

Audio Conversations — Church P.A. Systems, Part I

The following dialogue is a dramatic representation of the problems to be found in dealing with sound reinforcement for churches. Although the characters are fictitious, both the p.a. systems, and the problems discussed, are real.

INDIANA

JOHAN HAS JUST returned from a consulting job in a small, rural Baptist Church. After hearing John describe the most effective cure for their audio problems, Bob has been laughing himself hoarse for several minutes.

Bob: I don't believe you cut the cord on their amplifier!

John: If you'll stop laughing, I'll tell you why. The church is 60 years old, small and with the organ, choir, baptistry and all the worship service up in the front. The ceiling is a steep gable with large wooden beams to support the roof. The side and rear walls are broken up enough that they do not serve as plane acoustical mirrors. The place doesn't need a p.a. system.

Bob: Agreed. But, I'll bet that the place had at least three speakers on each side wall and probably two or three more

where the resident tinkerer had tried to cure an "I can't hear" complaint.

John: I don't take losing bets. Incidentally, all of the 8-inch speakers had 16-ounce magnets and the nicely finished closed boxes had at least 20 liters volume. The voice quality from any one speaker was surprisingly good. It was just the usual problem, the congregation could hear all of the speakers equally well. After five minutes, they were mentally sleeping through the sermons.

Bob: Still, weren't you a little irreverent for charging that minister \$50 just to cut the power cord on his amplifier??

John: (Expletive deleted) no. Joe Blank had already charged him a C-note for drawing up a set of plans to install a pair of columns and a third-octave equalizer. The construction bid was over 3 kilobucks. Besides, it took me an hour to explain why he did not need a p. a. system. Considering my travel time, I didn't make much on that job.

Bob: I have never been able to make enough to pay for my

J. Robert Ashley is an engineering staff consultant for Sperry Gyroscope.

efforts on a church job. Most of the remuneration is a good feeling for helping where help is so badly needed. How did you convince him in just an hour that the church did not need a p. a. system?

John: I used the sound and eyes argument. I had him sit in the second pew and I went to the lectern mike and started reading from the Bible. I got up close to the mike to almost overdrive the amplifier and read very fast. Within two minutes his eyes were wandering and I knew he had lost track of my reading. After four minutes, I stopped, went back and switched off the amplifier, and then resumed reading in a normal speaking voice and at the same rapid rate. He stayed with me for nearly 10 minutes. I told him of the psychological conflict of the sound coming from behind and the eyes telling the listener that the talker is up front. I find it best to keep the explanation simple—don't snow them with two-bit words like inhibition or directivity index. Keep the conversation moving so that he won't ask about the situation in the rear of the church where the sound is equally fatiguing but the eyes and ears argument doesn't hold much water.

Bob: Did he ask the usual question about how to make the timid reader heard in the back of the church?!

John: Naturally. I explained that their church is far enough from the road that traffic noise is not very loud. I asked if the timid readers were understood even using the p. a. system and his answer was no—he received lots of complaints about that. I suggested a training program to teach the timid ones the elements of public speaking. I've seen this work in other churches and I hope he has the patience and skill to sell the concept to his people.

Bob: Good work!! I've never seen a p. a. system help a timid talker and wondered how to correct the problem. Most tinkerers try turning up the gain, get a howl, make the timid one even quieter, etc. There's the great conventional wisdom that loud means intelligible—and it doesn't.

John: I'm going to go to their worship service next Sunday and brag about how well I heard the preacher from the back pew.

Bob: I'll bet you a six pack of Coors that the resident tinkerer installs a new cord within six months—

MARYLAND

Our friends have just walked out of a completely filled 300-seat Protestant Church after a funeral service.

Bob: That was a thought-provoking and wonderful eulogy. Did you notice that the preacher had the attention span of everyone for the full service? Did you notice how well this crowd of strangers joined in for the hymns?? It certainly proves that churches are better off without p. a. systems.

Paul: Yes it does—but you and I are called old fogeys for suggesting that most churches don't need p. a. systems.

Bob: I saw the speakers scattered around—they look like vintage 1950 to me. When did they give up tinkering around with speakers and amplifiers?

Paul: Well, the history is fairly typical for older churches. When it was built in 1920, Rice & Kellogg might have had a gleam in the eye, but their electrodynamic loudspeaker wasn't published until 1928. At first, only motion picture theaters could afford the expensive and bulky loudspeakers. It wasn't until after World War II that prices came down enough for churches to afford p. a. systems. In 1948, the old preacher passed away and a former chaplain was selected. He did a lot for the church and brought in a lot of GIs. One of them was a Navy sonar technician. With large crowds and some timid souls trying to lead the prayers, I suppose it was natural for someone to suggest putting in a p. a. system. Guess who was drafted to design and install the system?

Bob: That sonar technician!! Back in those days the amplifier must have had a pair of push-pull 6L6s with a rating of 50 watts.

Paul: Right. They got the power rating by reading the RCA

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Tube Manual and never bothered to measure it. I checked a few and found they would heat a resistor at 25 watts. That was plenty because the front speakers were close enough to the microphones so that it would howl long before the amplifier would overload. They moved those front two a half-dozen times and then turned them off. Then the choir members behind the preacher started complaining about not hearing the preacher.

Bob: I'll bet a sound level meter would have indicated to within 3 dB of the reading in the back pew. I suppose we did not then know about Auditory Backward Inhibition (ABI) and how the ears are different than sound meters.

Paul: They didn't need your two-bit words. They moved the two front speakers up and over the choir, tapped them way down in power, and declared it the best system in town. That poor sonar man, bless him, attended both services Sunday-after-Sunday to ride gain on the four mikes used. He never let a howl get through and it was surprising how loud the timid talkers sounded.

Bob: Did they still get complaints that the timid talkers could not be heard?

Paul: Yes, but there wasn't much starch in the complaints because the sound did seem loud enough. Nowadays, we call this hearing without understanding. It's the plague I've seen in most churches with p. a. systems.

Bob: I suppose the system was kept until there was a change of minister.

Paul: Yes, our chaplain moved on to a large city up North. There were several visiting ministers before a middle-aged chap with a strong, resonant voice was selected. Would you believe that it wasn't very long before he asked me what to do about that p.a. system?

Bob: But you don't live far enough away to come jetting in with a slide projector as a true expert. How did you turn it off without hurting the feelings of that sonar technician?

Paul: It wasn't easy. We waited until this fine man took a three-week vacation. I was asked to ride gain for those three weeks. The first Sunday, I got there a half-hour early with my Hewlett Packard Model 200 Audio Oscillator. As soon as a few people started talking on the church steps, I piped that trusty 200 into a mike input and swept the frequency and gain knobs like I was tilting a pinball machine. The racket in the church was horrible and sure enough, I got an arc on a dusty 6L6 socket, a ball of fire and a blown fuse. That preacher kept a poker straight face when I apologized for his amplifier blowing a frammatidazzle. I gave the timid talker a pep talk on speaking up and then stood in the back pew with my hand cupped on my ear to goad her to talk up—and she did. The preacher used that great voice of his to best advantage and got more compliments on his sermon than ever before.

Bob: Pretty sneaky. How did you keep it turned off??

Paul: Well, that frammatidazzle had to be ordered from Chicago and of course they sent the wrong size the first time. By the time the sonar technician got back, I had taken the amplifier home to try to improvise a frammatidazzle. He thought I was half-cracked but when he heard that great resonant voice of our preacher, he suddenly realized he was tired of riding gain all Sunday morning. Also, I got to the song leader with honest words about how much better the congregation was singing without the p. a. system and she got on her high horse about not needing a microphone. I think most folks got the p. a. fever out of their blood and knew they were better off without one.

Bob: I see a larger and newer Catholic Church down the street. I'll guess it was built in the mid-fifties and had to have a p. a. system to keep up with this church.

Paul: Right you are, except that the original reason given was that any 600-seat church had to have a p. a. system.

Bob: Without walking inside, I'll bet I can tell you about the sound system.

Paul: Since all Catholic Churches are supposed to be alike, you should be able to.

Bob: This isn't a matter decreed by the Pope but I sadly admit most of the Catholic Churches do have lousy p. a. systems. When was that church built?

Paul: 1953.

Bob: That was before the Vatican II reforms, so it has a choir loft with an electronic organ in the back.

Paul: Wrong—it's a good pipe organ.

Bob: That means they really have trouble with congregational singing now. Probably the sound system was designed by the architect or the electrical lighting consultant. It started out with six or eight 12-inch speakers mounted down from the ceiling. When it howled badly on day number one, one of the electricians got up and disconnected the front two speakers. The inexpensive microphones must have been high impedance with some single contact cable connectors and phone plugs along the way. At least the wiring met safety codes. In the excitement of moving into the new church, the fact that the system actually turned on and that adequately loud sound came out of each speaker convinced them that they had a good p. a. system. After all, every other church has the same kind of p. a. system—it has to be right!!

Paul: I suppose that is the conventional wisdom. For the first five years, our Catholic friends were sweating out the payments and couldn't have done anything even if they recognized trouble.

Bob: Did it ever break down long enough for them to realize it wasn't needed?

Paul: No. A local dentist took physics in college and is pretty handy with a soldering iron. They may have missed an occasional mass but never a couple of weeks in a row.

Bob: When did the Bishop rotate the pastor?

Paul: That was about 1962. The new priest immediately complained about the tinny sound of the system and let it be known that the Protestants down the street had a better p. a. system. After working on his teeth, the dentist got some free advice from our sonar technician. The dentist got a couple of friends to share the expense and put in some good cardioid mikes. They rewired the mike circuits with low-impedance balanced lines with Cannon 3-connector plugs and jacks.

Bob: That should have taken care of the hums, buzzes and squawks. Did the pastor think it sounded better?

Paul: No. They could get a little more gain before feedback but it still had that "church p. a. system" quality about it. Since it is a bigger church, it just can't sound as good with multiple speakers as the Protestant church with the same layout.

Bob: The next act is to put in better speakers.

Paul: Right you are! The dentist got his buddies to kick in a kilobuck—a lot of money in 1963—so that they could buy \$50 made-in-California speakers. You should have heard the oohs and aahs as they unpacked each one tenderly, admired the cast frames, the huge magnets, and those shiny aluminum dust caps. The el cheapos that came out looked pathetic by comparison—and a couple had dragging voice coils.

Bob: So, the sound was louder, the distortion gone, the voice response was smoother—and people still slept through the sermons.

Paul: That dentist had to fix my bridge around 1965. He told me all about the great rebuilding project. I asked him what the last Sunday's sermon was about and he couldn't tell me a thing. In fact, he confided to me that the new priest was boring and didn't prepare his sermons very well.

Bob: That is sad. The congregation sleeps through the sermon because of the lousy p. a. system and then blames the preacher. Did you give the dentist the word on turning off the p. a. system?

Paul: Of course—and he considered my free advice to be worth just what he had paid for it. After all, what does an electrical engineer know about the physics of sound?

Bob: I suppose they endured that system until the next rotation of pastors. How did they get along with the changes in the

Catholic liturgy that put more emphasis on congregational singing?

Paul: Not very well. I hear stories about the unpaid organists not having good rhythm, the song leaders singing flat, and that no one sings with them. The good news is Christmas and Easter. They put together a good-sized choir, rehearse for about a month, and just raise the roof with good singing. The best music in town is their midnight mass. The congregation really joins in for singing the Christmas hymns. Maybe that is because they are so familiar.

Bob: No, Paul. It is because the choir is in the back of the church and that dentist hasn't rigged a mike back there. The only Catholic churches where I have found good congregational singing are the ones without p. a. systems.

Paul: Come on Bob, you can't blame everything bad in the Catholic church on p. a. systems.

Bob: That isn't much of an exaggeration. Remember how music has evolved in the Catholic Church. Until the past decade, music was a dialogue between priest and choir or a monologue from the choir loft behind. The big pipe organ evolved to fill the large European cathedrals with sound—you have to hear Bach at Notre Dame to really understand this heritage. A good priest with a 10-man choir doing a Gregorian Chant will raise goose bumps even if you not understand Church Latin. Turn on a p. a. system and the whole thing goes sour—the larger the church, the more mischief from the p. a. system.

Paul: What is being done about this mischief?

Bob: Not much. In the older churches, the organs have been left in the choir loft and the song leader brought to the front of the church. In my experience the church where this works best is a 200-seat Mexican Architecture Church in rural Boulder County, Colorado. This is one where the tyrannical old pastor turned off the p. a. system. The cantors have college educations in vocal music. A big university nearby with a good college of music and a large pipe organ means that one can hire good

organists. The old Allen Electronic Organ is up in the choir loft. Once the singing gets started, the organ loudness is increased to punch through the melody line. The source of synchronization for the congregation is the organ—the singing is so loud that you can't hear the song leader beyond the first couple of pews. You have to hear it to believe it.

Paul: Don't most Catholic Churches seat more than 500 people?

Bob: Probably yes. When the song leader gets on the distributed speaker p. a. system and the organ plays from the rear you will hear many musical mistakes. If the musicians are non-professional, they will get out of step with each other. The resident tinkerer will be asked for help and he will often install another speaker near the organ console. Now the organist can stay in time with the song leader. However, you and I know that sound travels 345 meters per second and takes about a tenth of a second to get from the organ to the song leader. He thinks the organ is late by about a sixteenth note. Listen—every time you'll hear the tempo slow down in the first bar of music.

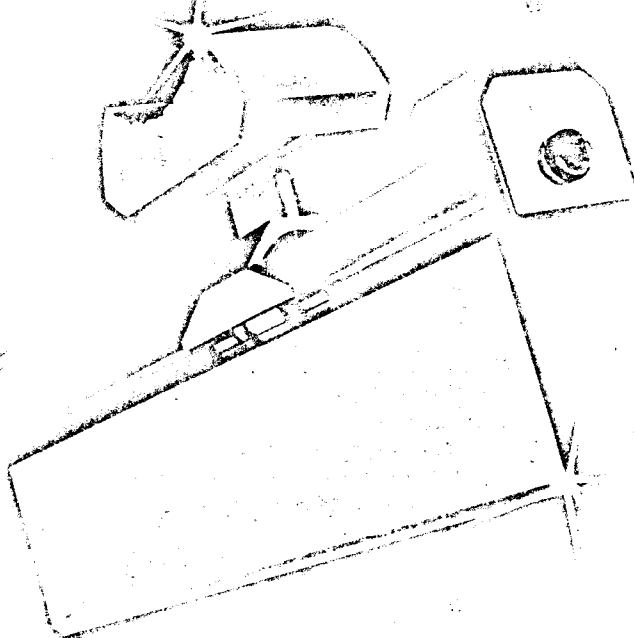
The people in the church are caught in the middle of this conflict and don't know whether to follow the organ or the song leader—so they meekly switch back and forth. Usually, less than half join in the singing and these do not sing with vigor. They are afraid of making a mistake. This kind of singing doesn't do much for the Catholic liturgy.

Paul: Why don't you Catholics just move the organ up front, where it is in most Protestant Churches?

Bob: I don't know. If it is an old church with a pipe organ, there are obvious construction difficulties to overcome. Moving an electronic organ is no big deal, but I haven't yet been able to talk a single pastor or parish council into moving the organ up front. I simply cannot convince them that the cause of their congregational singing difficulty is the sixteenth note of sound transit time between the front and rear of the church.

Paul: Can you quote any examples of better music with the organ up front?

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Bob: Yes. Every Protestant church I have been in where the organ is up front and the p. a. system not used for singing has excellent congregational singing. There is a five-year-old Catholic church 100 miles south of here which has the organ up front with the speakers flanking the altar. They don't even have a song leader and their singing is great. Just like that church in Colorado, the organ puts out a loud and clear melody line which synchronizes the singing. This works with the organ to the rear also—song leaders are not very necessary for congregational singing.

Paul: That's heresy.

Bob: Have you ever heard good congregational singing in any church where the distributed speaker p. a. system is used?

Paul: No.

Bob: Let's get back to the evolution of the sound system in the Catholic Church down the street. Most of the churches I know have some kind of a change to the sound system every ten years or so, usually when new people become involved.

Paul: Well, that dentist did move to a mountain town in Colorado and a new pastor was appointed about 1972. It didn't take him long to figure out that most people were sleeping through his sermons and that the congregational singing was anemic. After a big discussion, they decided to bring in a big city sound contractor.

Bob: And he put twin columns in the front of the church.

Paul: Well, what else could he do? The eight speakers on the ceiling were of the best brand he sold, the mikes and wiring were put in right by the dentist, and he had to do something different to justify his fee. The only other kind of p. a. system you see very often in medium size churches has a pair of sound column speakers, one on each side of the sanctuary, and about midway between floor and ceiling.

Bob: It sounded different—did he get paid for the job?

Paul: There was some dissention from the first because the bass response was not as good as it used to be—those p. a. columns have little speakers in them that cut off below 300 Hz. The contractor argued that that was the price to pay for good directivity and that now the eyes and the ears agreed that the talker was in the front of the church. They paid but were never convinced that they got their moneys worth.

Bob: The congregational singing probably went from bad to worse with an eighth note between the song leader and the organist. What did the sound contractor do about that?

Paul: He tried to sell them an electronic organ for the front of the church. No sale.

Bob: That would have probably worked better than their old system. Did the new resident tinkerer put a speaker back up by the organ console?

Paul: Yes, and the singing got a little better. About a year later, the pastor asked me to drop by to give a listen. I really didn't quite understand why the place seemed to sound more like a gym than it did with the eight speakers on the ceiling. At first glance, the twin columns ought to do better than that.

Bob: Most of the trouble was from that speaker up by the organ console. But, there is a booby trap in the twin-column idea which has snared most of the people who have tried them. The usual installation of a column speaker is for the bottom to be about eight feet up from the floor. This gets the directivity pattern over the microphones and brings up the acoustic gain. The booby trap is the usual smooth wall at the rear of the church. If you are in the front third of the church, you will get two bursts of sound spaced less than 10 milliseconds apart from the front speakers. Then, maybe 200 milliseconds later you will get a tight cluster of six bursts of sound reflected from the side and rear walls. Even a bounce from the front of the church after almost 400 milliseconds is surprisingly loud. With the eight speakers, there were just as many bursts of sound but they were spread out in time. The effects on intelligibility are quite different. The distributed speakers cause listening fatigue throughout the church. The twin columns are very intelligible in

the back quarter of the church and the intelligibility degrades to poor as you move to the front. This is ABI—hearing without understanding—at work.

Paul: Your guesses about the evolution of that Catholic sound system have been pretty good. They should be getting a new pastor one of these days—what will happen next?

Bob: Someone will sell them on hooking up the speakers on the ceiling again, putting in a new, high-power, solid-state amplifier, and a third octave equalizer.

Paul: (Feigning innocence) Won't that take care of the troubles?

Bob: (getting red in the face) Hell No! I've never seen a third-octave equalizer do any good in a church, high school or even a concert hall. They will make the sound level meter go 10 dB higher but do nothing for intelligibility. Intelligibility problems are solved with acoustics and loudspeaker array design. First, one must correct some well-known acoustical difficulties with diffusion and absorption. Then, exactly one correct speaker array in the right location will make the amplified sound crystal-clear. Anyone who installs a third-octave equalizer is just proving that he doesn't know much about psychoacoustics or speakers. All they are doing is ripping off a bigger sales commission.

Paul: Calm down, Bob, I don't want to go to another funeral. What would you advise this new pastor to do?

Bob: Take out the p. a. system. They don't need one.

Paul: I agree, but it won't happen. After they get the five kilobuck quote for the third-octave equalizer with all the bells and whistles, they're going to be around asking for more free advice. What can I tell them?

Bob: First, take your side cutters and a crowbar up to the choir loft and rip out that speaker near the organ console. Give it to the Salvation Army. Then, get a music dealer to demonstrate an electric piano for the front of the church. Make sure that the amplifier and speaker can really belt out the acoustic watts—don't improvise with a guitar speaker. This stuff is going to take the biggest bite out of the budget. If this piano seems distorted or anemic, try another dealer. The piano speaker will probably work best in the right front corner for a Catholic church. Run the gain on the song leader as low as possible and watch the congregational singing get as good as you Protestants do it.

Next, show the pastor the Klipsch ad which calls for putting Heresy® in your church. I would prefer a Benson electrically tapered linear array speaker but these are not commercially available. The omni-directional Heresy® has a lower f_3 of 60 Hz and over 1.5 percent efficiency. It will operate with negligible distortion as a voice speaker. The most important thing is to follow the Klipsch advice on where to hang this single speaker. It goes to the top of the church, right above where the center of the communion rail used to be. From this point, the transit time for amplified sound is within about 15 milliseconds of the transit time from any talker in the sanctuary. If the speaker is run just loud enough to get a good signal-to-air-conditioner noise level, most listeners will get a clear acoustic location of the sound as right at the talker's head—this is the precedence effect of Joseph Henry in action. The reason this works when the twin columns didn't is the higher location. Sound from the speaker that is mirrored off of the back wall is soaked up in the back pews.

If you have a spare kilobuck in your budget, get a four-input automatic mike mixer. This will give the well-known 6 dB higher acoustic gain compared to running the four mikes open all the time. A more important advantage is that the open extra mikes circulate the amplified sound; you can think of it as electronically increasing the reverberation time. This would help the organ but it will degrade speech intelligibility. The automatic mixer is one of the new gadgets that is really worth the money.

Paul: That free advice should be worth more than what they will pay for it.

We leave our friends until next month.