MULTICHANNEL RECORDING FOR ELECTRONIC MUSIC

2ND EDITION

Roland

Contents

Introduction

A high percentage of recordings sold in the world today are made in studios using multichannel recording techniques. In multichannel recording, the sound from different instruments or groups of instruments is picked up with separate microphones and recorded on separate tracks. Later, when the multichannel tape is played back, the recorded parts are mixed together and recorded using a second tape recorder to produce the finished master tape.

There are two very important advantages to multichannel recording. First, since the various parts are recorded on separate tracks, it becomes possible to record these parts at different times, or even in studios at different locations. By playing each of the parts and recording them separately it would be possible for one musician to single-handedly record an entire symphony, assumming this musician could play all of the instruments needed. In actual practice it is not uncommon for groups or bands to record themselves more than once to get a bigger sound on the record. It is also not uncommon for various tracks to be recorded at different studios or even in different cities. This possibility becomes a large advantage when working with musicians who have previous commitments that prevent them from taking the time to fly to a distant city to record part of an album.

The second major advantage of multichannel recording is that the decision as to the final balance of instruments can be made after the musicians have all gone home, after the hectic pressure of the actual recording session has ended. If a certain balance is not liked, it is necessary only to change the mixer controls rather than to record the music again. Also, if someone makes a mistake, that part can be recorded again without having to do all the other parts over, too.

The purpose of this book is to present basic techniques used in multichannel recording, particularly as they apply to electronic music. (Sound-on-sound recording techniques can be found in Volume 2 of *Practical Synthesis for Electronic Music* published by Roland). There are a wide variety of multichannel tape recorders available. They range from small four track machines which use standard 1/4" wide tape to sixteen and twenty-four track machines which use 2" wide tape. This book concentrates primarily on techniques using four track machines because they are the more common type. Musicians who are learning multichannel techniques will probably have easier access to a four track system than to a larger system. No matter what format is used, however, the recording techniques remain basically the same.

The author wishes to express grateful appreciation to his fellow workers at Roland without whose help and patience this work would have been impossible.

Robin Donald Graham
Synthesizer Project Manager
Roland Corporation

Osaka, Japan
December, 1979

Chapter One:
Tape Recorders

1-1 Introduction

The more one studies the theory behind the magnetic recording process the more one is apt to wonder how it is possible to record recognizable sound, let alone high fidelity music. The recording process itself is an inherently noisy process. This can be demonstrated with a simple experiment. First, take some virgin tape (new tape which has never been recorded), thread it onto the tape recorder and wind a meter or so of blank tape onto the take-up reel. Next, with the record level controls set at "0", put the recorder into the record mode and record several seconds of silence on tape. Rewind the tape to some place a little way before the point where the recording was started. Set the recorder in the play mode and turn the external amplifier volume control up high enough to hear the tape noise (tape "hiss"). When the tape reaches the point where the record mode was started, a very definite increase in tape noise can be heard, noise which is generated by the magnetic recording process itself since there was no signal input and the recording level was minimum. At the end of the recorded section, the noise level will again drop to the noise level of the virgin tape.

This chapter presents material useful to the musician contemplating multichannel recording. It contains a bare minimum of technical data as this kind of information is available from a number of other sources. Instead, we will concentrate more on describing the standard recording formats as well as listing those tape recorder features which would be useful in the studio.

1-2 Professional and Consumer Tape Recorders

In the studio, perhaps the most important consideration is the electrical performance of the tape recorder. In other words, how does it sound when playing recorded material? How much difference is there between the original signal and the signal when it is played from the tape? Present day consumer-type tape recorders will very often deliver sound which is very near or equal to studio quality sound. Generally, consumer machines will actually have a slightly better frequency response than studio machines. This is because audio enthusiasts tend to equate quality sound with a wide frequency response. Studio people, however, prefer a lower noise level at the expense of a slightly reduced frequency response. When the outputs from each track of a multichannel tape recorder are mixed together, the noise output from each track is also added together. Each time a tape or track is copied, noise is again added to the music. Noise, then, can become a very large problem in the studio.

Another difference between studio and consumer machines is the mechanical design. Studio machines must be able to stand up to constant use all day long every day with little or no rest. Studio machines usually make extensive use of plug-in components for quick and easy repairs. Also, calibration controls are easily accessible because the recorders in a studio may have to be calibrated several times a day to ensure that every bit of possible quality is squeezed out of the machines, a step necessary to professional quality recording. Most consumer machines require complete disassembly

for parts replacement or calibration, although some machines do provide front panel bias and equalization adjustments which are more than just selector switches.

The professional machines will generally provide other functions which are useful and time saving in the studio, such as complete remote control which allows not only transport control, but also remote switching between play, record, and sync modes of operation. Many also include automatic search functions so that at the press of a button, the recorder will automatically return to a pre-selected point on the tape, a feature very helpful in multichannel recording.

Because good quality consumer-type machines can produce sound which is similar in quality to studio sound, there is no real reason why this type of machine cannot be used in the electronic music studio, even in the studio which eventually hopes to become a full professional operation. This is especially true if a little care is used in the selection and care of the machine.

The Teac Portastudio is worth mentioning at this point because it represents the first multichannel cassette tape recorder to be placed on the commercial market. The tape speed of this unit is 9.5 cps (3-3/4 ips) which is double the ordinary tape speed of a cassette recorder. The result of this speed increase is improved frequency response and lower noise. A built-in noise reduction circuit also helps to keep noise levels low. The recorder includes such important features as: variable pitch control, punch-in recording, and a return to 000 memory function.

Integral to the Portastudio is a four-input, stereo output mixer which contains all of the features most engineers and musicians would consider essential in a studio type mixer. Reading the well written instruction manual included with the Portastudio will show how it is easily adapted to the recording techniques given in the following chapters of this book.

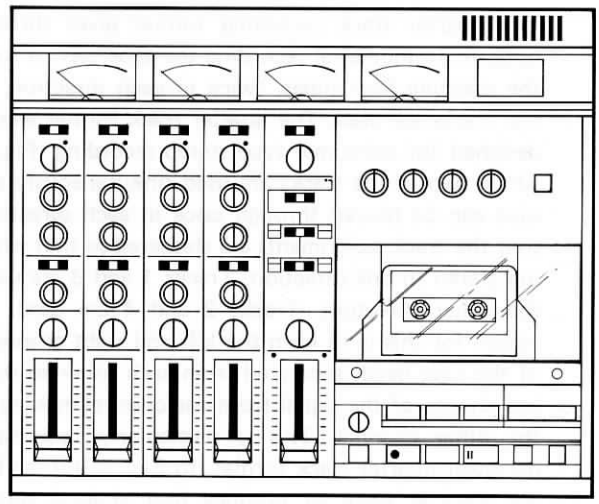
1-3 Recording and Tape Formats

Before discussing those features which would be useful in the studio it would be a good idea to first explore some of the standard recording and tape formats.

Tape for use in open reel audio tape recorders is produced in four standard widths: 1/4", 1/2", 1", and 2". In the 1/4" width, the three most common recording formats are: full track, half track, and quarter track, as shown in Fig. 1-1. Each track has a narrow area on each side which is not used for recording called a guard band.

In Fig. 1-2, it can be seen that there are three different standard *track* widths in use. The width of the track is closely related to the amount of noise produced in the recording process. The wider the track is, the more energy it is possible to record and store on the tape. The higher the level of energy strored on the tape, the lower the noise level in comparison. This is why most professionals prefer the full track or half track formats.

Fig. 1-1 Teac Portastudio



* Portastudio is the registered trademark of the Teac Corporation, Montebello, California

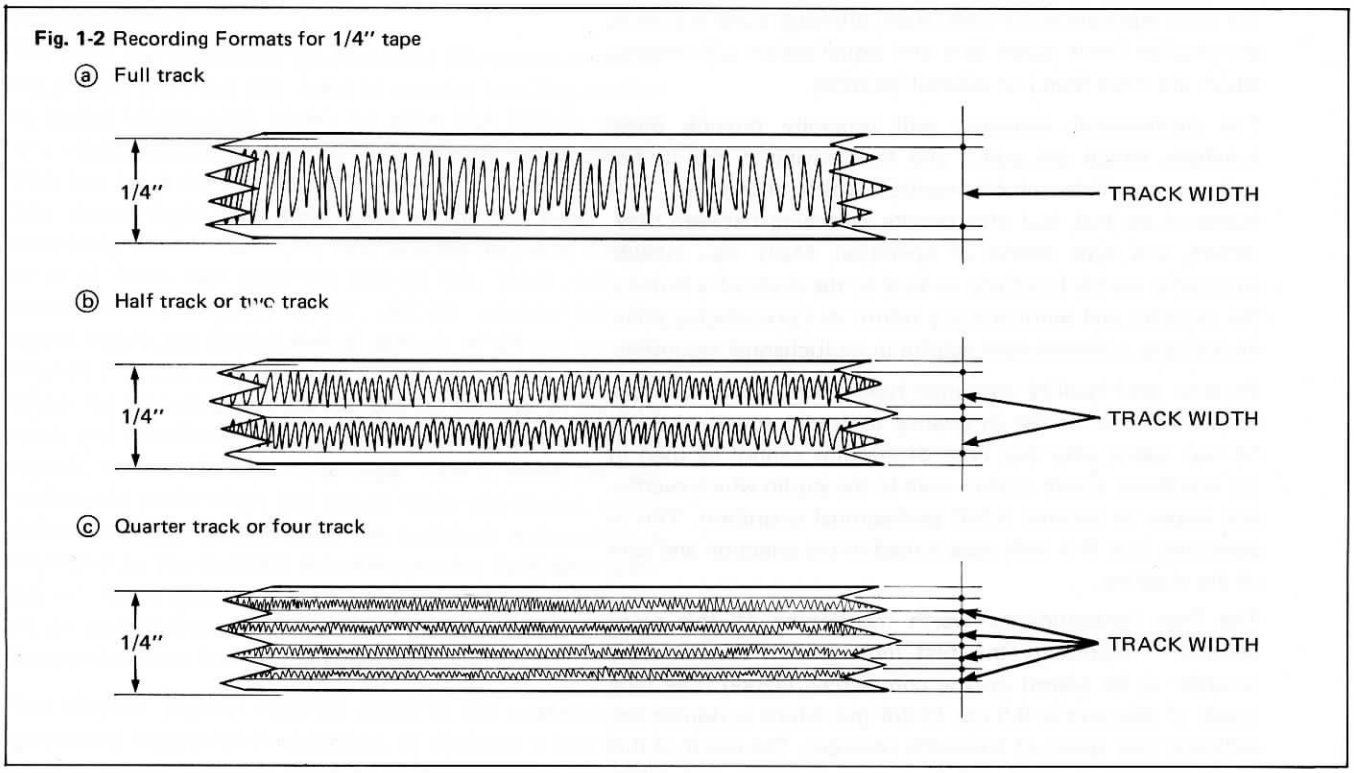
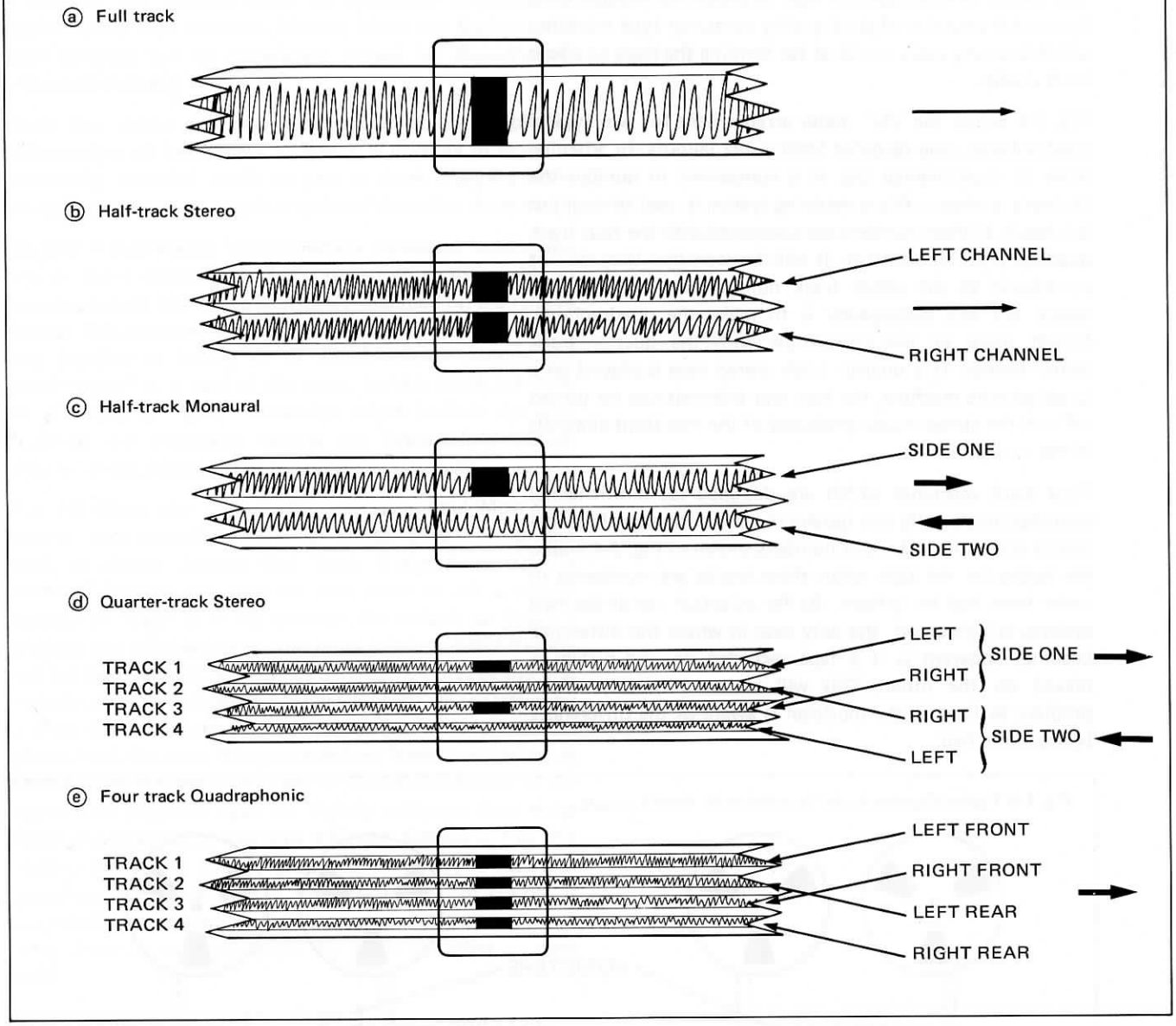


Fig. 1-3 shows the standard recording formats used with 1/4" tape recorders. In full track recording, except for the guard bands, the full width of the tape is used for recording. Full track recording is used primarily by professionals where the final product will be a monaural recording, as in television or radio work, or for motion picture sound tracks.

In half track recording, only half of the tape width is used when recording monaural. If the tape is flipped over end for end, a second monaural recording can be made on the other half of the tape width. In stereo recording, both tracks are recorded at the same time with the left channel information on one track (usually the upper) and the right channel information on the other track.

The quarter track recording format gives three different options. In monaural recording the tape can be run through the machine four times, twice in each direction, before all the tracks are used. The quarter track format was originally designed for consumer type stereo recording (Fig. 1-3(d)) in which two of the tracks are used simultaneously so that the tape can be played through once in each direction. Notice that the track assignments are staggered so that when recording stereo in one direction, Tracks 1 and 3 are used, and in the other direction, Tracks 2 and 4 are used. The main reason for this is to keep the left and right channel portions of the tape heads separated from each other so that there is less chance of the signal from one channel making its way to the other channel. This is particularly important in the narrower quarter track format. In Fig. 1-3(e), all four tracks are used at once to produce four channel quadraphonic sound.

Fig. 1-3 Common Head Formats for 1/4" tape recorders



The wider recording tapes (1/2", 1", and 2") are used most often in professional studios with track widths which are the same as the half track recording format. With tracks of this width, 1/2" tape will hold four tracks, 1" tape will hold eight tracks, and 2" tape, sixteen tracks. There are so-called semi-professional tape recorders which use the wider recording tape with track widths the same as in the quarter track recording format. The 1/2" machines record eight tracks, and the 1" machines record sixteen tracks.

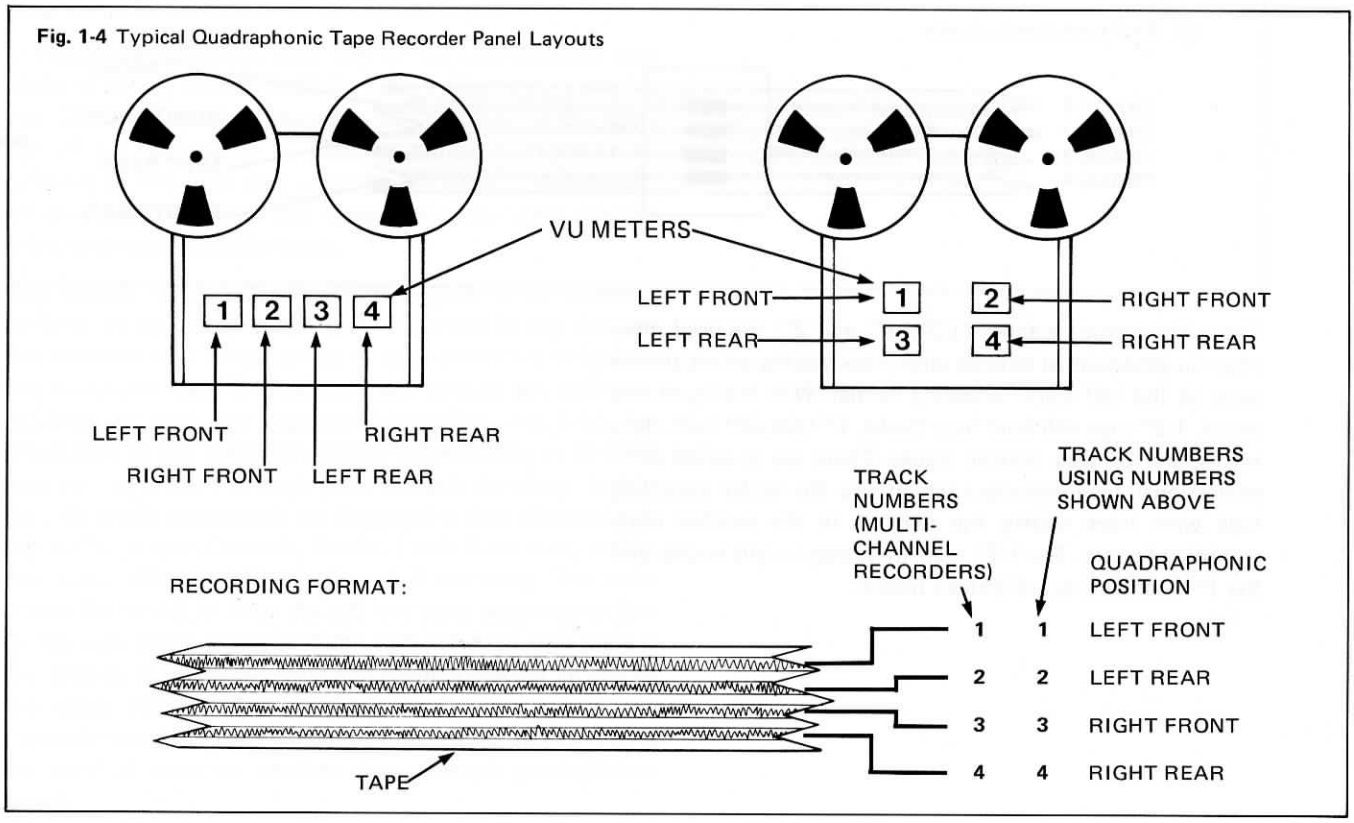
1-4 The Quarter Track Four Channel Recording Format

The advent of quadraphonic tape recorders has brought onto the market a number of good quality consumer type machines which in many cases are ideal for forming the basis of a four track studio.

Fig. 1-4 shows the VU* meter arrangement for two typical quadraphonic tape recorder front panel layouts. In adapting these to multichannel use, it is convenient to number the channels as shown; this numbering system is used throughput this book. If these numbers are compared with the four track quadraphonic tape format, it will be seen that they do not correspond to the actual track numbers of the tape. The reason for this discrepancy is to make the quadraphonic format more or less compatible with the quarter track stereo format. If a quarter track stereo tape is played on a quadraphonic machine, the two rear channels can be turned off and the stereo music produced of the two front channels in the normal manner.

Four track machines which are designed for multichannel operation exclusively will usually use the normal professional layout where the VU meter numbers shown in Fig. 1-4 match the tracks on the tape when these tracks are numbered in order from top to bottom. As far as actual use of the two systems is concerned, the only case in which the difference becomes apparent is if a tape recorded on one system is played on the other. This will be an extremely minor problem as long as the musician is aware of the differences between the two.

Fig. 1-4 Typical Quadraphonic Tape Recorder Panel Layouts



*VU = volume unit

1-5 Selecting a Four Track Tape Recorder

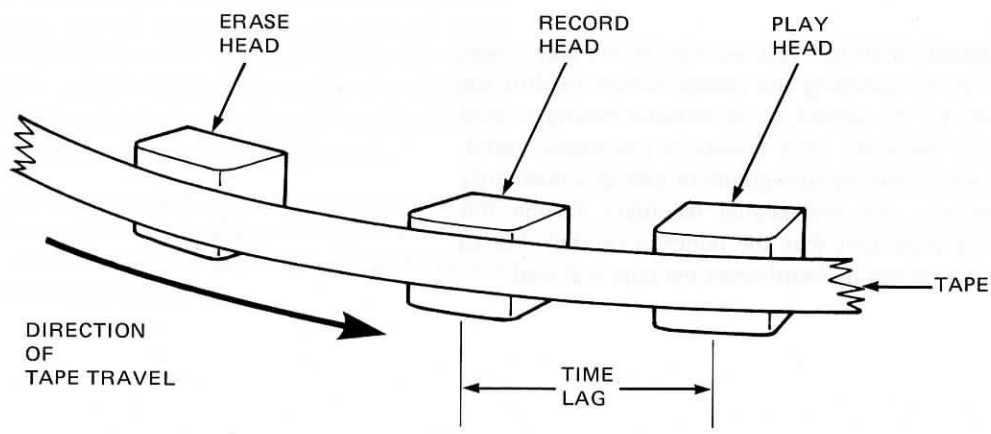
There are two features which are absolutely essential in a multichannel tape recorder. Without these two features, the tape recorder will be completely useless for multichannel recording purposes.

First, the record and play functions must be completely independent of each other so that it is possible to listen to previously recorded music on one or more channels while recording new music on one or more of the other channels.

Second, it *must* have a function where the record head in any one or more channels can be switched so as to be able to monitor (play) any music previously recorded on the related tracks. This function is sometimes called "sel-sync" or one of any number of terms, all of which usually include the word "sync" as a part of the term. In this book, we refer to it simply as "sync". Recorders which include the sync function will invariably include the independent record/play function mentioned in the previous paragraph.

Fig. 1-5 shows why the sync function is essential. Most good quality tape recorders use three heads: erase, record, and play, as shown. Assume that Track 1 already contains a recorded melody and that we now want to add a second melody to Track 2. If we monitor the melody on Track 1 through the playback head, the notes of the second melody will be recorded a short distance behind the notes of the first melody since the record and playback heads are separated by a short distance. If we can monitor the first melody from the record head, the notes being recorded on Track 2 will coincide exactly with the notes of Track 1. The characteristics of the record and playback head are slightly different since these heads are required to perform different functions. For this reason, the sound quality produced in the sync mode of operation will often be less than ideal. This, of course, is not usually a problem as the main purpose of the sync mode is to allow us to synchronize the music recorded on each track.

Fig. 1-5 Arrangement of Tape Recorder Heads



If given the choice between two tape recorders of approximately the same price, one with many extra features such as reverse play and tape sensing, the other rather Spartan with no particularly visible extra features, prefer the Spartan. With the first tape recorder, the price includes features which may be desirable for a home hi-fi system, but which are not particularly useful in the studio. If the Spartan comes from a reputable manufacturer, the money spent for it will usually be going into features which are more important in the studio, such as lower noise and more stable tape speed, or other features which do not necessarily show up on the front panel.

In selecting a tape recorder, the musician not familiar with the technical terms is advised not to bother with published specifications. The problem with specifications is that there are many ways to measure them and many ways to state the results. Each manufacturer prefers his own way of doing this and too many times these methods do not coincide between manufacturers. Specifications can sometimes be useful, however, when comparing machines produced by the same manufacturer. As long as the machine in question comes from a reputable manufacturer, however, the quality of the machine will more than likely coincide with its price.

1-6 Desirable Features in a Studio Recorder

The following lists features which would be useful or desirable in a studio recorder. Remember that the sync function mentioned in 1-5 above is absolutely essential; without this sync function, the recorder would be utterly useless as a multichannel recorder.

The features listed here will have varying degrees of desirability and the absence of one or more of these does not necessarily indicate that the recording of quality tapes is impossible; nor are the features listed in order of importance.

Remote Control: Remote control of the tape transport can be very useful. During different portions of the recording process the musician must be near the synthesizer, the mixer, or both. It is convenient to have the recorder located slightly away from this activity and controlled with a remote control unit.

Punch-in Record: With the tape recorder in the play mode, punch-in refers to punching the record button to shift the recorder over to the record mode without having to first stop the tape transport. This feature is extremely useful, particularly when making corrections to part of a previously recorded melody. All professional recorders include this function. It is important that the punch-in be click free so that the change cannot be heard when the tape is played.

Transport "Logic" System: Most good quality tape recorders use a tape transport logic system which allows the transport controls to be pressed in any order without damage to the tape or transport. This means that if the tape recorder is in the fast forward mode and the play button is pressed, for example, the tape will come to a complete stop before the recorder goes into the play mode. Without this logic system, the recorder would try to go into the play mode before the tape came to a full stop with the result of possible irreparable damage to the tape.

38 cps (15 ips) Record/Play Speed*: The physics of magnetic recording dictate that higher tape speeds produce a better noise level and a wider frequency response. This is the reason that professionals will sometimes use speeds as high as 76 cps (30 ips).

10" Reel Size Capacity: Higher speeds will mean less recording time with smaller reels, thus the larger reel capacity will become important with higher recording speeds. It is possible to get so-called extended play tape. This type of tape is thinner, thus more of it can be wound on a given reel. This tape is very inconvenient to handle in the studio and causes other problems, so it is better not to depend on such tapes for increasing recording time.

Pause/Cue: Most good quality tape recorders incorporate bars called tape lifters which push the tape away from contact with the tape heads when the tape transport is in any mode other than play or record in order to lessen head wear. Cue refers to a function which defeats the tape lifters so that it is easier to find selections on the tape by listening to the high pitched squeal produced when the tape is in contact with the heads in the fast forward or rewind mode. The pause function allows stopping the tape without taking the recorder out of the play or record mode. The pause function also usually defeats the tape lifters so that the tape reels can be rocked back and forth by hand in order to precisely locate some point on the tape. The main difference between pause and cue is that cue affects the tape lifters in all operating modes, and pause only when the tape is *not* in motion.

Peak Level Indicators: Many sounds, particularly electronic sounds, contain peaks which are so quick that they do not register accurately on VU meters. The inclusion of some kind of peak level indicator will help the musician to obtain maximum recording levels without the danger of distortion. Peak level indicators can be in the form of a simple LED which lights on peaks, or a peak reading VU meter.

Accessible Heads: In some types of consumer tape recorders, the heads are housed in all-enclosing covers which sometimes makes it very inconvenient to clean heads. Clean heads are essential to good quality recording.

*cps = centimeters per second; ips = inches per second.

Bias and Equalization: Correct bias and equalization are essential for producing quality recordings. Many consumer type machines provide selector switches for this purpose. For certain tapes, these settings will suffice, but for many other types of tape these switches will only be approximations at best. For this reason, it is recommended that the musician use the tape recommended by the manufacturer of the tape recorder in question. It stands to reason that the manufacturer knows best which tapes match the internally set bias and equalization adjustments. A few consumer machines include variable bias and equalization controls on the front panel. For the musician who is interested in learning how to calibrate these, this type of machine is ideal. It allows the machine to be set accurately for any desired tape.

Output Level Controls: Many tape recorders have separate controls for setting the tape recorder output level. These are convenient because they allow the musician to set the output level so that, when playing a tape, a previously recorded level reference signal will produce a "0" reading on the VU meter. Being able to match the output level to this test signal helps ensure low noise levels.

Pitch Control: The pitch control alters the pitch of the recorded music by altering the speed of the tape. Usually the pitch range available with such a control is rather narrow, but for most applications a narrow range is enough. Its most useful application is for matching pitches. For example, if it is decided to add a piano part to previously recorded music, it will prove much easier to tune the tape to the piano by changing the tape speed, rather than having to tune the piano to match the recorded music. With some recorders, the pitch control operates only in the play mode; it may prove more useful, however, if it can also be used in the record mode.

Chapter Two:
Basic Multichannel Recording Techniques

2-1 Introduction

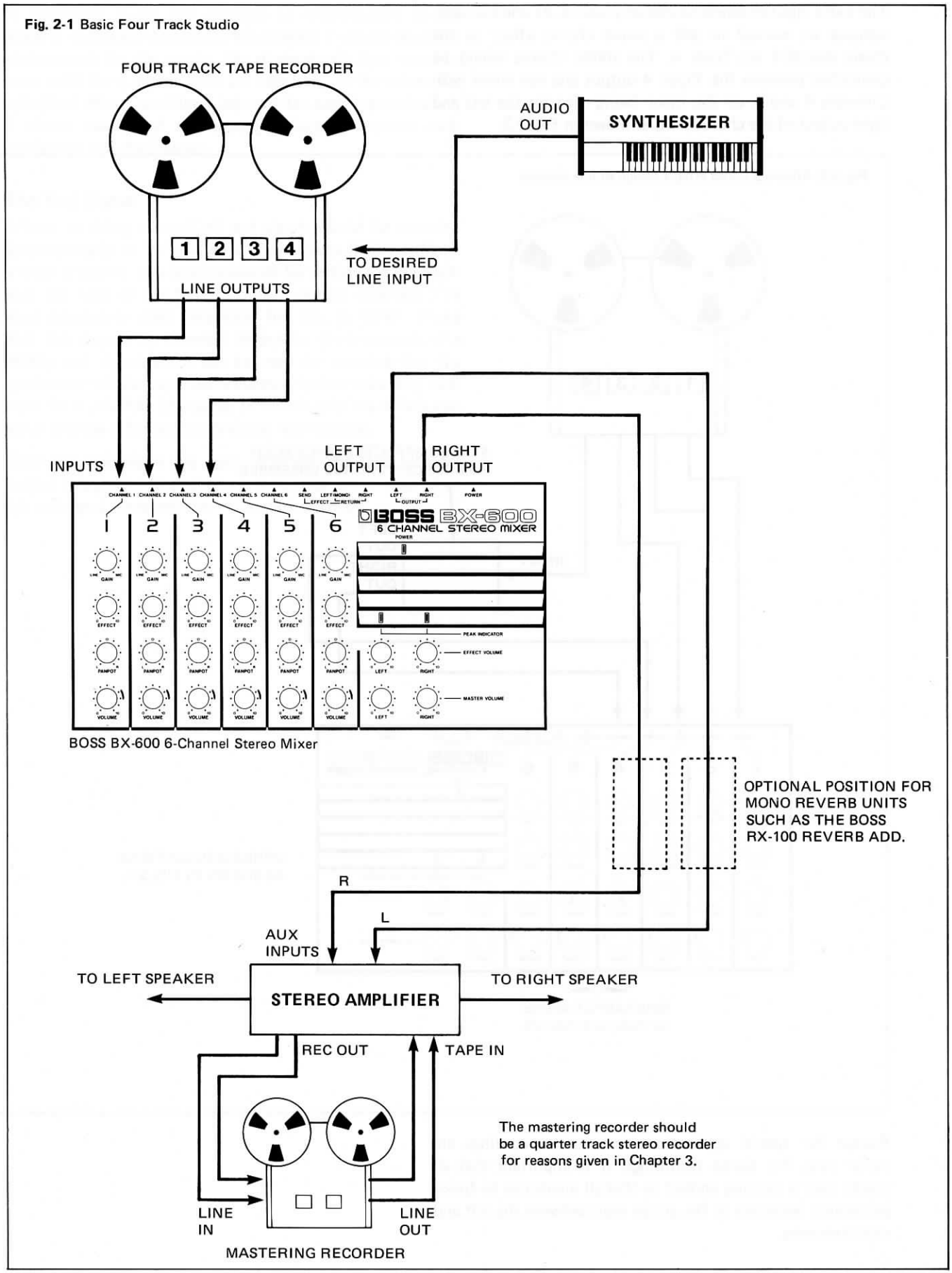
Basically, when using multichannel recording for electronic music, each voice is synthesized and then recorded on one track of a multichannel tape while listening to previously recorded voices. When all of the voices have been recorded, the tape is played back through a mixer which determines the balance of the voices and their position in the stereo field. The output of the mixer is connected to the input of the mastering tape recorder where the result of the mix is recorded.

2-2 The Four Track Studio

The heart of the studio is the mixer because this is where all of the parts come together to form the finished product. In the example studio arrangement shown in Fig. 2-1 we have shown the Boss BX-600 Mixer* for the following reasons: There are more input channels than the bare minimum necessary; the output is stereo with panning controls for each input channel; each channel includes an effects send level control.

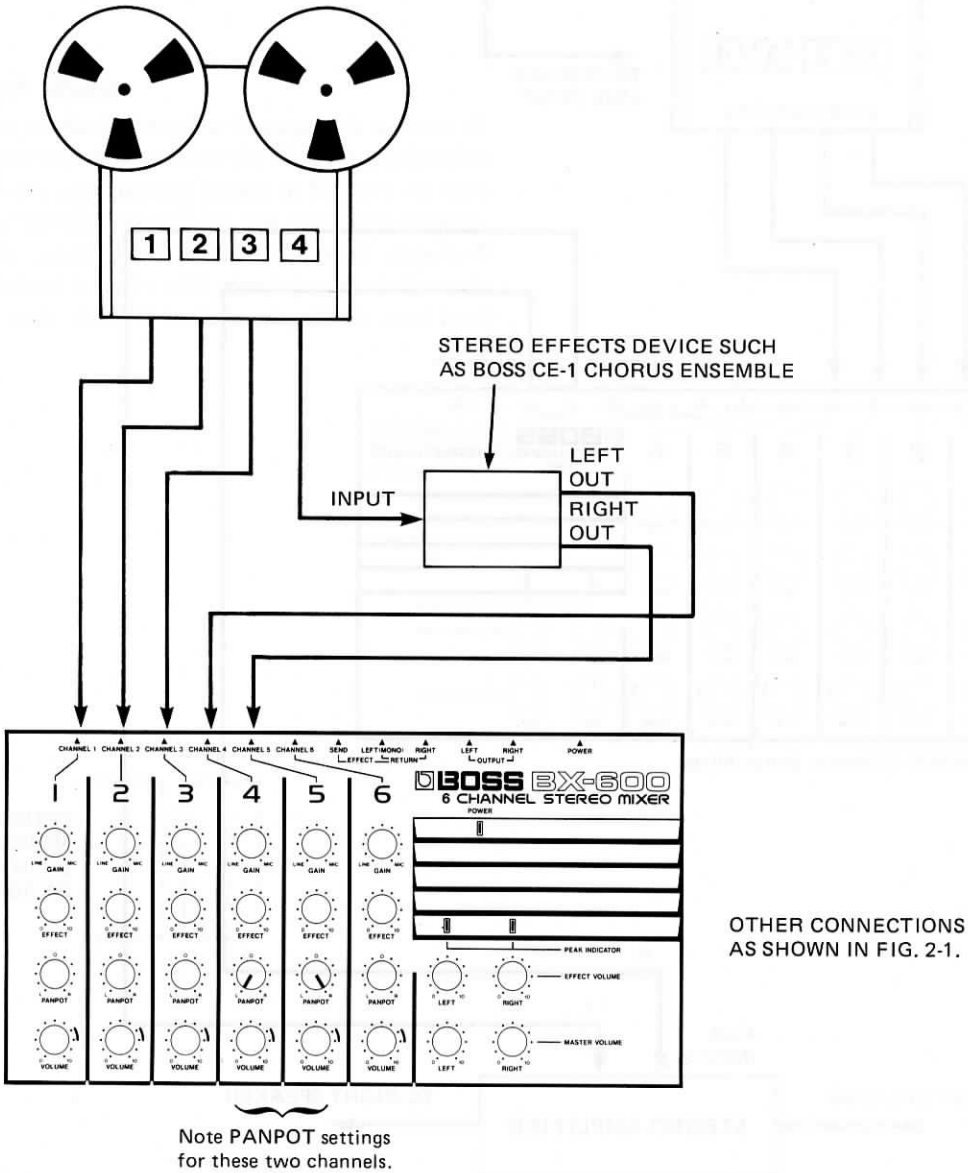
* Manufactured by Roland.

Fig. 2-1 Basic Four Track Studio



The extra input channels can be very useful. As one example, suppose we wanted to add a stereo chorus effect to the music recorded on Track 4. The stereo chorus would be connected between the Track 4 output and the mixer with Channels 4 and 5 on the mixer being used for the left and right output of the chorus unit, as shown in Fig. 2-2.

Fig. 2-2 Adding a stereo effects device to one channel



Except for special applications, monaural recordings are rather rare. For stereo recordings, it is important that all inputs have a panning control so that all inputs can be freely positioned anywhere in the stereo field between the left and right extremes.

In electronic music, the addition of reverberation to the music is extremely important for creating a natural sounding environment for the music. For stereo music, two reverberation units (or a stereo unit) are necessary. If the mixer has individual effects send level controls for each input channel, it allows control of the apparent distance between each instrument and the listener.

2-3 The Test Signal

Fifteen to thirty seconds of test signal should be recorded simultaneously at "0" VU on all four tracks. This test signal is used primarily as a level reference for setting the playback level for each of the tape recorder's output channels. The most commonly used frequency for this is 1kHz. Along with this should be recorded fifteen to thirty seconds of a 440Hz test signal which can be used for ensuring that the synthesizer VCO's are tuned accurately before recording each track. It is possible, of course, to record only the 440Hz test signal and use it for both tuning and level setting.

Once the test signal has been recorded, the tape recorder output (playback) level controls should be set so that when the test signal is played, the VU meters read "0".

2-4 The Metronome Track

It will often prove necessary to record at least a temporary "tic" on one of the tracks to act as a metronome beat. In some types of music, such as the Haydn *Serenade* shown in the appendix, only a measure or two of beats is needed to act as a countdown to ensure that all of the parts start together. In this case any track may be used as long as there is sufficient space between the last metronome "tic" and the first note of the music to allow easy removal of the metronome beat during final editing of the tape.

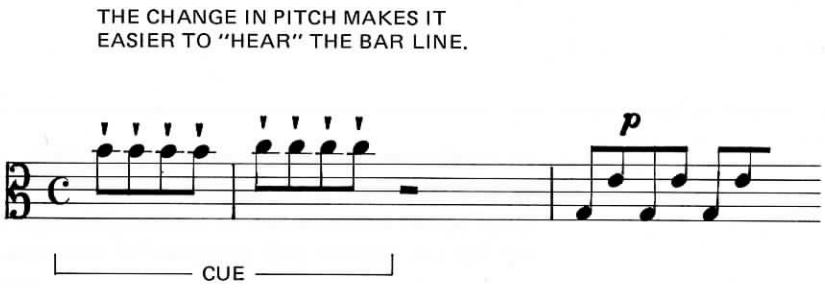
In other cases, particularly where there are many tempo changes or where there are many rests in different parts, it may be necessary to record a temporary metronome beat the entire length of the composition. Once the first three tracks have been recorded, the temporary metronome beat can be erased and that track used for a fourth part, in which case it may be desirable to leave a measure or two of metronome beats at the beginning to help in starting the new part on time.

2-5 Multichannel Recording

To demonstrate how the multichannel recording process works we will use the Haydn *Serenade* shown in the appendix. Being a string quartet, it is ideal for showing how the multichannel process works with a four track recorder. For ease in mixing, it would probably prove better to assign voices to the tape channels in the same order as they appear in the score. In other words, Voilin I would be recorded on Track 1, Violin II on Track 2, etc. Since each voice is recorded separately, they can, of course, be recorded in any convenient order.

The two inner voices, the Violin II and Viola parts, are steady and unbroken in rhythm from the beginning of the music to the end. One of these should be recorded first to act as a metronome for the other parts. It will also be necessary to record a measure or two of metronome beats to act as a cue to help start all the parts together. The pizzicato used for the inner voices is short and percussive and will make an ideal "tic" for the cue. This cue is shown in Fig. 2-4 in the Viola part, but it will of course not be present in the finished tape.

Fig. 2-4 Cue for Viola Part of Haydn *Serenade*
(See appendix for complete score)



To record the Viola part, connect the synthesizer to the Channel 3 LINE INPUT of the four track tape recorder. Set up the viola sound.* Use the previously recorded 440Hz test signal to tune the VCO. Set the Channel 3 record level while playing notes on the synthesizer. Record the Viola part and the metronome beats used for the cue. When this is finished, play the tape all the way through at least once to make sure that the sound as actually recorded is acceptable.

To record the Violin II part, connect the synthesizer to the Channel 2 LINE INPUT of the four track recorder. Set up the violin sound and tune the VCO using the recorded test signal. Put Channel 3 of the recorder in its sync mode and Channel 2 in its record mode. Record the part. Most recorders have less than ideal frequency response in the sync mode, so all channels should be returned to the play mode when playing the tape to check the sounds.

Record the remaining parts in the same way.

It should be mentioned in passing that when recording music in which sequencer controlled melodic patterns are used, it is essential that these patterns be recorded first. It is almost impossible to synchronize a sequencer with previously recorded music unless the sequencer passage is very short.

2-6 Mixing

When the four track tape is finished, it is played back through the mixer and the result is recorded on the mastering recorder. The balance of the instruments is determined by the level settings of the mixer.

Start with all the mixer level controls at minimum. Raise the Channel 1 (Violin I) level control to near maximum, then raise the two master output level controls to a point where playing the tape produces the Violin I part at the desired normal listening level. Set the panpot (or panning control) for Channel 1 so that the Violin I sound comes from the desired point in space. Since this is the melody part, it might be decided to place it slightly left or right of center. Set the effect return (or effect master) controls a little above "5" or "6". Raise the Channel 1 effect send control enough to produce the desired amount of reverberation. This being the melody, it may be desirable to give the sound only a little reverberation so that the sound seems near the listener. Try setting the Channel 1 bass control at "−10" and listen to see if this affects the sound quality of the violin sound. If it has no undesirable effect, then leaving the bass control at "−10" will eliminate possible undesirable low frequency noise elements from Channel 1.

* The synthesis of the string family of sounds is shown in the two volumes of *Practical Synthesis for Electronic Music*, published by Roland.

The bass part is often next in importance after the melody, thus it can be considered next. Raise the Channel 4 level control to the point which produces the desired balance between the 'Cello part and the melody. Add reverberation with the Channel 4 effect send control. Try moving the Channel 4 bass control into the "+" region to see if the 'cello sound can be improved. Try setting the treble control at or near "–10". If this does not affect the sound in an undesirable manner, leave it at "–10" to help minimize noise from this channel. Set the panpot as desired.

The two inner voices may be considered last in determining the balance of voices. Since they may be thought of as being relatively equal to each other in importance, either one may be adjusted next. Raise the channel level control of one so as to produce the correct balance in relation to the melody and bass. Add reverberation and check to see if the tone controls would be useful with the sound. Do the same with the remaining voice. For these voices, it might be desirable to place one on the left and the other on the right. It is usually better to avoid the extreme positions of the panpots because these positions produce an unnatural effect when listening to the music through headphones. For example, if the panpot is set as far right as possible, the sound for that channel will occur only in the right ear and not in the left ear at all, except possibly for some reverberation. Since these are inner voices, the reverberation level can be a bit high so that they seem to be in the background. Be careful not to set the level too high, however, because sharp pizzicato sounds can easily cause the reverberation unit to produce twanging sounds.

There is often a considerable difference between headphone and speaker monitoring. Before deciding on a given mix, it is always a good idea to listen to the mix at least once through each of these mediums to ensure that both versions are acceptable.

2-7 Mastering and Copying

Once the mix has been decided, it can be recorded on the mastering recorder. The first step is to calibrate the mastering record level so that the recorder VU meter readings match the mixer VU meter readings. Connect a test oscillator or the synthesizer VCO to one of the unused mixer input channels (Channel 5 or 6 in Fig. 2-1) and set the mixer level controls so that both mixer VU meters read "0" when the panpot is set at "0" or center. Put the mastering recorder in its record mode and set the record level controls so as to produce "0" on the recorder VU meters. Most professionals use 1kHz for this purpose.

If the resulting tape is to be used for making copies, it will need a fifteen to thirty second section of 1kHz signal as a level reference for copying. It can be recorded using the arrangement mentioned above or the arrangement shown in Fig. 2-3; it should *not* be recorded by copying the test signal previously recorded on the four track tape since a recorded signal is always slightly unstable in level when played.

Record the mix. Since the mastering recorder levels have been set so that the recorder VU meters match the mixer VU meters, it will be necessary to watch only the mixer VU meters. The mixer's output level controls should be set so the mixer VU meters seldom go over the "0" mark.

To make copies from the master, merely play the 1kHz test signal portion of the master tape and set the master recorder output levels for 0 VU, then set the copy recorder VU meters at "0". Start the copy recorder after the test signal has stopped. The four track recorder can be used for making open reel copies by feeding the master recorder outputs directly into the appropriate four track recorder inputs.

If the copies are to be cassette tapes, caution is necessary. Cassette recorders cannot record high frequencies at the same levels as used in open reel recorders. This means that the cassette recorder record level will almost always have to be set lower that 0 VU in order to prevent distortion. The actual permissible level will depend on the high frequency content and the dynamic range of the music. Start with the cassette recorder set at 0 VU and play the louder portions of the master tape so see if the cassette VU meters go too high. This is where peak level indicators will be invaluable. If the cassette recorder does not have peak level indicators, several test recordings may have to be made to determine the maximum recording level which can be used. Once the recording level has been determined, return the master tape to the test signal and note the level that this signal produces on the cassette VU meters. Make a note of this level on the master tape box so that future copies can be made without having to go through the above process again.

With a few master tapes. it may be possible to use 0 VU on the cassette recorder. With some tapes, however, it may be necessary to set the cassette recorder meters as low as "−10" VU to prevent distortion.

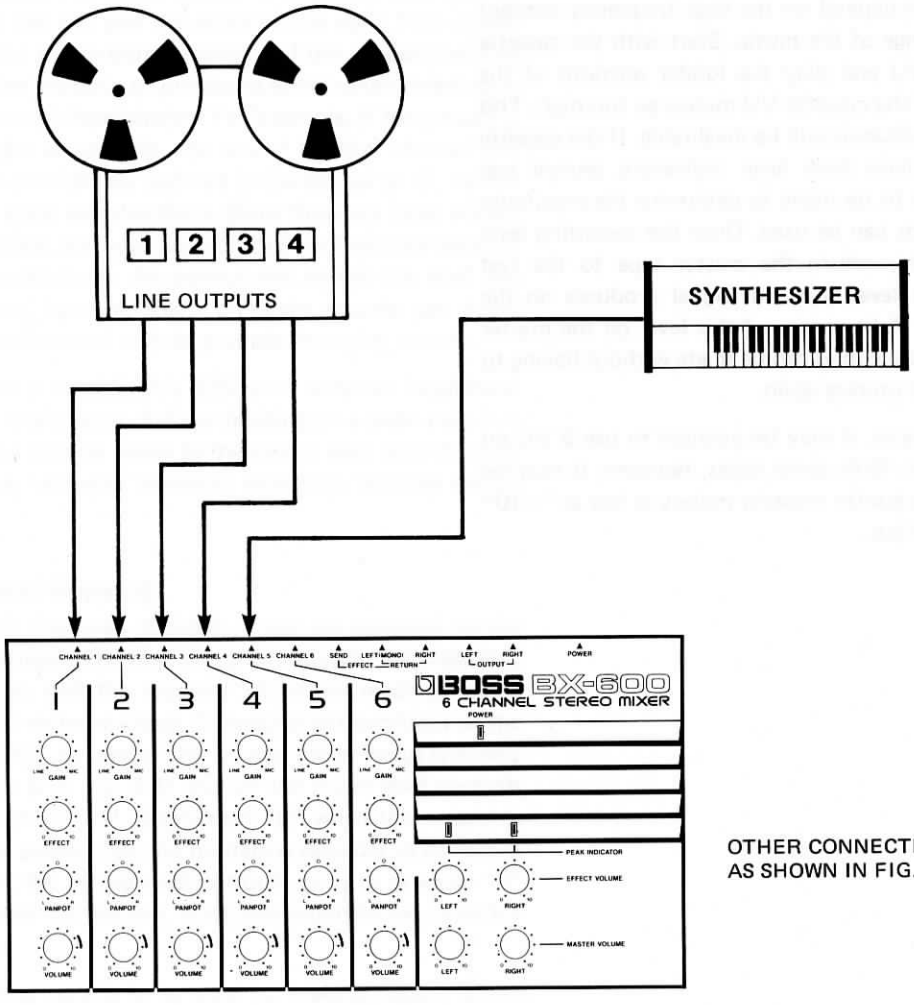
Chapter Three:
More Tracks from Four Tracks

3-1 Introduction

If we were limited only to the four voices available on a four track tape recorder, we would be working with a very large handicap, indeed. This would be so even if we were using polyphonic instruments to record each of the tracks. Fortunately, it is not too difficult to add more voices to the music and still retain much of the freedom and many of the advantages of multichannel recording.

The simplest and most obvious method for adding at least one extra voice to the four track mix is to add a fifth voice during the mixdown process, as shown in Fig. 3-1. First, the balance of the four voices on tape is set up on the mixer, then the level of the new voice is set so as to balance with the rest.

Fig. 3-1 Adding a fifth voice to the four track tape



3-2 Bouncing

One method of obtaining more voices from a four track tape recorder is to use internal bouncing, as shown in Fig. 3-2. One minor disadvantage of this method is that it requires the use of the sync mode in Step 7 for playing the sounds contained on Tracks 1 and 2 in order to keep these sounds synchronized with the mix on Track 4. The sync mode is usually less than ideal for playback, but this may not be too large a problem. The mixer tone controls might be of use to help compensate for this. It is also possible to experiment by recording a few sample sounds and playing them in the sync mode just to see how the sound is changed. It may be possible to synthesize the sounds in such a way that the sync mode actually enhances the sound. In the worst case, Steps 5 and 6 of this recording process could be devoted to adding voices which are to be relegated to the background where the change in sound will not be noticed so much.

Fig. 3-2 Bouncing

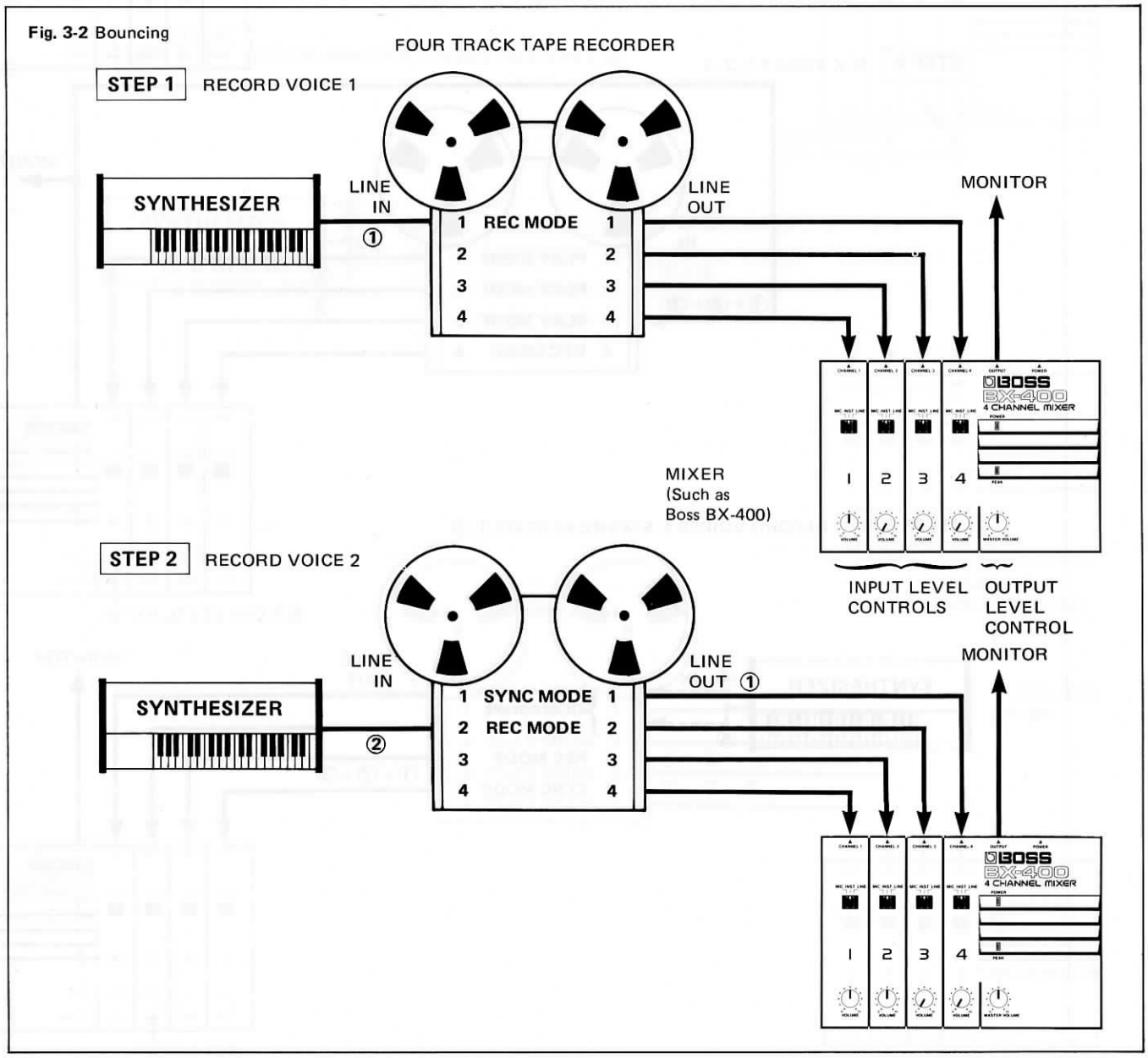


Fig. 3-2 Bouncing (Cont'd)

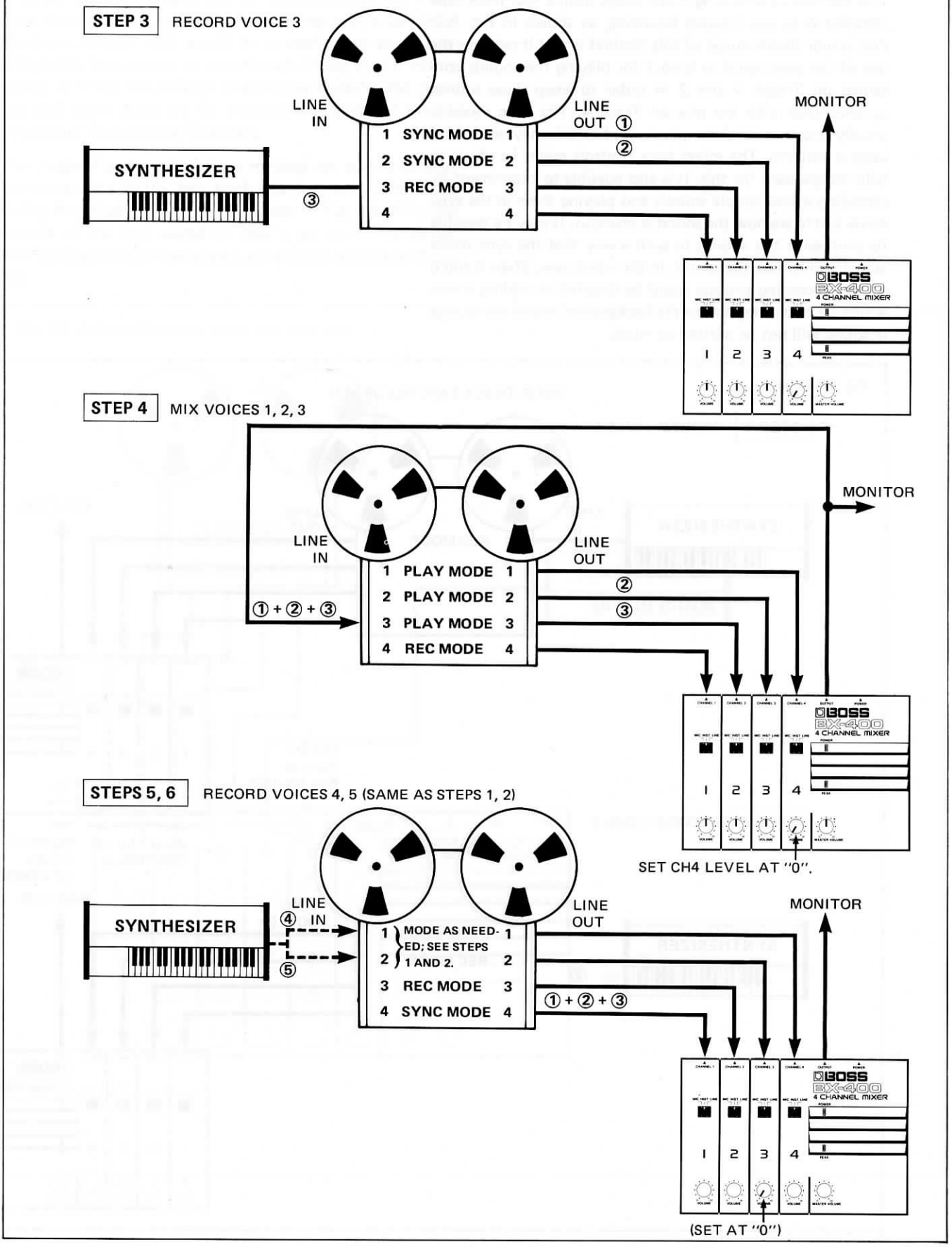
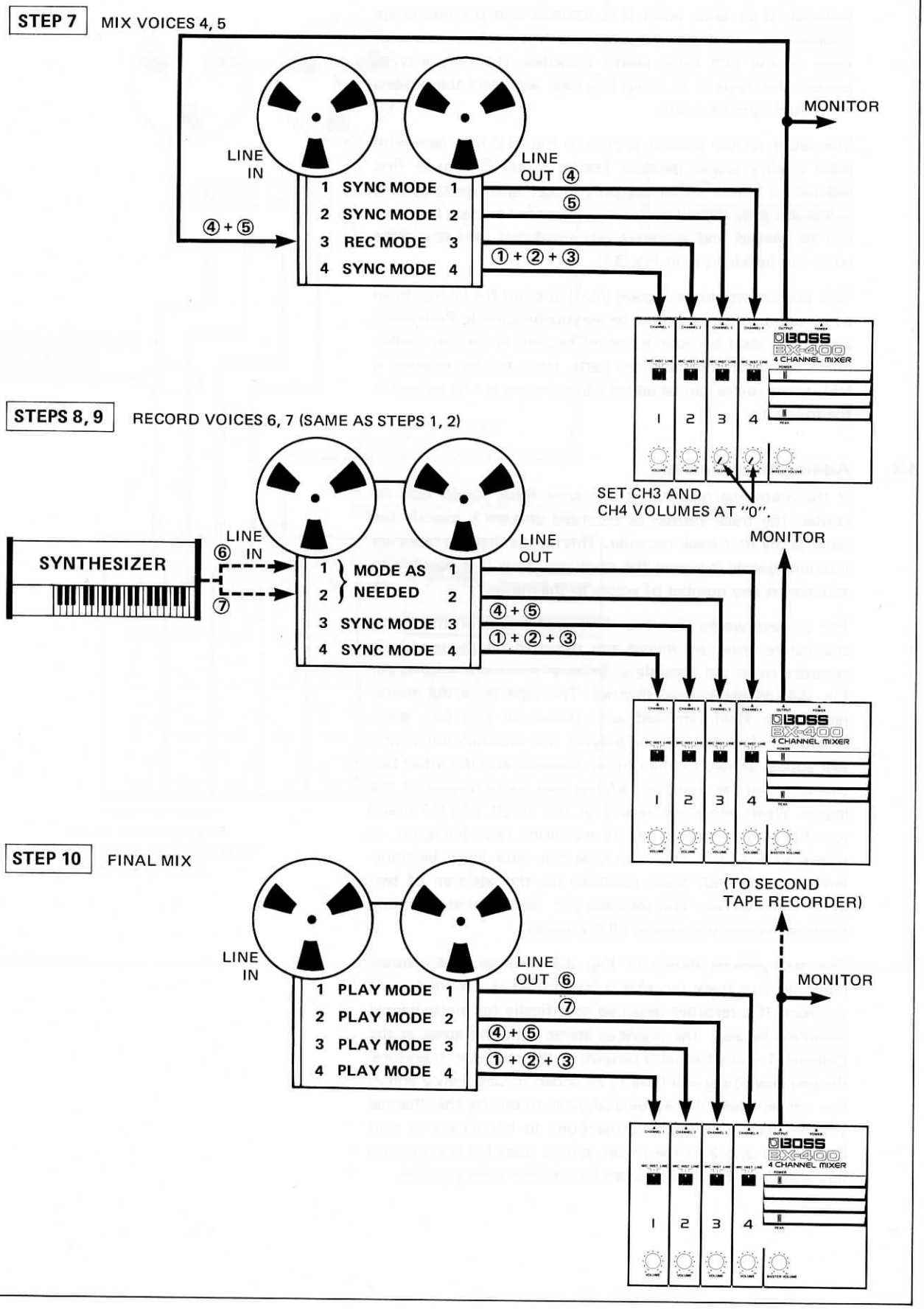


Fig. 3-2 Bouncing (Cont'd)



Another disadvantage of bouncing in this manner is that, following Step 4, it is necessary to erase previously recorded material. If at some point it is decided that the results are unsatisfactory and that the reason for this is a fault in one or more of the first three voices recorded, the only way to correct this fault is to scrap the tape and start the process from the beginning again.

The result of the process shown in Fig. 3-2 is a tape with good quality sound because Tracks 1 and 2 contain first generation voices (recorded only once) and the remaining voices are only second generation (recorded twice). This tape can be played and a stereo mix produced, and one more voice can be added as in Fig. 3-1.

This process would be a good starting point for laying down a foundation of string sounds or percussion sounds. Percussion would be ideal because it would become a built-in metronome for recording the other parts. Once this foundation is laid, more voices can be added using the process described in the following.

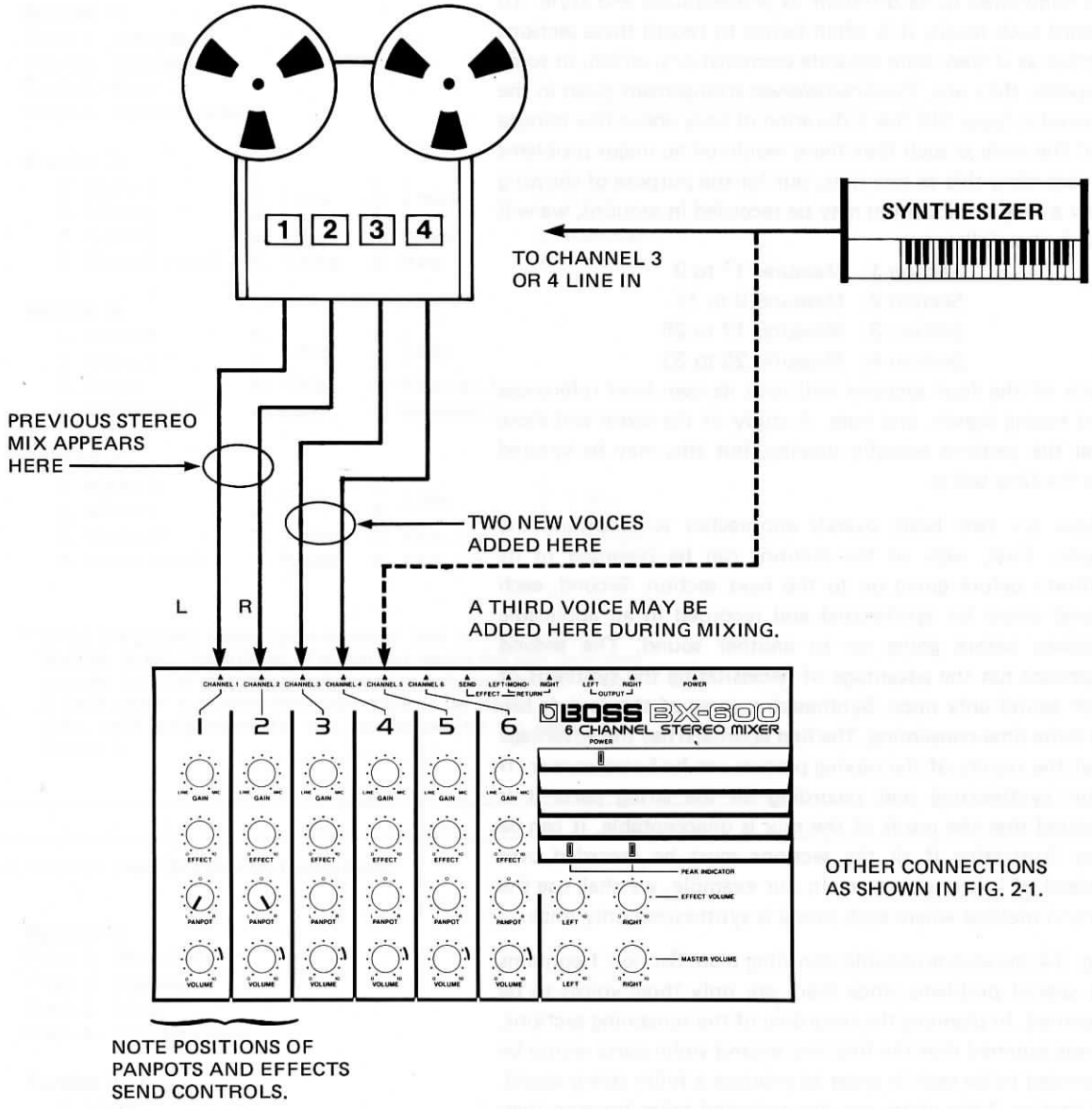
3-3 Adding More Voices

If the mastering recorder is a quarter track stereo tape recorder, the track format as recorded on tape is exactly the same as the four track recorder. This means that the tapes are interchangeable between the machines, thus it is possible to add almost any number of voices to the music.

The process works like this: The four tracks on the multichannel recorder are mixed and recorded on the mastering recorder (with the possible addition of one more voice as per Fig. 3-1) in the normal manner. The tape from the master recorder is then removed and placed on the four track recorder. When the tape is played, the previous stereo mix will appear at two of the output channels and the other two channels can be used for adding two more voices to the music. When these are recorded, the result can be mixed together and recorded on the mastering recorder again, as shown in Fig. 3-3. This new tape can once again be transferred to the four track recorder for the addition of two more new voices. This process can be repeated as many times as necessary to record all the voices.

The arrangement shown in Fig. 3-3 assumes that a quadraphonic four track recorder is being used as a multichannel recorder. If a recorder designed specifically for multichannel recording is used, the previous stereo mix will apear at the Channel 1 and Channel 3 output of the recorder; therefore, the two new voices will have to be added to Channels 2 and 4. For convenience, it may be desireable to reverse the Channel 2 and Channel 3 input connections to the mixer so that Channels 1 and 2 of the mixer will be used for the previous mix and the other channels can be used for adding voices.

Fig. 3-3 Adding new voices to the four track mix



3-4 Recording Complex Music

In long compositions there will be different sections which are sometimes quite different in orchestration and style. To record such music, it is often better to record these sections almost as if they were separate compositions, which, in some respects, they are. The *Greensleeves* arrangement given in the appendix (page 38) has a duration of only about one minute and the style is such that there would be no major problems in recording this as one unit, but for the purpose of showing how a long composition may be recorded in sections, we will divide it as follows:

Section 1: Measures 1* to 9
Section 2: Measures 9 to 17
Section 3: Measures 17 to 25
Section 4: Measures 25 to 33

Each of the four sections will have its own level references and tuning signals, and cues. A study of the score will show that the sections actually overlap, but this may be ignored for the time being.

There are two basic overall approaches to recording the music. First, each of the sections can be recorded in its entirety before going on to the next section. Second, each sound could be synthesized and recorded in all applicable sections before going on to another sound. The second approach has the advantage of necessitating the synthesis of each sound only once. Synthesizing some of the sounds can be quite time-consuming. The first approach has the advantage that the results of the mixing process can be heard sooner. If after synthesizing and recording all the string parts it is decided that the result of the mix is unacceptable, it can be very frustrating if all the sections must be recorded over instead of just one section. In our example, we shall use the second method where each sound is synthesized only once.

Fig. 3-4 shows one possible recording plan. Section 1 contains no special problems since there are only three voices to be recorded. In planning the recording of the remaining sections, it was assumed that the first and second violin parts would be recorded twice each in order to produce a fuller string sound. In Section 3 the violas are also recorded twice because they carry the melody in unison with the first recorder.

Fig. 3-5 shows an alternate recording plan for *Greensleeves* which adds a rhythm track to the music. A rhythm box would make an excellent source for producing a rhythm track. The addition of a rhythm track would negate the need for a metronome track.

* In normal practice the first complete measure in usually designated as Measure 1; this composition was originally arranged for a recording made using the Roland MicroComposer thus necessitating the measure numbering system used here.

Fig. 3-4 Recording Plan for *Greensleeves*

Section 1:

Track 1. Recorder 1
Track 2. Recorder 2
Track 3. Harp
Track 4. Metronome tic

Section 2:

1. Violin 1	1.] mix	1.] mix	1.] mix
2. Violin 1	2.	2.	2.
3. Violin 2	3. Violas	3. Basses	3. Recorder 1
4. Violin 2 (+cue)	4. 'Cellos	4. Harp	4. Recorder 2

Section 3:

1. Violin 2	1.] mix	1.] mix	
2. Violin 2	2.	2.	
3. Violas	3. 'Cellos	3. Recorder 1	
4. Violas (+cue)	4. Harp	4. Recorder 2	

Section 4:

1. Violin 1	1.] mix	1.] mix	1.] mix
2. Violin 1	2.	2.	2.
3. Violin 2*	3. 'Cellos	3. Harp, upper	3. Recorder 1
4. Violas (+cue)	4. Basses	4. Harp, lower	4. Recorder 2

*Since the second violins play a minor role in this section, it is possible to sacrifice fullness of sound and record this part only once in order to allow us to record the harp in two runs instead of one. If both upper and lower harp voices are to be played at the same time, track assignments for this section can be the same as for Section 2.

Fig. 3-5 Alternate Recording Plan for *Greensleeves*

Section 1:

Track 1. Recorder 1
Track 2. Recorder 2
Track 3. Harp
Track 4. Rhythm (+cue)

Section 2:

1. Violas	1.] mix	1.] mix	1.] mix	1.] mix
2. 'Cellos	2.	2.	2.	2.
3. Basses	3. Violin 1	3. Violin 1	3. Harp	3. Recorder 1
4. Rhythm (+cue)	4. Violin 1	4. Violin 1	4. – *	4. Recorder 2

Section 3:

1. Violas	1.] mix	1.] mix	1.] mix	
2. 'Cellos	2.	2.	2.	
3. Basses	3. Violin 2	3. Harp	3. Recorder 1	
4. Rhythm (+cue)	4. Violin 2	4. – *	4. Recorder 2	

Section 4:

1. Violas	1.] mix	1.] mix	1.] mix	1.] mix
2. 'Cellos	2.	2.	2.	2.
3. Basses	3. Violin 2	3. Violin 1	3. Harp, upper	3. Recorder 1
4. Rhythm (+cue)	4. Violin 2	4. Violin 1	4. Harp, lower	4. Recorder 2

* The asterisk designates tracks which are not used.

Fig. 3-6 shows a recording outline based on the plan in Fig. 3-4. Using this procedure, it will be necessary to synthesize each of the sounds only once. The following describes this process in a little more detail.

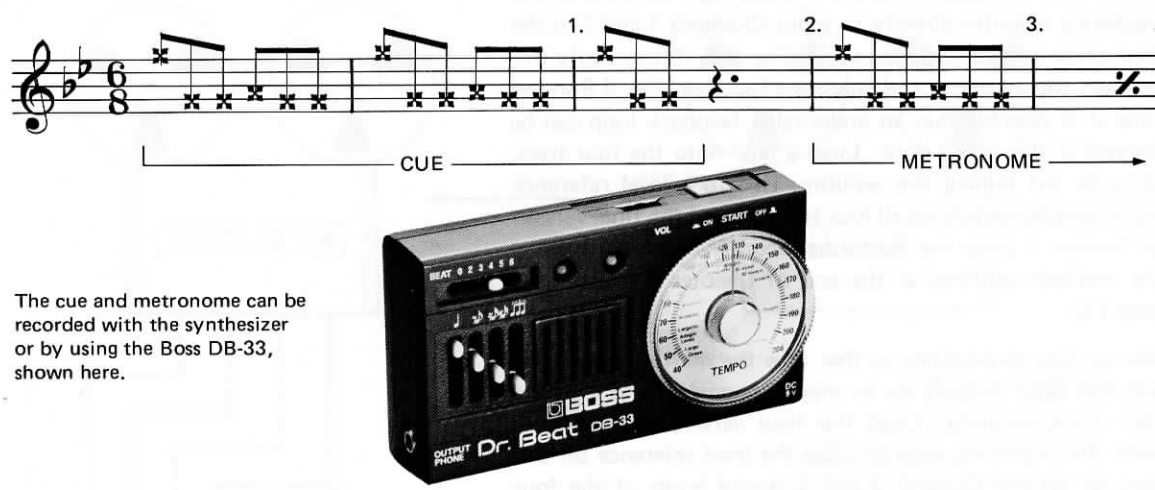
Fig. 3-6 Recording Outline for *Greensleeves* (based on Fig. 3-3)

1. Record test signals, metronome and cue tracks for all sections.
2. Record all first violin parts.
3. Record all second violin parts.
4. Mix Section 2.
5. Record all viola parts.
6. Mix Sections 3 and 4.
7. Record all 'cello parts.
8. Mix Section 2.
9. Record all bass parts.
10. Mix Section 4.
11. Record all harp parts.
12. Mix Sections 2, 3, and 4.
13. Record all first recorder parts.
14. Record all second recorder parts.
15. Mix all sections.
16. Join sections together.

3-5 Recording the Music

The first step is to record the necessary test signals. All four sections could be recorded on the same tape if the playing time for each section is estimated and space left between the test signals, but it would be easier to start with four separate tapes, one for each section. After recording the test signals (1kHz level reference and 440Hz tuning reference), record the cues. Also record the metronome tracks if these are desired. The cue consists of two or three measures of "tics" followed by a rest before the beginning of the music. The cue will be necessary to help start all the parts in each section together. The rest between the last cue "tic" and the point where the music or metronome part starts should be long enough to allow cutting the cue out of the final version of the tape. A temporary metronome beat can be recorded on Track 4 of each section to aid in keeping all the parts together at first, then erased when the voice on Track 4 is finally recorded. Fig. 3-7 shows a sample cue and metronome beat. The sound used for the cue and metronome should be very short and percussive. Accurate pitches are unimportant. The sound should be approximately two, or even three octaves above the pitches shown. It is *essential* that the tempo in each of the four sections of the music matches enough so that when the sections are joined, they will sound like one piece of music.

Fig. 3-7 Cue and Metronome



The cue and metronome can be recorded with the synthesizer or by using the Boss DB-33, shown here.

Next, synthesize the sound for the violin section* (or use a string synthesizer) and record all of the violin parts. When recording the first violins of Section 2, include the run up the scale which appears in Measure 9. Also include the run in Measure 25 when recording Section 4.

Mix Section 2 and record the result with the mastering recorder. Transfer this tape to the four track recorder when adding new voices to Section 2. Synthesize the viola sound and record all viola parts. The last note in Measure 17 should be played as a part of Section 3 and omitted from Section 2.

After recording the viola parts, mix Sections 3 and 4 using the master recorder. Synthesize and record all 'cello parts, then mix Section 2 (as per Fig. 3-3). Synthesize and record all bass parts. Remember that the bass should sound one octave lower than the written pitches. Mix Section 4.

The harp part would best be handled with a polyphonic type instrument such as an electronic piano or even a guitar. Such an instrument would allow the arpeggios in Sections 1 and 3 to sustain. Without such an instrument, it would be possible to use an ordinary synthesizer and play the arpeggios as if they were written like those of Section 2. The use of an echo machine and/or a high level of reverberation will help sustain the pitches. The recording plan of Fig. 3-4 was designed so that the left and right hand parts of Section 4 can be played separately on different tracks. This will allow the two parts to be placed in different positions in the stereo field which is a better effect than having both parts seem to originate from the same point.

Mix Sections 2, 3, and 4. Synthesize and record all the recorder parts. The last note of the first recorder part in Measure 17 should be played as a part of Section 3 and omitted from Section 2. Mix the four sections.

* The synthesis of group string sounds is covered in Volume 2 of *Practical Synthesis for Electronic Music*, published by Roland.

3-6 Joining the Sections

At this point the four sections are completed but still separated. Start by connecting the left and right outputs of the mastering recorder directly to input Channels 1 and 2 of the four track recorder, as shown in Fig. 3-8. Temporarily disconnect the inputs to the mastering recorder. Fig. 3-9 shows how it is possible that an undesirable feedback loop can be formed if this is not done. Load a tape onto the four track recorder for joining the sections. Record a level reference signal simultaneously on all four tracks. Load the final version of Section 1 onto the mastering recorder and copy it using the methods outlined at the end of Chapter 2 (starting on page 16).

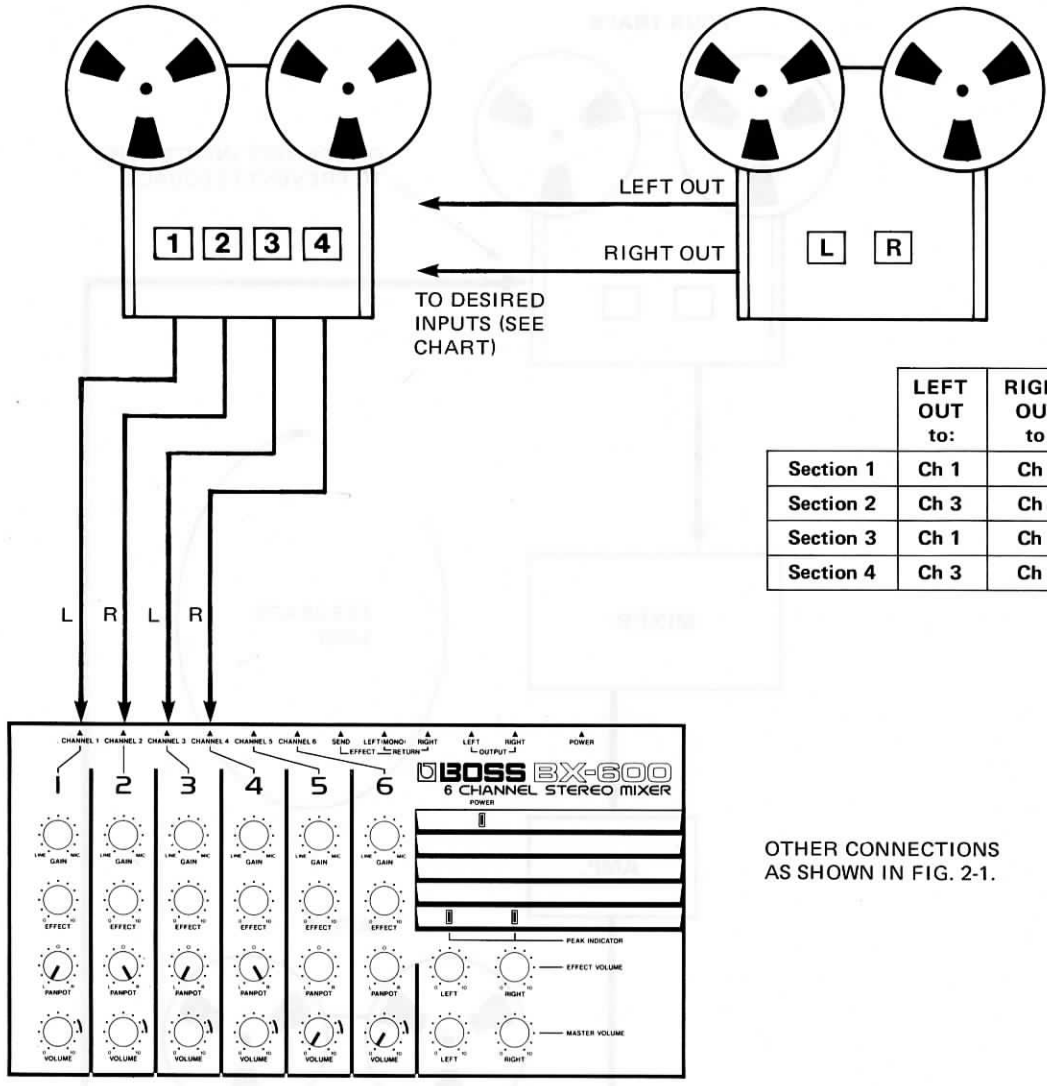
Change the connections so that now the mastering recorder left and right outputs go to input Channels 3 and 4 of the four track recorder. Load the final version of Section 2 onto the mastering recorder. Use the level reference on this tape to set the Channel 3 and 4 record levels of the four track recorder. Set the Section 2 tape at the point where the music begins. Put the mastering recorder in its pause mode and rock the reels back and forth by hand to find the exact starting point of the music. Set the tape at a point slightly in front of this start point. As a check, put the mastering recorder in its play mode, then disengage the pause control. The music should start with no pause, but without cutting off any of the attack on the first note. Reset the tape to its start point. On the four track recorder, put Channels 1 and 2 in the sync mode and Channels 3 and 4 in the record mode. Start the four track recorder at some point well before the end of the previously recorded Section 1 and count time as the music plays. An instant before the fourth beat in Measure 9, drop the mastering recorder out of the pause mode and record all of Section 2.

When finished, put all channels of the four track recorder in the play mode and play the tape to check that the transition between sections is smooth. The mixer levels may have to be adjusted so that there is no sudden change in loudness at the transition point.

The remaining sections can be added in the above manner. Section 3 would be recorded on the same tracks as Section 1. When recording Section 3, be sure to start the four track recorder at some point *after* the end of Section 1.

The resulting tape is a four track tape with the four sections of music alternating between two pairs of channels. It might be better to consider this tape the final master tape from which copies are to be made rather than mixing the result onto the mastering recorder for further copying.

Fig. 3-8 Joining the Sections



	LEFT OUT to:	RIGHT OUT to:
Section 1	Ch 1	Ch 2
Section 2	Ch 3	Ch 4
Section 3	Ch 1	Ch 2
Section 4	Ch 3	Ch 4

OVERLAPPING RECORD PATTERN (QUADRAPHONIC RECORDER)

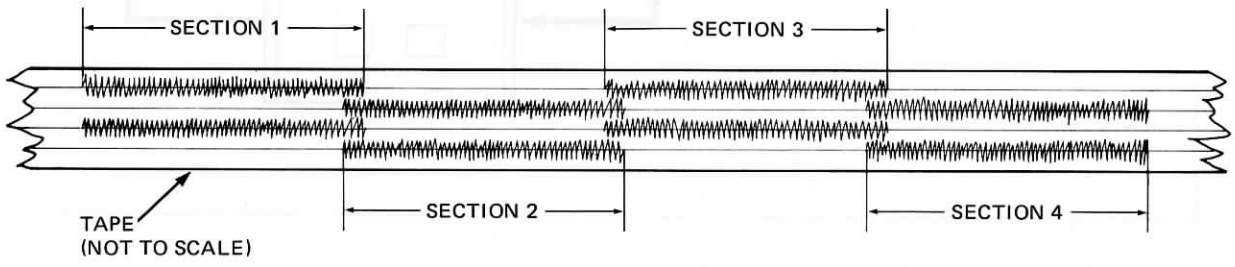
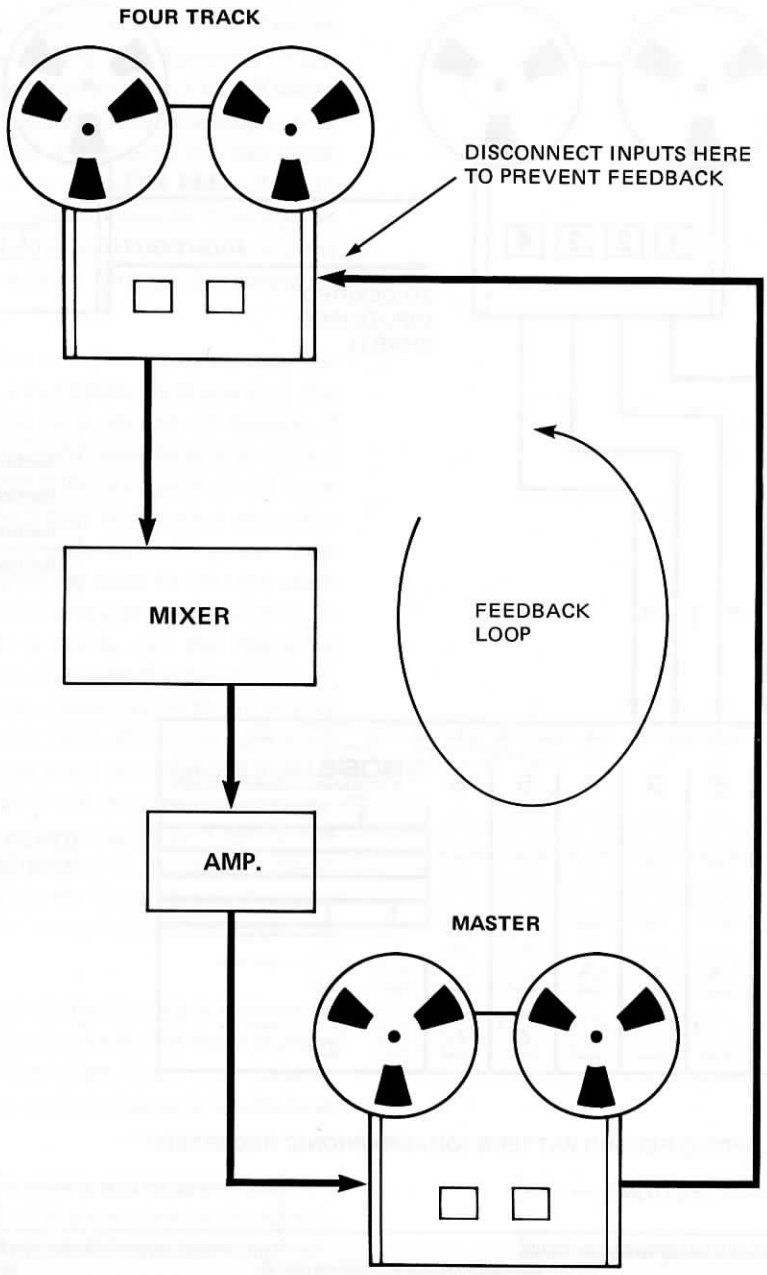


Fig. 3-9 Possible System Feedback Loop



Chapter Four:
Noise Reduction

4-1 Introduction

Noise is one of the biggest problems in multichannel recording, especially when using the quarter track format. Each time a new voice is added to the mix, the noise generated by that track is also added to the mix. There are a number of devices on the market designed for noise control and the musician who is interested in serious recording should give serious thought to procuring such a noise reduction system. Until this can be done, however, there are a number of things which can be done to help control noise.

4-2 Noise Control During Recording

The following items, when considered separately, improve noise levels slightly, but when used together will produce noticeably better results.

Always start with new or bulk erased tape. Previously recorded material which is imperfectly erased by the tape recorder can contribute to poor noise levels.

It is essential that the bias and equalization of the tape recorder match the type of tape being used. For this reason, always use the type of tape recommended by the manufacturer of the recorder. We can assume that they know their product best. This rule is especially important when using only front panel selector switches for setting bias and equalization. If more than one type of tape is recommended, use the best quality tape listed. The better quality tapes will usually produce a better frequency response and lower noise level than lower quality tapes. For the musician who has a favorite tape not listed by the manufacturer, it is possible to have the internal bias and equalization settings altered to match the tape.

Always use the highest possible tape speed when recording and use the highest possible recording level. Higher recording speeds allow higher recording levels which in turn produce a lower noise level in relation to the recorded sound. With some types of legato sounds, it is quite possible that some recorders will allow levels well over 0 VU before distortion occurs. With many percussive sounds, however, it is often necessary to record well below the 0 VU level. This is where a peak level indicator would be extremely useful. Without a peak level indicator, experimentation is the key to setting recording levels. Use the highest recording level which produces distortion-free sound on playback. Using a high recording speed produces a better frequency response, an advantage with electronic music where the frequency range is usually much wider than with conventional music.

When mixing, always try to keep the individual channel level controls high and the master output level controls relatively low for quiet passages, instead of the other way around. This will help prevent the mixer from adding noise to the music. In the same manner, keep the effect send controls relatively high and the effect return controls relatively low. This is especially true when using echo or reverberation units since these types of devices tend to produce more noise than other types of audio equipment.

4-3 Using an Equalizer

A graphic equalizer can sometimes be very useful in helping to reduce noise. Most of the objectionable noise which comes off a tape being played consists primarily of higher frequencies which produce a hissing sound. As an example of how to take advantage of this fact, if synthesizing a bass drum sound, the bass drum track can be played back through a graphic equalizer which has most of its high frequency sliders set at minimum, as shown in Fig. 4-1. This will prevent much of the higher frequency noise on that track from being added to the mix changing the bass drum sound.

Sometimes it is possible to use a graphic equalizer to add pre-emphasis to high frequencies when recording and again for de-emphasis to reduce noise when playing the tape. This works as follows: When recording, pass the sound through an equalizer set approximately as shown in Fig. 4-2(a). This will accent or emphasize the higher frequencies in the sound. When playing the tape, pass the sound through an equalizer set so as to produce a mirror image of the original curve, as shown in Fig. 4-2(b). This will have the effect of restoring the sound to its original frequency response and at the same time it will reduce the high frequency noise added in the recording process. In actual practice this method of noise reduction may not prove useful very often. This is because tape recorder circuits already incorporate this type of complemantary filtering to help reduce noise. The higher energy level produced in emphasizing the higher frequencies through an equalizer will probably necessitate a lower recording level to prevent distortion. The lower recording level will mean that the noise level will be higher than normal in relation to the recorded signal, thus, many times, offsetting the advantage obtained with the equalizer.

After going through many dubbings, the voices recorded on the first tracks have a tendancy to become dull. This is an excellent reason for recording foundation or background voices first. The fact that these voices will become dull actually enhances the overall effect. Sounds which are heard from a distance or in the background tend to be duller than sounds heard up close. If it becomes necessary to record more important parts first, it is possible to compensate for this dulling process by using a graphic equalizer to make the original sounds a little too bright when first recorded. The dulling process will then hopefully bring them down to the desired brightness.

Fig. 4-1 Reducing Noise on a Bass Drum Track

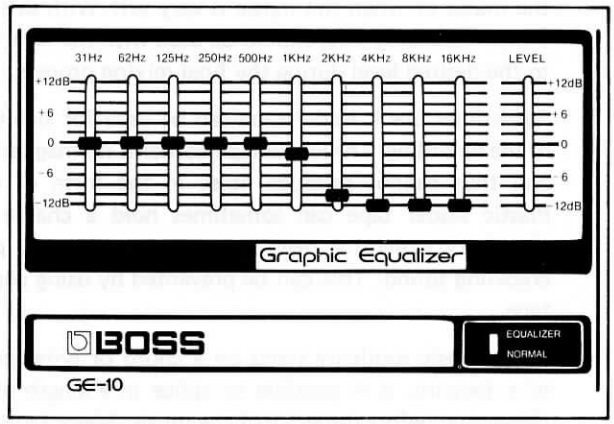
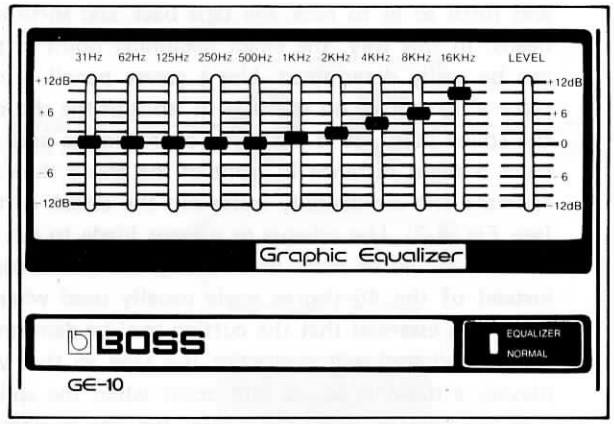
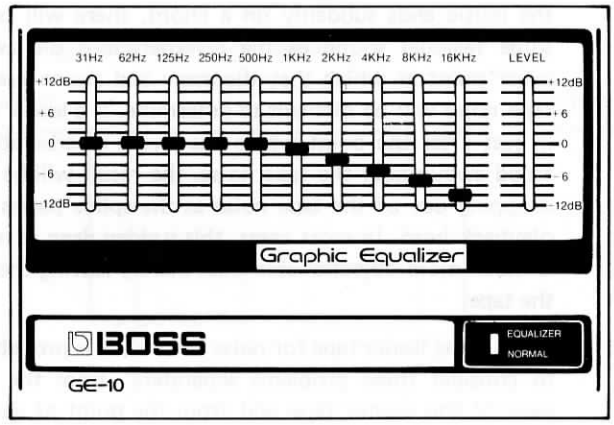


Fig. 4-2 Complementary Equalization for Noise Reduction

ⓐ Record Equalization



ⓑ Playback Equalization



4-4 Controlling Noise in the Master Tape

Normally, noise becomes a problem only in silent portions of the music or when the music is very soft. With soft passages, a high recording level should be used with the level cut down to the desired level during the final mixing process.

Sometimes blank leader tape can be used for silent portions of the recording. The leader tape contains no magnetic coating and thus cannot produce noise in the form of tape hiss. Plastic leader tape can sometimes hold a charge of static electricity which has been known to occasionally produce a crackling sound. This can be prevented by using paper leader tape.

If the music suddenly starts on a chord or note (as opposed to a fade-in), it is possible to splice in a length of leader a slit-second before the entry of the music. Many tape recorders have a pause or cue function which allows the tape transport to be stopped with the tape remaining in contact with the heads. Stop the tape at a point as near as possible to the beginning of the opening chord. With the recorder in the pause mode, grasp the two tape reels and twist them back and forth so as to rock the tape back and forth across the heads. In this way, the exact beginning point of the chord can be easily determined. Use a grease pencil or crayon to place a light mark on the tape in front of the chord to mark the splice point. It is better to overestimate and place the mark a slight distance in front of the chord than to underestimate and accidentally splice out the attack of the chord (see Fig. 4-3). Use scissors or a razor blade to cut the tape. The cut should be made at a 90 degree angle across the tape instead of the 45 degree angle usually used when splicing tape. It is essential that the cutting tool be demagnetized. A magnetized tool will magnetize the tape so that when it is played, a popping sound will occur when the splice passes over the playback head. The cutting tool can be demagnetized in the same way that the tape recorder heads are demagnetized.

The end of the music presents a different problem. Even if the music ends suddenly on a chord, there will be at least some residual sound as the reverberations die away. The exact point at which they die away and are covered by the tape noise will be difficult to determine. If a leader is spliced in just after the point where the dying reverberations have faded away under the tape noise, the result will be a sudden dropping out of the tape noise as the splice passes over the playback head. In most cases, this sudden drop in noise level is much more objectionable than merely leaving the noise on the tape.

When using leader tape for noise control, it is probably better to consider these problems separately: from the point of view of the master tape and from the point of view of the copies made from the master tape. With the copy, it may prove better to forget noise control and leave the noise generated by the copy tape, the only exception being that the first selection on the tape can start with the leader spliced just before the first sound.

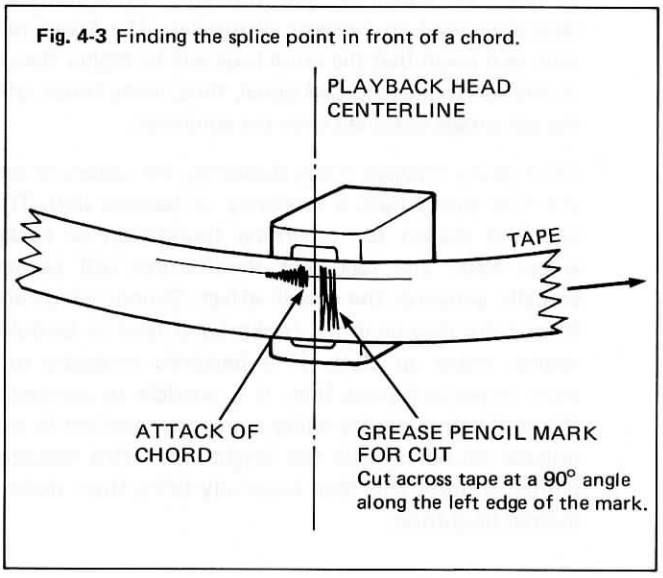


Fig. 4-3 Finding the splice point in front of a chord.

For the master tape, there can be leader tape between each selection. At the end of each selection, there should be several seconds between the final reverberations and the start of the leader tape. When copying the master tape, run the output of the master tape through the mixer. Make notes of the mixer levels needed so that each selection has the proper dynamic (loudness) level in relation to the tape program as a whole. When the end of a selection comes when copying, use the mixer's master gain controls to "follow" the fade-out of the final reverberations while listening carefully to the result. This operation is surprisingly easy and requires very little practice. It prevents noise from the master tape from being transferred to the copy. When the leader appears at the playback head of the master tape, move the mixer's master gain controls up to the level needed for the next selection. Do this just before the leader tape ends to minimize noise added by the mixer.

4-5 Using Noise Gates

Noise gates represent an inexpensive way to electronically control noise. In the process given above where the mixer faders were used to control noise between compositions on the master tape, it would be possible to use noise gates and eliminate the necessity of manipulating the mixer controls. In fact, if the dynamic levels of the compositions are all approximately the same, the mixer itself could be eliminated from the process.

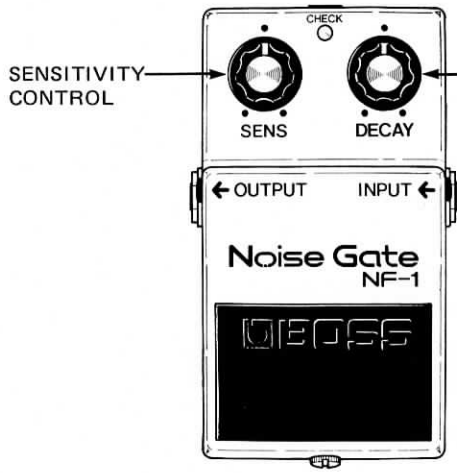
Fig. 4-4(a) shows an inexpensive noise gate designed as an accessory for electric guitars. The quality of this unit is such that it would make an excellent noise control device for electronic music studios, even on a professional level.

Fig. 4-4(b) shows a block diagram for the noise gate. When the detector senses the presence of a music signal, it triggers the envelope which opens the gate to let the music signal through. When there is no music signal, the gate is closed so noise from the source is blocked. Electronically, there is little difference between noise and music: They are both complex audio signals. Fortunately, however, noise levels are usually much lower than music signal levels. Ideally, the sensitivity of the detector section is set at a point slightly above the highest noise level which is expected, thus the noise gate will open only for the much higher music signal levels.

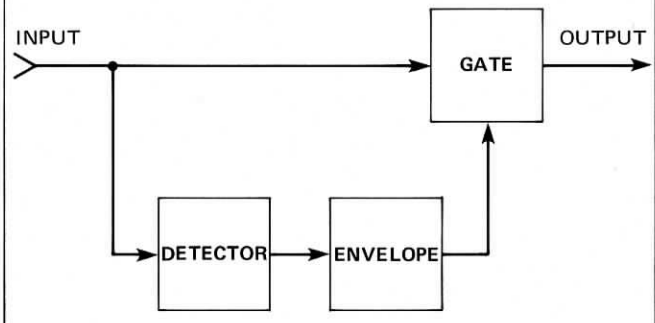
If the noise gate merely "snapped" open and closed when passing music and blocking noise, the end result would be almost exactly the same as using leader tape to control noise. It is desirable for the gate to open quickly so that the sharp attack of a percussive sound remains sharp. When the gate closes, however, it is desirable for the gate to close more slowly so that it "follows" the sound as it dies away, much as the mixer fader was used to control noise as described in the previous section. Different music will require different rates of fade-out. The decay control of the envelope section allows this fade-out time to be adjusted so as to match the music being played.

Fig. 4-4 Noise Gate

ⓐ Boss NF-1 Noise Gate



ⓑ Noise Gate Block Diagram



Ideally, when the noise gate is used, it should be impossible for the listener to detect that a noise gate has been used, except for the fact that there will be no noise in the silent portions of the music.

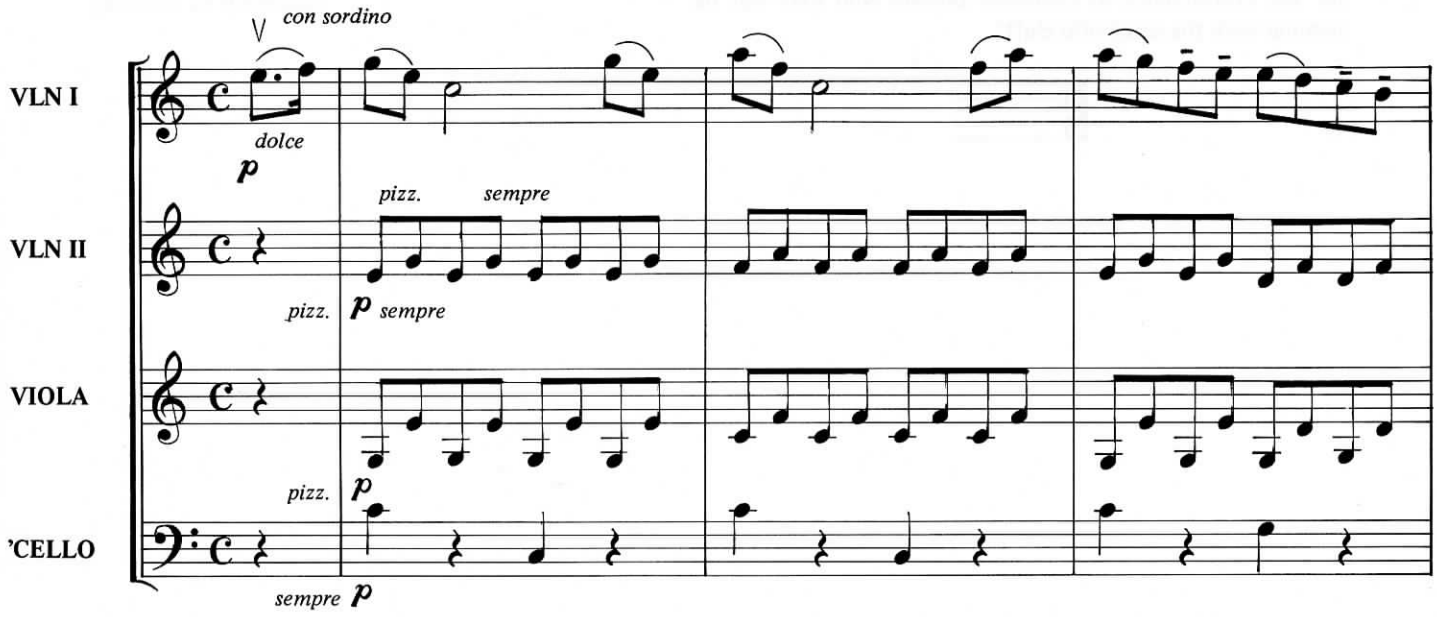
Appendix

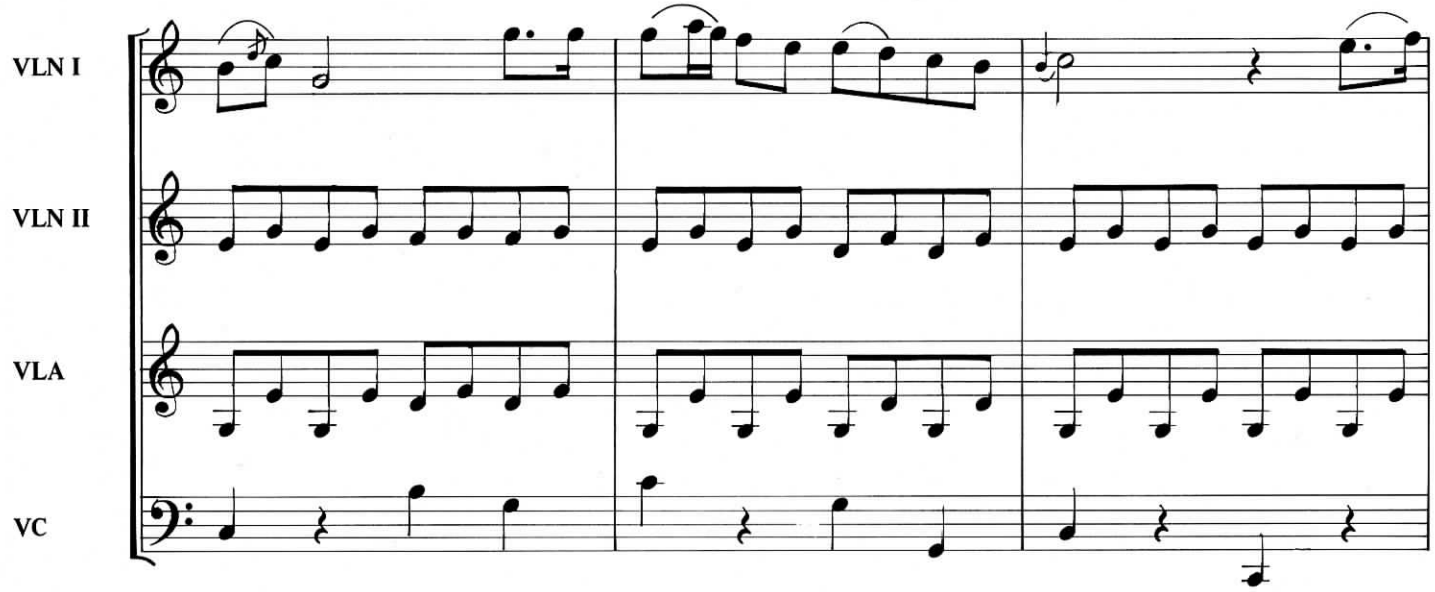
Note:

The viola part has been written in the treble and bass clefts for the convenience of keyboard players who may not be familiar with the usual alto cleft:

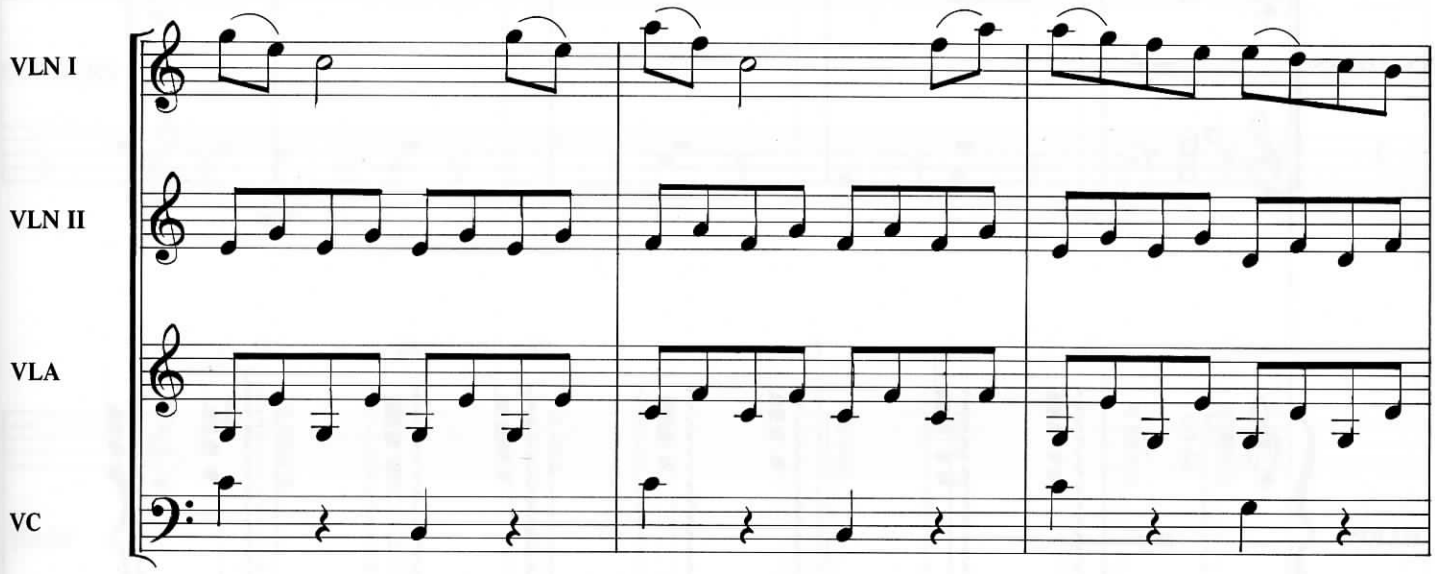
SERENADE

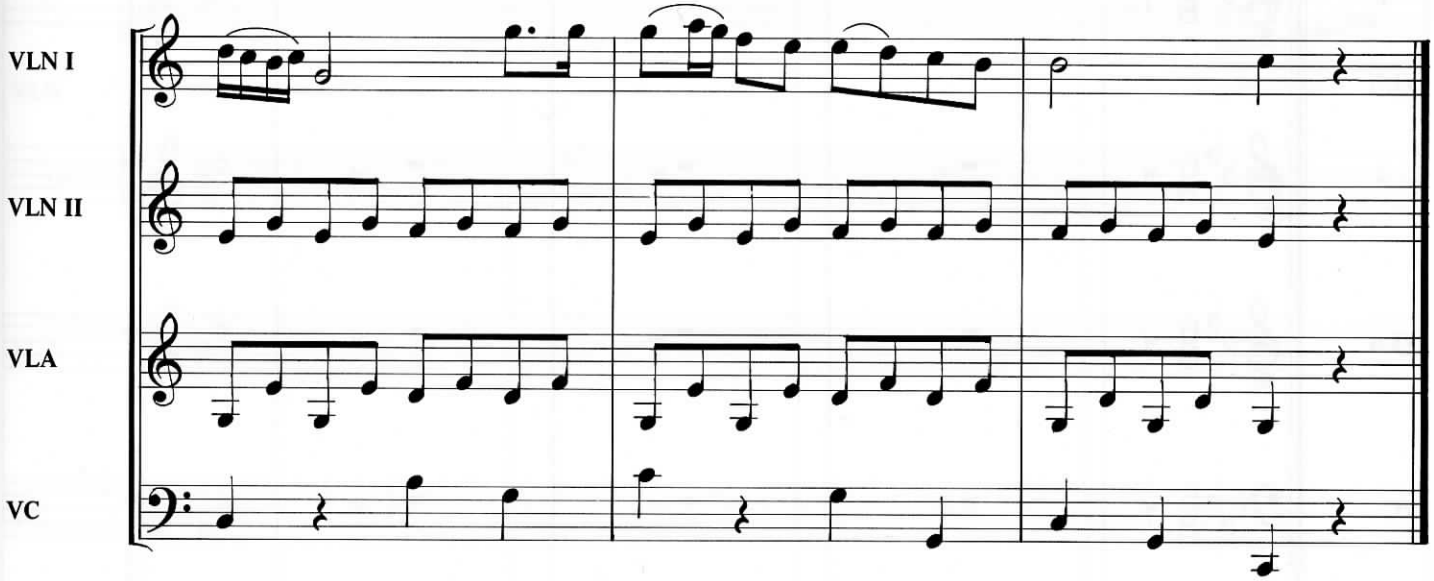
ANDANTE CANTABILE **HAYDN**

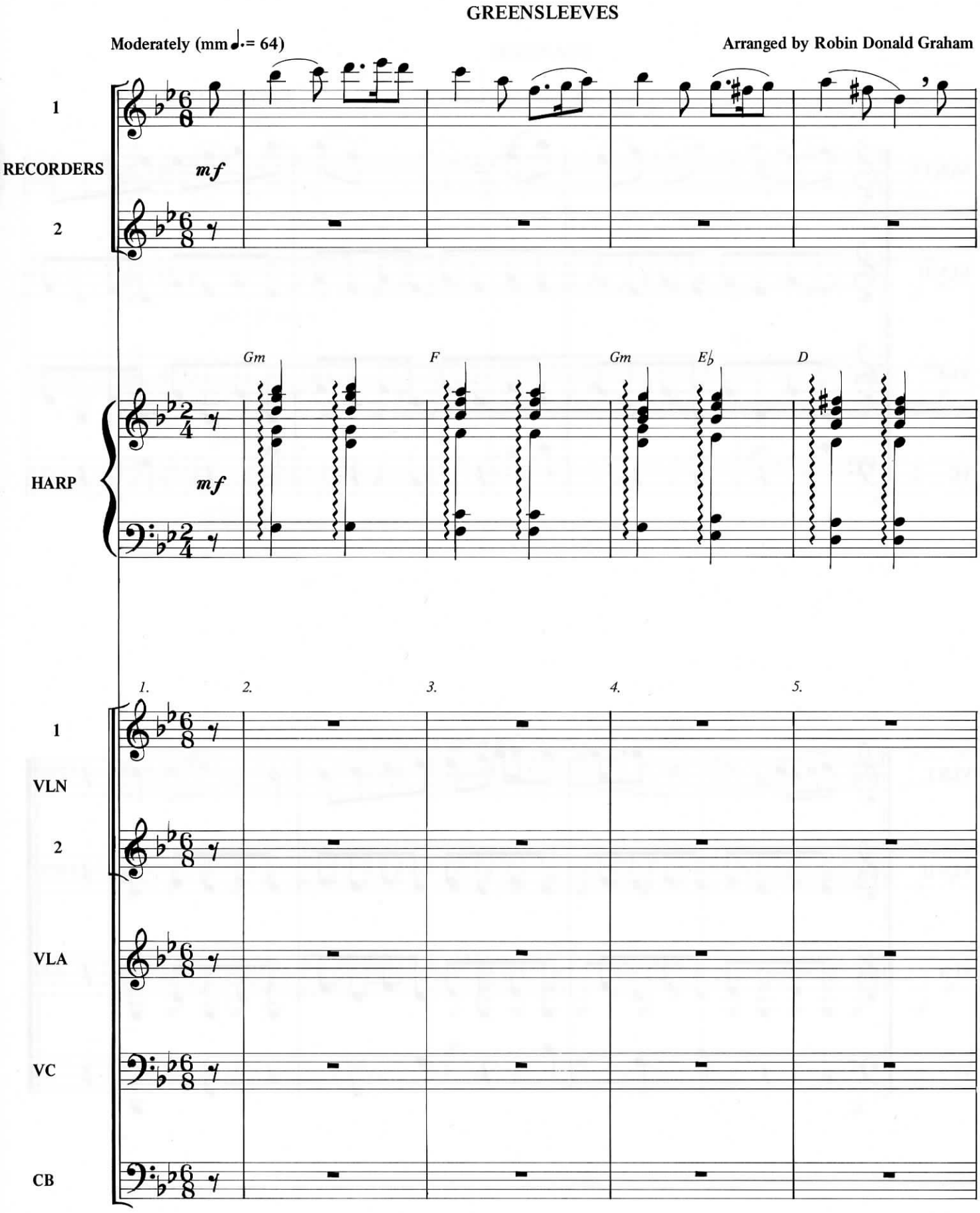




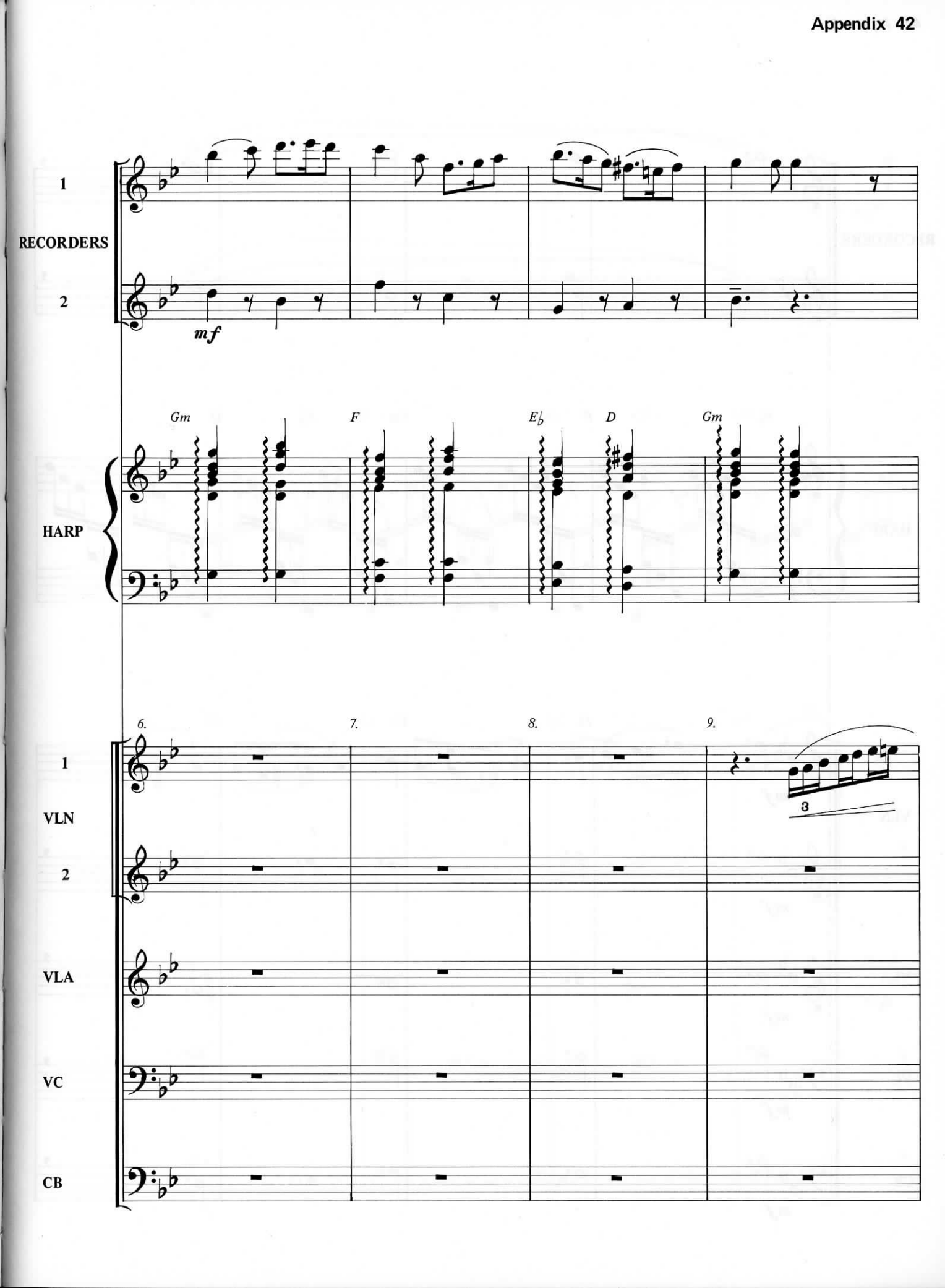
Step-by-step instructions for recording this music are given in Chapter 2 (p. 11).

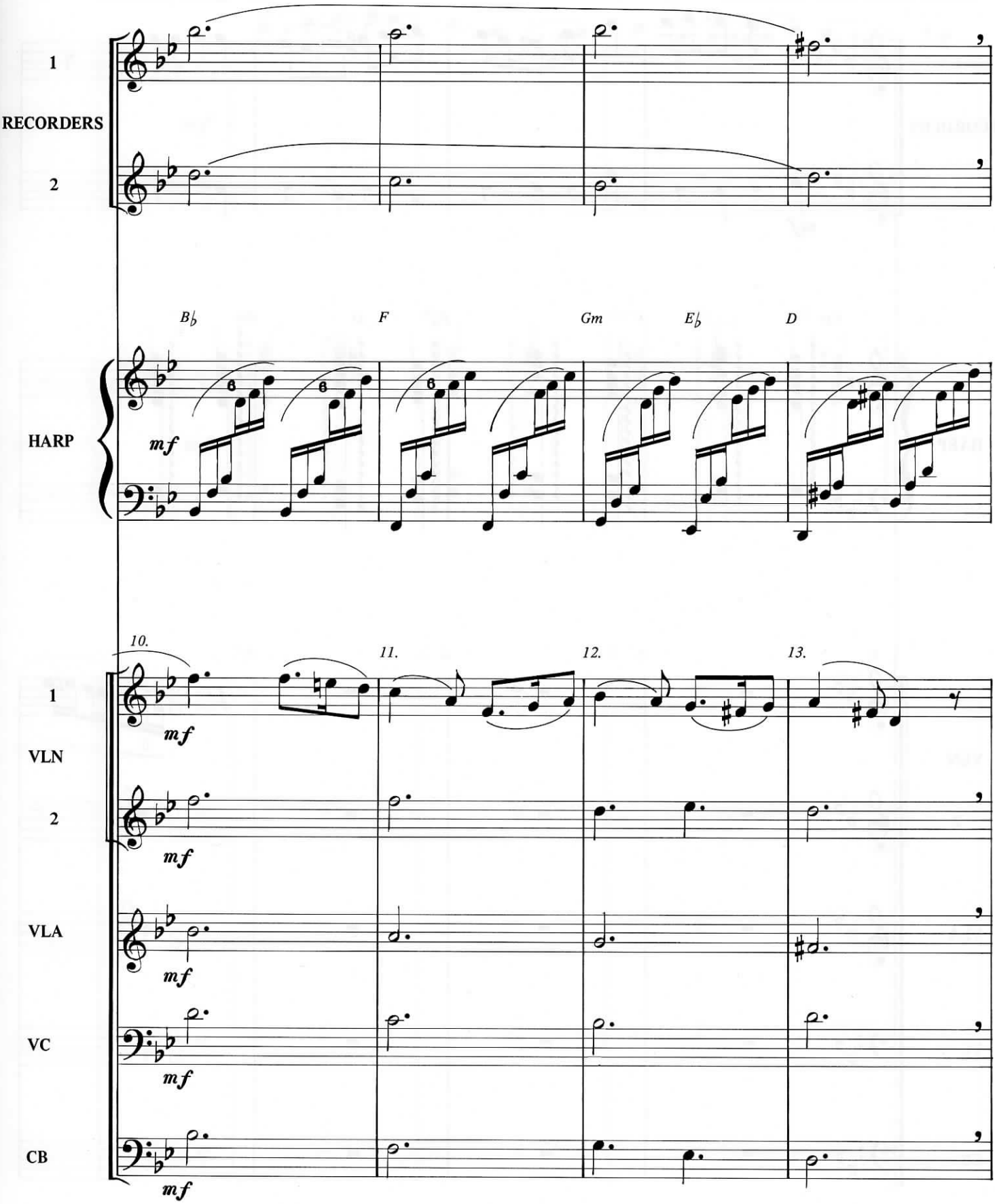

VLN I
VLN II
VLA
VC

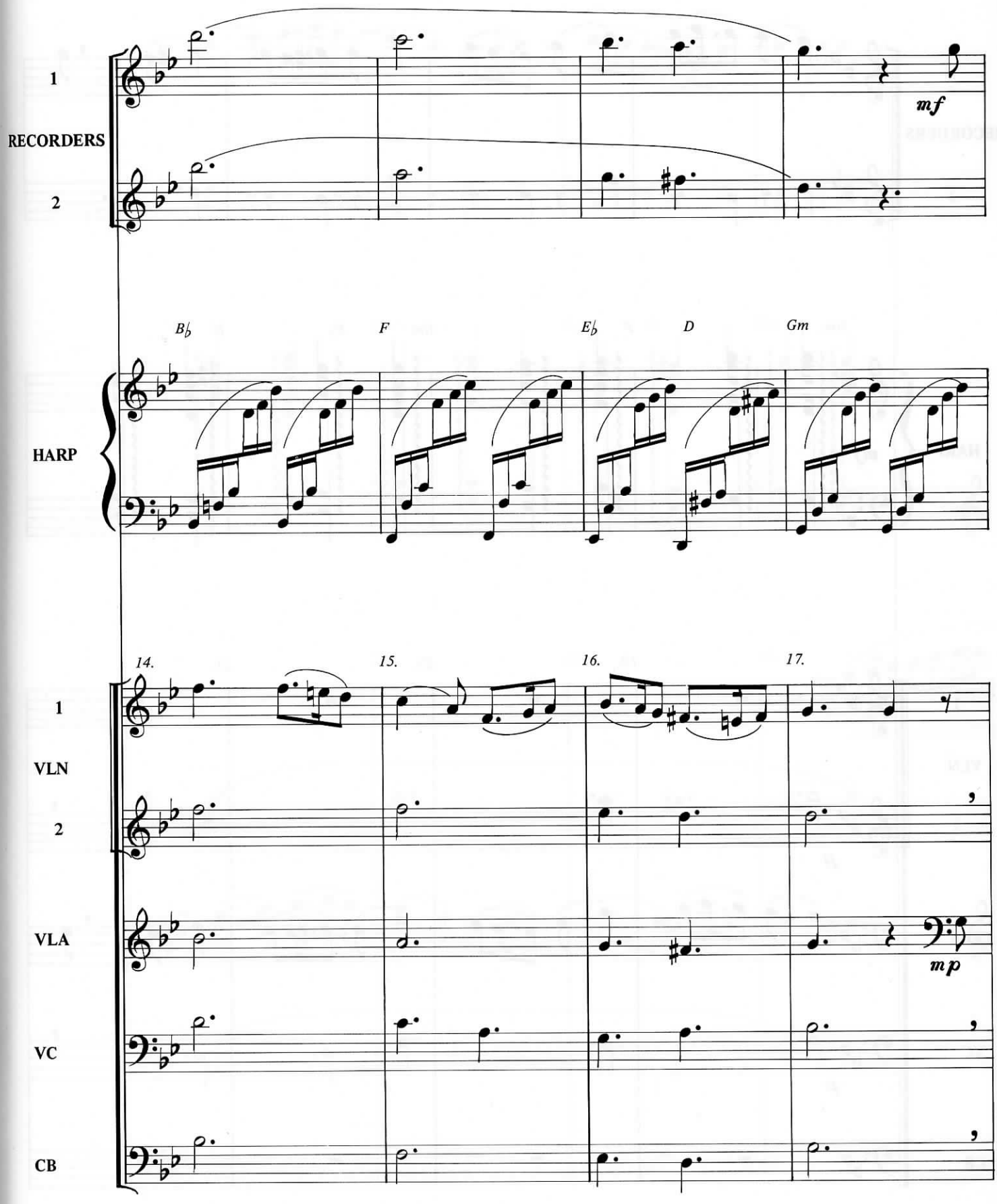

VLN I
VLN II
VLA
VC

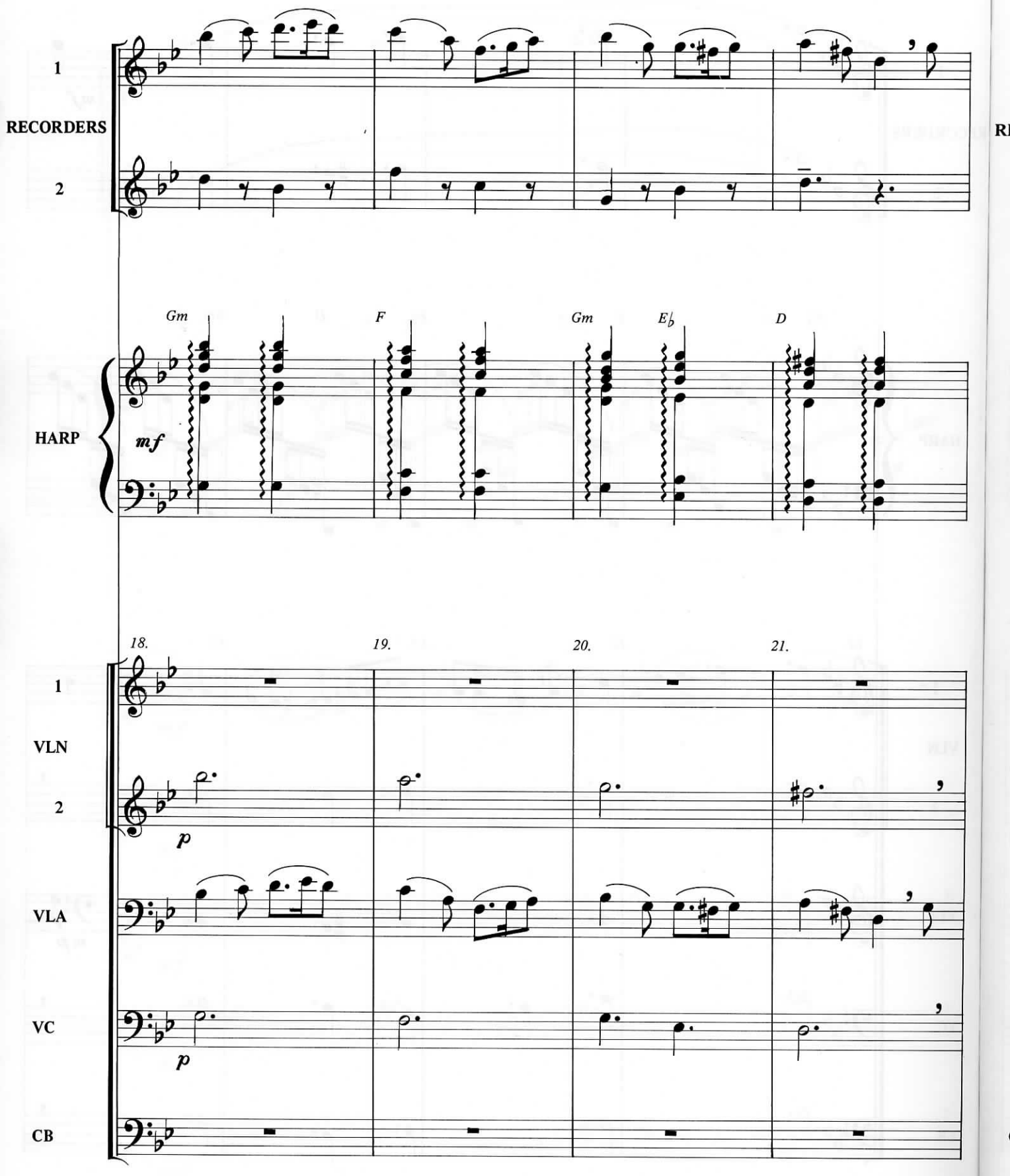


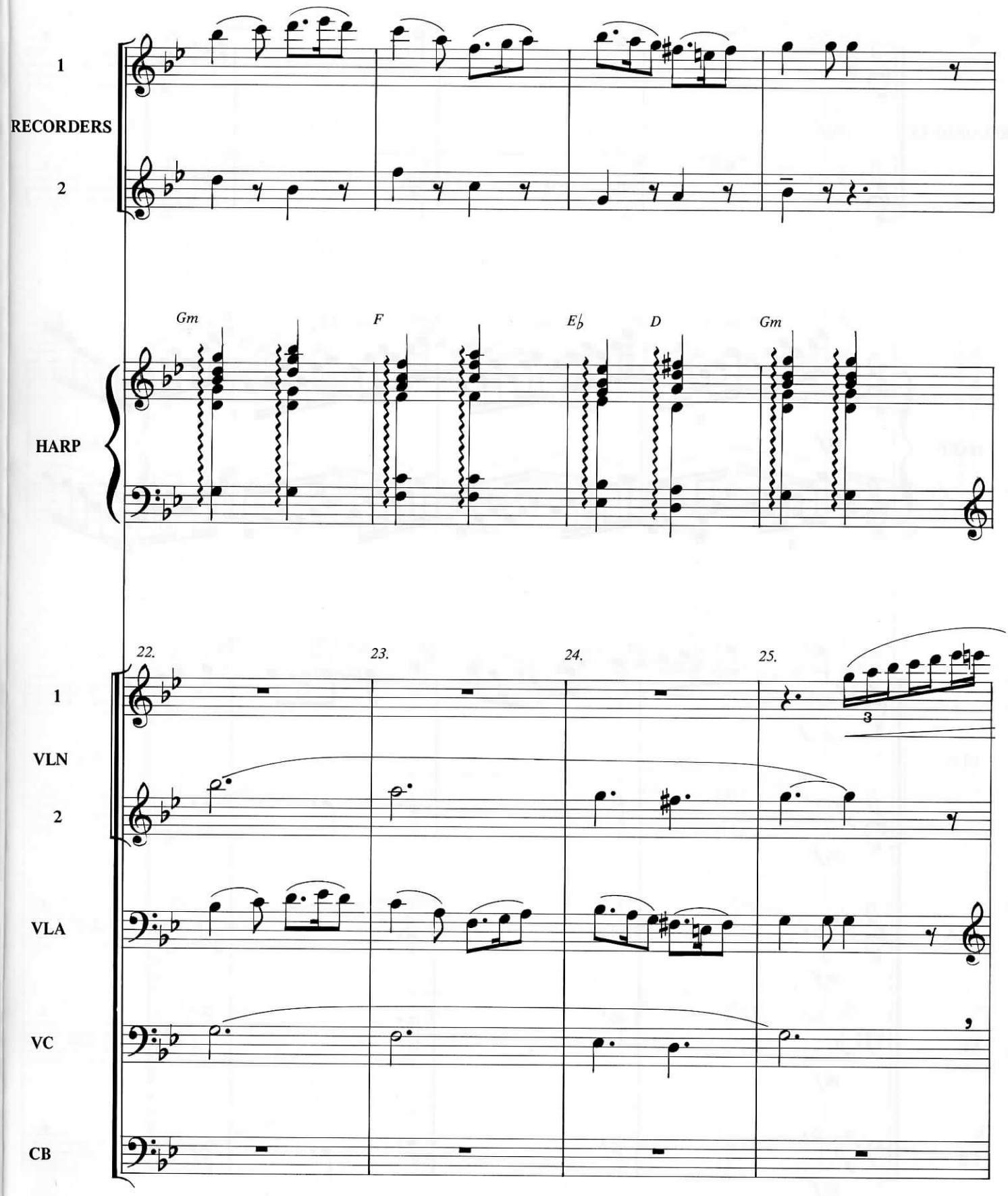
Step-by-step instructions for recording this music are given in Chapter 3 (p. 19).

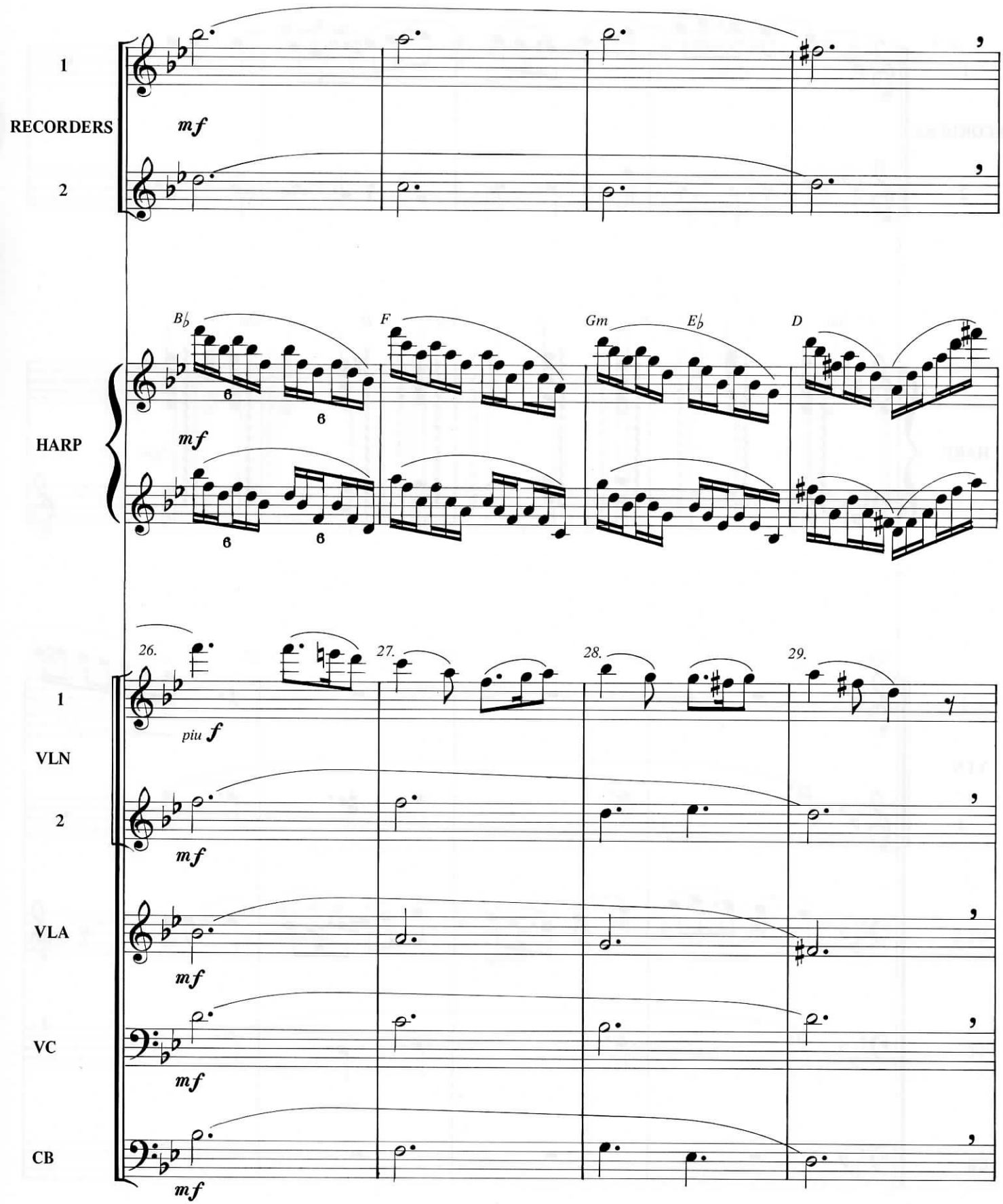

1
RECORDERS
2
mf
Gm
F
E♭
D
Gm
HARP
6.
7.
8.
9.
1
VLN
2
3
VLA
VC
CB

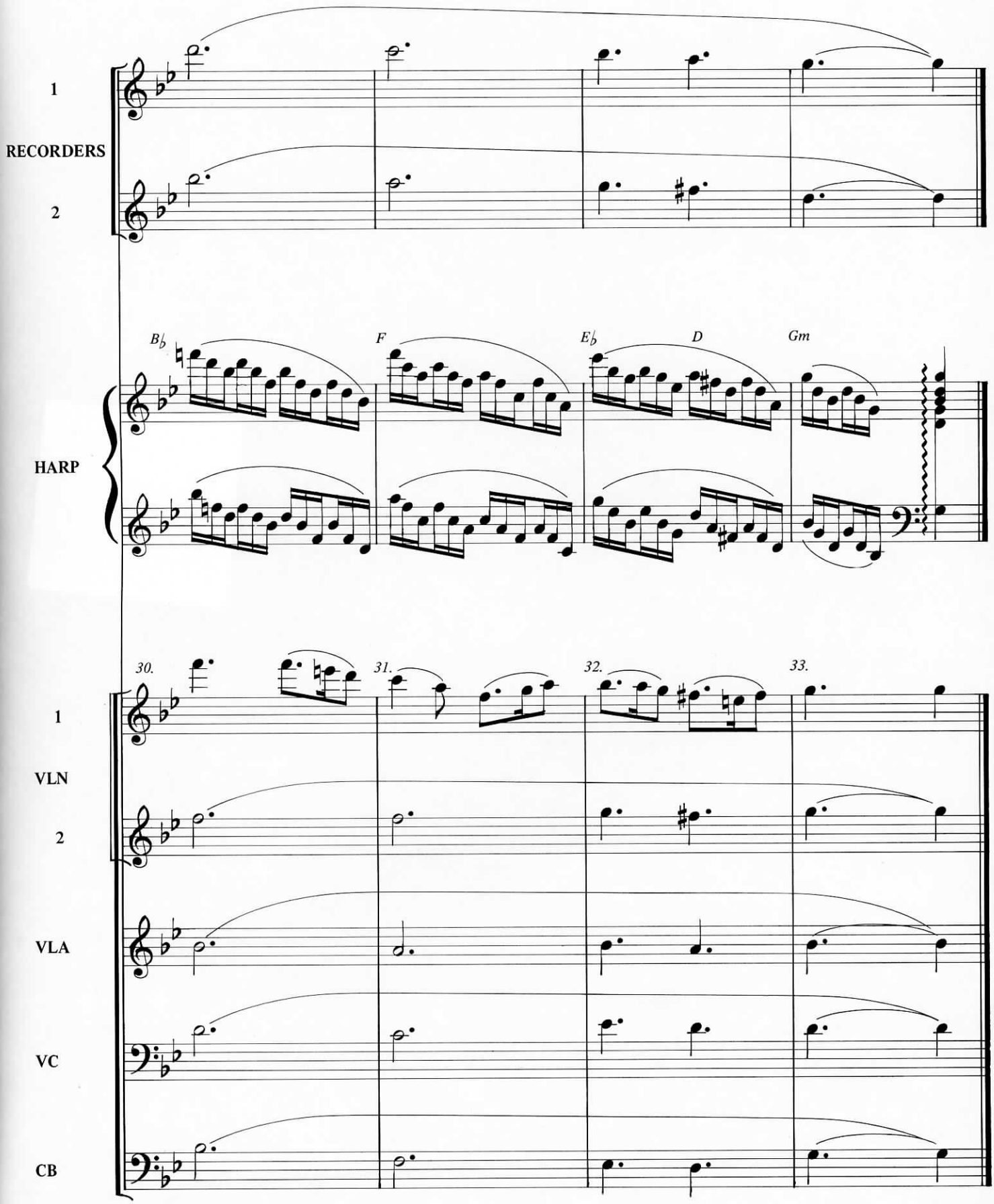

1
RECORDERS
2
B♭
F
Gm
E♭
D
HARP
mf
10.
11.
12.
13.
1
VLN
2
VLA
VC
CB
mf


1
RECORDERS
2
mf
B♭
F
E♭
D
Gm
HARP
14.
15.
16.
17.
1
VLN
2
VLA
mp
VC
CB


1
RECORDERS
2
Gm
F
Gm
E♭
D
HARP
mf
18.
19.
20.
21.
1
VLN
2
p
VLA
VC
p
CB


1
RECORDERS
2
Gm
F
E♭
D
Gm
HARP
22.
23.
24.
25.
3
1
VLN
2
VLA
VC
CB


1
RECORDERS
2
mf
HARP
B♭
F
Gm
E♭
D
mf
26.
27.
28.
29.
1
VLN
2
VLA
VC
CB
piu f
mf


1
RECORDERS
2
B♭
F
E♭
D
Gm
HARP
30.
31.
32.
33.
1
VLN
2
VLA
VC
CB