The Audio Engineer's Handbook

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Disc Cutting *continued*

Suction, Heat, and Lacquer Noise

● The reason for discussing all three of these subjects together is because they are closely inter-related. The lowest groove noise is achieved with a proper amount of heat applied to the stylus tip. The amount of heat is, in part, a function of the amount of suction. It is the adjustment of these variables that is the subject at hand.

First, the amount of suction must be adjusted so that the chip is properly picked up. This is controlled by varying the speed of the suction pump or by changing the vent opening of the suction pipe. The first choice is more desirable since it also reduces the airborne noise which may interfere with monitoring.

An ordinary vacuum cleaner is the most popular (and least expensive) way of obtaining the needed vacuum. Some studios prefer using a Variac to reduce power to the vacuum. There is yet another simple and effective means to reduce voltage if you lack a variable transformer.

Take an ordinary lamp with several sockets and install high-wattage bulbs. By varying the number of bulbs connected with the lamp in series with the motor, the speed will be reduced. A considerable degree of sophistication can be achieved by connecting the bulbs through switches so that higher vacuum speeds can be used for lead-in grooves, with a lower vacuum easily switched in for program modulation.

Proper amounts of suction are important because excessive suction will cause groove noise due to the rushing air modulating the cutting stylus. So the position of the suction pipe must be such that the chip is picked up easily without causing air modulation of the stylus. Proper positions can often be determined experimentally. Usually, it is found to be almost behind the cutting stylus.

The amount of stylus heat should be adjusted with the suction at its minimum-use setting. (Some lathes (such as Scully) feature automatic increases in suction during the lead-in spiral.) With the heat set for a minimum-suction condition the stylus will not be subject to overheating conditions.

Different lacquer batches may require different amounts of heat to achieve the lowest surface noise. The best way to adjust heat is to use a pickup arm mounted on the lathe so that the groove may be monitored directly after it is cut.

Cut a groove without any modulation. (Turn off the recording amplifier.) With a meter monitoring the playback pickup's amplifier, observe the noise level. Gradually increase the current through the heater. As the heat rises, the noise will be reduced. After a point it will begin to rise again. Back up the setting until the minimum heat for the lowest noise is determined. Note the amount of current and suction being used. Any change of suction will require a resetting of the heater current (except for the lead-in groove) where an increase in noise is tolerable.

Approximate heater settings can be made by adjusting the current until the wires leading to the heater just glow red. The measured current through the heater may be anywhere from 0.5 to 1 amp — depending on the suction.

It's worthy of note that the *type* of current may be important. Some cutters are sensitive to a.c. heaters because the feedback coils may pick up 60 Hz hum. For these cutters, of course, d.c. must be used.

I must warn that heat should not be set without suction operating. The flow of air around the stylus changes the heat.

Another warning: excessive heat produces a deeper groove at smaller radii. In extreme cases, lacquer may burn and stick to the stylus forming a hard shell around it. If you have been discarding styli because of this, some paint remover, epoxy solvent, or household cleaner will remove the residue. After applying the chemical to the stylus, wipe it off with a soft rag. Don't apply the solvent to the stylus shank.

Overheated chips often clog the suction passages. As a cure, place a little talcum powder on a piece of paper and let the suction hose pick it up. This will make the walls of the pipe non-sticky; this is particularly effective on highly humid days.

If acetone or other solvents are used to clean the stylus and advance ball, be sure none of the liquid finds its way onto the cutter coils or into its interior. This is an all too common cause of burned-out windings, stripped insulation, and damaged damping.

Another cause of coil burnouts is oil that is accidentally spilled on the cutter from the oil dash pot that is just above it. Oil seeps into the gaps between the coils and the pole pieces, restricting the motion of the armature. Feedback tries to correct this by sending a stronger signal into the coil, causing overheating of the winding and eventual burnout. (This condition does not exist in moving-iron cutters where the gaps are intentionally filled with oil for damping—and no tight feedback exists.)

Steel or magnetic filings can cause the same damage—only faster. So demagnetize and carefully wipe all screwdrivers and tweezers before bringing them close to the cutterhead.

Recording Amplifiers

The amplifiers used to drive cutters are still mostly tube-type. With present-day recording techniques, at least 100 watts/channel are needed. Although recently developed transistor amplifiers can deliver such power, the fact remains that most of the units in present use operate with tubes.

Most of these amplifiers contain pre-equalization circuits as well as feedback monitoring facilities. Because of the nature of cutter construction and response (just as with all mechanical transducers) phase reversal of the signal with multiple resonances is occurring over the audio spectrum. Motional feedback has the designation of flattening the response of the cutter by feeding the information back to the driver amplifier with inverse phase (negative feedback). At those frequencies where resonances occur, phase changes its sign and feedback may become positive instead of negative. At the higher frequencies, it becomes harder to prevent feedback from becoming positive as well as stopping excessive amounts of it from causing oscillation. As a result, the response of the feedback is restricted to those frequencies where it can be effectively controlled.

There is yet another aspect of feedback control of the cutter armature that restricts the usefulness of feedback. This is the relatively non-dependable coupling of the driving mechanism (coils) to the stylus. Since sensing for the feedback is usually done as close as possible to the cutting stylus (further away from the coils) tight coupling and steady phase relationships between the stylus-feedback system and the coils is not feasible.

In sum, feedback at the lower frequencies is an almost exact replica of the stylus motion; at higher frequencies feedback data (as well as compensation) is only as good as the feedback-sensing coupling to the stylus.

A sure way of determining the faithfulness of feedback is to feedback monitor the system, record the same signal, and compare the two. If they differ, then necessary compensation has to be applied and feedback monitoring must be restricted to reference use only.

Of course, the best monitoring is the playing of the disc itself. But for reasons of groove preservation for plating and stamping, it is bad policy to test play masters, even with the most compliant of cartridges. If you make an extra copy for quality testing, remember that high frequencies will sound duller on the lacquer than they will on vinyl pressings. This phenomenon occurs because the mechanical compliance of the lacquer groove is higher than one of vinyl. So the playback stylus tends to deform high-frequency excursions in the lacquer while vinyl will offer much more resistance to deformation.

Amplifier Care

Since most of the driver amplifiers are still tube-types, preventive maintenance is absolutely necessary to keep the system working at its peak. The most likely trouble spots are the tubes and the electrolytics. Just as tubes must be periodically replaced so must the 'lytics. When a 'lytic loses its capacitance there is a decrease of power output along with an increase in distortion and hum level. If the capacitor in question happens to be a cathode bypass device, it may cause excessive rolloff at the low frequencies.

Therefore, periodic checks of the amplifier for maximum power at rated distortion, along with frequency response and noise measurements should be done (at least semi-annually). Remember that only a 3 dB drop of output level at the specified distortion reduces the amplifier's power in half. More than once, I have seen amplifiers in for "repair" when the only fault was a need for fresh tubes. Yet this work had not been done by the studio's maintenance crew.

Many studios leave their equipment on all day, regardless of room temperature. True, the system should be preheated prior to cutting to eliminate all thermal drifts that occur during warmup. However, output tubes are limited in life and expensive in high-power amplifiers. It has been my experience that turning equipment on a half hour prior to cutting is quite sufficient to stabilize the circuits. This will also considerably prolong the life of the tubes.

Of course, the new transistorized amplifiers do not have to be turned on in advance since preheating is not needed.

Half Speed Cutting

There are a number of tricks used by recording engineers to put higher levels on a disc than the cutter will normally allow. One of these is cutting at half the normal speed. Of course, the master tape is also fed in at half the speed. With this method, frequencies are halved; 10 kHz becomes 5 kHz. Because of preemphasis, lower frequencies are easier to record. This is the basis for achieving higher amplitudes.

But watch out for pitfalls. 30 Hz becomes 15 Hz. The playback equalization of the tape machine and of the recording amplifier have not been altered although frequencies have changed. At these reduced speeds, the equalization crossover points must be adjusted if flat response is to be maintained. To determine the exact extent of needed modification, take a standard alignment/response tape and record it on disc — all at half speed. (Reduce the recording level at least 10 dB to protect the cutter.) Play the recording on a calibrated playback system noting the deviations. Inadequacies in the response can be corrected by using a program equalizer. This method works well with all equipment but is best with the newest direct-coupled (extended l.f. response) transistor amplifiers.

Reduced-speed cutting is particularly useful when test records or high-frequency tones must be recorded. Attempts to cut 20 kHz directly will prove to be impossible. At half speed, the problem is eliminated.

"Toy" Recordings

The toy industry has created a large demand for small-sized, vertically-modulated discs. These records must be run at fairly high r.p.m. because of their small diameter, producing linear speeds of 5-15 in./sec. (Diameters range from 2½-5 inches.)

But the most intricate part of the requirement is that the disc be cut with multiple parallel grooves. Although each message may be only a few seconds, there may be as many as fifteen messages. Needless to say, this job requires patience, experimentation, and is tricky. An oversize blank should be used, offering a chance to start the cut well outside the prescribed maximum diameter and to adjust the relative position of the groove with the spiraling mechanism. By the time the cut reaches the diameter needed it is positioned exactly where it should be relative to the previous cut.

There is one condition that must be observed. Once you decide upon a pitch — *don't change it.*

A stereo cutter is used, strapped for vertical cutting by paralleling both channels with one of them 180-degrees out of phase with the other. The job can be made easier if a means is devised to start the recorder when the cutter reaches a pre-determined point. Since most of these toy records are designed for high-speed reproduction, reduced-speed recording techniques apply here.