

Large Voice of the Theater Systems

by Jim Dickinson, Theater Consultant

Hold it!

Okay you've been to another theatre and heard its "super sound system" and yes it sounds impressive. Now you are back at your own and that old "Voice of the Theatre" sound system sounds kinda dull. Before you call your cinema equipment dealer to tear out your old system and install something new, maybe you ought to check further. If this interests you, read on.

Today the periodicals are fraught with ads and proprietary articles that claim that their loudspeakers are built with "new technology" While some of these claims such as the ones for better metallurgy and adhesives are valid, others are questionable and still others are out and out deceptions. No loudspeaker has an exemption from the laws of physics.

I am going to present my viewpoints on theatrical speaker design and a non-technical explanation of what you can do to the older "Voice of the Theatre" loudspeakers to meet and exceed today's sound system requirements.

What is a "Voice of the Theatre"?

The name "Voice of the Theatre", has been used by ALTEC Lansing to describe everything from large Hi Fi speakers to musicians, portable units to loudspeakers in stadiums and mostly for those used in movie theatres. These loudspeakers have been the standard of the cinema industry since their introduction by noted loudspeaker designers John K. Hilliard and James B. Lansing in 1945. In this writing I am going to discuss these "classic" VOTs which are comprised of a multicell or sectoral high frequency horn with H.F. driver(s) atop a combination bass horn/bass reflex enclosure with (a) 15" woofer(s).

There are roughly two families of "classic" VOTs, the large A-1, A-2 and A-4 and the smaller-family which includes the A-5, A-7, A-7500, older A-6 and 800 systems. At this time I will not discuss other styles of VOTs such as the sealed box A-9 and A-10 or vented box models such as the current A-6, the A-8 or the A-12.

Large Voice of the Theatres

The large family is based upon the A-4 system. The A-4 (Figure 1) consists of one 8 to 15 cell multicell horn driven by one 288 or two (A-4X) 288 H. F. drivers. The bass section uses one 210 bass horn/bass reflex cabinet with two 515 15" woofers. The crossover network is a large N-500 unit. Sometimes matching transformers are used on the outputs of the crossover to match driver impedances.

The A-2 is an A-4 with an additional 210 bass cabinet and 515 woofers (total four) with two 288 drivers on the multicell horn. The early A-2X had four 288 drivers on the multicell horn. The A-1 is an A-2 with an additional 210 bass cabinet and 515 woofers (total six). The early A-1X also had four 288 drivers on the multicell horn.

This is purposely a rough description of the "large family" of Voice of the Theatre systems. These loudspeakers are still being made and even though they resemble the originals in format, every part is different. Through the years these units have evolved and the changes would take a small book to list them all. I will deal with some of these differences in the renovations section.

What's so good about a large Voice of the Theatre ?

The large VOT speakers were designed to work in large movie palaces where often difficult acoustic conditions and significant distances exist. They were a replacement for midrange-poor folded horn systems such as the Shearer system. I have been in long theatres when these speakers actually project clear dialogue to the last row of seats 150 feet from the screen.

Until recently with the advent of the large pattern "constant directivity" H.F. horn, the multicell H.F. horns were without equal as to consistency and predictability of pattern control. Some newer units now use these large pattern "Mantaray" constant directivity horns.

The large mid bass horn projects the critical low midrange part of the dialogue evenly throughout the auditorium with a similar directionality to that of the high frequency horn. It also horn loads the woofers which reduces the cone motion and lowers distortion for a given sound pressure level. Lastly, the air column effect of the horn minimizes the ballistic differences between the extremely light diaphragms of the high frequency drivers and the relatively heavy cones of the woofers.

Due to both sections of the system being horn loaded, the speakers are extremely efficient which allows large theatres to have acceptable sound pressure levels with as little as 15 watts of amplifier power.

These speakers simply did their job and continued to do it year after year. I have seen A-4's over forty years old that have never been serviced. They were in no small way partially responsible for the continued success of the film industry throughout the years.

Perhaps these loudspeakers worked too well: they were forgotten about and left behind the screen working without attention for decades until they finally failed, mostly after projection booth renovation. Often "small family" A-7's were installed in places where A-4,s needed to be. This author believes that a full 50% of all voice of the Theatre installations are undersized, yet somehow they work.

What's wrong with a large Voice of the Theatre ?

In one word, nothing. In another, everything. Some people, especially their competitors, claim these loudspeakers are way outdated. As you will find from my renovation section, I do not believe this to be true. If these loudspeakers had been installed with care, updated, and had had the attention some of these "new super systems" are installed with, I wouldn't have to write this. Here are the problems I see with large VOTs.

1. Problem - Misinstallation

As I previously stated, many units were installed into theatres too large for them. Others used the wrong pattern high frequency horns, others used 70 v. speaker wiring or too small wire that limited fidelity while still other installations either did not install or later discarded the bass wings, limiting low frequency potential. Possibly the most prevalent problem is that of inferior amplifiers and low fidelity signal paths. In many houses the L.F. horns were mispositioned resulting in too little coverage in the horizontal axis while too much in the vertical axis stirring up unwanted mid-frequency reverberations resulting in loss of mid-band cohesiveness.

2. Problem - Deterioration

Some of these units are forty years old. In some the bass boxes have been damp, resulting in plywood delamination. Others have been victims of collisions. High frequency horns have rusted, been mashed or in the case of older tar filled multicells, leaked. Probably the most prevalent problem is that of

driver deterioration. I have seen woofer cones with their outer edge compliance (hinge) broken. Others due to time and/or dampness have rubbing voice coils. In some H.F. drivers the aluminum diaphragms eventually fatigue and break and other drivers, due to time or abuse, are now out of alignment with rubbing voice coils.

Possibly the least noticed and most prevalent problem is that of declining magnetism in the older alnico magnets. This evidences itself as loss of midrange in woofers and loss of extreme high end in H.F. drivers. It is not odd to find 10 to 20% magnetic loss due to the age of the units; this goes for all alnico magnetic drivers, not just Altec's. In drivers that have failed from overpowering or physical abuse a 50% magnetic loss is not uncommon. Reconing does not solve this, only remagnetizing does. This may explain why some drivers, especially H.F. units, repeatedly fail despite re-diaphragming. Failures of older deteriorated units often occur when new high-power amplifiers are installed in an effort to upgrade systems.

3. Problem - H.F. Drivers

As shown by the accompanying chart (Figure 2) the A-1, A-2 and A-4 series used many different 288 drivers. All 288 drivers regardless of vintage are excellent sounding drivers. The older 288, 288B, C, D and 8E do not work as well as the newer 288 G, H, K and L models, and in this author's opinion should no longer be used on large systems. The main problem experienced with all 288's is low power handling. Some operators have installed the heavier higher power composite diaphragms (this makes them 291 drivers) which while it stopped the failures, slightly limited the extreme high end transient response. Even 291 drivers have superior sound quality to most others. Only recently has ALTEC introduced the 299 driver which has superb sound quality and high power handling.

4. Problem - H.F. Horns

Until recently all large VOTs used multicell H.F. horns. ALTEC made about fifteen different cell and pattern configurations further complicating matters. Until the advent of the large pattern constant directivity horns, the multicells were the most reliable, consistent H.F. projection horns made. Multicells have their own characteristic sound. They sound different from radial/sectoral horns and newer constant directivity horns. Multicell horns have their admirers and detractors. Modern test equipment has shown individual cell lobbing and interference problems between adjacent cells, however, the perforated screen tends to diffuse these deficiencies (it also ruins precise patterns of C.D. horns). You will have to judge their merits. Some multicells work better than others with probably the best being the old heavy tar filled models. Actually most problems occur from using the wrong pattern horn for the space.

5. Problem - Woofers

The early 515 woofer (no suffix) was a great horn driver speaker. However, it did not have the proper compliance for the lower notes. It had superior mid capabilities via a very light cone. The second generation woofer, the 515B, was a great woofer with superior low frequency capability. It was a multipurpose speaker that could be used in horns, vented boxes, or even in sealed cabinets as was the case in the short lived A-9 and A-10. The cone was heavier than its predecessor and it achieved its midrange capabilities by increased current draw in the mid frequencies.

Some people claim the 515B is the world's greatest woofer. Often these units are reconed with after market cones and straight 16 ohm voice coils and without recharging the magnets. This decreases the midrange of the whole system. Even the current ALTEC R515 recone kit has a straight 16 ohm voice coil.

The 515C is a 515B with a straight 16 ohm voice coil with the newer ALTEC 16" frame. This unit is a wonderful vented box speaker and lacks the mids in the VOT bass horns.

The fourth 515 was the 515E. This was the first of the ceramic magnet 515's. It is an even better vented box

woofer than the 515C and suffers worse than the 515C in the horn enclosures. It also has a 16" frame. The current generation of 515's, the 515G series (both 8 and 16 ohms) are built exclusively for vented basshorn cabinets. These are by far the best woofer ever made for these boxes Unfortunately these 16" frame units will not fit into the older narrower 210 cabinets without carpentry being performed. They have a very large magnetic motor and a very-light cone with a proper compliance needed for use in vented horn enclosures. They are not an acoustic problem.

6. Problem - The Bass Cabinet

As with any commercial speaker box, the 210 horns used in the large systems are a compromise. They have their faults, which are:

A. Too flimsy, according to renowned acoustic designer Cliff Henderson. A bass enclosure should be made of 1 1/2" thick lead with no air leaks." This author believes that 4" thick reinforced concrete would be just fine. The 210's are made of the thickest commercial material, 3/4" plywood. They are also not braced enough and consequently some of the acoustical energy goes to wiggling the box, not to the audience. In their defense, other commercial theatre enclosures are no better made. As a practical matter it would be hard to ship a much heavier enclosure.

B. Box tuning.

The older 210 horns were tuned low to produce bass from low watt tube amplifiers with too small output transformers that were unable to produce clean bass notes. Therefore the ALTEC engineers tuned the reflex section to a low system resonance to make up for the amplifier deficiency. When used the older tube amps, the bass is acceptable. When repowered with large modern direct coupled transistor amplifiers, the bass becomes muddy with a thick midbass, a condition commonly known as "binny" Retuning eliminates this condition (see renovation section).

7. Problem - Size

Yes, large Voice of the Theatre's are big, too deep for some screen locations and hard to move around. They can be somewhat reduced in size. See renovation section.

8. Problem - Crossover and Matching Transformers

The A-1, A-2 and A-4 use the large N-500 series of passive crossovers most notably the N-500C and the current N-500F. These are some of the best passive crossovers ever made. This author believes passive crossovers have no place in professional audio and that production of all new ones ought to be banned. "Passive" crossover networks create all kinds of problems. Firstly, even the good ones lose 25% of the amplifier power in insertion loss. They create frequency selective differences in time arrival of signals to the different frequency sections and various annoying frequency selective distortions such as L.F. harmonics showing up in the high frequencies using up driver headroom.

Since the early 1970's bi-amplification has become the preferred method of professional audio. Only recently has this practice been used in the cinema and then only in a few cases such as THX systems.

Oftentimes matching transformers are used to match the H.F. and L.F. loads to the crossover. The 15067 autoformer is an excellent unit, however, it is another step in the audio chain and as with any step it creates new problems and loses others. The net result is most evident in a loss of transient response.' Crossovers and transformers in tandem create an audio disaster in any loudspeaker.

Now that I have pointed out the system's problems. I must say they are minor compared to some other loudspeakers. The faults I have described are only faults in the context of ultimate performance.

The basic design of the classic Voice of the Theatre was very carefully done by some of the world's best speaker designers. Most problems exist due to improper installation and maintenance.

Renovation Section

What can I do to these loudspeakers to make them perform to their potential ?

Renovation - Woofer

The first option of woofer update is to change them to current 515-8G or 515-16G woofers. Unfortunately, these will only fit in newer 3419 wide cabinets. Most 210 and 211 cabinets are the older 32 1/2" wide units. Don't make the new woofers fit by cutting off the edges of the frames as this compromises frame stiffness and may cause voice coil rubbing. Make a new 32 1/2" wide baffle board that will accept the 16" wide woofers. Remove the old one and cut a 2" wide slot in both sides of the cabinet (Figure 3) that begins with the baffle board mounts and is as high as the new baffle board. Fasten it in with screws and glue. Then cover the slots with a 3/4" plywood cover fastened with screws and glue on the outside of the cabinet. If you do not wish to use new woofers, almost as good results can be obtained by rebuilding the older alnico magnet 515 woofers.

Make sure all the woofers are the same 515 variant. In a single cabinet (A-4) or multiple cabinet system (A-1, -2) all woofers must be the same.

Remove the woofers and ship them back to the ALTEC factory for cleaning, realignment, reconing and remagnetizing. Have them reconed with either the 8 ohm R515-8G or 16 ohm R515-16G 515G series cones. Do not use the standard R515 cone kit. The G series cones will give you a better midrange and an overall sound similar to a 515G. Do not have a local reconer perform this task as it is likely they will not use the proper cone and voice coil and most of these enterprises do not have a magnetizer. It is almost certain these units have lost 30 to 50% of their magnetism due to age and abuses especially if the unit has failed before. A 515 with a low magnet will not produce sufficient midrange needed for horn use. I do not recommend using the ferrite magnet 515E in a reconditioned large VOT system. They work fine in the smaller short horn single woofer systems and extremely well in dual woofer vented box systems; use them there. Do not use other woofers designed for use in vented boxes. They won't work here, use 515's.

Renovation - The Bass Enclosure

As I have stated before, the standard A-1, A-2 and A-4 used ALTEC Lansing 210 cabinets. Simplex marketed different cabinets that positioned the midbass horn in the opposite direction. Occasionally you find a unit using ALTEC 211 bass horns that were the same exterior shape as the 210 with the midbass horn in the center for flat positioning (Figure 4) like that of the Simplex box. The 210 and 211 have the same size horn; the Simplex is slightly smaller. I am going to use the 210 as my renovation model. The same procedures may be used on the 211 and Simplex boxes with some modifications.

Like rebuilding anything, we can do a little or a full overhaul. I will list these renovations in stages of increasing complexity. If you wish full performance potential, follow these instructions in their entirety. Please note that what I am describing is not all that can be done to improve these units' performance. For brevity's sake I am describing these changes that effect the most improvements. If you wish further renovations contact me.

I. Retune A

The reflex chamber of the 210 is too big for its reflex parts. We can simply retune the older 210's; by taking out the' restriction boards between the vents (Figure 5).

2. Retune B

Do step A and seal off the area of the upper horn flare above the baffle board with plywood 2X2 batts,

sealant and screws. The box is now similar to the current ALTEC 210; it is still too big. For a 211 do the same thing then plug the vent on sealed side and open the working vent by removing the restriction board closest to the edge of the box. This is about optimum reflex space for the woofers. New or renovated 515's work best in about ten cubic feet of reflex space per woofer. You will have to calculate this for the Simplex box and act accordingly.

Renovation - Rebrace

Screw and glue 2X4's on edge diagonally on the inside of the enclosure on all large flat areas of the reflex chamber to stiffen it. Cut smaller areas in half with 2X2's. There is no such thing as too much bracing. Rebrace the areas in the closed off sections also. Rebrace the horn flare (both curvatures) by laminating 2" strips of 1/2" plywood to the inside of it. Use at least one lamination series between the center flare brace and the outside wall (total 4), preferably two (total 8). Hit the flare with your knuckles before doing this; remember the sound.

The easiest way to laminate these strips is to cut one to size and fit it in parallel to the center brace. Draw pencil lines on both sides of the strip. Drill holes within the lines about every four inches—from the inside through the flare. In the top flare you cannot get the drill in close to the top front of the cabinet. You will have to drill these holes from the outside of the flare. Apply glue to the strip and between the pencil lines and have a helper hold it to the inside of the flare. Attach the strip to the flare with, 1" drywall screws in the previously drilled holes from the outside. Laminate a second and third strip to the first one with glue and fasteners from the inside. Now hit the flare with your knuckles and notice the difference.

Tie the inside of the flare to the ends of the cabinet with 1X4 tension members. Tie the baffle board to the back with a 1X2 in the center. You now have a well-braced box. Further stiffening can be done by laminating plywood to the sides, ends and back of the enclosure with glue and screws. Use a minimum of 3/8 inch thick material, a maximum of whatever you wish.

Renovation - Volume Reduction

Since the 210 bass horn still has too much air in the reflex chamber, two approaches can be taken to cure this. The first is to fill up the inside of the reflex chamber by boxing off approximately nine cubic feet. The second is to remove 12 inches of the reflex chambers reinstall the end and rebrace the box. This makes the "reduced" 210 the same reflex volume as the "reduced" 211 box, just right for the woofers. A better livelier bass will result. An added bonus is that the box is now smaller and easier to move. Report the "reduced" 210 to approximately 180 square inches.

Renovation - Wings

All theatre enclosures need bass baffles for maximum low frequency output. These baffles prevent the omnidirectional low bass notes from spilling behind the loudspeaker and wasting bass on non-audience areas. This creates a condition known as "half space" and gives a resultant 100% increase in bass sound pressure levels. The standard ALTEC 210 has two 84" by 24" wings. If they are gone, increase them to whatever size you can; a full four feet works well. Baffle walls work even better. The wings were merely intended to be portable baffle walls in theatres in which the speakers had to be moved for stage events. Brace wings with 2X4's every sixteen inches vertically, two feet horizontally. Use at least two knee braces to brace them to the enclosure. For speakers that must move fold the wings via hinges and demountable knee braces. Some smaller theatres do not have room for full wings between the speakers. Build baffles between the bass enclosures use at least 3/4" material.

Renovation - High Frequency Horn

This is a judgement call: You can reuse the multicell H.F. horns or you can replace them with the new ALTEC Lansing large pattern "Mantaray" constant directivity horns. Your preference or pocketbook will make this decision. Remember whatever horn you use it must have the right pattern for the auditorium.

Renovation - High Frequency Drivers

This author believes that even though they are better sounding drivers than some others currently sold, the older 288 drivers, the 288, 288B, C, D and 8E should not be reused in a large system. The later larger alnico magnet models, the 288-8G, 16G, 32G, 8H, 16H and the ferrite magnet 288-8K, 16K, 8L and 16L, are far superior units. They have an overall 2 db more efficiency and far more output above 10,000 Hz.

If you do not have any of the later drivers, I recommend replacing the older ones with ALTEC's newest driver, the 299-8A (8 ohms) or 299-16A (16 ohms). These units handle 2 1/2 times the power of any of the 288s with no loss of sound quality. If you have any of the later larger alnico magnet drivers (288-8G, 16G, 32G, 8H, 16H), I recommend a trip to the ALTEC factory for cleaning, realignment and remagnetizing. While there, have 25884 8ohm or 25885 16 ohm 299 diaphragms installed. These units will then handle the same power of the 299. If you have the ferrite magnet drivers 288-8K, 16K, 8L or 16L, you may also wish to install these higher power diaphragms. Ferrite magnets do not lose magnetism like alnico magnet ones do, however, please check these drivers (and any others for that matter) with an audio oscillator for voice coil rubbing. An out-of-alignment driver while it works sounds awful.

If you must reuse the older smaller magnet 288 drivers (288, 288B, C, D, 8E), send them back to ALTEC for rebuilding and have them install the higher power 299 diaphragms. Please note that the 288 and 288 B must be converted before new diaphragms can be installed. These rebuilt drivers will function very well atop vented box or smaller single woofer bass horn low frequency systems in smaller auditoriums where lower sound pressure levels are needed. These drivers work well on the medium ALTEC "Mantaray" horns, the MR II5- series, in these spots. For maximum performance use the larger magnet drivers. I believe there are no better sounding units.

Renovation - Crossover

Biamply your renovated loudspeaker. Sound quality improvement is on the order of ten over the same unit with a conventional crossover. It is this author's opinion that it would be folly to use a passive crossover after all this work. The only thing I can think of using a passive crossover for is for an emergency reserve with a conventional amplifier. Biamply, please, and whatever you do, don't use any speaker matching transformers anywhere.

Renovation - Summary

Now that we have worked over our Voice of the Theatre system, we have a world class loudspeaker. These units have better midbass projection, less ballistic tonal difference between the high and low frequency sections, higher overall conversion efficiency and lower midrange distortion via the horn loaded bass cabinet than vented box systems. If you have followed my renovation plan, the deficiencies are now gone.

Reinstallation

If we have the world's best equipment, we can make it misperform by bad installation practices.

Make sure you use the right high frequency horn for the space. If you do not have access to an ALTEC Array perspective program, lay the pattern of the horn out on blueprints of the

auditorium seating and vertical section. While this is not completely accurate, it's better than nothing.

Another trick is to take a protractor and lay out the limits of the true pattern of the horn on its bell with masking tape. Raise the horn to its permanent position, look through the throat and see how it covers the seating inside the masking tape limits. If it is too wide# get a narrower pattern horn. If it's too small get a wider one. If the room is in between horn patterns err to the smaller pattern; the performance screen tends to expand high frequency patterns. Listening is the final proof. Remember, if you have a difficult spaces a too wide horn may cause unwanted reverberation.

When you have the high frequency pattern established compare it to the pattern of the bass horn. A single 210 horn has a midbass pattern of about 90 degrees with the flares and about 60 degrees opposite the flare (Figure 5) Oftentimes we find we need to turn the bass horns on their sides to avoid projecting too much signal into the ceiling which brings unwanted midfrequency reverberations. After turning the bass horn on its side, leave the lower wing in its position. Remove enough of the upper wing to position the high frequency horn above the center of the bass horn. Apply a new wing to the end of the bass box opposite the reflex chamber vents (horn end).. In the case of long theatres, two or three bass boxes may need to be stacked to get the desired long distance pattern needed, as when low frequency horns are stacked the pattern narrows. To get wider vertical or horizontal patterns, the enclosures must be splayed (Figure 6).

In the 2-woofer A-4, the low frequencies' pattern control extends down to 90 Hz; in the 4-woofer A-2 the pattern extends to 60 Hz, and the pattern of the 6-woofer A-1 extends to 45 Hz. There are further tricks to get increased directivity in these bass cabinets. If you wish to know them, contact me.

For powering these devices, I of course recommend biamplification. Renovated or new 515's hold about 75 watts of "real world" power each. I recommend powering them to their maximum, even if you don't need the sound pressure level. Drivers survive much better with clean peaks than clipped signals. The 299 and 288 drivers with 299 diaphragms have a 50 watt pink noise power rating; regular 288s have a 20 watt pink noise rating.

Use 16 ohm woofers in an A-4. In parallel this yields a nice 8 ohms. Use adequate sized wire for less than 10% power loss. For the four 'woofer A-2, use 16 ohm woofers in parallel for a net 4 ohm impedance or 8 ohm woofers in series/parallel for a combined impedance of 8 ohms. For the 6-woofer A-1, 16 ohm woofers in series/parallel yields 12 ohms. 8 ohm woofers in series/parallel yield 6 ohms. 16 ohm woofers in parallel sum to 2.7 ohms. There are some amplifiers that will load to 2 ohms so this is a possibility. However, your wire must be quite large to have less than a 10% wire loss. If you have lots of wire raceway capacity, you may run individual driver or series leads back to the booth for less wire losses with smaller wire. Don't use matching transformers anywhere; keep your fidelity.

Large Voice of the Theatre's seem to biamplify best with 500 Hz 12 db/octave slope electronic crossovers. 18 db slopes sound unnatural in these units. 24 db Linkwitz/Reilly type crossovers would be my second choice.

The last touch to proper installation is to align the high frequency assembly to the low frequency box. The easiest way to do this is to use the null method as described in ALTEC Application Note #9. This method requires only a real time analyzer and a polarity switch. Do this as the final tune-up before Equalization.

If you follow this guide, you can have a sound system that is among the best available. You may also rest assured that it didn't cost as much as that "new" one that might or might not work in your theatre.