

TALES FROM THE LAB

& The **SUBWOOFER**

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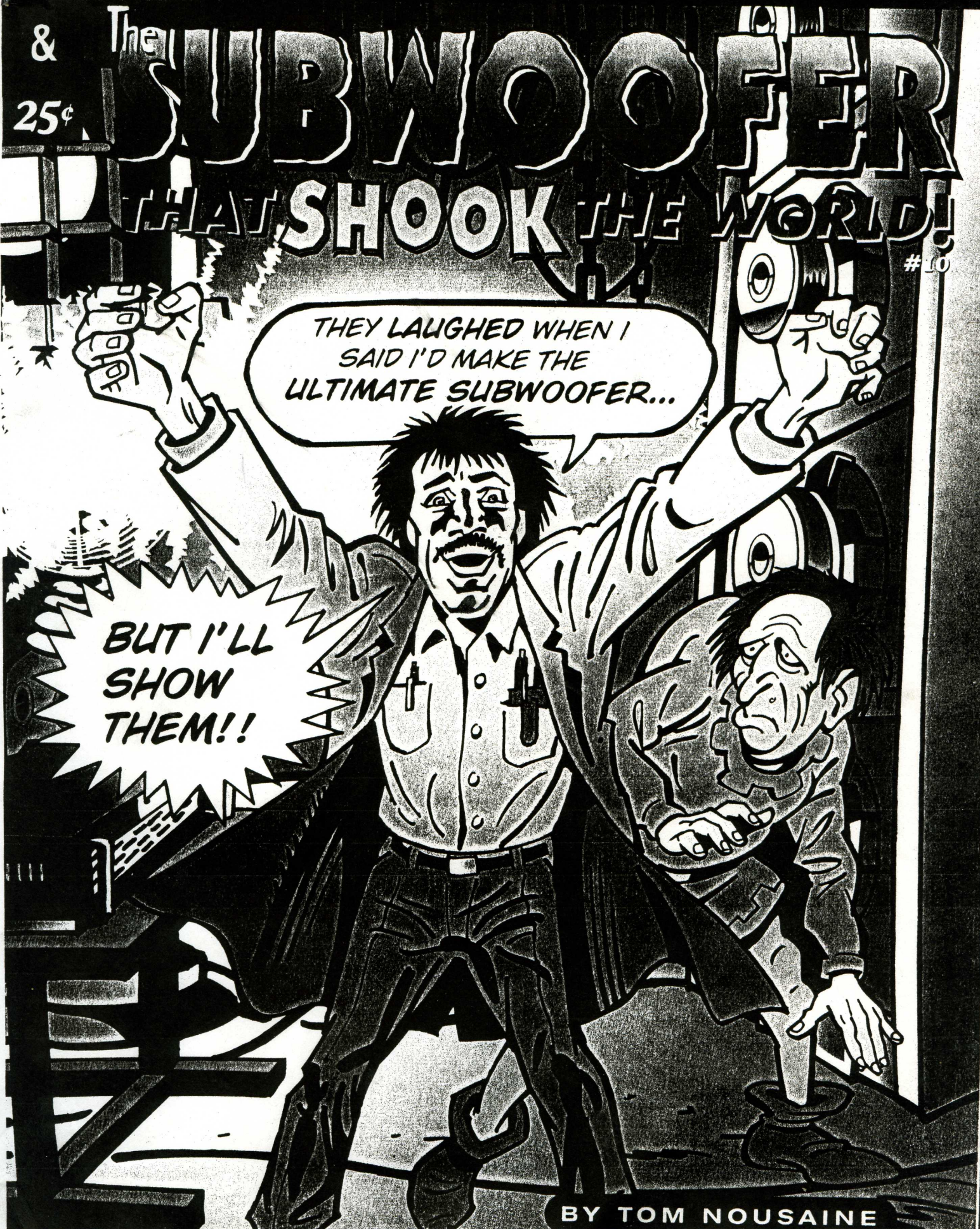
WHAT SHOOK THE WORLD!

#10

THEY LAUGHED WHEN I SAID I'D MAKE THE ULTIMATE SUBWOOFER...

BUT I'LL SHOW THEM!!

BY TOM NOUSAINE



I admit it. I am a bass freak. While other audiophiles and home theater enthusiasts get high on the highs and midrange, I live for the lows. For me, a sound system just doesn't spring to life unless I can feel the impact of Deep Impact. I need a system

with bass that moves me — literally. When it comes to subwoofers, I simply must have the biggest and the best.

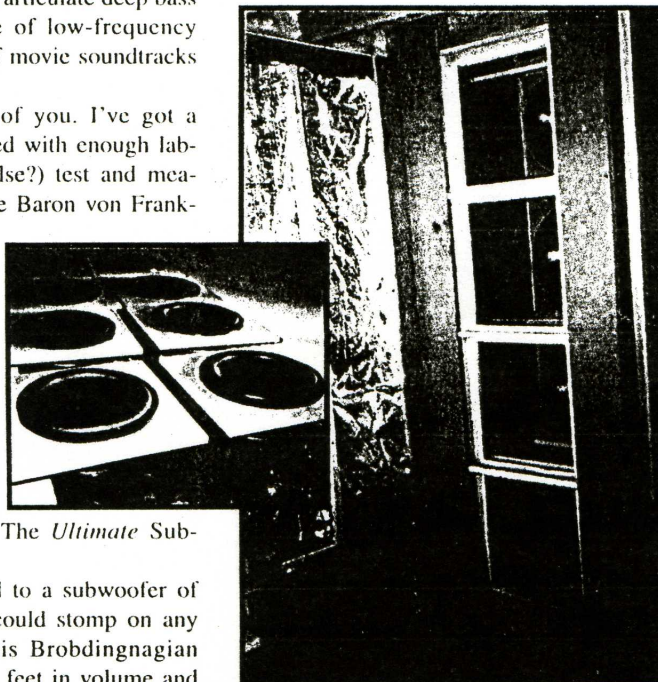
I know most of you are satisfied with factory-built, store-bought subs. I also know that the best commercial subs provide enough extended, articulate deep bass to add a high degree of low-frequency realism to playback of movie soundtracks and music.

But I'm not most of you. I've got a Secret Laboratory filled with enough laboratory-grade (what else?) test and measurement gear to make Baron von Frankenstein green with envy. I also have enough speaker-modding computer programs to bust a hard drive and a workshop that is equipped to construct any speaker — any speaker — I might desire. And my desire was to create The *Ultimate* Subwoofer.

For years I listened to a subwoofer of my own design that could stomp on any store-bought sub. This Brobdingnagian creation was 25 cubic feet in volume and had an 18-inch driver, but it recently woofed its last valiant woof. I've listened to a wide variety of commercial subwoofers over the past few years. Most were good, even exceptional in performance, but they all left me hungering for more. Even the best manufacturers are constrained by practical considerations of size and cost, limiting the bandwidth of their subs at 16 to 20 Hz and their output to around 110 dB sound-pressure level (SPL). I needed more. More gut-churning bass. More pants-flapping power. More structure-shaking volume!

Like a nail in a coffin, this point was driven home by a test of four large-displacement subwoofers I conducted a few months ago for *Sound & Vision's* sister publication, *Audio* ("Monster Bass," Janu-

ary 1999). Incredibly, these subwoofers used no floor space inside the listening room. Instead, each used a basement or an adjoining room as the "enclosure" for its gargantuan bass. The overall performance of these four bass systems exceeded that



Above, the cabinet with four drivers installed (on far side). Inset, all eight drivers on separate baffle boards prior to installation in the cabinet.

of the conventional subs I had been listening to by a large margin.

After retreating to my laboratory, I became consumed with subwoofer envy. I couldn't rest until I had created a monster subwoofer able to obliterate all subs that came before it!

There's no getting around those pesky laws of physics. To move a lot of air and play low frequencies at concert-hall or airport levels, you need a gargantuan enclosure and a mammoth driver complement — something you're not going to be able to buy at your local hi-fi emporium. When

it comes to subwoofers, size *does* matter — there is a direct relationship between the size of the enclosure and the extension and efficiency of low-frequency speaker systems.

But how do you fit a huge box into your listening room? You don't. You can't. That's why the four monsters I tested each used a separate room. Well, I have a basement, too! Why not use that as the enclosure for my *Ultimate* Subwoofer?!

My research showed that the best do-it-yourself subwoofer systems pump out a maximum SPL of more than 120 dB at the listening position, with low distortion down to 16 Hz and in excess of 105 dB SPL at 10 Hz. (When it comes to bass, I love excess.) Still not good enough! My performance target was a *minimum* of 120 dB SPL from 12 to 62 Hz, with low distortion to boot.

To achieve that performance would require an immense cabinet housing several large-diameter, high-excursion drivers working in tandem with the room volume of my basement. I selected no fewer than eight 15-inch drivers, all from TC Sounds of San Diego, a company that bills itself as "The Leader in High-Excursion Bass Drivers." Indeed.

The cabinet was made from 3/4-inch medium-density fiberboard (MDF) and 1 x 2-inch hardwood studs running floor to ceiling on each side of a ceiling joist. It measures 96 inches high, 36 inches wide, and 17 1/2 inches deep, with four 20-inch-square removable panels on each of two facing sides. The panels hold the drivers, which deliver their sound into the upstairs listening room through a 14 x 33-inch hole cut into the floor in a corner of the room. The whole thing resembles a chimney with its top open to the upstairs and the backs of the woofers sticking out.

The cabinet walls can be filled with sand or lead to increase mass if I decide later that it needs even more rigidity. The basic structure is put together with dry-wall screws and carpenter's glue. It's connected to the basement wall and the house structure at the joists and floor with silicone glue and the kind of construction adhesive used for subfloors. Because these adhesives dry in an elastic state, they serve as a damping/isolation material to minimize mechanical transmission of sound.

I used removable driver panels affixed to the frame with 1 1/2- and 1 3/4-inch #10 cabinet screws in case I want to substitute other drivers later. (The enclosure will accept up to sixteen 10-inch or eight 12- to

SUBWOOFER THAT SHOOK THE WORLD!



15-inch drivers and can easily be modified to accept up to eight 18-inch or sixteen 12-inch drivers.) The drivers are mounted facing each other, a configuration that minimizes relative internal movement and cabinet "rocking" because the drivers' push-pull force is equally distributed. Remember, the cabinet is only a chamber that channels the drivers' output into my living room. The basement itself is the "enclosure."

Once the Godzillian cabinet was completed, I connected the woofers for a nominal impedance of 4 ohms (3.5 ohms minimum). Each woofer bank is driven by one channel of a large stereo power amplifier (better than 800 watts per channel), and the signals are fed through a 120-Hz, 24-dB-per-octave low-pass crossover filter, complemented by a 12-dB-per-octave low-frequency shelving filter with a 30-Hz turnover frequency. The basic resonance of the drivers is 30 Hz, with a system resonance of 21 Hz. Take that, Nikola Tesla!

Although the crossover frequency may

seem high, the acoustic output of the system's main speakers begins falling at 70 Hz, and the 120-dB crossover matches the subwoofer perfectly with the rest of the system. However, the crossover I'm using now — a Rane RPM26 cannibalized from my car audio test system — isn't optimal.

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I have a cabinet in the listening room that houses a couple of amplifiers. After

"When I fed the system test tones, glasses rang inside my cupboard, and my flatware jiggled like the Bride of Frankenstein being shocked into life."

I really need to install a filter with a boost centered at 12 Hz. Still, as it stands the system is flat to 15 Hz.

It was time to fire up the beast and let it loose. How did this mega-mondo-monster creation sound? Heart-pounding! Jaw-dropping! When the subway trains blew past Richard Gere in *The Jackal*, a wave of immense energy rippled through the room, shaking the couch and floor.

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one particularly spirited session, a massive 150-watt amplifier actually walked itself halfway off the second shelf and knocked open the cabinet door! A friend couldn't resist looking into the hole in my floor while I was playing a seriously bass-heavy CD. As he was standing over the hole, his pants legs were flapping like crazy. Too bad he didn't get to see Marilyn Monroe's ghost checking it out the other night — looked like that famous scene with the wind blowing her



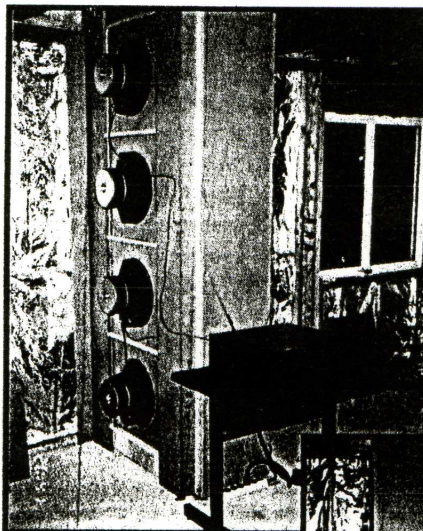
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skirt up. Who says mad scientists have no fun?

The gurgle of rotary piston engines idling at an airport on Tracks 1, 6, and 7 of *Round Sounds Volume 1* (Aircraft Records) was breathtaking. The couch vibrated, and the floor shook. I had to stop myself from getting up and checking to be certain an airplane hadn't just landed on the roof. The dinosaur steps in "Jurassic Lunch" from Telarc's *The Great Fantasy and Adventure Album* were pulse-poundingly scary, especially that first one about 12 seconds into the piece — it felt as if a huge animal had bumped into the far side of the house.

But that's just showing off. The real reason for this Herculean level of bass performance is to have the headroom to play *anything* with deep bass the way it was meant to be heard. The Subwoofer That Shook the World adds an astonishing sense of power and scale to blockbuster movie soundtracks, rock, and symphonic music, bringing my system remarkably close to the sound of real life. True, a good commercial subwoofer takes most



Two views of the subwoofer wired with a Crown Macro Reference amp rated at 800 watts per channel. The crossover is located upstairs.



people anywhere they want to go, and systems like this are only for those who are driven. Like me.

Did I achieve my goal? Not at first! My instruments registered 125-dB SPL peaks with ease, but, as noted, I couldn't test the system at full output because I didn't want to

have to replace my windows. I couldn't actually listen for long at my goal of 120 dB, either — there were a few unforeseen side effects from my project.

After a couple of months the subwoofer cabinet developed a rattle during high-volume playback. The woofers were flexing the mounting panels enough to pull the screws loose — actually enlarging the screw holes from their back-and-forth movement! I added cross bracing to tie the facing sides and frame together to solve that problem — and was able to measure peaks of 129 dB!

I now have to tighten light bulbs more often. And the nails holding down my plywood floor seem much less tight than they were before. Well, I'm not worried about structural damage. No, really. After all, I'm used to hearing mysterious creaks in the night. Nevertheless, when I replace the

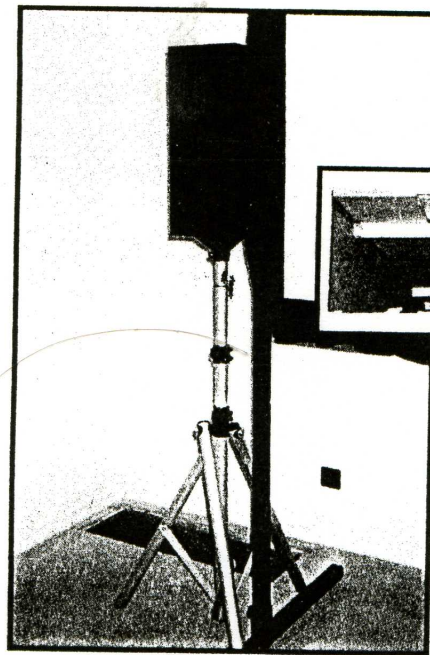


carpet I plan on screwing the floor to the joists.

Sure, I have to fasten my tchotchkes down to make sure they won't rattle or fall off a shelf, but I don't live in fear that my house will be blown down by the subwoofer's huffing and puffing. I did notice that the paint seal between the trim molding and the wall in the basement staircase has cracked open. Must be cheap paint.

What about bothering the neighbors? It's not a problem. In apartments, bass travels right through walls, ceilings and floors. A wall with 3/4-inch sheetrock on both sides stops only about 33 dB of sound at 125 Hz, less than half as much at 20 Hz. But I live in a house, far from my nearest neighbor, and although bass travels well in the earth, it is attenuated dramatically in the process. It would take a lot more than even *my* mondo-mega subwoofer to shake my neighbor's house — he never even hears it.

Perhaps some of you are concerned because I crave listening at 120 dB SPL. After all, isn't 120 dB the threshold of pain? Let no one accuse me of conducting evil experiments. For the most part, hearing



Left, the corner of my home theater with the opening for the "throat" of my subwoofer; inset, looking down into the belly of the beast.

most soundtracks max out at about 105 dB when they are played at the calibrated Dolby level.

I have achieved my 120-dB goal — but I'm not done yet! Even though my sub has 40 percent more displacement than the largest of the four monster subs I tested, my room is so large and has so little bass reinforcement that my 129-dB peak is still 2 dB shy of the best SPL I've ever measured. I will conduct experiment after experiment until my sub is truly the world's ultimate. I certainly have gotten most of the way there, my friends! Just 3 dB to go . . . 3 dB to go . . .

But first, I need to install a grate over the subwoofer hole. When my guests get too close to the opening in the floor and are startled by a loud transient, they fall in — never to be seen again.

S&V

damage is a high-frequency phenomenon. We perceive low frequencies by bone conduction, not through our eardrums, and there's no problem listening to 120-dB bass levels. Also keep in mind that

