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Applied Tape Techniques for Use With Electronic Music Synthesizers.

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/APPLIED TAPE TECHNIQUES FOR USE WITH ELECTRONIC MUSIC SYNTHESIZERS/

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ABSTRACT

This monograph presents information that deals with musical materials recorded on tape. It describes a number of taping techniques including overdubbing, editing, splicing, and special effects. It also examines techniques for the spatial placement and movement of sound. It further includes information about recording tape and tape decks, as well as a description of rudimentary recording, playback, and erasing procedures. The techniques described are limited to those which are possible using a half-track or quarter-track stereo tape deck and a quarter-track quadraphonic tape deck with separate record and playback heads and selective synchronization.

The overdubbing techniques described include sound-over-sound, sound-with-sound, sound-on-sound, and selective synchronization. The special effects described include sound reversal, channel reversal, tape reversal, magnetic particle removal, the use of different tape speeds, tape echo, and tape loops. The techniques for the spatial placement and movement of sound are limited to those effects which are possible using only a quadraphonic tape deck without external mixing or panning devices. However, there is also a brief discussion of other factors besides taping procedures that are involved in the spatial placement and movement of sound.

INTRODUCTION

This monograph contains taping information and techniques which are useful in producing electronic music. It is limited to those techniques which are possible using at least one open reel half-track or quarter-track stereo tape deck, and at least one open reel quarter-track quadraphonic tape deck which has separate record and playback heads and selective synchronization (also known by such trade names as "sel-sync," "simul-sync," and "syncro-trak"). Explanations of these terms and tape head formats are contained in the following chapters. This monograph does not include information about microphones and related techniques. However, nearly all the techniques discussed are applicable to the general assemblage of electronic music.

In order to be made more meaningful, the techniques presented in this monograph should be put into actual practice. In this respect, it is hoped that this monograph will serve as a practical guide.

I. BASIC TAPING INFORMATION

Recording Tape

Recording tape is usually made of either acetate or polyester (also known as mylar). Polyester is generally preferred to acetate because it can withstand temperature variations better and will last much longer (acetate tape tends to become brittle with age). Polyester will not break as easily as acetate tape but this is not really an advantage. Should something cause an unusually large amount of tension on the tape (a faulty tape transport mechanism, for instance), polyester tape will stretch and possibly become unusuable, whereas acetate tape will usually break cleanly, allowing the tape to be spliced and to remain useable.

Recording tape comes in three thicknesses, .5 mil, 1 mil, and 1.5 mil. A few tape decks have a tape tension selector to adjust the tape transport mechanism for the various tape thicknesses. One of the disadvantages of thinner tape (.5 mil and 1 mil) is that it will often allow print-through to take place. Print-through occurs when one layer of tape on a reel transfers some of its magnetic signal to adjoining layers of tape. The result of this is often heard as an echo before or after the original sound on the tape. The use of 1.5 mil tape minimizes print-through. Also, 1.5 mil

tape will not stretch as readily as thinner tape, and is easier to handle when editing and splicing than is .5 and 1 mil tape.

The main advantage of thinner tape is that it allows for more recording time per reel of tape. If a 7 inch diameter reel of .5 mil tape (2400 feet of tape) is recorded at the speed of 7 1/2 inches per second (ips), it will provide a recording time of one hour in one direction. Using the same tape speed and reel size with 1 mil tape (1800 feet of tape) results in a recording time of forty-five minutes in one direction. A 7 inch diameter reel of 1.5 mil tape (1200 feet of tape) recorded in one direction using a tape speed of 7 1/2 ips results in a recording time of thirty minutes. While these recording times may seem to be relatively long, they would be halved if the tapes were recorded at a speed of 15 ips. Because this speed is often used for electronic music applications, the length of the available recording time becomes a serious consideration. The easiest way to avoid this problem is to use a 10 1/2 inch diameter reel of tape, which provides twice the recording time of a 7 inch reel of tape.

In addition to the 7 and 10 1/2 inch diameter sizes, tape reels come in 3, 4, 5, and 14 inch diameters. 10 1/2 inch and 14 inch reels usually have NAB (National Association of Broadcasters) hubs or centers, rather than solid hubs with a 5/16 inch center hole (Figure 1). However, adapters are available to make 10 1/2 inch NAB hub reels fit

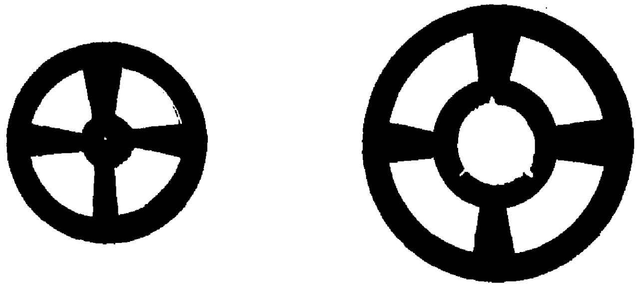

Fig. 1.--Examples of solid and NAB hub reels.

a tape deck designed for solid hub reels with a 5/16 inch center hole, provided that such a tape deck can accommodate 10 1/2 inch reels.

Recording tape comes in various widths, from 1/8 inch tape for cassette recorders to 2 inch tape for large multi-track recording studio machines. The most common tape width for relatively inexpensive open reel tape decks is 1/4 inch, though some electronic music studios do have machines which use 1/2 inch and wider tape. One of the advantages of wider tape is that it allows for more signal to be recorded on tape and therefore a better (larger) ratio between the residual noise of the tape itself (usually heard as hiss) and the recorded signal. This is known as signal-to-noise ratio.

Another factor which partially determines signal-to-noise ratio is the type of tape used. In the open reel format, the main tape types available are known as standard tape, low-noise tape, and low-noise/high-output tape. The advantage of low-noise and low-noise/high-output tapes over standard tape is that they can store more recorded signal

before they become saturated and distortion occurs. This increases the signal-to-noise ratio.

Low-noise/high-output tape, as well as being able to store as much or more recorded signal as low-noise tape, reproduces the high frequencies of a recorded signal at higher levels than do standard and low-noise tapes. This allows for the treble to be reduced to a normal level during playback which therefore reduces the amount of tape hiss at the same time. Also, some of the most recent low-noise/high-output tapes have a coating on their outside (the side of the tape which is away from the tape heads) which is dull looking and a bit rougher than the usual uncoated polyester of other tapes. This special coating is intended to reduce static electricity which collects dust and produces tape hiss, and to allow for a smoother flow through the tape transport mechanism.

For each of the above mentioned tape types to be recorded at its optimum signal-to-noise ratio, a high frequency signal called the bias current (which is combined with the input signal to be recorded and fed to the tape through the record head of the tape deck) must be correctly adjusted to each tape type. Most good quality tape decks have a switch which allows for changes in the bias current to suit the various types of tape. Such switches usually have two settings, one for standard tape, and the other for both low-noise and low-noise/high-output tapes. Usually, the manufacturer of the tape deck will give the specific brand name of

the tape for which their particular machine is correctly biased.[1]

In general, it is recommended that a good quality polyester based, 1.5 mil, low-noise/high-output tape be used, as poor quality tape may have drop-outs (places where the strength of the recorded signal is suddenly reduced), gum up the tape heads, and cause excessive tape head wear.

Tape Decks

A tape deck consists of a tape transport mechanism, tape heads, preamplifiers, and various other electronic components. It does not contain an amplifier and speakers for monitoring (listening to) the playback of the tape, but usually has a headphone jack which allows for monitoring the tape with headphones. For monitoring through a playback system, the outputs of the tape deck must be connected to the appropriate inputs on an external amplifier. This is accomplished by connecting the outputs on the tape deck's back or side, labeled line-out, to the inputs, labeled tape-play (or tape-in, line-in, aux-in, etc.), on an external amplifier. The signals to be recorded by the tape deck from the synthesizer may be connected directly to a line-in jack on the tape deck, or may be routed through the external amplifier and then connected to the line-in jacks on the tape deck. The line-in jacks are next to, or above, the line-out

[1]For further information on tape bias see Michael B. Martin, "Tape Performance and Tape Recorder Biasing," Stereo Review, Vol. 32, No. 4 (April, 1974), pp. 56-60.

jacks on the tape deck.

Line inputs and line outputs are high level, high impedance connections (600-ohms and above) and must consequently be connected to other outputs and inputs which are also high level connections. For instance, the line output of one tape deck channel may be connected to the line input of another tape deck channel and vice versa.

Microphone inputs are low level inputs. They may have a high impedance or a low impedance (50- to 600-ohms). On some tape decks, the impedance of the microphone inputs may be changed to suit both low and high impedance microphones. To avoid hum and high frequency losses, high impedance microphones should not be used with cords longer than about ten feet, while low impedance microphones may be used with much longer cords.

The Tape Transport Mechanism

The tape transport mechanism moves the recording tape from left to right across the tape heads for recording and playing back the tape. It can also move the tape rapidly in either direction through the use of Fast Forward and Reverse controls. Some tape decks provide a Pause control which can quickly stop and start the tape while the deck is in the record mode. This is useful for special editing applications, such as leaving out breaks between movements when recording live concerts. The tape transport must be able to maintain the movement of the tape at a constant rate of speed during recording and playback. This is achieved

through the use of a capstan and capstan roller, as well as through the motion of the supply and take up reels (Figure 2). Any variation of speed will result in an unwanted

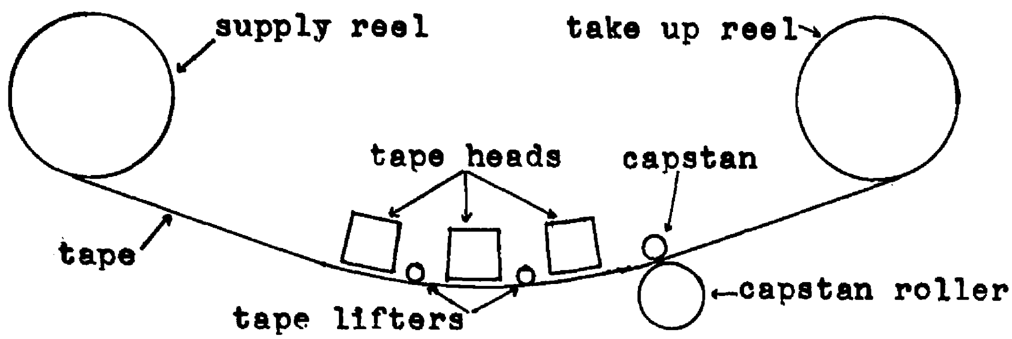

Fig. 2.--Diagram of the supply and take up reels, tape heads, capstan, capstan roller, and tape lifters.

change in the frequency of the sound being recorded or played back. If this change in speed is periodic and produces a vibrato like effect on the recorded material, it is known in audio terminology as "wow and flutter." Wow includes those periodic variations in frequency which occur from once every two seconds to about six times a second, while flutter includes those periodic variations in frequency which occur more than six times a second up to about two hundred and fifty times a second.[2]

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[2]In his book The Principles and Practice of Electronic Music, (New York: Grosset and Dunlap, 1973), p. 109, Gilbert Trythall states that "wow is an indication of uneven reel motion; flutter indicates variations in capstan speed." Wow and flutter are actually designations which indicate slow and fast periodic variations in frequency of recorded material caused by the tape transport mechanism. While uneven reel motion and variations in capstan speed may cause wow and flutter, these should not serve to differentiate between the terms wow and flutter. For more information on wow and flutter, see Craig Stark, "Tape Horizons," Stereo Review, Vol. 30, No. 2 (February, 1973), p. 142.

The tape transport is operated through the use of controls, usually either levers or buttons, on the front of the tape deck. Inexpensive decks usually have a single motor which through various clutches and belts turns the tape reels and the capstan. More expensive decks usually have three motors, two for operating the tape reels, and one for turning the capstan. On such tape decks, the transport mechanism is usually operated electronically through the use of solenoid switches. Solenoid operation allows for remote control operation of the tape deck.

The tape speeds usually used for recording are 1 7/8 inches per second (ips), 3 3/4 ips, 7 1/2 ips, and 15 ips. It should be noticed that each speed is twice as fast as the preceding one. Few tape decks provide all four speeds though some provide three of the four, usually either 1 7/8 ips, 3 3/4 ips, and 7 1/2 ips, or 3 3/4 ips, 7 1/2 ips, and 15 ips. More decks offer only two speeds, usually either 3 3/4 ips and 7 1/2 ips, or 7 1/2 ips and 15 ips. Cassette decks operate at 1 7/8 ips and some professional studio machines offer the speed of 30 ips.

The faster the tape speed, the larger the amount of signal stored on the tape within a given length of time. This results in a better reproduction of the frequencies being recorded, which in audio terminology is measured by "frequency response." At the speeds of 7 1/2 ips and 15 ips, the best semi-professional tape decks are able to reproduce all the audible frequencies (from 20 to 20,000 Hz)

equally well, and a few tape decks do record with excellent fidelity at the speed of 3 3/4 ips.[3] However, most taping should be done at 7 1/2 ips or 15 ips for good fidelity and a good signal-to-noise ratio. Also, at the tape speeds of 7 1/2 ips and 15 ips it is easier to make good splices because each second of recorded sound corresponds to 7 1/2 or 15 inches on the tape, and consequently there is more distance on the tape between sounds than there is at slower speeds. This makes the tolerances involved in the editing and splicing procedure less exacting. The slower tape speeds are useful for tape echo and other special effects, as well as for recording for extremely long periods of time.

A few tape decks offer a variable speed control which may be useful for correcting the speed (pitch and tempo) of a tape recorded on a deck whose speed was not exact. Also, variable speed control can be used for unusual effects. Tape speeds, including variable speed control, are further discussed in Chapter III.

The supply and take up reels are also part of the tape transport mechanism. They should be locked in place on the

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[3]For optimum performance, all frequencies from 20 to 20,000 Hz (the term Hertz, abbreviated Hz, has generally supplanted cycles per second in audio terminology) should be reproduced without any change in frequency content or change in the relationship of the amplitudes of the individual frequencies to each other. Therefore, to be meaningful, a given frequency response should include any variances (in decibels) from an established norm frequency. The norm established by the National Association of Broadcasters, is the output level of a tape deck at 400 Hz, which is arbitrarily rated at zero decibels (db). An excellent frequency response would be a record/playback rating of 20-20,000 Hz, $\pm$ 2 db.

spindles of the tape deck, either with the built-in spring type locks which pull out and twist to hold the tape reels in place, or with rubber caps. If a tape deck can accommodate 10 1/2 inch reels as well as 7 inch reels, it will probably have a switch to set the correct amount of tension on the tape for both reel sizes.

Most tape decks have tape lifters which lift the tape off the heads during fast forward and reverse to protect the heads from excessive wear (see Figure 2). Most tape decks which have tape lifters also provide a way of defeating them (turning them off) for editing purposes.

<u>Tape Heads</u>

Tape heads are small electromagnets whose external surface consists of two metal poles with a small gap in between. The gap is filled with a non-magnetic material. Tape heads are specially designed to serve different functions. On inexpensive quarter-track stereo tape decks and most cassette decks, there are usually two tape heads, one designed to erase the tape and another designed to both record and playback the tape. More expensive tape decks may have three tape heads. These include an erase head and separate heads for the record and playback functions. Figure 3 shows the three tape heads placed in the normal order in which they occur on a tape deck. Since the playback head follows the record head, a signal which is being recorded can be immediately monitored directly from the tape. The

Fig. 3.--Erase, record, and playback heads in normal order.

separation of the record and playback heads also allows for tape echo to be produced (see page 48). Another advantage of separate record and playback heads is that they can be manufactured specifically for their individual functions (have different head gap sizes, for instance) which results in better fidelity. To erase a tape, an erase head produces a magnetic field whose polarity is rapidly changing. As the tape crosses the erase head and moves away from it, the magnetic fields on the tape are weakened until they are nearly nonexistent, and the tape is consequently erased. In recording, the record head turns the electrical impulses it receives into rapidly changing magnetic fields which it transfers to the recording tape as it passes by. During playback, the playback head reads the magnetic signal on the tape and changes it back into an electrical signal.

Tape heads may be "stacked" together in one housing so that more than one channel can be recorded at the same time. This is usually done in such a way that the gaps of the two or more heads in one "stack" are in line with each other.

Figure 4 shows examples of various head and head stack formats.

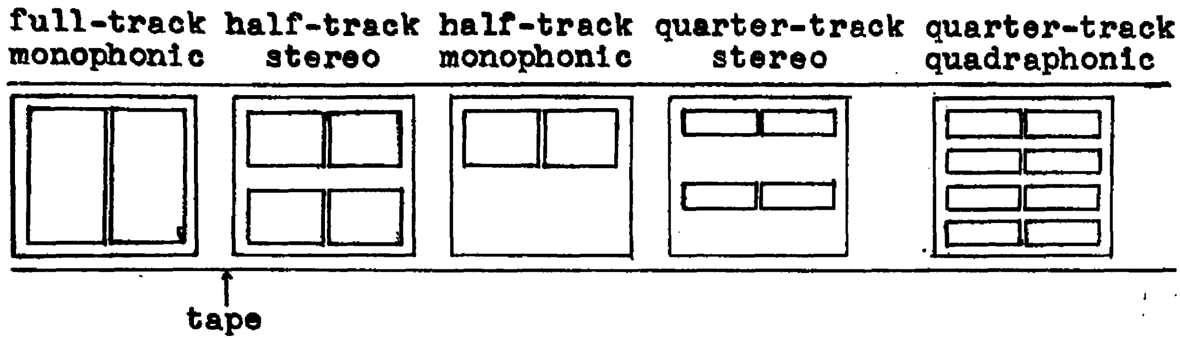

Fig. 4.--Different head and head stack formats.

In full-track monophonic recording, the signal from the tape head is recorded on nearly the entire width of the tape, and the tape is recorded in only one direction. In the half-track stereo format, two tape heads which each cover approximately half the total width of the tape are stacked together with their head gaps in line. This head format can be used to simultaneously record two channels, with the tape recorded in only one direction. In the half-track stereo format, there is enough space left between the two recorded channels so that their signals will not significantly transfer across the tape to interfere with one nother. Such interference is known as "crosstalk" and is measured by the difference in decibels between the strength of the recorded signal on each channel and the amount of signal transferred across the tape from one channel to another. The half-track monophonic format uses only one of the half-track tape heads. One chennel may be recorded in

one direction on the tape, and then the take up reel may be turned over, placed in the position of the supply reel, and another channel recorded in the opposite direction on the tape (Figure 5). This procedure may also be accomplished using only one channel of a half-track stereo tape deck, if so desired.

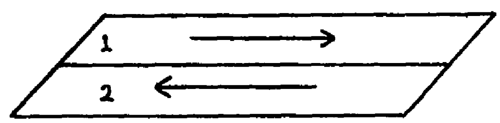

Fig. 5.--Two channels recorded in opposite directions, using the half-track monophonic tape head format.

In the quarter-track stereo format, two tape heads which each cover approximately a quarter of the total width of the tape are stacked together with their head gaps in line. As can be seen in Figure 4, their placement corresponds with the first and third heads in the quarter-track quadraphonic head stack. This permits two channels to be recorded in one direction on the tape, and then for the take up reel to be turned over, placed in the position of the supply reel, and for two more channels to be recorded in the other direction on the tape. This results in all four channels of tape being recorded, with the first and third channels recorded in one direction, and the second and fourth channels recorded in the other direction (Figure 6). The quarter-track quadraphonic format uses four tape heads which each cover approximately a quarter of the total width of the

Fig. 6.--Two sets of channels recorded in opposite directions, using the quarter-track stereo tape head format.

tape and are stacked together with their head gaps in line. This format can be used to simultaneously record four channels in one direction on a tape.

In the one quarter inch tape width, the full- and half-track tape head formats allow for a better signal-to-noise ratio, better frequency response, and less crosstalk than do the quarter-track stereo and quadraphonic formats. This is because larger heads record more signal on tape and the space between channels on tape is greater in the half-track stereo format than in the quarter-track formats. In the one half inch tape width, the quarter-track quadraphonic format uses heads the same size as half-track heads for the one quarter inch tape width and therefore retains the potential for an excellent frequency response and signal-to-noise ratio. The main advantage of the quarter-track stereo format is that it allows for twice as much recording time per reel of tape as the half-track stereo format. However, this advantage is negated by the fact that in most electronic music applications, the tape must be spliced and can therefore be recorded in only one direction.

Some of the various tape head formats are compatible with one another, while others are not. Assuming that all the following tape decks use the same width tape, a tape produced on a half-track monophonic deck could be played on a half-track stereo deck by monitoring the first channel of the stereo deck, and a tape recorded in quarter-track stereo could be played on a quarter-track quadraphonic deck by monitoring the first and third channels of the quadraphonic deck. Also assuming the same tape width for the following machines, a quarter-track quadraphonic tape deck could successfully monitor a stereo tape produced on a half-track stereo deck. This would be done by monitoring the first and fourth channels on the quadraphonic deck.

However, a half-track stereo deck would not be able to successfully monitor a tape recorded in quarter-track stereo because its heads would cover the second and fourth channels on the tape as well as the first and third channels. Assuming that the second and fourth channels were blank, a half-track stereo deck would still pick up a large amount of hiss from the empty channels which would seriously degrade the fidelity of the recorded material during playback. In order to avoid this problem, some half-track stereo tape decks have three head stacks for the erase, record and playback functions, and a fourth head stack in the quarter-track stereo format for monitoring tapes recorded in quarter-track stereo.

The compatibility of different tape decks with the

same head formats may be affected by slightly different tape heads, different bias settings, and by different head alignment. Head alignment is simply the physical alignment of the two or three tape heads on a single deck. If recorded on a tape deck with incorrect head alignment, a tape may suffer a serious loss in signal-to-noise ratio and a poor frequency response when played back on a different tape deck.

Other Electrical and Mechanical Components

The preamplifiers of a tape deck are used to control the amount of input signal to be recorded on tape, and to control the amount of playback signal (from the tape) which is sent to the external amplifier and speakers and/or the headphones for monitoring. The level of the signal to be recorded is determined by the settings of the input knobs (one for each available channel). These may be divided into separate groups which have different functions, one to set the level of a signal entering the deck through the line inputs, and the other to set the level of a signal entering the deck through the microphone inputs. Some decks provide the feature known as mic/line mixing, which means that signals entering the deck through the microphone and line inputs may be mixed together and recorded at the same time on a desired channel.

A visual indication of the amount of signal being recorded on tape is provided by the VU (Volume Unit) meters. There is usually a VU meter for each channel on the deck. As can be seen in Figure 7, VU meters may have two scales, the upper

one reading in decibels and the lower one reading in percent. At zero db or 100 percent, the maximum amount of signal has been recorded on tape before distortion will occur.

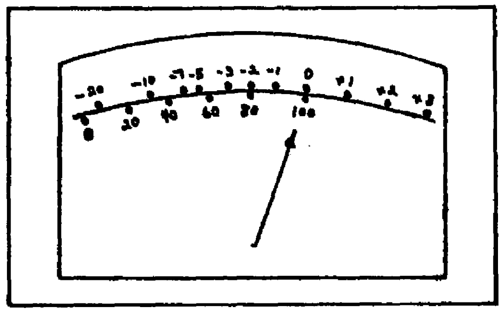

Fig. 7.--Example of a VU meter.

The level of the signal being played back is determined by the settings of the playback knobs (one for each channel). Other sets of switches which control various record and playback functions may be available on a tape deck. These are discussed in the following section on recording, playback, and erasing procedures.

An important feature built into the preamplifiers of all tape decks is known as equalization. Equalization is a boost in amplitude to the treble and bass frequencies to compensate for the various characteristics of the playback head, bias current, and the tape itself which cause a loss of treble and bass frequencies. The playback equalization of all tape decks is standardized by the National Association of Broadcasters so that a tape recorded on one deck may be played back on another. However, the equalization during

the recording process may vary from deck to deck.[4]

A mechanical device found on most tape decks is an index counter which permits the indexing of various sections within a reel of tape to facilitate locating them later. On most decks, the index counter indicates the number of revolutions made by the supply reel rather than the number of feet of tape which have passed the heads. Counters which measure feet of tape, or actual playing time of the tape, are available and may be purchased separately.

One other feature of most tape decks is automatic stop. Generally, automatic stop stops the motion of the supply and take up reels once the end of the tape has passed a sensing device placed near the tape heads. On some decks, this sensing device is a small rod or lever which is allowed to fall once the end of the tape has passed it. Sometimes, even when the tape is correctly threaded across the tape heads and between the capstan and capstan roller, the tension on the tape will be loose and it will not fully lift the automatic stop lever. Consequently the tape deck will not run when it is turned to Play, Record, etc. This can be simply remedied by increasing the tension on the tape. Another type of automatic stop sensing device is an "electric eye" which will stop the reel motion when there is no tape covering it. The use of clear leader tape with such a

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[4]For a more detailed discussion of equalization, see Craig Stark, "Tape Horizons," Stereo Review, Vol. 27, No. 3 (September, 1971), p. 128, and Vol. 27, No. 4 (October, 1971), p. 146.

shut-off device also stops the reel motion, and if spliced into a reel of tape could provide convenient stopping points in a tape composition. Some tape decks also have foil sensing devices which cause the deck to stop automatically at a spot on the tape pre-marked with a piece of sensing foil. A few such decks also have a special scanning mode in which they will "find" a pre-marked spot on the tape from the fast forward mode, stop, automatically rewind to the pre-marked spot, and begin the play mode at that point.

Though it has been implied that the use of quarter-track stereo and quarter-track quadraphonic tape decks designed for one quarter inch tape may not be ideal, it often becomes a matter of practicality to use such equipment due to its availability and the general lack of money to buy more expensive equipment. While they may not be "ideal," some of the semi-professional quarter-track stereo and quadraphonic tape decks which use one quarter inch tape have very fine specifications and are suitable for use in electronic music studios.

Recording, Playback, and Erasing Procedures

The first step to take before operating a tape deck is to read the instruction manual which came with it. This should be used to help find the specific knobs or switches described in the following list of procedures. Any of the following steps which are not applicable to the specific tape deck being used should be omitted.

1) The external amplifier used for monitoring should be set so it will monitor the line output from the tape deck. The line outputs of the tape deck should be connected to the external amplifier as described on page 6.

2) The power cord of the tape deck should be connected to an a.c. outlet and the power switch of the deck turned on.

3) The supply and take up reels should be locked in place on the tape deck and the tape threaded across the tape heads and between the capstan and capstan roller, following the instructions in the tape deck's instruction manual.

4) The bias switch should be set for the type of tape being used.

5) The switches which adjust the tape tension for thin or thick tape and for large or small reels should be set for the tape thickness and reel size being used.

6) The tape speed switch should be set for the desired speed. Usually the fastest available speed should be selected as this allows for the best possible fidelity during recording and playback.

7) In the section of switches which controls the tape deck's recording functions, the switch controlling each channel should be set on the Safe, or Playback, setting. This will prevent a pre-recorded channel on tape from being erased, even if the tape deck's Record and Play controls are engaged simultaneously. The recording functions switches also have a Record setting which permits a given channel to be recorded.

Depending on the tape deck being used, the recording

functions switches may have another possible setting, designated by one of the trade names for selective synchronization--Sel-sync, Syncro-trak, Simul-sync, etc. However, a separate set of switches for the selective synchronization process may be found in another area on the tape deck. Selective synchronization is discussed in the following chapter.

8) In the section of switches which controls the tape deck's playback or monitor functions, the switch controlling each channel should be set on Source or Input. The Source setting allows for the monitoring of a signal coming into the deck through the line inputs or the microphone inputs. The other setting for these switches, labeled Tape or Tape monitor, permits the monitoring of a signal which has been recorded on tape. During the recording process, these switches may be changed back and forth from Source to Tape to allow for a direct comparison of the incoming signal before and after it is recorded on tape.

9) The knobs which control the recording level of the tape deck's line inputs and microphone inputs should be set at their lowest level.

10) The knobs which control the playback level of the tape deck should be set at their lowest level.

11) The signal from the synthesizer which is to be recorded should be connected to the line input of the desired channel on the tape deck. Then, the knob which controls the input level of the channel to which the signal from the

synthesizer is connected should be slowly turned to the right. As this occurs, the VU meter which corresponds to the channel being used will begin to register the incoming signal. The input level knob should be turned to the right until the VU meter reads 0 db.

The level on the VU meter indicates the amount of signal which is being put on tape during the recording process. If too much signal is put on the tape, distortion will occur. If too little signal is put on tape, the residual hiss of the tape itself will become obtrusive in soft passages. Therefore, it is necessary to put as much signal as possible on tape without causing distortion in order to have the best possible signal-to-noise ratio. Theoretically, at a 0 db VU meter reading, the maximum recording level has been reached before distortion will occur. However, most good quality tape decks can be "pushed" beyond a 0 db VU reading before distortion will occur, thereby increasing the signal-to-noise ratio. It is necessary to experiment with various recording levels from a 0 db VU reading up to a +3 db VU reading and beyond to find the optimum recording level for a given tape deck. During this experimentation, the needles of the VU meter should not be continually pinned to the right, as this could damage the VU meter. The optimum recording level should be set for the loudest input signal entering the tape deck, not an average signal level.

12) Using a 0 db VU reading as the optimum setting for the moment, the switch in the recording functions section

which controls the channel in use should be set on Record. Then, at the same time, the Record and Play controls should be engaged, causing the tape to move past the tape heads and be recorded.

13) If desired, the volume of the signal being recorded may be altered by changing the setting of the recording level knob, as long as the peak or highest permissible recording level (the optimum setting on the VU meter) is not surpassed. While recording, the tape motion may be stopped and started through the use of a Pause control without disengaging the recording process, if the deck offers this feature. The tape motion may be stopped and the deck disengaged from the recording process through the use of the Stop control.

14) Playback is accomplished as follows. The Reverse control should be engaged, causing the tape to be rewound. Then the Stop control should be engaged, halting the tape at the point at which recording began. The recording functions switch for the recorded channel should be set back to Playback (or Safe) from Record, and the monitor switch for the recorded channel should be switched from Source to Tape. The Play control should then be engaged and the knob which controls the playback level of the recorded channel should be turned to the right so the recorded signal may be heard. The playback level should be adjusted so that the recorded signal is clearly heard but the residual noise of the tape itself is inaudible.

15) The erase head of a given channel operates while the channel is being recorded, erasing the tape before it crosses the record head. Therefore, erasing a given channel is achieved by setting the recording functions switch of the channel to Record, setting the recording level knobs of the channel (for both the microphone and line inputs) to their lowest levels, and simultaneously engaging the Record and Play controls. This puts the tape deck into the recording operation but since no signal is introduced to the tape, the tape is simply erased.

Bulk tape erasing devices which can erase an entire reel of tape in a few seconds are available. These can save time and unnecessary wear and tear on the tape deck being used.

II. OVERDUBBING TECHNIQUES

Sound-over-sound, sound-with-sound, sound-on-sound, and selective synchronization are overdubbing techniques used to synchronize and/or mix musical materials on tape without the use of external mixing devices.

Sound-over-sound is achieved the following way. A set of musical materials is recorded on a single channel. The erase head stack is then turned off, if this is possible, or shielded from the recording tape. This shielding may be done by covering the erase head stack with something similar to a piece of photographic film. Another set of musical materials is then recorded on the same channel. When the second set of musical materials is recorded over the first, the first set of musical materials loses much of its fidelity, particularly its upper frequencies. Also, when using this procedure it is difficult to synchronize the two sets of musical materials with one another. However, if the first set of musical materials can withstand a certain amount of deterioration of its fidelity, and the two sets of materials do not require exact synchronization, the results of this procedure may provide a useful blend of the two sets of musical materials.

Sound-with-sound involves the use of two or more separate channels. However, the results obtained from the

sound-with-sound procedure vary, depending on whether or not the tape deck being used has separate record and playback heads. Assuming the deck has a single head which serves for both the record and playback functions, sound-with-sound is accomplished in the following manner. A set of musical materials is recorded on one channel. The tape is then rewound, and while the first channel is being played back, a second set of musical materials is synchronized with it and is recorded on a second channel. This results in two separate channels of musical materials in synchronization with one another, with no loss of fidelity to either channel. If the two sets of musical materials need to be synchronized at their beginnings, cues preceding the first set of musical materials may be used to provide for this synchronization. These cues should be recorded along with the first set of musical materials. Cues may also be used with the sound-on-sound and selective synchronization procedures, and can later be spliced out of the tape or erased.

The same sound-with-sound procedure may be followed using a tape deck with separate record and playback heads. However, though during the recording of the second set of musical materials with the first the two sets of materials sound in synchronization with one another, on the playback of both channels, the second set of materials sounds later than the first and the two channels are out of synchronization. This delay occurs because the first set of musical materials is monitored from the playback head stack while

the second set of musical materials is being recorded at the record head stack. Since the playback head stack is an inch or two <u>to the right</u> of the record head stack, the first set of musical materials is already past the record head stack when it is monitored for synchronization purposes. Subsequently the second set of musical materials is recorded late and is out of synchronization with the first set of musical materials by the amount of time it takes a given sound on the tape to move between the record and playback head stacks. Sound-on-sound and selective synchronization are two procedures which result in the synchronization of two or more sets of musical materials when used with tape decks having separate record and playback head stacks.

Sound-on-sound is accomplished as follows. A set of musical materials is recorded on one channel. The output (line-out) of this pre-recorded channel is connected to the line input of a blank channel. The output from the synthesizer which carries another set of musical materials is also connected to the input of the blank channel. This may be done by using a Y type connector to "split" the line input of the blank channel into two separate inputs. The playback levels of the pre-recorded channel and the new set of incoming musical materials from the synthesizer should be set. Then, the record functions switch of the blank channel should be set to record and a "dry run" should be made, playing back the pre-recorded channel and introducing the new set of musical materials while setting the optimum

recording level for the "blank" channel. Once this recording level is established, the tape should be rewound and the process repeated, the second set of musical materials (monitored from their source) being synchronized with the materials on the pre-recorded channel (monitored from the playback head) and both recorded on the blank channel. Once two sets of musical materials are on one channel, they may be combined with another set of musical materials using the above procedure. These three may be recorded back onto the original channel or on to another channel, if four channels are available.

However, each time a pre-recorded channel is dubbed (recorded) onto another channel, the tape hiss, wow and flutter, and distortion from the pre-recorded channel accumulate on the new channel. Also there is some loss of high frequencies in the set of pre-recorded materials. Though all of these may at first be inaudible, with the several successive dubs necessary to combine three or more channels, they can rapidly become audible, particularly the tape hiss. A large amount of tape hiss can be quite disturbing should the final copy of the tape be played at the loud listening levels necessary in a concert situation.

Sound-on-sound may be internally wired on some tape decks, removing the need for having to make the various connections externally.

Sound-on-sound may also be accomplished with the use of two tape decks. Both machines should be threaded with

tape and a set of musical materials should be recorded on one channel on one of the decks. Then, another set of musical materials may be combined with the first at the line input of a blank channel on the other deck, and the two sets of musical materials synchronized and recorded on the blank channel.

The disadvantages of the sound-on-sound procedure in layering many sets of musical materials may be avoided by the procedure known as selective synchronization. The selective synchronization of various sets of musical materials is achieved in the following manner. A set of musical materials is recorded on a desired channel. The tape is rewound and the switch which controls the recording functions of the recorded channel is switched to the Selective Synchronization setting (or one of its trade names--Sel-sync, Syncro-trak, Simul-sync, etc.). If the switches controlling the selective synchronization function are separate from the recording functions switches, the recording functions switch of the recorded channel should be set on Playback (or Safe), and the selective synchronization switch for the recorded channel should be turned on. The remaining selective synchronization switches should be placed in the off position. This activates a circuit which causes the record head (in the record head stack) which corresponds to the recorded channel to function as a playback head and at the same time switches off the playback head (in the playback head stack) which corresponds to the recorded channel. Therefore, during

playback, the recorded channel will be monitored from the record head stack. However, the other heads in the record head stack will still function as record heads. At this point, the switch which controls the playback or monitoring functions of the recorded channel should be switched to the Tape setting. Then, the signal output from the synthesizer should be connected to the line input of a blank channel, the recording functions switch for the blank channel set to Record, the playback functions switch for the blank channel set to Source, the optimum recording level of the blank channel appropriately set, and the Record and Play controls on the tape deck engaged simultaneously. Now, those materials on the pre-recorded channel will be played back, and a new set of musical materials may be recorded in synchronization with them. Using a quadraphonic tape deck which offers the selective synchronization feature, up to four separate sets of musical materials may be recorded in synchronization with each other by following the above procedure.

Because the heads used for the playback and record functions during the selective synchronization procedure are in the same head stack, the resulting recorded channels will be in synchronization with one another when monitored through the playback head stack. Since each set of musical materials is recorded only once and remains on its original channel, the fidelity of the tape is not degraded in any way. However, due to the differences between the record and playback heads, a record head used as a playback head will playback with a

considerable loss of high frequencies. While this is adequate for synchronization during the selective synchronization procedure, it is not of sufficient fidelity to be used for normal playback purposes.[5] For normal playback purposes the tape should be monitored through the playback head stack.

Sound-on-sound and selective synchronization may be used together to produce more than four layers of musical materials. However, because of the problems resulting from the sound-on-sound procedure, the number of times a set of musical materials is moved from one channel on tape to another should be limited. In their article on multi-track recording, Walter Carlos and Benjamin Folkman suggest that no set of musical materials be removed from its final result by more than three generations.[6] As Carlos and Folkman are referring to recordings made with professional equipment of excellent quality, it could be suggested that if semi-professional equipment is to be used, a set of musical materials should not be moved from channel to channel more than twice (a once recorded channel would be moved only one time, leaving a final possible "dub down" for setting the final balance between the various channels, etc.). However, the decision of how many times a set of musical materials may be moved from channel to channel depends on a composer's

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[5]For a method of producing high quality playback through a record head, see: Walter Carlos and Benjamin Folkman, "Multi-Track Recording in Electronic Music," _Electronic Music Review_, VI (April, 1968), p. 23.

[6]_Ibid._, p. 21.

judgement as to what is an acceptable signal-to-noise ratio.[7]

Assuming that semi-professional equipment is to be used, and that no recorded set of musical materials is to be moved from channel to channel more than once, it is possible with a quadraphonic tape deck featuring selective synchronization to achieve seven synchronized layers of musical materials. In Figure 8, it is shown that three sets of musical materials are recorded in synchronization with each other on tracks I, II, and III, using the procedure for selective synchronization. These, plus another set of musical materials are then recorded in synchronization on track IV, using the procedure for sound-on-sound. Three more sets of musical materials are then synchronized with the materials on track IV, and recorded on tracks I, II, and III, using

Tape Tracks				
I	1		5 →	5
II	2		6 →	6
III	3		7 →	7
IV		1, 2 3, 4 →	→	1, 2 3, 4

Fig. 8.--The synchronization of seven sets of musical materials on four tracks.

[7]The recent development of relatively inexpensive noise-reduction units provides the possibility of improving the signal-to-noise ratio of semi-professional equipment by as much as 10 db. A description of one such device, a Dolby noise reduction unit, may be found in "Equipment Test Reports," Stereo Review, Vol. 25, No. 4 (October, 1970), pp. 37 and 40. Also, more information may be found in "The New Noise-Reduction Units," Stereo Review, Vol. 27, No. 6 (December, 1971), p. 63-69.

the procedure for selective synchronization. More sets of musical materials could not be synchronized with one another without using the record head for normal playback purposes on at least one of the four tracks.

If a quarter-track quadraphonic tape deck and a quarter-track stereo deck, both utilizing one quarter inch tape, are used to layer sets of musical materials, up to eight layers of musical materials may be synchronized with no recorded set of materials being moved from channel to channel more than once. This process avoids the problem of having to synchronize tape decks. In Figure 9, it is shown that four sets of musical materials are recorded in synchronization with one another on the quadraphonic deck, using the

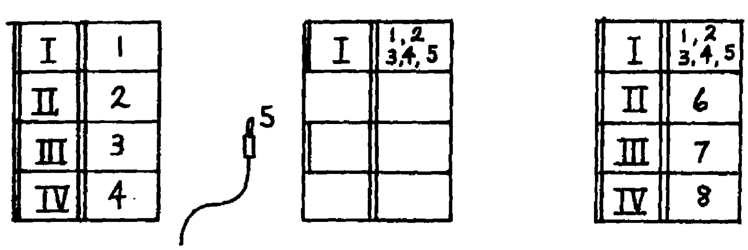

Fig. 9.--The synchronization of eight sets of musical materials using both a quadraphonic and a stereo tape deck.

procedure for selective synchronization. Then, these four plus a fifth set of materials from the synthesizer are synchronized and recorded on the first track of the stereo deck, using the sound-on-sound procedure. Since the head formats of the two decks are compatible, the tape from the stereo deck is placed on the quadraphonic deck and the

remaining three sets of materials are recorded in synchronization with the first five, using the procedure for selective synchronization. If more than one tape deck were used and a recorded set of musical materials could be moved from channel to channel more than once, many more layers of musical materials could be synchronized with one another.

Besides the consideration of general tape quality (frequency response, signal-to-noise ratio, etc.) there are other potential problems which may arise from or during the use of overdubbing procedures. For instance, if a channel could be monitored through its record head for normal playback purposes, more sets of musical materials could be synchronized with one another. However, as mentioned on page 32, this type of monitoring usually involves a considerable loss of high frequencies. Also, more sets of musical materials could be synchronized if the tape decks being used could be synchronized. This usually requires variable speed controls and some practice. There are other considerations besides the number of layers of recorded materials. For example, if a section of one track is recorded and another section of the same track is to be recorded later, there must be enough room between the sections to avoid an accidental erasure of part of the first section. Also, some switching procedures (such as changing a recording functions switch from Playback to Record) may cause clicks or pops on the tape if the tape is in motion. This should be avoided unless such unwanted noises can be spliced out.

The use of splicing and spatial placement of sound must be considered as well. Splicing requires cutting across the entire tape. Therefore if the materials on one track need to be spliced to other materials while the materials on the remaining tracks should be continuous, the splicing should take place before the various sets of materials are layered together. Spatial placement is discussed in Chapter IV.

III. TECHNIQUES FOR EDITING, SPLICING, AND SPECIAL EFFECTS

Editing and Splicing Techniques

Tape editing is a general term for the organization of materials which are already recorded on tape. Splicing is therefore a basic part of tape editing. Splicing is used to repair broken tape, connect desired sections of tape, remove unwanted sections of tape, add leader tape, make tape loops, etc. The necessary equipment for editing and splicing includes a splicing block or jig, demagnetized sharp and dull razor blades, good quality splicing tape, a clean place to work, and a tape deck. Both paper and plastic leader tapes are also useful.

There are several types of splicing blocks or jigs. The simplest type consists of a block or piece of aluminum which has a path across it for the tape to lie in. Across this tape path are several cutting guides or slots, usually at 45 and 90 degree angles to the tape path edge. In his article on splicing tapes in Audio magazine, Andrew Persoon says the ideal splicing angle is from 45 to 60 degrees.[8] As the angle of cut increases beyond 60 degrees, the abrupt change in the magnetic particles on the tape which occurs at

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[8]Andrew H. Persoon, "Splicing Tapes," Audio, Vol. 54, No. 1 (January, 1970), pp. 28-29.

the splice causes a pop or click to be heard on playback. If the angle of the splice is below 45 degrees, the pointed ends of the recording tape may peel back from the splicing tape. For these reasons, the 45 degree cutting angle is most often used for normal splicing purposes. The splicing block may also have arms or clips to hold the ends of the recording tape in place during the splicing procedure.

A somewhat different splicing jig is known as the "Gibson Girl" type. It also has a path for the tape to lie in and arms to hold the tape in place, but has built-in cutters to make the 45 degree angle splicing cut and to trim the edges of the completed splice. This type of splicer is useful for all but the trimming procedure, which is discussed below.

The razor blade used for cutting the tape on a simple splicing block should be demagnetized. If it is not, it will slightly magnetize the ends of the tape being spliced together and cause a click or pop on the tape during playback. A dull razor blade may be used for separating an already completed splice. This may be done by sliding it under the edge of the splicing tape which holds the splice together, and gently peeling the splicing tape off the recording tape.

The adhesive tape used for splicing should be specifically designed for that purpose. Other types of adhesive tapes should not be used because they will not perform satisfactorily. According to Persoon, splicing tape is designed

to be thin but strong, have a minimum of "adhesive escape" around its edges, and last an indefinite period of time. It has three adhesive qualities, shear adhesion, peel back adhesion, and "wet grab."[9]

Shear adhesion resists against the normal pull or tension on the tape caused by the transport mechanism of a tape deck. Lack of shear adhesion may cause a splice to gradually pull apart or "creep," producing a gap between the two ends of the recording tape which are spliced together. Peel back adhesion resists against the splicing tape being peeled away from a surface it is adhered to--normally the recording tape. Peel back is often caused when the tape bends around a tape guide in its path on a tape deck. "Wet grab" is the stickiness of the splicing tape itself, and actually has little bearing on the other two factors. However, a splicing tape which is excessively sticky may ooze around its edges and damage the layers of tape immediately next to the splice. Because all splicing tapes may ooze or "bleed" slightly over a long period of time, the width of the splicing tape should be slightly less than that of the recording tape to be spliced. This will help to keep the adhesive from binding many layers of tape together should the splicing tape bleed. The 7/32 inch splicing tape width is generally considered the best for use with 1/4 inch tape. In his "Tape Horizons" column in the February, 1970, issue of Stereo Review, Craig

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[9] Ibid.

Stark suggests this problem may be solved by rubbing a sticky splice with talcum powder, being careful to remove the excess talc to keep it from fouling the tape heads.[10]

The longer the piece of splicing tape used on a splice, the better adhesion it has. This is particularly true of its peel back adhesion. Therefore, the smaller the radius of the bends which occur in the tape path, the longer the splice should be. However, because the recorded material in the area where the splicing tape is bonded to the recording tape has a drop in its output level from two to four decibels, a splice should be no longer than is really necessary.[11]

The hands should be clean during the splicing procedure. Any dirt or oil on the recording tape can cause a drop in the output of a recorded signal by several decibels. Also, dirt on the adhesive backing of the splicing tape reduces the strength of the splice.

Leader tape may be spliced onto the ends of a reel of tape to protect them from the bending they receive during threading and from the battering they may receive on the completion of fast forward and reverse. This also allows

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[10]Craig Stark, "Tape Horizons," Stereo Review, Vol. 24, No. 2 (February, 1970), p. 129.

[11]In his book Electronic Music (Dubuque, Iowa: William C. Brown Co., 1972), pp. 104-105, Allen Strange mentions the signal loss caused by long splices and says, "The shorter the splice, the better." This may be somewhat misleading because the length of a splice also depends on the various adhesion factors discussed above. From the author's experience, splices about 3/4 inch or slightly less in length, made with good quality splicing tape, will hold satisfactorily. At a tape speed of 15 ips, such a splice when properly made will be inaudible.

more of the recording tape to be utilized. Leader tape may also be spliced into a reel of tape to mark the beginnings and endings of various sections or to provide sections of silence. Paper leader tape is useful for silent areas because unlike plastic leader tape, it will not pick up static electricity which can cause a slight amount of hiss during playback.

Before the splicing procedure is done, the exact points on the tape which are to be spliced together must be found. This is accomplished by playing the tape until the area to be spliced is reached. The deck is then stopped and the tape reels moved by hand until the desired point on the tape is heard. This may take some practice because the musical materials on tape will sound distorted and much lower in pitch than they normally do. On some tape decks, the tape lifters must be turned off during this procedure so the tape will rest against the heads and can be heard. Some decks also provide an edit button which turns off the reel motors and brakes and allows the reels to turn freely. A few decks may require the tape to be threaded so it does not pass between the capstan and capstan roller and the deck to be put in the play position in order for the tape to be heard while it is being moved by hand. Once the desired point in the recorded material is heard, the back of the tape should be marked with a wax pencil or felt tipped pen at the point at which it crosses the gap in the playback head. The tape is then laid in the splicing block with its

back side up and is cut at a 45 degree angle across the point marked on the back of the tape. Then, the other point on the tape which is to be spliced to the one already prepared is found in the same manner and is also cut at a 45 degree angle. The two ends of the tape to be connected should then be placed in the splicing block with their back sides up and so they are flush and exactly in line with each other. Then, a piece of splicing tape (slightly narrower than the width of the recording tape) is placed over them so it does not overlap the edges of the recording tape, and is pressed down firmly. Any small patches of air or air bubbles between the splicing tape and recording tape should be removed by sliding a pencil eraser or finger nail firmly across the completed splice. If the ends of the tape are misaligned, slightly overlapped, or have a gap between them, the splice will be audible, causing a click or sudden drop in signal level during playback.

If the splicing tape being used is slightly narrower than the width of the recording tape, there is no need to trim the splice. However, if the splicing tape is simply laid across the recording tape, it must be trimmed. Figure 10 shows three different splices. The first is a splice correctly made using splicing tape slightly narrower than the recording tape. The second is a splice trimmed by one of the "Gibson Girl" type splicers. The trimming is done in the shape of an hour glass which actually removes part of the recording tape. This may actually cut into part of the

recorded signal and also allows any "bleeding" of adhesive from the splicing tape easy access to the adjacent layers of tape. The third is a correctly trimmed splice made with splicing tape which covers the full width of the recording tape. The trimming may be done with a demagnetized pair of scissors or razor blade.

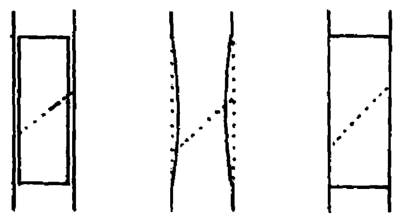

Fig. 10.--Three splices having different splicing tape widths or trimmings.

There is another method for marking the points on the recording tape to be cut and spliced, known as offset edit marking. The distance between the playback head gap and an

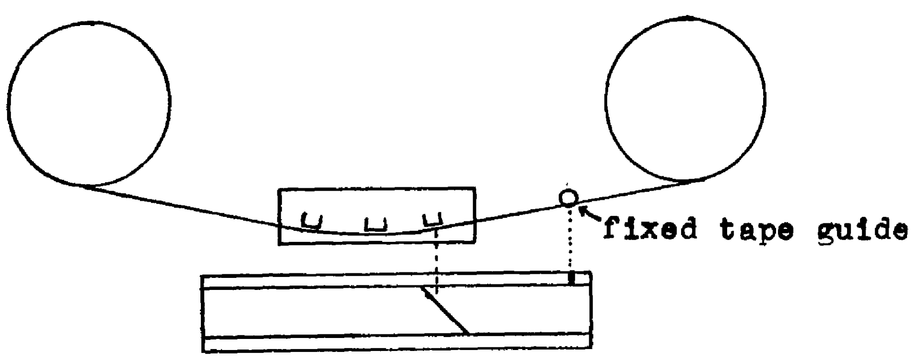

Fig. 11.--Offset edit marking.

easily accessible fixed point further along the tape path (such as the right edge of the tape head cover) is measured and then marked on the splicing block (Figure 11). Then,

after the point at which the tape is to be cut is heard, the tape may be easily marked at the fixed point in the tape path and this mark lined up with the mark on the splicing block. The tape may then be cut at the 45 degree angle cutting guide. This method is advantageous because it is easy to use and takes little time. Further, the head cover need not be removed, and the possibility of scratching or marking the playback head stack is lessened. Also, if the head cover does not need to be removed during the splicing and editing procedure, the splicing block may be fastened to the top of the head cover. In this position, the splicing block is close to the tape and minimizes the need to remove the tape reels during the splicing process.

Techniques for Special Effects

Tape recording lends itself to the production of special sound effects. These may provide sound materials for use in electronic music composition.

Sound Reversal

Reversing a recorded sound is achieved by playing the tape backwards. Using a half-track stereo tape deck, this may be done by recording a sound on the first (left) channel. The take up reel is then turned over and placed in the position of the supply reel. This results in the leading and trailing ends of the tape being reversed (the back side of the recording tape remains away from the tape heads). The reversed sound is heard by monitoring the second (right)

channel of the tape deck. This same procedure may be used with a quarter-track quadraphonic tape deck as well. A sound recorded on the first channel would be monitored by the fourth channel, and vice versa. A sound recorded on the second channel would be monitored on the third channel, and vice versa.

Sound reversal does not work with a quarter-track stereo tape deck. If a sound is recorded on either the left or right channels (the first and third tracks on the tape), and the take up reel is turned over and placed in the position of the supply reel, the tape heads will monitor the second and fourth tracks of the tape and no sound will be heard (this head format is described on pages 14 and 15).

Gilbert Trythall suggests some possible effects produced by sound reversal, such as splicing the forward and backward positions of a taped sound together.[12] Another type of sound reversal effect is produced by monitoring a tape while it is being rewound.

Channel Reversal

It has already been noted in the discussion of sound reversal that sound reversal produced by half-track stereo and quarter-track quadraphonic decks results in the recorded channels being reversed or having their position in regard to the tape heads changed. Channel reversal without sound reversal may be accomplished by simply switching the cords

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[12]Trythall, Principles and Practice of Electronic Music, p. 124.

connecting the line outputs of the tape deck to the external amplifier.

Tape Reversal

Tape reversal means turning over the recording tape and playing it with its back or reverse side against the tape heads. This causes the recorded materials to sound muted. Tape reversal may be done by splicing a desired section of tape into a reel of tape so its back side will face the tape heads. When the tape is kept in its normal direction, the tape reversal procedure results in the same channel reversals or changes which occurred in the sound reversal procedure. It may therefore be used with half-track stereo or quarter-track quadraphonic tape decks (which should be monitored in the exact manner as in the sound reversal procedure), but not with quarter-track stereo decks. However, if tape reversal and sound reversal procedures are done at the same time, all three types of decks may be used. The recorded materials should then be monitored from the same channels on which they were recorded.

Magnetic Particle Removal

The magnetic particles on the side of the tape which normally faces the tape heads may be removed to produce special articulations and periods of silence. This may be done by scraping off the particles with a dull razor blade or removing them with a cotton swab moistened with acetone. According to Trythall, the magnetic particles "move freely

around the tape where scraping has occurred, and scraped tapes soon contain noise." Trythall suggests that copies of such tapes should be made soon after the tape has been scraped to prevent unwanted noise from appearing later. He also states that when the magnetic particles are removed by acetone, less noise is produced.[13]

The Use of Different Tape Speeds

A set of musical materials may be played at tape speeds faster or slower than the speed at which it was originally recorded. If this speed is twice as fast as the original, it raises the pitch an octave and makes the tempo twice as fast. This procedure produces a special sound quality and is also useful for producing difficult technical passages by recording them at a slow speed (3 3/4 or 7 1/2 ips) down an octave and at half tempo. A unique sound is also produced by playing a set of musical materials at half or quarter speed.

The pitch and speed of a set of musical materials may also be changed through the use of a variable speed control. If no such control is available, or if the variation in speed provided by the variable speed control is too limited, the capstan of the tape deck may be pinched between the thumb and forefinger, causing considerable change in the tape speed. Another way the speed may be varied is by applying pressure to the supply or take up reel. On some

[13] *Ibid.*, p. 125.

decks the pause control may also allow for well controlled speed variation. Except for a built-in variable speed control, none of the procedures should be used extensively as they may damage the tape deck being used.

One possible sound effect which is produced by variable speed control is discussed in an article in the December, 1973, issue of Audio magazine, called "'Phasing' in Tape Recording" by Herman Burstein.[14] Phasing as described by Burstein may involve the use of two tape decks, one featuring selective synchronization. A set of musical materials is dubbed onto a blank channel on the deck which offers selective synchronization. Then, using the selective synchronization procedure, the same set of musical materials is recorded in synchronization with the first, but during this process is alternately speeded up and slowed down, causing the two sets of the same musical materials to come periodically in and out of phase with each other.

Tape Echo

Tape echo is produced by utilizing the time delay caused by separate record and playback heads. It is achieved in the following manner. The line input of a given channel on a tape deck having separate record and playback heads is "split" with a Y-type connector, providing two possible inputs to the channel. The line output of the channel is "split" in the same way. The output from the synthesizer

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[14]Herman Burstein, "'Phasing' in Tape Recording," Audio, Vol. 57, No. 12 (December, 1973), pp. 54 and 56.

(or another tape deck) is connected to one of the line inputs on the channel. One of the line outputs of the channel is connected to the external amplifier and the other line output is connected to the remaining line input of the channel itself. The channel is set to record and the monitor functions switch of the channel is set to Tape. The Record and Play controls on the deck are then simultaneously engaged. When the signal is recorded on tape, it is monitored at the playback head and fed back on itself. It is then recorded, played back again, fed back on itself, etc. The recording and playback levels of the channel should be set at low enough levels so they do not create feedback which grows (such feedback, which could damage the tape deck, may be stopped by turning down the recording level knob). The speed of the echo is determined by the tape speed and the distance between the record and playback head stacks.

Tape echo may also be used with more than one channel. All the channels to be used should have their line inputs and outputs "split" with Y-type connectors. One of the line outputs from each channel should be connected to an external amplifier. The output from the synthesizer should then be connected to the line input of the channel which is to be heard first. The remaining output of that channel should be connected to a line input on another channel, the remaining output of this channel connected to the line input of another channel, and so forth. The line output of the last channel being used may be connected back into the line input of any

of the channels, completing a feedback circuit. If the feedback circuit is not completed, the number of echos which occur will be one less than the number of channels being used. Each channel should then be set to be recorded and set to be monitored from the tape. If the feedback circuit is completed, the recording and playback levels must be set low enough to avoid damaging the tape deck with feedback. The Record and Play controls are then engaged and the signal from the synthesizer introduced, producing echo. If four channels are used for tape echo, during playback through a discrete four channel playback system the echos will each occur at a different speaker. Once the tape echo procedure is complete, the resulting tape may be used with the various techniques already discussed, such as sound reversal, variation in tape speed, etc.

Tape Loops

A tape loop is a length of recorded tape whose ends are spliced together, forming a continuous loop. It may be used to play such materials as repeating ostinato patterns or various sequences of sounds. To play a tape loop, the loop should be placed between the capstan and capstan roller, around the tape guides, and across the tape heads. Depending on the size of the loop, it may also be placed around a pair of empty tape reels on the spindles of the tape deck. A certain amount of tension must be maintained on a loop for it to flow smoothly through the tape transport mechanism. This may be provided by a hand-held pen or pencil around

which the loop flows, or by a specially designed loop holder which may be adjusted to the size of a given loop. Trythall suggests that the tension for long loops may be provided by weighted microphone stands which can be moved to adjust for the size of the loop.[15] Once the tension is adjusted so the loop is held firmly in place but may still flow freely, the Play control on the tape deck is engaged. The capstan will move the loop across the tape heads while the supply and/or take up reels spin freely. If desired, new materials may be recorded on a loop while it is in operation.

One possible effect produced with a tape loop is created by using the loop with two tape decks. A pre-recorded loop is threaded across the heads and between the capstan and capstan roller of both decks. It is then played back on one deck and that playback is recorded back onto the loop through the other deck. This creates a feedback circuit which causes a rapid degeneration of the pre-recorded materials. This degeneration results in an entirely new set of sound materials.

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[15]Trythall, Principles and Practice of Electronic Music, p. 127.

IV. TECHNIQUES FOR THE SPATIAL PLACEMENT AND MOVEMENT OF MUSICAL MATERIALS

Factors Involving the Spatial Placement and Movement of Musical Materials

With the use of a quadraphonic tape deck and a discrete four channel playback system, musical materials may be placed at points or moved around a listener. However, a number of factors may determine the spatial placement or movement of the musical materials besides the manipulation of the musical materials during the taping process. These include the acoustical charateristics of the listening room, the placement of the speakers in the listening room, the quality and type of speakers being used, the placement of the listener, and the characteristics of the musical materials themselves.

Since it is usually impractical to alter a listening room, the placement of the speakers and the listener in the listening room is of considerable importance. In an article about four-channel stereo playback, Robert Berkovitz presents a diagram which shows the best locations for listening to four channel acoustic-field recordings. He also states:

> The arrangement having the largest effective listening area for such recordings is a square, as large as can be arranged in a given room, preferably with the speaker systems near the corners, for best

channel separation and directional accuracy.[16] Figure 12 includes diagrams similar to those Berkovitz included in his article.[17] In Figure 12b, the four speakers

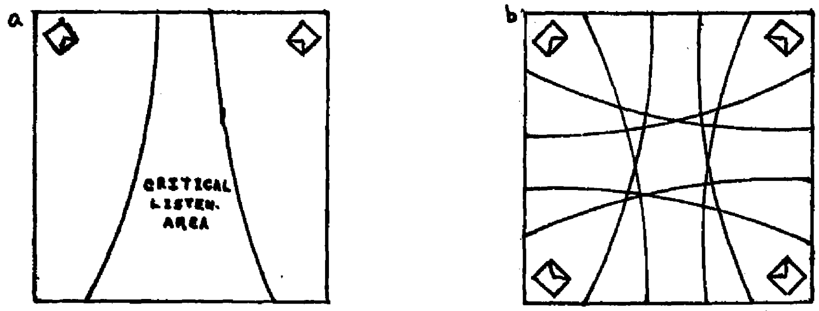

Fig. 12.--Diagrams showing ideal listener placement for two and four channel playback.

actually function in pairs. The area where the critical listening areas of the four "pairs" of speakers coincide is where a listener should be located for optimum accuracy in the spatial placement of musical materials.

Acoustic-field recordings are intended to give a realistic reproduction of live musical events, including the spatial placement or movement of various sounds during such events. When four discrete channels are involved, the rear channels are supposed to reproduce the sound presence (such as room reverberation) heard from behind the listener, therefore adding to the realism of the reproduction. Berkovitz states that a listening room tends to absorb high frequencies more than middle or low frequencies.[18] Therefore,

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[16]Robert Berkovitz, "Four-Channel Stereo," The Gramophone, XLVIII (November, 1970), pp. 868 and 873.

[17]Ibid., p. 873

[18]Ibid.

for correct reproduction of acoustic field recordings, the treble should be slightly boosted during playback. However, in situations where spatial placement is produced artificially in the first place, there is no need for such a treble boost.

The type of speakers to be used for quadraphonic sound reproduction is the subject of an article by Benjamin Bauer in the March, 1973, issue of Audio magazine.[19] Bauer prefers directional or semi-directional speakers to omnidirectional speakers because omnidirectional speakers placed near walls or corners produce reflections which emphasize some frequencies while totally cancelling others. According to Bauer, omnidirectional speakers also produce a more limited area of quadraphonic perception than do semi-directional and directional speakers.[20] Berkovitz also states that speakers of a reflecting type may create directional images which are not part of the program material.[21] However, the type of speaker which best suits a given quadraphonic listening situation also depends to a large degree on the other factors listed above.

The characteristics of the musical materials themselves may determine the distance a given sound may appear to be from the listener. Also, the characteristics of the

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[19]Benjamin B. Bauer, "Quadraphony Needs Directional Loudspeakers," Audio, Vol. 57, No. 3 (March, 1973), pp. 22-30.

[20]Ibid., p. 30.

[21]Robert Berkovitz, "Four-Channel Stereo," p. 873.

musical materials may help the listener judge the velocity of a given sound's movement through the Doppler effect as well as by the rate of shift in the sound's apparent position. These characteristics are discussed in John M. Chowning's article "The Simulation of Moving Sound Sources," Journal of the Audio Engineering Society, Vol. 19, No. 1 (January, 1971), pp. 2-3.

The Spatial Placement and Movement of Musical Materials During the Recording Process

With the use of a quadraphonic tape deck, musical materials may be placed at points or moved around a listener in a rudimentary manner. This may be accomplished as follows.

As is seen in Figure 13, the four channels of a quadraphonic playback system can be considered to form four pairs, each of which covers a fourth of the total 360 degrees around a listener. The point at which a given set of

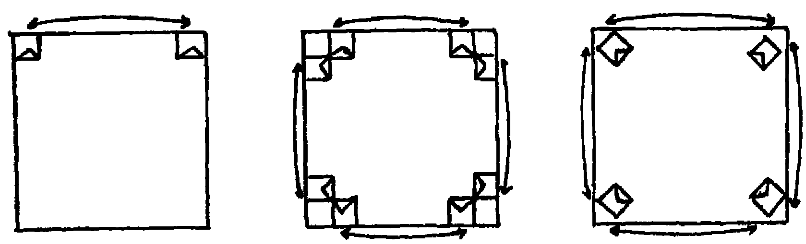

Fig. 13.--Four channels acting as pairs to cover a 360 degree area.[22]

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[22]These diagrams are similar to some included in Robert Berkovitz, "Four Channel Stereo," p. 873.

materials is to be placed in relation to the listener should be determined. The signal from the synthesizer is then connected to the line inputs of the pair of channels on the tape deck that correspond to the speakers which encompass this point. The recording levels of the two channels on the tape deck are then balanced to place the sound at the desired point between the speakers (this may take some experimentation). Once the balance is set, the incoming signal is recorded on the two channels. If a sound is to be placed in one of the "corners" of the 360 degree area around the listener, the signal is recorded on the one channel which corresponds to the speaker in the desired "corner."

As previously mentioned, the characteristics (including timbre, density, texture, articulation, pitch, and volume) of a set of musical materials may also determine the success with which the musical materials may be placed at points around a listener. While a clearly articulated simple sonority might be successfully placed, a complex group of rapidly changing sonorities having a thick texture might not be placed as easily. Therefore, the placement of any given sound can only be determined through experimentation.

The technique for moving musical materials around a listener also uses the four channels in pairs. The signal to be moved is connected to the line inputs of all four channels on the tape deck. The recording levels of all the channels but the one which corresponds to the speaker where the sound is to be initially heard are turned off. The

recording level of this initial channel is set at a desired level. Then, all four channels begin recording. The sound is moved from the initial channel to an adjacent channel by gradually increasing the recording level of the adjacent channel and at the same time decreasing the recording level of the initial channel, until the initial channel is turned off and the recording level of the adjacent channel is at the desired level. This process is repeated with the remaining channels, the signal being moved from one channel to the next, until it has moved completely around the listener. The signal may also be moved back and forth between channels in this manner, either between one of the four pairs of channels or across the listener from the left front channel to the right rear channel or the right front channel to the left rear channel.

Because the process of placing sound at points around a listener, or moving sound around a listener, involves the changing of the recording levels of at least two channels at once, the number of sounds which may be recorded and placed and/or moved at one time is quite limited. If the recording levels of all four channels were left open and the sounds were moved from channel to channel through the use of external mixing or panning devices, several sounds could be recorded and moved at once. One such device, known as the Stirrer, is discussed in detail by Lowell Cross in Source magazine.[23]

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[23]Lowell Cross, "The Stirrer," Source, Music of the Avant Garde, Vol. 2, No. 2 (July, 1968), pp. 25-28.

Other devices for both moving and placing sounds are discussed by Allen Strange in his book Electronic Music.[24]

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[24]Allen Strange, Electronic Music, pp. 72-73 and 75-85.

V. SUMMARY

The techniques which have been discussed in this monograph provide relatively new ways to manipulate and organize musical materials electronically. All of the techniques are factors which should be considered during the compositional process in the same way that timbre, range, and technical limitations of conventional instruments are considered during the composition of non-electronic music. With a mastery of these techniques, the composer will recognize both the technical limitations of the techniques as well as their inherent potential. The composer may then be free to create, organize, and develop his musical ideas in a meaningful way, and is restricted only by his own imagination.

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VITA

Robert Bruce Greenleaf was born in Auburn, Alabama, on April 28, 1949. He attended Auburn High School where he was graduated in 1967. After attending Auburn University for the school year 1967-68, he transferred to Florida State University in Tallahassee, Florida, where he majored in clarinet. He was graduated _cum laude_ from Florida State University with a Bachelor of Music degree in June, 1971. During his junior and senior years, he held a fellowship from the Florida State University Graduate School.

Mr. Greenleaf attended graduate school at Louisiana State University in Baton Rouge, Louisiana, where he held a National Defense Education Act Fellowship. He received a Master of Music degree in clarinet in the summer of 1972, and the Doctor of Musical Arts degree in clarinet in the summer of 1974. During the spring semester of 1973, he organized and taught the first course in electronic music offered at Louisiana State University.

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Date of Examination:

July 18, 1974