The Tape Guide

Stereo Considerations

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For those considering the purchase of a stereo tape machine here is an informed discussion of the merits of four-track tape systems.

MOST OF WHAT has been said in previous articles applies to mono and stereo tape operation alike (unless specifically directed at one or the other). However, stereo recording and playback entail certain special questions, which are the concern of the present article. The topics to be discussed here are four-track versus two-track stereo, the tape cartridge, coordination of the two channels, and conversion for stereo.

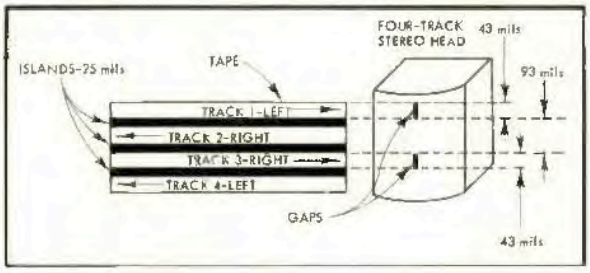

Fig. 2. Four-track stereo tape.

Four-Track Stereo

When stereo tape was first introduced, it employed the same track arrangement as half-track mono tape, shown in *Fig.* 1A, except that the lower track (for a tape running from left to right) was used for the second channel. Originally, a staggered-head arrangement, shown in *Fig.* 1B, was used to record and play 2-track stereo tape, but this eventually gave way to a single in-line head, shown in *Fig.* 1C. The staggered arrangement employed two conventional mono heads, spaced about 1¼-in. apart, and positioned so that the gap of one head spanned the upper track while the gap of the other spanned the lower track. Use of separate heads permitted individual adjustment of azimuth of each gap, assuring maximum treble response on each channel; and it avoided the problem of crosstalk between heads, namely the appearance of the left signal in the right head and vice versa.

With improvements in manufacturing techniques, the in-line head proved to be a reliable and not overly expensive device. Thus the staggered-head arrangement, innately a clumsy one, became obsolete, and so did the tapes that had been recorded by this method. It was not feasible to use an in-line head to play a tape with a displacement of 1¼-in. between channels, corresponding to a time difference of 1/6 second at 7.5 ips and 1/3 second at 3.75 ips.

Two-track stereo tape ran into problems of tape economy and convenience

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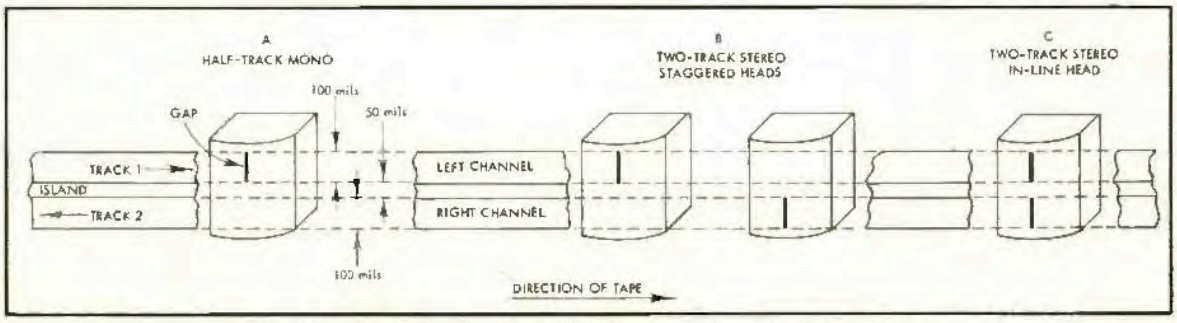

Fig. 1. Head configurations for half-track mono and two-track stereo tape.

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of operation. In the case of mono half-track operation, one could record or play the tape in one direction, reverse the reels, and promptly continue operation in the other direction. But two-track stereo permitted the tape to be used only in one direction, which was wasteful of tape, particularly for commercial applications. In the case of prerecorded tape, the tape itself presents a major item of cost, whereas in the case of a phonograph disk the vinylite material is a matter of a few cents. Moreover, after a two-track tape has been recorded or played, it is necessary to rewind it in order to get it back on its original reel; this is not the case for mono half-track tape, where half the width of the tape (approximately) is recorded in one direction and the other half in the opposite direction.

The problems of tape economy and convenience of operation were solved by four-track stereo recording, as shown in *Fig.* 2. Tracks one and three are recorded (and played) in one direction, and, after the reels are reversed, tracks four and

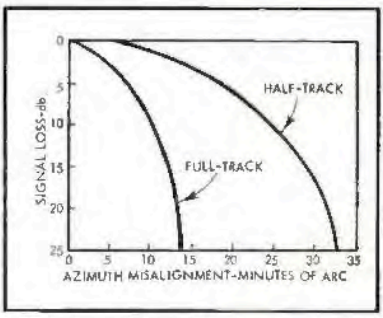

Fig. 3. Signal losses due to azimuth misalignment at 7500 cps at a tape speed of 7.5 ips.

two are recorded in the other direction.

The major disadvantage of four-track compared with two-track tape is a reduction in signal-to-noise ratio. The tracks of the former are about half the width of the latter, so that there is a proportionate reduction in the amount of signal that is recorded. Consequently the signal level obtained from the four-track tape in playback is about 6 db less than the signal from a two-track tape. This means that the ratio of audio signal to noise and hum produced by the tape recorder electronics is decreased 6 db.

However, ways are being found around this problem. For one thing, tape electronics today tend to be less noisy than those of yesteryear due to improvements in circuit design and in tubes or transistors. For another, it is possible through skillful design to produce playback heads with increased output for a

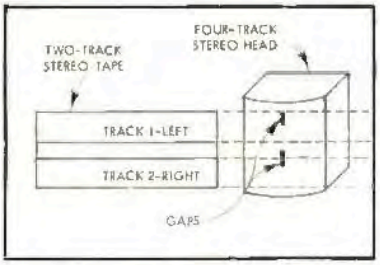

Fig. 4. Mismatch between the lower gap of a four-track stereo head and the lower track of a two-track stereo tape.

given amount of signal recorded on the tape. Third, there have been continual improvements in tape quality, and it is reasonable to believe that time will bring improvements with respect to the amount of signal that can be recorded on the tape without increasing distortion or other undesirable effects. In sum, one may look forward to eventually achieving a signal-to-noise ratio on four-track track that approaches the ratio achieved in the past on two-track tape.

On the other side of the coin, four-track stereo tape has two positive advantages over two-track tape. One is the fact that azimuth alignment becomes less critical as track width is decreased, thereby reducing treble losses due to slight departures from exact azimuth. *Figure* 3 suggests the benefits obtained from narrowing the track. It compares azimuth losses for a half-track mono recording with those for a full-track mono recording. Obviously, much greater azimuth misalignment, in relative terms, is tolerable for the narrower track. The benefits obtained by going from two- to four-track stereo are comparable with those indicated in *Fig.* 3.

The second advantage of four-track tape lies in the greater separation between the two gaps of the in-line head. Hence there can be greater separation between the two sections of the head, resulting in less crosstalk. Comparison of *Figs.* 1C and 2 shows that there is 50 mils (thousandths of an inch) separation between the gaps of a two-track stereo head, compared with 93 mils between the gaps of a four-track head.

Although it is indicated that four-track stereo tapes will supersede two-track stereo tapes, there will remain the problem of playing valued two-track tapes purchased or recorded in the past. Therefore the manufacturers of tape machines have sought to make it possible to play two-track stereo tapes with four-track heads. The problem lies in the fact that the lower gap of the four-track head does not lie fully within the recorded area of the lower track of a two-track tape. This is made clear in *Fig.* 4. The fact that part of the lower gap spans unrecorded space means less output on the lower track, with a consequent reduction in signal-to-noise ratio.

Some tape machine manufacturers have chosen to accept this limitation on signal-to-noise ratio of one of the channels. Others, however, have incorporated a mechanical device for shifting the head up and down. For four-track tape, running from left to right, the head is shifted up. It is shifted down for two-track tape. There is some danger of impairing azimuth alignment as the head is shifted up or down. Consequently in a few high-price machines a separate head has been introduced for playing two-track tapes.

Most home tape machines use the same head for record and playback. Such machines, perforce, permit four-track recording as well as playback. However, the higher-price tape machines usually employ separate record and playback heads. Some of them use two-track record heads, while others provide four-track record heads. It would appear, however, that eventually all home machines will permit four-track recording.

(As a side note, it is of interest to observe that the four-track head makes possible four-track *mono* operation, thereby doubling the playing time obtainable from a reel of tape. The recording or playback sequence is: tracks one, four, three, and two. A number of tape machines, through extra switching facilities, take advantage of this opportunity. Switching must do the following: (1) In recording, it must channel the input signal first to one section of the head (for tracks one and four) and then to the other section of the head (for tracks three and two). (2) At the same time, in recording, it must shut off the bias current to the record head section not in use and it must shut off the erase current to the erase head section not in use. (3) In playback it must channel the signal first from one section of the head and then from the other section to one of the playback amplifiers. If one uses

Fig. 5. The RCA tape cartridge.

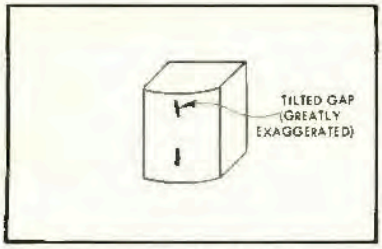

Fig. 6. Stereo head with tilted gap.

double-play tape at 1.875 ips, it is possible to record as much as 17 hours of program material on a 7-in. reel.)

The Stereo Cartridge

It has long been the goal of a section of the tape industry to simplify the playing of prerecorded tape to the point where this is just as easy as playing a phonograph disc. To this end the tape cartridge has been introduced. First on the scene was the RCA cartridge, shown in *Fig. 5*, which houses the tape in a plastic container with apertures that permit the tape to contact the heads, capstan, and guides. It is merely necessary to position the cartridge on a tape machine designed for the purpose and push a button, whereupon the machine takes over without the need for the operator ever to touch the tape. Some cartridge players are designed to stop the tape after it has played in one direction, while others will reverse the tape and play it back in the opposite direction against another head, after which the tape is automatically stopped.

The RCA cartridge can hold up to 600 feet of tape, which at 7.5 ips affords a maximum playing time of 32 minutes if the tape is operated in two directions. But to be competitive with the stereo disc, the stereo cartridge must be able to provide up to an hour of program material. Therefore it is necessary to reduce the speed of the tape cartridge to 3.75 ips. In sum, the RCA tape cartridge and the 3.75 ips speed go hand in hand.

Fortunately, improvements in tape heads, in other components, and in techniques have made it possible to obtain good fidelity at 3.75 ips. Thus it appears that the tape cartridge will prove to be a suitable medium for popularizing prerecorded tape. While the 3.75 ips speed may not be suitable (yet) for truly high fidelity, it is still good enough to provide pleasurable reproduction of music to the many persons who own moderate-price sound systems and who do not demand the ultimate in available quality.

On the other hand, for those who demand the best it appears that for some time to come the 7.5 ips speed will be used, combined with four-track stereo recording on open reels.

At 3.75 ips, it is possible today, owing to playback heads with extremely fine gaps, to preserve frequency response substantially out to 15,000 cps, closely rivalling the performance at 7.5 ips in this respect. Still, in terms of distortion and signal-to-noise ratio, 3.75 ips recordings lag behind those at 7.5 ips. To achieve response out to 15,000 cps or thereabouts at 3.75 ips, it is necessary to reduce bias current fed to the record head below the value employed at 7.5 ips, thereby reducing treble losses due to bias erase. The decrease in bias current results in an increase in distortion. The increase in distortion can be offset by lowering the recording level. But the latter measure means less signal on the tape and therefore a lower signal-to-noise ratio in playback. In practice, the course usually followed is to accept some increase in distortion and some decrease in signal-to-noise ratio, rather than just one or the other.

As stated just before, response to 15,000 cps is feasible at 3.75 ips. But to achieve such response, greater attention must be paid than at 7.5 ips to factors that can adversely affect treble response: too wide a gap in the playback head; incorrect azimuth alignment; poor tape to head contact because of dirt, brittle

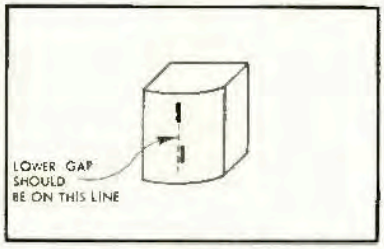

Fig. 7. Stereo head with displaced gap.

tape, improperly adjusted pressure pads, etc.; excessive bias current to the record head; improper record or playback equalization.

Although the 3.75 ips speed has only quite recently, and after much striving, proven capable of good quality, the 1.875 ips speed is hard on its heels in vying for serious consideration. The further reduction in speed would make prerecorded tapes still more economical and would permit tape cartridges and cartridge players to be more compact. Along this line CBS and the 3M Co. recently announced a tape cartridge designed to be operated at 1.875 ips. While commercial production was estimated to be several years distant, demonstrations to the trade were convincing as to the possibilities of good results at this speed. Moreover, the machine designed to play this cartridge incorporated a changer mechanism, putting tape fully on a par with the phono disc for simplicity and convenience of operation.

It may be added that a number of open reel tape machines already incorporate the 1.875 ips speed. While they do not claim high fidelity performance at this speed, the results are surprisingly good. For example, they can reproduce music quite satisfactorily for background or party purposes, where the presence of competing sounds makes it pointless to strive for high fidelity. But the 1.875 ips cartridge proposes to go a major step forward by lifting the quality at this speed to meet at least minimum high fidelity requirements.

Coordination of Channels

A unique problem of stereo tape machines is that of properly coordinating the two channels in various respects. This problem may lie with the manufacturer of the machine, with the user, or partly with both.

1. *Co-Linearity of the Stereo Head Gaps.* One of the problems of manufacturing a good stereo head is to insure that the gaps are in exactly the same straight line. If one gap is tilted with respect to the other, as illustrated in *Fig. 6*, then it is not possible to achieve correct azimuth on both channels simultaneously; hence high frequency response will suffer on one channel or the other, or both. If one gap is displaced with respect to the other, as illustrated in *Fig. 7*, then the time relationship between the left and right signals will be altered. Some experts have claimed that extremely small changes in the time relationship can significantly alter the stereo effect.

2. *Equal Playback Levels.* One section of a stereo playback head may produce a few db more signal output than the other for the same amount of signal level recorded on the tape. Or one playback amplifier may have more gain than the other. To determine the relative playback levels on each channel, set the playback gain controls at the position most apt to be used, and play a full-track test tape. Compare the signal levels with a VTVM or by ear, assuming in the latter case that the channels of the rest of the audio system are balanced right through to the speakers. Adjust one of the gain controls on the tape machine for equal volume on both channels. If the tape machine does not have separate playback gain controls for each channel, then it becomes necessary to use the input level sets, if any, on the audio system amplifier to equate the signals. If there are no input level sets, then the balance control of the stereo amplifier must be used for this purpose. It is then necessary to take note of the balance control setting which achieves signal equality on tape playback.

3. *Equal Recording Levels.* Some tape machines use a single switched record level indicator for both channels, while others use separate indicators for each channel. The fact that both indicators

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give the same reading does not necessarily signify that the same level is being recorded on each channel of the tape. For the same signal input, there may be differences in recording level due to variations between the sections of the stereo record head. Or, for the same signal input, the recording level indicators may each give a slightly different reading. To check for equal recording level and the relative indications by the record level indicators, the following procedure can be used.

Assume that the position of the playback gain controls for equal signal output has already been determined. Feed the same signal, say from a mono phonograph disc, into each recording input. Adjust the input gain controls for equal indications on the record-level indicators. Play back and compare the signal outputs with a VTVM, or by ear. If these signal outputs differ substantially, repeat the process, but after reducing the recording gain control setting for the channel with the louder signal. Continue this procedure until the playback signals on the two channels appear equal. Now note the relative indications on the record-level indicators, and be guided accordingly in the future.

4. *Matched Frequency Response.* A check for reasonably similar frequency response on each channel can be made quite easily. Record a high quality mono disc on both channels; the disc should be one that substantially covers the audio range. Then in playback compare one channel with the other by switching between the left signal and the right signal, as most stereo amplifiers enable one to do. If there is a significant difference in frequency response between channels, this can be due to such factors as differences in equalization, in bias current, in playback head gap width, and in azimuth alignment. The last three factors named will primarily affect treble response.

5. *Common Bias Frequency.* It is im-

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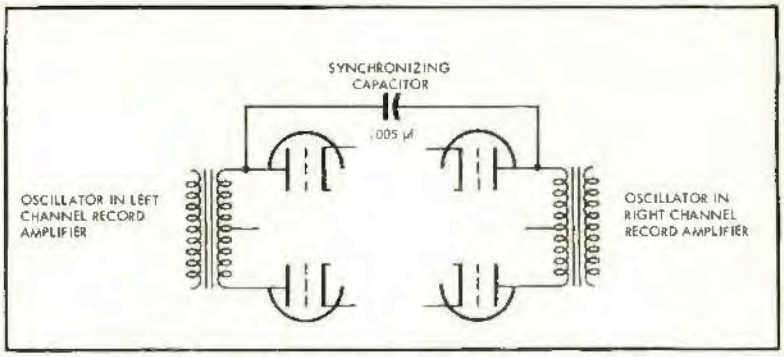

Fig. 8. Synchronizing the frequencies of two bias oscillators.

portant that the bias frequency be the same on each channel. Bias current passing through one section of an in-line head tends to leak through to some degree to the other section. Hence there are two bias currents through each section, although of different magnitude. If the frequencies of these two currents are different, there will be resultant beat frequencies that are recorded on the tape. If the stereo tape recorder employs separate record amplifiers for each channel, each with its own bias current supply, it becomes necessary to synchronize these two frequencies so they are the same. This is a simple matter, at least for the audio technician. As shown in *Fig.* 8, a small capacitor can be connected from the plate of one bias oscillator to the plate of the other for synchronization. This assumes that the two bias frequencies were originally fairly close together, say within about 10,000 cps of each other.

6. *Crosstalk.* Coordination between channels in this case means keeping the left signal in the left channel and the right signal in the right channel. Crosstalk can occur because of improper vertical positioning of the head or because of construction of the head. In modern high quality heads, crosstalk within the head has been reduced to negligible proportions by shielding between sections and by other design factors. Such crosstalk as does occur consists primarily of the higher audio frequencies, so that crosstalk due to the head characteristically has a tinny sound.

Conversion for Stereo

Converting a tape machine for stereo purposes may mean either (1) converting from mono to stereo or (2) converting from two- to four-track stereo.

In the latter case, the conversion is usually quite simple, involving the replacement of the two-track head by a four-track one in the same mounting fixture, and possibly the addition of an electronic component or two. *Figure* 9 shows a conversion kit put out by Ampex that enables owners of its two-track stereo machines to convert a four-track stereo for playback.

Most tape recorder manufacturers offer a conversion kit. If they do not, it is possible to purchase a stereo head from one of several prominent manufacturers of tape heads, such as Brush, Nortronics, Shure, and Viking. Sometimes the head is available in a variety of mounting styles so as to fit the

Fig. 9. Four-track conversion kit.

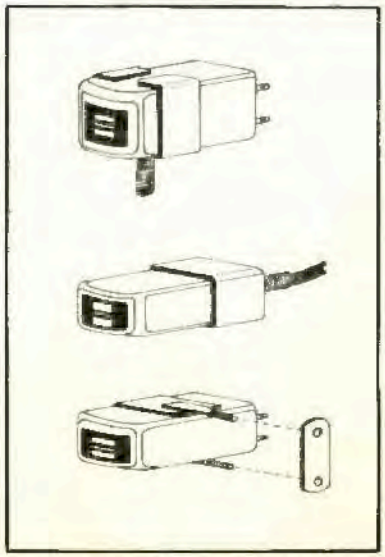

Fig. 10. Various head mounting methods for four-track stereo conversion.

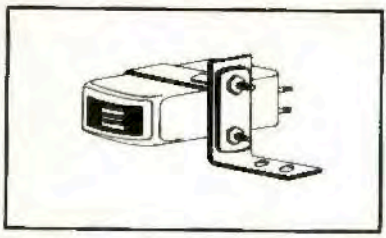

Fig. 11. Mounting the head "outboard".

mounting fixture in a particular machine. For example, as shown in *Fig.* 10, Nortronics makes three mounting styles, which among them will fit the majority of tape machines on the market. For all other machines, Nortronics has a fourth mounting style, with an accompanying mounting bracket, as shown in *Fig.* 11. In the last instance it is necessary to attach the mounting bracket to the tape deck with self-tapping screws. The bracket has slotted mounting holes to permit proper vertical positioning of the head relative to the tape. Azimuth adjustment is performed by bending the bracket. It is usually desirable when using an "outboard" head installation of this kind to also install a tape guide post, such as that in *Fig.* 12, to insure proper passage of the tape across the head.

If the tape machine is a mono device, then it is necessary to install not only stereo heads (including a stereo erase head), but also additional electronics for the second channel. If the tape machie is intended for playback only, at least for stereo, it is likely to be unnecessary to purchase a second playback amplifier because most stereo amplifiers provide an input for accommodating the signal directly from a tape head. On the other hand, if it is desired to record as well as play stereo tapes, then a second tape record amplifier, which incorporates the required amplification and equalization for the second channel, must be acquired. Such tape amplifiers are available from several manufacturers. As discussed previously, when separate record amplifiers are used for each channel, it is necessary to synchronize their bias oscillators to avoid beat notes. Æ

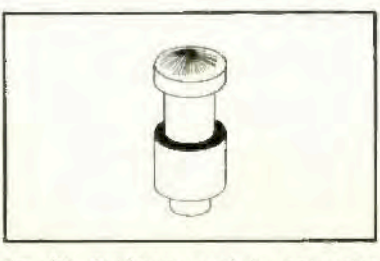

Fig. 12. Guidepost used in conjunction with "outboard" head mounting.