# Echo Effects with a Tape Recorder

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**Applying the principles of a reverberation generator to conventional tape machines to provide—in a limited fashion—a variety of effects not usually available.**

SINCE THE ADVENT of tape recorders with a separate playback amplifier to permit monitoring of the tape while recording, enterprising engineers have seized upon the delay introduced by the playback as an effective means of producing, artificially, the effect of some sort of reverberation chamber. The usefulness of this effect in dramatic work or even on some types of spot annoucements is, of course, obvious to those who have worked with such effects to any extent. While the principles outlined here are not intended to be taken as original, there are some concepts which the author thought might be of more than academic interest to the engineer who has been called upon to provide this facility. The recorders used in the original experiments were two Presto PT-900 machines. They were rack mounted in the control room, immediately behind the control console, for easy access by the operator. One machine was set to run at 7½ in./sec., and the second machine was set at 15 in./sec. Their respective inputs were bridged across the output of the console, so they recorded everything that came from the console. The two outputs were connected to separate faders in order that they might be individually controlled as to volume. The faders then actually control the decay period, as will be explained later. The diagram, *Fig.* 1, illustrates the set-up used.

### Theory of Operation

A short review of the principles of reverberation and echo, will clarify the problems involved and permit better understanding of the use of this system. Echo is a single return of a sound to its source, generally by being reflected from one or more surfaces so spaced and angled as to direct the sound back in the direction from which it came, much as a mirror does with light. This sound, although generally of lesser intensity than the original and changed slightly in quality and timbre, can be louder than the original if the source is large in relation to the listener and if the configuration of the reflecting surface is such as to focus the sound back to the listener. This effect is familiar to anyone who has heard his voice reflected off a cliff, or even from a nearby forest.

Reverberation is similar to echo, except that it is the *multiple* return of sound from many points of reflection, all at different distances, so that the sounds return at different times. This effect is produced also by the same sound being bounced back and forth between nearly parallel surfaces, if some of each reflection is returned to the listener. This is often noted in hallways, indoor swimming pools, and—as the ultimate—in water-filled caves, especially large ones.

An additional effect noted in reverberation is the constant attenuation of each successive wave of sound that is returned to the source. Although theoretically the sound will bounce around in a closed area forever, it is eventually absorbed and lost as heat, in actuality. Long before this occurs, however, it has become inaudible. It is the period of time from the incidence of the sound to the point of inaudibility that will concern us here. The reverberation time is governed by two main factors—the absorbtion coefficient of the reflecting surfaces, and the distance between them. Other factors which enter in a smaller degree are the original intensity of the sound and the dispersion of the sound; i.e., how much of the sound striking the reflecting surface is not absorbed, but sent in the direction of another reflecting surface, or back to the point of origin. Assuming a fixed decay time, it will naturally take a loud sound longer to become inaudible than a soft one.

With these facts in mind, it is easy to see the two main problems that arise in producing artificial reverberation. First, that of providing a suitable delay for the sound originally emitted before it is heard again; and second, providing a suitable decay period before it will fade into inaudibility. The first is provided by the variable speed at which the recording is run. On the 7½ in./sec. speed on the machine used, the delay from the recording head to the playback head is approximately 0.75 sec., while at 15 in./sec. it is just one half as long. According to Tall,[1] the ear, or the brain center associated with the ear, is incapable of distinguishing between two sounds that occur closer than about 0.14 sec. apart. Therefore, the 0.375-sec. delay provided on the faster speed seems to be about optimum. The decay period is provided by the fader on the console. Consulting the diagram, it is seen that the circuit for any one machine is a feedback loop. Such would be the case, were it not for the delay occasioned by the tape in running between the record head and the playback head. All sounds that leave the console are impressed on the recorder, so when the original sound is played back, it becomes part of the output of the console again, and is reimpressed on the recorder. This process repeats continuously until the sound has completely died out. If the total gain and loss around the circuit is unity, the sound will be reimpressed on the tape with the same volume as the original, and it will never die out. Suppose, for example, 3 db of net loss is inserted by means of the fader. This will put the second impression of the sound at a level 3 db lower than the original. When it again comes around, it will have lost 6 db, and so on. Since for broadcast use, the minimum effective usable level is about 30 db below 100 per cent modulation, the sound will make ten reverberations before being lost. At 15 in./sec.—which would mean a delay time of 0.375 sec.—it would take the sound 3.75 sec. to reach 30 db attenuation. This is a very long decay time and should be long enough to accomplish any desired purpose.

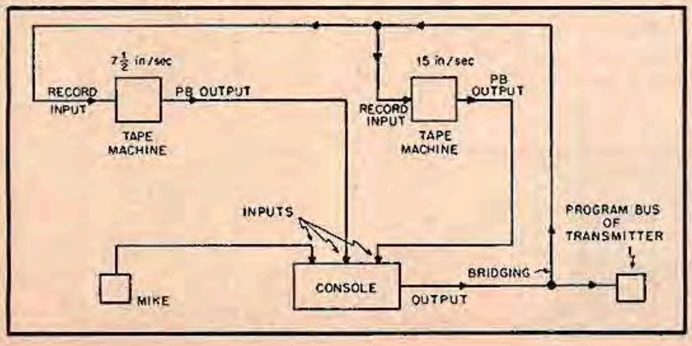


Fig. 1. Block diagram of method of connecting two tape recorders in a control room to provide reverberation effects.

### Putting Theory to Work

In some of the original magnetic-tape reverberation "chambers," a wire recorder was used with some ten pickup coils spaced at intervals along the wire. Each of these went through a variable attenuator so as to vary the decay time. The delay was varied by changing the

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[1] Joel Tall, "Tape editing." AUDIO ENGINEERING, May, 1952.

speed of the wire. This is obviously a rather cumbersome method and does not provide the degree of flexibility sometimes needed. In the system outlined here, the reverberation time may be changed at will with one control; in the old system, it might require up to ten adjustments. The amount of attenuation necessary can be determined quickly by experiment. In the first setup of such a system for a dramatic program, it is desirable to experiment with the amount of attenuation, and when the desired effect is obtained, simply log the setting for use in that particular show.

In trying to duplicate certain locations known to listeners, it might be helpful to remember which function duplicates which feature of the reverberation. The size is most generally indicated by the time delay, whereas the characteristics of the reflecting surface will determine the rate of decay. Also, the tonal quality of the reflected sound may be altered by the nature of the material. A soft substance will generally absorb the high frequencies and cause the sound to be "muddy" or lacking in brilliance. A tone control may be helpful in further enhancing the effect of reality. It is astounding how an otherwise good production can be ruined by poor acoustical effects, such as, in a live studio, the echo of walking feet when the scene is supposed to be outside.

#### Two-Machine Set-up

No mention has been made so far about the use of two machines as shown in the diagram. One machine, running at 15 in./sec., is capable of many realistic effects. By proper manipulation of the fader, almost any desired acoustical effect can be approximated, ranging from large caverns to very small hallways. But at times a lack of fullness that defies realism will be noted. Better results can be obtained if a second machine, running at 7½ in./sec., is used. The two machines together—if properly mixed—make the effect come alive. In this event, the sound is fed back at two different delays, with both machines recording the original sound as well as both playback outputs. With both of them delaying all the sound, the effect becomes almost overwhelming. The 7½-in./sec. machine cannot be used to the fullest extent unless it is used alone, or the result will be an unintelligible mass of sound, completely masking the original. If used alone, however, it is effective if the illusion of vastness is needed. When used in combination, the two machines have been used to simulate Mammoth Cave, or, with moderation, the sewers of Paris. In this case, the water provided the proper effect necessary for realism, and listeners inquired as to where "recordings" of this effect were obtained.

#### Notes on the Use of the System

A few of the difficulties which can be encountered may be of interest. The biggest trouble was that of actual, or apparent, feedback. At high levels of attenuation around the recording loop, there was no difficulty with this problem. But when the gain approached unity, even though there was some delay involved which should prevent feedback, residual noise on the tape often built up to feedback proportions, and would occasionally simulate a tone. The frequency encountered in this case was around 12,000 cps. A 10-kc low-pass filter cured the situation almost entirely. The gain could then be greater than unity for short periods, until it overloaded the amplifiers. At the slower speed, it was not necessary to add a separate filter to reduce the high-frequency response—the recording equalizer was simply switched to the 15-in./sec. position. The lack of high-frequency response at the slow speed provided all the filtering necessary. As will be noted in listening, there is some frequency distortion when allowing more than about three repeats. The lows are slowly lost, and the effect becomes almost "tinny" if allowed to continue. This may or may not be desirable, depending on the effect to be created.

In controlling the level of the playback, it was noted that when operating near the point of unity gain, the usual graduation of 2 or 2½ db per step was too much, and would throw the system into feedback. It was found that ½ db-per-step faders would give the desired gradation. This would make it seem stepless to the ear, and would permit working much closer to the point of unity gain without incurring the danger of so-called feedback or of spilling over into positive gain in the loop.

Any change of level should be made slowly if there is a signal in the system. If a change of more than 2 db was made during the transit time of a given point on the tape, this change will be repeated for as many times as the sound takes to decay. This gives rise to thumping at the slow speed or flutter at the fast speed.

By using a "filter mike," additional and almost amazing effects can be created. Many ethereal effects are possible, and they can add charm, humor, reverence or macabre, depending on the type of show involved. For instance, if a set of chimes—or a vibraharp with the dampers off—is played with a soft mallet and the sound run through the echo system, the effect is "heavenly." An additional feature of this system is that the recorder is still being used to record the program in its entirety. As long as the playback fader is kept closed, the recorder functions normally and captures the main program. When the echo effect is needed, merely open the fader to the predetermined position, and there is the echo. This too, becomes a part of the program material. When the echo is no longer needed, the fader is closed, and the recorder is left running to capture the rest of the program.

With a little practice, any operator should be able to familiarize himself with the techniques involved for the various effects, and indeed, to create new situations to suit his own requirements.