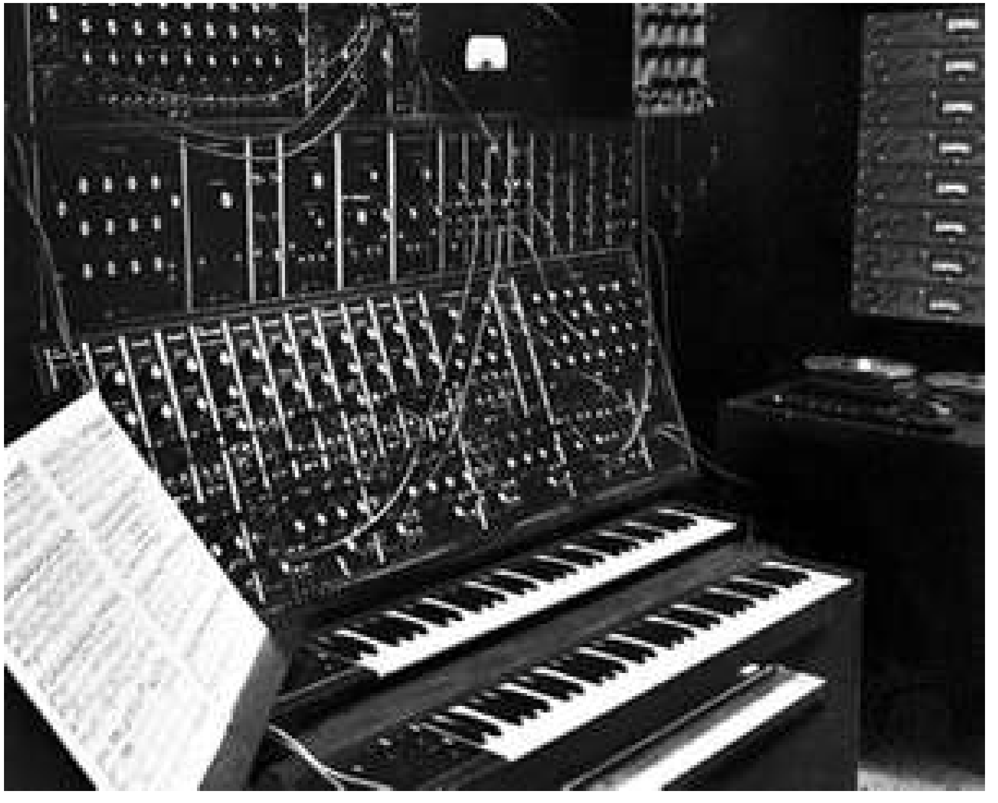
Physics 1240: Sound and Music

Today (8/6/19): Electronic Sound: Instruments, Editing

Next time: Special Topics



Review

Types of Instruments
(Hornbostel–Sachs classification)

- Chordophones: vibrating strings

- Aerophones: vibrating columns of air

- Idiophones: vibrating the whole instrument

- Membranophones: vibrating membrane/skin

- Electrophones: vibrating loudspeaker

Review

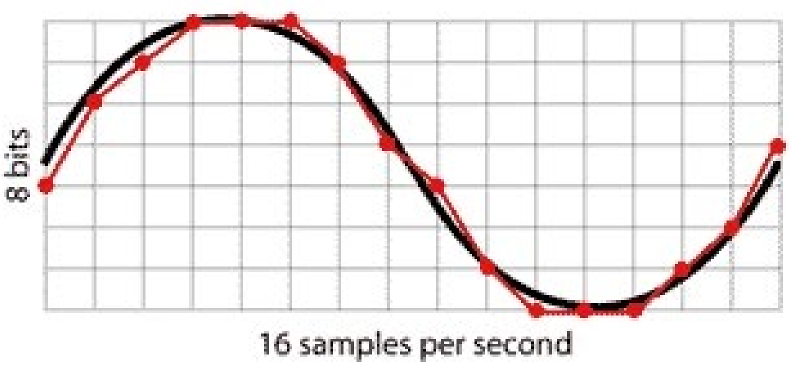
- Transducer: any device that converts a signal from one energy form to another
  - *Loudspeaker*: voltage oscillations in magnetic coil move diaphragm to produce sound
  - *Microphone*: sound moves diaphragm to produce voltage oscillations
    - condenser vs. dynamic, omni vs cardiod

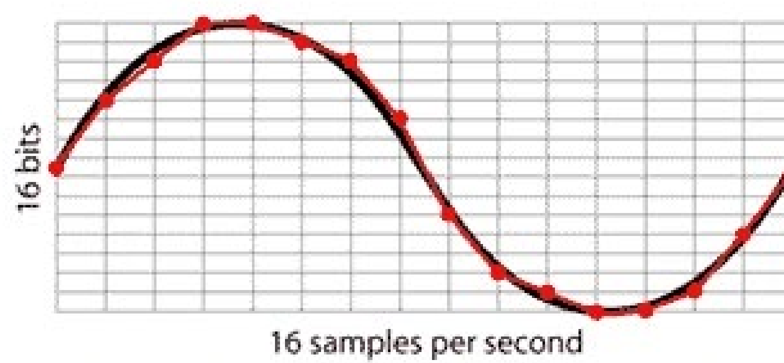
- Analog (continuous signal) vs digital (discrete signal)

Electric Recording

- Sampling rate: how often analog signal is measured [samples per second, Hz]
  - e.g. 44,100 Hz

- Sampling resolution ("bit depth"): precision of numbers used for measurement: the more bits, the higher the resolution
  - e.g. 16 bit





BA

Clicker Question 20.1

What is one advantage of recording with a phonograph disc instead of a CD?

A) Phonographs are a more recent technological advance
B) Phonographs are analog, whereas CDs can only approximate the acoustic wave patterns
C) Phonographs record equally in all directions, whereas CDs have a preferred direction
D) Phonographs can store more information than CDs
E) None of the above

BA

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Clicker Question 20.2

Why does the advantage from the previous question actually not matter much?

A) The typical sampling rate for a CD is much higher than any frequency we can hear
B) The typical sampling rate for a CD is much lower than any frequency we can hear
C) CDs are cheaper and so still win
D) It does matter #vinyl4lyf

BA

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Clicker Question 20.3

If the sampling rate of a cassette tape recorder is 32 kHz, how many samples are present on a cassette where both sides record 30 minutes of audio?

A) 58 million

B) 91 million

C) 115 million

D) 906 million

BA

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$$\left(32000\,\frac{\text{samples}}{\text{sec}}\right)(2\times 30\text{ min})\left(\frac{60\text{ sec}}{1\text{ min}}\right)$$

$$=115{,}200{,}000\text{ samples}$$

BA

Clicker Question 20.4

If the sampling rate for a CD is 44.1 kHz (kHz="1000 samples per second") and the bit depth is 16 bits per sample, how many bits can be stored on an 80-minute CD?

A) 220,500 bits
B) 3,386,880 bits
C) 13,230,000 bits
D) 56,448,000 bits
E) 3,386,880,000 bits

BA

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$$\left(44{,}100\,\frac{\text{samples}}{\text{sec}}\right)\left(16\,\frac{\text{bits}}{\text{sample}}\right)(80\text{ min})\left(\frac{60\text{ sec}}{1\text{ min}}\right) = 3{,}386{,}880{,}000\text{ bits}$$

BA

Clicker Question 20.5

The Voyager Golden Record has a plaque indicating that one rotation of the phonograph record should take 3.6 seconds to complete one revolution. If there are 900 layers of grooves from the outside to the inside, how many minutes of audio are on a single side?

A) 4 min
B) 20 min
C) 54 min
D) 60 min
E) 80 min

BA

$$\left(3.6\ \frac{\text{sec}}{\text{rev}}\right)\left(\frac{1\ \text{min}}{60\ \text{sec}}\right)(900\ \text{rev}) = 54\ \text{min}$$

Clicker Question 20.5

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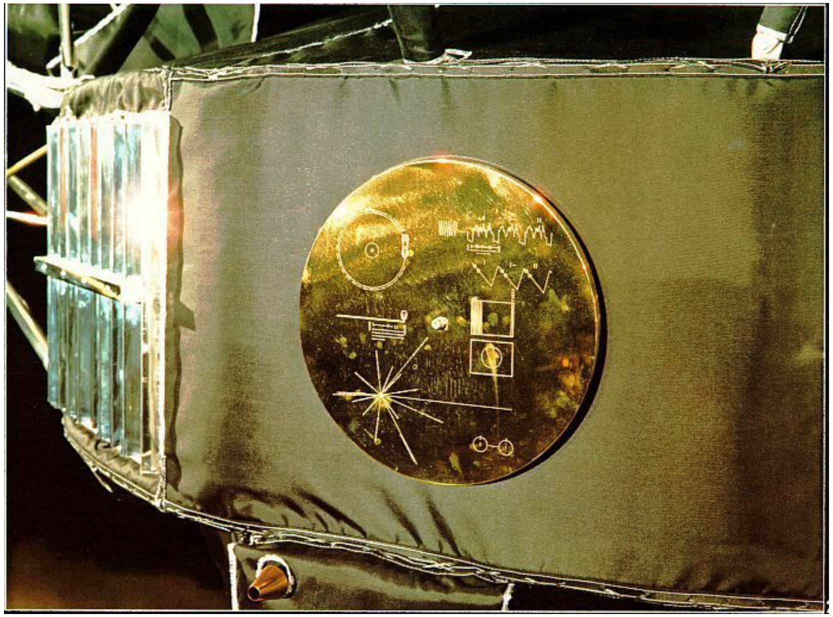
Voyager Golden Records

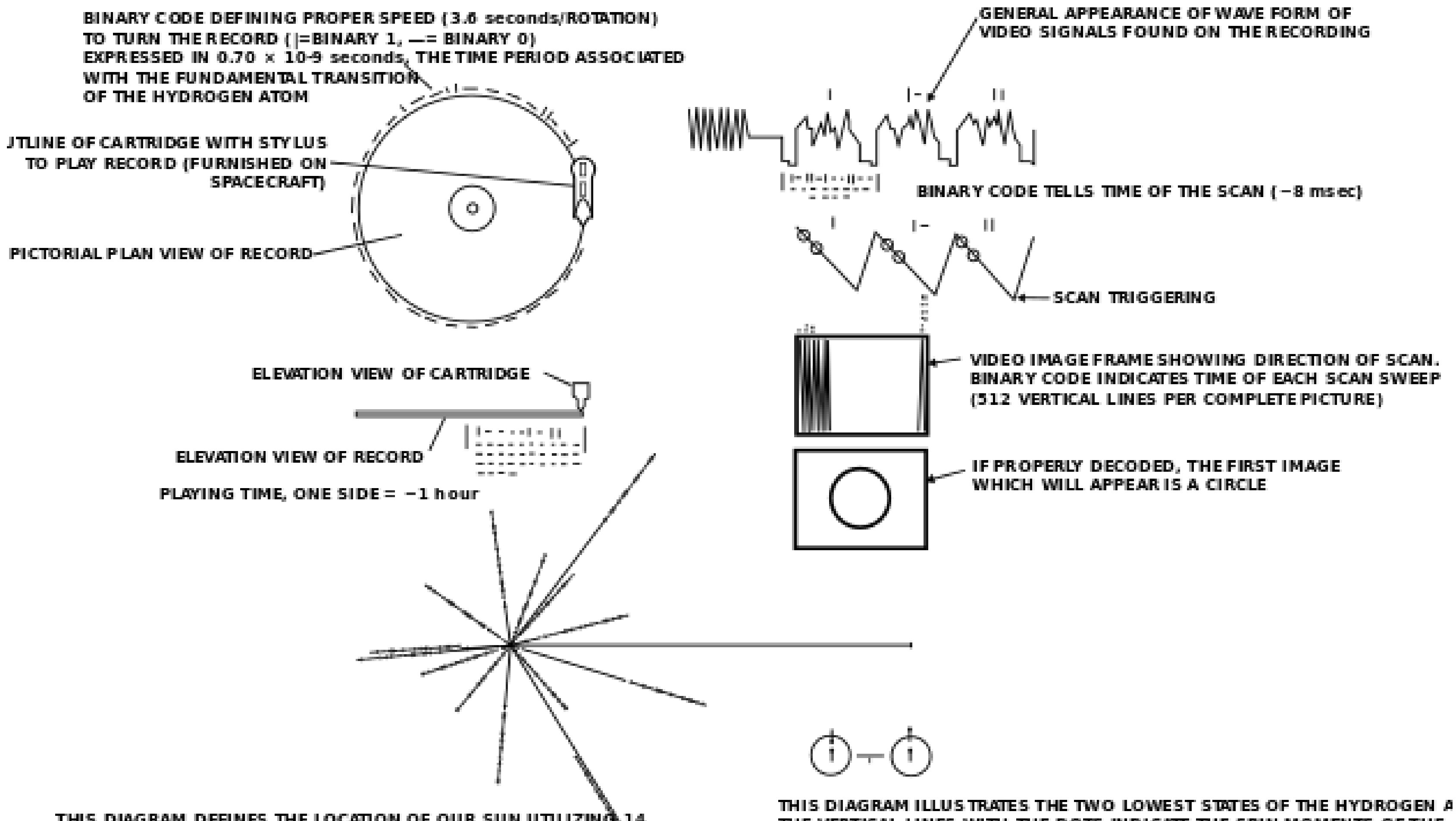
- 2 phonograph records sent into deep space with Voyagers 1 and 2 in 1977
- "Sounds of Earth" selected by Carl Sagan and team of scientists
    - Spoken greetings in 55 different languages
    - Sounds of nature
    - 90 minutes of music



https://www.youtube.com/watch?v=ROMKbthmyOU

EXPLANATION OF RECORDING COVER DIAGRAM

THE DIAGRAMS BELOW
DEFINE THE VIDEO PORTION OF THE RECORDING



THIS DIAGRAM DEFINES THE LOCATION OF OUR SUN UTILIZING 14 PULSARS OF KNOWN DIRECTIONS FROM OUR SUN. THE BINARY CODE DEFINES THE FREQUENCY OF THE PULSES.

THIS DIAGRAM ILLUSTRATES THE TWO LOWEST STATES OF THE HYDROGEN A THE VERTICAL LINES WITH THE DOTS INDICATE THE SPIN MOMENTS OF THE PROTON AND ELECTRON. THE TRANSITION TIME FROM ONE STATE TO THE OTHER PROVIDES THE FUNDAMENTAL CLOCK REFERENCE USED IN ALL THE COVER DIAGRAMS AND DECODED PICTURES.

Digital Sound

- Digital compression: replacing a file with another that is smaller in size (fewer bits)
  - e.g. ZIP: lossless (gets rid of redundant data, but when you unzip a file, all the original data is restored)
- Audio file formats
  - .wav
  - .aiff
  - .wma
  - .flac
  - .mp3
  - MIDI

.wav, .aiff — raw uncompressed

.wma, .flac — compressed (lossless)

.mp3 — compressed (lossy)

MP3

- MP3 format: lossy compression
  - Reduces data from raw file by about 90%

    (compare to ZIP (lossless), which reduces by 10%)
  - Goal: get rid of audio details we wouldn't hear anyway
    - Cuts out repeating info in stereo recording (data that are the same on the left & right tracks)
    - Cuts out frequencies masked by louder frequencies
    - Cuts out frequencies outside of range of hearing

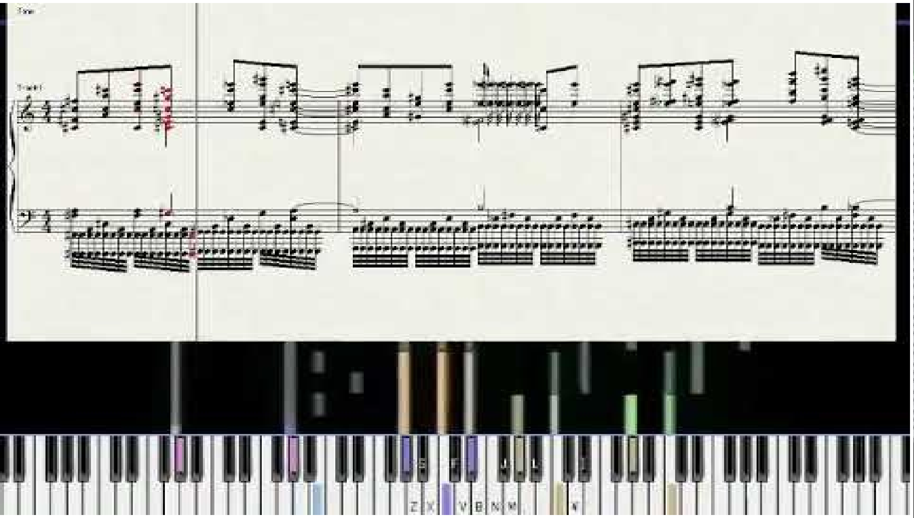
https://www.youtube.com/watch?v=UoBPNTAFZMo

<u>MIDI</u>

- Musical Instrument Digital Interface
- Contains information about each musical note’s pitch, duration, volume, and instrument
- Predecessor: piano rolls

MIDI

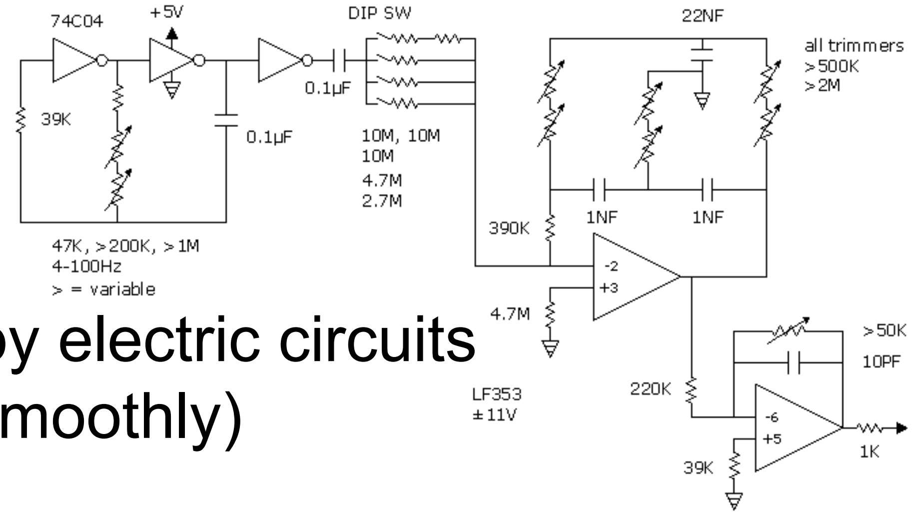
- Advantage: very small file size
- Used for ringtones, synthesizers, samplers, drum machines, games, karaoke, pop music…



MIDI Controllers

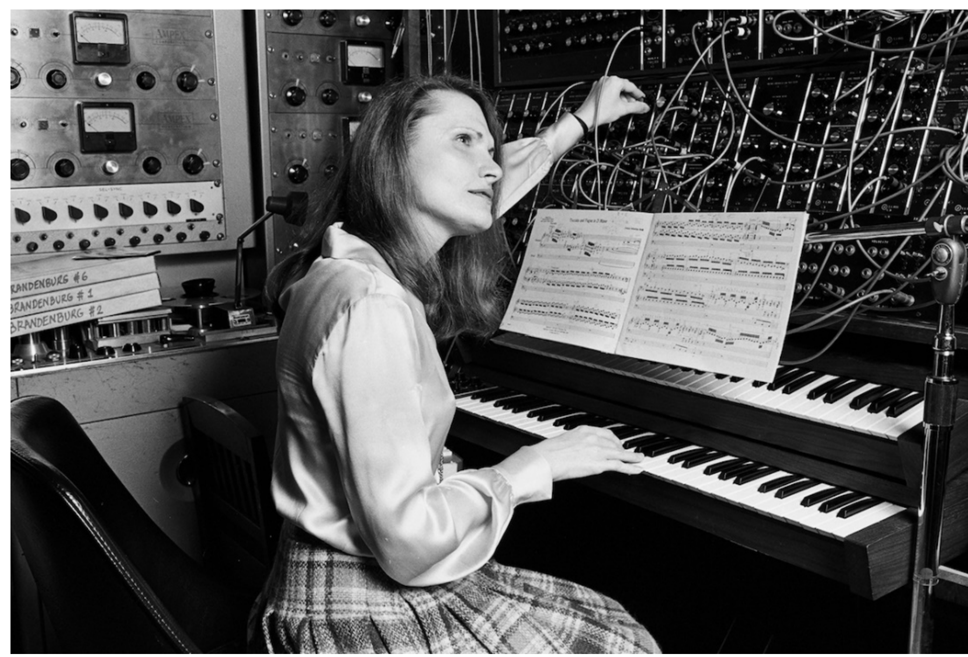
Any device that generates and transmits MIDI data

- Digital: electric keyboard, drum pads, sampler
- Analog: synthesizer



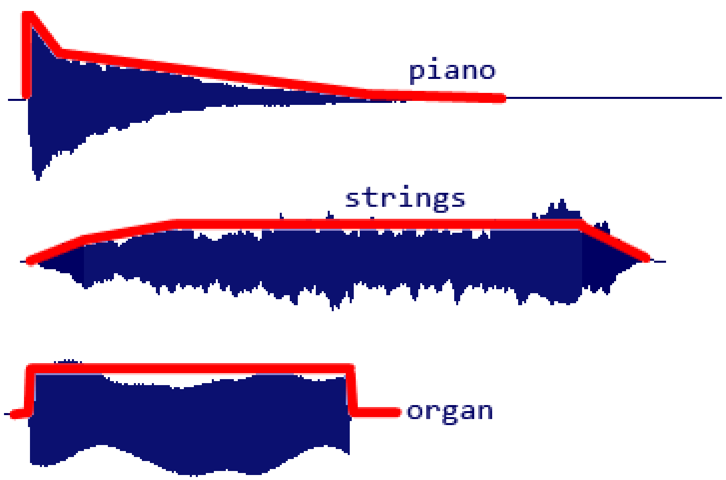
Synthesizers

- Analog: signals generated by electric circuits
  (voltage changes smoothly)
  - Sound adjusted with variable resistors, high-/low-pass filters, ring modulators
- Moog synthesizer (1960s)

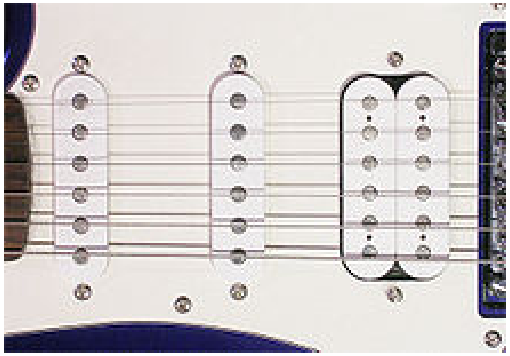


Synthesizer Components

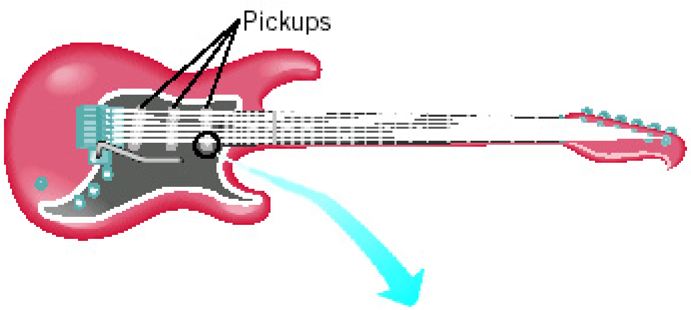
- Additive synthesis: combine waveforms so that their frequencies match the harmonics of an instrument
- Subtractive synthesis: filter out waveforms that are already harmonically rich
  - ADSR sound envelopes
  - Arpeggiator

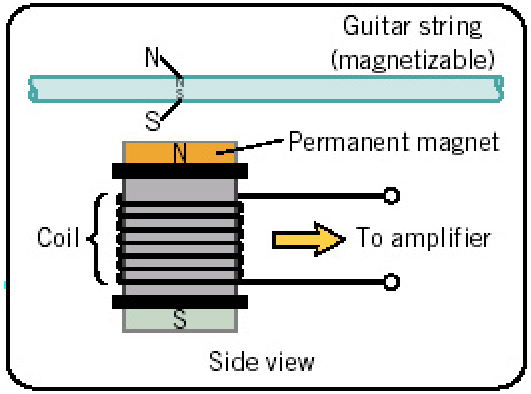


Other Electrophones



- Electric Guitar (1931)
  - *Pickup*: transducer that converts string vibrations to electrical signals
  - Earliest: "Frying pan"

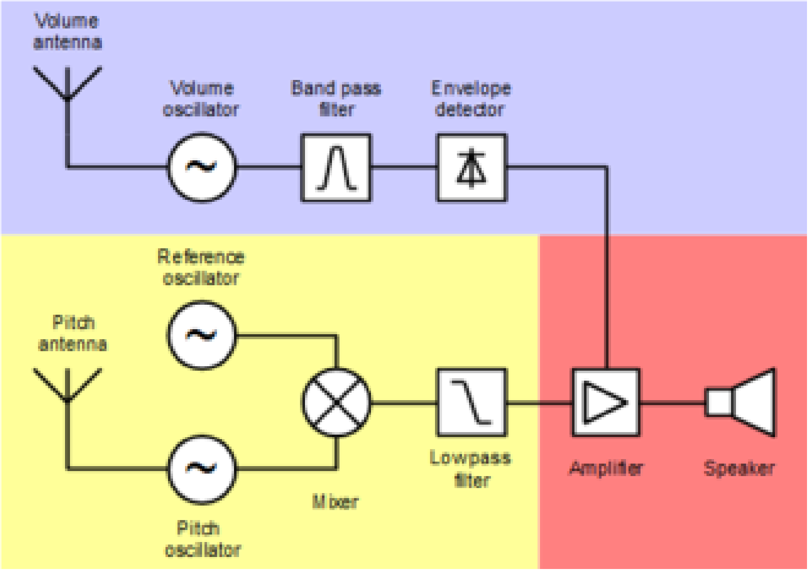




Other Electrophones

- Ondes Martenot (1928)

- Theremin (1920)
  - Hand acts as grounded plate of capacitor
  - One antenna for pitch control and one for volume

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