Preservation Re-Recording of Audio Recordings in Archives: Problems, Priorities, Technologies, and Recommendations

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Abstract

This article offers a context for examining archival audio holdings, determining preservation needs and priorities, and planning audio re-recording (reformatting) projects. It addresses such issues as identification of the most vulnerable recording types, the meaning of "preservation re-recording," and the skills, equipment, and personnel that are necessary for working with older recordings. The information provided is drawn in part from the experiences of archivists at Georgia State University during an in-house archival audio re-recording project funded by the National Historical Publications and Records Commission.

In recent years, preservation of audio recordings has become a topic of increasing concern to archivists. Unfortunately, many archivists are discovering that their professional training has not prepared them for dealing with recording media and systems, and they find themselves at a loss when attempting to administer and preserve their audio collections.

This article is intended to offer a context for examining archival audio holdings, determining preservation needs and priorities, and planning audio re-recording projects. It will attempt to clarify several key issues relating to audio preservation, including the types of recordings that are most at risk of loss, the meaning of "preservation re-recording," and the skills, equipment, and personnel that are necessary for working with older recordings. It will not explore issues relating to cylinder, dictation, wire, or acoustical recordings; nor will it provide specific details on selecting recording equipment or cleaning and restoring recordings. These topics are complex, and most are

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discussed at length in other publications.[1] The information provided here is drawn in part from the experiences of archivists at Georgia State University (GSU) during an in-house archival audio re-recording project funded by the National Historical Publications and Records Commission conducted from 1992 to 1994.

Prologue

Audio re-recording is expensive and time-consuming. In order for any re-recording project to be both successful and efficient, its plan must be based on a clear understanding of the problems to be addressed, of the strengths and weaknesses of the available preservation options, and of the types of personnel, equipment, and administrative support necessary for success. Time invested, before a project is begun, in studying the institution's collections and learning about re-recording options will save money and reduce frustration as work progresses. While the various issues can be divided and presented in a number of ways, the presentation here will roughly follow the progression pursued by personnel at GSU in planning and implementing its preservation project:

A. Examining the collection:
   - identifying vulnerable types of recordings
   - identifying sizes, speeds, and formats
   - setting priorities
   - determining when to re-record

B. Understanding "preservation re-recording":
   - how recording technology works
   - defining "preservation re-recording"

C. Transfer technology options and recommendations:
   - the importance of careful reproduction (playback)
   - transfer technology: analog vs. digital; tape, disk, or other new media

[1] See, for example, George Boston, ed., *A Guide to the Basic Technical Equipment Required by Audio, Film and Television Archives,* written by members of the Coordinating Committee for the Technical Commission of the International Organizations for Audio, Film and Television Archives (1990); *Archiving the Audio-Visual Heritage: A Joint Technical Symposium, Fédération Internationale des Archives du Film, Fédération Internationale des Archives de Télévision, International Association of Sound Archives,* published in 1984, 1988, 1991; Association for Recorded Sound Collections, Associated Audio Archives Committee, *Audio Preservation: A Planning Study — Final Performance Report* (Silver Spring, Md., 1988); Alan Ward, *A Manual of Sound Archive Administration* (Brookfield, Vt.: Gower Publishing Co., 1990); Gerald Gibson, "Decay and Degradation of Disk and Cylinder Recordings in Storage," in *Archiving the Audio-Visual Heritage,* edited by Eva Orbanz (Berlin: Stiftung Deutsche Kinemathek, 1988); Christopher Ann Paton, Stephanie E. Young, Harry P. Hopkins, and Robert B. Simmons, "A Review and Discussion of Selected Acetate Disc Cleaning Methods: Anecdotal, Experiential and Investigative Findings," *ARSC Journal* 28 (Spring 1997): 1–23; Marie P. Griffin, "Preservation of Rare and Unique Materials at the Institute for Jazz Studies," *ARSC Journal* 17, no. 1–3 (1985): 11–17.

- documenting the preservation process
- the audio technician
- current recommendations for preservation transfers

D. Final considerations:
- estimating cleaning and transfer time
- estimating costs (including in-house and out-of-house considerations)
- support staff needs
- space considerations

Examining the Collection

Identifying Vulnerable Types of Recordings

The first step toward starting an audio preservation re-recording project is determining which recordings are vulnerable to loss due to age, damage, or inherent vice. Although all sound recordings are subject to wear and tear during use and as a natural result of aging, only a few types are currently considered "at risk" and in need of prompt attention. Detailed descriptions of both historic and contemporary formats can be obtained from a number of sources;[2] what follows is a brief overview of some of the types of audio recordings commonly found in archives and the formats posing the greatest concern for archivists.

Grooved Phonodisc Types. The grooved phonodisc family includes the "78s," "45s," and "LPs" familiar to those born and raised prior to the advent of cassette tapes and compact discs, and also includes the less-familiar "instantaneous" recordings known variously as "acetates," "lacquers," and "direct-cut discs."[3] Shellac-type 78s, and vinyl-type 45s and LPs are not presently considered especially vulnerable to age-related deterioration or inherent vice.[4] "Instantaneous" or "acetate" recordings, however, present serious preservation concerns.[5]

[2] See, for example, Roland Gelatt, *The Fabulous Phonograph, 1877–1977*, 2d rev. ed. (New York: Macmillan Publishing Company, Inc., 1977); A.G. Pickett and M.M. Lemcoe, *Preservation and Storage of Sound Recordings* (Washington, D.C.: Library of Congress, 1959); John Van Bogart, *Magnetic Tape Storage and Handling: A Guide for Libraries and Archives* (Washington, D.C.: Commission on Preservation and Access, June 1995); and Gilles St.-Laurent, "Preservation of Recorded Sound Materials," *ARSC Journal* 23, no. 2 (1992): 144–56.

[3] For more information, see Ward, *A Manual of Sound Archive Administration*; Gibson, "Decay and Degradation of Disk and Cylinder Recordings;" and Christopher Ann Paton, "Preservation of Acetate Disc Sound Recordings at Georgia State University," *Midwestern Archivist* 16, no. 1 (1991): 11–20.

[4] Pickett and Lemcoe, *Preservation and Storage of Sound Recordings*, 46; "Recorded Sound Carrier Formats" chart, *Audio Preservation: A Planning Study*, 84.

[5] See *Audio Preservation: A Planning Study*, 84; Gibson, "Decay and Degradation of Disk and Cylinder

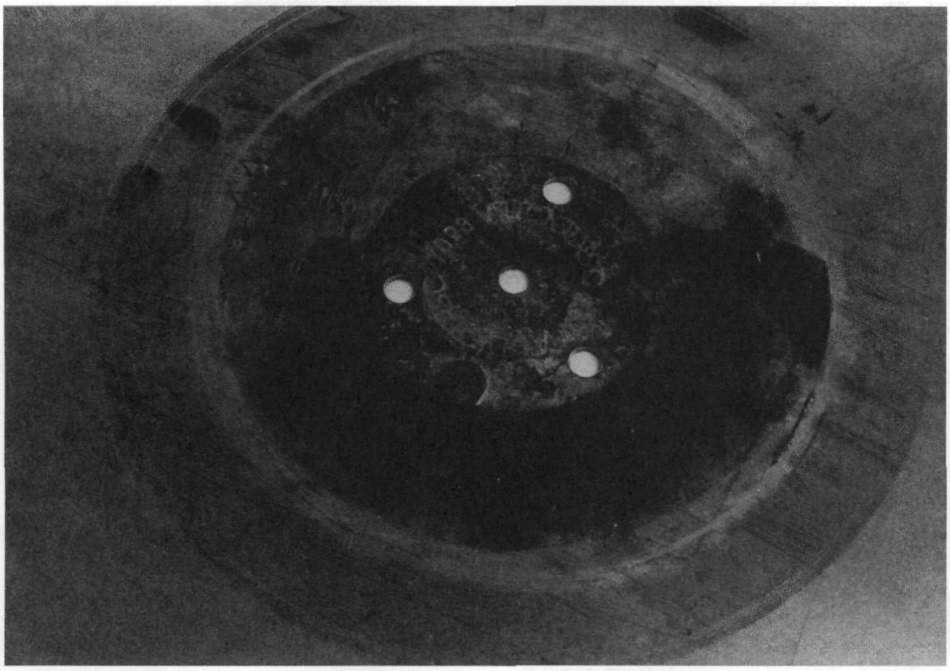

FIGURE 1. Detail of a deteriorating instantaneous disc, showing both a heavy accumulation of plasticizer residue and the extra holes surrounding the spindle hole that are often found on these recordings.

Acetate disc recordings came into common use in the 1930s. They were used for commercial, broadcast, and home recording purposes before magnetic tape technology was perfected. They also existed side-by-side with tape in regular use for a period of years (ca. 1946 - 1960s), and are still used today in the production of long-playing (LP) phonodiscs. Acetates consist of a soft plastic coating over a base disc of aluminum, glass or cardboard; the grooves are cut into the surface of the blank disc by a disc recording machine, often referred to as a cutter, producing a grooved phonodisc that can be played like the commercially-pressed discs with which many adults are familiar. Although their audio quality can be surprisingly good, they are inherently unstable and will inevitably deteriorate until they become unplayable. In most instances, it is the plastic coating (cellulose acetate or cellulose nitrate) that deteriorates; in other cases, the glass base breaks, the cardboard base is damaged (by exposure to water, for example), or the metal base is bent or dented. Deterioration of the plastic coating is marked by the appearance on the disc surface of a greasy white powder and eventually a shrinking, cracking, and peeling of the coating from the base material (see Figures 1 and 2). The

Recordings," 49–50; Ward, *A Manual of Sound Archive Administration,* Chapter 6; Paton, "Preservation of Acetate Disc Sound Recordings;" and Paton et al., "A Review and Discussion of Selected Acetate Disc Cleaning Methods."

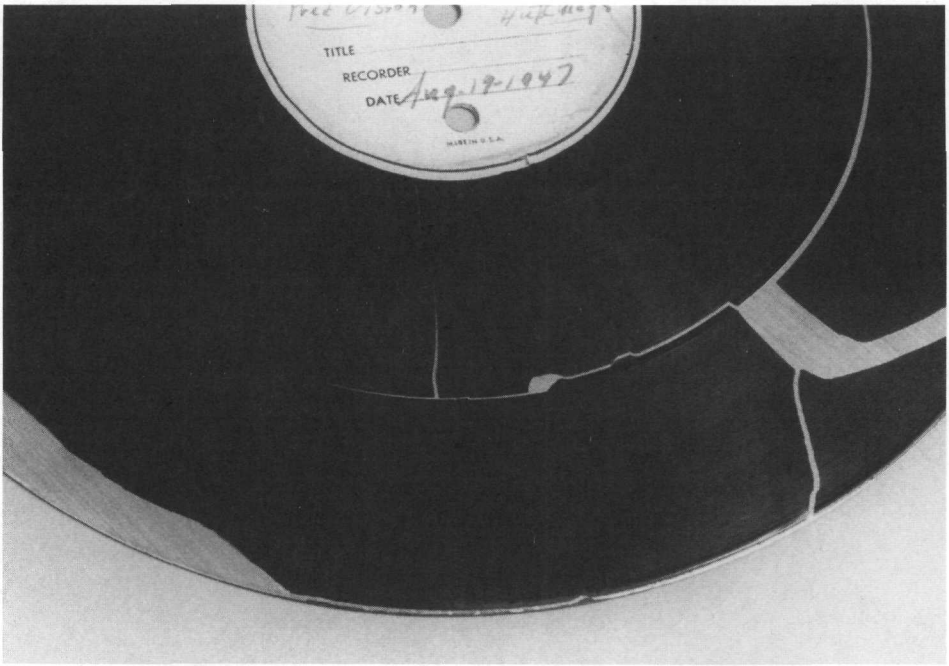

FIGURE 2. Aluminum-based instantaneous disc with shrinking, peeling coating.

white powder, which can be mistaken for mold by the uninitiated, is composed of byproducts (fatty acids, notably palmitic acid and stearic acid) produced as the coating's plasticizers deteriorate.[6] Although careful storage under cool, dry conditions will prolong disc life to the fullest possible extent, all acetate discs will eventually deteriorate and must be re-recorded if their audio content is to be preserved.

While acetate discs appear similar to other types of phonodiscs, and are often confused with them, they can be distinguished from other members of the phonodisc family in several ways. Most acetates have typed or handwritten labels instead of the formal, printed labels common to published, commercial sound recordings. Many discs also have, in addition to the center spindle hole, one or more additional holes near their center, sometimes hidden under the label. These fit over the pins that were provided on certain models of cutters, to keep the disc from slipping during recording; if the disc base material is metal or cardboard, the metal or cardboard layer can often be seen inside these holes, as well as inside the spindle hole. Not all acetates will have such holes, as some types of cutters use a vacuum system to hold the discs firmly in place during recording. The base material may also show through at the rim of the disc, where the plastic coating is often thinner and somewhat transparent. Glass discs frequently bear labels identifying them as

[6] Paton et al., "A Review and Discussion of Selected Acetate Disc Cleaning Methods;" Gibson, "Decay and Degradation of Disk and Cylinder Recordings;" Ward, *A Manual of Sound Archive Administration*, 150–51; St.-Laurent, "Preservation of Recorded Sound Materials," 146–47, 153.

glass, and when held (carefully) up to the light will usually prove translucent. The appearance on the surface of the disc of plasticizer residue (as opposed to mold) is a sign that a record is likely an acetate and not a regular LP or other commercial phonodisc; peeling plastic coating that exposes a metal, glass, or cardboard base material, is, of course, another good indicator. Archivists should be aware that some types of commercial discs, shellac 78s in particular, are also laminated products, featuring cardboard or paper sandwiched between layers of shellac-type substances. In addition, the surfaces of shellac discs that have been played very heavily can have a white appearance. Such discs are usually easily distinguishable from acetates, however, by an examination of the labels (which are usually printed with the record company name, issue number, and other key information) and also by the appearance and texture of the disc and its surface.

Magnetic Tape Types. *Reel-to-Reel Tape.* Although magnetic tape has historically been considered fairly sturdy, it does deteriorate over time, sometimes catastrophically.[7] All tape consists of a flexible base, most commonly plastic of one sort or another, a binder, and minute magnetic particles (usually referred to as "oxide"), along with various lubricants and other ingredients that help improve tape functioning. Modern polyester-based tape also has a back-coating, which is applied to the underside, or back, of the tape to help control static electricity generated by the polyester and enable the tape to move through the tape deck mechanisms more easily. Deterioration of the tape can occur in the base, the binder, or the oxide, with base and binder problems being the most common causes of premature tape failure. In order to evaluate the condition, potential life expectancy, and preservation needs of audio tape in an archives, the archivist must know which types of tapes are present and how they age and deteriorate.

Some tapes made in the 1940s used paper as the base material. Paper tape can be identified by its pale appearance, sometimes with plain paper exposed beyond the oxide at the edges of the tape. Although paper-based tape is often found to be in surprisingly good shape, given its makeup and age, the paper base is both fragile and, frequently, nonstandard in width, and is easily torn during playback. Consequently, these tapes should be given high priority for copying to a modern medium.

During the 1940s and 1950s cellulose acetate was the most common tape base. Acetate tape becomes brittle with age and is subject to cupping, curling, and other forms of physical distortion. In addition, it can suffer from the "vinegar syndrome" that afflicts acetate motion picture and photographic

[7] See Van Bogart, *Magnetic Tape Storage and Handling*, 2–7, for a discussion of magnetic media structure and deterioration.

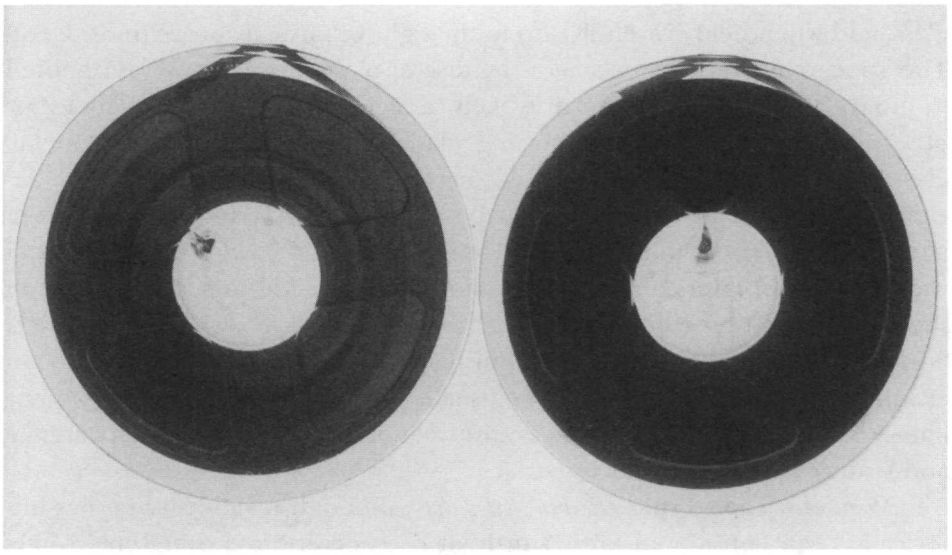

FIGURE 3. Two reels of magnetic tape, one holding acetate base tape (left) and the other containing polyester base tape (right), photographed on a light box. Note the translucent appearance of the acetate tape and the completely opaque appearance of the polyester tape.

film.[8] To determine whether a tape base is cellulose acetate, hold the reel of tape up to a light source and look through the flat, circular surface of the tape pack (as if looking into a hand mirror); if the tape pack appears translucent it is most likely cellulose acetate (see Figure 3).[9] Another test for acetate base involves breaking a small piece off the end of the tape, being careful, of course, not to break off any of the tape that is recorded. Acetate-based tape will break easily across the width of the tape. It is wise to pay attention, when testing any tape, to whether the tape has a leader (length of blank tape, often clear, white or some other color) attached to the end. Leader materials often differ from the main body of the tape, and testing the leader may give incorrect results.

Although the primary mode of failure for acetate tape is usually embrittlement or distortion of the tape base, failure of the binder, accompanied by shedding of the binder and oxide, is also possible. Reliable life-expectancy figures are not available for acetate tape (although such tapes frequently exceed all reasonable expectations for sturdiness and durability), but since virtually all cellulose acetate tapes are now at least thirty years old, and many are nearly fifty years old, they are considered a high priority for copying. Tapes exhibiting signs of vinegar syndrome (identified by an odor of vinegar

[8] See Van Bogart, *Magnetic Tape Storage and Handling*, 6; and Dietrich Schüller, "Sound Tapes and the 'Vinegar Syndrome,' " Phonographic Bulletin 54 (July 1989): 29–31.

[9] Van Bogart, *Magnetic Tape Storage and Handling*, 6; Ward, *A Manual of Sound Archive Administration*, 173.

about the tape) should receive particular attention. Paradoxically, acetate tapes that are in good condition may still outlast "preservation" copies made on newer polyester-based tape, much of which has a shorter life expectancy.

Polyester has been the standard tape base since the 1960s. Because polyester is much stronger and more stable than cellulose acetate, does not break easily, and is not greatly affected by changes in temperature and humidity, one might reasonably expect that tape made with this base would have a greater life-expectancy, but this is not necessarily true. Shortly after the tape manufacturers changed the tape base, they also changed the type of binders used to hold the oxide to the base and added an anti-static "back-coating" to improve tape handling and reduce static electricity. The binders adopted throughout the tape manufacturing industry, and still in use today, employ polyurethane as a primary component. In the late 1980s archivists and recording engineers began to encounter tapes that squealed when played, and shed oxide and binder that stuck to the playback heads. It is now understood that tape hydrolysis, or "sticky shed syndrome," as it is commonly known, is caused by absorption of moisture by the binder, resulting in binder failure.[10] When the tape is played, the binder sticks to the tape transport and begins to peel off, taking the magnetic particles with it. Although there are temporary fixes for this condition (notably baking the tapes at low temperatures for a period of time), in the long run, tapes afflicted with sticky shed syndrome must be copied if their content is to be preserved. Manufacturers have made an effort to improve the binder formulations, but life expectancy predictions vary, and most tapes manufactured today carry only a ten-year warranty. Tapes made prior to the discovery of the problem (from the mid-1970s through the mid-1980s), or used and stored under humid conditions, may have shorter life expectancies. In most cases, the polyester base will almost certainly last longer than both the binder/oxide mixture that contains the recorded information and the back-coating.[11]

To identify polyester tape bases, hold the reel up to a light source and look through the flat, circular surface of the tape pack as if looking into a hand mirror. If the tape pack appears opaque, it is most likely polyester (see Figure 3). Acetate-based tape, as noted earlier, usually appears translucent when held to the light; it may be useful to perform a comparison test by viewing one reel of each type of tape.

Audio Cassettes. The audio cassette deserves special attention here, if only in recognition of the great quantities of cassettes that reside in archives. In brief, the cassette is an inexpensive, short-lived format that should not be

[10] Van Bogart, *Magnetic Tape Storage and Handling*, 3–5; Scott Kent, "Binder Break-Down in Back-Coated Tapes," *Recording Engineer/Producer* (July 1988): 80–81; Philip De Lancie, "Sticky Shed Syndrome," *Mix* (May 1990): 148–55.

[11] Van Bogart, *Magnetic Tape Storage and Handling*, 6.

relied upon for long-term storage of historical information. Audio cassettes contain exceptionally thin and narrow tape which causes them to be more susceptible to damage and failure than reel-to-reel tape. These tapes are particularly prone to damage during playback. The tape in shorter cassettes, such as those running up to sixty minutes, is usually the sturdiest because it is the thickest, while longer-running cassettes, particularly the 120-minute varieties, contain thinner tape which poses an increased risk of damage through fouling (being "eaten" by the playback unit). Other common problems with cassettes include leaders that become disconnected from the tape hubs, and a gradual degradation of both audio quality and playback ability.

Although there are no published figures available on the life expectancy of audio cassettes, some archivists feel that any cassette over two years old is suspect. In any case, cassettes should be considered likely candidates for preservation re-recording.

Identifying Sizes, Speeds, and Formats

It is important to note the sizes of recordings present in a collection while examining them for possible preservation action, because size is one factor used in calculating their cumulative playing time and determining the types of equipment needed to play them. It is also important to determine the speed of the recordings, which constitutes a separate factor in determining their playing time. Each "family" of recordings includes characteristic sizes and speeds with which the archivist should become familiar.

In addition to sizes and speeds, the archivist should become aware of the various formats associated with each type of recording. By "format," the author means whether the recording is monaural or stereo (or one of the many other, less common, formats), and the way in which the recorded information is captured on the recording (types and sizes of grooves, or, for tape recordings, track configurations—the number, size, placement, and orientation of the recorded tracks on the tape). The format of each recording can be an additional factor in determining playing time, and will determine the types of equipment needed to play the recording.

Grooved Phonodisc Sizes and Speeds. Phonodiscs commonly range in size from about 7 inches in diameter (the size of a 45 or "single") to 16 inches (a size frequently used in broadcasting), although smaller and larger sizes are also possible. Most middle-aged adults today remember that commercial 12-inch LPs play at 33⅓ rpm (revolutions per minute) and 7-inch singles play at 45 rpm. Some still remember that 10-inch shellac discs play at 78 rpm. Speed is not related to disc size, however, except by custom, and the speed of a disc should not be assumed based on its size. A 7-inch disc can play at 33⅓, 16, or another speed besides the usual 45 rpm; 10-inch discs can

be recorded at 33⅓ or other speeds (such as 80 or 66) instead of 78. Although certain sizes and speeds have dominated the *commercial* market over time (such as the 7-inch 45 rpm single, the 10-inch 78, and the 12-inch 33⅓ rpm LP), the possible size-and-speed combinations for *instantaneous* discs ("acetates") are potentially limitless, and it is not unheard of to find acetate discs that bear multiple "cuts" recorded at different speeds or that play at a different speed for each side. In practice, most tend to play at approximately 78 or 33⅓, but this can only be confirmed by playing the recordings.

Phonodisc Formats. Grooved phonodiscs recorded prior to 1948 are almost always monaural and recorded with what are called "coarse" or "standard" grooves (defined as measuring approximately 85 to 150 grooves per inch of recorded surface), using equalizations that differ from current standards. In addition, if they are instantaneous discs, they may play from the inside out rather than the outside in. In order to play the discs in a manner that accurately reproduces their recorded content, preservation project personnel, especially the audio technician, must have access to monaural styli of dimensions suitable for the larger grooves, and to an adjustable equalizer to recreate as nearly as possible the equalization of the original recording. Equalization refers to the practice of increasing and decreasing the level of various parts of the sound spectrum during recording and playback for the purpose of improving the overall sound of the recording. If the discs are larger than 12 inches in diameter, a turntable capable of playing the larger discs will also be necessary. The most common speeds for pre-1950s acetate discs are nominally 78 rpm and 33⅓ rpm; because speeds may vary slightly, a turntable with an adjustable speed control is recommended and is sometimes required. Sixteen-inch discs in this format (coarse groove, monaural) recorded at 33⅓ rpm ordinarily hold about 15 minutes of recording per side. The playing time of grooved disc recordings can be estimated by using the following formula:

$$T = \frac{NS}{rpm}$$

where T is the playing time in minutes, S is the recorded width in inches, N is the number of lines per inch, and rpm is the turntable speed in revolutions per minute.[12]

Phonodiscs recorded after 1948 but before the mid-1950s are usually monaural, but may be "microgroove" in format rather than coarse groove, because the LP microgroove disc, whose longer playing time was made possible by fitting more grooves of a smaller size across the disc surface (200-300 grooves per inch), was introduced to the commercial market in 1948. Micro-

[12] Howard M. Tremaine, *Audio Cyclopedia*, 2d ed. (Indianapolis: Howard M. Sams & Co., Inc., 1969), 670 (section 13.115).

groove recordings gradually replaced the "coarse groove" format, and became the standard for 7-inch singles and 10- and 12-inch LPs. The monaural styli used during playback of microgroove recordings must, obviously, be substantially smaller than coarse groove styli in order to properly fit the grooves.

Phonodiscs recorded after the mid-1950s will often, but not always, be stereo in addition to being microgroove, and if they are stereo, they will require a stereo microgroove cartridge, stylus, and electronics for playback, as opposed to either a monaural or coarse/standard set-up. Such recordings are more likely to employ the Recording Industry Association of America (RIAA) equalization that became standard in the recording industry in the mid-1950s. Monaural and stereo microgroove technology, using RIAA equalization, co-existed in the recording industry for a number of years, while some broadcasters continued to use monaural, coarse-groove recording equipment and their own in-house equalization customs into the 1960s. Consequently, it is not wise to assume either that all post-1948 recordings are microgroove, or that all recordings made after 1955 are stereo with RIAA equalization. Only examination of the discs and supporting documentation will clarify groove type. Confirmation of equalization, particularly for broadcast and home recordings, may not be possible until the recordings are played and examined by an audio technician. Even then, many discs remain mysterious in this regard, leaving the technician to make a "best guess" judgment on equalization.

Magnetic Tape Sizes and Speeds. Reel-to-reel tapes are usually found on reels measuring from 2 or 3 inches to 10.5 inches in diameter (14-inch diameters are also possible), with 5, 7, and 10.5 inches being the most common sizes found in archives. Hub diameters (the diameter of the centermost part of the reel, around which the tape is wrapped) can be small, medium, or large; larger hubs allow the tape to wrap in a more gradual curve, as opposed to a very tight circle, and are therefore less stressful to the tape. The length of the tape on each reel can vary greatly, depending on the thickness of the tape and the size of the hub. The thickest and sturdiest tape has a base that measures about 1.5 mils thick, and has superior recording and performance qualities. A full 7-inch reel of 1.5 mil tape contains 1,200 feet of tape; the same size reel will hold 1,800 feet of thinner (about 1.0 mil), "time and one half" tape; and 2,400 feet of "double play" tape, which is the thinnest of all reel-to-reel tapes (about .5 mil).

Tape speeds can range from $^{15}/_{16}$ ips (inches per second) to 30 ips. The speeds most often found in archives include $^{15}/_{16}$, $1^{7}/_{8}$, $3^{3}/_{4}$, and $7^{1}/_{2}$ ips, along with lesser quantities of recordings at 15 and 30 ips, which are more likely to be found in performing arts collections. Modern audio cassette recorders are standardized at $1^{7}/_{8}$ ips, although some recorders offer the recordist "slow speed" or "high speed" options. As with phonodiscs, the size of reels, lengths

of tape, and tape speeds present in the collection are major factors in calculating the amount of material to be copied.

Magnetic Tape Formats. In addition to the size of the reel, tape length, and tape speed, the tape recording format is a factor to be considered when calculating the playing time of audio tapes. Magnetic recordings made prior to the mid-1950s are usually monaural, and many recordings of the types that frequently come to archives, such as conference and meeting recordings, were recorded in monaural format well beyond the advent of stereo technology, sometimes into the 1970s and 1980s.

On a ¼-inch wide audio tape, the size most commonly found in archives, a monaural signal can be recorded in a number of configurations. Common monaural formats include "full-track" (recorded the full width and length of one face of the tape in one direction only); "half-track" (down one side of one face of the tape and, if the tape is recorded on both sides, up the opposite side of the same face with a space between the two tracks, somewhat resembling a divided, two-lane highway); and "four-track" (up and down the face of the tape four times, with spaces between each track).

Stereo tape formats were developed in the mid-1950s. Common stereo formats include "two-track" or "half-track" configurations (two channels, one "left" and one "right," running the length of the tape in one direction with a space between them); and "four-track" versions (two pairs of tracks, one pair running the length of the tape in one direction, and the other running in the opposite direction, with spaces between each track, and sometimes with the tracks interleaved).[13] Archivists should note that other formats exist, and that terminology for even the few formats mentioned here is not standardized: one audio technician's "half-track" can be another's "two-track" or "double-track."

The combined elements of format and speed can have a dramatic effect on playing time. The playing time for a 7-inch reel holding 1,200 feet of recorded tape will run about thirty minutes at 7.5 ips, full-track; approximately one hour when recorded at the same speed in a double sided two-track format; or about two hours using the same speed and a monaural four-track format. The same tape, recorded in monaural four-track at 15/16 ips will play for approximately seven and a half hours. It is also common, of course, to find reels that are only partially recorded, or that contain multiple recordings that have been spliced together on one reel, sometimes recorded in different formats. In any case, knowledge of how tape sizes, speeds, and for-

[13] In open reel four-track stereo formats, the pairs of tracks are interleaved, meaning that, if the tracks were numbered "1,2,3,4," from one edge of the tape to the opposite edge, tracks 1 and 3 would constitute one pair, running in one direction, and tracks 2 and 4 the other pair, running in the other direction. On cassette tapes, the four tracks are not interleaved; instead, one pair of tracks runs down one side of the tape, while the other pair runs in the opposite direction on the other side, with a space between each track and between the two sets of pairs.

FIGURE 4. This chart, showing estimated playing times in minutes and seconds of specific lengths of magnetic tape recorded in full-track format, is adapted from a similar chart distributed by the 3M Corporation.

Tape Length	Nominal Tape Thickness	Reel Size	15/16 ips	1 7/8 ips	3 3/4 ips	7 1/2 ips	15 ips	30 ips
600	1.5	5"			:32	:16		
900	1.0	5"			:48	:24		
1200	1.5	7"			1:04	:32	:16	:08
1800	1.0	7"			1:36	:48	:24	:12
3600	1.0/1.5	10.5"	12:48	6:24	3:12	1:36	:48	:24

mats interrelate is essential in any attempt to estimate playing time (see Figure 4 for a list of common tape recording speeds, tape lengths, and playing times for full-track recordings).

When estimating playback time and determining the types of equipment required to play magnetic tapes, one must know the track configurations as described above, the tape width and length, and the recording speed. While size of reel and width of tape can be determined by visual inspection, it may be necessary to have help from an audio technician in determining speeds and track configurations, unless that information is documented elsewhere (perhaps on the box or reel label, or on the leader) in a reliable fashion. To estimate the playing time (in minutes) of a full-track recording, use the following formula: multiply the tape length (in feet) by 12 (to convert it to inches), then divide that number by the speed (expressed in inches per second) multiplied by 60 (to convert the speed into inches per minute). Longer playing times are achieved by recording at a lower speed, by using a longer tape, by using a format that fits more information on the tape (such as two or four tracks instead of one), or by a combination of these means. Longer playing time, naturally, equates to longer preservation transfer time, a calculation that is critical to formulating preservation project timelines and budgets. Many archives, particularly those holding large numbers of tapes of conferences and proceedings, will find that their recordings were made at slow speeds using two- or four-track configurations, producing long-playing tapes of relatively poor audio quality that can be difficult and expensive to copy.

Setting Priorities

Identifying the recordings in an archives' holdings that are either vulnerable to deterioration or that depend upon obsolete or nearly obsolete equipment (hardware) for use constitutes the first step toward setting priorities for audio preservation. As with all preservation projects, the prioritizing

should not stop at this point. The content and quality of the recordings should be examined as well; if the content is not important, the recording probably does not warrant the effort audio preservation requires, and if the audio quality of the recording is exceedingly poor, the effort may be useless anyway. Another question to consider is whether the content of the recording merits retention in audio form, as opposed to a textual transcription. Some types of sounds (musical and theatrical performances, historic speeches and news events, and sounds of animals and nature, for instance) cannot be transcribed effectively. Proceedings of meetings and conferences, on the other hand, often can. If there is no inherent reason to maintain the recording in audio form, it may be more economical in the long run to invest time and money in producing good transcriptions, rather than continue to reformat the recordings generation after generation. This can allow the archives to focus its preservation effort on its most valuable audio recordings, those which are vulnerable and which also contain important audio content.

Determing When to Re-Record

Archivists have hoped for years that someone would develop a test to predict the optimum time to re-record audio materials, a time before the recordings deteriorate significantly but not so early as to be foolish. Unfortunately, such a test does not presently exist, and may never come to be. This leaves archivists to make their own best guesses as to when recordings should be transferred. Obviously, one wants to transfer tapes before they shrivel or become sticky, and acetate discs before they delaminate. The experience at GSU indicates that it is wise to transfer (re-record) acetate discs before significant deposits of plasticizer residue have formed on their surfaces. Doing so saves time that otherwise must be spent cleaning this substance off, and helps ensure that the surface of the disc is in better condition, which leads to improved audio quality in the copy recording. During the GSU project, acetate disc recordings that were forty years old or less were found to be in far better shape than those in the forty-five to fifty year age bracket. At the same time, audio cassettes more than twenty years old were found to be significantly noisier and more difficult to handle than younger ones (under ten years old), but the archivists questioned whether the increased noise was due largely to advanced age or, on the other hand, was mostly characteristic of the nature of the cassettes and cassette recording technology used during that period. Acetate tapes, even those that were nearly forty years old, presented few problems as long as they had been recorded properly and stored well.

Understanding "Preservation Re-recording"

Having examined its holdings, identified vulnerable materials that merit preservation, and determined the approximate number of hours of recordings needing preservation, the archives must consider what is meant by the term "preservation re-recording." This is an important decision. For recordings that cannot be preserved for very long in their original form, longevity will be achieved only by regular and repeated copying, a process whose integrity will be shaped by the choices the archives makes as it structures its preservation procedures.

How Recording Technology Works

Before considering theories and goals of audio preservation, it is perhaps wise to review, in very simple terms, how the recording process works.

When an audio recording is made, sounds (of voices, music, birds, etc.) are converted by a microphone into electrical energy (called the "signal") which is captured on sound carriers (phonodiscs, tapes, etc.) in the form of grooves on phonodiscs, magnetic patterns on tape, or, in the digital realm, "pits" on laser discs. During reproduction (playback), a reading device (phono cartridge and stylus, tape playback head, or laser) recovers the signal from the sound carrier, converts it back into electrical energy, and sends it to the loudspeaker or headphones through an amplifier so that the recorded sounds can be heard again. The recorded sounds are referred to as the signal, and it is the signal that archivists preserve when copying (transferring) the information from a failing sound carrier to a new medium.

The sound quality of all audio recordings, whether analog or digital, depends on a number of factors, including the use and placement of the microphone (when making "live" recordings), the quality of the recording equipment and tape used, and the skill of the technician. Poor techniques and equipment lead to poor-quality recordings; careful planning, skill, and adequate equipment combine to help create high-quality recordings. Anything that disrupts the signal during the recording or preservation transfer processes produces flaws that may be audible in the form of noise, missing portions of the sound ("drop-outs"), or distortion. In preservation work, such disruptions are commonly caused by damage to the original recording, by dirt and debris on the playback or recording equipment or on the recording itself, by poor cables or connections between the various pieces of equipment, by electrical fluctuations, and by use of inappropriate or malfunctioning equipment. Many of these problems are not discernible without special equipment coupled with experience and a thorough understanding of both the recording process and the nature of the recordings being transferred. Other transfer problems are caused primarily by human error or ig-

norance, such as incorrect reproduction of historic formats or misuse or overuse of technologies such as filtering, noise reduction, and signal processing.

In the end, the quality of an audio preservation project depends upon accurate reproduction of the original recordings and careful transfer of the signals to the new sound carrier. It is around such issues as "accuracy" that much of the discussion among audio archivists has circled in recent years.

Defining "Preservation Re-Recording"

For many years now, at professional meetings and in professional literature, audio archivists have discussed what it means to "preserve" audio recordings.[14] Although considerable progress has been made toward building a consensus regarding the proper role of re-recording in audio preservation, standards for preservation re-recording remain elusive, and archivists are left to wonder what the term means. Obviously the intent is to preserve the recordings, or at least the content of the recordings, by transferring the information to a newer storage medium which will eventually stand in the place of the lost original. But recordings can be copied in many different ways, not all of which are suitable for preservation purposes. The audio information, or signal, can be enhanced or clarified; noise can be reduced; and old recordings can be modernized to make them sound more contemporary. Which methods and goals are appropriate for preservation work?

The Technical Coordinating Committee (TCC) for the International Organizations for Audio, Film, and Television Archives offers the following definition of preservation re-recording: "Re-recording serves a very specific function; it is a means to preserve the original sonic content of a recording . . . . The archivist's function is to preserve history, not to rewrite it. Given this precept, the archivist must always strive to maintain objectivity in the application of various re-recording techniques."[15] The TCC goes on to identify several specific types of re-recording, and to discuss which types have a place in archives.[16]

This definition of audio preservation, which is supported by sound archives in the United States and abroad, encourages archivists to transfer, or copy, the signal from the original source to the new medium as accurately as

[14] See William D. Storm, "A Proposal for the Establishment of International Re-Recording Standards," *ARSC Journal* 15, no. 2–3 (1983): 26–37; William Storm, "The Establishment of International Re-Recording Standards," *Phonographic Bulletin* (July 1980): 5–12; Dietrich Schüller, "The Ethics of Preservation, Restoration, and Re-Issues of Historical Sound Recordings," *AES Journal* 39 (December 1991): 1014–17; Boston, *Guide to the Basic Technical Equipment*, section 4, "Audio Archives."

[15] Boston, *Guide to the Basic Technical Equipment*, 39.

[16] Boston, *Guide to the Basic Technical Equipment*, 39–41 and 64–65.

possible, neither "improving" the original nor allowing the introduction of new distortion or flaws. Under this definition, careful reproduction that respects the particular character of the historic recording is emphasized as a means of preventing or minimizing noise and distortion. Filtering, noise suppression, and other enhancements may be employed in producing service copies, if desired, but should be avoided except in extraordinary circumstances when creating the preservation copy. The transfer process should be carefully documented and there should be no "secret formulas" or practices employed during re-recording.

Archives that accept this definition of audio preservation transfer will not find that it answers all of their questions, but they will find that it provides them with at least four goals to help guide their preservation projects: (1) to make sure that the original recordings are reproduced (played) accurately during the transfer process; (2) to choose recording technologies and media for the preservation copy that will capture the quality of the original signal as faithfully as possible; (3) to employ, for audio preservation work, technicians who possess the knowledge and skills to work with aging and often obsolete recordings and the ability and willingness to employ technology and techniques that are appropriate to archival work; and (4) to document what is done with and to the recording during the preservation process.[17] These goals provide the archives with a framework to use in selecting personnel and equipment for the project, evaluating and choosing recording technology and media for the preservation copy, explaining and justifying these choices and decisions to administrators and funding agencies, and evaluating their work.

Transfer Technology Options and Recommendations

Having examined its collections and defined its goals for the project, the archives has three major steps remaining before it can finalize its budget, personnel needs, and timeline, and begin the project. It must use the information it has collected regarding the audio recordings that need preservation to determine what is needed to ensure accurate reproduction of the original recording, select the recording technology and sound carrier it believes will serve most faithfully and reliably as a preservation medium, and choose an audio technician to carry out the work.

The Importance of Careful Reproduction (Playback)

Playing the original recording appropriately, using equipment that matches the format and engineering characteristics of the original, and that

[17] Boston, *Guide to the Basic Technical Equipment*, section 4, "Audio Archives."

is well maintained and skillfully operated, maximizes audio quality while minimizing noise and distortion. It will also minimize the wear that is unavoidable when playing recordings, enabling playback that neither destroys nor unnecessarily degrades the original recording. This is the first necessary technical step toward good audio transfer work.[18] A clean, carefully played "old" recording can sound amazingly good under the right circumstances. Accurate reproduction requires access to the equipment, or hardware, that matches the archives' recordings, or software, and knowing how to use it.

For tape recordings, this means having playback machines that can accommodate the size and track configurations of the original tape. For disc recordings, it means locating and acquiring appropriate modern phonograph equipment and then using it intelligently.[19] For all types of recordings, care must be taken to ensure that the equipment is installed, maintained, and used properly. If it is not functioning correctly or if the installation is poor, both the signal passing through the system, and, consequently, the preservation copy can be flawed. Malfunctioning equipment can also damage or destroy tapes and discs as they are played.

Acquiring the equipment for appropriate playback can be a challenge, particularly now that both grooved phonodisc and analog tape technology are becoming obsolete. For both tape and phonodisc playback, the purchase of modern equipment is recommended over the use of vintage equipment, largely because modern equipment is more reliable and easier to keep properly calibrated. It is still possible to purchase new equipment to play most older tape formats, but the cost of these machines is increasing at the same time that fewer vendors are willing to carry them. Professional tape equipment is available through local and regional dealers, as is some modern phonograph equipment. Specialized phonograph machines and supplies, suited for use with historic disc formats, can be obtained from a number of individuals and small companies; a selected list of sources is appended to this article.

Transfer Technology: Analog vs. Digital; Tape, Disk, or Other New Media

The next technical step toward accurate re-recording involves choosing an appropriate technology and storage medium to re-capture the signal, or content, of the original recording. This is where the choices become more complicated. At the present time, archivists have two basic forms of recording technology from which to choose: analog and digital. In addition there are

[18] Boston, *Guide to the Basic Technical Equipment*, 41, 44–58.

[19] For a good discussion of the types of equipment required for both disc and tape reproduction, see Boston, *Guide to the Basic Technical Equipment*, 43–58. The equipment and procedures outlined with regard to commercial 78 rpm records are similar to the requirements for older (1930s–1940s) acetate discs.

several different types of analog and digital recording media from which to choose, including open-reel tape, various types of cassettes, recordable CDs, and computer disk. Which of these are appropriate for preservation work? What are the factors to consider in selecting a preservation medium? To resolve these questions, archivists must first decide whether to select analog or digital transfer technology, or perhaps a combination of the two. Rumors and opinions abound regarding the advantages and disadvantages of both technologies. The following discussion may help clarify the issues and provide a more balanced picture of present options.

Analog Technology: Pros and Cons. Analog technology has existed since the beginning of recorded sound. It works by recording a representation (an analog) of the original sound wave onto a storage medium (such as grooves on a phonodisc or magnetic tracks on a tape). When properly employed, analog recording technology produces clean, clear recordings with minimal distortion. While there is some loss of quality and fidelity from one analog generation to the next, the loss is gradual, and is minimized if the transfers are skillfully made. The usual recording medium for analog preservation work is open-reel magnetic tape in widths beginning at ¼ inch.

The primary advantages of analog technology are that it is fully mature; its formats are both standardized and well known; and it can capture and reproduce sounds with very good fidelity. In addition to its maturity and reliability, the major arguments in favor of analog technology have been that it has been expected to remain available for some time to come, and that analog playback equipment can be recreated by skilled engineers, if necessary, after it becomes obsolete. As of this writing, however, it appears that vendors and manufacturers of analog recording media and equipment are hastening its obsolescence by withdrawing products from the market in spite of the enormous quantity of recordings and equipment still in use. While skilled engineers certainly can reproduce analog playback devices, the number of engineers capable of doing this is very small in comparison to the quantity of extant analog recordings, meaning that most archivists cannot expect to maintain analog equipment for very long after supplies and spare parts cease to be readily available from commercial sources.

One primary disadvantage of analog tape technology is "tape hiss," a form of noise that is inherent in analog tape recording. A second disadvantage is the gradual loss of quality and cumulative increase in tape hiss that occurs with each successive generation. Contrary to popular myth, however, the loss of quality from one generation to the next is not so dramatic and sudden as to be startling, unless something is greatly amiss with the transfer process; rather it is subtle and cumulative. "Analog ages gracefully," audio technicians say today, and while such aging may not be desirable, it is pre-

dictable and can be controlled to a certain extent by careful storage, use, and transfer of the recordings.

Digital Technology: Pros and Cons. Digital recording came into common use in the 1980s, and is both the current technology of choice for many audio technicians and recording studios and the technology that will eventually supplant analog recording. In digital recording, the sound wave is "sampled" and converted to binary code by use of an analog-to-digital converter (ADC). The code is then stored on a recording medium, usually magnetic tape or optical disk. During reproduction (playback), the code is converted back into analog form for listening purposes, by use of a digital-to-analog converter (DAC).

The quality of the sound produced by digital technology depends upon a number of factors, including the sampling rate and the quality of the converters and filters used, in addition to the concerns listed above under "How Recording Technology Works," (microphone placement, quality of the recording medium, and the skill of the technician).[20] Archivists must keep in mind that "digital recording" does not refer to just one type or format. There are presently several different digital storage *media* (including DAT/RDAT, ADAT, 4 mm, 8 mm, Beta, VHS, and other forms of cassettes; open reel tape; and optical disk), a variety of types of recording *equipment*, and at least three different *sampling rates*, with new developments reaching the marketplace on a regular basis. It should also be understood that a digital copy of an analog source does not automatically mean a reduction of noise or improvement in sound quality; such changes are accomplished by use of filters, noise suppression, and signal processing techniques, not simply by copying a recording using digital technology.

Digital recordings offer certain specific advantages over analog recordings. Many technicians find them easier to edit, and the recording systems themselves are inherently less noisy than analog systems. In theory, at least, it should be possible to "clone" digital recordings, permitting the creation of many generations of identical copies. Many technicians believe that digital recordings are free of the distortion that is known to afflict analog recordings, and count this as an advantage; other technicians take the more pragmatic position that all audio recording systems are subject to distortion, and that the differences between analog and digital distortion are a matter of type and degree rather than presence and absence. This latter approach is finding support in articles appearing in audio engineering literature that discuss forms of distortion that are unique to digital recordings.[21]

[20] See, for example, Bob Hodas and Paul Stubblebine, "Five Outboard A/D Convertors," *Mix* (May 1991): 82–88.

[21] See, for example, Bill Foster, "The J-J-Jitter Bug," *Studio Sound* 36 (October 1994): 37–40.

There are several particular disadvantages associated with present-day digital technology. The technology is still evolving and improving at a very rapid rate, and, consequently, hardware obsolescence is a major concern, as it will require the migration of recordings to newer storage formats on a regular and frequent basis. As of this writing (summer 1996) there is no consensus on what constitutes an appropriate sampling rate or method for archival work. While many archivists believe that even the highest of the current rates is too low, others think that even the lowest is acceptable. The longevity of digital storage media, both tape and disc, is currently suspect. Technicians and archivists report sudden, unexplained failure of some digital tapes, and optical disk life expectancies are still under discussion.[22]

And, finally, the ability of digital recordings to be cloned indefinitely without loss of quality has been questioned by some technicians and archivists.[23] It is certainly true that digital processes include error detection and correction mechanisms which, theoretically, allow the generation of flawless copies; it is not true that this ability has been fully perfected, tested, and confirmed as reliable. Errors exist naturally in recording media, and if they are severe, or multiply from generation to generation to the point that they exceed the capability of the error correction system being used, the recordings suffer from "mutes" (drop-outs caused when the playback system cannot read or locate the information needed at that point in the recording) that cannot be corrected.

In short, many of the factors that make digital technology potentially so attractive for archival uses are still evolving and improving. Although digital technology offers great promise, and will eventually become the standard recording technology, it is presently neither perfect nor a magic cure, and should be utilized cautiously and with a full understanding of the long-range implications of such a decision. In keeping with the long-standing tradition among archivists of using only proven, mature, trustworthy techniques for preservation purposes, analog technology is presently preferred over digital for audio preservation re-recording, although the making of simultaneous digital transfers is becoming more common. This preference for analog technology is likely to change soon, particularly if higher digital sampling rates come into common use, improved digital recording media become available, and analog equipment and media continue to be withdrawn from the market.

Recording Media. Choices made regarding transfer technology will, to a certain extent, dictate the choice of recording media. For analog recordings, the medium of choice is open reel tape. The tape should be new (not previously recorded on) and of high quality. At present, both of the major U.S. manufacturers of magnetic tape (Ampex and 3M) have withdrawn from the

[22] Sam Wise, "DAT Tape Tests," *Studio Sound* 35 (May 1993): 61–70 and "What's DAT Error," *Studio Sound* 35 (August 1993): 63–65.

[23] Bob Hodas, "The Question of Digital Transfers," *Mix* (May 1991): 85.

market altogether, and at least one of the best-known European manufacturers (BASF) has also discontinued its tape line. The Ampex and 3M product lines have been taken over by a new company (Quantegy), which will continue to manufacture recording tape domestically. Archivists will find that all of the remaining well-known manufacturers are foreign. Whether these changes mark the beginning of a sudden decline in quality and availability of tape, or simply one more step in the pending obsolescence of the medium will only become clear over time. Whatever the end result, in the interim the decades-old dance between archivists who seek reliable product information and manufacturers who are pledged to protect proprietary interests is likely to become even more complicated.

For digital recordings, the medium will depend upon the type of digital hardware to be used. Some digital systems require magnetic tape, in open reel or cassette form, while others use recordable CDs. Other types of media will undoubtedly appear soon, if they have not already. At present there are no easy answers, except for a general consensus among sound archivists that DAT cassettes are unsuitable. Some technicians point to the inherent minute flaws that inevitably exist in magnetic tape as evidence that tape is not a good digital recording medium, while many archivists question the life expectancy of recordable CDs, which, although highly touted by their manufacturers, remain a new and therefore slightly suspect medium. It appears that tape will become outmoded in the near future, but the nature of its replacement cannot be reliably predicted at this time.

Documenting the Preservation Process

As recordings are reproduced and transferred in the course of a preservation project, details of the reproduction and transfer should be carefully documented so that future technicians and archivists will understand both the nature of the original recording and the techniques used to preserve it. "Documentation" means that the technician and the archivist keep a record of how the copies were made, including information on the original format, how the original recording was played during transfer (including the equalization used, in the case of phonodiscs), and how the transfer recording was made. Recording speeds, the presence of test tones, the track configuration, and any other information that will help archivists and technicians understand clearly what the new recording is and what the original recording was should also be noted. Documentation adds time, and therefore cost, to the process, but also leaves a trail of clues that future caretakers will appreciate.

The Audio Technician

Of course, as noted previously, equipment alone does not ensure the success of a preservation project. Of all of the components of a preservation

project, the audio technician is the most important. No matter how good the equipment, how fine the recording medium, or how elaborate the studio, the entire effort will be wasted if these elements are not coordinated and employed skillfully and intelligently. Unfortunately, at the present time there are no formal training programs to teach audio technicians about archival work, and there is no consensus about what an archival audio technician should be or do. Only a handful of technicians in the U.S. who specialize in working with archival recordings are available to help with projects on a contract basis, yet, in recent years, the number of recording studios soliciting archival work and claiming to be expert in audio preservation has increased noticeably.

Archivists seeking an archival audio technician might begin by looking for a person with a good background in studio work coupled with experience working with archival and obsolete recordings. Word of mouth is always helpful in selecting a project technician or vendor, and colleagues who have undertaken audio preservation projects can often provide good leads and references. The technician should be willing to listen to the archives' desires regarding the handling and re-recording of the materials. He (most technicians presently doing this work are male) should be willing to openly and honestly discuss his usual procedures, including cleaning and preparation treatments. He should possess or have access to the equipment needed to play the older formats. He should not force the archives to accept recording technology that it does not want, or be secretive about how he handles and treats the recordings.

Technicians who have worked extensively with old recordings usually have their own preferred methods for handling, cleaning, and copying them. They should be willing to discuss their reasons for these preferences, which may be well founded; it is especially helpful if they are willing to consider altering their usual practices if the archives prefers. Most experienced technicians will admit that it is never possible, in this line of work, to have all the answers or to have "seen it all." Humility is sometimes a good sign; a technician who is aware of his limitations is less likely to proceed blithely with inappropriate treatment or techniques. Experienced technicians will be aware of the critical role of proper reproduction in the preservation process. A recording that has been carefully cleaned and played on appropriate equipment by a knowledgeable technician will be quieter, with less distortion than might otherwise be the case.[24] Such treatment requires patience in addition to knowledge and skill, and a willingness to forgo the simpler, quicker solutions of relying on filters and after-the-fact signal processing.

Technicians one might well avoid include those who promise a quick fix for aging recordings, who offer to digitize and enhance recordings as they

[24] Boston, *Guide to the Basic Technical Equipment*, 42.

"lock them in time," who are vague about what they do with the recordings, or who believe that they can handle everything without assistance or further discussion. By failing to understand and respect the unique qualities of older recording formats, such technicians may play them improperly, thereby introducing inaccuracies, or alter the sound significantly in a misguided attempt to "correct," "improve," or "modernize" the sound—actions which are not acceptable for preservation work.

Archives that wish to train their own staff members for audio preservation work will find the lack of educational opportunities especially frustrating. Two options for providing staff training are to send personnel for mini-training sessions at archives with existing preservation programs or to hire consultants to do in-house training. When training in-house personnel, it is important to designate the person or persons who will be trained and to keep their work focused on audio preservation as exclusively as possible until they are secure in their skills. Such training takes time, and cannot be accomplished by half-way efforts or by dividing training among several different staff members. The temptation to employ cheaper labor for this purpose in the form of student assistants, work-study students, or interns is best avoided unless a truly knowledgeable and capable technician is available, on-site, to train and supervise the staff.

Once located, hired, and, if necessary, trained, the audio technician should be charged with ensuring that the technical portion of the project is handled as objectively and appropriately as possible. The technician should clearly communicate his or her plans and progress during the project, and should understand and be willing to discuss all issues that arise relating to the playing and copying of the recordings.

Current Recommendations for Preservation Transfers

Although standards for audio preservation re-recording have not yet been developed and approved, the major sound archives in the United States and abroad, along with the recording media manufacturers, recommend the following guidelines for audio preservation transfer projects (as of summer 1996). Readers are cautioned that these recommendations may change by the time this work is published, and are advised to check with other archivists for the most current information before proceeding with reformatting projects.

Recommendations:

- Use analog recording technology.
- Use virgin (brand-new, unused) reel-to-reel tape with an overall thickness of 1.5 mils and a minimal base thickness of 1.2 mils.
- Record in full-track format for monaural original sources and half-track for stereo original sources at a speed of 15 ips (many archivists

substitute 7.5 ips for spoken word recordings; preservation copies should not be made at speeds lower than 7.5 ips).

- Store the tapes on metal NAB reels with unslotted hubs (standard professional quality tape can be purchased on appropriate reels, eliminating the need to purchase reels separately).
- Avoid having splices in preservation tapes (splices create bumps in the tape pack which can lead to deformation of the tape during long-term storage, and their adhesives tend to bleed onto adjacent layers of tape, causing additional damage).
- Include a series of test tones recorded at the head of each tape (this helps future audio technicians and archivists understand how the tape is set up and recorded).
- Never use preservation copies as service copies.

N.B.: Standard analog audio cassettes are not suitable for preservation work under any circumstances. All analog cassettes held by archives should be copied to more robust formats, and suggestions that such formats are suitable for preservation work because they are cheaper, smaller, or easier to handle should be resisted at all costs. Most major sound archives also avoid using DAT/RDAT cassettes for preservation re-recording; the relative fragility of the tape and its high data density, combined with problems stemming from hardware that is frequently unreliable, do not recommend this medium for long-term storage of important information.

Final Considerations

As noted throughout this article, audio preservation re-recording is time-consuming and costly. Just how time-consuming and costly is difficult to imagine without having carried out such a project.

Examining the collection, setting preservation priorities, hiring a contractor or setting up an in-house operation, preparing recordings for transfer, documenting the process, cataloging or indexing the recordings, and producing service copies—all of this takes time, and that time must be accounted for in project workplans and timelines. The flow of the work is important as well, requiring a steady supply of recordings provided to the audio technician at a pace that matches his or her pace of work.

Estimating Cleaning and Transfer Time

Estimating the time needed to prepare and clean recordings is difficult, and depends greatly upon the condition of the recordings and the preferred cleaning and preparation methods. Transfer time (defined as the time it takes

the technician to transfer the signal from the original recording to a new preservation medium), however, can be accurately estimated at three to five times the playing time of the original items for acetate discs, and about two or two-and-a-half times the original playing time for tapes. In some cases service copies can be generated as the preservation transfers are made; but if that is not feasible, additional time will be required. For making copies of analog preservation tapes that are in good condition, allow at least one-and-a-half times the playing time of the tapes.

Estimating Costs

The most costly single items in the budget for out-of-house projects will likely be the audio technician's time and a supply of new recording media for the transfers. As of this writing, studios regularly charge $50 to $85 per hour of work time, and high-quality tape can cost $18 per reel or more, even when purchased in bulk. In addition, cleaning supplies for acetate discs can also be costly, depending upon the method chosen. After investigating a number of cleaning methods and options, the GSU project chose Kodak Lens Cleaner as its cleaning fluid. If purchased off the shelf in small quantities, the cost would have been prohibitive (several dollars for a very small bottle). Even when purchased in bulk, the cost was not insignificant.

In-house projects incur these costs, plus costs relating to the outfitting of space for the transfer portion of the project. Ideally, this means outfitting a studio that has been designed specifically for audio preservation work. More commonly, space is set aside and modified to be minimally acceptable for preservation work. The space must be quiet, should have its own separate, well-grounded electrical supply to reduce the chance of electrical fluctuations that can produce audible flaws in the recordings, and must be outfitted with all the equipment needed to play and copy the recordings. If the recording equipment is to be maintained by qualified on-site personnel, test equipment such as oscilloscope, voltmeter, tone generator and test tapes will be needed. If maintenance will be handled by outside contractors, funds will be required to pay the related fees.

Support Staff Needs

Audio preservation projects require staff to help clean and prepare the recordings, document the actions taken, and (for an in-house program) service the equipment regularly to keep it running properly. The amount of support staff time needed to clean, prepare, index, and rehouse recordings should not be underestimated, particularly if recordings need to be cleaned or, in the case of tapes, wound carefully to even and retension the tape pack prior to transfer.

During the GSU project, many of the acetates with surface deposits of plasticizer residue required forty-five minutes each to clean, more than double the time originally estimated. Winding tapes can also be time-consuming, and routine cleaning, checking, and calibration of audio equipment (required of an in-house project) require both time and money; neither the technician nor the rest of the staff can use the equipment while it is being serviced (a cost of time) and qualified technicians must be hired and scheduled to perform some or all of the maintenance (a cost of money—sometimes a major one, since the supply of good repair technicians is nearly as small as the pool of competent archival audio technicians). Archivists planning an audio preservation project will do well to think carefully about all of the tasks involved and to avoid underestimating the amount of staff time that will be required.

Space Considerations

Original recordings should not be discarded unless they have completely deteriorated (and it should be noted that some engineers expect that improvements in imaging technology will enable "playback" of broken discs by this means in the future). This means that space and shelving will be needed to store the preservation copies, which should be kept in addition to, not in place of, the original recordings. If the project generates preservation reel tapes recorded at 15 ips, for example, this can mean a substantial amount of space if the project is large. One or two slender 16-inch discs can fill a reel of tape that takes up an inch of shelf space. One hundred such discs, when copied to tape, can require an additional six to eight feet of shelf space. Use copies, of course, require additional, separate, storage.

Epilogue

To summarize the issues outlined in this article, the production of preservation copies of aging audio recordings is much harder than it appears on the surface. Every aspect of the work is difficult (some prefer the term "challenging"), from acquiring appropriate equipment to finding knowledgeable audio technicians and developing in-house guidelines for the creation of preservation copies. Given all of the obstacles, relatively few archives will have both the energy and the resources to invest in pursuing preservation of their audio holdings, and those who do will find themselves making difficult compromises along the way.

Then why attempt preservation of audio recordings at all? Because we must, in some cases, because of institutional mandate or other obligations; but more importantly, because of the unique and sometimes startling or spectacular elements such recordings can add to the historical record. Recordings that contain

"medium-specific" content, such as musical performances, stump speeches by key figures in politics, or the call of a bird or other species that is perhaps extinct; all of these inform us as the written word cannot, capturing, in addition to the "plain facts," the sound and flavor of a place, a creature, an event, or an era. The work, in short, can be tremendously rewarding, in spite of the enormous obstacles that archives must sometimes overcome.

In order to improve our ability to preserve important audio recordings, given the current, rather sorry, state of this particular art, archivists need to focus more on broader issues rather than strictly institutional or collection-specific ones. For example, the lack of any type of formal or informal educational opportunities for audio technicians who wish to work with archives recordings continues to retard research and development in transfer techniques, and the ongoing lack of research and development continues to contribute to the difficulty and high cost of preserving audio recordings. Where, when, or how this chicken-and-egg cycle will be broken, if it is broken, remains a mystery; in the meantime, the related lack of published standards for preservation copies simply serves as an additional stumbling block to archivists who try to implement audio preservation programs.

The archives community must mobilize to improve education about audio recordings and the means of preserving them; to participate in the development and promulgation of standards for archival audio technicians, for preservation re-recording and for recording media; to continue pressuring the tape and recording media manufacturers to produce media with an increased life expectancy; and to work with funding agencies to improve education, training, and preservation relating to audio recordings in archives. Continuing to wait for someone else to accomplish these things will reap the same lack of results so visible today, and will contribute to massive losses of audio recordings in the near future.

Appendix—Selected List of Sources for Audio Supplies

The companies listed below offer a wide variety of products and services, some of which are used regularly by audio archivists while others are not. Inclusion of a company on this list should not be construed as a recommendation regarding the appropriateness of the product for use in an archives, and the author urges readers to select their audio equipment, products, and services with care.

Sleeves, Boxes And Containers:

Conservation Resources International, Inc.
8000 H Forbes Place
Springfield, VA 22151
1-800-634-6932; 703-321-7730
Record storage sleeves (multi-layer, for 12" and 16" discs)

Gaylord Brothers
Box 4901
Syracuse, NY 13221-4901
1-800-634-6307
Record storage sleeves (paper, for 10" and 12" discs)
Anti-static plastic inner-sleeves (for use with 12" vinyl LPs)
Record storage envelopes (paper, for 12" and 16" discs)
Phonograph record storage boxes (cardboard, for 12" and 16" discs)
Magnetic media storage containers (audio and videotape boxes in cardboard and plastic)
Optical media storage products (sleeves and boxes for CD's, laser discs, etc.)

Plastic Reel Corporation of America (PRC)
Brisbin Ave., Lyndhurst, NJ 07071, 201-933-5100
8140 Webb Avenue, North Hollywood, CA 91605, 818-504-0400
5410 West Roosevelt Road, Chicago, IL, 60644, 773-378-3800
Cardboard and plastic audio tape boxes in a variety of sizes.

Shield Pack, Inc.
411 Downing Pines Road
West Monroe, LA 71292
318-387-4743
Record storage sleeves (multi-layer, for 7", 10", 12", 16", and 18" discs)

University Products, Inc.
517 Main St.
P.O. Box 101
Holyoke, MA 01041-0101
1-800-762-1165

Record storage sleeves (paper, for 7", 10" and 12" discs)
Anti-static plastic inner-sleeves (for use with 12" vinyl LPs)
Record storage envelopes (paper, for 10" and 12" discs)
Record storage boxes (cardboard, for 7" and 12" discs)

Record Cleaning Products and Solutions:

Discwasher
2950 Lake Emma Road
Lake Mary, FL 32746
1-800-325-0573

Lane Audio and Records
1782 Manor Drive
Vista, CA 92084
760-945-7017

The LAST Factory
2015 Research Dr.
Livermore, CA 94550
510-449-9449

Nitty Gritty Record Care Products
4650 Arrow Highway #F4
Montclair, CA 91763
909-625-5525

Record Cleaning Machines:

Audio 78
P.O. Box 187
San Anselmo, CA 94979
415-457-7878

Monks Record Cleaning Machine

Nitty Gritty Record Care Products
4650 Arrow Highway #F4
Montclair, CA 91763
909-625-5525

VPI Industries, Inc.
77 Cliffwood Avenue, 3B
Cliffwood, NJ 07721
Phone: 732-583-6895
Fax: 732-946-8578

Audio Equipment and Supplies for Use in an Archives Setting:

Audio 78
P.O. Box 187
San Anselmo, CA 94979
415-457-7878

Turntables and tone arms to accommodate discs up to 20" in diameter; custom styli; adjustable pre-amp; other supplies.

Diapason
81 Mineral Street
Reading, MA 01867
Phone: 781-944-8002
Fax: 781-944-8077
Contact: Jeff Duboff

Turntables designed for use with older phonograph records, including a model that will handle discs up to 20" in diameter.

Esoteric Sound
4813 Wallbank Avenue
Downers Grove, IL 60515

Turntables, styli, adjustable phono equalizers, and other supplies and equipment designed for use with older phonograph records.

Expert Stylus Company
P.O. Box 3, Ashtead
Surrey, England KT21 2QD
Phone: (01372) 276604
Fax: (01372) 276147

Cartridges and styli for cylinder and phono disc recordings.

Lane Audio & Records
1782 Manor Dr.
Vista, CA 92084
760-945-7017

Turntables; analog strobes for setting turntable speeds; geometry kit for aligning stylus, tone arm and turntable; adjustable preamplifier; other supplies and equipment.

Stanton Magnetics, Inc.
101 Sunnyside Blvd.
Plainview, NY 11803-1511
516-349-0235
Contact: Pete Bidwell

Phono cartridges and styli in a variety of sizes and styles.

Magnetometers (Gaussmeters) and Head Demagnetizers:

R.B. Annis Company
1101 N. Delaware Street
Indianapolis, IN 46202
317-637-9282

Please Note: Annis products should be available through local professional audio/video products suppliers. The R.B. Annis Audio-Video Han-D-Kit includes both a magnetometer and the "Han-D-Mag" demagnetizer; both items should also be available separately. The demagnetizer also comes in a long-probe model for working in small spaces, such as inside audio cassette decks.