Vinyl Records and Slinkies

A Learn in 30 presentation
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Agenda

- A short history of recorded music, and my music collection.
- My college Chemistry Course and Elasticity
- Slinkies and Elasticity
- The Elastic Limit
- Vinyl LPs, Tonearm Cartridge Needles, and Elasticity
- Radio stations, LPs, and slip-cueing.
- Audio CDs versus vinyl LPs

A short history of Recorded Music, and my music collection

The Earliest Recorded Music

- Thomas Edison invented the wax recording cylinder media and a player for that media.
- Players were initially driven by hand.
- The recordings became popular when a spring-driven player came on the market in the mid-1890s.
- Edison's peak year of recording sales was 1903. By the end of that year, his total cylinder sales were in the millions.

The Earliest Recorded Music

- The flat disk was a later competing audio medium with advantages:
  - The spiral groove could be stamped quickly on a blank disk.
  - The groove was deeper, hence the sound produced was louder than was possible on the cylinder.
  - Maximum 78 rpm disk play time was five minutes, longer than max cylinder play time.
- The cylinder remained economically viable because offices could afford desktop cylinder recording machines for recording dictation.

Long Play (LP) history

- Edison marketed 33.3 RPM Long Play disks with 20 minute capacity in the mid-1920s, before electricity and electric motor-driven players were widely available.
- Later, other companies tried to market variations.
- The Capitol Records Long Play (LP) version in 1948 was widely adopted by the industry.
- It was well timed. WWII vets had lots of money and lots of demand. Electricity was available.
- A Capitol Records LP pressing plant opened in Winchester VA in 1969 and operated until 1988.

I have been collecting music for a very long time

- The Beatles kicked off the British Invasion in 1963. That caught my attention.
- I owned a tiny transistor radio to listen to Top 40 on WEAM, AM 1390, as of that year.
- I made a bit of money mowing lawns and later much more delivering newspapers. So I could afford to buy LPs and later stereo gear.
- I studied and performed music: piano, clarinet, oboe and guitar, from second grade through twelfth grade.

My first stereo system

- When I started my freshman year in college, I owned about 50 LPs.
- I owned a component stereo system including KLH loudspeakers from Massachusetts, a Lenco turntable from Sweden, a Uher open-reel tape deck from West Germany, and a Pioneer stereo receiver from Japan.
- Moving the stereo system and LPs home for the summer and back to college for the school year was not a trivial effort. I learned to use UPS and its competitors.

My College Chemistry Course and Elasticity

My College Chemistry course

- To fulfill the college chemistry requirement during my freshman year, I took a course in Solid State Chemistry, taught by Prof. Wolf.
- Solid State in that year, 1971, did ***not mean semiconductors*** such as silicon or germanium.
- In that course, I learned about **Elasticity** of solids. That includes steel I-beams, ceramics, plastics, ice, and even rock.
- It turns out that one of the wonder toys of the 1960s, a **Slinky**, does a good job of demonstrating Elasticity.

Slinkies and Elasticity

- The 1960s Slinky was a basic metallic coil spring. Now many Slinkies are made of plastic.
- Either way, Slinkies demonstrate Elasticity.
- Stretch a Slinky with your hands, and you can feel tension within it, pulling against the stretch.
- That is a practical demo of a law of physics: **every action has an equal and opposite reaction.**
- When the Slinky is stretched, let it go. The stretched Slinky returns to its original compact shape, demonstrating Elasticity.

Modern Slinkies on Amazon

Rebound Time

- When stretched or compressed, and then released, every solid has a **characteristic rebound time** during which it returns to its original shape.
- That time can be a fraction of a second, or many hours.
- The time varies due to the material, its thickness, and the degree of stretch.
- Keep that rebound time concept in mind. It is important.

In college, my LP collection grew

- I spent a bit of my summer job income on rock LPs.
- I also developed a very useful skill: **a reviewer of LPs and rock concerts.** The student newspaper arts editor gave me concert tickets and LPs to review.
- In 1975, I graduated with a collection of about 300 LPs.
- In 1978, I graduated from law school with about 500 LPs.
- Watching the moving company convey that LP cabinet back to my parents' house in 1978 was quite a sight.
- My interest in music has never faded.

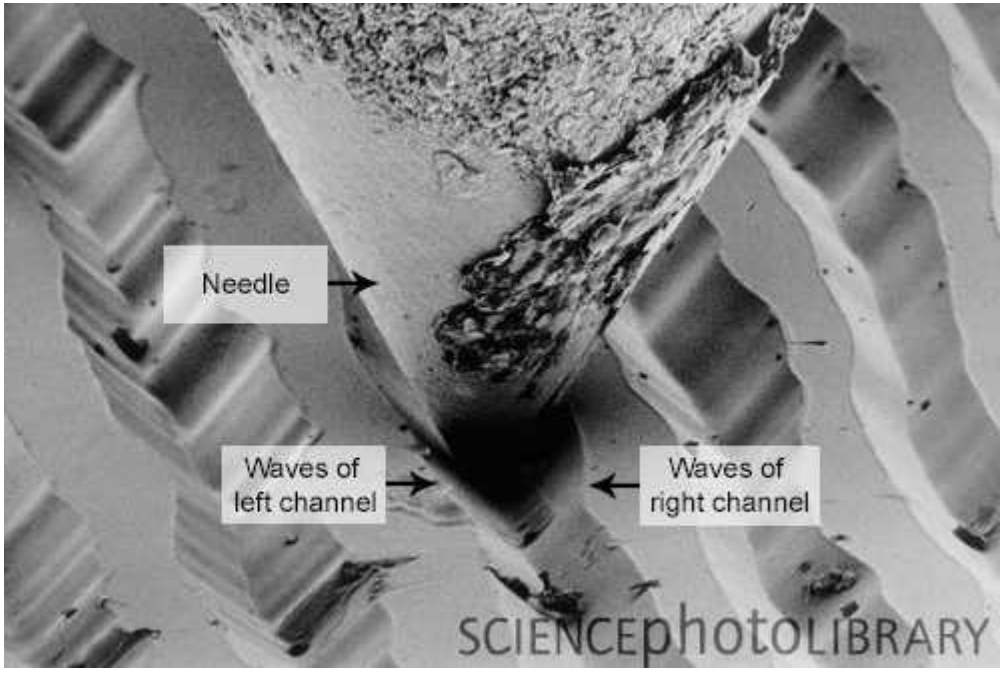
The Elastic Limit

- Later, in the early 1980s, I learned this: **every solid has an Elastic Limit**.
- If a material is stretched ***past its elastic limit***, then the shape to which it returns is NOT its original shape. The shape change is permanent.
- Alternatively, stretch a material past its elastic limit, and it might break apart.
- True even for a Slinky. Some of you may have stretched a Slinky too far, even without knowing the term Elastic Limit. Or maybe your kids stretched a Slinky too far.

Vinyl LPs, Tonearm Cartridge Needles, and Elasticity

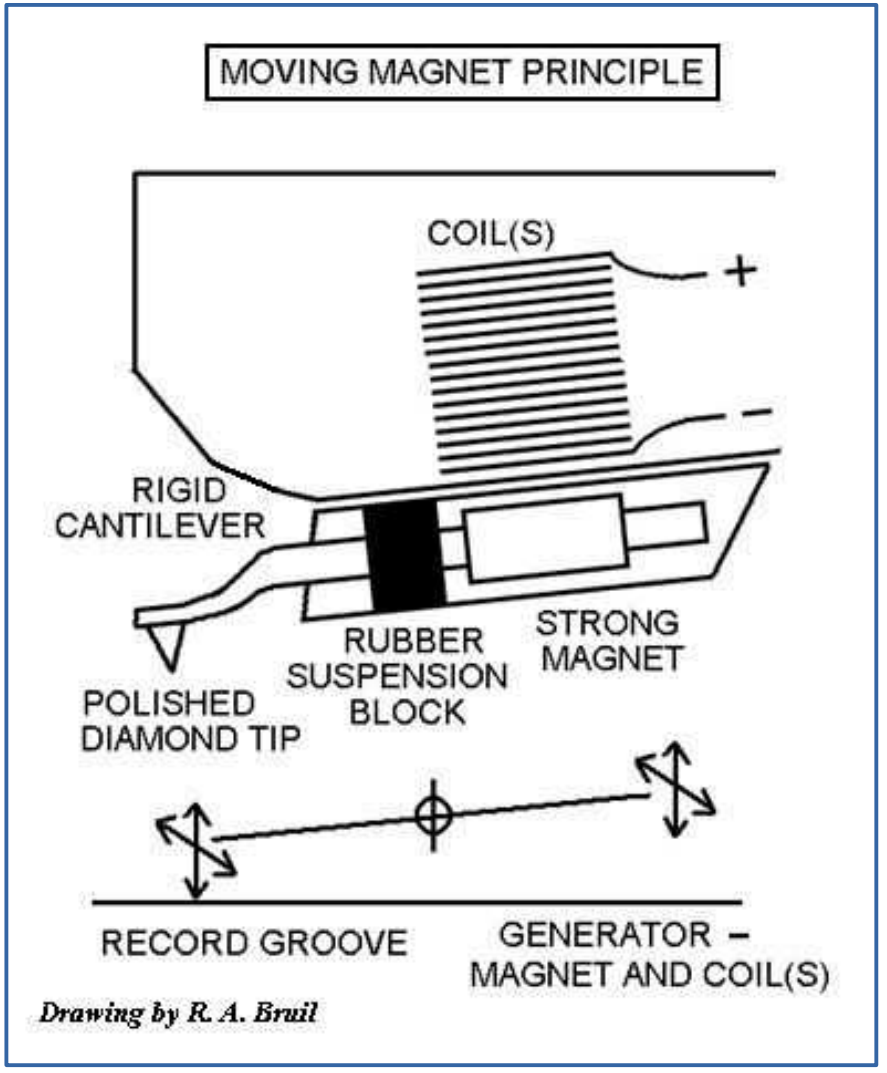
How an LP groove becomes sound

- An LP groove has a shape that varies.
- Each side of the groove looks much like an oscilloscope graph of sound.
- The tonearm needle “reads” the shape of the groove.
- The needle is GIGANTIC compared to the groove.



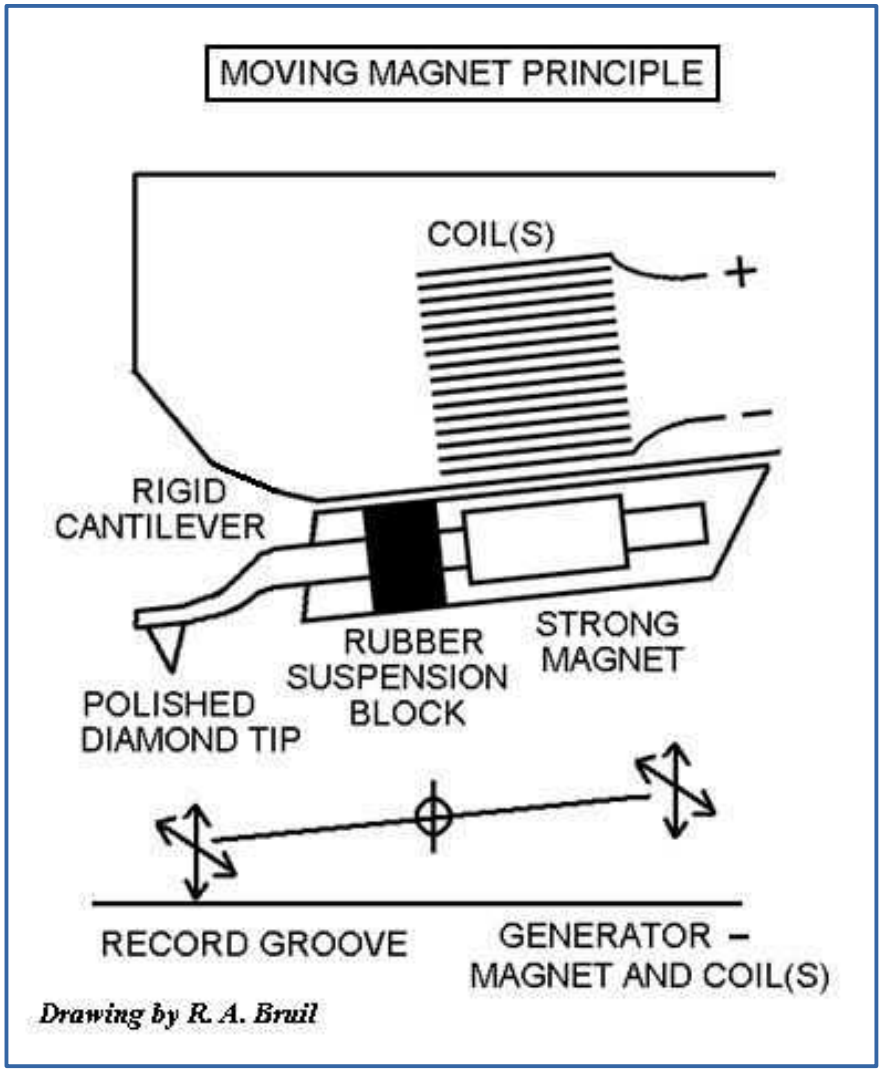
How an LP groove becomes sound

- The **needle cantilever** causes small movements of the needle to wiggle tiny but strong magnets.
- Those magnet wiggles vary electricity minutely (millivolts) in wire coils.
- The modulations are greatly amplified so people can hear the recording.



How an LP groove becomes sound

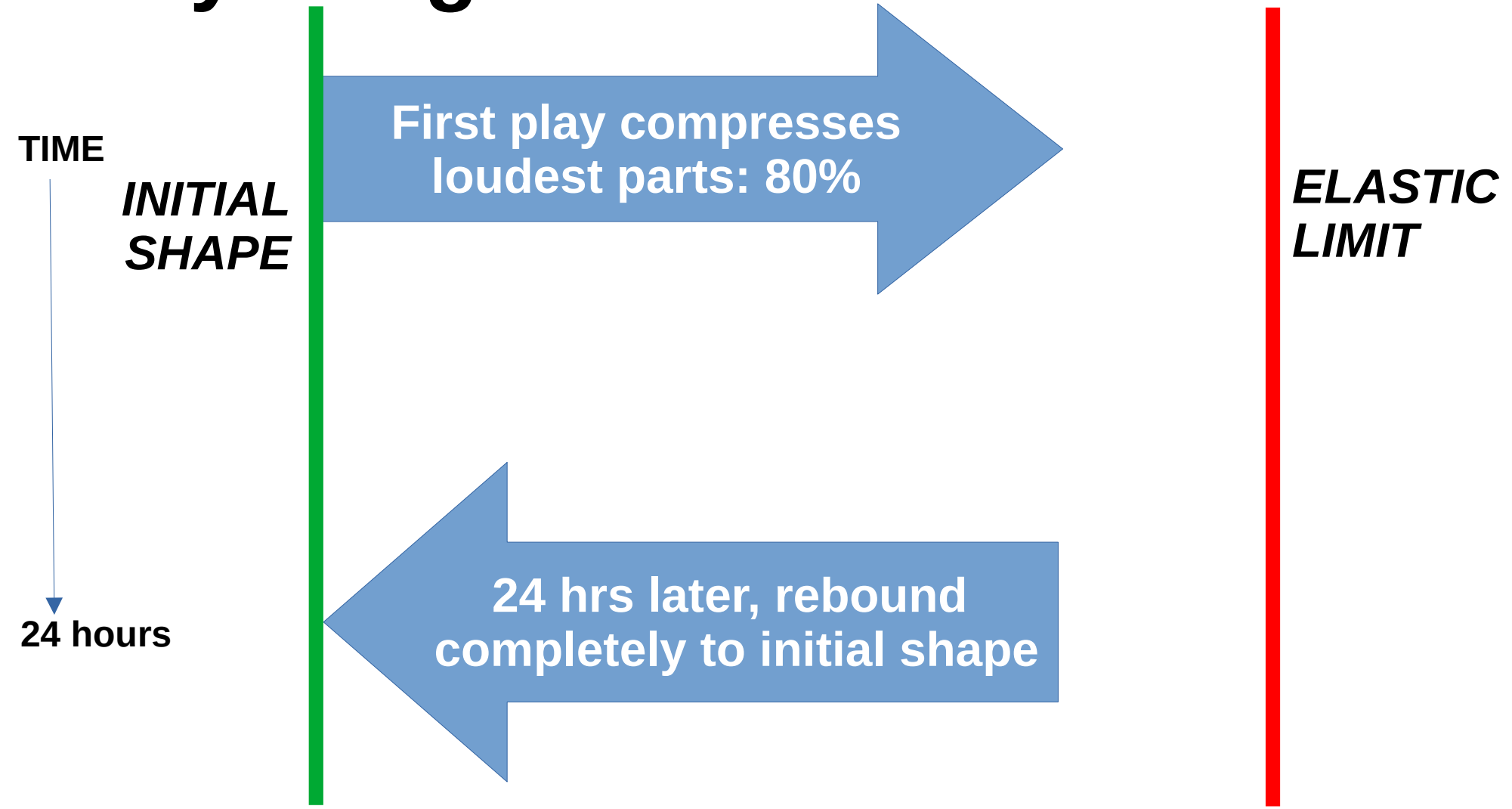
- Recall this physics principle: **every action has an equal and opposite reaction.**
- **When the groove side pushes the needle, the needle pushes the groove side.**
- The vinyl material in an LP does demonstrate Elasticity when pushed (compressed) by a cartridge needle.



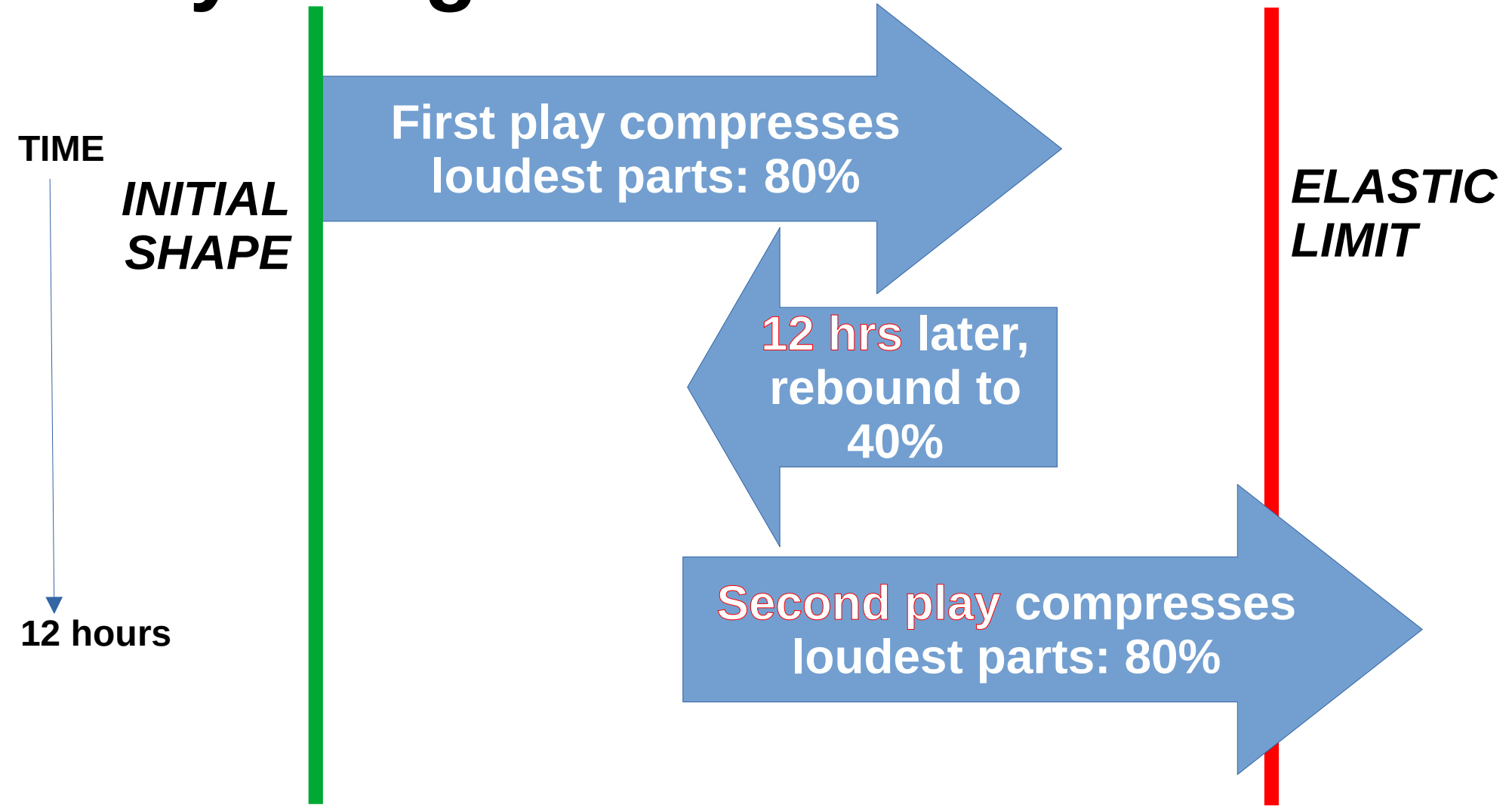
Vinyl LP groove and Rebound Time

- When the groove side is compressed by a tonearm needle, over time the groove rebounds to its original shape.
- That rebound can take a long time, **about 24 hours**.
- Playing an LP for a second time ***in less than 24 hours*** means the groove is in some places not yet completely rebounded. And can compress past the elastic limit.
- That permanent shape change means those portions no longer sound like the original recording.

Vinyl LP groove and Rebound Time



Vinyl LP groove and Rebound Time



I figured out vinyl rebound time and repeated plays too late

- College culture often meant the first purchaser of a brand new LP might play it two or three times in 24 hours so other music fans in the dorm or frat or apartment had an opportunity to hear it.
- Years later, after I learned about Elastic Limit, I realized I had damaged some of my favorite LPs by playing more than once in 24 hours, compressing the LP groove past its elastic limit in some places.

Radio Stations, vinyl LPs, and slip-cueing

Radio stations and LPs

- In graduate school, I became a disk jockey (deejay) at the college radio station.
- I learned a standard **slip-cueing technique** for a **segue**, starting the next song precisely at the end of a song played on a different turntable.
- The turntable platters were covered in felt.
- Put an LP on the turntable. Turn on the turntable motor put the needle in the groove, and play the first few seconds of the desired song.
- Turn off the turntable motor.

Radio stations and LPs

- Manually rotate the record backwards on the felt surface. Find the point where the song begins.
- That effort involves back and forth manual rotation of the LP, and therefore back and forth movement of the needle in one (mostly silent) portion of the vinyl groove.
- Rotate back roughly another ¼ turn of the platter.
- When the turntable motor is started, the song will start in roughly 0.2 seconds.
- Moving the needle through the same groove portion during slip-cueing can create groove noise.

Radio Stations and LPs

- The noise imposed by slip-cueing compression past the elastic limit of a vinyl groove was known throughout the radio business in the 1970s as **cue burn**.
- Still, nobody in the business other than those who took Prof. Wolf's Solid State Chemistry course had ever heard of elastic limit.
- About seven years ago, I explained cue burn in terms of elastic limit to an email list of 100+ alumni of that college station radio station. They were astounded.

Audio CDs versus vinyl LPs

Audio CDs have advantages

- Playback does not damage audio CDs. They are more rugged than LPs.
- Audio CD players are often standard features in cars even now. Try playing an LP in a car!
- Audio CDs have far greater dynamic range than LPs.
- Dynamic range is the amplitude difference between the quietest parts and the loudest parts.
- I I bought CD copies of many of my LPs, and I bought many later albums released only on CD.
- I own about 550 audio CDs now.

Think of LPs and audio CDs as Alternative Goods

- Aside from the Elastic Limit issue, LPs are easy to damage.
- Nudge the surface on which a turntable sits, and the tonearm goes skating sideways across the LP. Maybe a child or a pet does that.
- Spill something on an LP, and it is done for, and maybe that turntable too.
- Leave an uncovered LP where the sun shines through a window, even for a few minutes, and it won’t be a disk anymore.

The End