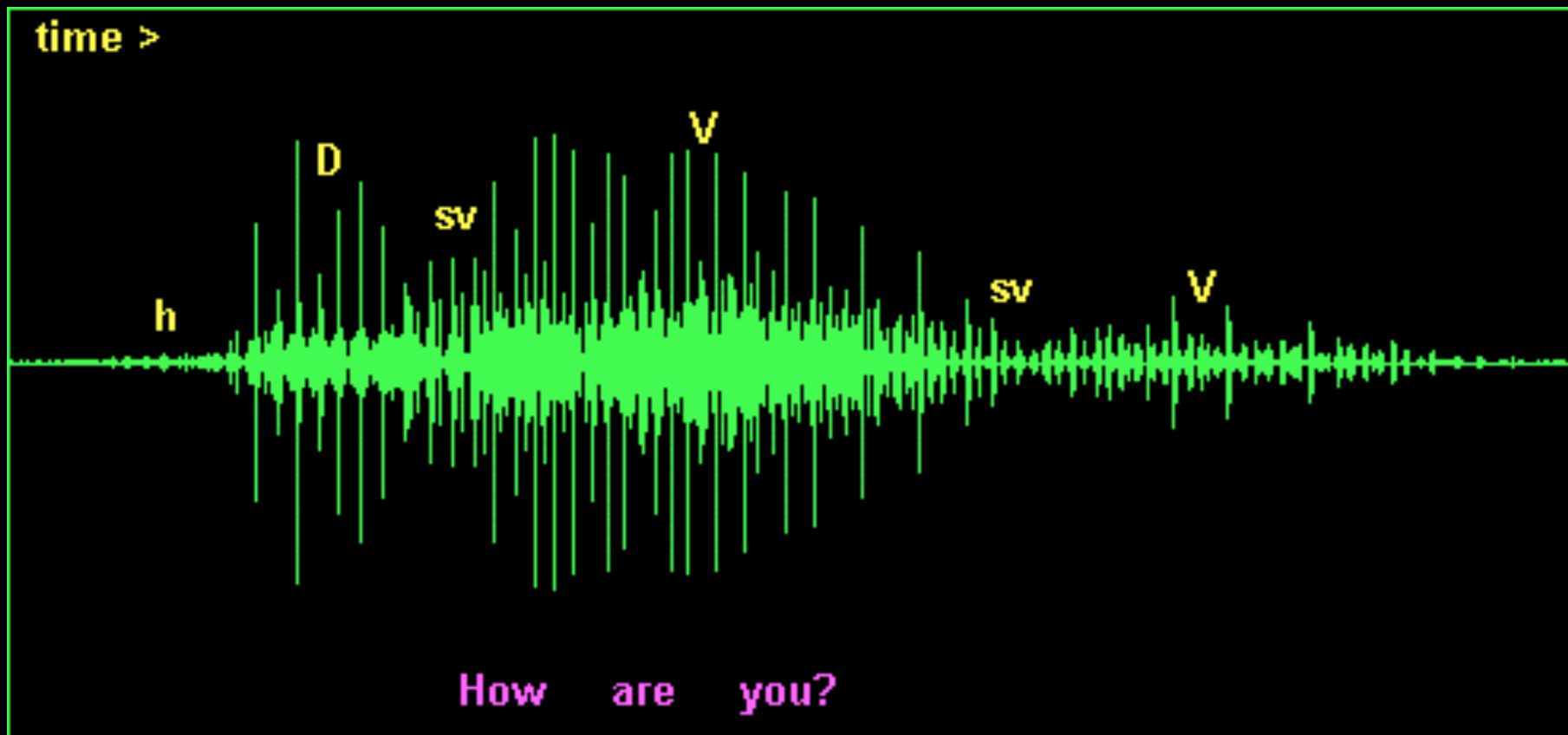


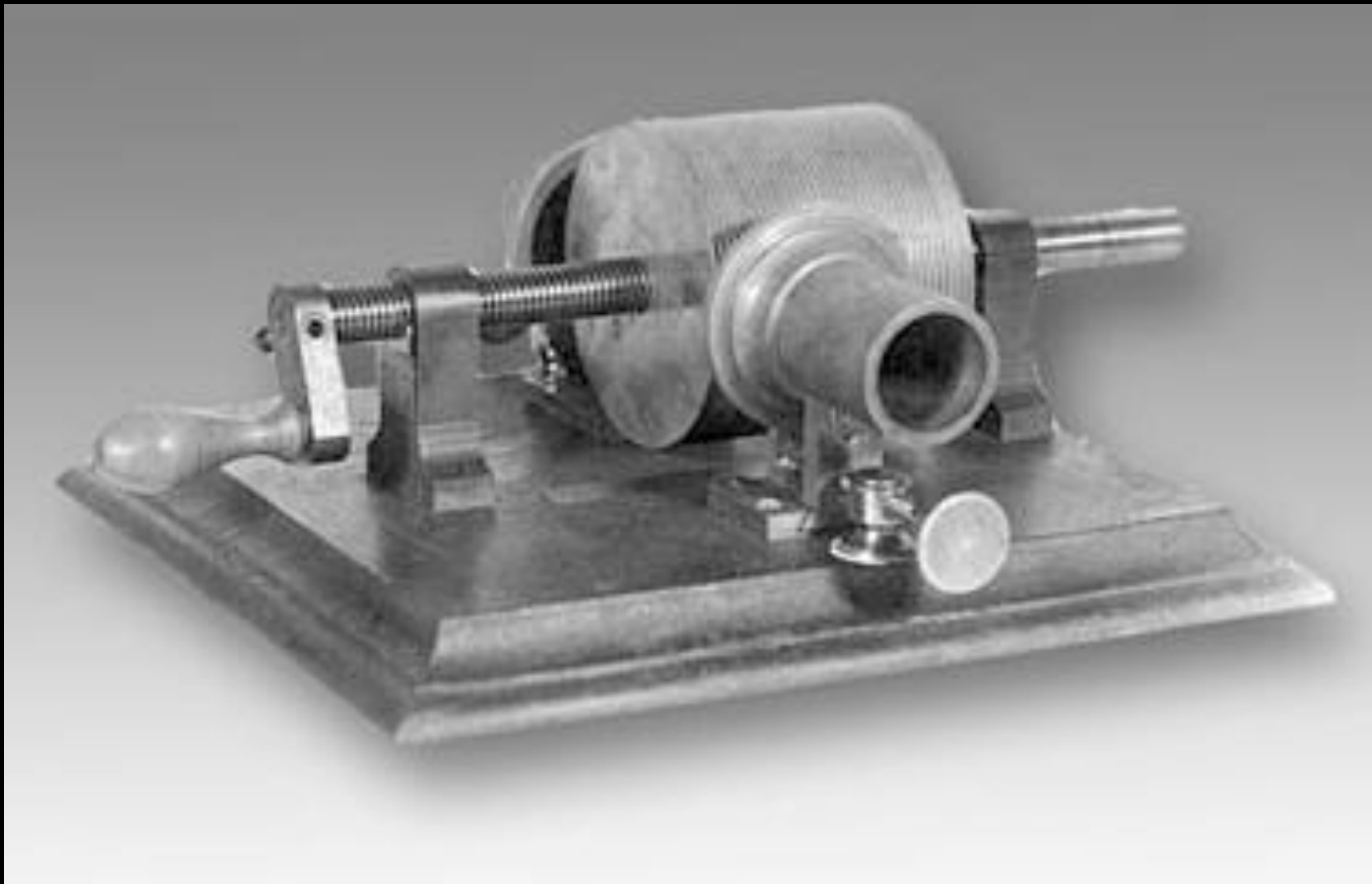
Signals / Storage

FPA 147 Week 2



Analogue Representation





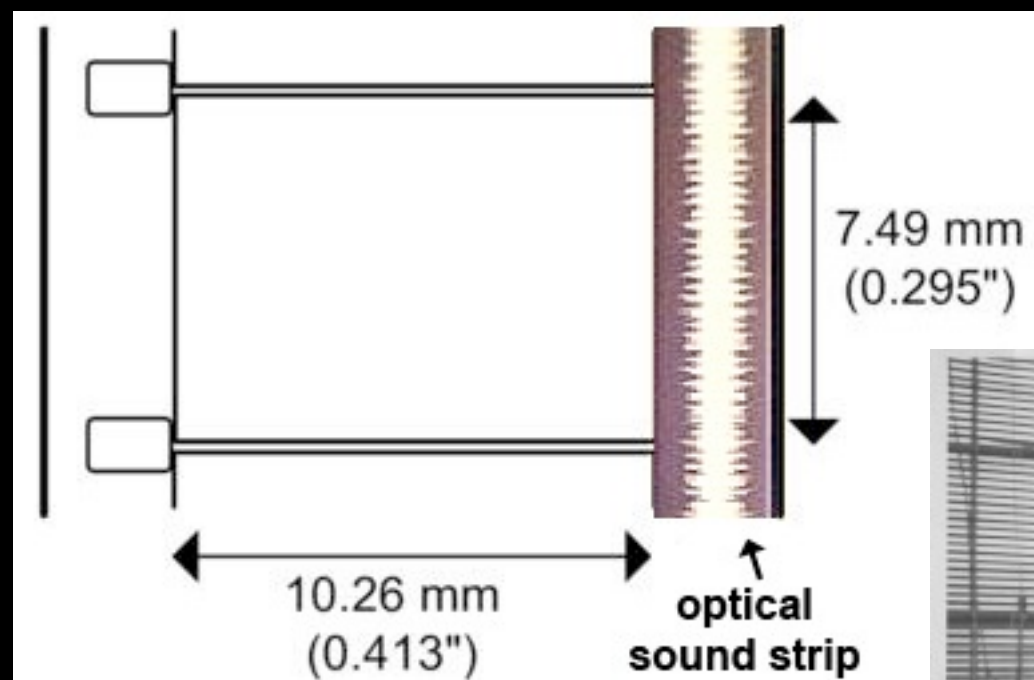
1877 – Thomas Edison (?) first sound recording – initially on metal foil and then on soft wax.
In 1888 – wax cylinder replaces the foil...



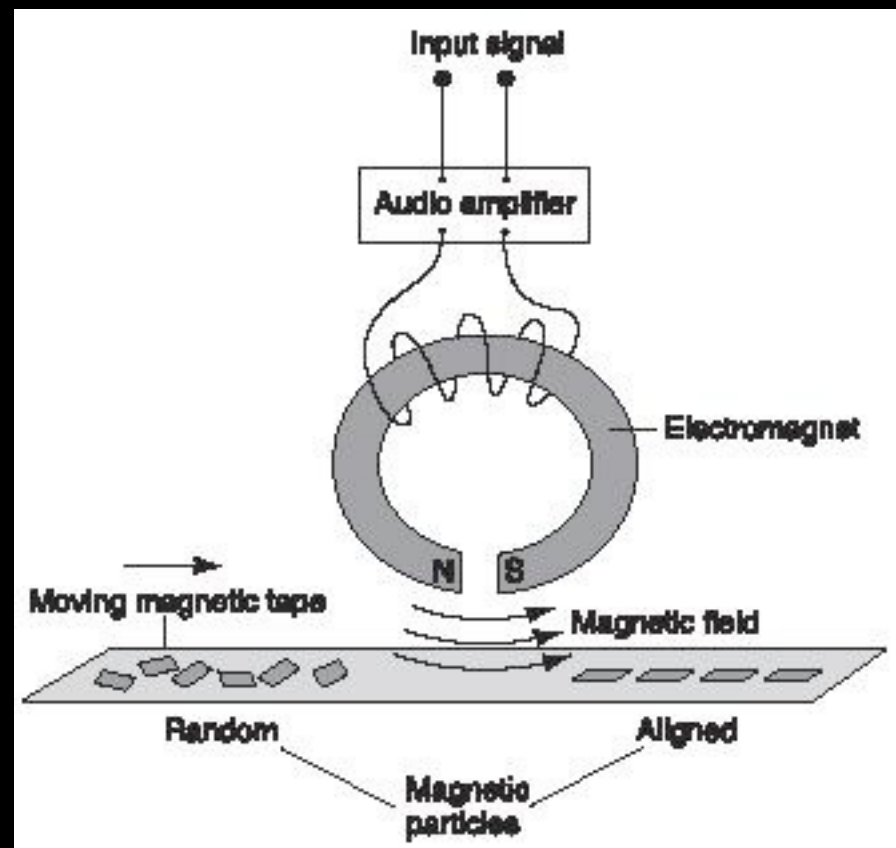
A horn focusses the sound waves to a needle which vibrates sympathetically. The needle etches the vibrations onto the cylinder. Playback is the reverse. A completely mechanical system. In subsequent years the cylinder became a platter and the speed of recording became standardized at 78 revolutions per second. Recording on discs was the common way to record sounds until the advent of tape recording in the 1950s.



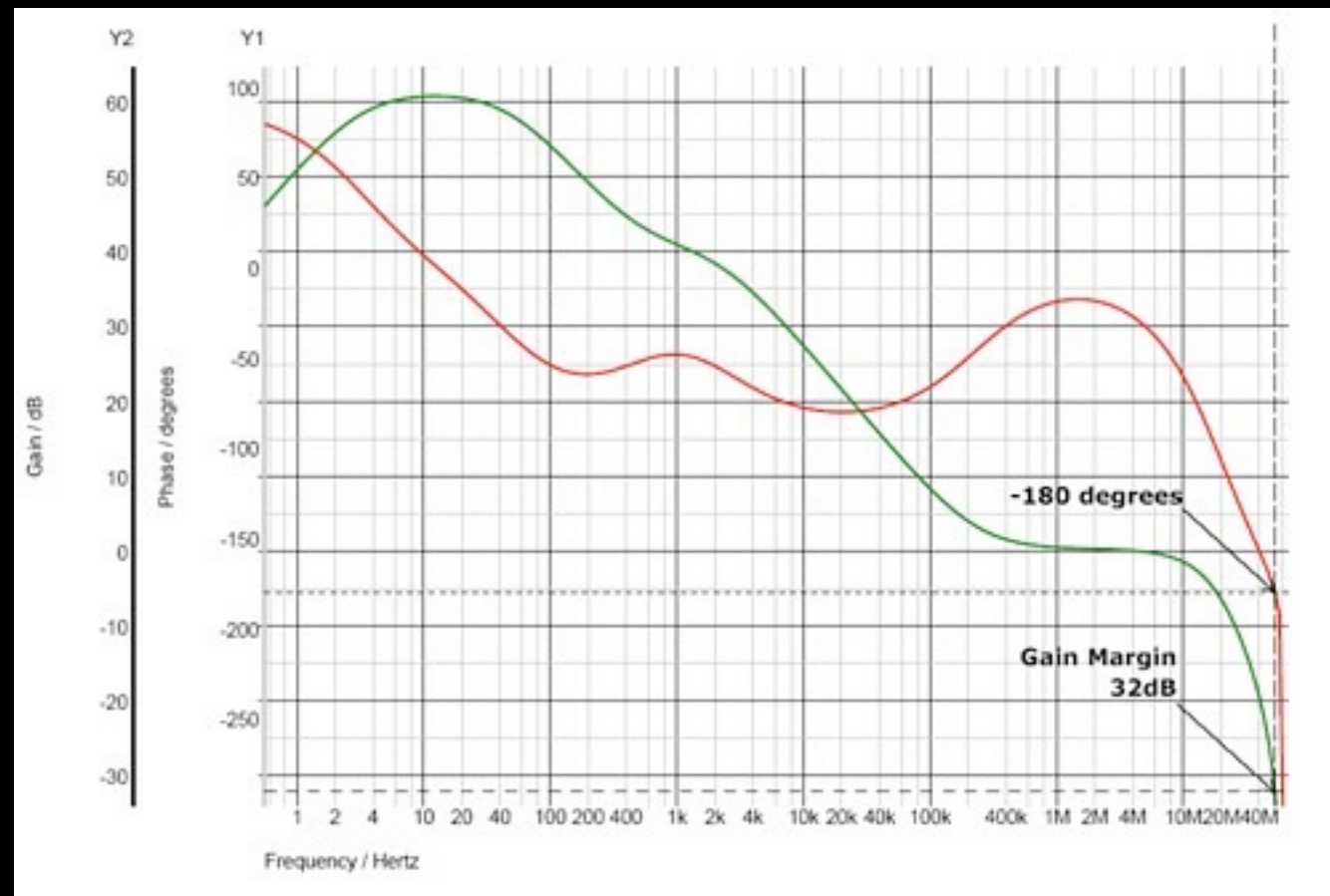
Danish inventor Valdemar Poulsen's magnetic sound recorder (circa 1898). Magnetic recording continued on piano wire until it was replaced by wire ribbon (extremely dangerous) and then magnetic tape. After WWII, tape remained the dominant form for recording sound until the advent of reliable digital systems in the 1990s.



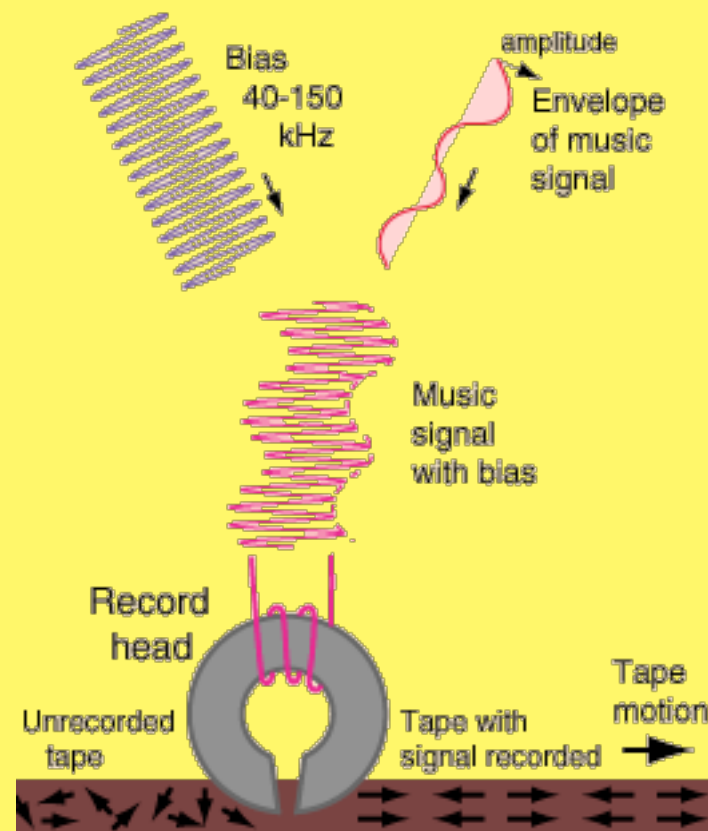
Optical film recording was another way to capture sound as an image. Sound waves modulate a light source (amplitude=brightness). This began in the late 1920s and continued into the 1980s. Only recently has digital encoding completely replaced optical soundtracks on feature films for example. Still the standard for 16mm films.



The audio signal modulates the magnetic field (an electromagnet or tape recording “head” – placing patterns analogous to the sound waves in the magnetized particles glued to the tape. For playback a magnet transforms these patterns found on the tape into current. The tape, like a recording wax disc must move at the same speed in playback as it did in recording. Any deviation or fluctuation will result in pitch/time distortion.

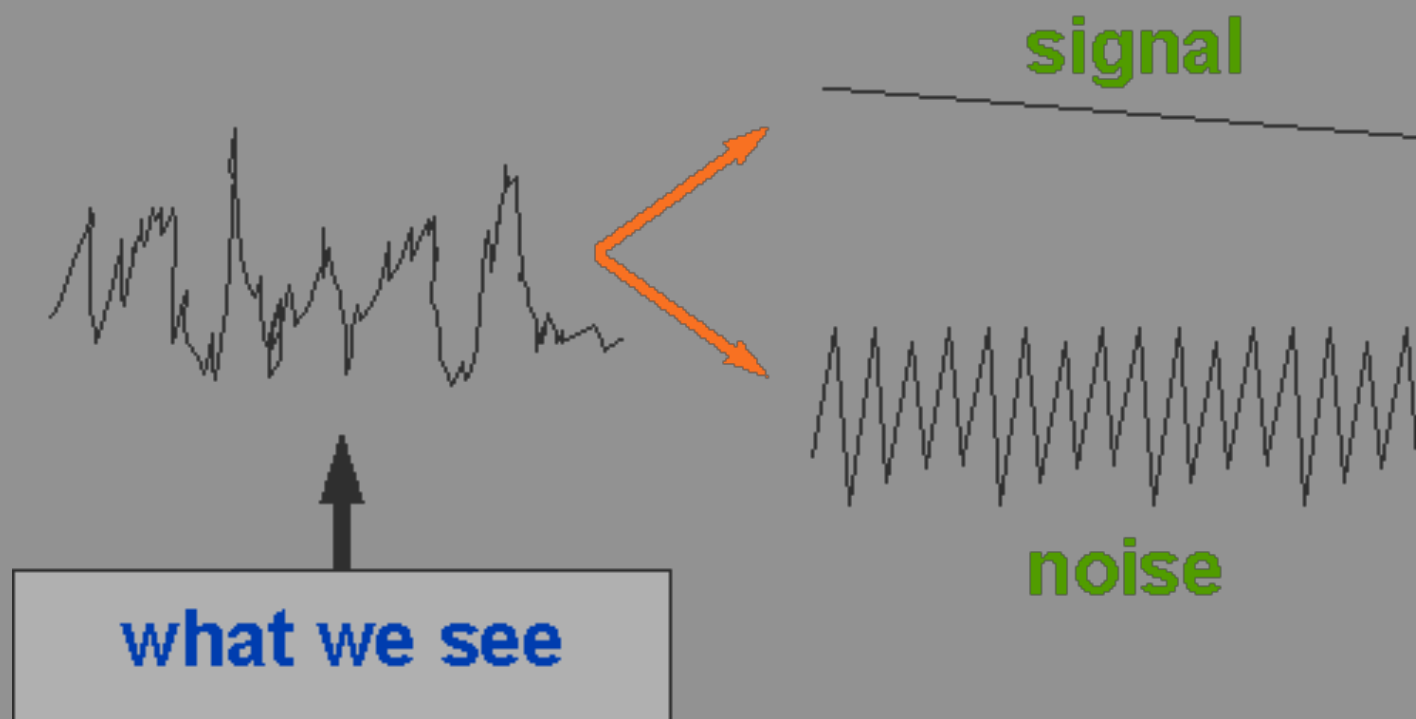


RIAA curve: **RIAA equalization** is a specification for the correct recording of [gramophone records](#), established by the [Recording Industry Association of America](#) (RIAA). The purpose of the [equalization](#) is to permit greater recording times, improve sound quality, and to limit the vinyl damages that would otherwise arise from recording analog records. The [RIAA](#) equalization curve was intended to operate as a [de facto](#) global [industry standard](#) for the recording of vinyl records since 1954. However, it is almost impossible to say when the change actually took place.



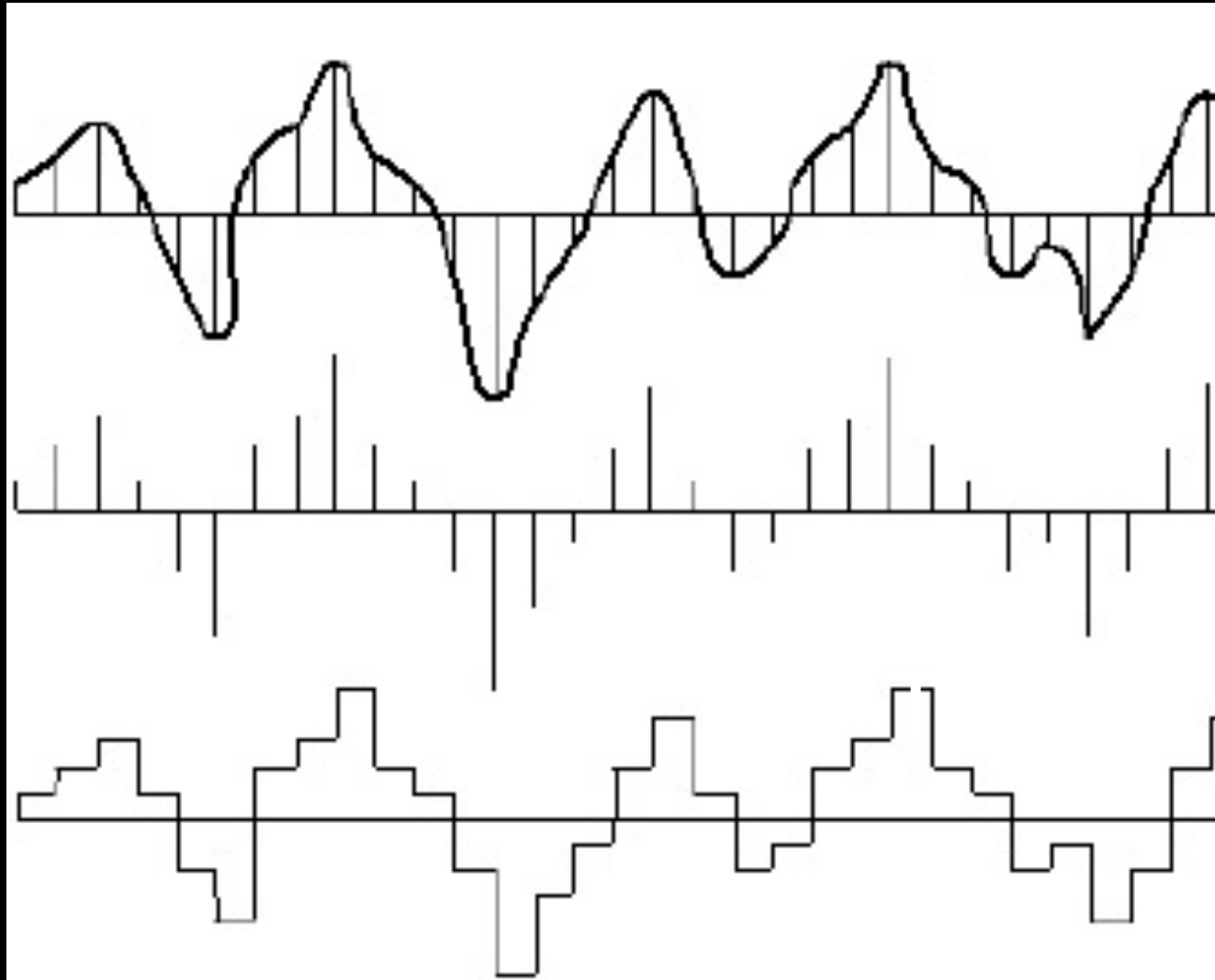
Tape bias is the term for two phenomena, **DC bias** and **AC bias**, that improve the fidelity of analogue [magnetic tape sound recordings](#). DC bias is the addition of a direct current to the audio signal that is being recorded. AC bias is the addition of an inaudible high-frequency signal (generally from 40 to 150 [kHz](#)) to the audio signal. [Magnetic tape](#) has a [nonlinear](#) response at low signal strengths, as measured by its [coercivity](#). Bias increases the signal quality of most audio recordings significantly by pushing the signal into the linear zone of the tape's [transfer function](#).

What we observe can be divided into:



signal to noise ratio

This is the difference, measured in decibels, between the noise floor of an audio system and the largest signal it can record without distortion. See [dynamic range](#).

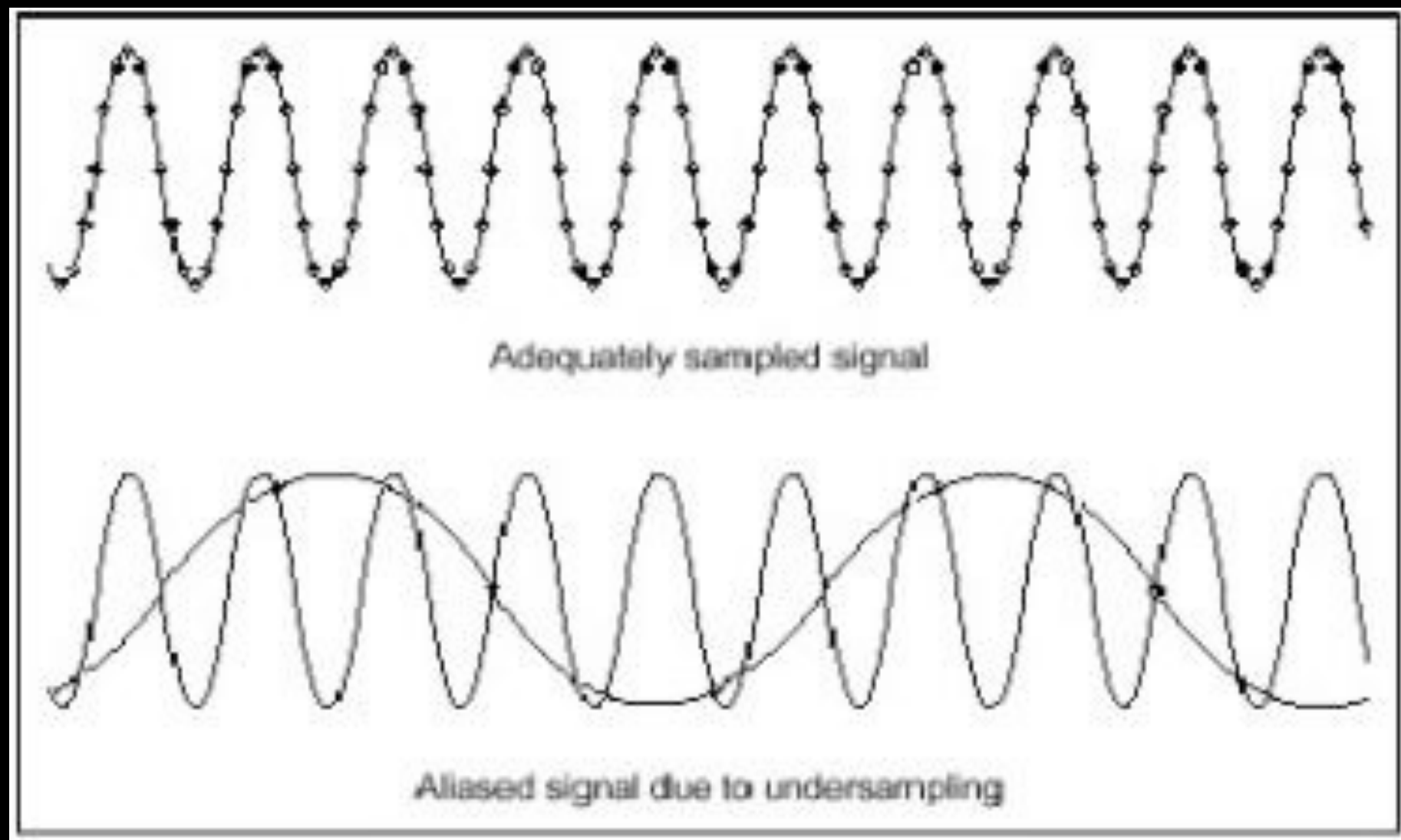


original signal

digital conversion

reconstruction

Sample the amplitude of the audio signal. (analogue to digital conversion)
Convert into a numeric value.
Convert value to a voltage for playback (digital to analogue convertor)



Nyquist Theorem: Sampling rate must be at least twice value of the highest frequency!

errors

http://www.sfu.ca/~gotfrit/ZAP_Sept.3_99/d/digital.html
aliasing, quantization error, foldover (filters, sampling rate)
sample size, sample rate

binary

The **binary numeral system**, or **base-2 number system**, represents numeric values using two symbols, 0 and 1. More specifically, the usual base-2 system is a positional notation with a radix of 2. Because of its straightforward implementation in digital electronic circuitry using logic gates, the binary system is used internally by almost all modern computers.

8 bit = 255 values
16 bit = 65,535 values
24 bit = 16,777,216 values
32 bit = 214,748,647 values

Byte = usually 8 values
Megabyte = 1,000,000 Bytes
Gigabyte = 1000 Megabytes
Terabyte = 1000 Gigabytes

digital representations

Also: sampling rates: 44,100 (CD), 48,000, 96,000 (44.1KHz, etc.)

The Signal Path



Signal path http://www.sfu.ca/~gotfrit/247_09_signal_path1.htm

Pierre Schaeffer



Pierre Henri Marie Schaeffer (14 August 1910 – 19 August 1995) was a French [composer](#), writer, [broadcaster](#), [engineer](#), [musicologist](#) and [acoustician](#) of the 20th century. His innovative work in both the sciences — particularly [communications](#) and [acoustics](#)— and the various arts of [music](#), [literature](#) and [radio](#) presentation after the end of World War II, as well as his [anti-nuclear activism](#) and [cultural criticism](#) garnered him widespread recognition in his lifetime.

Amongst the vast range of works and projects he undertook, Schaeffer is most widely and currently recognized for his accomplishments in [electronic](#) and [experimental music](#), at the core of which stands his role as the chief developer of a unique and early [form](#) of [avant-garde music](#) known as [musique concrète](#). The genre emerged out of Europe from the utilization of new [music technology](#) developed in the post-[Nazi Germany](#) era, following the advance of electroacoustic and acousmatic music. Schaeffer's writings (which include written and [radio](#)-narrated essays, biographies, short novels, a number of musical [treatises](#) and several [plays](#) are often oriented towards his development of the genre, as well as the [theoretics](#) and [philosophy of music](#) in general.



Steve Reich



Stephen Michael "Steve" Reich born October 3, 1936 is an American composer who together with [La Monte Young](#), [Terry Riley](#), and [Philip Glass](#) is a pioneering composer of [minimal music](#). His innovations include using [tape loops](#) to create [phasing](#) patterns (examples are his early compositions, "[It's Gonna Rain](#)" and "[Come Out](#)"), and the use of simple, audible processes to explore musical concepts (for instance, "[Pendulum Music](#)" and "[Four Organs](#)"). These compositions, marked by their use of repetitive figures, slow harmonic rhythm and canons, have significantly influenced [contemporary music](#), especially in the US. Reich's work took on a darker character in the 1980s with the introduction of historical themes as well as themes from his Jewish heritage, notably the [Grammy Award](#)-winning [*Different Trains*](#).



Come Out is a 1966 piece by American [composer Steve Reich](#). He was asked to write this piece to be performed at a benefit for the retrial of the [Harlem Six](#), six black youths arrested for committing a [murder](#) during the [Harlem Riot of 1964](#) for which only one of the six was responsible. [Truman Nelson](#), a civil rights activist and the person who had asked Reich to compose the piece, gave him a collection of tapes with recorded voices to use as source material. Nelson, who chose Reich on the basis of his earlier work [It's Gonna Rain](#), agreed to give him creative freedom for the project.



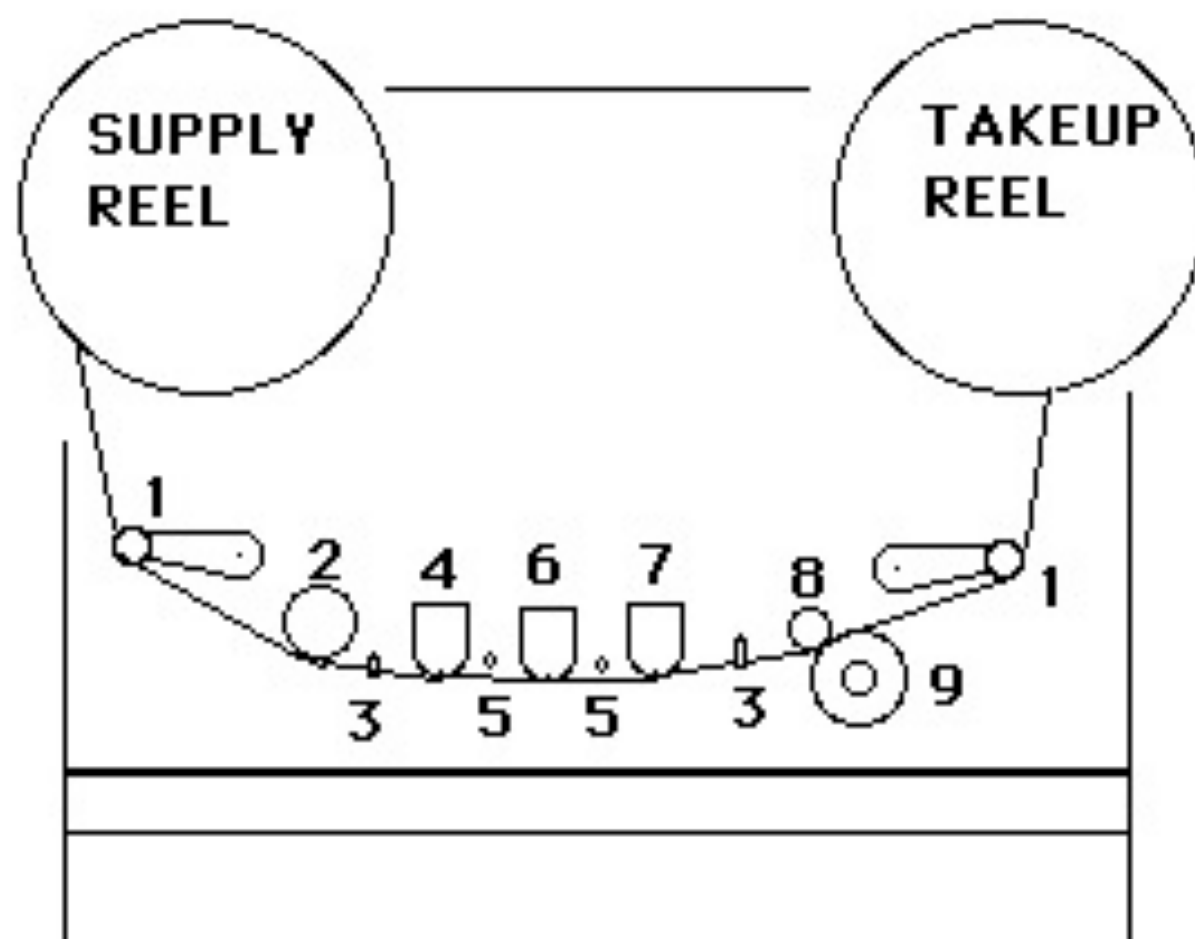
Reich eventually used the voice of [Daniel Hamm](#), one of the boys involved in the riots but not responsible for the murder; he was nineteen at the time of the recording. At the beginning of the piece, he says, "I had to, like, open the bruise up, and let some of the bruise blood come out to show them" (alluding to how Hamm had punctured a bruise on his own body to convince police that he had been beaten). The police had not previously wanted to deal with Hamm's injuries, since he did not appear seriously wounded. It is probably the earliest instance of which a member of [the Nation of Gods and Earths](#) was recorded.

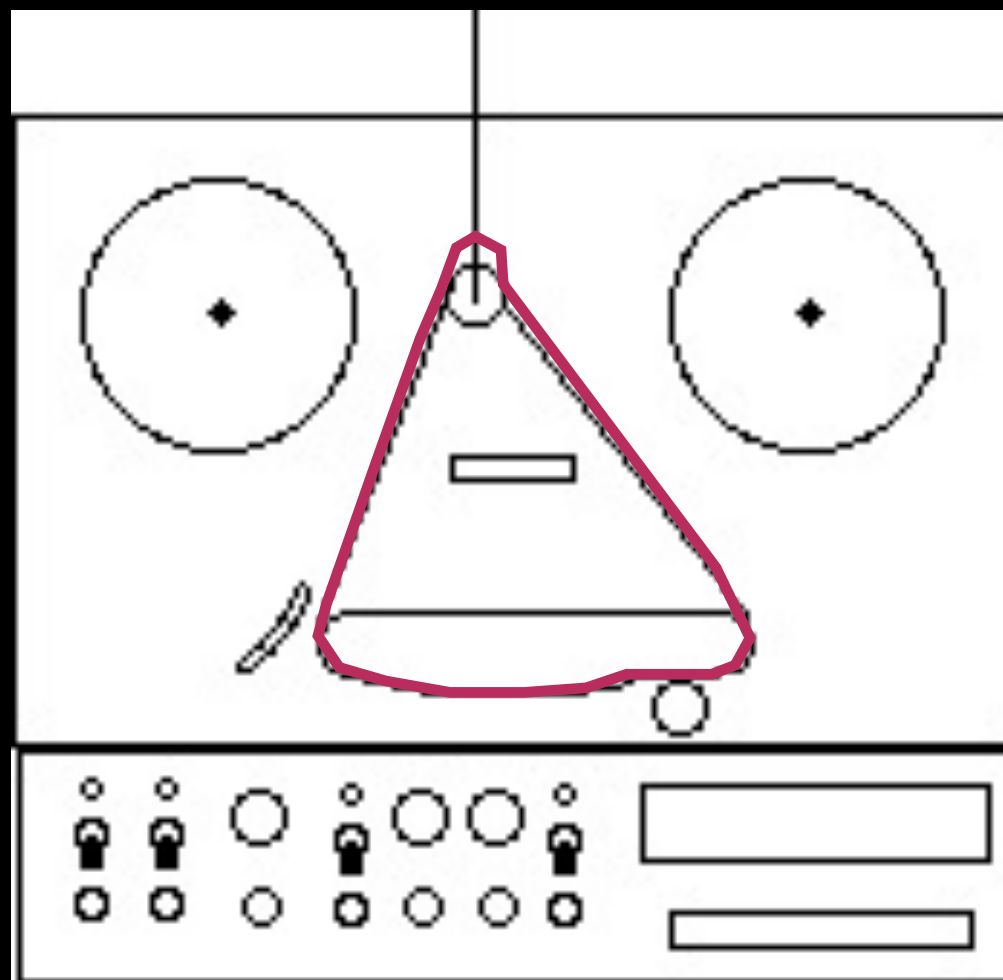
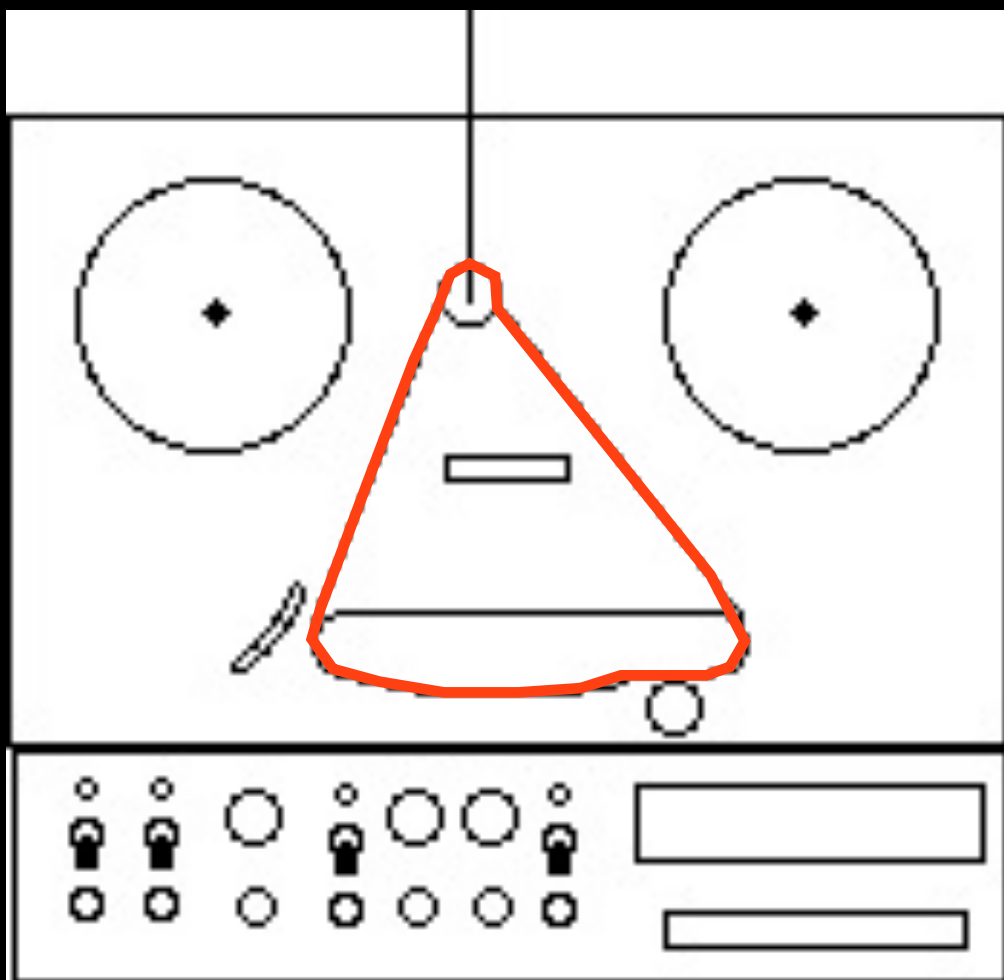
Reich re-recorded the fragment "come out to show them" on two channels, which initially play in [unison](#). They quickly slip out of sync to produce a [phase shifting](#) effect, characteristic of Reich's early works. Gradually, the discrepancy widens and becomes a [reverberation](#) and, later, almost a [canon](#). The two voices then split into four, [looped](#) continuously, then eight, until the actual words are unintelligible. The listener is left with only the [rhythmic](#) and tonal patterns of the spoken words. Reich says in the liner notes of his album *Early Works* of using recorded speech as source material that "by not altering its pitch or timbre, one keeps the original emotional power that speech has while intensifying its melody and meaning through repetition and rhythm." The piece is a prime example of [process music](#).



Revox tape recorder...

1. TENSION ARM
2. IDLE ROLLER
3. GUIDE
4. ERASE HEAD
5. TAPE LIFTERS
6. RECORD HEAD
7. PLAY HEAD
8. CAPSTAN
9. PINCH ROLLER





Two loops – one is slightly shorter/longer. So they play in unison 1st time round, 2nd time they are slightly out of phase... Loops would be bigger for this piece as 1" would be 15 inches or perhaps 7 1/2 inches (?)

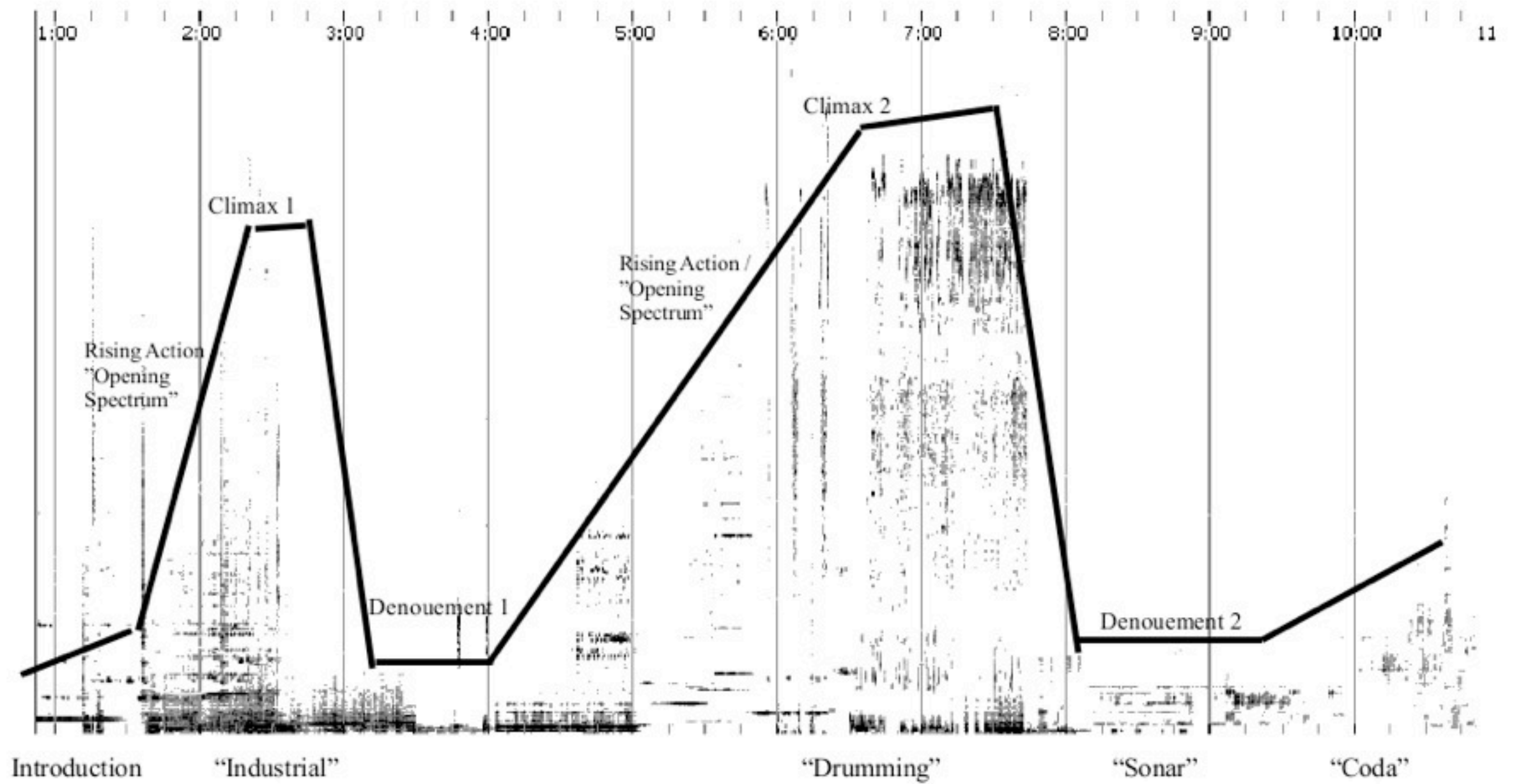
Iannis Xenakis



Iannis Xenakis (May 29, 1922 – February 4, 2001) was a Romanian-born [Greek](#) ethnic, naturalized [French composer](#), [music theorist](#), and architect-engineer. He is commonly recognized as one of the most important post-war avant-garde composers. Xenakis pioneered the use of mathematical models in music such as applications of [set theory](#), [stochastic processes](#) and [game theory](#) and was also an important influence on the development of [electronic music](#).

Among his most important works are [Metastaseis](#) (1953–4) for orchestra, which introduced independent parts for every musician of the orchestra; percussion works such as *Psappha* (1975) and *Pléïades* (1979); compositions that introduced spatialization by dispersing musicians among the audience, such as *Terretektorh* (1966); electronic works created using Xenakis's [UPIC](#) system; and the massive multimedia performances Xenakis called *polytopes*. Among the numerous theoretical writings he authored, the book *Formalized Music: Thought and Mathematics in Composition* (1971) is regarded as one of his most important. As an architect, Xenakis is primarily known for his early work under [Le Corbusier](#): the [Sainte Marie de La Tourette](#), on which the two architects collaborated, and the [Philips Pavilion](#) at [Expo 58](#), which Xenakis designed alone.

Figure 1: Dramatic form and Spectrum in *Orient-Occident*



<http://asymmetrymusicmagazine.com/editorials/intuition-and-order-in-xenakiss-orient-occident/>