THE ANCIENT AUDIOPHILE'S QUEST FOR THE ULTIMATE JBL HOME SYSTEM

Do you long for the old days--do you fondly remember the JBL "wallbanger" sound? Knocking that hideous art-deco kitchen clock off the wall with Mercury's Antal Dorati recording of the 1812 and evoking ooh's and ahh's from dumbstruck friends who couldn't believe their ears on hearing your massive 60 watts per channel and the sound of Bob Prescott's "Cartoons in Stereo?"

In 1961, those of us who could capriciously defy our wives or parents and spend $355.80 plus the outrageous $10-$12 cost of high-grade plywood lumber to build our own 14 cubic-foot cabinets, lived in bliss with the reverently held belief that a pair of D130's and 075 bullets was as good as a speaker system ever needed to be, that recorded music could never challenge such a system, and that some day if we ever got a huge tax return we might think about adding a pair of 175DLH's to make the ultimate system. We were the audio elite--the cognoscente who held court for those who thought we were geniuses because we could plug together a Mac 60 and a preamp and actually set the correct disc equalization for any one of the many individual record company disc cutting EQ's used back then--to the chagrin of non-engineer music lovers.

If you're like me, a child of the fifties, chances are your memory of those early high-efficiency systems nags at you and makes you wonder what in the world all the fuss about "digital-ready" speaker systems is all about. Yes, JBL was digital-ready 35 years before digital was ready!

Of course, you can still get an E130 and a 2402 (the current model numbers of the old components) and fool yourself into thinking that's hi-fi, but if you're still the audio tweek you were in 1961, the results of this out of date thinking will prove uninspiring--the sound you remember won't be good enough any more. The sound you get won't live up to the memories of it in view of what you've probably heard over the last 25 years.

Well wallbanger fans, since 1961, some progress has been made in understanding the listening experience, the reasons sound systems never sound like live performances, and how to improve that enigmatic situation. We know how all the hardware works now, and we know a lot more about why there are so many ways to make bad speaker systems. As Danish philosopher Kierkegaard would probably have said, "audio is like philosophy; at every step it sloughs off an old skin into which creep its useless hangers-on." If you want to stay

on the leading edge of your favorite technology, you have to have an ecclectic view of past design improvements. Never mind the fact that today's "recording engineers" have green hair and can't read music and that most of what goes into the grooves of pop records emanates from a programmable box. To be fair, there are plenty of well recorded compact discs available to listen to, and every reason to expect that good program material will be made by those who care about music and audio quality more than mass marketing.

Although JBL's sales of raw components to the home-grown market has been continually expanding since the fifties, JBL as a company, has done so well in professional audio (permanently installed sound systems, touring sound systems, movie theater sound and musical instrument speakers and components) over the past decade, and the hi-fi marketeers have innundated the public with so many ready-made speaker choices, that the proportion of JBL's total sales of raw components to the hi-fi market has been overshadowed to the point where supporting that market segment is now unprofitable. JBL loves its loyal fans, but the time it takes to answer the thousands of questions from them offsets the resulting sales. As a result of this and the fact that almost all the consumer calls received by JBL Professional are now inquiries into building ultimate systems (despite our efforts to send you to Harman America and sell you the spectacular 250 Ti top of the line consumer loudspeaker system), I have decided to answer all your questions in writing in hopes you won't call and nag me.

This then is what I personally think I would do if I had a lot of money to spend on my own home system and could not countenance the occasional doctor with his super-expensive integrated MacIntosh system, challenging for bragging rights.

HOW GOOD CAN IT GET WITH PRO COMPONENTS?

A sizeable number of dissatisfied audiophiles, bass freaks and a lot of JBL hi-fi old-timers have called and written insisting on my recommendations for "larger" home stereo playback systems that might deliver all the gut-thumping reality of curling up in fetal position inside a rock-n-roll kick drum. Although the merits of self-inflicted hearing destruction escape me, I offer what I consider a useful alternative (for those so inclined) to hiring a live band and a tour sound company when the urge for auditory self-abuse arises.

The "dream system" described here won't peel the paint from your walls or

suffice as a P.A. system for rooms larger than a typical vertical assembly building, but it should satisfy the auditory cravings of even highly altered punkers, disco-droids and the most masochistic metal-rock fans, while still providing adequate subtlety for delicate baroque chamber music, your annual Hogwood Brandenburg, and those ubiquitously popular insect sound-effects records.

The system consists of the following:

[4] 2245H 18-inch subwoofer drivers.
[2] 2220H 15-inch midbass drivers.
[2] 2123H 10-inch midrange drivers.
[2] 2445J 4-inch compression drivers.
[2] 2382 Flat-Front Bi-Radial horns.
[2] 2405 Diffraction tweeters.
[1] 6290 power amplifier.
[4] 6260 power amplifiers.
[2] 6230 power amplifiers.
[2] 525 active crossovers.
[2] 3105 passive crossovers.

The total system cost for these components only, is around $12,000 so dust off the old mortgage papers and gas up the Rolls for the trip to the bank for a second on your house.

The amplifier complement listed will, on demand, deliver 1200 watts to the four 18-inch woofers, 1200 watts to the two 15-inch midbass drivers, 1200 watts to the two 10-inch midrange drivers and 600 watts to the two compression drivers and tweeter units. The total on-demand power is a clean 4200 watts. This may also place demands on you--from your neighbors and local police.

Now before you gasp and expectorate "yech!, horns?" be aware that everything you've heard is history and most of it was wrong. The model 2382 is a two-inch throat, 120-degree waveguide type device with a rapid flare rate and virtually non-existent "horn sound" which is due to horn throat non-linearities associated with smaller one-inch throats and exponential flare rates and it won't be used in this system to reproduce low enough frequencies to be obnoxious anyway. Remember the JBL catalog copy of the Sixties: "Steep wavefronts of explosive loudness are taken in stride by the powerful magnet and 4" diaphragm." Keep an open mind if you expect to be rewarded with high sound pressure levels. It's one of Nature's immutable laws that you must make at least some concessions to get certain benefits (like extremely high sound levels). Sorry, but you can't change the laws of physics with money. Your buddy's 7-foot tall Acoustats are going to sound like a $4 transistor radio next to your system, so stop biting your nails and write the check.

ENCLOSURES

You will need to build or otherwise acquire (don't call us, we can't help) cabinetry that will provide an internal volume of 20 cubic feet for each pair of 18-inch bass drivers, a separate enclosure of 1.5 cubic feet for each 15-inch midbass driver, a sub-enclosure or separate enclosure of 0.3 cubic foot for the 10-inch midrange drivers and mounting surfaces for the horns and tweeters. The whole affair (one left or right member of the pair) will probably be between 48 and 60 inches tall, about 5 feet wide, about 3 feet deep and will weigh a lot.

Build the low-bass enclosures out of something stiff like 6-inch poured concrete cast around woofer mounting rings made from 14-ply Finland birch plywood, or just use the plywood and two-by-four bracing glued and screwed down on-edge anywhere where you can detect any panel resonance when pounding on the panel with your 2-pound framing hammer. The goal here is to make the finished cabinets as rigid as concrete or at least as rigid as possible. Keep in mind that the system will sound better if you build the whole thing into flush-mounting soffits in the wall, so you'd better have a long lease or own the house you intend to modify.

The exact interior box dimensions for the subwoofer enclosures are 41 x 33.5 x 29 inches. The 29 x 40 side is used for mounting the woofers. The ducted vent consists of two boards, 9.25 x 29 inches installed in the center between the two woofers. This slotted vent tunnel serves both to tune the enclosure and brace the side panels. The open area of the vent and tunnel is 4.5 x 29 inches (the width of the box), with a total depth of 10 inches. The 13 inch diameter tube thus replaced, wouldn't fit on the baffle anyway, and slots work the same as tubes--there is no difference at all in performance.

Line the box interior on all sides with a single layer of 1-inch thick, half-pound density fiberglass for internal reflection damping. There is no benefit, and in fact, there could be deterioration in performance if lots of fiberglass is used. Fiberglass adds virtual volume to an enclosure. Wear a mask and gloves when you staple the stuff around the bracing (unless you have put the bracing on the outside of the box) or onto the panel interiors and then take a cold shower when you finish. Maybe you won't itch and cough for a week.

A word of warning for animal lovers: if you have a cat, you should use a

screen of chicken wire on the inside end of the ducts in the woofer enclosures to prevent curious felines from losing any of their nine lives when the cannon from the 1812 overture awakens them from their cozy nap inside the box.

For the midbass driver, you have to create a very solid, resonance-free enclosure to set on top of the bass enclosure. Once flushed into the wall, it won't matter if the boxes don't match width and depth dimensions. The exact interior dimensions of the midbass enclosure are 18.9 x 15.4 x 13.4 and you will need a vent consisting of a 2-inch x 5-inch slot, cut in the 3/4-inch material of the baffle, somewhere near the edge of the midbass driver. As with the woofer enclosure, apply a layer of fiberglass to the interior walls of the box.

The midrange driver is housed in a separate sealed enclosure whose inside dimensions are 10.7 x 8.7 x 7.6 inches. This enclosure too, should be lined with the same fiberglass padding, with an extra layer against the back of the box. It is best to build the enclosure onto a large flat baffle to accomodate mounting the driver since it is 6 tenths of an inch larger than the inside width dimension of its ideal enclosure and some relief routing will be needed to furnish a good mounting and ensure a good air seal.

The horns can be mounted on 3/4-inch baffles made of the same lumber, and don't require sides or boxes, just the front baffle and some way to support it is enough. If you're a golden-eared audio wizard, you may wish to "align" the timing of the acoustical signal arrivals at your listening position; to do this, all you need to do is move the tweeter back over the flat-front horn to a point where the backs of the two magnet assemblies are lined up vertically, and move that whole assembly forward to within 3 inches of the position of the magnet assembly of the midrange driver. If you do this and baffles or horn walls end up shadowing the mounting surface of the midrange driver, simply line all facing surfaces (those that have a view of the midrange driver) with Sonex or similar sound diffusing, irregular-surfaced foam. Do the same on top of the 2382 horn so the tweeter won't be spraying sound down onto a reflecting surface.

CONNECTING THE SYSTEM

Once you've finished the cabinets and mounted all the drivers and horns and done all you can to assuage your family that you don't need outpatient psychiatric help, you can hook everything up. Start by making speaker cables out of the heaviest wire you can find--battery jumper cable is not too large!

The only advantage the "esoteric" cables have over ordinary speaker cables is that they are usually a heavier gauge, beyond that there is no measureable (or it would have been published) difference. Cut your cables 50% longer than you think you'll need for the minimum run, but be careful to locate the power amps close to the speakers so there is no extra cable length. Carefully label all your cables (VLF, LF, MF, HF) for left and right and mark polarity if necessary so you won't get confused, and to be helpful, you should be able to feel any markers in the dark or around in back of the amp rack if you're working in confined spaces. The amp rack (crossovers and power amplifiers) should be wired according to logical engineering practice, crossing signal and speaker wiring at right angles and isolating any chassis grounds as necessary to prevent ground loops and hum. It should be possible to assemble and wire your amp rack so there is no audible hum, just some hiss (associated with high-sensitivity loudspeakers) from the amplifiers when their gain controls are wide open.

The 525 crossovers should be set to divide the subwoofers (VLF) and midbass (LF) drivers at 100 Hz. The 6290 power amplifier, in turn, is connected to the two pairs of 18-inch drivers wired in parallel to each channel, and the two 6260's are switched to bridged mono mode and each drive one of the midbass drivers. The MF outputs of the 525's feed one each 6260, set to bridged mono mode, which are connected in turn, to the midrange drivers. The dividing frequency for the LF-MF drivers should be set to 500 Hz. The HF outputs of the 525's feed the remaining pair of (bridged) 6230 power amplifiers which in turn each feed one of the 3105 passive crossovers. The dividing frequency for the MF-HF section should be set to 1200 Hz.

The 2445J compression drivers are connected to the low-frequency outputs of each 3105, and the 2404 tweeters are each connected to the high-frequency outputs of the 3105 crossovers.

Hook up the 15-inch midbass drivers in reverse polarity from the 18-inch drivers. Hook up the midrange drivers in reverse polarity to the midbass drivers (the same polarity as 18-inch drivers). The horns and tweeters, through the 3105's, should be connected according to the red-black instructions on the 3105 crossover instruction sheet and wired so the input to the 3105 (red terminal) is reversed polarity from the midrange driver, unless you have physically aligned the horn and tweeter forward over the midrange driver, in which case you will flip the polarity of the 3105's input. (NOTE:

this one item may require some fudging and adjustment including polarity experimentation, to achieve the best group delay characteristics.)

TUNING AND TWEEKING

After you're finished putting everything together and flushing it all professionally into your living room wall, you will need to get a 1/3-octave spectrum analyzer or an audio engineer who has one, and set everything up properly by adjusting gain controls and the like. If you live in a metropolitan area, you might even find someone with a TEF machine who is curious enough to measure and tweek a system the likes of which he has almost certainly never seen. I recommend that you don't try to play any music through the system until some measurement and adjustment can be done, so that you will have no chance to suffer buyer's remorse when, because the system is not properly adjusted, it doesn't sound right. If you've spent this much money, you owe it to yourself to finish the job properly.

The best procedure for setting correct gain between all the amplifiers is by the use of sharply defined, octave-wide bands of pink noise. If octave band filters are not available, use the rule of thumb that the subwoofers are the least sensitive portion of the system, so they have to be used as the level reference for the other components, in other words turn them up all the way, then turn up midbass, midrange, and horns, in that order, until the levels sound like they match. The frequency response measurement capabilities of the TEF measurement system are probably the best way to ensure proper system setup and the machine's time-energy and phase measurement capability make it easy to properly physically align the components along the listener's Z axis, forward or back.

THEORY OF OPERATION

My philosophy on speaker system design is in accord with JBL's. Simply stated, the acoustic power output of the speaker system in a diffuse, reverberant field, should be as flat as possible. Individual driver elements should be smaller than the wavelengths they are asked to propagate. I also feel that none of the system elements be should stressed during operation at typical listening levels. For the latter and I believe most important reason, I have chosen midbass and midrange drivers that are the most efficient available in order to start out with the advantage of operating nominally below 1 percent of rated power capability. You should find, when listening to

this system, that there is an effortless, bigger-than-life sonic quality that makes for a very detailed and revealing reproduction of the input signal. This is due in large part to the high sensitivity of the system components.

Although there is every reason to want a single small driver to reproduce the entire audio frequency spectrum, we know from direct experience that small drivers can't handle enough power to produce sufficient acoustic output. The cone of a 4-inch speaker would have to be able to move back and forth 4 feet to move as much air as the subwoofers in this system are capable of moving. In addition, the wider the frequency range one driver has to cover, the more it is subject to doppler distortions; non-harmonic and non-musical irritating sounds caused by the modulation of higher frequency sounds by large diaphragm movements associated with simultaneous low-frequency reproduction. The answer for doppler distortion and power handling capacity is to divide the audio frequency spectrum into bands, each of which represent a small portion of the total required power and each of which require only successively smaller drivers to propagate the successively smaller wavelengths those frequency bands require.

The essence of the system's performance is its ability to track transients, which, in well recorded musical software, will have peak levels 20 to 30 decibels higher than the average power used to play at reasonable listening levels.

Lower efficiency speakers suffer heating of their voice coils and subsequent output compression, from high-power inputs. My thinking is that for a loudspeaker to faithfully reproduce incoming signals, it must at each moment in time, act as though the signals are the first stimulus received; that is, it is impossible for a loudspeaker to be accurate if the signals just reproduced alter the loudspeaker's electrical or mechanical characteristics, by for example heating the voice coils or stretching the active materials that make up the loudspeaker's moving parts. In the case of electrostatic speakers, losses occur as the result of finite power and motion capability. Electrostatic speakers also suffer from extremely low efficiency. The solution is to keep input power levels nominally low so heating is minimized, and to do this it's necessary to use high-efficiency drivers as system elements. The disadvantage of high efficiency drivers is that they cover narrower frequency bands as their efficiency increases. Conversely, wide-bandwidth drivers (the JBL LE8 is an example) always exhibit low efficiency--a direct manifestation

of physical laws.

You may wonder why it's necessary to provide a bridged 600-watt amplifier for a driver that will be operated nominally at a watt. A 20 decibel musical transient peak requires 100 times the power required by the average signal and a 30 decibel peak requires 1000 times the power required by the average signal. The 600-watt power output capability of the amplifier driving the midbass units represents just a bit less than 28 decibels above 1 watt of power reserve for the tracking of transients. If you are an electrostatic or bi-polar speaker fan, you will loathe the sound of this system until you get used to it, after that you will loathe the electrostatic and bi-polar types. An analogy of the perceived effect is that this type of system (high-efficiency type) is like removing an electronic compressor from an otherwise good speaker system.

There is bound to be "time-smearing" or "image smearing" from any sound source that is not a simple point in space, but by aligning the system elements in a straight vertical line (except the subwoofer drivers), horizontal time and image smearing is eliminated. Humans don't perceive vertical time and image smearing unless they jump up and down in front of the speaker system--a practice I don't recommend for critical listening (divides your attention). Since JBL's individual component loudspeakers are matched very closely as a matter of manufacturing practice, the stereo imaging of the system should be spectacular.

DISCLAIMER:

A serious word of warning: the system described here is easily capable of producing sound pressure levels far in excess of that which will cause irreversible hearing loss--don't take this lightly. You might suffer not only permanent hearing loss, but also constant ringing in the ears that can cause insomnia and lead to nervous disorders or emotional problems. JBL and this writer make no claims and take no responsibility for the design, operation or consequences of using the system described here.