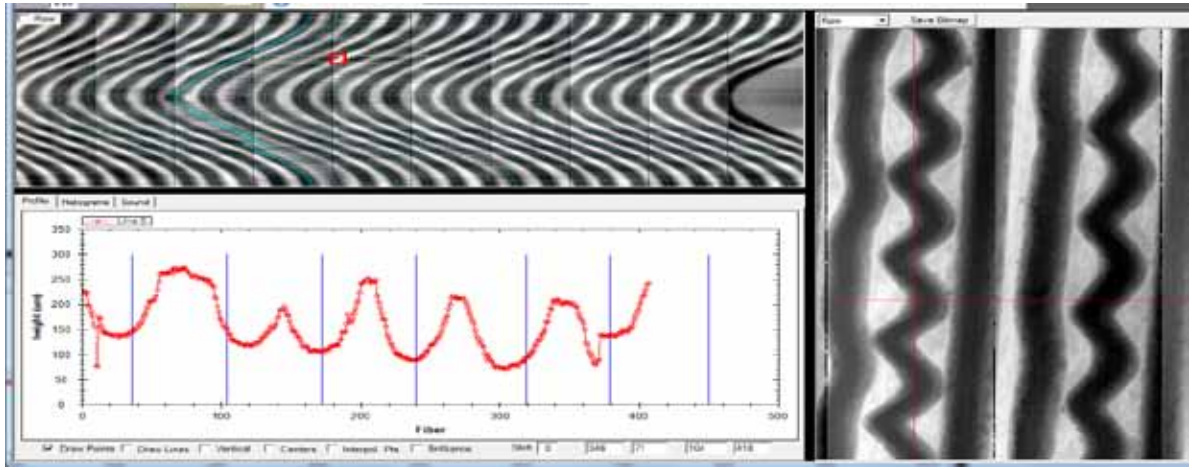
prob. earliest example of a lateral cut disc record!

Restored in 2011 using 3D optical scan

Trrrrrr 1 2 3 4 5 6 trrrr trrrrr





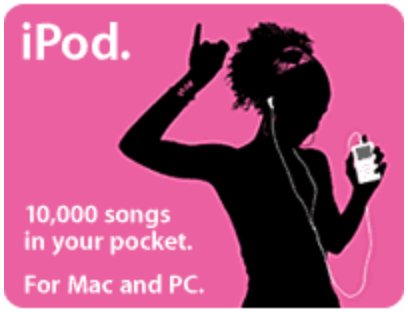


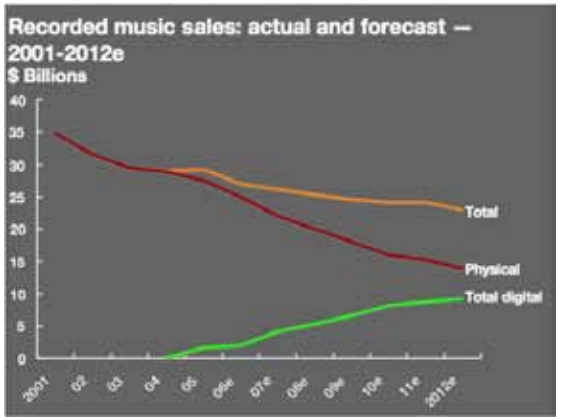
Accompanying Notes

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."

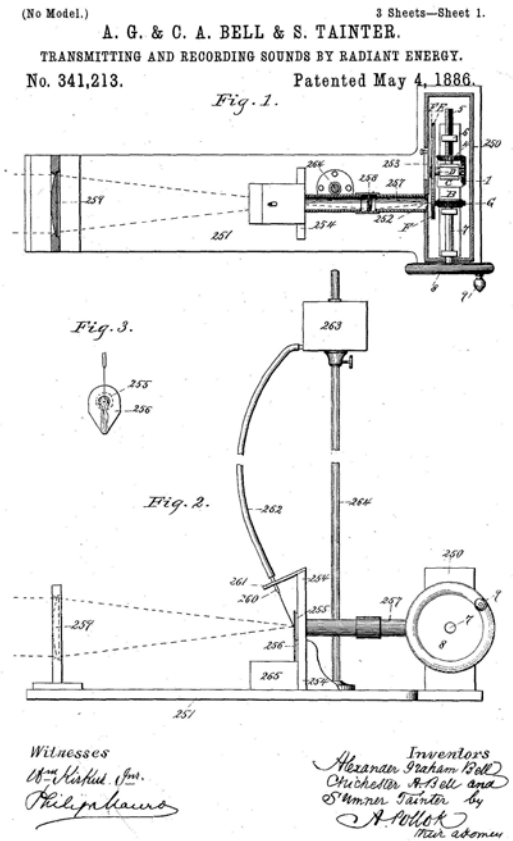




Optical Sound Recorder (1885)

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.

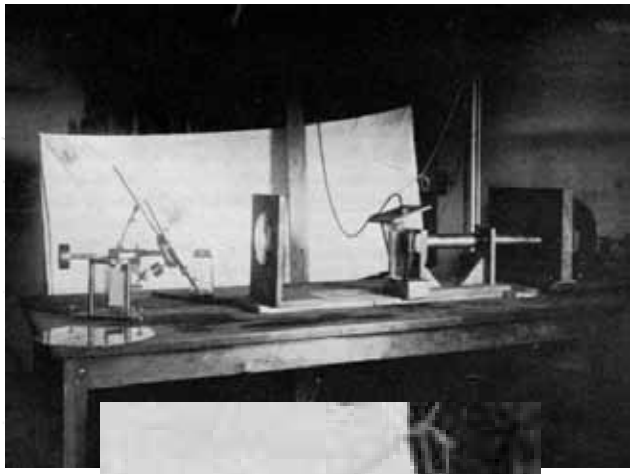
Fig. 1.

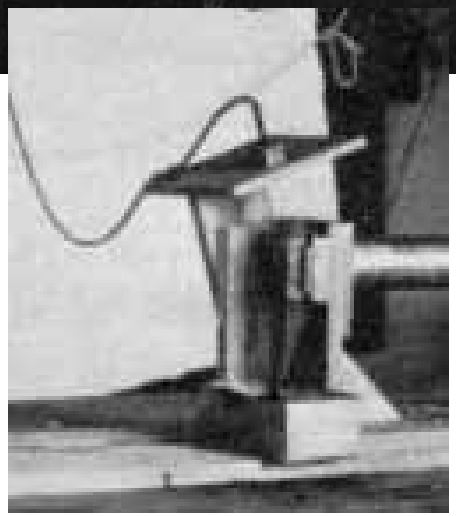
Fig. 3.

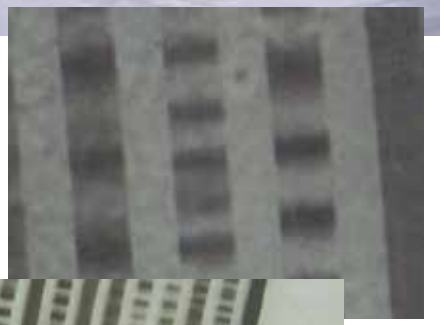
Fig. 2.

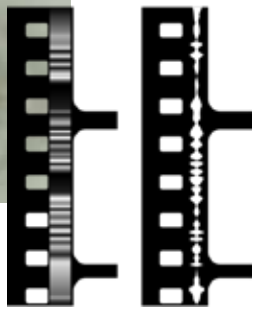
Witnesses

Inventors









…H G Rogers

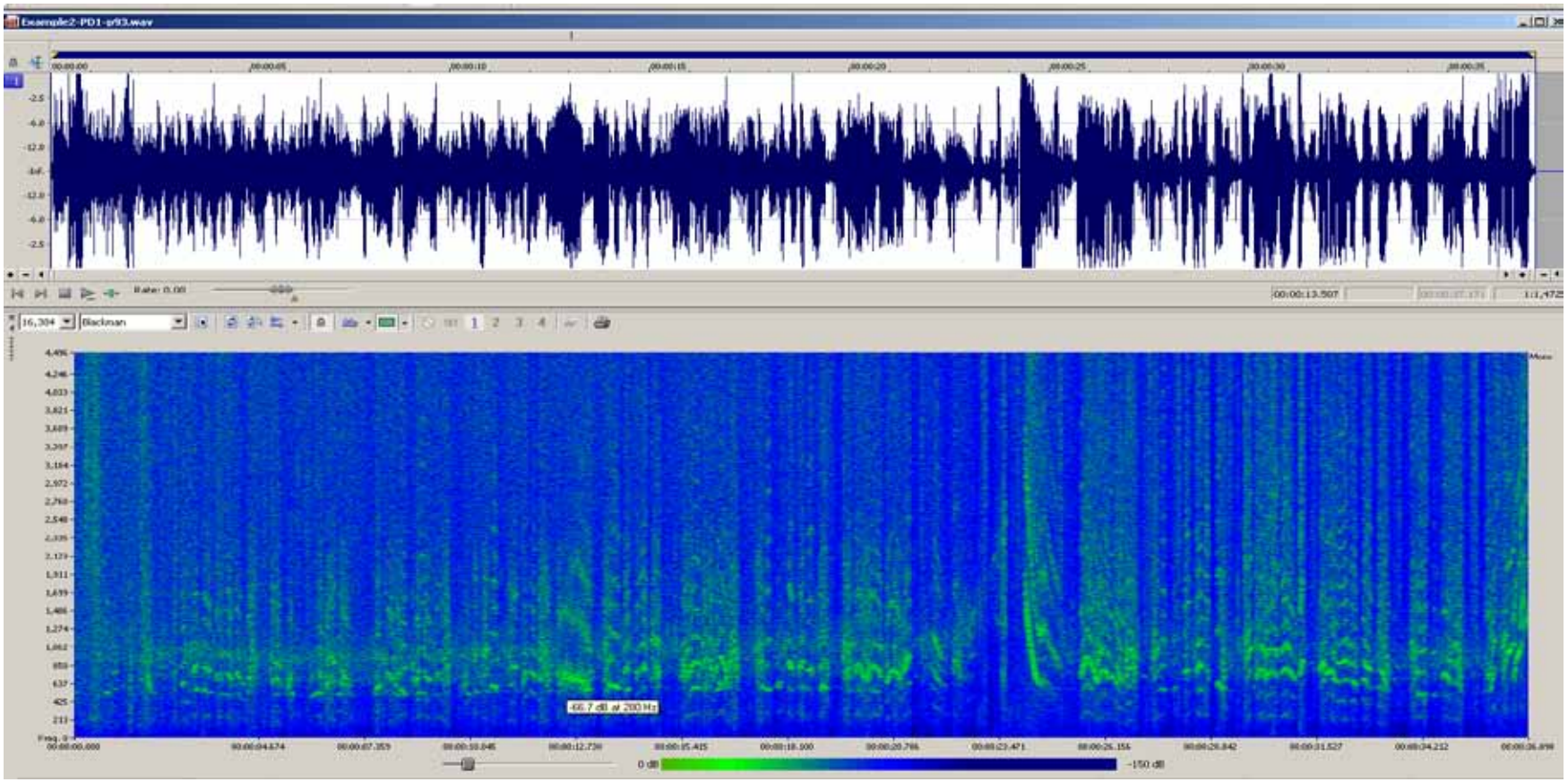
It's the 11th day of March 1885

Trrr..?who put in the pipe ??

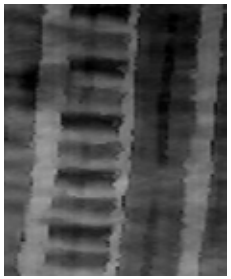
Mary had a little lamb and its fleece was white as snow. Everywhere that Mary went..oh no!

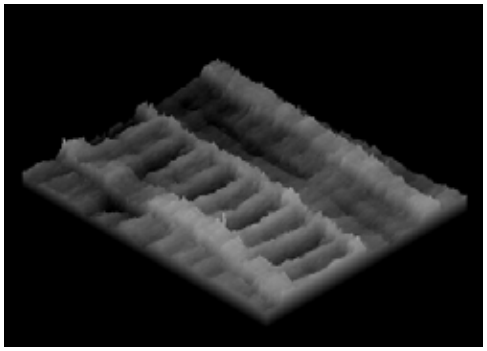
Trrr.. Mary had a little…

How's that for high? Trrr…



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



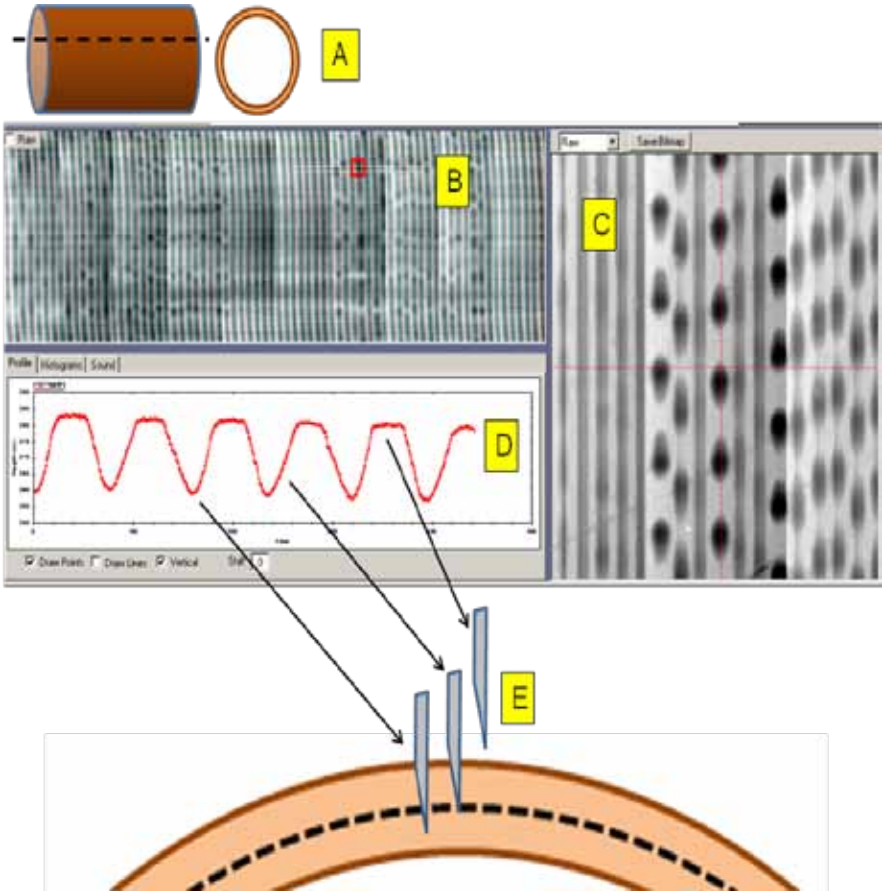


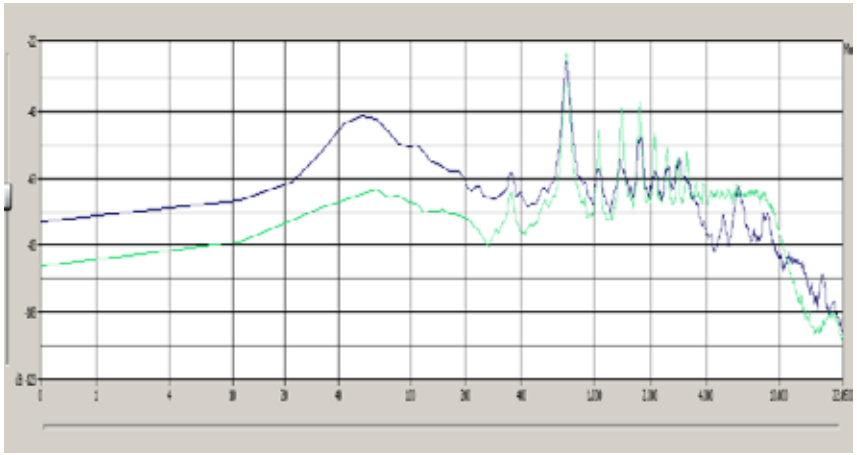
- This item was an experimental prototype for product sold by Edison some years later
- It is believed to be the first known recording of a woman and the first recording made for commercial purposes
- The product was a flop and Edison referred to the dolls as "little monsters", he had the remainder buried.
- 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

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



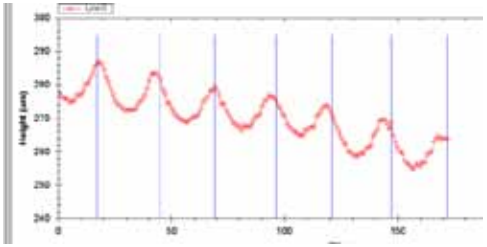


Stylus version (black)

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

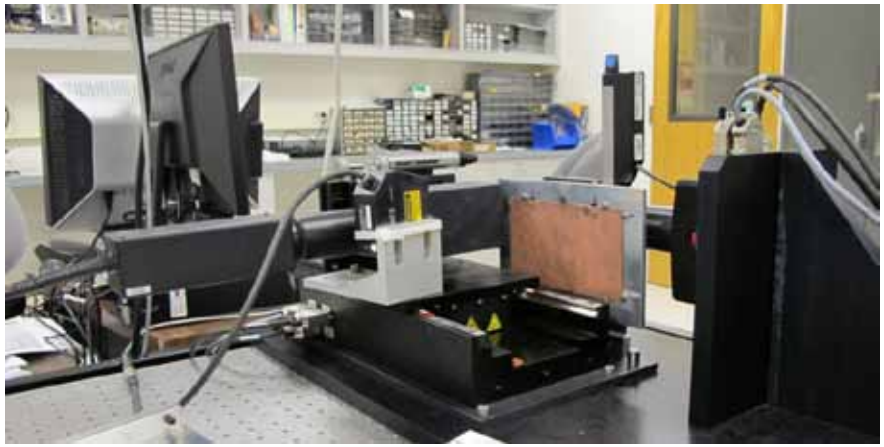


Galvano Study

- 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

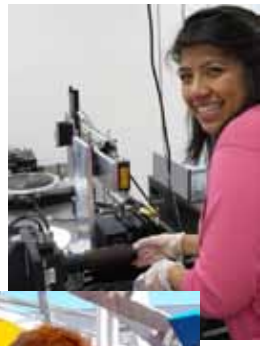
Stylus

3D



Collaboration, Sociology, and Outreach

- Strong collaborative response from collections communities, large and small.
- Considering we came from the “outside”, been amazed by the engagement, openness, and enthusiasm we have encountered.
- For scientists, the opportunity to study the earliest attempts to record information, has been, well…!!!!
- ~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/

- Sound historian, discographer, and author Tim Brooks, quoted in the New York Times, Jan. 30, 2012, describes the: "…explosion of discoveries in early recorded sound over the last five years."
- "The ability to digitize old recordings and the use of new imaging techniques to map the grooves of damaged cylinder records without touching them has contributed to the onslaught", Mr. Brooks said, adding, "You can actually hear history as well as read about it."