It happens to just about everyone who dives into producing their own musical works: you spend weeks recording and mixing your first song, and stop when it sounds great, then you make a tape (or more likely, a CD these days) and when you play it somewhere else, you hear something completely different than any of the other stuff you listen to. Some things you might say to yourself might be: What happened!? How come my levels aren't as loud as *that other* CD? How come it sounds great in my studio and when I play it in the car, it sounds weak, and the bass sounds nothing like it does at my studio, what happened!?

The feeling of going back to square one happens to just about everyone who jumps into production these days. This surprises a lot of people new to making music today because the mastering process is one of the least talked about and misunderstood aspects of the music production process. Another reason might also be because there has been a huge leap in recording technology in the last 20 years; what was once a process that was only reserved to artists who acquired a record deal is now available to anyone for just a few hundred dollars, so many folks don't fully understand the process of producing a record. Having that "polished" sound is the key, the difference in sound quality that sets apart amateur productions from professional ones, but how do you get it?

Welcome to this series on Mastering. The point of this collection of articles is to demystify what Mastering is, what it does, what it doesn't do and what you can do to get your recordings to sound just as good (and sometimes better) than material that is being distributed commercially out there right now.

- **Part I** is an introduction to Mastering and gives us a semi-chronological history of Mastering from the early beginnings of Mastering for vinyl to the present popular format, the CD.

- **Part II** discusses mixing and gives you tips on how to come up with an excellent mixdown ready for Mastering.

- **Part III** will describe some of the tools used in Mastering, from tools used to fix problems to tools used creatively to enhance the material.

- **Part IV** goes into specific detail on CD Mastering, and how getting the levels right for a CD release is only the beginning. It also talks about what you should expect from a Mastering Engineer.

- **Part V** examines the current trend of "hot" mastering and how "louder" isn't always the best thing for your songs in the digital domain.

- **Part VI** wraps it up by talking about what might be in store for Audio Mastering, and talks about new alternate media that might be used by the recording industry to distribute albums in the future.

This is not a guide on how to do Mastering yourself, and I hate to tell you this, but I rather tell you now before you think you're about to read yet another DIY guide on Mastering:

Mastering is best done by a fresh pair of ears, someone who hasn't listened to the same song over and over again during the developing stages of the song, who isn't "hearing" more in the music than what is actually there. A professional Masterer has experience in mastering music for commercial release, and knows how to manage the frequencies of a good mix with precision analog and digital tools to make it sound rich and full everywhere, from your car to the club and in your headphones; someone who has an acoustically-treated room and the right set of loudspeakers for mastering. More than likely, a typical recording setup is not going to allow a monitoring environment without other equipment or other things getting in the way, affecting the overall sound in that room, since typically a recording signal path is noisier than one set up for mastering.

In these days of all-in-one boxes, MDR's that have built-in mastering tools and software packages that do the same thing, it's easy to feel like you can do everything at home, without the need to involve anyone else, but the truth is that music is and should always be, a collaborative effort. Somehow, and it's probably because it's a matter of having several perspectives combined, music sounds better when more than one set of ears are involved.

Mastering, or for the sake of what we're about to get into, means getting your music to sound as good as everything that's out there, hopefully better, and it involves quite a bit more than just having the tools to be able to master. A lot of times, people identify Mastering Engineers with having "Golden Ears", and a big chunk of that gold is the ability of being impartial with the music.

That said, it's important to understand this also: that doesn't mean you can't attempt to master your own music (after all, it's your music and there are no rules to what you do with it!) Hopefully, this series will give those of you who want to try and master their music a better understanding of the process for optimal results. Will you get the same results mastering your own music as opposed to letting someone else who isn't as attached to your project master it? More than likely, no. But hey, you can achieve good enough results if you're careful and give yourself plenty of room and time to make it happen. We will be going into mixing for mastering and what you should and should not do at the mixdown stage to prep your material for mastering. The mixdown stage is the most critical stage, and contrary to what you might have heard, it's the quality of the mixdown

that dictates the quality of the overall master; mastering can't fix errors that could have been fixed at the mixdown stage or prevented at the tracking stage.

Mastering is the process of working with a recording's best mixdown possible (or best set of mixdowns possible) and trying to preserve as much of the original recording's quality for mass reproduction.

These days, the CD format dictates the quality of audio material being distributed. In order for CDs to playback audio files, they have to be compressed down to the 16-bit, 44.1kHz format. If you are downloading music files from the Internet today, which is something that people do more and more everyday, you probably know that MP3s are audio files that are compressed down even further from the CD format. This series will also explain the role of the Mastering Engineer in today's industry, since the role of the "Masterer" has changed quite a bit since Mastering began, back in the late 40s, before there was such a thing as a mastering or editing stage.

In the beginning...

The first recordings were done straight to the media that was used to store and play them, aluminum cylinders, then shellac, then later, vinyl. The fact that the master recording was on a piece of material that wasn't very durable and easily deteriorated posed a major concern.

When the magnetic tape was developed in the 1930s to record sound, it created a need for someone to handle and transfer sound from the tapes and cut the records. In those days, the Mastering Engineers were called simply Sound Technicians, and their job was to transfer the recordings from the master tapes and make the records. While the process of cutting hasn't changed much, what happens right before that has changed drastically. In those early days, Technicians didn't do a whole lot to the master tapes before cutting records and it was basically an entry-level position at a record label. It was only after recording studios opened up outside of the big record labels that the Mastering process that we know today was born, back in the late 60s. Before then, only the record labels had recording studios and with the development of multitrack recording back in the 50s, these technicians became Mix Engineers, who had a lot more control while recording performances and could alter the way things sounded during and after a recording. Some of these engineers branched out on their own and opened up their own recording studios. Many of these engineers also maintained, repaired and many times customized their own processors, so they started offering exclusive effects and gear not found in other studios to their clientele. In order to compete with the others, some of these studios started offering additional custom treatment to the master tapes before cutting the records, and this practice became known as Custom Mastering.

Custom Mastering didn't start to flourish until the late 70s. To give you an idea of how many engineers there were, back in the late 1970s, there were around 150 Mastering

Engineers[1]. It started to pick up because records being made with custom mastering had a wider dynamic range than those made earlier, so pretty soon, this new process was something many artists wanted applied to their music.

Very early on, Mastering Engineers found that traditional recording studios weren't practical for mastering. Things like large consoles, buzzing amplifiers and various pieces of gear, introduced noise or helped bounce it around the room, and very soon, recording studios that also offered mastering set up separate rooms for it. Engineers who might have also known about acoustics realized the importance of the room used in mastering, and very early on, having a room treated for acoustics became synonymous with the tools used to dynamically change the material before cutting. Because mastering now also involved altering the dynamic character of the material and an accurate representation of the applied changes was needed, proper monitoring speakers became essential, and these needed to truthfully reproduce the changes being made to the material, and while there is no such thing as a perfectly "flat" loudspeaker, those that came close to being as flat as possible without introducing other elements into the sound became the standard. The practice of custom mastering transformed from an entry-level position in the recording industry to a separate practice before pressing.

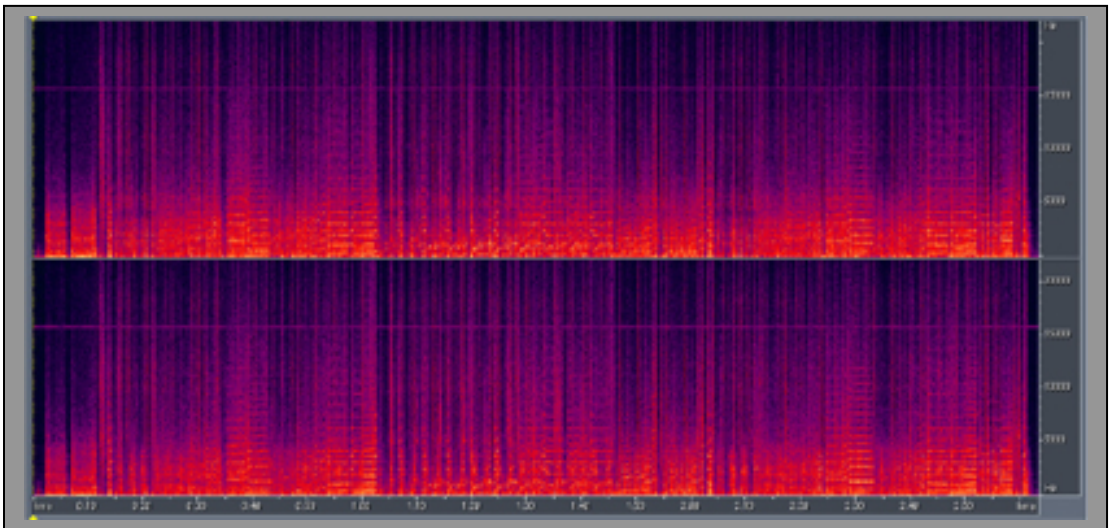
Because only a few albums were being mastered, there were songs on the radio that appeared to sound "bigger" and "louder" than others and pretty soon, record labels started to hear from listeners who said they preferred these "louder" songs as opposed to the softer ones on the radio because they simply sounded better. This was the beginning of what is known as the "Loudness Wars". Many people suggest that it was the record executives who are to blame for this, to compete with other albums from other record companies, but in fact, in a lot of cases, the artists themselves were looking for that extra loudness, willing to make compromises with the dynamic sound of their music just to have a louder record, so the blame doesn't fall entirely on greedy record executives. Another common misconception is that the "Loudness Wars" started with the Compact Disc. It really began when custom mastering became available, but the thing is, there was only so much you could do with vinyl as far as making it loud, so it was more of a problem for mastering engineers than anyone else…

From Analog to Digital

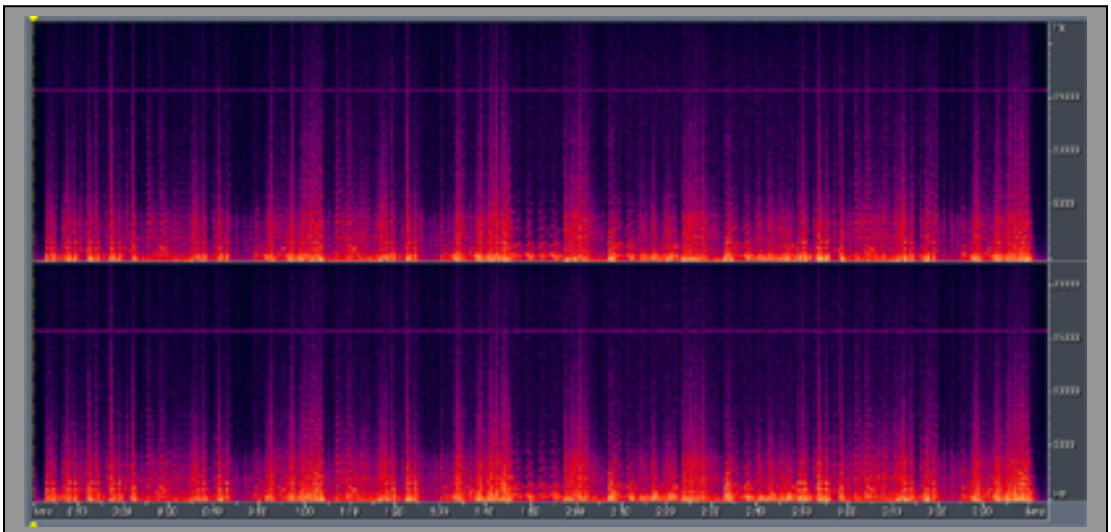
For some types of music, boosting the levels worked beautifully, but not for others. Take Disco for example; aggressive compression in Disco gave a more energetic feel, giving drums and bass lines a punch that was preferred by all listeners, from the dancers to the DJs, who loved the sound of a louder record. In Classical music, however, the opposite is true; those who listen to Classical records usually play close attention to the nuances and climaxes of a performance, something that up to a certain point can be enhanced in mastering, but if one were to make a Classical record sound as loud as a Disco record, that dynamic ladder would be lost. Hardly anyone complained that nuances in the music

[1] The Billboard Studio Directory, 1978

were over-exaggerated by mastering on a Disco record. Take a look at the following examples of two spectral waveforms for a visual comparison of a Disco record and a Classical record:



A Fifth of Beethoven – Walter Murphy
1977 RSO Records, Inc.

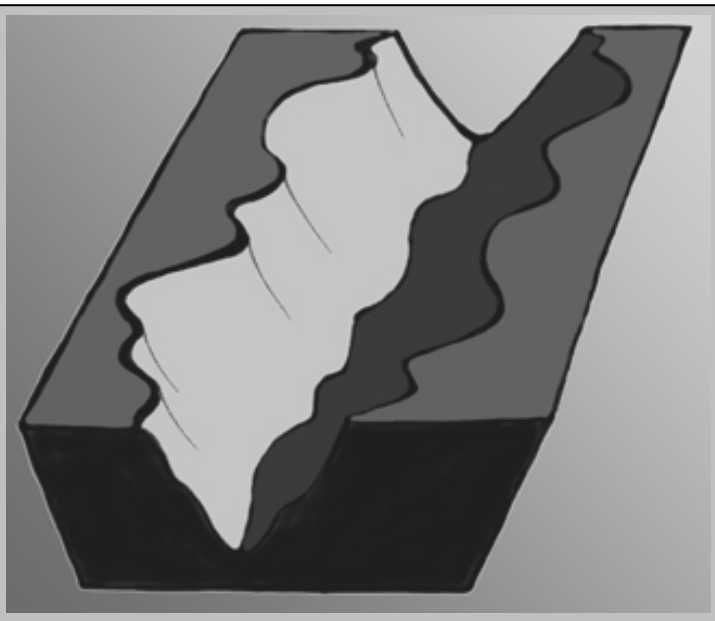


Beethoven Symphony No. 2 in D Major – Wurttembergische Philharmonic
1977 Gary Stanley/Festival Distribution

The screenshots above are of vinyl recordings recorded at unity gain. As you can see from comparing the two images, the Disco record has a higher average loudness than the classical record.

Mastering became a double-edged sword when artists started asking for "louder" as opposed to "optimal dynamic range" out of custom mastering. The biggest problem mastering engineers had before the days of CD were the limitations they confronted with vinyl. Recordings with a higher dynamic range eat up more of the vinyl real estate, since

the louder a recording is, the wider the groove gets, which in the end means fewer songs on the record. Vinyl also has a lower dynamic range in comparison to CD (around 50db vs. 85db and more) and even the thickness of the vinyl was an issue.



An exaggerated illustration of what a groove on a record looks like up close.

When cutting vinyl, there are two important things to keep in mind: One is that the pitch of the material is recorded sideways, and two: The loudness is recorded vertically. As if things weren't complicated enough, the process of cutting vinyl got a little more complicated when wax started being cut in Stereo in the late 50s. Phase cancellation wasn't an issue with one (mono) channel. Adding that second channel opened the door to a lot of experimental uses of panning, but when material started to phase out, especially with bass instruments, it caused the cutting needle to not respond to those frequencies that were canceling each other out. Part of the reason why bass guitars were tracked in mono is because of this, and you also had to be careful where you panned your bass lines in the stereo field. Mastering for vinyl required Mastering engineers to adhere to these limitations, so there was only so much that could be done at the mastering stage and Mastering Engineers learned to walk the fine line between what sounded great and what cut well.

Experienced Mastering Engineers learned to tell what had to be done at the mastering stage for the record to be a successful cut; it no longer was an optional process, especially with the introduction (and phase issues) of Stereo vinyl. Record Labels quickly focused on those who were the pioneers of custom mastering, and because of the demand for quality custom mastering of the few engineers who truly had mastered the practice, the price of mastering a record was in the thousands. This is also where Mastering Engineers are believed to have developed a mysterious reputation of having that "magic touch" and it set them in a world of their own.

The position of what was once an entry-level spot at a recording studio became one of the highest paid in the world of audio engineering and the final part of the record-making process. By this time, Mastering Engineers had equipment and rooms exclusively designed for mastering, so there was a clear distinction between a recording/mixing studio and a Mastering studio. To be able to Master meant knowing where to make adjustments to the

material to make it sound more pleasing or spot problems while listening to a mix, problems that could ruin a pressing. This placed the Mastering Engineer at the important position of being the final say, the last stop before a record got pressed.

This didn't diminish the role of the mix engineer, however. The great engineers started to get a feel of what worked great for cutting as well, since typically Mastering Engineers asked for a few mixes for them to critique and choose for cutting vinyl. An excellent mix engineer could foresee how something in a mix would be affected at the mastering stage, and make adjustments to the mix based on experience, so it didn't take very long for mixers and masterers to work together and produce some of the best-sounding albums.

In the late 70s, things were excellent in the world of cutting records, it appeared as if things could not get better. Albums like Steely Dan's Aja, considered by many engineers to be one of the best mixed and mastered albums of the times had demonstrated that it was possible to make a record loud and have it sound good at the same time, and as we learned earlier, part of that compromise was because of the limitations in the record-making process. If it were up to artists and engineers to run things in the recording industry, things probably would not have changed much in the last 30 or so years, but the fact is that ever since recording technology began, back in the late 1800's, there has been a moving force of individuals looking for better alternatives to store sound and data, and like many things, the aim is to develop storage that is smaller, cheaper and has a longer shelf life. In addition to that, the recording industry has always studied alternate forms of media to develop and distribute music as well.

Cutting Lathes, such as the Neumann lathe pictured above, have not changed very much in terms of technology.

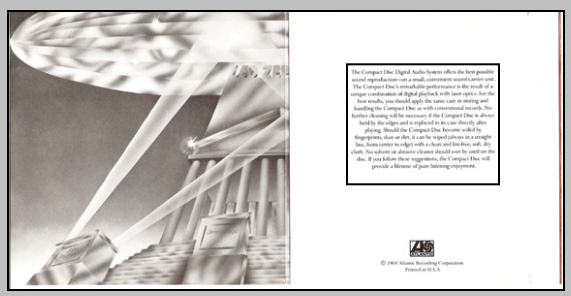
In 1978, many musicians were pushing the musical envelope. Excellent recordings were being made, and the art of cutting vinyl was at its peak. At the same time in Europe and in Japan, Philips and Sony were demonstrating a prototype of a new form of media that would change all aspects of recording music forever.

The Compact Disc

In retrospect, the Compact Disc has many advantages over vinyl that made it possible to take over. Higher dynamic range with a lower noise floor level, more storage, less space and less maintenance on the media and playback systems made it highly attractive to the recording industry and consumers. We're not going to get into the argument of whether digital actually sounds better than analog, so we'll stick to reality – it took over the industry. In 1988, CDs officially outsold LPs worldwide and in the world of mastering audio, things had changed drastically.

As far as quality, the first CDs produced were not the best sounding, and many condemned them. For the most part, this was a result of using first-generation Analog-to-Digital converters, but as developers of high-end converters such as Apogee and Prism started producing highly accurate AD conversion, subsequent CDs got better, and started to meet their intended dynamic quality. Some of the early CDs even had special blurbs that tried to condition consumers into the new media, such as this example taken from the first production of Led Zepellin II's CD liner notes:

The Compact Disc Digital Audio System offers the best possible sound reproduction—on a small, convenient sound-carrier unit. The Compact Disc's remarkable performance is the result of a unique combination of digital playback with laser optics. For the best results, you should apply the same care in storing and handling the Compact Disc as with conventional records. No further cleaning will be necessary if the Compact Disc is always held by the edges and is replaced in its case directly after playing. Should the Compact Disc become soiled by fingerprints, dust or dirt, it can be wiped (always in a straight line, from center to edge) with a clean and lint-free, soft, dry cloth. No solvent or abrasive cleaner should ever by used on the disc. If you follow these suggestions, the Compact Disc will provide a lifetime of pure listening enjoyment.



Most of the CDs produced in the late 80s and early 90s also featured a 3-letter SPARS (Society of Professional Audio Recording Studios) code that told consumers how the material was originally recorded, mixed then transferred to CD (therefore the last letter is always a "D"):

AAD – Analog recording, mixdown also in Analog then converted to Digital.

ADD – Analog recording, mixdown recorded to Digital format (DAT for example), and then Digitally transferred for CD.

DDD – Digitally recorded, mixed down and mastered in digital.

This coding system was scrapped in the mid 90s because it confused consumers into thinking the codes gave a representation of the quality of the CD.

When mastering for LPs, as explained earlier, mastering engineers had to consider the limitations they were working with while cutting vinyl, but with digital, that changed; 0dbfs was now the limit, and that meant more room to play around with, no more phase issues to worry about, and naturally, the loudness wars would resume – only this time, with a larger dynamic field.

Because the limitations of working with vinyl didn't exist with CDs, you didn't have to alter the dynamics of the material before making the glass master; you could very well just transfer the master recordings straight to a Sony 1630 and produce the glass master and replicate CDs, but because custom mastering had already proven it could make the source material sound better, the need for it was very much still there, except this time for aesthetic purposes only. Instead of limitations, there were a series of specific things that had to be in place for a CD to be successfully pressed, but systems like the 1630 which had a built-in error detection mechanism took care of this, but that had nothing to do with the dynamic character of the material, so long as the signal did not peak at 0db and go over, causing data errors, a CD could be pressed.

The DAW (Digital Audio Workstation)

Aside from classic analog equalization, compression and limiting that could affect the dynamic quality of the material before pressing CDs, the digital age also brought along refined digital tools to be used in mastering towards the late 80s. Noise reduction systems like the one developed by Dolby labs in the 50s were improved to operate in the digital domain and towards the end of the 80s, the Digital Audio Workstation was born. Workstations like the SonicStudio pioneered DSP processing as well as the NoNoise reduction process and delivered CDs from a desktop unit. At this time, personal computers weren't powerful enough to do what these dedicated units did. Other DAWs followed, such as the SADiE workstation in 1991 and pretty soon, many respected names in custom mastering were using one of these workstations to custom master albums in the digital realm. It was such an advancement in technology that most of the CDs being released at the time specified when an album was "Digitally Mastered" or "Digitally Remastered". At this point, these workstations were very much out of anyone's price range except for those mastering houses with the budget to afford them. The interesting point here is that this opened the doors to digital systems designed exclusively for custom mastering.

In the recording world, digital was also taking over with recorders like the Alesis ADAT, which was introduced also in 1991 and could be dixie-chained with additional units to add more recording tracks. Mixdowns also started to be recorded in digital, typically to stereo DAT recorders and the mixdowns could then be transferred over to mastering systems via S/PDIF (another development of the Sony/Philips partnership) which allowed lossless transfer of data. These new digital recorders allowed those who could not afford something like a 24-track Studer and tape media which could alone run in the thousands the ability to track a full-length album, since the media used in these newer digital recorders cost a fraction of the cost, and the quality was better than the home recording

technology at the time, which was typically cassette tape-based multitrack recorders. The cost of the newer digital media also began phasing out ¼" analog reel-to-reels, which sounded better than cassette-based multitrack recorders.

As a result, the doors opened up for even more studios to set up shop. Because a lot of the mixdowns were recorded on DATs, Mastering Engineers who used to only take the U-matic tape format for mastering CDs had to meet the demand of the new studios mixing down to DAT, and started to also accept DATs as premasters. This didn't immediately phase out the U-matic tape format, since DAT was limited to only providing the music and track IDs, and not the more detailed and required information for replicating CDs from systems like the Sony 1630.

Personal computers were also on the map in the recording studio in the 80s. IBM released the first PC in the early 80s, but soon after that, Apple released their personal computer, the Macintosh and established itself as the leader in personal computing. MOTU's Performer which started back around '85 and Opcode's Vision allowed musicians the ability of synchronizing MIDI instruments and edit sequences with precision, but audio recording didn't come into the picture until '91 when Digital Performer was released and added digital audio capabilities in conjunction with a platform developed by Digidesign called Audiomedia, which was later renamed Pro Tools. When these came out, computers weren't powerful enough, so dedicated platforms like the Audiomedia were necessary in order to handle the audio data processing. At this time, the idea of having a personal computer handle all of the necessary processing tasks for digital mastering was unheard of, but some began to see where things were headed, and many interesting articles began to appear in trade magazines about the future of computers in the studio. Things began to change in the mid 90s, as computer manufacturers began to produce better quality processors and other peripherals; things then began to be cheap enough for the home recordist to buy. In the recording world, this new onslaught of cheaper and reliable technology for recording music was quickly embraced, especially with the development of the CD-R, and as that technology became less expensive, more people jumped on it.

The key thing to keep in mind at this point is that with computers and CD-R technology becoming affordable for musicians, this meant that they could now publish their own CDs. The need to have a mastering engineer do the final transfer of the material to publish a CD was no longer a required step.

Mastering engineers didn't embrace the new, cheaper personal computing technology. For starters, many saw it as their own demise, since towards the end of the 90s, for about $2,000 you could own a computer that was capable of producing a CD-R of your music, that you could play on most CD players, without the need to have a mastering engineer produce a premaster for you. This opened the doors to many independent artists, who would self-produce their own albums and distribute them themselves, without the need of a record deal. Many were skeptical (and with good reason) of the new hardware.

Most of the affordable hardware made for computers in the mid 90s was not suitable for professional audio. Noisy components also introduced too much floor noise, and with CD-Rs, it was believed that it simply was not possible to create a premaster CD on a computer with less errors than you would with a proper CD mastering rig, which allows the smallest amount of data errors.

Things began to change towards the end of the 90s, with higher-quality components and better software for burning red book-compatible CDs on desktop systems. Things got so much better that practically all of the replicators who used to only accept the U-matic and DAT formats for replicating CDs also began accepting CD-Rs to meet the demand of the new independent record labels, which were burning red-book CD-Rs with high-quality burners such as the Plextor 8/20, right from their own computers.

Digital Signal Processing also made a leap in the 90s, introducing software processors and DSP cards that rivaled the analog counterparts in sound quality. As a result, many mid-level studios have done away with most of the analog gear, save for the high-quality microphones and mic pres needed to capture the source as best as possible, but as far as effects, many switched to the practically noiseless and highly-accurate software effects. Thanks to today's powerful processors and components that are suitable for working with audio, it's possible to produce professional-quality recordings all in the digital domain.

Today, Mastering Engineers can take advantage of the best of both worlds, incorporating classic analog processors in the digital environment. While it is not necessary to send your music to a mastering house to be able to hear your music on a CD, mastering exists for aesthetic purposes and as we discussed earlier, the tools used in the process are only a part of it.

Mastering, like mixing is an art form, separate than the creative process of putting together a composition, or writing a good song and no matter how advanced technology becomes, the magic of bringing out the best in a good mix isn't something that comes in a box with a preset button. Above all else, it's about knowing what you're listening to and knowing what to alter in the frequency spectrum to bring out the best of it; that, for the most part, is a matter of taste and perception, which can take many years to develop.

In part II, we'll discuss mixing for mastering and how to come up with an excellent mix for mastering.