ALL ABOUT CASSETTE TAPES

17-Nov-79

INTRODUCTION ·

This is a random collection of ideas and notes about cassette tapes for the Atari 400 and 800. It is being compiles at a request by John Ellis for a tape test system for production Q.C., but since I have a lot of things on my mind about tapes at the moment, I'll use this time to write them down. These notes are straight from head to keyboard; random (except I'm following a quick outline); no attempt at readibility will be attempted and I'll very likely not re-do this.

Sorry about the overkill, John. If you don't use all this, maybe someone else will.

ATARI CASSETTE TAPE FORMAT

Tapes are recorded 1/4 track stereo, 1 7/8 ips. The tape can be recorded both ways (both sides). Tracks 1,2 are side A left, right; tracks 3,4 are side B right, left (industry standard). On each side, the left channel is used for audio, right for digital.

Audio is recorded on the tapes the normal way, then mixed with Pokey audio in the 400 or 800 and sent to the TV. I've noticed that overmodulation nearly always occurs when both the tape and Pokey are making noise, resulting in distortion. Whenever the tape is moving (i.e., the tape unit has power) any audio on the tape will be fed to the 400/800. The audio is low-pass filtered (in the 400/800?) 6dB/octave at 1kHz to reduce effects of leak from the digital track.

Digital is recorded using the Pokey 2-tone mode producing FSK data up to 600 baud. Asynchronous serial byte-transmission is used 1 start bit (space), eight data bits (0=space, 1=mark), bit zero first through bit 7 last, then one stop bit (mark). More marking is always allowed. The mark frequency is 5327 Hz, space is 3995 (both about 1% lower if made on PAL systems).

To date, tapes have been made in one of two ways (not counting outside Atari's influence or engineering test tapes, which I know nothing about): either with the Atari 410 cassette machine or high-speed mass-production from tapes mastered at our mastering station.

The 410 has no bias oscillator; erasure is DC (I think) and uses a standard 1/2 track erase head, therefore any audio is erased. If the machine is stopped, the tape will drift (flywheel effect) but the heads are off and any info on the tape at that point will not be erased. The digital track is recorded from the right-channel playback head, and no bias means saturated recording is used. I was told once that the only current driving the head comes straight from Pokey!

Four tapes are made (to date) for each mastering session on the mastering station--two 7 1/2 ips quarter-track stereo masters (on Maxell tape so far) and two cassette check copies. Pokey serial out is sent through an RC low-pass filter to cut highs (to reduce channel leakage at higher frequencies)--but this and further processing produces some "AM-ing"--more on this later. Since standard tape machines are used, the recording is normal "biased" audio recording. An audio track may be recorded at the same time, coming from a source recorder. Synchronization is achieved at this time either by using data in the digital track on the source tape, or by hand.

The resulting cassette is read by the 410 machine under control of the 400/800. The cassette is stopped/started under control of the computer (the PLAY button must be pushed). Audio is simply sent to the audio mixing circuit--the computer never sees it. Digital is demodulated by a special circuit in the 410: First the signal is AGC'd to a constant level (I don't know what the reaction time of the AGC is). The AGC was built in to allow the 410 to read through tape dropouts. The resulting constant-level signal is then fed through two bandpass filters whose analog outputs are compared. The "winning" filter represents the tone currently under the read head, and the machine produces a zero or one accordingly.

The AGC is very sensitive--"blank" tape contains enough hiss on certain models of the machine that the filters are activated, producing a random pattern of 0's and 1's (to date, plastic cassette leaders have not exhibited this problem--reading a leader produces a constant Mark). Of course, unerased tapes on inter-record and inter-file gaps will be read this way, in particular if there had been data there on the tape before. The Operating System (OS) and Educational System software is only somewhat tolerant to this "garbage" data--much more on this later.

The filters react strangely to shifts in the two tone frequencies, caused by variations in the tape speed. In particular, the demoduation leans toward either 1 or zero, that is, if you run a 50% 0/1 alternation then read it back at another speed, the result does not exhibit a 50% duty cycle. This effect reduces the speed tolerance of the system, and as far as I know neither the OS nor the Ed system takes it into account in their automatic playback baud rate correction. Nevertheless, the Ed system, when being developed, was measured to work correctly over a +-7 1/2 % range, and I believe the OS probably has a similar tolerance. No problems with either, other than "normal" occasional errors have been noticed around the lab. The manufacturing tolerance of the machines, I'm told, is +- 3%--so if a user of a 3% slow machine sends a tape to a 3% fast user, the difference is around 6%--we've apparently got it covered.

EDUCATIONAL SYSTEM TAPES

Ed system tapes contain "stream" data in the digital track-- that is, characters are not blocked together. Most data byte values have meaning, but some are unassigned and just ignored if read. 96 characters are graphics (the eighth bit is a color/blank flag). The remaining 32 characters are for control (the eighth bit may or may not be used). One of these characters is used for tape speed measurement.

The printing characters correspond roughly to ASCII, except that Dorsett has redefined a few of the characters. The ASCII control characters have been redefined for the Dorsett system, with meanings such as stop tape, set color, etc. ALL CHARACTERS ARE INVERTED ON THE TAPE, that is, 0 is changed to 1 and vice versa (NOT counting the start and stop bits!). This was done so that the 00000000 character (used for baud measurement) would appear on the tape as 11111111--in other words, the data bits look just like the stop bit!

Tapes in the Atari format are created as follows: A Dorsett (processed) master tape is fed to the Atari mastering system. The mastering system contains the equivalent of the Atari 800 computer with a special version of the Ed system program, plus a special set of circuitry to read the tape in Dorsett's format. The master is made in one continuous pass (except, perhaps, between the lessons-- more later). The Audio goes directly the the Atari master, the digital is read by the computer and reprocessed into the Atari format.

A few notes on Dorsett's tapes: The digital is in the left
track, the audio in the right.   There are a number of problems with
the audio--the tapes have been reprocessed many times.   Leak from the
digital track is sometimes noticeable.   Speed variations, tone changes,
level changes are all noticeable.   Often there is noise or distortion.
The changes occur often rrom rrame to frame--sections of the audio have
been re-recorded.   Sometimes Dorsett has had to cut out sections of
audio or re-record them to correct errors or shorten a lesson to
less than 15 minutes.

        We have recently added an audio limiter to help with level
variations.   Any tape processed with version H or later uses the limiter.
The limiter does not have a noise gate attached, so audio "breathing" is
apparent--but only if listened to on high-quality tape.   For now, I
have decided that since the tapes will ultimately be low-pass filtered
and fet through home TV's, the "breathing" is OK.

        The digital track shows similar problems with speed variation.
Some problems are somewhat alleviated since Dorsett sends us "processed
masters." I don't know for sure what this means, but I have been told
that 1) processed masters have the old 50 and 120 (?) Hz tones filtered
from the audio (often overtones get through, though, since the tones
are not clean on the original masters) and 2) the tones on the digital
track are "squared up" and level-adjusted.   Note that is tones, not
bits or bytes.

        The digital track consists of data bursts of CUTS (K nsas City)
format info at 300 baud.   The bursts are discontinuous since Corsett's
development stations are used to create the digital track in short
segments.   In fact, to correct errors, sections of digital information
are often re-recorded.   This all too often leaves small bursts of
partially-erased old information.

        Our best attempts (presently in use) at "reliably" reading
these tapes start with a carefully-adjusted version of Dorsett's
demodulator.   The three outputs of this demodulator (data, 16x clock,
and Carrier Detect) are fed to an ACIA (Data, 16x clock and a ready
pin which acts somewhat like a reset).   The ACIA data is read by the
computer.   Frame-error bytes (no stop bit detected) cause the system
to beep at the operator, and are not written to the output tape.

        Perhaps the biggest problem with the way the Dorsett interpreter
was implemented is that each characteer read stands alone, that is,
must be interpreted.   There is no parity, CRC, or any other check on
the validity of data (except frame error checking, and, at this
writing, I don't even remember whether the frame error is ignored
or not!) Everything read is assumed good, and the interpreter cannot
tell the difference between good data and blank tape/random data.

For this reason, no blank tape must be allowed on the final cassette. To ease the mastering of a bin loop, or to allow sufficient slop for the Recortec process, about 20 seconds of leader is applied at the beginning and end of the master. Around 20 seconds of no-data is also applied between each two lessons on each side, both because when two of dorsett's masters are spliced together that is about the gap that results, and a small amount of blank between lessons has been advertised as an aid to the consumer in locating the second lesson.

When the two Dorsett masters used on a side are spliced together, the side is recorded in one operation. When the side comes from two tapes, the recording is stopped during the gap in the middle to cue up the second tape. This should be the only discontinuity on any Ed system tape's digital track. I have not measured the discontinuity but have merely insured, through many trials, that the Ed system interpreter does not seem to trigger on it.

Just before the start of digital data the "timing marks" are turned on. The marks consist of start bits spaced two byte-times (20 bits) apart. These are read as 11111111 characters, and MUST appear on the tape ONLY as timing marks (the original Dorsett codes left this code open; Dorsett has been informed of our use of the NUL ASCII code for this). Two successive NULs are treated as timing marks, and a running binary damped average of the variance from zero (0) MOD (131) of the difference between values of Antic's VCOUNT when each NUL was read is used to control the tape input baud rate. That is, in an ideal world each timing mark is spaced 262 TV lines apart, and the two VCOUNT values read would be equal. The difference read in the counter represents the fraction of 262 that the marks were too close or far apart, and that fraction controls Pokey's baud rate. (Software stops were put on the correction, at about +- 7%, due to the bit size skew at these extremes. It had turned out that if Pokey were set at one extreme a single start bit was stretched out to be read as two 0's, producing the data 11111110--timing marks were no longer recognized.)

These timing marks are written onto the output tape wherever there is a gap in the data from Dorsett's tape, after the copy system operator has turned them on. They are turned off on some tapes during the inter-lesson gap. They should be turned off at each end of the tape, but watch for copy system operator error.

The same tapes can be used in Europe, but since VCOUNT has a different modulus in PAL, the interpreter must be changed so that it properly interprets the timing marks. I believe that the OS must undergo a similar change, since VCOUNT was used in its baud rate check software also.

Note that the timing marks are 262 lines apart, which
corresponds to 20 data bits. This means a slight deviation from 600
baud so that 20 data bits is a close as possible to 262 lines.

OPERATING SYSTEM DATA FORMATS

        Accuracy of this section is the best I have, but I have
not been intimately involved in this aspect of the system and
errors are certainly possible.

        The OS writes files in fixed-length blocks at 600 baud.
(The baud rate for PAL version OS is unknown at this time, but
may be 1% less than NTSC. This may be unfortunate if so, since
it will cut down on tolerance to cassette speed variation if tapes
are to be compatible between the US and Europe.) Records are
131 bytes long: two marker characters for speed measurement, a
control byte, 128 data bytes, then the checksum byte.

        The marker characters are each 55 (base 16), resulting in
a strict alternation of bits for 20 bits (including the start and
stop bits). The marker characters follow "leader tone" which is
pure mark tone. I believe (and suggest you check yourself if you
want to be more certain than I) the OS checks the tape speed like
this: the software looks at ﬁ a Pokey serial in bit continuously,
looking for a start (zero) bi.. When it finds one, the OS stores
the current "time" by saving the Antic VCOUNT (and some frame count
information). Continuing to look directly at the serial in bit,
the OS counts the twenty bits, then uses VCOUNT and the frame counter
to determine the elapsed time. The baud rate to use is derived from
the result. This is done for each record.

        [WARNING: excessive computing in interrupt routines during
tape speed measurement will upset the measurement. Be wary of
computation done in Antic display list routines. Note, however,
that SIO operates as "critical" code so the default VBLANK routine
does very little (optional code is not performed). Bypassing the
OS in interrupt handling should be done with care.]

        I believe the writing of each record is continuous--that is,
there is no space between the marker bytes and the subsequent data.
I have no idea about the timing of the transition between looking
directly at the timing bits and the transition to letting
Pokey read the rest of the record itself.

        Notice that this system will fail if the first 20 bits are
not the 55 bytes. As far as I know, the OS has no real way of

knowing what it is reading nor how long it takes while it is measuring
the tape speed--it just counts off 20 bits (ten each of alternating
zeros and ones). I don't know if any "stops" were placed on the
resulting measurement, that is, if the baud rate will only be set in
a fixed range of values. The system depends on proper tape positioning,
that is, each time a record is to be read, the reading must start in
the leader tone for that record, that is, the first zero sensed should
be the start bit of the first 55 byte.

Much more on the tape positioning and timing, but first,
I'll finish with the tape formats. The third byte in each record
tells the OS about the type of record. A normal record contains
FC (hex) in this byte. This indicates that there are 128 bytes of
data in the record. A short data byte is indicated by FA (hex).
The actual number of data bytes, 1 to 127, is stored in the position
of the last data byte. I don't know what any unused data bytes
contain in such a record. An end-of-file record is indicated by
FE (hex) and is followed by 128 zero bytes.

The checksum is a single byte sum of all the other bytes
in the record, including the two 55 bytes. The checksum is computed
with end-around carry, that is, as each byte is added into the
sum, if there is a carry out of the partial sum at that point,
one (1) is added to the partial sum. Any carry out of the final
addition to the partial sum is added back in.

The actual data stored in each record is, of course, up to
the program calling on the OS to put it on tape. One data format
is supported by the OS, however, so it is mentioned here: cassette
boot format. The first six data bytes of the first record are:
OS DFLAGS, apparently unused by current OS code (i.e., reserved);
2) record count byte, the count including the first record (I think);
3 and 4) Load address--all data, including these 6 bytes, are written
starting at this address. I assume the address is standard 6500
indirect address form. 5 and 6) Entry address minus 6 (I'm told).
The file is not read in short IRG mode (see below).

Now back to timing and positioning. A file may be opened,
on output and subsequent input, in either normal mode or "short
inter-record-gap" (short IRG) mode. Normal mode is meant for readback
interleaved with processing; the tape must be able to come to a stop
if the processing takes more time than is in the gap. Of course,
in normal readback situations, it isn't known whether there's time
or not, so the unit is always stopped after each record is read
(meaning "stopped" in the computer program sense; if, in reality,
the computer "stops" the tape but gets back to another read fast
enough, the cassette deck may see only a slight dip in the control
line). Similar arguments hold for writing the tape--it stops between

records to let the computer compute.

Short IRG mode is somewhat misnamed--the gaps are not necessarily
short. Short IRG mode really means simply that the tape is not
stopped between records, either when being written or during readback.
On readback, the program must issue a read for each record before
it passes the read head. If there is a potential problem with this,
the software that writes the tape must allow long enough gaps. The
only common use of this mode so far is storage of BASIC programs in
internal (tokenized) form where on readback BASIC has nothing more
to do with the data than put it in RAM. The special BASIC commands
CSAVE and CLOAD specify this mode. In this case, the gaps are, in
fact, very short.

The OS writes mark tone wherever possible in the gaps. This is,
of course, impossible when the tape is stopped and restarted. Two things
happen when the tape is stopped or restarted: the motor changes speed
and the electronics lose (or regain) power. The system loses power
more slowly than it regains it (due to filter capacitor). The motor
stops more slowly than it starts up (inertial stop versus powered start).
The result is that, whenever there is power enough to write on the tape
the resulting frequency (assuming readback at normal speed) of the mark
tone will increase with decreasing tape speed, and there will be sections
where the tape is not erased, since the erase head loses power.
(If the design of the record-head system is such that it is powered
directly from Pokey, then it does not lose power.)

All of which is no problem for short IRG mode, but the normal IRG
mode must first write the gap in such a way that there is plenty of
safety margin for varying tape stop times, and then read the tape
back in such a way that the tape will be ignored during the unknown part
of each gap. There are a number of time-spans and time-outs the OS uses
when writing and reading back the tape: write pre-record gap time,
write post-record gap time, read gap ignore time, write OPEN leader
time, read OPEN leader ignore time, and read/write timeout. Many of
these times differ depending on short or normal IRG.

They differ on another point, too--there are two releases of
the OS. The April 1979 OS (April) was produced in small numbers
(a few thousand) and is supposed to be killed, but some units may
be seen either on store shelves (demo units) or maybe on the market.
The June 1979 OS (June) is the current OS.

Now a walk through the timing: For OPEN (output), each OS
starts by writing a mark leader, 9.6 sec long (April) or 19.2 sec (June).
In either case, the OS returns from the caller AFTER writing this
leader, but leaves the tape running and writing mark. The write/read
timeout counter is set as the OS returns, about 15 sec (April) or

35 sec (June).   If the timeout occurs before the first buffer is
written, the tape will stop, leaving a (probably unrecoverable) gap
between the OPEN leader and the first record leader.

        NOTE: Due to a SYSTEM RESET bug, the leader tone may be written
as space, not mark.   If this occurs, the file cannot be read back
successfully.   The operator should ensure that Pokey is properly
reset before doing any cassette output.

        Each record is written with the following timing: The motor
is started (even if it was already for short IRG) and the pre-record
write gap mark tone is written.   The duration of the tone depends
on short or normal IRG mode, 3 sec normal or 0.25 sec short IRG.
The record follows, then the post-write mark gap is written.   The
length of the post write marking is zero (0).   The motor is then
stopped for normal mode, but continues writing mark for short IRG
mode.   Note that the gap, in normal mode, consists of a period
of tape with unknown data (up to 1 sec possible, depending on the
cassette machine) followed by 3 seconds of marking.

        Due to an OS bug, the mark-tone continues after the file is
closed, but the motor is stopped after the last (EOF) record in
both short and normal modes.

        When a tape file is opened for input, it is the user's
responsibility to position the tape for proper reading prior to
opening the file.   On open, the OS starts the tape, then ignores
it for 9.6 sec (June) or about 2 sec (April).   After this, the OPEN
input routine in the OS returns to the calling program, but leaves
the motor running.   The user must then read the first record
before either the first record passes the read head or the
write/read timeout occurs (about 15 sec April or 25 sec June).

        Read timing for a record involves ignoring the tape after
the motor starts.   The ignore time is 2 sec for normal IRG mode, and
about 0.17 sec for short IRG mode.   After this, the OS reads the
record.   The record must be fully read before the write/read timeout
occurs.   After the record is read, the motor continues (short IRG)
or is stopped (normal).   Of course, the next read must come in time
for the next record in short IRG mode.

        It is obviously impractical to read a short IRG file normally,
and vice-versa.   However, it is possible to take a tape from one
version of the OS to the other, assuming timeout differences are
properly accounted for.   The major difference is in length, timing
and positioning in the long header before the first record.   Not
all cases will be covered here, but the case of making a mass-
produced tape readable by both will be.   Two cases are discussed.

the case of the first file on the tape and that of closing one and
then opening the next.

For June OS users, it is desirable that they simply be able
to rewind the tape to position for the first file, since that is the
procudure stated in the user documentation. This requires that the
leader tone be found within 9 seconds and the first record appear
long enough after that that it is not skipped, but close enough that
timeout does not occur (the actual time to the first record from
rewind may depend on the particular application). To read the same
tape using the April OS, the user starts at the splice between leader
and tape. This requires that the leader tone start within 2 seconds
of the splice. Note that the April OS has a rather short timeout.

Between files it is assumed that the tape has been stopped
at a known place at the end of a file. The leader on the new file
must be at least 9 seconds from that point (June OS) but not more than
2+15 (approx.), that is 17, seconds (to avoid April timeout).
Note that BASIC seems to have its own end-file mark on a CSAVE type
file, and that it does NOT seem to read the EOF record (written by
the OS) when doing a CLOAD. Thus, after CLOAD, the tape is positioned
just ahead of the last record of the file. This record is longer
than allowed by the 2 sec wait of the April OS, and must be removed
if April OS is to read the next file. For other reasons, too,
this last record may be removed on some spliced tapes. The cutting
and splicing operation is do   by hand, and the cut may be before,
in the middle of, or after t is record.

The noisy I/O feature is useful for determining the success of
reading the tape, particularly CLOAD. One quickly learns the good
and bad sounds the OS makes. With practice, one can learn how to
sccessfully do random access file location by guessing and listening
to the leak into the audio channel from the digital (difficult if
audio also exists on the tape).

Tapes made for mass production on the mastering system may
present a problem since there is no motor control on the tape machines.
To date, all's fine, since the only tape formats recorded so far are
Dorsett (a continuous process), BASIC CSAVE (continuous) and the
binary marking format discussed in the next section (also continuous).
Note that the OS bug of leaving the mark tone on after each record
(including the last) is useful here, since the tone is therefore
continuous and even continues after the last record, which is often
useful for production reasons (see production considerations).
If other file formats are created, where the computer needs time to
"think" between writing records, the recommended method is to write
the tape on a 410 cassette recorded, then feed that tape to the
mastering system and re-digitize it onto good mastering tape.   It

may also be possible to write the program that makes the tape in
such a way that the resulting master is properly timed. Note that
a redigitized master made from a normal IRG tape may (will?) have
garbage after each record, before the next pre-record marking.

OTHER DATA FORMATS (AS OF THIS WRITING) AND HYBRID FORMATS

A data format has been developed for timing audio tracks to
running BASIC programs. Simply, the data track contains continuous
mark tone (1) except where a timing mark (space=0) is placed.

To date, tapes using this format have been written on the
Dorsett mastering system running BASIC. Short BASIC routines are
used both to write and read such tapes. BASIC is not really good
at producing reproduceable results as far as length of marker tone
is concerned--the mark sizes probably vary widely.

It is feasable to mix this marker tone method with OS
records, and it will probably be done. That is, first the BASIC
program cues up the tape to a marker tone, then reads a record
through CIO.

Since the mastering station does not have machine control over
tape motion on the recorders, the stop and start characteristics
of the 410 recorder are not matched. Instead, first the BASIC
program is written, then the audio (with timing) is written, then
the two are physically spliced together. A glitch of some sort
occurs at the splice. Two-sided tapes are not mastered on the same
tape; instead two masters are created which must then be copied to
each side of one tape. Note that the splices occur at places where
the computer will not be reading the finished cassette.

ABOUT MASS PRODUCTION OF TAPES

Our masters are converted to cassettes through high-speed
copying in one of two ways (so far): the Bin Loop method and the
Recortec method. (The latter is not presently in use but is under
consideration).

Ed system tapes have different requirements than the OS (BASIC)
tapes. It is possible to produce tapes in a format that works for
both; but this may not be the most cost-effective. Ed system requires
NO blank tape; the OS does not require this, but if a tape is to
be compatible with both the April and June OS, the blank tape must be
less than 2 seconds. On the other hand, the OS tapes require a "short"

leader while Ed tapes do not. Short leader tapes with no blank tape
will satisfy both.

        First I'll discuss bin loop methods.   Our master is copied by
the tape company to produce a "loop master".   The loop master may be
on 1/4", 1/2", any tape width, depending on the copmany (Cory uses
1/4").   NORMALLY (not for us) the bin loop is then spliced into a
continuous loop with a short clear leader at the splice.   It is then
placed in a high-speed loop master machine and repeatedly read.   As
it is read each time, the data (all four tracks) is copied onto
a "pancake" of 1/8" cassette tape, many times end-to-end, on one
or more "slave" machines.   As the clear section in the loop is
sensed, the master machine produces a "cutting tone" which is recorded
on one or more tracks of the copies (at final speed, the cutting tone
is between 5 and 15 Hz, depending on the system).   Finished pancakes
are then fed into automatic loading machines which wind the tape into
C-zero cassette shells.   The shells come with a small loop of leader
which is bound to the cassette tape hubs.   The loader pulls the leader
from the shell, cuts it, and splices the end of the pancake tape to
one side.   The tape hub is then used to wind the tape into the shell
until the cutting tone is sensed, where the tape is cut and spliced
to the leader on the other hub.   The slack is removed and the tape is
fully wound into the shell.   Note that only one cut is made between
lessons.

        Depending n the company, each tape may then be "exercised"--
fast wound and/or rewound.   The most common QC action is to check
the first tape fr.a each pancake, sometimes the last from each pancake,
and sometimes a r.adom pick from the middle.

        This procedure has problems for Atari tapes, and has been
modified.   First, automatic loading machine require C-zero shells with
about 24 inches of leader.   This corresponds to about 7 seconds of
leader at each end IF the leader is cut in the middle (also there is
some variation in leader length).   The result is that short leader
shells must be used for OS format tapes, and must be loaded on hand-
assisted machines.   Automatic loading is presently used for Ed system
tapes, though.

        Worse, though, is the fact that there is blank tape when the
standard processing is used.   The clear leader used to trigger cutting
tone results in blank sections (not counting the tone) of tape, and
since only one cut is made between lessons on a pancake (i.e., no
tape is thrown out), that blank tape appears at either one end or
the other of each cssette, or both.   The solution has been to eliminate
the clear marker and splice the bin loop to itself, with continuous
tone in the digital tracks.   There is some phase discontinuity in the
tone at the splice, but the 410 recorder seems not to notice.   There is

also usually some sort of dropout at the splice, but this has so far
not been seen as a problem. The cutting tone is then placed on the
loop master on the audio tracks--unortunately at high level and very
non-linear. The cutting tone is audible on the resulting copies.
This technique has been used so far for all Ed system tapes and most
other tapes also.

Note that if both sides of the tape are not going to be used it
will be possible to put the cutting tone sufficiently into the
digital leader that the cut is guaranteed to be inside it. Some if it
will be cut off at the end of the next cassette, etc, but this procedure
will eliminate the phase glitch mentioned above.

The Recortec technique is done on a single machine which
winds the tape into the shell from the pancake while it is being
recorded from the master. Recortec uses our tape as master, meaning
1) we must make it in their format, and 2) it will eventually wear out
and must be replaced. The recording is done each way alternately, that
is, first the master moves one way, then the other. The resulting
cassettes must be exercised so that they all result wound for side one.

Recortec has problems, too. Their into-the-shell method is
awkward for speed control and speed fluctuations are often noted on
the resultant copy (not noted on the latest samples received).
They may or may not be able to support short leaders needed for OS
tapes (I don't know at this time). They requir masters with sides
A and B properly placed (we do this for all Ed tapes), but, of
course, could make the master from two supplied by us. Their machines
DO leave blank tape when unmodified, but they have recently come up
with a modification to eliminate it. I don't know a great deal about,
the process at this time, but speculate it may (or may not) have to
deal with the problem of coming up to speed (i.e., the tape should
be up to speed as the splice crosses the record head in order for the
tone to be at the right frequency at the splice). The technique they
developed involves rewinding the tape out of the shell back to the
cutting station to insure that no blank tape is left in the cassette,
but it probably winds back too far (needed slop) and some recorded
data is left on the beginning of the next wind (which will be
re-recorded, but how well??) Nevertheless, the Recortec process
has promise.

Recording levels are, at this time, one of the possible
problems we are having with tapes. I just received a very expensive
set of industry standard reference tapes but have not had time to use
them to calibrate our machines. With our machines calibrated to known
industry levels, we will be much better able to discuss level problems
with our vendors. At any rate, when bin loop masters are made, our
tape is recopied and the levels may be (usually are) changed--to what

they think we want.   The levels may also be adjustable from the bin
loop to the cassette tape slaves--if this is so, we're likely to run
into operator error.   I don't know if the Recortec system has level
controls--if they don't, then our levels set the result. This may
also be a problem.

TESTING CONSIDERATIONS

        This section will mostly consist of a listing (with occasional
discussion) of the problems seen on mass-production type tapes so far,
either vendor samples or tapes off the production line.   Some
testing suggestions may follow that.

        This section incomplete now due to lack of time.