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Beyond the Thunder Dome

The Acoustical Rescue of a Venue from Hell

by Daniel Sweeney

The New Bremen American Legion had a problem on their hands. They'd purchased an auditorium with a view to hosting dances and musical events, and the acoustics of that hall were so dreadful they couldn't pay people to attend. Speech intelligibility was terrible, and musical reproduction was worse. High volume sound reinforcement set off uncontrollable bass resonances that fed back through stage mics, while high frequencies were almost totally lost. A complex pattern of focused reflections caused the reverberant sound to exceed the level of direct sound at the stage by 10 dB at 100 Hz.

New Bremen is a little town in Ohio about a hundred miles north of Dayton. It is not a town with a lot of entertainment resources, and virtually any venue providing musical entertainment stands a good chance of drawing widely from the surrounding area. But the hall's original owner went bankrupt trying to operate a restaurant-night club in the building's unpromising interior environment after a futile attempt to correct the acoustics with absorptive treatments to the wall and ceiling. The Legion bought the place on the cheap with the hope they could somehow control the reverberation sufficiently to achieve acceptable acoustics, and by the terms of the sales contract, final sale was conditional upon the rectification of the hall's acoustics.

The American Legion soon found that it had a considerable task on its hands.

The Legion contacted several local sound contractors for proposals, but none of them were even prepared to bid. The consensus among the professionals was that the hall was irredeemable. Finally the Dayton-based sound contracting firm Panacom agreed to have a go at the structure. Acoustical engineer John Murray, now employed at Electro-Voice, was assigned to the project. He in turn contacted Acoustic Sciences Corporation, the manufacturer of Tube Traps and other room damping devices and acoustical treatments. Thus began a most difficult renovation.

BEFORE

"It was a concert hall from hell," recalls John Murray. "It had the worst acoustics of any structure I ever encountered. The focused reflections were the worst aspect of it. You'd get reverberation that was a good 10 dB louder than the direct sound a couple of seconds after the direct sound had arrived."

The basic structure of the New Bremen Legion Hall is a concrete dome. The dome consists of a four inch thick shell of concrete which was literally sprayed over a huge inflated plastic form. The dome is not circular; rather it resembles one half of an egg shell. The structure measures 120 feet in length, and is 100 feet at its widest point. Maximum height is 35 feet. An interior concrete block wall divides the structure at the point of greatest height. The smaller segment of the dome is used as a club house, while the larger segment was designated a concert/dance space.

A half dome of this sort has inherently poor acoustics for speech and music reproduction. The gently curving interior ceiling surface functions as a wave guide, channeling reflected sound against the back wall where it is reflected back, redirected, and reflected back again through many, many wave cycles. In this case the situation was made worse by the fact that the stage was located opposite the partition wall, at the narrowest part of the structure where the reflections converged. The RT60 (time required for reverberant sound to decay 60 dB) of the New Bremen Legion Hall was nearly five seconds at 60 Hz. Bass boom was simply overwhelming, and overhang in the lower midrange was sufficiently long to garble speech intelligibility badly.

As indicated earlier, the previous owner had attempted an acoustic fix, and the treatment he employed actually made the problems more severe. He covered the partition wall with tectum, and sprayed almost the entire ceiling of the dome with 1" acoustic

The New Bremen Legion Hall in Ohio.

cellulose. These treatments brought the RT60 down to less than a second for frequencies above 1 kHz, but did nothing to tame the uncontrolled bass and lower midrange, and indeed made them seem even more resonant. By the time Panacom and ASC were brought in, the building was at its acoustical nadir.

Murray intuited correctly that two steps had to be taken to achieve acceptable acoustics in the room. First, the bass and lower midrange had to be severely damped, and second, the room had to be livened in regions above 1 kHz.

"The Legion went along with the idea of controlling the bass," recalls Murray. "That was obvious to anybody, but they didn't like the idea of livening the highs. That took some convincing."

For bass control Murray turned immediately to Acoustic Sciences Corporation. "I'd worked with them before, and they made the only commercial product that seemed suitable."

Murray had access to TEF equipment and he made a series of measurements of the building with swept sine wave signals. He measured an RT60 of 4.41 seconds for a 60 Hz tone. An octave up, decay time was nearly as long, and it was still above 2 seconds at 500 Hz. Murray sent the information to ASC.

ANOTHER LOOK

Art Noxon, President of ASC, was confident that the structure could be salvaged, but the total budget of $15,000 presented a real challenge. Noxon realized almost immediately that several hundred running feet of acoustical treatment would be required simply to attenuate the bass, and in terms of his company's pricing structure that quantity posed a problem.

ASC's basic product is the Tube Trap. The Tube Trap may be described as a damped resonator consisting of a wire mesh supporting frame wrapped with layers of compressed fiberglass, and surrounding a hollow interior. The Tube Trap, which comes in a variety of different sizes and configurations, has been designed to be reflective to mid and high frequencies, but absorptive of low frequencies. It tends to be most effective when placed at room corners where acoustic pressures are high. The constrained fiberglass layers then face high pressure nodes, which push air past the fiberglass and into the low pressure interior of the trap. Disposed in this manner, the individual strands of fiberglass are exposed to maximal sheer forces, and thus dissipate low frequency energy as heat much more effectively than simple wall panels of packed fiberglass.

ASC is both a pro sound and a consumer audio company, but its primary market is recording studios. The company has been relatively inactive in sound contracting and in supplying concert hall architects, so the Bremen Hall project was a bit outside the company's normal activities. Nevertheless, Noxon was convinced he could set the hall to rights within the budget. "I knew it was going to take some improvising though," says Noxon. "We didn't really have a ready-made product to suit this application."

Noxon generally likes to measure a room using Techron equipment manned by ASC personnel, but in this case he was satisfied with the reliability of Murray's measurements and accepted them at face value. Techron testing was supplemented with the construction of a scale model at ASC's Eugene, Oregon headquarters. Noxon made the model by stretching metalized mylar on a wooden framework, and then reflected a penlight beam off the mylar surface and used the pattern of light reflections to predict how sound waves would behave in enclosed space of the same form. The model is admittedly rough, but Noxon has found such mockups to be generally reliable instruments for determining the gross low frequency characteristics of an acoustic space.

THE FIX

ASC TubeTraps in use at the hall.

Noxon quickly determined the general characteristics of the hall, and realized, as had Murray, that not only would the bass

have to be tamed, but that high frequencies should be livened. The job would have been easier if the tectum and cellulose had never been applied, but since it was impractical to remove all of the treatment, Noxon had to find some other way to make the room more reflective. Altogether, what was needed was a complex arrangement of reflective and absorptive surfaces which would not entail high construction or materials costs.

tended to cause the panels to resonate strongly in the upper midrange, livening up the room in that critical frequency range. On the other hand, high frequencies were reflected with no sympathetic resonance. The panels provided limited attenuation in the lower frequencies, though most of the bass absorption was accomplished by the Half Rounds.

"The RT60 for 63 Hz was down to 2.92 seconds and an octave up the time was 2.64 seconds. Measurements were not made for frequencies past 500 Hz, but the hall was subjectively much livelier."

After the "fix," improvement in RT60 was dramatic.

ASC had no standard product that would address all of the hall's problems, so Noxon had to fabricate some one-off devices for the job.

For bass absorption Noxon settled on a modification of an existing product, the company's 16" Half Round. This is essentially a fabric covered half cylinder designed to lie flush against side walls. For this application Noxon left the fabric off on the flat side to reduce costs, and specified that the half cylinders be directly bonded to the tectum on the partition wall. The Half Rounds were stacked one on top of the other from a few feet above floor level all the way to the ceiling, and a total distance of two and a half feet separated each vertical stack. In this space sheets of corrugated fiberglass were placed, again glued directly to the tectum. The fiberglass sheets, which are basically a ceiling material, had flat-topped corrugations which made for a good glue bond, and which also

In total, 410 running feet of Traps were employed in the job. Total cost of the material supplied by ASC was $9,000. The total bill presented to the American Legion by Panacom was roughly $15,000. No sound reinforcement equipment was provided.

THE RESULTS

The New Bremen hall was subsequently re measured by John Murray with Techron equipment, and improvement in RT60 terms was dramatic. The RT60 for 63 Hz was down to 2.92 seconds and an octave up the time was 2.64 seconds. Measurements were not made for frequencies past 500 Hz, but the hall was subjectively much livelier. In fact subjective impressions of hall acoustics were uniformly positive after Panacom had finished its work, and the Legion began to book acts and stage events on a profitable basis.