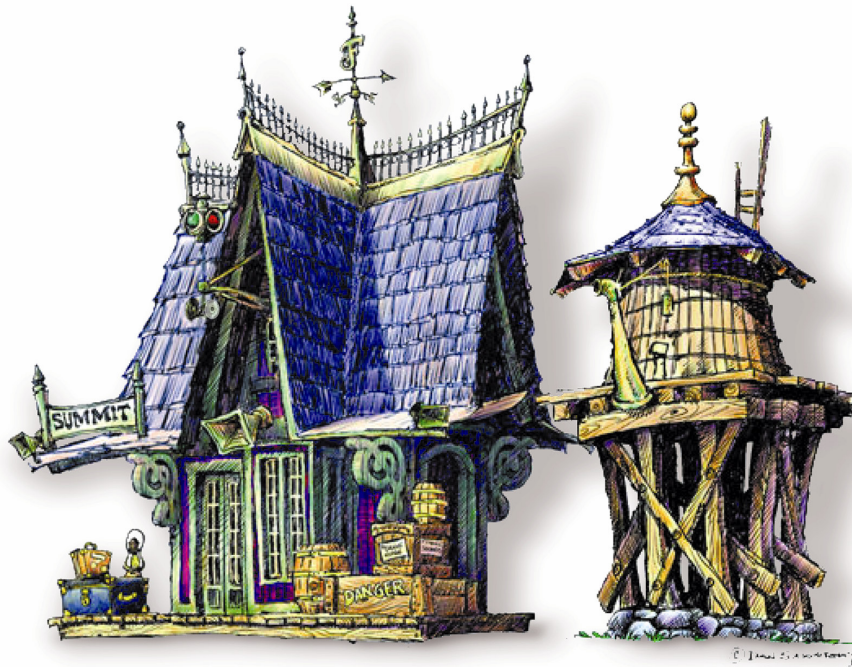


SCALE MAGICTM SOUND OWNER'S MANUAL



By **FantaSonicsTM**
Engineering

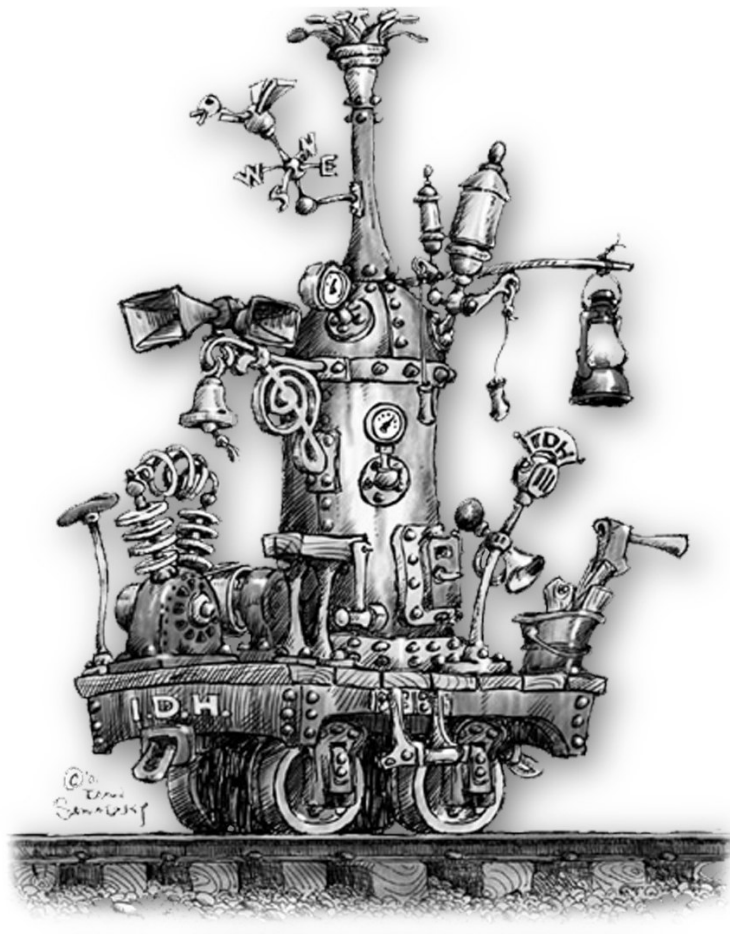


Table of Contents

- 1. Introduction**
- 2. The Nature of Hearing & Scale Sound**
- 3. The Secrets of Scale Magic Soundtracks**
- 4. Scratch Building a Scale Sound System**
- 5. Installing a Scale Sound System**
- 6. Camouflaging a Scale Sound System**
- 7. Getting Creative**
- 8. Help**
- 9. Legalese**

Introduction

The Illusion

The sound of life and activity appear to come from a scene, the sound changes appropriately as you move anywhere around the scene, yet there are no speakers visible, and they cannot be discovered by either looking or listening! The two keys to performing this illusion successfully are in physically aligning the aural image 'into' the scene, and in visibly disguising the speaker locations.

NEVER REVEAL THE SECRET! You don't have to keep the secrets you are about to learn, but it is always more fun when you do...

Scale sound is fun!

Congratulations! You have just purchased a very nifty magic trick for your model railroad scene. We really do want this experience to be fun for you, so we are going to make it as easy as possible. We're going to give you all the tools you will need to successfully work this magic into your pike.

Fool your friends and amaze your enemies! As in all magic, Scale Magic™ 'magic', isn't really magic at all. It is an illusion based in very practical science. For the most part, the magic is in the CD. If you know what we put into it, you will have the best chance to get it back out.

And the more you understand about how the illusion works, the better you (and your layout) will perform it. In order to share this information with you we must break the magician's first commandment; never reveal the secret! We are going to reveal all the secrets. You'll learn what to listen for by learning how (and why) we create it.

Of course, the most difficult and tedious part of creating scale sound is creating the soundtrack itself, and we have already done that for you. The magic is already in the CD.

Scale Sound is cheap!

We will show you how to use simple cheap gear. You may already have everything you need lying around. Your soundtrack is optimized for cheap tiny speakers and 'itty bity' amps (to use technical terms). In fact almost any system that claims to be able play music at any audible volume will be more than competent to recreate your new scale magic sound images.

Scale sound is VERY forgiving!

With our imaging, almost everything you try will sound good. In fact, it is almost impossible to goof this up. Try it for yourself, lay the speakers face down on any surface (that will not harm them), and the imaging will still work. It will sound different, but it will still work. Our imaging is bulletproof, so just jump in with both ears and have some fun.

Are we ready?

All you need is average hearing and the usual model railroading skills, tools and materials. The more you understand about what you hear, and what to listen for, the better your results will be. In any successful installation, you will spend most of your time listening.

We advise putting your Scale Magic™ CD into anything that can play it as soon as possible. It is always a good idea to have your soundtrack playing as you work (or read) along.

The Nature of Hearing & Scale Sound

We are going to briefly discuss some of the terms we will be using throughout this manual.

The ears never blink!

That's right, whether we realize it or not, we hear every audible sound around us at all times, even while we sleep.

Hearing is natural. Most of the time it is a little too natural, we tend to take it for granted.

Hearing vs. Listening

Although we are always hearing, we are not always listening. When we pay attention to what we hear, we are listening. Listening is also quite natural.

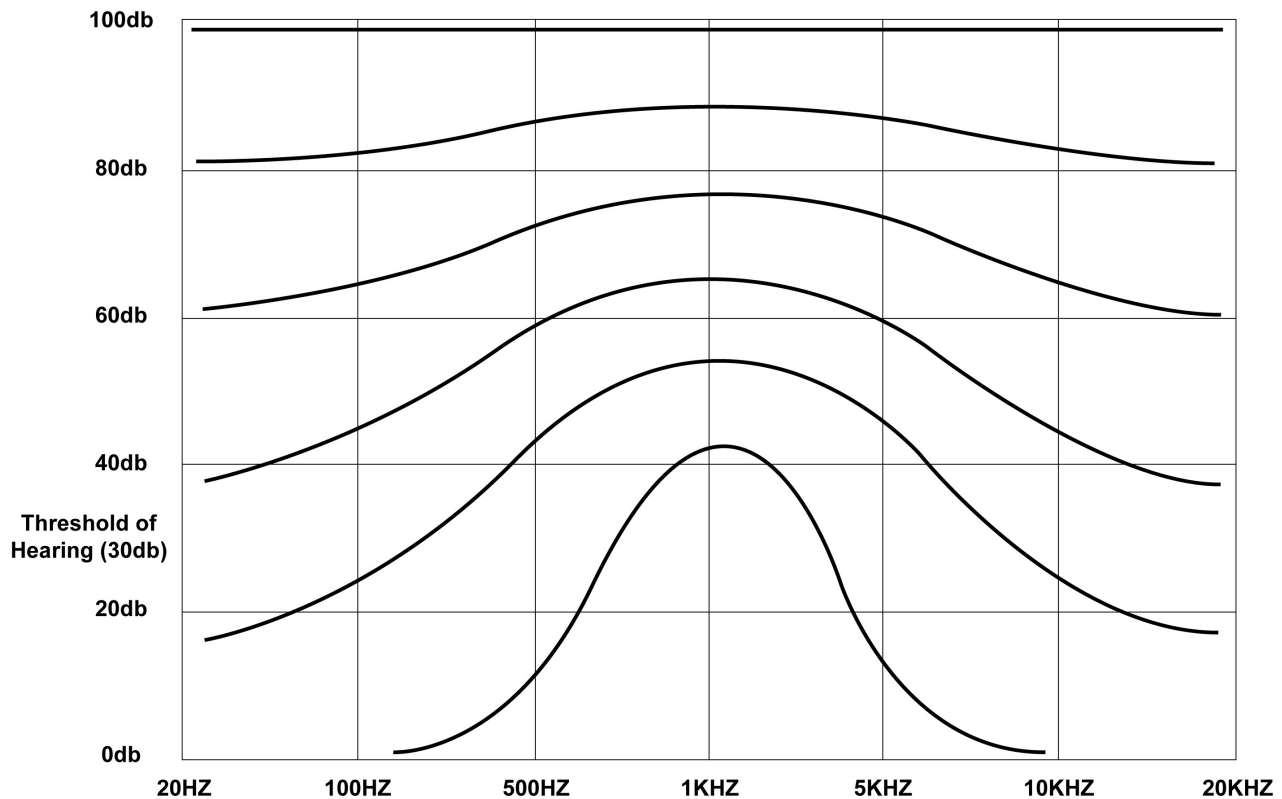
Training your ears

Assuming only that you have normal hearing for your age, you can already hear everything you need to listen for. Training your ears is simply learning to recognize specific things about the sound you hear.

Fletcher-Munson Equal Loudness Curves

It is in the nature of human hearing that we cannot hear the lowest and highest frequencies as well at quiet listening levels. If we start with all of the frequencies from 20hz to 20khz at the same loud volume level (say, 100db), we will be able to hear less and less of the lows and highs as we turn the overall volume level down. Eventually we are only able to hear a narrow bump in the midrange as the volume approaches the threshold of hearing (around 30db). The bass and highs are still just as loud as the midrange, but we cannot hear them. This is why you find a 'loudness' button on many stereos... to compensate (in this case boost) the lows and highs so we can hear them at quiet listening levels.

Fletcher-Munson Equal Loudness Curves



The implications of equal loudness in scale sound applications are obvious. It is one of several reasons that we tend to turn 'full scale' recordings up too loud... we want the bass & treble back!

The Point Source

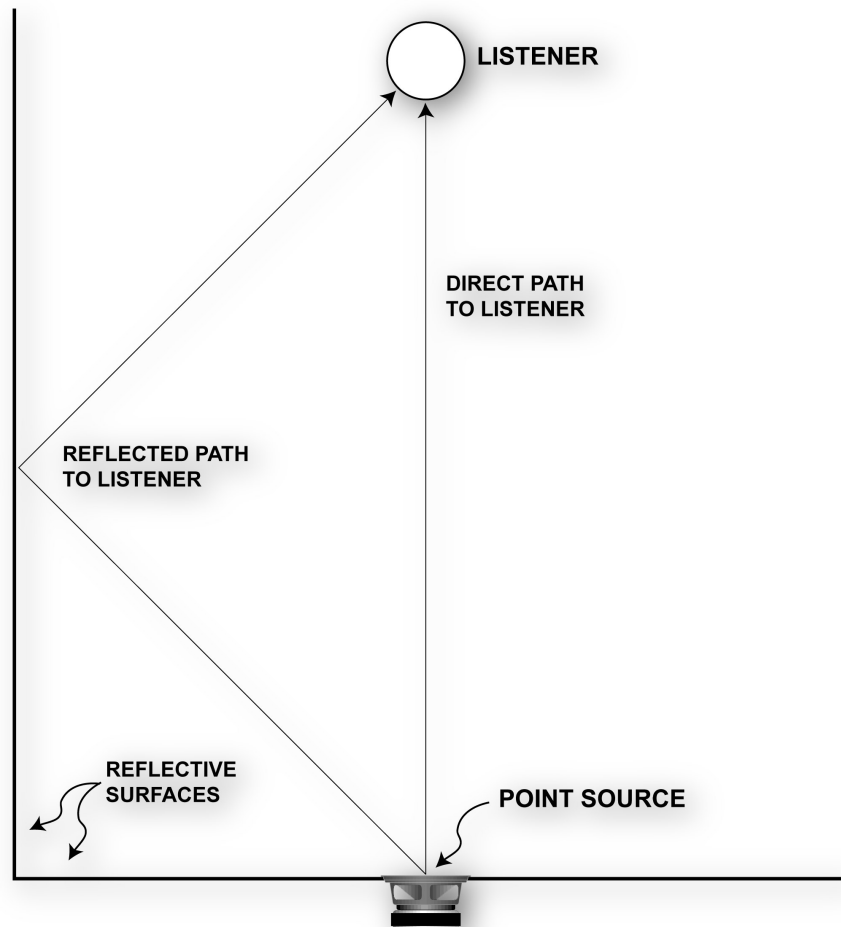
Quite literally, everything audible presents a point source, a perceived point of origin. This includes a speaker in a scale scene.

Direct Sound

A sound traveling through the air directly from the point source to our ears is a 'direct sound'.

Reflected Sound or 'Ambiance'

Sound traveling any other route to our ears, is reflected sound, or 'ambiance'.



Acoustic Environment

The combination of direct and reflected sound presents an overall image to our ears, an aural image of the scene we are in. The ways in which a scene reflects and absorbs sound defines the acoustic environment of that scene.

Point Source Localization

Our brains use tiny differences in the arrival time of direct and reflected sound at each ear (phase differences), to develop our perceptions of a sound's location.

The combination of direct and reflected sound arriving at each ear helps us in point source localization, and in perceiving the acoustic environment we are in.

The Speed of Sound

At sea level and at a specific humidity and temperature (that I have long forgotten) sound travels at approximately 1,164 feet per second. For the purposes of scale sound I round it off to 1,000 fps, without problems. When estimating distance in a scene, thinking in terms of 'one millisecond per foot' is always easier.

Delay

By definition, reflected sound is delayed relative to the direct sound. Reflected sound travels farther and always arrives at our ears slightly after the direct sound, and it is therefore technically an echo. Ambiance is actually many echoes, at many delays. A delay of 30 milliseconds is generally considered the shortest audible delay.

The Nature of Ambiance

The ambient image (the image 'around' a direct sound) gives it a sense of place and is an integral part of a sound's realism in a scene. In most recordings, ambiance is much quieter than the direct sound of the point source because it travels farther, and loses energy with each reflection. This ambient image can effectively disappear when we turn the direct sound down to an appropriate scale volume level.

The ambient image is traditionally defined as having three distinct components: early reflections, discrete echoes, and reverb decay.

Early Reflections

As their name suggests, these are reflections or echoes arriving at the ears via surfaces immediately surrounding the point source. These echoes are sometimes defined as reflections arriving at the ears within 100 milliseconds after the direct sound.

Discrete Echoes

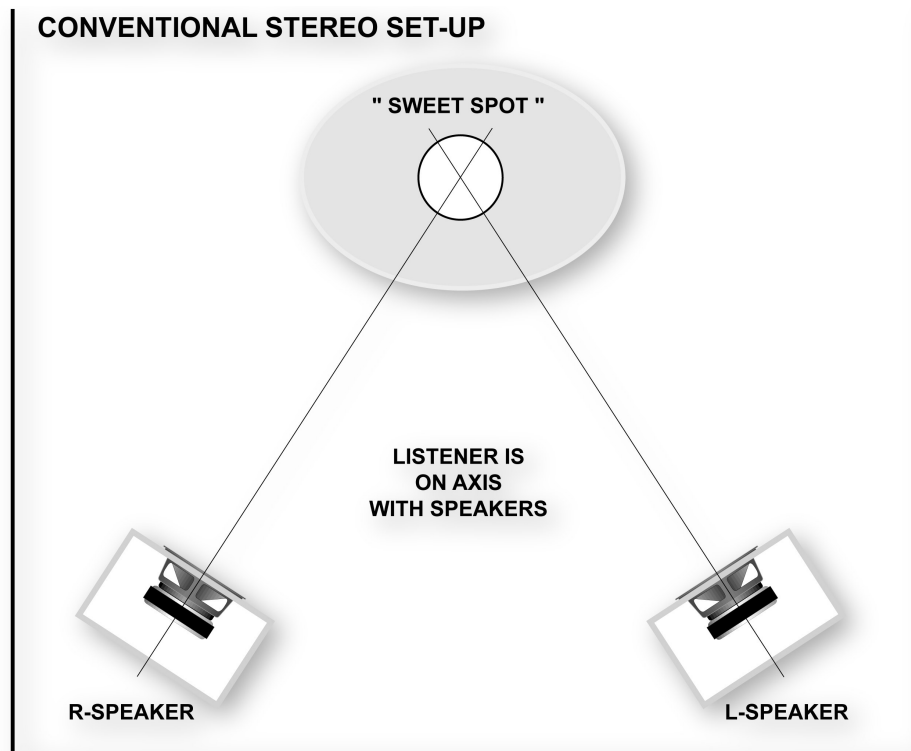
These are individual reflections, more defined and discernable (discrete), arriving at the ears via surfaces more distant from the point source. Depending upon the distances involved in our acoustic environment, discrete echoes may arrive at our ears at delays of a second or more.

Reverb Decay

These are also echoes, but are the resultant smoother image of hundreds or even thousands of reflections over a short period of time (decay time). Reverb decay is literally the result of the overall ambiance losing its energy as it is absorbed by, and reflected from, many surfaces in the acoustic environment.

Stereo

Most of us have set up any number of stereos. You will likely be using conventional stereo components in your scale system, but do not let this confuse you. We will not be recreating a stereo image.



In its simplest form, stereo is simply a recording made with pair of microphones separated by a given distance. In theory, if the speakers reproducing this recording are approximately the same distance apart they will do a decent job of recreating the original event. This assumes that all of the elements (woofer, midrange, and tweeter) in each speaker system are directly facing the listener, and that the listener is centered between the speaker enclosures in the 'sweet spot'.

But Scale Magic™ Imaging works best when the speakers are facing away from the listener, and it works regardless of the location or distance of the listener. Scale Magic™ Imaging also works regardless of the relationship between the speaker elements. Changes in relative location and orientation of the various speaker elements will cause audible differences, but as long as the two channels influence each other (share the air between them) the imaging will still work!

Life is not in Stereo!

Technically life is comprised of multiple monaural point sources combining and mixing within the acoustic environment and air around us. Things in this aural environment will appear to stay where we originally perceive them to be, even if we move around within the environment.

Life presents a continually differing image as we move around within it. A stereo recording only presents the image originally presented to the microphone(s) recording it, and then only to the sweet spot. Scale Magic™ Imaging creates a scene in miniature each time you play it... regardless of your listening position. It is fun move around within our images (close up magic), and then stand back and hear the scene from a distance.

We do not hear in Stereo!

We do have two ears, but we hear binaurally, not in stereo. Binaural hearing is far superior. For one thing, it allows us to ‘localize’: to know instinctively where a sound is coming from. And it allows us to do this quite effectively even if the point source is located somewhere behind or above us.

Your Scale Magic™ CD soundtrack is not stereo.

We want to distinguish Scale Magic™ Imaging from any traditional stereo imaging right from the outset. Indeed, a legitimate argument could be made that our scale imaging is a stereo image... turned inside out. (see: Inside/Outside imaging in section 3).

Scale Magic™ scenes are not recordings of a ‘place’, they are built from scratch, and they have never been a real place. In other words, there was no original ambiance to ‘capture’... so we scratch build that, too.

Scale Magic™ imaging is created in the air around your scene ‘for the first time’... each time you play it. Everything is there in miniature for your binaural hearing to perceive naturally from any angle or distance.

For now, all you need to know is that your Scale Magic™ CD soundtrack is definitely not a conventional stereo recording, nor does it require conventional stereo speaker systems and speaker placement (or people placement!) in order to work.

Why we always want to ‘turn it up’ too loud!

Based upon what we have learned so far we can understand some of the reasons why we are rarely satisfied with normal recordings at scale volume levels:

We want to be able to hear the bass and high frequencies.

We want to be able to hear the ambient image.

We want everyone to be able to hear everything at all times.

We can do something about the first two... the latter is usually called a rock concert, and you will have to hire your own concert sound company for that.

Scale sound by definition should not be audible at all times. Keep in mind that the only difference between sound in scales is volume. You do not want to turn it up too far out of scale. Putting scale sound on a layout that is too loud is tantamount to putting an LGB car on HO track... no matter how nice the LGB car may be, it would always seem out of place.

A few other thoughts on scale volume levels

We offer no formula for computing the exact scale volume level for a given sound in a given scale. And even if someone wanted to come up with one, I would personally never use it. You will always determine the correct volume level for your scene, in your scale, in your room... by ear!

In most railroads, the ‘right’ volume level will be a bit out of scale (a bit too loud). This should be neither art nor science, just fun. Some small exaggeration is perfectly acceptable. However, if you are not sure always err on the quiet side. Scale sound should encourage the visitor to interact with the scene... to lean in and connect with the scene both visually and aurally.

Your soundtrack has an overall dynamic range built into it. There will be quiet passages, and louder passages. Don’t let these changes in overall volume fool you, it is easy to get caught up in perfectly vicious circles. To avoid this, set a volume, and live with it for a while.

Your soundtrack can and will make itself known... at brief moments. At these moments, the volume will be out of scale... and in small doses, this is usually fun. We call these brief caricatures of volume, 'calls'. They are intended to do exactly what their name implies, they call out to distant listeners. A call can also make the statement, "we could be louder... if we wanted to be". Calls can be used as a 'reference' when setting or checking volume level.

Most of the time your soundtrack will just cruise along at a quiet, inviting, overall ambience level... something fun will come along soon.

Scale Magic CD Soundtracks

No "real places" were harmed in the making of this soundtrack!

This is where we are going to spill all the beans, and reveal the fundamental secrets behind our proprietary scale imaging. If you know what we put into your soundtrack, you will recognize it when it comes back out.

No recordings of real places are ever used in our soundtracks. Each scene is hand crafted from hundreds of individual sounds.

Scratch built

Of course, we do usually start with recordings of real sounds, but we start with recordings of individual sounds, never complete scenes. If we need a machine, we scratch build it up squeak by squeak, and clink by clink. When we build a forest, we build it up cricket by cricket, and birdie by birdie. When a sound cannot be recorded or obtained in any other way, we will employ true sound design, and cobble it from scratch out of raw materials. Our approach directly parallels that of scratch building a model in the visual image. The only real difference is that our finished model presents an aural image.

Before we compose them into a scene, we do horrible things to each little sound in the digital domain to prepare it for scale reproduction.

Pre-production

Pre-production most often initially entails conversion to monaural, even when original source material is in stereo. We strip sounds of background noise and existing ambience where necessary. Individual sounds are compensated for equal loudness at scale volumes, and often a dynamics caricature (a hand mix of the sound's envelope) is manually built to help tiny direct sounds "leap out" of small speakers.

Building vignettes and super details

We build scenes just as you would scratch build any other model scene: by individually making major elements (we call them vignettes), combining them together into larger scenes, and then adding 'just enough' super details.

Composing a scene

Building individual sounds, vignettes and super details into scenes is always a fun part of the design process. In fact, fun is a primary criterion. We have to put sounds together in some way, if we can figure out a funny way, we usually go with it. We do take all this fun seriously. We always take a symphonic approach to our compositions, creating a dynamic story in real time. Any good symphony must have a sense of overall dynamics, quiet passages to compliment the crescendos and soloists.

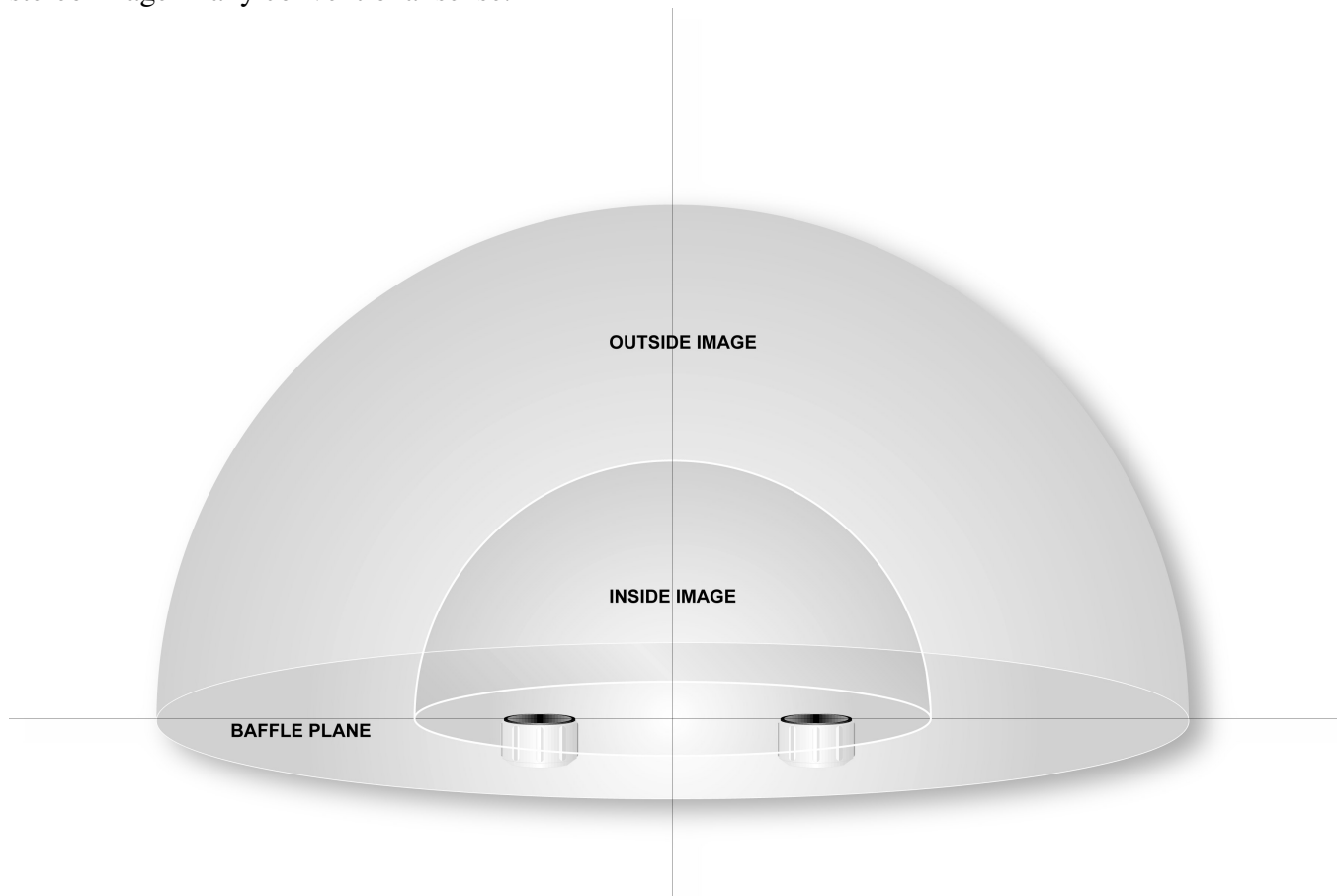
Scale Magic™ Imaging: Building an image ‘around’ the entire scene.

Once all of the major elements and super details are in place within a scene, we go about adding an overall image around the scene. Think of it as creating a concert hall around our little symphony orchestra. We call this proprietary process “Inside/out imaging”.

Inside/out Imaging

Scale Magic™ sound imaging is created in the air within and around the scene...

Although you are using stereo components, your Scale Magic™ Soundtrack does not create a stereo image in any conventional sense.



Two discrete images coexist in our soundtracks. They become separate images only after they mix in the air above your scene. Think of these images as two hemispheres, a smaller one existing primarily between the speakers, and a larger one existing primarily outside of the speakers.

There is an 'inside image', which is somewhat similar to conventional stereo. Often, direct 'dry' sounds are placed across the inside image.

There is also an 'outside image' which, through phase canceling, is only truly audible in areas outside of, or away from the speakers. Ambiance is usually placed across the outside image.

Phase Canceling

By taking one half of a stereo pair of sound tracks 180° out of phase, whatever is on that pair will largely cancel out wherever the two signals mix in the air between the speakers. The reverse is also true. Sounds will only be audible (allowed to propagate) where they are not cancelled. Although it is not precise, this cancellation really occurs and it can be quite startling.

The two images co-exist in the CD, amp and speakers. They are only physically (and audibly) separated in the air, after they 'mix'.

We tediously create individual early reflection, discrete echo, and reverb decay stereo pairs appropriate to the scene. Each stereo pair is phase cancelled into its own discrete outside image. Including the direct sounds, we now have four stereo pairs... for one scene. You can see how this might afford us a great deal of versatility in creating ambiance, and caricaturing scene ambiance relative to direct sounds.

This really is audio magic and aural illusion, and although it is a bit tedious (isn't all scratch building?), it is based upon a simple principle (isn't it always?). The principle is phase canceling. By taking specific information out of phase, we are predictably 'erasing' a part of that image in the air between the speakers.

A Little Air Show

All of the little sounds only become a 'place' when they finally meet in the air (on your layout). This is a spontaneous acoustic event that happens in mid air on your layout, each time you play it. Direct sounds are inside, ambiance is forced outside. The direct sounds that form the scene are honestly separate from the ambiance around them. You can binaurally perceive this from any vantage point, and in a very natural way.

This is audio ventriloquism! With this process, we are able to fly birds or planes overhead, and cause tiny sounds within the scene to appear to echo in the distance.

At the same time, we caricature the volume of ambient images relative to the direct sounds. Rather than disappearing below the direct sound at scale volumes, the caricatured ambient images may still approach full scale volume levels, and they are much better able to couple up to full scale listeners.

Now you know the secrets behind Scale™ Magic sound scenery. If you thought reading about it was a bit bewildering, imagine how we felt when we first started stumbling into all of this. The important thing is that from now on you will recognize scale imaging whenever you hear it.

Scale Magic Don'ts:

Just a few words of caution before we move on...

Headphones

Don't try to listen with headphones, you will likely be disappointed. Remember that a great deal of the imaging is dependant upon cancellation which happens in the air between the speakers... it will likely sound awful when your head is occupying that air space.

Big systems

Actually, our CD Soundtracks can sound splendid on larger systems (some scenes may be bass heavy), just keep the volume down at scale levels and you should be ok. Bigger systems create huge images that are better able to destroy themselves! It is also possible to create an image that is simply too big for the room, so keep the volume soft. Our imaging traditionally works in Dolby Surround decoding systems (out of phase information is decoded and sent to the rear speakers). Please do keep in mind that our soundtracks are not intended for playback on 'prototype' sound systems.

Mismatched speakers

The speakers on the left and right channels must be matched. It is important that out of phase information be reproduced symmetrically in order for cancellation to occur. It does not matter how big or small, or how expensive or cheap the speakers you are using are, as long as they are matched, the effect will work.

Turn it up – it cancels out!

Regardless of the size of the system or speakers you use, you will always be able to turn it up too loud. This is not just a matter of distortion (although it can cause severe distortion), and it is not simply a matter of the volume being out of scale. You can easily turn the out of phase information up so loud that phase cancellation occurs too well, effectively erasing the scale imaging altogether. Turn it down and it becomes more vibrant.

Data compression

Avoid converting your soundtracks into other file formats, if you can. Depending upon the specific file format you use, it may work out. But any data conversion will introduce its own distortion, noise, bandwidth limiting. Some mpeg formats degrade imaging to a point where it no longer works. Copying directly onto another CD (a working copy) is legal, and will usually give good results.

Our soundtracks seem to hold up well in conversion to MD (mini disc).

Equalization

Equalization (EQ) is just tone control. If your scale sound system has EQ control, you will be tempted to use it. Avoid using EQ! Like any other signal processing, if you need it, use it. But if you do, please keep some things in mind.

First, your soundtrack has already been equalized. Many of the sounds already have huge bass and treble boosts added to them. We have already compensated for Fletcher/Munson, and for the 'midrange only' characteristics of smaller speakers. It is easy to overdrive an amp, and even easier to overdrive small speakers with only modest boosts in bass or treble. If you are using smaller speakers, you may not initially hear the resulting distortion.

You can always safely make cuts in the EQ.

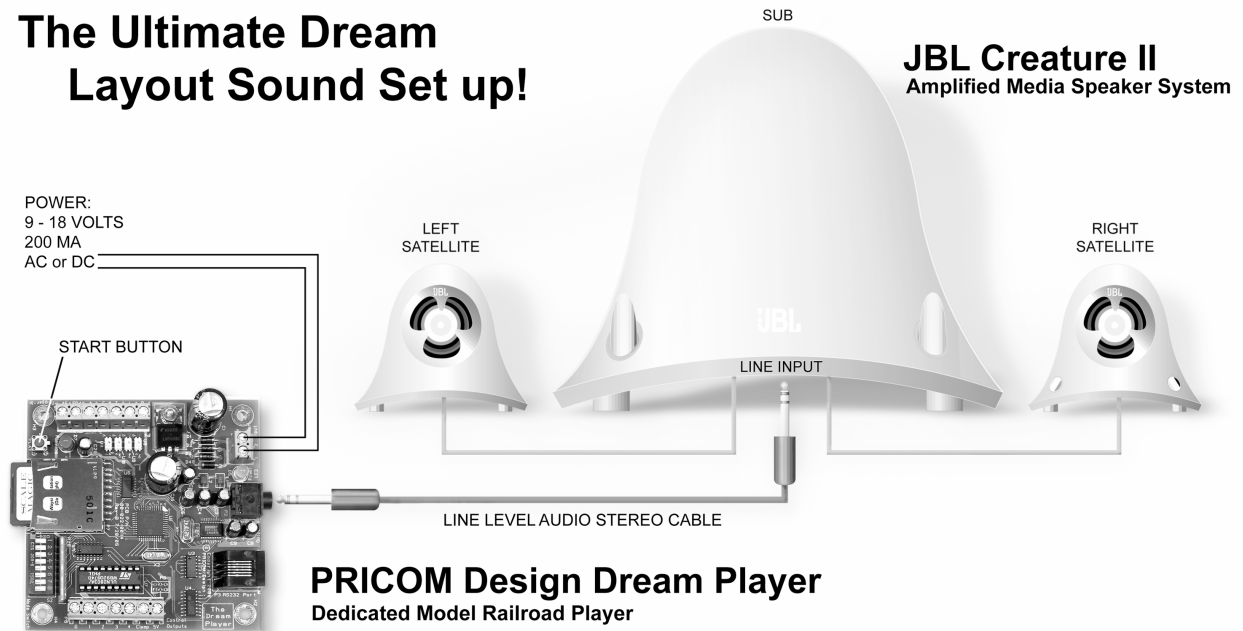
Set everything flat initially (no EQ). Try working with variations in volume and in speaker placement, first. Resort to EQ if you have to, but always go back and carefully compare new EQ settings against the 'flat reference'.

It is always better to find an acoustic solution if you can. There are no electronics... like 'no electronics'.

Scratch Building a Scale Sound System

If you really want your new soundtracks to sound their very best, get the 'dream system'. This is comprised of the Dream Player from PRICOM Design (www.pricom.com) and the latest JBL computer media system, the Creature II. The JBL Creature II system is the one we use here to reference your soundtracks. The Dream Player is a dedicated model railroad layout sound player, it sounds terrific and it allows complete freedom to integrate the sound with your pike. This set up is not cheap, be prepared to lay out around \$150.

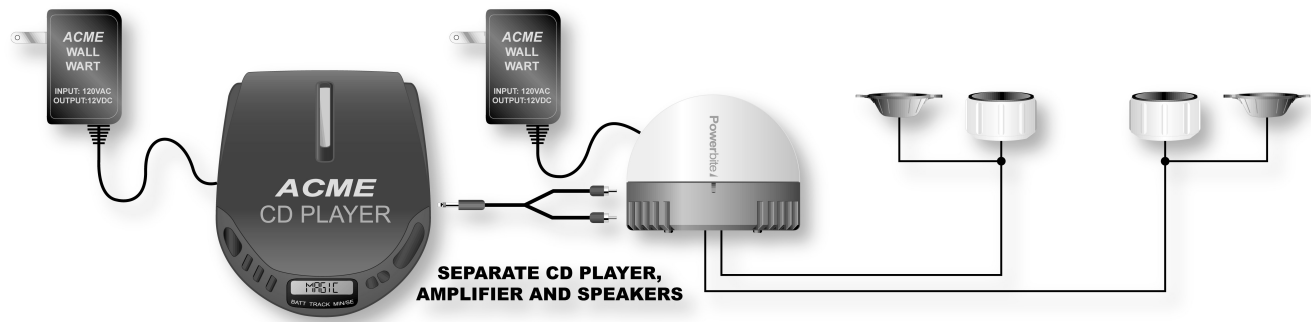
The Ultimate Dream Layout Sound Set up!



But scale sound systems do not have to be high priced, or even high tech... indeed, they invariably work just ducky when they are simple and straightforward.

Contact PRICOM Design:
Robert Scheffler
www.pricom.com
Bob@pricom.com

Scratch building a scale system can be as simple as plugging together a few off-the-shelf components. Even building your own speaker enclosures is easy. The components of a scale sound system are no different from those of any conventional stereo system. There are variations, but any scale sound system will always be comprised of three basic component parts: a program source, an amplifier, and speakers.



Program source:

We recommend using a CD player. Most any player will work, if it works at all. An old home component player, a cheap portable, or even an old car stereo player may be used. Expensive CD players will not likely provide any audible improvement in scale applications, but they can surely be used.

Any media that is capable of reproducing CD quality sound (44.1k /16 bit) will do. You could use an old computer as a program source. Even if a computer has no CD drive, it may be able to run software that can play extracted or copied files. If it has line level inputs and outputs, it may work.

Avoid converting soundtracks to other file formats such as mpg, or other data compression schemes. Avoid media such as cassette, or other tape formats. These will always provide disappointing results.

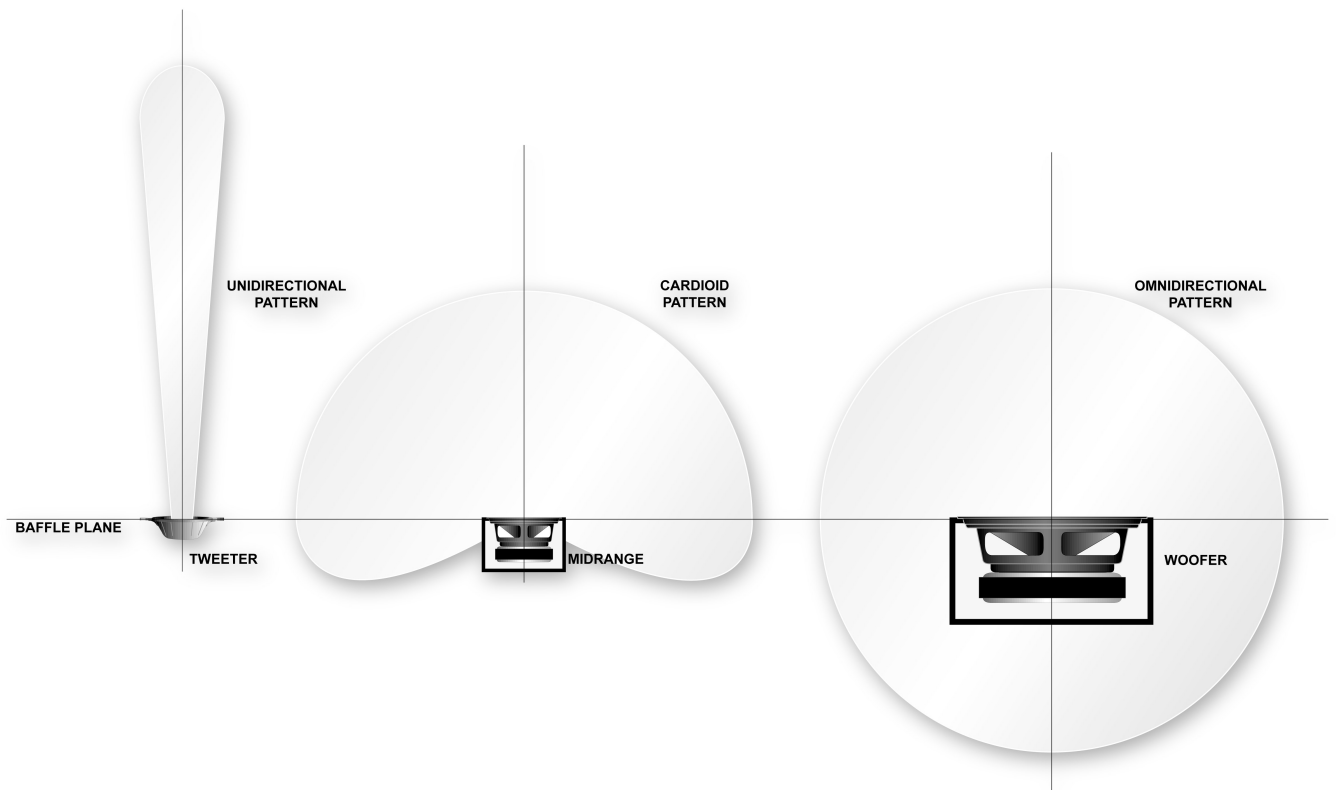
Amplifier:

When it comes right down to it, an amp is an amp. Most any amp rated at 2-3 watts (or more) per channel will likely be up to the task.

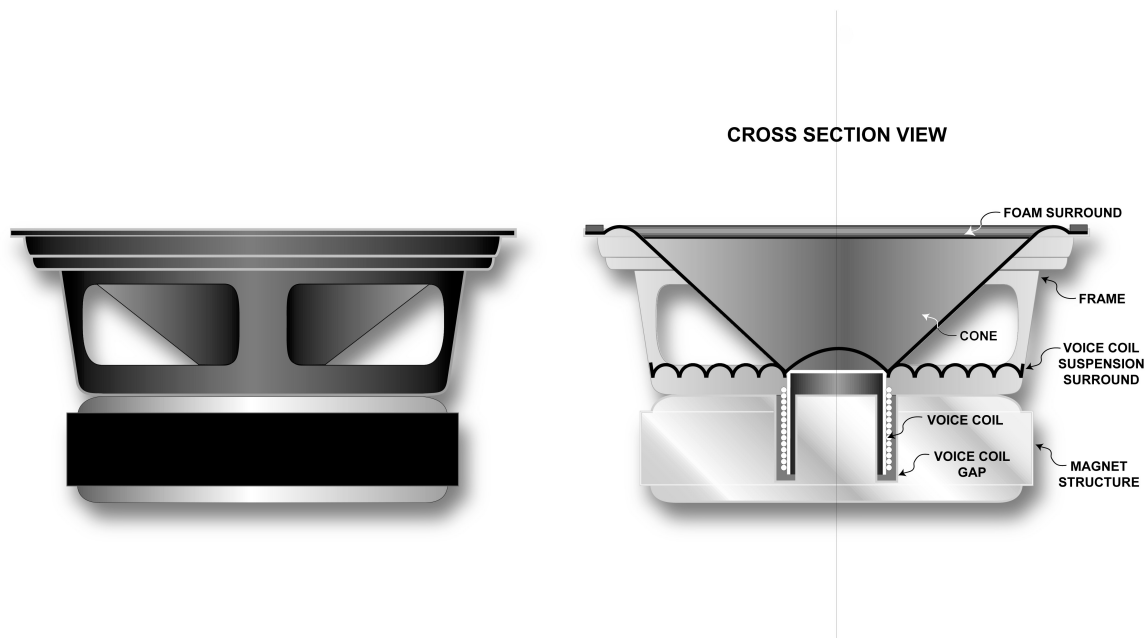
Speakers:

Use whatever you have, as long as you have two of them. Unless they are blown, they will probably work just fine. We recommend using 2" to 3 1/2" speakers. Your soundtrack is engineered to sound good on these smaller speakers. Larger speakers are always more trouble to install and hide, but they will work.

Typical polar patterns



The diagram above shows typical polar patterns for each type of speaker device. The actual sound fields are three-dimensional and less defined. A tweeter will create a conical beam akin to a flashlight, a cone will create a sound field more akin to a mushroom, while a woofer is more like a ball. All three patterns change both size and shape with changes in frequency (higher frequencies present a narrower pattern), changes in volume (quieter is smaller), and they may be modified by installation and concealment. The patterns here are shown to help you visualize the approximate amounts of air that you are exciting (moving) around your model.



If you are buying speakers separately, we recommend looking for hefty ferrite magnets, and paper or fiber cones. Look for a beefy small speaker and you will likely be happy with the results.

Take manufacturer's specs with a grain of salt (they are rarely precise), but look for full range and higher power handling. Usually, a beefier construction is an indication of a better speaker, so you might want to look at 'shipping weight' when reading the specs.

Mylar cones are often not a good choice for installations that will be viewed close up because of inherent near field distortion (the mylar rattles), but if you need to cover a large area with a pair of small speakers, mylar cones can be quite handy.

Speaker Enclosures

Any speaker must have an enclosure. Do not get hung up on fancy enclosure design, unless you enjoy such things. In scale applications, all we need to do is to create an air seal on the back of the speaker. We need only to move scale amounts of air with the front of the cone. As long as the air moved by the back of the cone is isolated, the enclosure will likely work just fine. We routinely use PVC pipe caps as scale speaker enclosures. Caps that are barely larger than the speakers themselves are small and easy to work with, and they can really get up and bark when we ask them to.

The ideal enclosure would never make a sound... only the speaker in it should. Ideally, we want only the speaker cone to excite air, not the enclosure, or the scenery around the enclosure, or anything else for that matter. Fortunately, at scale volume levels (which contain less mechanical energy) you will not be exciting much of anything but air.

Quite honestly, you can build a suitable scale enclosure with little regard to size, shape, material, or good looks. If it is somewhat solid and creates a good air seal, it will likely be just ducky.

Impedance Matching

In general, you should not have to be concerned about matching speaker impedance to an amplifier. Almost any amp will be able to drive almost any speaker, at scale volumes. If you know absolutely nothing about a given speaker and amp, try it out. Start with the volume turned all the way down, and turn it up slowly. Either it will work, or it won't, but it will not likely hurt anything to try. If you run into anything tricky, contact us. Of course, you can avoid the entire issue by simply going with a (matched) amplified media speaker system.

Off-the shelf Components

There are a number of ways to go about creating a scale sound system.



ANY GHETTO BLASTER WITH A CD PLAYER

If you have an old ghetto blaster with a CD player in it, and if it can be relegated to scale sound duty, you may not need to buy anything else. You may be able to remove the speakers for use in your layout, and pigtail the speaker leads out without too much effort.

Keep an eye out for 'mini-blasters' (usually available for under \$25) that will provide you with everything you will need. This is a terrific way to collect matched components. Again, you need only to remove a few screws in order to pigtail the speakers out. Some of the small blasters have removable speakers... and enclosures that are small enough to use without having to build new enclosures.

CD players are ridiculously cheap these days. We routinely see them for under \$20 (including a wall wart power supply and headphones) at the stores that have 'Mart' in their names. We occasionally see them for sale on line for even less.

There are plenty of amplifiers available in both kit and built up versions. If you need or want to go with a separate amp, almost any amp will do. However, you will often find that a separate amp (and power supply) can cost more than a media speaker system which includes a matched amp. Either way, always make sure your amp comes with a power supply or wall wart.

One of the best and least expensive ways to go is to buy a separate CD player, and then add a pair of amplified media speakers. These are the little speaker systems intended for use with your computer. They are a terrific way to go and we recommend this approach.

Amplified media speakers are routinely available for under \$10, and we have seen them for as little as \$6 (the shipping was more expensive). Do not let a cheap price scare you, all of the cheap systems we have tried have worked just fine for most soundtracks in most scales. Of course, you can spend a little more and get a better system. But in general, a media system in the \$10-20 range is all you will ever need.



Do a Google search for 'amplified media speakers' and you will find comparison listings for a zillion systems in every configuration and price range. The big computer outfits will usually have a wide selection available in a wide range of prices.

Some soundtracks will sound better at quiet volumes, on a system with better bass reproduction. If you are working with a city soundtrack, an industrial, mining or sawmill operation, or larger water features (rivers or waterfalls) you might consider looking for a media system that includes a sub woofer with a satellite pair. A sub is a terrific way to achieve a full range feel... at appropriate scale volume.

Here again, the cheapest media systems will invariably be more than enough to do the job. We have seen media satellites with powered subs for under \$30.

A sub may be mounted under the bench, but keep it as close to the scene as you can for several reasons. Media (smaller) systems often cross over between the sub and satellites at higher frequencies, 300-800hz or higher, and subs can quickly become directional. Unless your sub completely rolls out above 150hz, it will not act entirely 'omnidirectional'. As long as the satellites are directly connected to the air in your scene, the effect will work.

2-way speaker systems.

See 'Getting Creative' in section 8 of this manual.

Installing a Scale Sound System

The first and most important step in the installation process is simply choosing speaker mounting locations in your model.

Location, location, location!

Picking proper speaker locations is the most important decision you will make! Picking locations for the speaker elements can be time consuming, but it is easy. Primarily, you will simply be listening.

Always pick locations by ear. Try not to let mounting or concealing dictate this process. These are legitimate considerations, but try not to let them distract you from the primary consideration... the sound! Find locations that sound good, and then do whatever you must to make them work.

Enclosures

If your speakers are not already enclosed, you will want to mount them in some type of enclosure. It is the only way you can make valid judgements when trying out potential speaker locations.

If you intend to fabricate your own enclosures, we recommend making them smaller rather than larger. Smaller enclosures will invariably be easier to install and conceal, but more importantly, they will be easier to try out in various places while auditioning potential mounting locations.

Operating while you work

If possible, have your speakers in their final enclosures while you are picking locations, and have them playing as you work along.

Take your time aligning the image into your model. You really cannot take too much time to find the ideal speaker locations. Or to put it another way, you can take all the time you want finding the right locations if you have working sound the whole time.

Play it by ear!

Try not to let visual or physical considerations distract you, they are not the reason we are mounting speakers. Find locations that sound good and do whatever it takes to install them there.

Other considerations include ease of installation and access, ease of running wires, and ease of concealment. Start by setting the speaker elements behind buildings or stands of trees, where they will not be easily seen even before you have installed or concealed them. This can simplify things later, as long as it sounds good.

The usual hideouts...

Scenery

Hiding speakers in scenery is usually simple, and easy. If you have access to the location from the back, often all you will need to do is open a hole in the scenery, glue the speaker/enclosure in place, and then conceal it with scenic fiber and ground foam. You will find more information about locating speakers in scenery in the upcoming section, 'Mounting Speakers'.

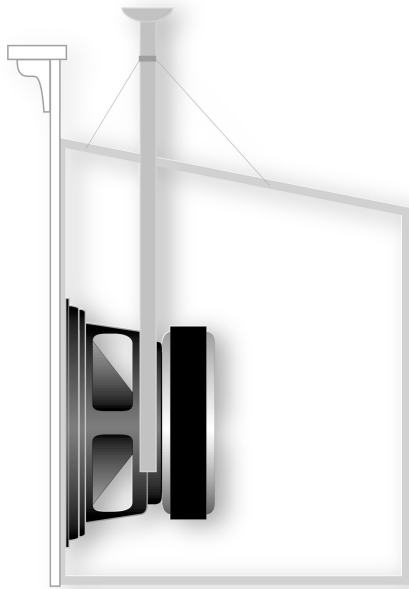
It doesn't seem to make any real difference 'when' you install scale sound, but I prefer to install sound after the scenery is finished, or substantially in place.

Buildings

Do not hide a speaker inside a building, even if the sound should appear to be coming from that building. This is simply a matter of direct coupling. You want to create the sound of a scene in the air, not the sound of a scene inside a little plastic or wooden box. It always sounds better if you can hide a speaker close to, behind, or even partially under a building, so that it can directly couple to the air outside of the building.

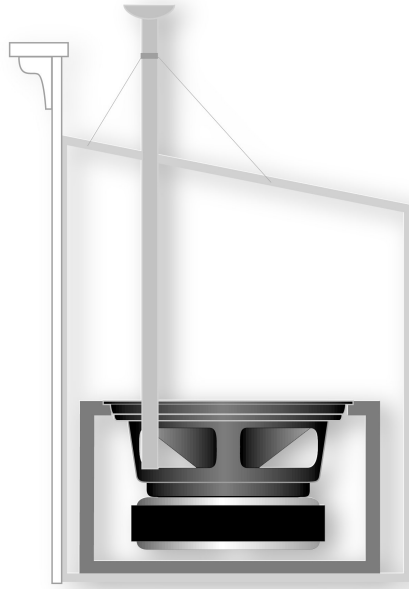
In all fairness, a particular speaker mounted inside a particular model might sound fine. But breadboard it first and listen to it before you make any commitment. There are also other ways around these inherent problems.

wrong...



A

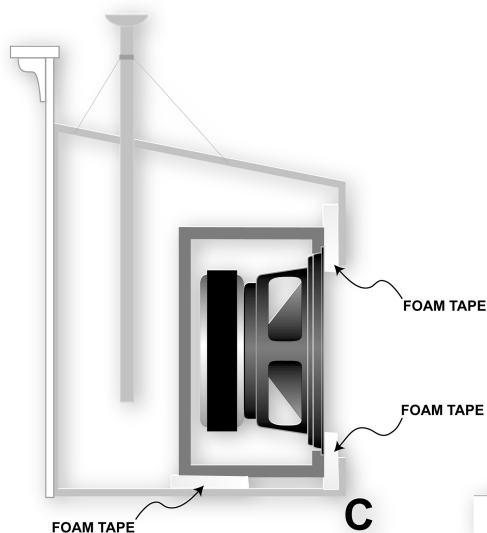
wrong...



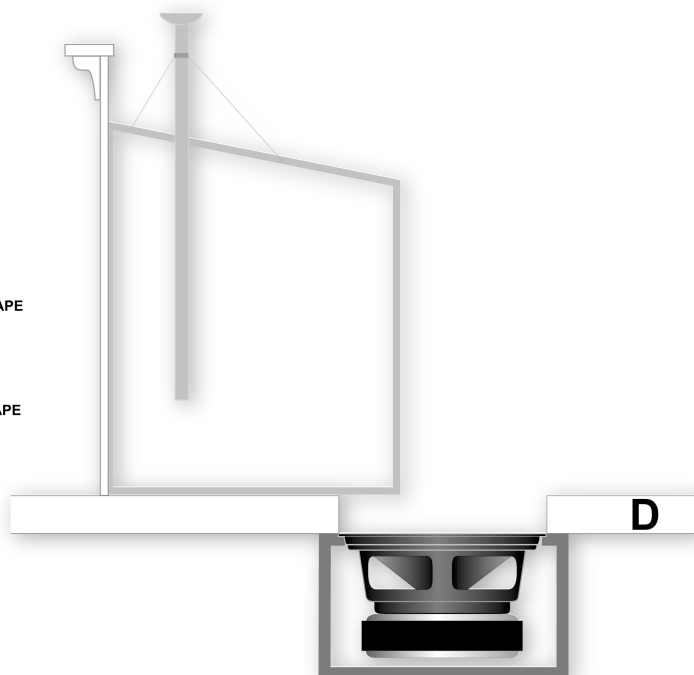
B

Figure A is wrong simply because it uses the building as the enclosure. This approach rarely works out, and it can cause rattling or buzzing. **Figure B** is wrong because the speaker cone is firing into the interior of the model, and only indirectly couples to the outside air. If you want it to sound prototypical... don't hide it inside a scale model.

right...



right...



You can hide an enclosed speaker inside a building (**Figure C**), but follow two rules. First, the speaker cone must couple directly to the air outside of the building, which can be difficult or impossible to hide unless it fires out the back (out of view). Second, do not use the building itself as the enclosure. Use a separate enclosure, one that is completely mechanically isolated from the structure of the building with foam tape or the like (to avoid conduction). If you genuinely cannot do these things, try to find another location at or near, but outside of the structure, **Figure D**.

If you have separate tweeters, you may be able to successfully hide one inside a building to create a point source. The only way to know for sure is to try it out and listen. With tweeters, this is usually easy.

When working with scale sound, it is sometimes true that things that should work... don't. It is more often true that things that should not work... do. If you have an ideal location that defies everything we teach, try it. If it works, button it down. If it doesn't, try it one of our ways.

Under bench mounting

This can be a terrific location as long as the speaker cones can couple directly to the air above the bench. Mounting speakers entirely under the table rarely sounds pleasing. It can draw the point source away from the scene, and can act as a distraction.

On the other hand, a terrific installation can be achieved with a wooden enclosure built into the benchwork, as long as the speaker cones connect directly to the air in the scene above. The only drawback to this is that you cannot hear the results before hand, and you cannot easily move it if you are unhappy with the results. This type of mounting usually works just ducky.

Avoid aiming any speaker directly at the listener!

Aiming speakers at listeners will make it easier for them to localize on the speakers as point sources. As long as the speakers can excite the air in the scene, the illusion will work. The goal is to disguise the speaker's location both visually and aurally.

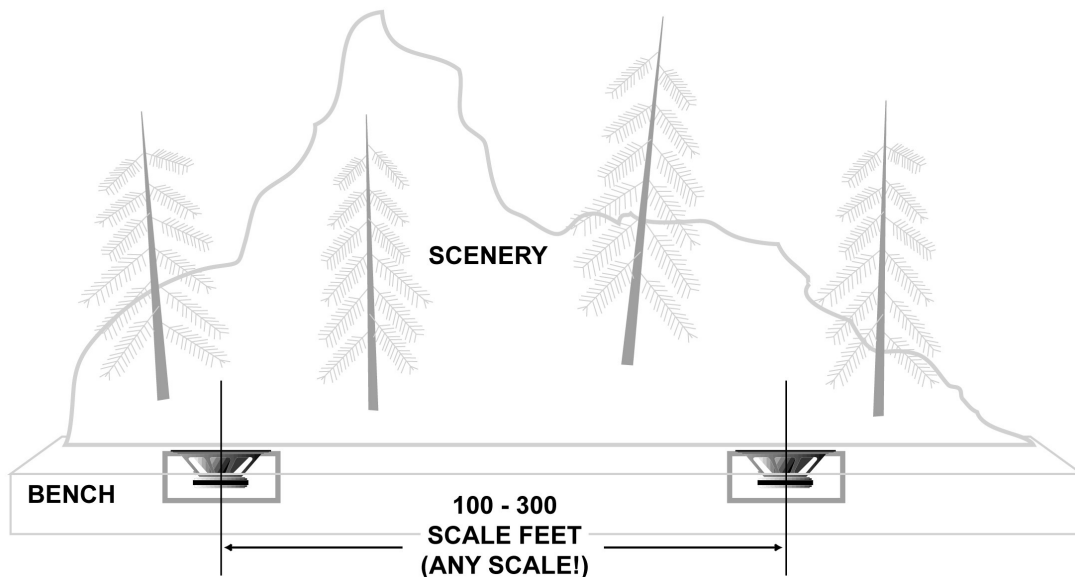
Basics of speaker placement

Where you place speaker elements is determined by ear. The correct approach is always a matter of trial and listening. Do not rush this phase of installation. You should have sound playing on your model right from the beginning, so try as many combinations of speaker placement and orientation as you can think of, and 'live with' each for a while.

Take your time, invariably, one combination will sound 'right' within the visual image your model presents. You are looking for positions that create an aural image that appears natural when you are looking at the model scene. Sounds should appear to come from the 'right places' from many different listening positions. Move around and listen from every position that you or a visitor might normally view the layout. Step back, then lean in to the scene. You have sound on your layout, and you are already having fun with it, so take your time and become familiar with what you are hearing.

You will discover that almost any speaker locations and orientations you try will 'work', but look for the speaker placement that presents an image that sounds natural. The time spent finding the best location is time well spent.

TYPICAL SPEAKER PLACEMENT IN SCENE



The diagram above shows typical relationships between the speakers. This is only rule of thumb. Start with something like this, and listen.

There are no wrong ways to install your speakers, as long as it sounds good. Cones are much less directional (harder to find just by listening) than tweeters, and can more often be placed somewhere that will make mounting easier.

The diagram above shows speakers facing up, but they can face in most any direction. Avoid facing them directly at potential listeners. Start your sound, and keep it running as you work. You will become familiar with your speaker's operation quickly when you are actually holding the sound in your hands.

Each speaker may be individually oriented at any angle. Speakers do not need to be positioned symmetrically. They do not need to be at the same height, or distance from listeners, or facing in the same direction. As long as they both couple to the air in the scene and are in proximity to each other, the imaging will work.

Scale Distance

The graph shows the approximate actual feet on your layout for 100 and 300 scale feet in all of the most popular scales. Again, this is approximate; you never need a ruler, measuring tape, or yardstick!

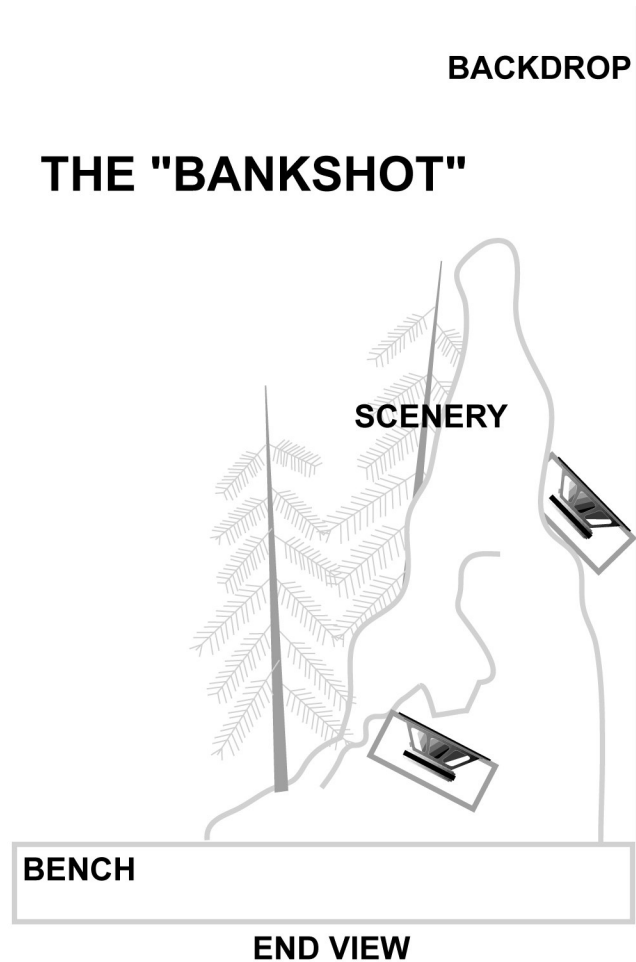
APROXIMATE SPEAKER SEPARATION

SCALE	100'	300'
G	4.4	13.3
1	3.1	9.3
O	2.2	6.6
S	1.5	4.6
HO	1.1	3.4
TT	.8	2.5
N	.7	1.8
Z	.5	1.3

The only time it should sound like you are actually 'there' in a scene is when you are leaning right into the scene... when your ears are within a couple of hundred scale feet of the speakers. At this distance, the speakers and your ears begin to couple up to each other. In scale proximity, the speaker systems begin to act more like a comfortable pair of open-air headphones. Our scale images work close up magic, too.

The Bank Shot!

This approach can work with cones or tweeters. The diagram shows the speakers aimed at the back wall or backdrop behind the model. This is a great approach in many situations, for several reasons. For one thing, a speaker may not have to be farther concealed if it is already out of view; a dollop of hot glue or silicone may be the only 'installation' necessary.



You don't need a backdrop or wall for this to work. For example, a cone could be mounted near the front edge of the scene, pointing back towards the scenery. In this case, you are aiming the sound at the area in which it should appear (although this does not always work in a way that you might expect).

One final note on speaker locations. Look for locations that will physically surround the viewer/listener's head when they lean 'normally' close to the scene, this is the best approach to creating a sense of really 'being there'. Have fun listening!

Mounting the Speakers

Once you have found locations for speakers, it is time to mount them. Everything about this is dependent on the nature of your particular layout. Mounting is never the same twice, not even in the same layout, or scene.

Your friend; the hole saw...

You will often have to open a hole in existing scenery. How you do this will be dictated by the particular location in your layout, your scenery technique and the scenery and bench work materials you use. You should consider how you will create the hole, how you will camouflage it later, and how the speaker will be physically attached.

We like the hole saw for many installations, although it takes a bit of courage to bring a high speed spinning saw blade into contact with your beautiful scenery work. The first time I did this was on some of the most beautiful scenery work I had ever had the pleasure to witness (and it was not my work). It can be traumatic. Just take a deep breath, and hold the drill firmly with two hands. Do not try to work at arm's length. All you need to know about this technique is that you must have firm control of the power drill (both hands!), you must go slowly (the drill turns fast), and there WILL be dust.

A hole saw can also be used to put holes in the frame or bench top for mounting from underneath or behind benchwork. If you are going to make a smaller hole, or an irregular shaped hole, a hand motor tool at high speed with a grinding wheel attachment can be used with the same cautions as above. Don't forget that there may be another location that does not require an environmental impact report...

Hole saws can cut a hole at an angle in wood, just start perpendicular to set the pilot bit, and then angle the drill to make contact to the surface. Again, two hands! You can also set an angled hole into plaster and/or foam scenery in a similar way, just keep up those RPMs.

Irregular openings

If you plan to create an irregular hole, keep in mind the 2/3 rule: as long as two thirds of the cone area is exposed directly to the air in your scene, your sound will work. The two-thirds rule is a rule of thumb, but it is always best to keep the cone as unobstructed by solid material as you can.

The cone of any speaker must be able to couple to the air in your scene. It should be mounted near or level to the surface of the scenery or benchwork in which it is to be mounted. A recess of more than 1" might require some sort of countersink measure to bring it nearer to the surface, listen to determine this. Usually creating a hole is just messy, and nothing much worse.

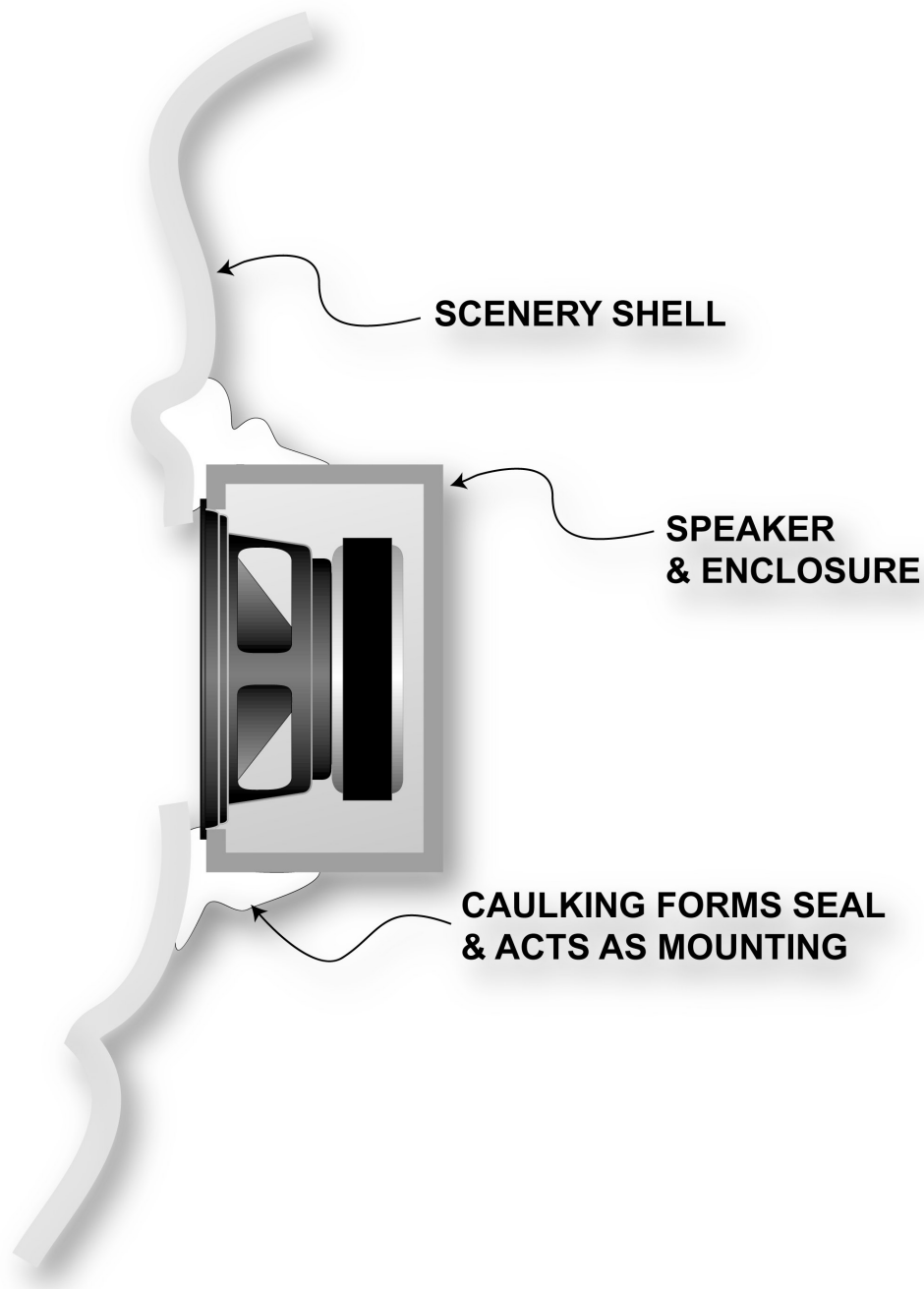
Leave a wiring route

You will want to provide for a way to route the wire from the speaker back to the amplifier. Sometimes this is simply a hole drilled up from the bottom of the bench. It should be straightforward choosing a route, just be sure to do this before you attach a speaker.

Attaching a speaker enclosure

How you attach a speaker device is up to you. You can use most any mechanical method or glue that works, as long it does not adversely interfere with the sound. One of our favorite methods is latex or silicon caulking. This is an excellent material for several reasons. It is the entire mechanical connection. You do not have to fabricate anything else, just squirt it into place. It is a filler where there are gaps. It dries to a rubber state, which acts as a shock isolation and air seal gasket.

We use DAP Alex Plus acrylic latex silicon caulking, it is a bit more expensive, but it dries to hold a speaker in a couple of hours or less, cleans up with water, and can take acrylic artist colors while wet or after it dries. It is also easy to work in and shape to create an air seal/fillet. I suspect that the average silicon bathtub sealer will do a fine job too, although it may be a bit more messy and smelly to work in. If necessary, use tape or a wood block (or anything else that works) to hold the speaker in place while caulking dries.



It is good to keep in mind that a hollow hard shell mountain can act very much like the body of an acoustic guitar. Generally, you do not want sound conducting into the scenery through hard resin, epoxy, or hot glue. Conduction can cause interior resonance that will not sound natural, and it is best avoided.

A rubber seal around the speaker also keeps the sound from leaking back into the interior of a hollow scenery shell, which can create a hollow sound inside a mountain.

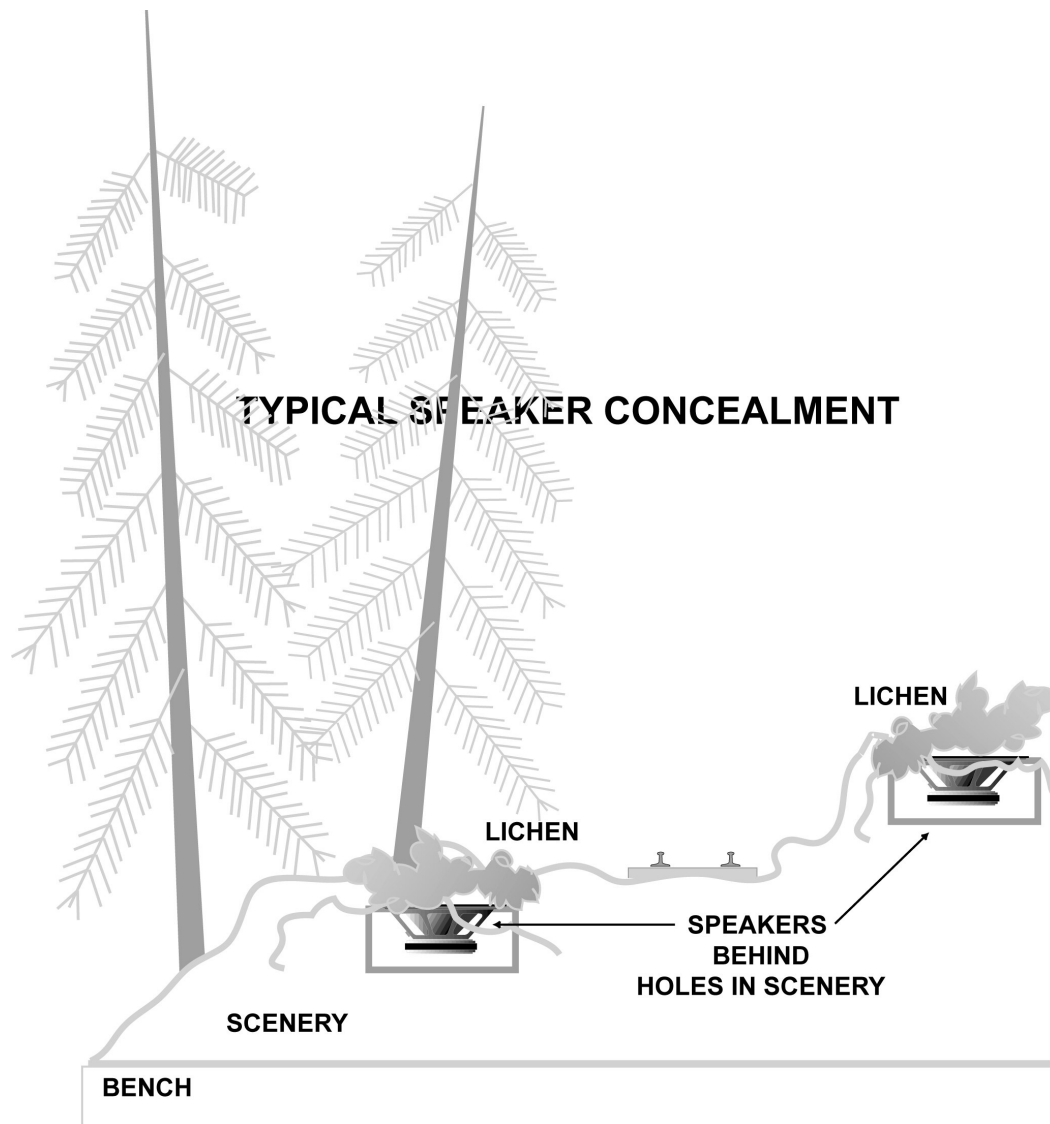
Hot glue can be used to mount speakers, be sure to use the quick drying (fast cooling) variety of hot glue. To avoid too many drips, start by tacking the speaker into place, and continue tacking until you have completed a seal around the speaker.

No matter how you wind up mounting your speakers, never allow anything to come into contact with the cone, and you will have success. That hole saw which creates a hole the right size is starting to seem like a better idea all the time, isn't it? Many times the hole is the mount, and the glue is just insurance and a seal.

When you boil it down, mounting is just getting the speakers to stay in the right place. Your pike will dictate your approach. If you run into an unusual situation not covered here, contact us for help...

Camouflaging Scale Sound

Concealing and camouflaging the mounted speakers can be one of the most fun parts of the installation process, and in general, it is one of the easiest too. On a layout with existing scenery, use the same techniques and materials you used when originally modeling the scene. This will help you to create disguises that easily blend in.



In the diagram, the viewer would typically be looking in on the scene from the upper left. The trees in the foreground (to the viewer) would be the first layer of concealment in obscuring the speaker locations. The irregular shape of the hole in the scenery would help to break up the geometry of the speaker. Although it is not illustrated here, the speakers might be painted (with care) to blend in to the surrounding terrain color. The lichen brush acts as a speaker grill cover, and helps to further break up the man made lines of the speaker with shadows and light.

The main thing you want to accomplish is to break up the symmetry of the speakers. The best camouflage is always deceptively simple.

The two things to remember when you are designing your disguise are that anything you place directly in front of the speakers should be acoustically transparent, and that nothing with weight or rigidity should ever come in direct contact with the cones. Follow these two guidelines, and your disguise will work.

No 'wet' water!

White glue and aliphatic resin are two commonly used adhesives in scenery building, and are potentially disastrous to your sound! Even if you are listening while you work (always recommended), you will not hear the problems that these glues can cause until it is too late. The problem with white or resin type glues is that they harden when dry. Even at dilute solutions of 10:1 or less, these glues can stiffen cones and restrict movement enough to cause audible degradation. Full strength white glue can lock a cone resulting in a serious drop in volume and can cause heat build up in the voice coil. Even diluted, white glues can cause a tweeter to effectively cease operation altogether.

Speakers are little mechanical devices. Scenic treatments to these little machines should be approached in a similar way as you might approach scenery around a turnout!

The only sure way to be safe is to avoid getting diluted glue, water, alcohol, soap, thinner or anything else that is wet on or near a speaker.

Spray contact adhesive

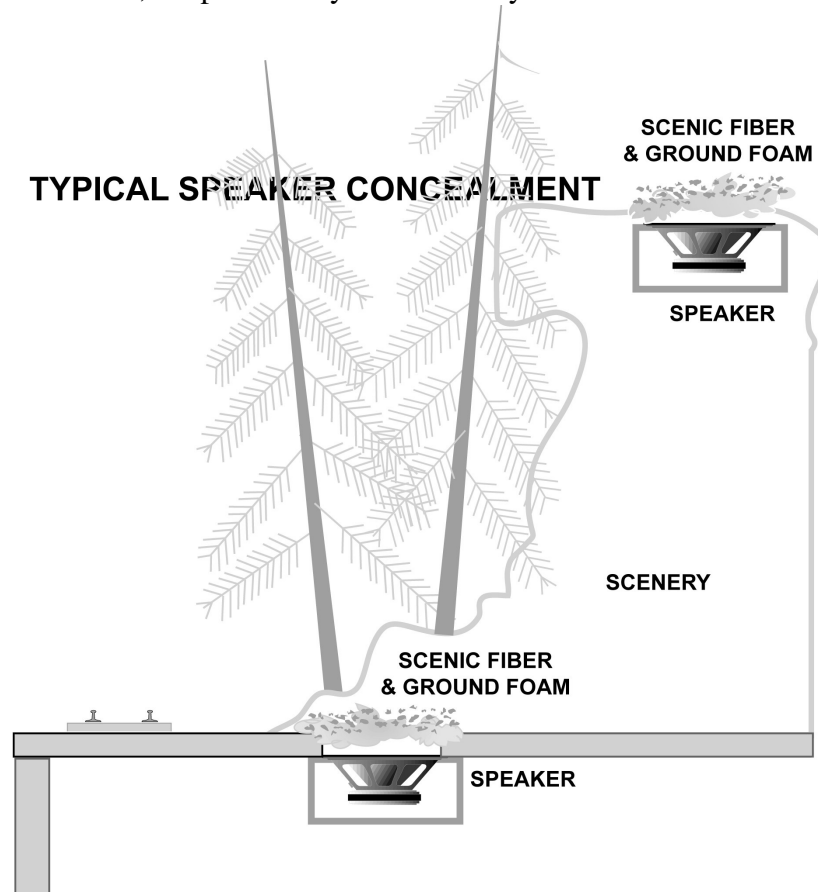
We highly recommend using spray contact adhesive to fix scenic materials around and over speakers. It is less 'wet' than the other adhesives, and works faster too. You can spray it directly at a speaker cone, but use caution with most tweeters. If a small piece of ground foam or other material does happen to fall against a cone unnoticed, it will likely become attached, and 'ride' onboard the cone without rattling. Try to avoid using too much of any adhesive when working around speaker cones and the sound will likely survive the trauma just fine.

Obscuring a speaker

Any foreground scenic elements such as trees or buildings can make the job of concealing the speakers themselves easier. I try to avoid actually placing buildings or other solid objects directly over or in front of a speaker, but it can sometimes be done. Sometimes a diffuse or splay approach will work wonderfully, and it is usually easy enough to try it as an experiment. It is much better to place a building between the viewer and a speaker, or partially over the speaker (the 2/3 rule), than directly over it. Again, if there is some room for the sound to expand and couple to the air before it is covered or obscured by a solid object, the technique might work. Be sure to have sound running while you work, and always listen closely when you attempt to cover a speaker in any way. It is sometimes surprising at what you can get away with putting in front of a cone, without hurting the sound.

Acoustic Transparency (speaker coverings)

The best things to place over or directly in front of a speaker are acoustically transparent materials. The best description of acoustically transparent is anything that allows the air (sound) out, but breaks up or restricts light from entering (or exiting). Lichen is an ideal acoustically transparent scenic material. Almost anything you might need to use should work as long as it allows a speaker to breathe... that is, couple directly to the air in your scene.



Scenic Fiber and Ground Foams

Most materials that are used for creating ground cover or shrubs and bushes are also appropriately transparent. This includes all of the scenic fiber materials and ground foams commonly used in models. These materials are so handy for disguising speakers, and are the only exception to the 'no direct contact with cones' rule. These materials can be spray contact glued right onto most cones without problems.

Care must be taken to keep loose material away from the cones. You will want to check at each step in the concealment process to make sure that nothing with any weight has come loose and fallen on the cone. You should also check for this from time to time after the installation has been completed. The smallest piece of plaster or gravel could 'trampoline' on a moving cone, creating a buzzing or rattling sound, listen for this as a matter of routine maintenance.

Loosely woven cloth material is used for conventional speaker grills, and could theoretically be used as a base over which you might place rocks or gravel. Screen or wire mesh could also be used in this way, and might work better than cloth as it could be shaped to conform to surrounding terrain, and would hold its shape. To be honest, I have never tried either cloth or screen simply because I have not yet had a need to. The other techniques described here have always been appropriate and have worked, so far. We all tend to stick with what works. If you think a cloth or wire grill approach would work in your model, try it. Just make sure it can breathe!

Scenery around speakers

Care must be taken in several ways when you are 'attaching' materials around and over a speaker. Speakers may survive getting damp, but they are not invincible. Most cones are not waterproof, and most tweeters are extremely delicate. This means that you must take precautions if you use spray bottles and water. Avoid getting the cone of a speaker wet, water can warp the cone or cause it to become separated from its frame. A good approach here is to cover or protect cones with paper or 'tac dulled' masking tape, and to use caution and care when working with 'wet' materials.

Painting

There will usually be some 'high end' trade off associated with painting a speaker. Keep in mind that you are simply trying to continue the surrounding color, and trying to break up any visible symmetry of the speaker's construction. With camouflage, less usually works better. And always listen for any change as you work.

You are likely going to cause some audible degradation to the sound any time you allow anything to come into direct contact with the cone. For this reason, you must take extra care when you use any type of paint around or directly on an exposed speaker. Keep in mind that lichen, or scenic fiber and ground foam will often completely disguise speakers all by themselves. Thick opaque coats of paint, or even light coats of paint, are usually unnecessary. Cones and tweeters each present their own set of considerations when it comes time to disguise with color. Avoid painting tweeters, if you can.

Artist acrylics can be sprayed with an airbrush if you have it. Use several light 'fog' coats! And let them dry between coats. Keep in mind that you are losing some high end and midrange response with each coat. Any one layer may not result in an audible loss by itself, but listen for a collective loss of 'sparkle'. It does not take much paint to make a difference with tiny speakers. Think of what you are adding to a cone, in scale. A 2" speaker is a woofer the size of a house in N scale; a thin coat of paint might scale out to be several inches thick.

Enamel or oil based paint should be avoided, or used with extreme caution, and a test is essential. Spray color when possible, but always avoid wet, thick or heavy coats. Your paint job must remain flexible when dry.

Experience tells us that almost everything you try will work, and most every attempt at disguise will be successful. Got a cockamamie idea not described here? Go ahead and try it, there is a real chance it might work. The worst that can happen is that you will not like the way it looks or sounds, and you always have the option to pull a speaker and try again. This is still model railroading.

Getting Creative

Editing Soundtracks

Love the CD but hate one of the tracks on it? Only like one of the tracks? Perhaps there is something prominently featured in your scene that is 'missing' in our soundtracks? While we cannot possibly teach it here, you do have the option of editing the tracks yourself, and burning a customized 'working copy' for your railroad.

We create Sound Designer II stereo audio files (an industry standard) for CD mastering. Our CD's always contain several individual tracks. Any or all of the tracks on a CD can be 'extracted'. Rearranging, deleting, or duplicating individual tracks in any way you wish would be straightforward with any CD mastering software, no different than making a music CD.

If you are comfortable with editing or remixing, or if you want to learn these skills, you should try it. There are any number of free or cheapware digital audio workstations available for every platform. ProTools, the software we use, offers a free trial version you can download and run native on most any machine. If you enjoy such things, try your hand at the imaging techniques we describe in section 3 of this manual!

Two-way speaker systems

If you have a two-way speaker system or are working with separate cone and tweeter components, separate them physically in your layout. Cut tweeters out of enclosures with a Dremel tool if you must. Apply and install each cone and tweeter separately even if it is a bit more work. A 'resultant image' is a powerful illusion.

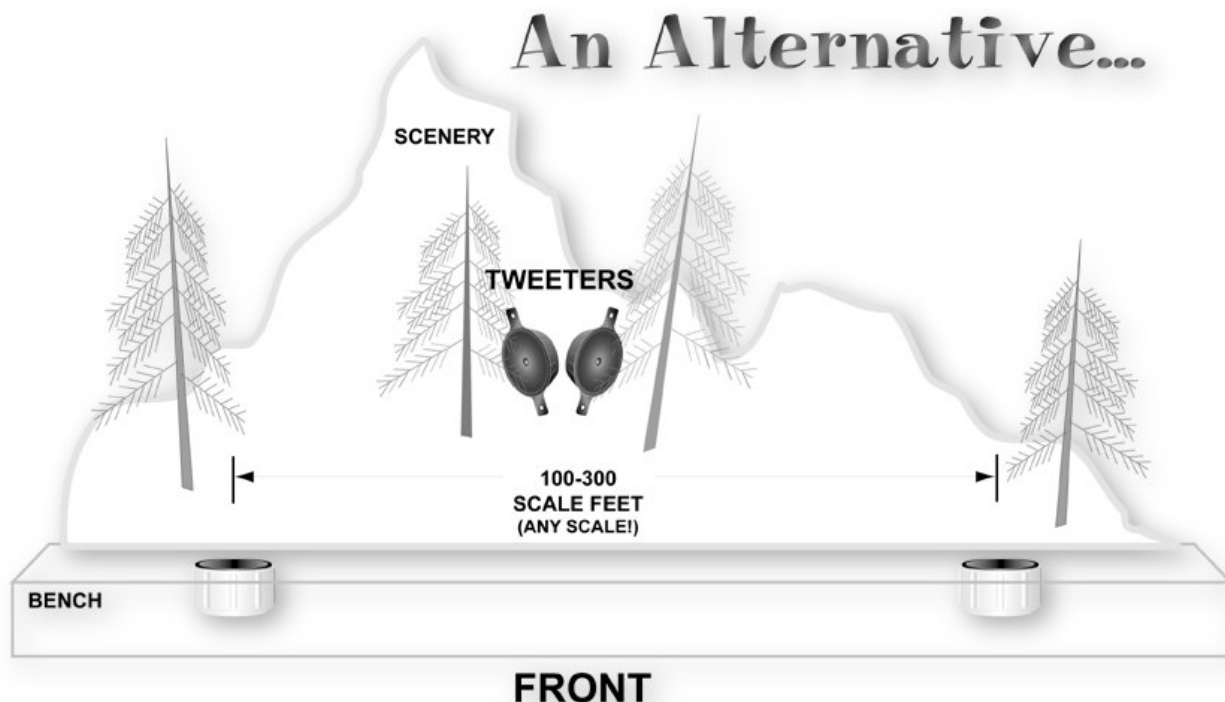
'Resultant Image'

Resultant Image...



The diagram above shows the perceived point source that is the result of image skewing between two speaker elements on a channel. The cone and the tweeter work together, to create a single aural image. This resultant image appears to emanate from somewhere in between the two speaker elements. This perceived point source can be quite pronounced, and can be used to your advantage when bringing the sound into alignment with your model. A happy by-product of this phenomenon is that visitors will naturally look for a single speaker... in the wrong place! Maybe we shouldn't, but we always delight in watching people stare into a piece of lichen we have deliberately glued on at the 'perceived point source'. A cone and tweeter may be placed in almost any physical relation to each other, but a separation of a foot or more will allow you to create a baffling "resultant image".

Just remember that you are creating an image in the air. Speaker locations should not be obvious; that is, the exact locations of the four speakers should not be obvious just by listening. Every effort has been made in the soundtracks to disguise the point source characteristics of speakers. In many cases, the soundtrack has been optimized to create images that honestly appear 'away' from the speakers. Still, you should avoid aiming speakers directly at listeners whenever you can.



The diagram above shows an alternative approach to tweeter placement. In this configuration, the tweeters are in between the cone speakers and are facing away from each other. Because of the narrow beam width of the tweeters, and because they face away from each other, they do not mix or cancel each other out even though they are in close proximity. Tweeters can be pointed in most any direction, but they should face away from listeners whenever possible (and avoid facing them towards each other).

If you are installing speakers for an environmental or nature soundtrack, make a special effort to locate the speakers (or the resultant image) in stands of trees. Or plant a stand of trees especially for this purpose! Most critter sounds would actually come from wooded locations in the prototype, and trees make excellent camouflage. It is as important that the sound 'appear' to come from the trees, as it is for the sound to actually be hidden in them.

Tweeters are much more susceptible to weight riding on board the cone. Avoid painting them altogether if you can, or color them with caution. This is because they work in the extreme high frequencies, and there is very little mechanical power to move anything other than their small cone, and tiny amounts of air.

The narrow beam of a tweeter is the ideal point source (it can be easily located by ear), when pointed directly at the listener. This can be used to advantage if you wish to deliberately create a point source at a specific location in the scene. Hide the tweeter where you want to create a point source, the cone may then be located away from the point source.

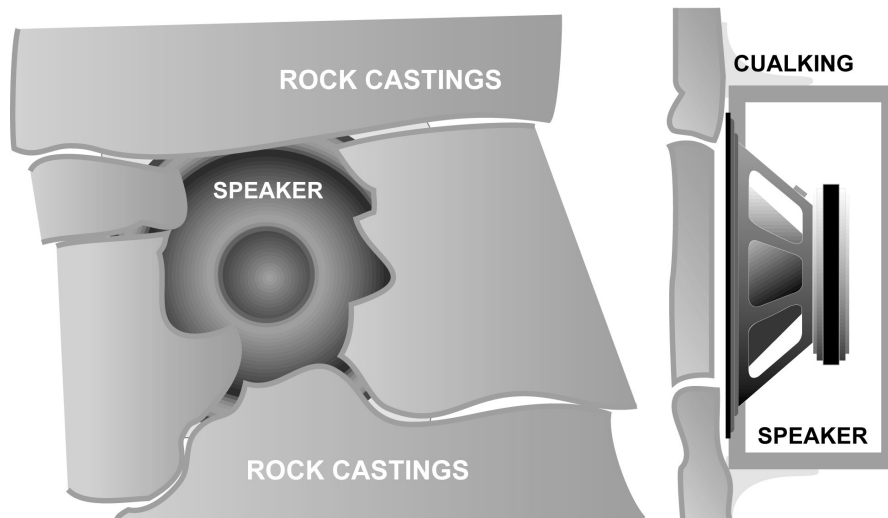
But when reflected off a wall or a backdrop a tweeter becomes splayed or diffused, and almost impossible to find by ear. The 'bank shot' can be your ally in this way, and can be a very desirable effect. If it applies to your pike, try it out. As with every other suggestion we make, this may or may not work in your model, but you will know one way or the other, as soon as you hear it.

Locating speakers in rocks

Finally, locating a speaker in rock can work quite well (and is a personal favorite!), although it is usually a bit more work. You can either carve an irregular opening in an existing rock outcropping, or you can build the rock around a speaker using castings and pieces of castings. The resultant crevice or cave can be farther obscured with lichen, or a light coat of paint. Try to create a seal between the scenery and speaker to prevent the sound from leaking behind the scenery. We only want to move the air in front. Leakage is a waste of perfectly good 'moving air'. Leakage could also cause an unnatural hollow sound within the model, so do try to create a good seal.

Creating an irregular shape around the speaker to break up the symmetry is a terrific disguise, just remember the 2/3 rule. Try to allow 2/3 of the cone to couple up to the air in your scene. Many times you can obscure more (or even most) of a cone with satisfactory results, but tread lightly and listen closely as you work along.

THE TWO-THIRDS RULE



Help!

We really do want you to have fun with your new scale sound. If we did not answer any questions in this owner's manual, you may contact us for help. It is best to email your specific question, if you can:

enginears@fantasonics.com

Please put 'scale sound question' in the subject line.

Legalese

Your Scale Magic™ CD Soundtrack is protected under copyright law. You have the right to use it in your personal layout in any way you wish.

You also have the right to make working copies for your private use.

You do not have the right to make and distribute copies to others, not even if you give them away. Please respect that distributing our soundtracks is an important part of our business. We need your help in order to continue creating fun scale sound products...

Public display is encouraged, with written permission. Please contact us if you have questions about public display.



(The Theme Park People...)

695 Crescent Avenue B
Orcutt, CA 93455
enginears@fantasonics.com

Copyright©2004, Fantasonics™ Engineering, all rights reserved.