THE JACK MULLIN/BILL PALMER TAPE RESTORATION PROJECT*

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What do you do when you are presented with three large cartons of flangeless reels of 50+-year-old tape? There is no metadata,[1] no list of contents, no tape speed, no A or B wind information, no EQ curves—only tape. Where do you begin?

I recently found myself in this position. It all started innocently enough. As a member of the AES Los Angeles Section Committee, I had undertaken the organization of a program at one of the Section's monthly meetings. Also as a member of the AES Technical Committee on Archives, Restoration, and Digital Libraries, I thought tying our Section meeting into the Technical Committee's charter would be useful and informative. I approached fellow Technical Committee member and noted tape expert Jim Wheeler to speak at the meeting about tape restoration challenges. Jim had been at Ampex from 1961 to 1994. During that time he worked on a variety of projects, including the first tape-based portable instant-replay VTR in 1964. He has consulted on the Nixon White House tapes and unstuck the tape on the Galileo space probe while it was 400 million miles (650 Gm) away.[2] In the course of our discussions, he mentioned that Peter Hammar, the creator of the Ampex Museum of Magnetic Recording, had entrusted him with some of the original German tapes that John T. (Jack) Mullin and William A. (Bill) Palmer, a San Francisco filmmaker, had used for a variety of purposes right after World War II.

These tapes represent the earliest days of magnetic recording in the United States, including performances, outtakes, and between-take banter by Bing Crosby, Dinah Shore, Peggy Lee, Burl Ives, and Claudette Colbert. Perhaps the gem of this collection is a portion of Bing Crosby's 1947 Christmas Eve show. The segment starts with Crosby singing "White Christmas," followed by Crosby and others performing Charles Tazewell's 1947 Christmas story "The Small One," and closing with "Silent Night." To be safe, we transferred this one twice! The collection does not contain any complete shows, although the Christmas program runs 21 minutes. Other material included industrial film narration, Rainier Beer and other radio commercials, and miscellaneous items.

Wheeler was interested in hearing and copying the tapes. I have been recording on tape since the early 1970s and have been restoring tapes for the past 10 years. There was only one thing to do: rise to the technical and logistical challenge.

The tapes arrived in three cardboard cartons that looked quite old. Inside was an amazing array of packaging. As is often the case in a restoration project, we had the old recordings and a modern tape reproducer,[3] but no knowledge of either the original equipment used to make the tapes or knowledge of the recording conventions common in the late 1940s. Some of the initial challenges that presented themselves were:

- The tapes were on AEG (Allgemeine-Elektrizitäts-Gesellschaft, the German General Electric) hubs with rectangular center holes, nearly identical to today's IEC hubs. We had no adapters for these hubs (see illustration on next page).
- All of the tapes but one were in pancake form without flanges, rather than on standard NAB reels.
- Many of the tape packs were larger than the 10-1/2-inch (267-mm) diameter that is commonly used today.
- There were several different types of tape, each with its own unique characteristics. Most of the tapes were not coated but were homogeneous tapes, that is to say a polyvinylchloride ➥

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[1] S. Lyman, "Why Archive Audio Metadata?" *J. Audio Eng. Soc.*, this issue, pp. 622–625.

[2] Jim Wheeler obtained his BSEE degree from the University of California in Berkeley in 1961. He and his wife live in Oceano, CA. He can be reached via e-mail at jimwheeler@aol.com.

[3] The reproducer available was a Sony APR-5003V that is a center-track timecode stereo machine with servo capstan and reel motors, and a 75-in/s (1900 mm/s) "library wind" mode. We originally used the two 2-mm-wide stereo tracks, recording them on two separate channels with the idea that we could use either or both in parallel for the final transfer. If the tracks were paralleled that would provide the equivalent of a 4-mm reproducing track. Subsequently we used an alternate head stack with full-track mono heads that resulted in slightly better reproduction than any of the configurations using the original two-track head. Although we did not perform the experiments, recording theory predicts that the full-track (6.3-mm) reproduction, compared to 4-mm-width reproduction, would have flatter low-frequency response, and a 2 dB greater signal-minus-noise level. Compared with a single track, the full track head would have a 5dB greater signal-minus-noise level. Therefore we will go back and retransfer the most important segments and use this configuration for future transfers. I would like to thank Don Ososke and Joe Dundovic for assistance in this further refinement.

Fig. 1. Scenes from the restoration

(PVC) film with the iron oxide particles mixed into the film and embedded throughout the thickness of the tape.[4] We also received other tapes that were early samples of Scotch 111 and some were labeled (back-printed on the tape) "audiotape" from Audio Devices. There were other unidentified, coated tapes that were different from the tapes manufactured by Scotch and Audio Devices. Subsequent research revealed these tapes to be I.G. Farben Magnetophonband Typ C, which is a cellulose acetate base film coated in the modern method with iron oxide. These were the oldest tapes in the collection.

- There were hundreds of splices in these tapes. Due to the limited supply of this then-irreplaceable German tape—Mullin only had 50 reels and no hope of obtaining more until an American manufacturer stepped in—he found sections of tape with the same sensitivity (output level) and spliced them together. He also edited shows and later reused the spliced tapes for new projects and respliced them. Many of these splices fell apart when we spooled the tapes, and we had to remake them.
- The whole lot smelled of vinegar.[5]

We improvised a clamp for the hub by using the old-style Ampex collet hold-downs. In the beginning we used a spacer carved out of the bottom of a plastic bottle that fit a circular recess in the hub, but that was abandoned as we obtained equally good results merely with friction.

As we began to play the homogeneous type L tapes, we were pleased with the quality, although the highs seemed to be somewhat lacking. The third reel we opened contained some very early Scotch 111 tape wound with the oxide surface out (commonly known as a B-wind). It dawned on Jim that the Magnetophon's heads were positioned on the opposite side of the tape, unlike all modern tape recorders after the Ampex model 200A. When we went back to the first two tapes and made a 180-degree twist between the supply reel and the first guide, we were totally amazed at the quality of the sound! We found out later from German magnetic recording historian Friedrich Engel that determining which side of the homogeneous type L tapes should face the playback head is a common problem among German archivists, usually solved only by trial and error.

We faced many other challenges, including work flow, an important

[4] Some of the tapes were in boxes marked Magnetophonband with an IG logo and the name I.G. Farbenindustrie Aktiengesellschaft, Frankfurt a. Main. This tape was identified as Magnetophonband Typ L, referred to in this article as type L tape. In the process of preparing this paper we found out that there is a good deal of published historical information about the tape recorder and the tape used to make these recordings that we are restoring. See "A Selected Bibliography of Histories of Magnetic Tape Sound Recording," at http://recordist.com/aeshc/docs/bibliographies/histmagrecbib.html.

[5] Vinegar (acetic acid) is a decomposition by-product of acetate, the carrier or backing material of the tape. http://www.afionline.org/preservation/about/det.html#vinegar offers a brief discussion. Its effect on the narrower audio tape as compared to the wider magnetic film has not been thoroughly studied. The acidic vapors from one decomposing film can "infect" adjacent films. Until this syndrome is better understood as it applies to tape, it is prudent to separate any tapes that have the vinegar smell from others that do not. Also do not store tapes in sealed containers. Dispersing the acidic vapor is an important part of the defense against this form of degradation. Jim put A-D (acid detection) strips in some of the cans and boxes, and the majority showed insignificant buildup of acid. However, there was one 35-mm film can that contained five tapes, and that had an excessive amount of acid, but the five tapes played fine and were not noticeably degraded.

subject to consider when processing more than a few tapes. In this case we had over fifty. Jim had purchased 28 12-inch (305-mm) empty reels and 30 10-1/2-inch (267-mm) reels. The first step was to set up a procedure to minimize tape handling. Most of the tape pancakes were stored in high-acid paper envelopes. We opened the first carton and processed the tapes in the order they presented themselves, which minimized handling of the fragile tape packs.

The German tape presented another problem—it was not 1/4-inch (6.35-mm) tape, but rather 6.5 mm (0.256 inch) wide. That is approximately 0.15 mm wider than the tape guides of our reproducer.[6] Fortunately the machine we used was convertible to 1/2-inch tape. We removed the upper sections for the intake guide, the idler, and the spool-out guide, although the last one was removed and replaced on a per-tape basis.

We then had to determine which way the tape was oriented. Many of the tapes were heads out, whereas some were tails out. Some were even spliced together so that the recordings were in both directions. We solved each of these problems in a way that minimized the amount of tape shuttling that had to be done.

The Scotch 111 and other coated tapes presented the greatest problems, as they were cupped and quite stiff. In a few instances we used a cotton swab and sometimes even a degreased thumb as an auxiliary pressure pad to maintain head-to-tape contact and reduce dropouts, but by and large the native tension in the player maintained good contact. The amount of vertical deformation that manifested itself as waviness or weave was amazing. While we did not attempt to measure it, it appeared that the tape was moving vertically by about 10–15% of its height. The slightly oversized homogeneous tapes (which are still very supple) did not suffer from this weave problem.

The mechanical instability of the tape would have caused some concern about azimuth, but azimuth anomalies are minimal at 30 in/s (760 mm/s). We did not look at the signal on an oscilloscope, but there was no significant attenuation of high frequencies when the two stereo channels of our reproducer were summed. In the final transfer, each of the two stereo channels was recorded discretely, enabling later selection of the better of the two channels. The fact that the tapes were spliced together also indicated that the azimuth might have changed within a tape. Head height was not an issue, as all tapes appeared to be full-track mono. There were World War II–era stereo Magnetophons, but Mullin's were mono.

As stated previously, Mullin had spliced and respliced these tapes. We found splices 6 inches apart—that is one-fifth of a second at 30 in/s! These splices may have been made with a black cellophane-like tape, or the tape had turned black with age. More than a few of them came apart which, coupled with the tendency of the splices to stick to adjacent layers, influenced our winding procedures. Fast forward and rewind were modes we could only dream of as we stayed up late nights. We never used these breakneck speeds on any of the tapes. The highest speed we used was the 75-in/s (1900-mm/s) spool mode, and that was used only on relatively splice-free areas of tape. If we were lucky and the tape was heads out, we would play it at 30 in/s and leave it tails out on the take-up reel. If the tape were tails out, we would try the 75-in/s spool speed with periodic checks of what was on the tape. In many instances we chose to play the tapes at 30 in/s rather than using the 75-in/s spool mode. We also spooled some at 45 in/s (1140 mm/s) (30 in/s with +50% vari-speed). In a few instances where there was layer-to-layer adhesion, we spooled the tapes as slowly as 3-3/4 in/s (95 mm/s) (7-1/2 in/s with –50% vari-speed). In areas where we had to spool as slowly as 3-3/4 in/s, doubling the speed to 7-1/2 in/s would have greatly increased the likelihood of a major tape tear. The homogeneous type L tape had a bad habit of tearing at a very acute angle, resulting in diagonal tears of 6–18 inches (150–450 mm) in length. Fortunately the longest ones happened in noncritical areas. Splicing these tears back together was extremely difficult because of the length of the tear and the fact that the tape did not fit into a standard editing block due to its slightly greater width.

Three of the tape pancakes did not even have hubs, presenting us with perhaps the greatest challenge of the project. One of the tapes would not pack properly onto the take-up reel because it contained so much edge damage and pressure-induced folds (see Fig. 2). After several attempts at winding back and forth, we managed to wind the original 12-inch (300-mm) diameter pack onto two 10-1/2-inch (267-mm) reels. The other two were easier to spool, although one had a 7-inch (178-mm) diameter hole in the center.

Cleanliness was paramount. While the tapes did not exhibit any substantial binder breakdown—unlike tapes half their age made with urethane binders—there was a fair amount of oxide dust generated that we had to clean off everything. Part of this appeared to come from edge damage and popped strands. We used 99% isopropyl alcohol and cotton swabs. We cleaned the heads and guides between tapes and used ➥

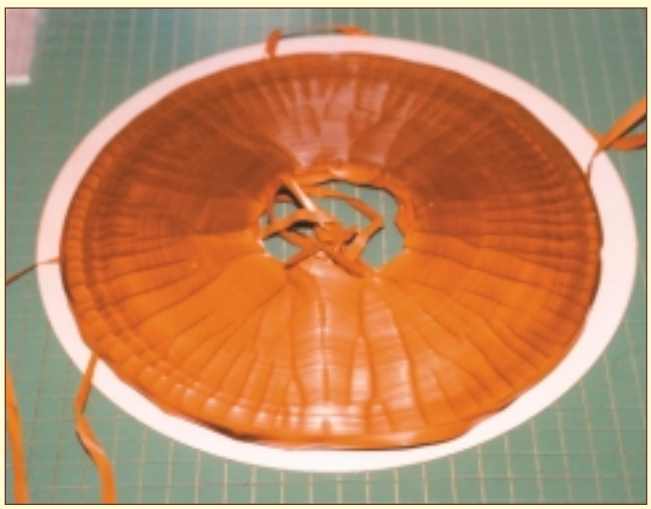

Fig. 2. An example of scalloped tape.

[6]Originally U.S. tape manufacture was 0.250 inch (6.35 mm), but that was subsequently reduced to 0.248 inch (6.30 mm). Tape guides typically are slightly larger than 0.248 inch.

Fig. 3. Jim Wheeler with the one that got away.

canned compressed air to blow away the dust.

The recorded level on the tape was very low by today's standards, but the noise floor of the recordings on the German tape was also very low, which surprised us. While the dynamic range is probably in the range of 45–50 dB, as estimated from the DAT meters, the noise is not intrusive. We estimate that the bulk of the recordings were made at a reference fluxivity of approximately 75 nWb/m. For many years, Ampex suggested 185 nWb/m, and 250 nWb/m is common today. The electronics chain of the reproduce machine was quieter with tape stopped than with tape running, so all of the noise that we were seeing appears to be on the tape.

We decided that we were not going to transfer everything, as there were many experimental sections, random noise, and other material of no historical interest. We transferred a broad cross section of material and maintained content logs of all the tapes. The tapes are now wound on NAB flanged reels, better protecting them for posterity.

The signal from my Sony APR-5003V tape player passed through a pair of Dolby 361 noise processors (switched to "no noise reduction" and used for the balanced-to-unbalanced transition in my home studio) and then was passively connected to a pair of Panasonic SV-3800 DAT recorders. We recorded two simultaneous DAT transfers at 44.1 kHz. We selected this sampling frequency because we knew we wanted to archive and preserve the material on CD and did not want to expose the signal to the 48 to 44.1 kHz sample rate conversion process. We realized that DAT is not the optimum archival medium, but the format solved most of the problems we faced during the transfer process. The DAT machines in use have competent analog-to-digital converters, and the format offers reasonable interchange and will survive for at least another 10 years.

Our project will not be completed until we copy a portion of the material from the DATs to audio and data CD-Rs. The logs that we kept about the program content and technical details represent metadata that we will record on the data CDs and as a CD-extra component on the audio CDs. We hope at some point that these recordings can find a home in a secure digital archive.

I am very pleased to have had the opportunity to open this magnetic time capsule, and I am even more pleased with the reproduction quality. Thanks are due to Jim Wheeler for his faith in me and my equipment. I would also like to thank my fellow members of the AES Los Angeles Section Committee for allowing me to present Jim Wheeler and a preliminary report on this project to the Section. Thanks are also due to my wife, Mary Beth, for allowing me the time to undertake this project and to Marie-Lynn Hammond for providing preliminary editorial advice. Jay McKnight and Peter Hammar provided substantial editorial support. I would also like to thank Jay for providing the link to historical information, as well as magnetic recording historian Friedrich Engel of Germany for his input. Jim Wheeler and I did this work at our own expense with no outside financial support. Any potential availability of any portion of these historic recordings will need to be deferred until the intellectual property issues are resolved.

THE AUTHOR

Richard L. Hess obtained a B.S. degree in communications from St. John s University in 1973. He worked in the engineering department of ABC Television in New York under Max Berry, John Gable, Ben Greenberg, Joe Maltz, and Hans Schmid from 1974 through 1981. In 1981 he joined McCurdy Radio in Toronto, where he ultimately became director of engineering. In 1983, after George McCurdy sold the company, Mr. Hess joined National TeleConsultants in Glendale, CA, where he continues to work on a variety of large-scale broadcast facility projects. He maintains a web site at www.richardhess.com, which contains some information on tape restoration. He may be reached via email at richard@richardhess.com.