Audio and video carriers

- Recording principles
- Composition of carriers
- Stability
- Deterioration

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Type of carriers

- Mechanical carriers
  - Recording principle
  - Composition of carriers and stability of their components
    - Cylinders
    - Coarse groove discs
    - Microgroove discs
  - Deterioration by replay
- Magnetic carriers
  - Recording principle
  - Composition of magnetic tapes and stability of their components
    - Base film materials
    - Magnetic pigments
    - Pigment binders
  - Stability of magnetic information
  - Deterioration by replay
- Optical carriers
  - Recording principle
  - Composition of carriers and stability of their components
  - Recording quality as a constitutive factor of life expectancy of recordable optical disks
  - Deterioration by replay

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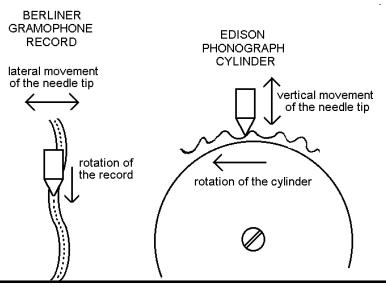
Mechanical carriers

- Oldest type of carriers for audio recordings and reproduction
  - cylinder phonograph (1877) 1888 ➔ late 1920s
  - mechanical disc: late 19th century ➔ 1980s
    - CD
- Recording principle
  - originally purely mechanical
  - electrical amplified system (around 1925)
  - optical replay



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Cylinders

- Modulation of the sound signal is engraved vertically
  - wax cylinder: self recorded
  - cylinder replication
    - from masters: few copies
    - from a galvanoplastic negative
- Wax cylinders
  - chemically fairly stable, if properly stored
  - highly susceptible to fungus growths
    - a typical storage artifact is fungus.
- Celluloid cylinders
  - suffer from fragility of the cellulose nitrate surface
- Mechanically, all wax cylinders and the plaster cores of celluloid cylinders are extremely fragile.

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Wax cylinders

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Gramophone discs

- Emile Berliner invented the gramophone in 1887.
  - The grooves are arranged as a spiral on the surface of a disc.
  - The modulation of the grooves is lateral
  - Galvanoplastic negatives can be easily made
    - the first metal negative ("father") serves only as a master for a metal positive ("mother").
    - This is used to produce an unlimited number of metal stampers ("sons") which are used as the pressing tools for the replicated discs.
- Types of discs
  - Shellac Discs
  - Instantaneous Discs
  - Microgroove Discs

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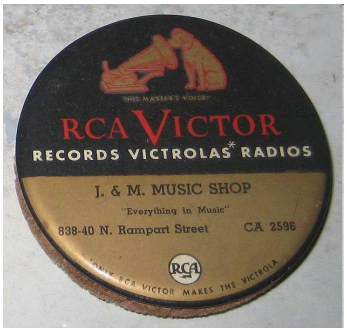
Shellac discs

- Replicated coarse groove discs (shellacs)
  - from 1888 to mid 1950s
  - material: shellac (*gommalacca*)
    - a mixture of mineral powders bonded together by binders, originally containing shellac resin.
    - chemically generally very stable if kept under fairly dry conditions.
    - fragile



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Instantaneous Discs (*direct-cut discs*)

- from 1940
- The same discs were used for both the recording and the replay without the need for galvanoplastic processing and pressing.
  - Their surfaces are soft enough to permit the cutting of the groove but hard enough to permit a number of replays.
- Most of these discs are unique recordings.
- Material (acetate)
  - substrate: metal (or glass)
  - A lacquer coating, consisting mainly of cellulose nitrate, carries the information.
- The lacquer coating becomes fragile with age and shrinks,
  - often crazing and flaking off the substrate.
- may craze at any moment:
  - should be immediately transferred to digital

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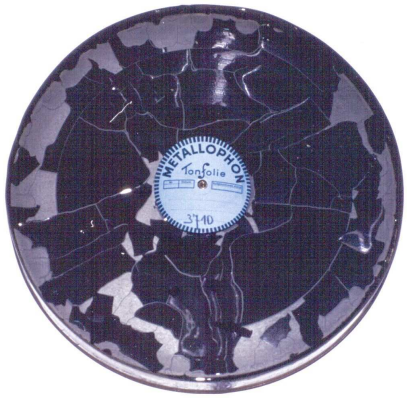
Instantaneous disc

Instantaneous disc 1990

2001



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Microgroove Discs *(LPs, vinyls)*

- From the late 1940s onward
- Material
  - co-polymer of polyvinyl chloride (PVC) and polyvinyl acetate (PVA)
- Two new formats.
  - RCA:
    - seven inch (= 17 cm) disc
    - runs at 45 rpm
    - playing time of three minutes per side
      - the same as the old shellac disc format.
  - Columbia:
    - 10 inch (= 25 cm) LP, later enlarged to 12 inch (=30 cm),
    - run at 33⅓ rpm.
    - Playing times are 15 and 25 minutes per side, respectively.

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Microgroove Discs *(LPs, vinyls)*

- Almost amorphous structure of the material
  - allowed much finer mechanical signal representation
    - narrower grooves,
    - lower speeds
    - ➔ longer playing times possible.
  - produced considerably less surface noise than shellac discs.
- PVC/PVA co-polymer is chemically very stable.
  - Apart from few very early discs, all are in good shape.
- The material is comparatively soft,
  - ➔vulnerable to mechanical damage, e.g. to scratches.

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Deterioration by replay

- With all mechanical formats the rate of deterioration in normal use is high.
- Most of the preserved mechanical records are, therefore, not in their original shape and quality.
- The quality and the correct adjustment of replay equipment is not only a constitutive factor for the replay of the signal.
  - Misalignments and inexperienced operation may severely damage, even destroy a mechanical carrier.
- Electrical shellac records from around 1930 onward and microgroove discs
  - can be transferred by trained and skilled staff.
- Cylinders, early shellacs, and all instantaneous discs
  - must be handed over to more experienced specialists.

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Magnetic carriers

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Magnetic recording: history (audio)

- Developed in the 1930s by AEG Telefunken
  - widely used within the German Radio.
- Late 1940s ⇔ early 1950s:
  - broadcasters and recording industry.
- From around mid-1950s onward
  - home audio recorders, which operated at slower speeds.
- In the 1960s, several cassette formats were developed.
  - the compact cassette swiftly dominated the market
- Digital audio recording on magnetic tape was introduced in the 1980s.
  - R-DAT, a digital recording cassette format
- All audio-specific magnetic tape formats are now, in practice, dead

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Magnetic recording: history (video)

- From 1956 onward, for video recording.
  - Several professional reel-to-reel formats, until the late 1970s.
- For home recording,
  - around 1970: early open reel formats
  - around 1980: cassette home formats, e.g. VHS format.
- For small handheld camcorders ("handy cams")
  - an 8mm cassette system became popular (Video8, VideoHi8) which was still in use in the early 2000s.
- Digital recording:
  - in the mid-1980s: for professional use
  - in the mid-1990s: digital home formats.
- Video-specific magnetic tape formats are still in wide use:
  - but recording and storage will also become part of the IT world.

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Magnetic recording: history (IT)

- Audio recording, post production and storage
  - part of the IT (computer) world with its nonaudio-specific carriers and formats.
- Magnetic media:
  - the most prominent storage media of the IT world.
    - Magnetic tape: computer backup medium
    - Hard disk drives (HHD): in professional and home applications.
- Magnetic disk technology:
  - for portable recording and replay audio and video
  - the backbone of professional digital audio and video archiving
- The principles are also more or less valid for magnetic computer media.

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Recording principle

- A magnetic tape is moved across a recording head.
  - varying magnetic field
  - magnetic layer
- Signals can be retrieved by running the tape across a replay head.
- Audio tape:
  - the head is stationary while the tape is moving.
- Analogue video, as well as digital audio and video signals,
  - higher recording speeds
  - a rotating head
- An intimate tape to head contact is essential.
  - keep storage and handling areas clean.

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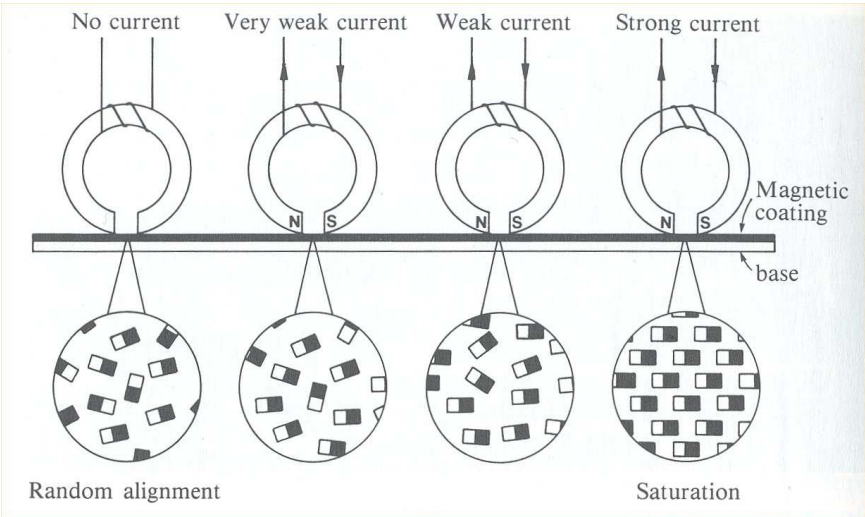
Magnetization



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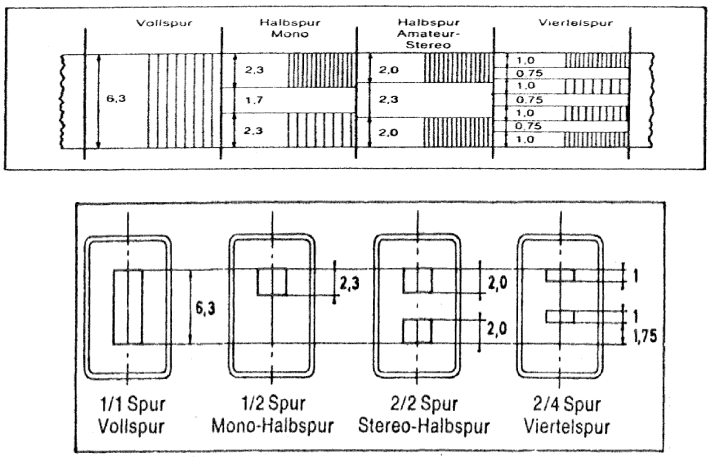
Quarter inch audio tape track formats



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Composition and stability of magnetic tapes

- Magnetic tape is composed of two layers:
  - the base film
  - the magnetic layer
- *Base film materials*
  - cellulose acetate (AC): mid-1930s ⇔ mid-1960s
    - deteriorates with time:
      - becomes brittle and shrinks
      - high humidity levels and high temperature: deterioration
      - ➔ endangered carriers
  - polyvinyl chloride (PVC): 1944 ⇔ 1972
    - no systematic chemical deterioration
    - electrostatic behaviour: winding
  - polyester (polyethylene-terephtalate, PE or PET): late 1950s onward
    - mechanically robust and chemically very stable.

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Composition and stability of magnetic tapes

- *Magnetic pigments*
  - γFe_2O_3 chemically stable, low information density
  - other pigments
    - e.g. pure iron particles (MP, **M**etal **P**article): potentially endangered.
- *Pigment binders*
  - cellulose acetate, then PVC, and polyester urethane (PEU)
  - lubricants to minimize friction between tape and heads
- Stability of magnetic information
  - magnetic information does not vanish with time.

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Deterioration by replay

- Fairly modern and well preserved magnetic tape can be replayed several hundred times without any measurable loss of quality.
  - well maintained replay equipment of the latest generation which handles the carriers gently.
- Old or poorly serviced machines may severely deteriorate a tape
- Cleaning and de-magnetizing is an important routine measure to remove the danger
  - of damage to tape surfaces
  - of magnetic deterioration of the tape.

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Optical carriers

- In the form of photographs, they have been in use for analogue image representation for almost 160 years.
- In the form of moving images, for over 100 years.
- For the storage of electronic audio and video signals
  - the youngest group of carriers
- Compact Disc: in 1982 (Red Book standard).
- "CD-ROM: in 1985 (Yellow Book standard)
- 1991: recordable CDs (CD-Rs) and rewritable CDs (CD-RW, Orange Book standard)
- 1985: DVD
- HD DVD and the Blu-ray Disc (BD)
  - lasers of shorter wavelength ("blue laser")

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Recording principle

- *Replicated CDs (CD-ROMs)*
  - a transparent body of polycarbonate of 1.2mm thickness
  - "pits" (holes) and "lands" (non-holes) of different lengths
- *Recordable optical disks (dye disks, CD-Rs, DVD-Rs)*,
  - a preformed groove in the upper surface of the polycarbonate body filled with an organic dye
  - recording is made by a laser of much higher energy
- *Rewritable disks (CD-RWs, DVD-RWs or RAMs)*
  - a metal alloy film which,
  - creation of a pattern of amorphous and crystalline spots
  - this process is reversible.

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Composition and stability of carriers

- The polycarbonate used for optical disk bodies is a transparent polymer.
  - modern polycarbonate stable for several decades (*hope*)
- Aluminium, silver, silver alloys and gold are used as reflective layers.
  - All, except gold, are prone to oxidation.
- The protective lacquer layer of CDs must be resistant against penetration of humidity.
- Oxidized reflective layers, particularly aluminium, render optical disks unreadable.

- With DVDs, unknown the stability of:
  - the semi-transparent layer in dual layer disks
  - the bonding that keeps the two halves of a DVD together.
  - the colors used in recordable CD/DVDs.

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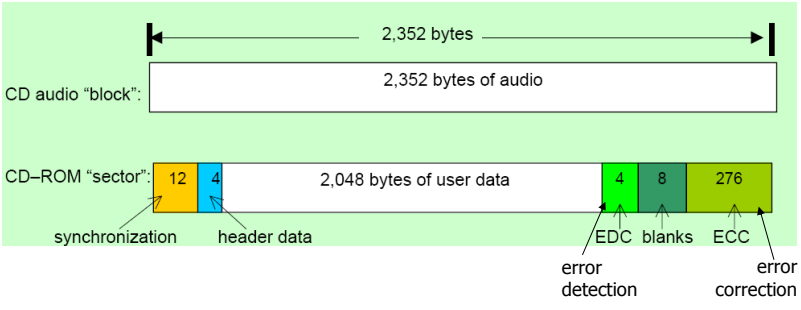
Recording quality and life expectancy

- Recordable optical disks reliability depends on a error correction system.
  - The error correction capability is limited
  - ➔ almost error free recording
    - to compensate for handling and ageing effects



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Optical carriers: care

- Proper care of optical carrier includes:
  - Keeping discs out of direct sunlight and with limited exposure to light in general.
  - Keeping discs in a cool, dry environment. What is most comfortable for humans is most comfortable for discs, too.
  - Keeping the discs away from large swings in temperature and humidity.
  - Keeping discs in protective cases when they are not being used.

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Reference

- Dietrich Schüller: Audio and video carriers. p. 1-9

  http://www.tape-online.net/docs/audio_and_video_carriers.pdf

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