

The History of Vinyl

Neville Roberts

The Beginning of Recorded Sound

The history of recorded sound dates back to 1796 when Antoine Favre, a Swiss watchmaker, described his idea for what we now call the cylinder musical box. This is really an automated musical instrument which does not record an arbitrary sound. It was, however, a means of playing a pre-determined tune at will. In order to play an acoustic signal, a means to record the sound had to be devised.

Sound is a longitudinal wave that is generated by a source, such as a musical instrument, and travels through a medium (air) to reach the ear, which in turn converts the vibrations of the ear drum into an electrical signal that is interpreted by the brain. The term 'longitudinal' refers to the sound wave being in the same plane as the direction of travel of the wave. This is unlike the ripples on a pond which are transverse waves as the water moves up and down in the same spot as the wave travels along the surface of the pond. Sound waves are successive compactions and rarefactions of the air about a mean point as the wave travels at 330m/s through the air. The challenge of sound recording is to record these air vibrations in a permanent form.

Sound was recorded in 1857 on a 'phonoautograph' by a Frenchman called Leon Scott on a cylinder blackened with smoke. However, there was no way to play this recording back and this was, therefore, of little use.

Thomas Alva Edison's early attempts at recording involved recording Morse code on a disc. This was essentially a disc with binary data recorded as a track on the surface - sound familiar? Edison did not consider this suitable for recording sound at the time (how right he was!) as he turned his attention to analogue means.

The wax cylinder was the first commercially produced acoustic recording. This was based on a technique invented by Edison in 1877. By wrapping tin foil around a cylinder, he spoke 'Mary had a little lamb' into a diaphragm which caused a stylus to cut a groove of varying depth on the tinfoil, which corresponded to the movement of the diaphragm caused by the air vibrations that impinged on it. Using a separate stylus and diaphragm, he was able to play this recording back. Edison ignored his invention for a few years while he worked on electric light. However, he later resumed his interest in sound reproduction and devised a way of mass-producing cylinders by making a one-piece cylindrical mould of a master cylinder by electroplating.



Figure 1. A Cylinder

In 1887, Emile Berliner patented a machine that recorded these vibrations on a zinc disc, rather than a cylinder. This was called the gramophone recorder and it imprinted grooves on the flat side of the disc. Instead of recording the sound by varying the depth of the groove (the 'hill and dale' method of recording) as with the phonograph, the recording was made laterally in a spiral groove of constant depth on a flat disc. Berliner called this audio disc a 'gramophone record'.



Figure 2. 10" and 12" Shellac 78s

Both of the above methods were, of course, totally mechanical. In order to transfer enough energy to the cutting stylus to record the vibrations, some form of acoustic impedance matching had to be devised that matched the high impedance of the air to the low impedance of the diaphragm. This was achieved by the use of a tapered horn with an exponential flare. This was tremendously important - try listening to a phonograph or acoustic gramophone without the horn attached! Without a horn, the sound is quiet, thin and tinny. With the horn, the volume increases dramatically, and so does the frequency response. These horns became beautifully decorated features of the design of phonographs and gramophones. The larger horns produced the best sound and often required metal support structures to hold them in place.



Figure 3. Parlophone label on 10" Record of "Jumping Bean"

Early disc recordings and phonograph cylinders had about the same audio fidelity, although the cylinder has theoretical advantages of constant linear groove speed and the greater dynamic range of the hill-and-dale groove geometry. Cylinders were either two or four minutes in duration and recorded at 160rpm. Berliner's discs ran at 30rpm and ran for two minutes.

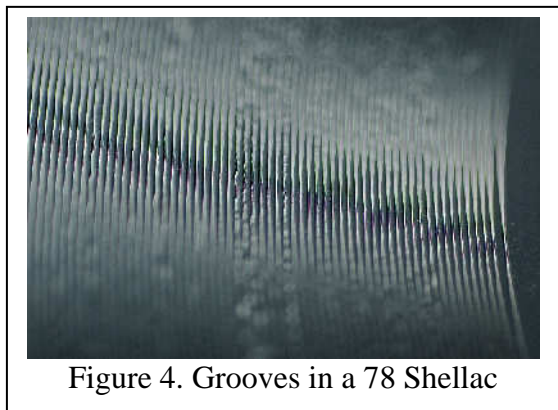


Figure 4. Grooves in a 78 Shellac

The Development of the Recording Industry

Edison was still trying to develop a process of mass-production of his cylinders in 1887 and it took until 1900 to solve the problem. Edison used a type of wax which, after being cast into a mould, shrank just sufficiently on cooling to release itself from the grooves enabling it to be withdrawn from the mould.

The Columbia Phonograph was formed in 1889 to market a treadle-powered graphophone, although the company had more success selling cylinders of music, especially of military bands and the music of Sousa.

In 1894, the American Graphophone and Columbia Phonograph companies merged to form the ancestor of the Columbia Record Company. Meanwhile, Berliner's Gramophone Company started marketing a 7" 70rpm single-sided disc that played for two minutes at a cost of 50 cents each.

Power for both cylinder phonographs and disc gramophones ranges from hand-cranked and treadle-powered motors to spring-driven clockwork and battery-powered electric motors.

Although the cylinder and the record co-existed during the first decade of the 20th century, the gramophone record was easier to mass-produce than cylinders. By 1913, the disc record prevailed and cylinder phonographs were no longer made.

Dance music was all the rage and orchestras were formed to meet the demand. Edison created thick discs of ballroom music with a vertically modulated groove rotating at 80rpm. Other manufacturers produced discs recorded at 78rpm and the programme material catered for all tastes, including classical, jazz and dance music, as well as popular performers of the time like Harry Lauder.

When World War 1 ended in 1918, the record industry took off and in the following year, Victor produced the first pop music record that sold over one million copies ("Dardanella" by the Ben Selvin orchestra). By 1922, recorded music was the most popular form of entertainment in the USA.

The recession hit in 1923 and Columbia and Victor were hit hard. However, Western Electric, together with AT&T and Bell Labs, developed an electrical recording system which revolutionised the recording process. Now, microphones could be used instead of acoustic horns which gave a huge leap in the quality of the recordings. Records were produced double-sided and played for about 5 minutes per side.

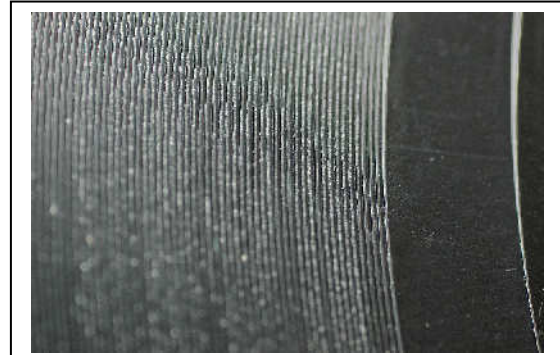


Figure 5. Grooves in a 78 Vinyl

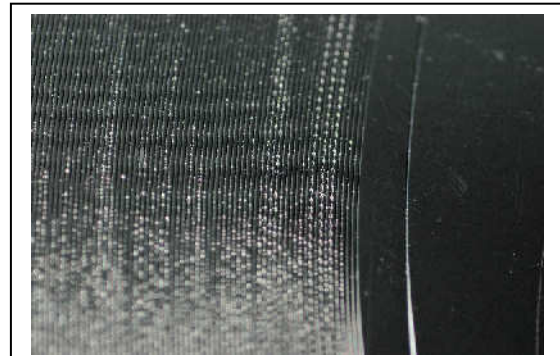


Figure 6. Grooves in a 45 Vinyl

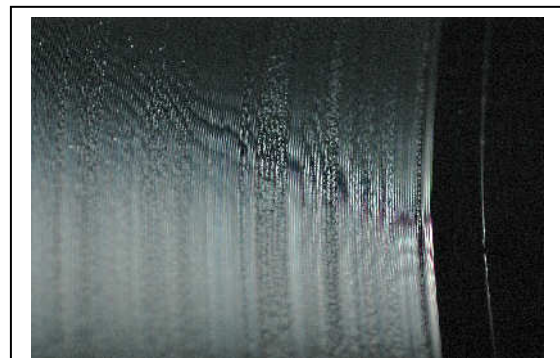


Figure 7. Grooves in a 33 Vinyl

In 1925, the speed of a record was standardised in the USA at 78.26rpm. This speed was chosen as it was easy to achieve with a 3600rpm electric motor and a 46-1 reduction gear ($3600/46 = 78.26$).

By 1930, the natural material of shellac was replaced with synthetic resins, but they were still noisy, brittle and easily broken.

The Second World War saw many of the performers drafted into the armed forces and the production of gramophones was suspended. However, after the war, the industry took off again and so did developments in technology. RCA had conducted some research into a new form of record material in 1931 using “Vitrolac” vinyl plastic that recorded at a 33 1/3rpm ‘professional’ speed. This failed to replace the popular 78s at the time, but the lower surface noise and greater resiliency was remembered. Also, shellac was in short supply so 78s started to be manufactured in vinyl.

In 1948, Columbia Records introduced the 12” microgroove LP recorded at 33 1/3rpm and pressed in vinyl. Not to be outdone, RCA Victor launched the 45rpm vinyl single in 1949. This was a turning point as the 45 held the same amount of material as a 12” 78 and was lighter and more rugged. Singles made in the USA had 1½” diameter centre holes and required an adaptor to be fitted, either to the record or the turntable, to play on UK standard ¼” spindles. Most juke boxes were of USA origin and UK singles had a push-out removable centre to accommodate the USA standard spindle.



Figure 8. A Columbia 45 single

The hey-day of the 45 came with the rock-and-roll era. The 45rpm single was a low-cost, collectable commodity that teenagers could smuggle home unnoticed to play on their trendy Dansette record players in their bedrooms! For the Mums and Dads, there was the radiogram that were pieces of furniture that graced the sitting room. The improved sound quality of the vinyl LP, coupled with the large wooden cabinets of the radiograms, led to the birth of the Hi-Fi era and the record industry rose to meet the challenge.

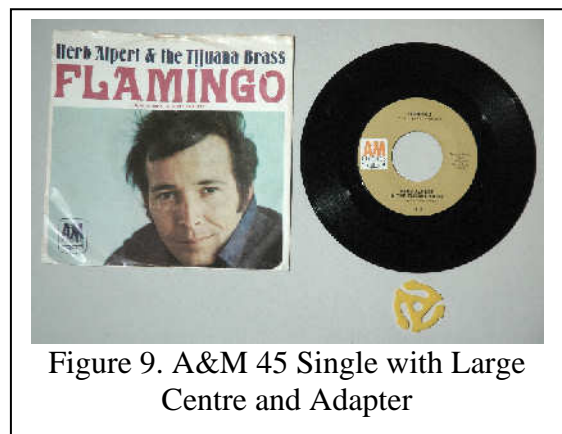


Figure 9. A&M 45 Single with Large Centre and Adapter

Equalisation

At this point, it is worth discussing equalisation. This is the process of changing the frequency response of the recording to reduce noise and make best use of the recording medium.

For acoustically recorded cylinders or records, a constant velocity recording is produced. This provides a flat response, where the velocity is measured as the stylus crosses the depth

corresponding to an unmodulated groove. For a given loudness, the variation in groove depth (modulation) is proportional to the reciprocal of frequency.

When electronic amplification came along for records, a constant velocity recording was ideally suited to a magnetic cartridge for playing back '78s as these produce an output proportional to velocity. However, this also reproduced the surface noise of the record and this method of recording did not make best use of the groove as the high frequencies produced only a tiny modulation of the groove. So in the 1950s, the RIAA (Record Industry Association of America) standard was adopted that boosted high frequencies during the recording process, which would then be attenuated during playback and therefore also attenuate the high frequency noise. In addition, this process made much better use of the groove and resulted in a modulation that was largely constant across the frequency range, which is effectively a 'constant displacement' recording. Furthermore, the discovery of the piezo-electric effect gave rise to lighter and simpler-to-manufacture crystal and ceramic cartridges. These produce a much higher output and an output signal proportional to displacement, not velocity. RIAA recordings could then be played back on low-cost players with simple circuitry as no playback equalisation was required.

The Development of Stereo

Towards the end of the 1950s, Hi-Fi versions of the radiogram were available. These were the first integrated Hi-Fi systems, albeit mono. However, developments would be influenced by the research of Alan Blumlein in the 1930s into binaural sound for cinemas.

Blumlein was aware that two audio channels could add a special dimension to recorded sound, but a commercially viable system would have to be developed. Back in 1931, Blumlein patented a system for recording two channels in a single groove of a record recorded at 45 degrees, giving a sum and difference signal. A great advantage of this is that existing mono record players would pick up the sum signal and play both channels through the speaker, hence the system was compatible with mono equipment.

EMI, Blumlein's employer, had not made any use of Blumlein's binaural patents since the mid 1930s. In 1955, Decca tried to patent a two-channel system that they called 'stereophonic sound' and, although this was not successful, it did prompt EMI to begin experimenting with the concept again in April 1955. Sir Malcolm Sargent conducted a series of tests at Abbey Road and this led to the first stereo LPs being produced in 1958.

To play these new stereo LPs, audio equipment manufacturers rose to meet the challenge. For example, the Pye 1207 stereogram, designed by a young furniture designer, Robin Day, whose square edged and matt-finished modern designs fitted in well with the '60s contemporary tastes in furniture, became a best-seller. Designer names like Denmark's Bang and Olufsen competed with international companies such as Phillips, based in the Netherlands.

The 1960s saw the birth of the Hi-Fi separate and established names like Quad and Leak had competition from the likes of Trio (the UK-branded version of the Japanese maker Kenwood) and US makers Fisher and Scott.

In 1963, Leak introduced one of the first stereo transistorised amplifiers, the Stereo 30. Leak claimed that the sound quality from their transistorised equipment was every bit as good as

that from valves, but such early solid-state models were not always praised (or later ones for that matter!).

The development of quadraphonic records was announced in 1971. This process recorded four separate sound signals on an LP. A variety of techniques was used. One method recorded the four channels by electronically matrixing the channels down to two. When the records were played, circuits in the amplifiers were able to decode the signals back into the original four channels. There were two main systems of matrixed quadrophonic records produced, the SQ system from CBS and the Sansui QS system. A different format, CD-4 developed by RCA, encoded rear-channel information on an ultrasonic carrier, which required a special wideband cartridge to pick it up. Typically the high-frequency information wore off after only a few playings, and CD-4 was even less successful than the two matrixed formats. All these formats proved commercially unsuccessful, but were an important precursor to later 'surround sound' systems, as seen in SACD and home cinema today.

In the late 1970s, 'direct-to-disc' records were produced by the likes of Sheffield Labs for the audiophile niche market, which completely bypassed use of magnetic tape in favour of a high quality transcription directly onto the master lacquer disc. Also during this period, half-speed mastered and 'original master' records were released, such as Mobile Fidelity Sound Lab's recording of 'Dark Side of the Moon', using expensive state-of-the-art technology.

The early 1980s saw the introduction of 'DBX-encoded' records, again for the audiophile market. These were completely incompatible with standard Hi-Fi systems as they required sophisticated DBX noise reduction encoding and decoding hardware. The purpose of this was to provide a significant reduction in playback noise and increase dynamic range. A similar and very short-lived technique involved using the CBS-developed CX noise reduction system.

Also in the late 1970s and 1980s, a method to improve the dynamic range of mass-produced records was developed, using highly advanced disc cutting equipment. These techniques, marketed as the CBS Discomputer and Teldec Direct Metal Mastering, were used to reduce inner-groove distortion.

Rival Formats

While all this development was going on, the vinyl record was the primary medium for distributing recorded material, with reel-to-reel ¼" tape coming in as a distant second. The 8-track cartridge was developed primarily as a medium for car stereos, but companies like General Electric tried to market portable 8-track players, but these never caught on.

It was the Phillips Compact Cassette with its small size and recordability that triumphed in the 1970s over the other rival formats to the LP record. However, the quality could never match that achieved by a well produced vinyl LP.

It took the development of domestic digital formats to finally oust vinyl from the mass market and the 1980s saw the introduction of the convenient and rugged Compact Disc, which took over from the LP.

The End of Vinyl?

Now that the CD has completely replaced vinyl for the distribution of classical music, the music industry is only producing records for the specialist pop music market and for use by disc jockeys. Further developments with digital formats such as SACD and blue ray technology has led to the CD now being classified as a 'legacy format'!

Much has been written about the innate quality of an analogue recording and how much inaudible high frequencies can contribute to the depth, clarity and spaciousness of the sound. Despite the apparent limitations of susceptibility to scratches, limited dynamic range and wearing ability, a well cared for high quality vinyl recording played on a good system can, in my opinion, still out-perform the best that digital has to offer and I for one, will not be discarding my record collection in a hurry!

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Timeline

1850

- Sound waves drawn in soot on a cylinder by Leon Scott

1860

1870

- Edison records "Mary had a little lamb" on tinfoil

1880

- Emile Berliner records sound on a zinc disc

1890

- Columbia Phonograph formed
- The Gramophone Co. sells 7" 2min discs at 50cents

1900

- The 'Flower' horn & spring driven motor developed
- Victor Talking Machine & Victor Records formed
- Victor uses painting of dog 'Nipper' listening to His Master's Voice

1910

- Columbia launches the two-sided record

WORLD WAR 1

1920

- Victor sells over 1 million copies of 'Dardanella'
- Western Electric develops an electrical recording system
- Record speed standardised at 78.26rpm

1930

- Shellac replaced with synthetic resins
- Alan Blumlein experiments with binaural sound for EMI

1940

WORLD WAR 2

1950

- Columbia Records introduces the Vinylite 12" microgroove 33 $\frac{1}{3}$ rpm
- RCA Victor launches the 45rpm vinyl single
- RIAA equalisation standard adopted
- Decca and EMI independently work on developing stereo

1960

- First stereo LP produced
- Hi-Fi separates developed
- Leak introduced the Stereo 30 transistorised amplifier

1970

- Quadraphonic records launched

1980

- Direct-to Disc audiophile records produced
- 'DBX-encoded' records introduced

1990

- The Compact Disc introduced

2000

Record Mastering - A Pressing Engagement?

Neville Roberts

When Edison first started making cylinder recordings for sale to the general public, he realised that he would have to devise some method of mass production. Several master cylinders could be cut at the same time by having a number of cylinder recorders recording the live performance simultaneously. In the early days, all recordings were indeed original recordings but as the volume of sales increased, it was soon realised that a method of mass production would have to be devised.

A problem with cylinder recordings is that a conventional split mould would produce a seam where the two halves of the mould join. This would produce an unacceptable click at every half-revolution. However, in 1900, Thomas Lambert developed a process that created a copper negative of a wax master cylinder using heat and pressure to mould celluloid copies from the copper negative. Thomas Edison saw the potential of this method and thanks to a team of lawyers (Lambert's company was out of business by 1907!) managed to apply this process using a wax that shrinks slightly on cooling so that it can be withdrawn from a one-piece mould without damage. The master cylinder was electroplated to produce the one-piece negative mould, from which a large number of wax cylinders could be produced. However, as demand increased, many masters were needed and this required the performers to repeat their performance many times over!

A record is much easier to mass-produce using a conventional two-part mould. In the early days, discs were cut directly from the live performance and this was an entirely mechanical process. The invention of the electronic valve enabled microphones to be used that were connected to an amplifier which drove the cutting stylus. With the development of magnetic tape recording, a master recording was made on audio tape and this was then used to cut the master record.

Early master records were made using a disc of zinc that had been coated with a thin wax. The recording stylus cut through the wax to expose the metal underneath. The disc was then etched with acid to form a groove in the metal master positive. This was then copied to make a negative copy which was subsequently used to press the final discs for sale.

Later, discs were mastered by cutting the full groove directly into a hard lacquer. The lacquer is subsequently electroplated with a nickel alloy. The metal is then removed from the lacquer to produce a master that is a negative of the original disc. This is then electroplated again to produce a positive "Mother" copy. From this, a number of negative "Stampers" are created that are used in the hydraulic presses to mould the final records. This system allows a large number of records to be pressed quickly by using multiple stampers and all from one original performance, much to the relief of the artists! Furthermore, as the stampers wore out, new ones could be made from the mother positives.

Pressing Materials

Early disc records were made from vulcanite by the likes of Emile Berliner in 1893. However, in 1897, a shellac mixture was used as this was much harder wearing. Shellac is a

natural plastic made from the secretion of an Indian lac beetle. This was mixed with cotton and powdered slate together with wax to provide some lubricant.

Phonograph cylinders were originally made of wax. In 1912, Edison started using Blue Amberol, a form of celluloid that had a lower surface noise than either wax cylinders or shellac records. But by 1913, Edison realised that the flat disc record had won the format war of the time and he started selling records made of a resin plastic called Condensite. This material was similar to the first artificial plastic, Bakelite. Edison used a reproducer that was similar in design to the one he had developed for his Blue Amberol cylinder players.

Shellac, and the synthetic resins used later, was the medium of choice for records until 1950. In 1948, Columbia had perfected the 12" LP vinyl disc, followed by RCA Victor who launched the 45rpm vinyl single in 1949, which held the same amount of material as the 12" 78rpm shellac disc. Vinyl was much lighter, more rugged and had a much lower level of surface noise than shellac and quickly became the standard for all sizes of record.

Over the years, the commercial pressure to keep manufacturing costs to a minimum resulted in thinner records being produced and an increase in the use of recycled vinyl being added to the mix. This resulted in a decline in the quality of many records produced in the 70s with poor surface noise and a greater tendency to warp. However, the late 70s and 80s saw the development of audiophile recordings that used 100% virgin 180g vinyl.

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