An Experiment in Sound Embossing

A Repurposed Dictating Machine Uses CD/DVD Media

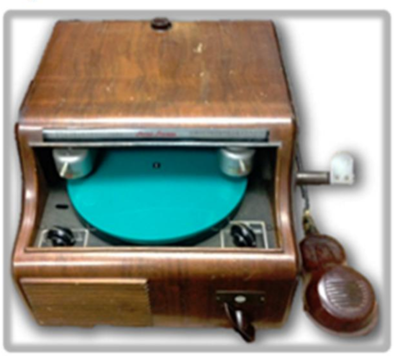
BACKGROUND

Thomas Edison didn't foresee the popularity of his phonograph as an instrument for entertainment. Rather, he thought it would find widest use in business and commerce as a dictating machine.

Edison, Dictaphone and a couple of other companies refined the cylinder-recording format into workable office dictating systems that were universal through the 1930s. Simpler and more compact belt and disc machines later became common in offices well into the 1960s. Magnetic tape came to dominate, especially the Philips cassette and its mini- and micro- versions, until digital recording eclipsed all previous methods.

THE SOUNDSCRIBER

One of the more popular disc-based dictating machines was the SoundScriber, introduced in the mid-1940s. This device 'embossed' (pressed) a groove into a plastic disc that spun at 33⅓ r.p.m. The SoundScriber discs were characterized by their bright green color and square center hole. Discs came in various sizes, from about 8" in diameter down to 3", depending on the vintage and model of the machine, and the minutes of recording time afforded. The unit shown here is an early one.



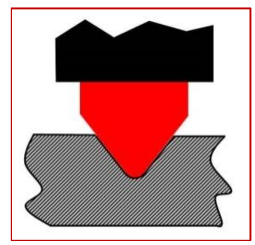
SOUND EMBOSSING

Common phonograph records are stamped into vinyl plastic with heat and high pressure. But the original lacquer master disc is 'engraved' using a complex and precisely-ground chisel-like stylus that cuts a smooth, clean groove in the soft lacquer surface of the master disc. An engraved (cut) groove best preserves all the nuances of the electrical signal that drives the recording head, yielding low noise and high audio fidelity.

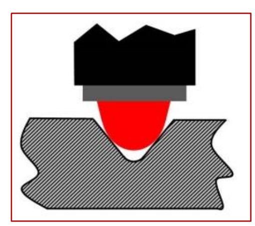
But cutting a groove requires a certain amount of training and skill, qualities not necessarily native to the typical secretarial pool. Embossing, on the other hand, uses a simple spherical metal stylus that simply presses a groove into a plastic material. The primary reasons that embossing was chosen for dictating machines were the simplicity of the process and ruggedness of the machine.

Let's look at the difference between a cut (engraved) and an embossed groove.

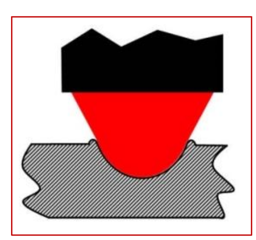
This first image is the head-on view of a chisel-tip disc recording stylus cutting into a lacquer-coated master disc. Note the angled, straight sides and a small tip radius. As the groove is cut, the thread of material removed from the disc, called 'chip' or 'swarf,' is sucked-away by a vacuum. The groove conforms exactly to the shape of the stylus. The engraving stylus is subjected to wear as it cuts the groove, and generally is made from a hard jewel like synthetic sapphire or ruby, which is precision-ground to very precise dimensions.



Here is that same groove as it is played on a phonograph. The tip, again a jewel in most cases, has a spherical shape and rides on the groove walls. The stylus actually contacts the groove at just two, theoretically-infinitesimal tangential points. This is what allows recovery of the high frequency waveforms necessary for quality sound reproduction.

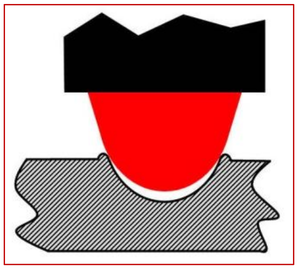


This is a head-on view of embossing action, which differs markedly from engraving, or (cutting) a groove.



First of all, the embossing stylus is spherical, forming curved groove walls. Secondly, embossing throws-up little 'horns' on either side of the groove. Embossing requires high downward pressure at the stylus tip to force a groove into the material, and the horns 'flow' out of the groove as a result.

Also, playback of an embossed recording is not as precise as that of an engraved groove.



In this first illustration, the playback stylus is a bit too fat for the groove, actually riding on the horns. Although this case may best approximate the desired small contact-point condition when playing an engraved recording, the horns more or less flowed into place and the high frequency detail is not as well defined in embossing as in the engraved groove. The horns are also somewhat fragile, so the recording won't deliver as many plays before the sound quality degrades.

In this second case, the stylus is too small and rides in the bottom of the groove. It's easy to see that the stylus can 'rattle around,' generating noise and distortion that degrades sound quality.

So, what about a stylus exactly the same size and shape as the recording stylus? Yes, that might help, but embossing a groove by applying high pressure at the stylus tip is a 'fluid' process, and the material tends to spring-back and even shrink after it is deformed in passing under the recording stylus. Therefore actual groove geometry is neither very predictable nor well defined. A slightly oversized playback stylus does yield better sound.

RECORDING MEDIA

Polycarbonate CD and DVD discs were chosen as the recording medium at the start of this project. In the first place, this particular model won't accept a disc that's much bigger than a CD, but the choice was also largely based on the prior work of other experimenters who found that polycarbonate embosses easily and quietly, with less tendency to flow and spring-back than some other common plastics. Not only that, but even brand new CDs and DVDs are cheap, and discarded ones work just as well.

The Internet "Lathe Trolls" disc-recording group, lathetrolls.com, is a valuable resource for the disc recording enthusiast. There you can find a wealth of information on both record cutting (engraving) and embossing. Many Lathe Trolls members embrace disc embossing, doubtless because the recording styli and blank media are far less expensive than their counterparts that have been precision-crafted for critical phonograph record mastering.

STRIPPING A SOUNDSCRIBER

The SoundScriber chosen for this project was a later desktop model, perhaps from the late 1950s. Typical of SoundScribers in general, it is a solid, exquisitely-crafted machine that must have been quite expensive in its time.

The first step was to remove the various electrical, mechanical and optical parts of the machine that enabled the start/stop/review functions common to office dictation needs and practices. This stripped the machine down to its primary functions of spinning the disc and guiding the recording and playback heads laterally across the disc surface. Here's a snapshot of the disassembled machine.

A plywood box was hastily assembled to house the project, with ample front and rear panel areas for connectors and controls, and room for the electronics.

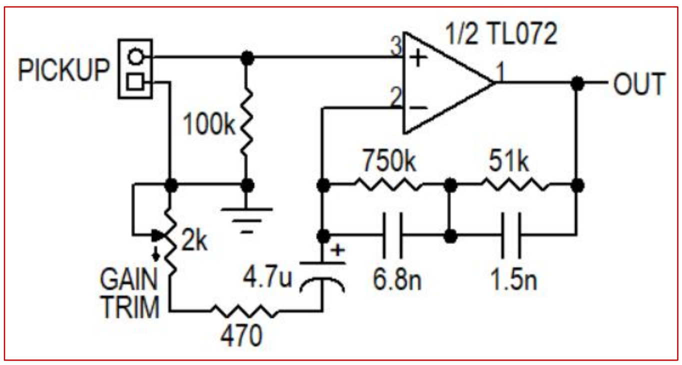
This next photo shows the SoundScriber deck plate reassembled and mounted. A number of unnecessary hunks of the main casting were sawn-off and discarded, and the turntable covered with a rubberized cork material. Also visible is the 2-piece spindle adapter for the 15mm CD/DVD center hole, machined as a favor by a friend. The loose piece screws-down over the other to clamp the disc so it won't slip on the turntable.

DEVELOPING THE ELECTRONICS

With the mechanics in hand, the next step was to provide playback and recording circuitry to replace the original vacuum tube electronics.

Fortunately, the SoundScriber playback cartridge turned out to be a high quality magnetic type, not unlike a monaural phono cartridge from the '50s hi-fi era. Anticipating that discs made on this machine might also be played on a standard phonograph, the RIAA playback curve seemed a good one to use here as well.

One section of a TL072 op-amp and a handful of parts produced the quite respectable reproduce preamp diagrammed below.

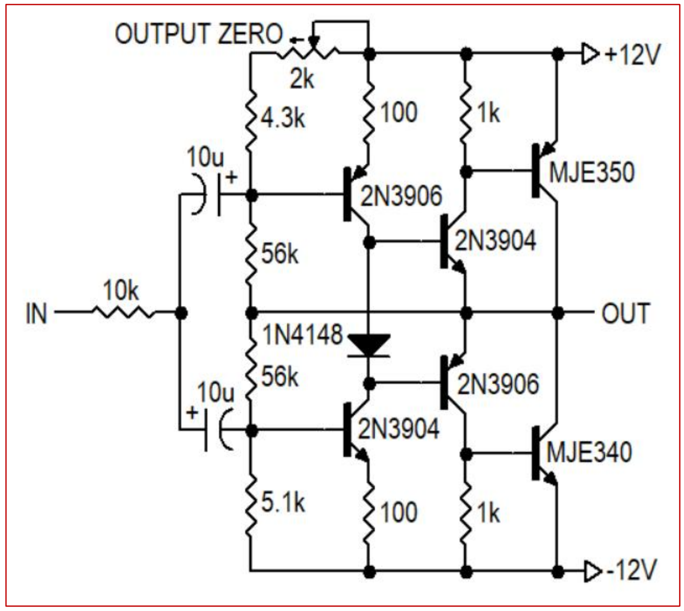


With playback functional, the recording amplifier and its equalization were next on the list.

The default choice for a recoding amplifier would probably have been a boring, integrated circuit power-amp chip. The tube amp that originally drove the recording head used a 50C5 power pentode in a circuit that looked much like an 'All-American Five' table radio output stage, suggesting that just a couple of watts would be sufficient for our purpose here.

But there appeared to be something quite odd about the SoundScriber recording head. Any junk box power-amp IC connected to it either broke into wild oscillation, or it delivered an output waveform that didn't much resemble the input signal. Neither the venerable LM380 nor its sturdier cousin, the LM1875, could be made to work. The head was even opened-up and inspected to make sure there was no EQ or other embedded network inside that might appear abnormally reactive to the driver.

Rather than do battle with this unexpected and annoying issue, a simple and straightforward discrete-transistor amplifier design came to the rescue. The circuit, diagrammed below, has minimal negative feedback. The high loop gain of the IC amplifiers might have had something to do with the problem; after all, the original tube amp had no feedback at all!

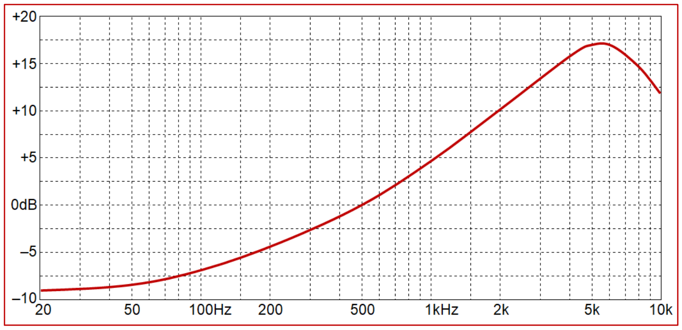


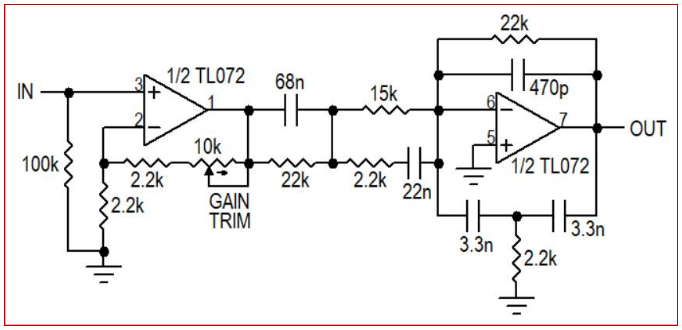
RECORDING EQUALIZATION

With the recorder operational, a series of test recordings quickly revealed overall response limitations and became the basis for developing an optimal recording curve.

Rather than starting with an 'inverse-RIAA' equalizer, a concept used in establishing tape recorder EQ was followed instead. In short, once the playback equalization is determined, simply use whatever recording pre- or de-emphasis yields best overall response. This automatically factors-in both electronic and wavelength-dependent (mechanical) losses.

At the outside diameter of a polycarbonate CD, the best ±3dB response topped-out at 5kHz. 3kHz was about the limit at the inner diameter. Rather than try to brute-force response beyond the mechanical cutoff of the system, a resonant equalizer with a peak just above 5kHz was placed ahead of the recording amplifier. Here is the recording EQ curve and a schematic of that equalizer circuit.





FINISHING TOUCHES

Electronic circuitry was hand-wired on a scrap of perf-board with plug-in ribbon cables connecting the front and rear panels.

In addition to what's shown in the schematics here, there is a line output stage that switches between source and playback, and a rectifier circuit for a VU meter salvaged from an old tape recorder. DC power comes from a pair of 12-volt 'wall-wart' switching supplies. All of this is visible in the underside view below.

Here is a photo of the finished recorder.

...and this closeup shows the unit in action.

You can listen to a recording made and played on this machine here:

https://www.dropbox.com/s/425hx8xo8pzoh09/SoundScriber.mp3?dl=0

Repurposing an old dictating machine actually turned out to be a fun and rewarding project!