and looked in. I explained my predicament and asked for his advice. He immediately suggested that the drummer hit his drum *before* he heard a window crack. What a wonderful solution! Now we had unpredictability, anticipation, and the element of time. Something banal in music was turned on its head. Now you had response and call, which was much more interesting.

Vespers

In the late Sixties I was looking for something outside of music that would inspire me. I didn't want to write the kind of music that everyone else did. It didn't interest me to write for conventional musical instruments. It didn't even interest me to play an instrument, actually, although I was making a living as a choral conductor. I wanted to find my own idea. Virgil Thomson gave a lecture once in which he said, "What I demand from a composer is that he be original." The audience booed him. They didn't like the idea that a composer would think he or she had to be original.

I began to read *Listening in the Dark* by Donald Griffin, a pioneering work in echolocation. Griffin had also written a more popular book on this subject, *Echoes of Bats and Men*. It was a comprehensive study of the sound sending and receiving acuity of bats. Griffin discovered how bats avoid obstacles and hunt for food. He extended wires across his lab and observed how bats avoided hitting them. They were extremely skilled in doing this. Because sound waves have to be smaller than the objects they're bouncing off of, bats learned to emit trains of extremely high pulse waves, so high we humans can't hear them. Low sounds have longer wavelengths; they spread out, they can even go around corners. High sounds, with shorter wavelengths, are more directional. You can actually measure the wavelength of any musical sound. Here is a simple formula for doing so:

Wavelength = speed of sound (ca. 1130 feet/second)/frequency.

So A-natural at 440 cycles per second has a wavelength of about 2.6 ft.

When the echoes from a flying insect come back to the bat, it can tell how far away the insect is, where it is, and how fast it's moving. Griffin's book gave me a lot of ideas. I began thinking of sounds in terms of short and long wavelengths, not as high and low pitches or notes written in time from left to right on a page. I was truly impressed by these creatures that employ sound so exquisitely for survival.

There was an interesting program on television the other night. A young man has learned how to echolocate skillfully enough to negotiate through his neighborhood without bumping into things. He makes clicks by snapping his tongue against his palate. It was uncanny. He could tell you what every object was. It was the first time, I think, that a human being has learned how to echolocate.

It often happens that when you are looking for something and your mind is prepared sufficiently you find it almost as if by accident. I happened to meet a man in Cambridge, Massachusetts, who was working for a company called *Listening Incorporated*. The company was trying to develop ways of communicating with dolphins. They were manufacturing a device called a Sondol (sonar-dolphin), a hand-held pulse wave oscillator. You know what sonar does. You send out a sound wave, it reflects off an approaching ship, for example, bounces back and tells you how far away it is. Radar is similar but it employs radio waves. I borrowed a prototype of a Sondol and turned it on. I adjusted the pulse rate—you couldn't change the volume or any other parameter—and immediately heard reflections off the surrounding environment. It was beautiful! When I beamed it at a wall I heard that the echoes that came back differed from the pulses that went out. If I aimed it at glass window I noticed that the echo was different from that which came from the wall. I visualized the sounds getting squashed on the impact. If we had perfect hearing, we should be

able to tell how far away that wall is. Because sound travels about 1130 feet per second in air (under water it's five times faster), if it returns to you in a second, you can assume that the reflective surface is about 600 feet away. Half a second out, half a second back. The echoes are beautiful outdoors; you can hear the leaves on trees. By aiming the Sondol at certain angles one can create multiple echoes. They ricochet all over the room. Musicians ask to borrow my Sondols for concerts but I can't let them have them; they're one of a kind and can't be replaced if lost.

One night I had a vivid dream. (When you're deeply involved in a project, you start dreaming about it.) I saw humans—astronauts perhaps, I may have been one of them—exploring a dark space in an alien environment. They were beaming sound guns into darkened rooms, collecting information about those rooms and relaying it back to Earth. It was kind of a science fiction idea.

I bought four Sondols from *Listening Incorporated* and thought about making a performance piece. In those days you often didn't know how your piece was going to go until the day of the concert. In 1968 I was invited to Ann Arbor, Michigan, to the *Once Festival* Bob Ashley and Gordon Mumma had organized. I decided to present a piece with four performers playing Sondols. Not until the dress rehearsal was I clear about the form of the performance. Nothing in my training could help me organize the structure. I couldn't use what I'd learned in school because that had to do with notes and pitches and meters and rhythms. This piece had to do with pulse waves echoing off walls, ceilings, and floors of enclosed spaces.

The performance took place in the Michigan Union Ballroom, a huge space on the University of Michigan campus. I blindfolded the performers and stationed them in the four corners of the room. As a sort of prologue to the performance I walked around the room. My shoes, which had leather soles, made sharp, clicking sounds. I pulled apart the drapes on the windows to make the

room more reverberant. I stacked up some chairs and positioned a couple of potted plants as obstacles. I hoped that the performers, as they approached the plants and chairs, would hear echoes coming back from them and could avoid walking into them.

Instead of writing a score that stipulates when each player plays and in what combinations I simply asked them to move to a central point in the darkened space, listening to their echoes as they moved. I gave them the task of orienting themselves in the dark, avoiding obstacles, and arriving at a predetermined goal. If they followed this simple task rather than imposing their own ideas about something musical everything would fall into place. For example, when four people are playing at the same time, the texture is so dense that none of them can hear his own echoes. The players have to stop playing every once in awhile to allow each other a clear sound-image to follow. So silence is built into the performance. I didn't indicate when it should occur. Stops, starts, silences, density, and texture are built into the task of orienting oneself by mean of echolocation. A performance of *Vespers* gives you an acoustic signature of the room, as if one were taking a slow sound photograph over a long period of time. You hear what the room sounds like. That was mysterious to me and wonderful. It really turned me on.

I called the piece *Vespers* for two reasons. Vespers is one of the seven canonical hours the Catholic Church held in the late afternoon or early evening. Although I am not religious I thought of it as a ritual in some way. *Vespers* also refers to the common bat of North America, of the family *vespertilionidae*. I wanted to pay homage to these courageous and supremely skillful creatures that are so maligned by our culture. Bats are just fabulous! They scoop up insects with their wings. They do all sorts of fancy things.

Once we performed *Vespers* in Finland. I had bought five hundred little toy crickets to take along with me. You know those metal toy crickets you can buy for a few cents each? They make sharp

clicking sounds. Toward the end of the performance I passed a bunch of them out to people in the audience. Three hundred people or so began playing their crickets. The hall was ringing! The sound image of that room was marvelous. The room was being used as an instrument. Then a professor from the local music conservatory went out and got his violin. He started playing it in the middle of the performance. Can you believe that? People around him started making vulgar vocal sounds, or banal rhythms by clapping. If people were going to interfere with my pieces I wish they'd do something more interesting. I was depressed. After the concert as I was walking through the streets of Helsinki I could hear people that had been at the concert playing their little crickets. At two o'clock in the morning I could hear the loveliest trains of ticks and their accompanying echoes. It was beautiful. Some people finally got the point of the piece.

I Am Sitting in a Room

One day during the fall of 1968 I bumped into Edmond Dewan in the hallway of the Brandeis Music Department. In casual conversation he remarked that a professor at MIT named Bose had just given a lecture in which he described a way of testing a loudspeaker he was designing. He recycled sounds into his speakers to hear if their responses were flat. That's all I remember of our conversation. I picked up on the idea and decided to make some preliminary experiments in one of the practice rooms at Brandeis. I made sounds of various kinds and recycled them into the room over and over again. The results were strident; the room was too bright acoustically.

During the spring of 1969, I was living in an apartment at 454 High Street, Middletown, Connecticut. I was teaching during the spring semester at Wesleyan. It was a sordid habitat, the kind universities rent to part-time faculty. It had a green shag rug, heavy drapes on the windows, and an old armchair. I mention

this because it has a lot to do with the acoustics of the room. The kitchen was supplied with one pot, a skillet, and a coffee cup. But that was okay; I was by myself and ate out a lot anyway.

One night I borrowed two Nagra tape recorders from the Music Department. They had purchased them for ethnological field recording. At that time Nagra machines were the *sine qua non* of the recording industry. They were the finest portable reel-to-reel recorders for films and field recording. Any Hollywood Western you ever saw was probably recorded with a Nagra. They were beautiful machines. I had a Beyer microphone, a single KLH loudspeaker, and a Dynaco amplifier. I set the mike up in the living room, sat down in the armchair, and wrote out a text that explained what I was about to do. In those days, there was a genre of work in which the process of the composition was the content of the work. I remember a Judson Church dancer, Trisha Brown I believe, describing her motions as she was doing them. I decided that the work would have no poetic or aesthetic content. The art was someplace else.

I placed the two machines on a table outside the door so the spinning reels wouldn't make noise. I unplugged the refrigerator, turned off the heat. I waited until the radiator pipes had cooled and the room got quiet. I waited until after 11 o'clock when a nearby bar, *The Three Coins*, closed. It was snowing that night so it was relatively quiet outside. There was not a lot of traffic going by. I went outside into the hallway, turned on one of the Nagras and, returning to the living room, read the text into the microphone. When I was finished, I went back out into the hallway, stopped the machine, rewound the tape, and listened to the results through headphones. The levels on the meters were okay. They hadn't peaked into the red zone. That would have indicated distortion. I transferred the tape to the second recorder, which was routed through the amplifier to the loudspeaker. I had positioned it on the chair I had been sitting in. I wanted the copy to

sound as much like my original speech as possible. I wanted it to sound as if I were there in person actually talking in the room.

I went back outside the room and played this copy into the room again, recording it on the first recorder. I repeated this procedure until I had sixteen versions, one original and fifteen copies. I stayed up all night doing it. As the process continued more and more of the resonances of the room came forth; the intelligibility of the speech disappeared. Speech became music. It was magical.

I chose speech to test the space because it is rich in sounds. It has fundamental tones (formants) and lots of noisy stuff—p's, t's, s's, k's. It was crucial to avoid poetic references—poems, prayers, anything with high aesthetic value. I felt that would only get in the way. I wanted the acoustic exploration to be paramount, the room acoustics and it's gradual transformation to be the point of the piece.

Imagine a room so many meters long. Now imagine a sound wave that fits the room, which reflects off the wall in sync with itself. It will be louder (constructive interference). This is called a standing wave. If the wave doesn't fit it will bounce back out of sync and dissipate its energy (destructive interference). This is a simplistic model of what happens in *I Am Sitting in a Room*. All the components of my speech that related to the physical dimensions of the room are reinforced; those that don't, disappear. Think of yourself singing in the shower. You instinctively find the resonant frequency(-ies) of the small space you are in. Your voice sounds rich because it reinforces itself.

While the procedure of the work was repetitive, the rate of change of the resonance went at its own speed. I was careful not to influence the results in any way. I didn't raise or lower volume levels on purpose to make the process go faster or slower. I did have to carefully monitor the levels, however, in order to keep the recording from distorting or getting too soft. I did this minimally. I wanted the room to do the work.

I've made several versions of *I Am Sitting in a Room*, one for the dance *Dune* by Viola Farber, another in my house on 7 Miles Avenue. Each one sounds different. A couple of years ago some folks in Toulouse made several versions of the work. One of them was in a dialect peculiar to that region in France.

Chambers

In 1968, composer Pauline Oliveros, who was on the faculty of the University of California in San Diego, invited me out to be a guest artist. Every day I used to drive out on Route 1, along the ocean from La Jolla to Leucadia, and I would pass by a seashell shop. One day I stopped to buy several conch shells, some rather large. Pauline and I sawed the ends off them to make them into wind instruments. It's not the first time shells have been used as trumpets; they've been used in many cultures as that. I thought about when you're a child: you put a seashell up to your ear, and you hear the ocean. You hear the sounds around you resonating in the interior of the shell. I started to think of those shells as small rooms that had special resonant characteristics.

When I came home, I composed *Chambers*. The score consists of two lists: one is a collection of resonant objects one can find; the second is a list of ways of making them sound. It started as a conceptual piece that has several versions. One is that you find, collect, or make small resonant environments that you would put a sound in somehow, and hear the sound of the environment that the sound was originally made in in this new environment, and you would hear the change in the sound. I made a performance piece in 1968 for the Museum of Modern Art in New York. I gave everybody money and sent them out to buy materials for the performance. We had brought along suitcases, boots, bags, lunch boxes, vases, pots, pans, and other small, enclosed chambers. All we needed were sound sources that functioned by themselves. In a couple of hours the players came back with toy airplanes, trucks,

16
RECORDING

Sferics

Sferics is the shortened term for atmospherics, electromagnetic disturbances in the ionosphere. They're natural radio waves in the audible spectrum caused by electrical storms in the ionosphere. You can't hear them with the naked ear. They're not sound waves, they're radio waves. But they're low enough in frequency that you don't have to transpose them down into the range of human hearing.

Scientists call these phenomena bonks, tweeks, and whistlers. A whistler is a bonk that has been caught by the magnetic flux lines surrounding the earth and actually travels thousands of miles, producing a long descending whistling sound as it does so. Doesn't Thomas Pynchon's *Gravity's Rainbow* open with a scene at a whistler listening station in Africa?

I had done a couple of performances with noisy disc recordings made by astrophysicist Millett Morgan at Dartmouth, but thought it would be wonderful to record them for myself. In 1968 Pauline Oliveros invited me to the University of California at San Diego to record these phenomena. Nobody knew how to do it then. We went out into canyons with homemade radio receivers, trying to avoid electrical hum from power lines. Whenever you're near electric lights or electric power you get a 60-cycle hum that interferes with clear reception. If you could get away from electric power, you'd get a clearer signal. There was nowhere to go in Southern California to get away from electric power. One evening Pauline

and I went out to a helicopter launching pad in La Jolla. All we got was the noisy signals of fighter planes taking off for Vietnam from a nearby naval air base. The performance was a disaster.

Years later Ned Sublette recommended *Listening to Radio Energy, Light, and Sound*, a do-it-yourself book by Calvin R. Graf. The author tells you how to make large loop antennas by crossing a couple of strips of wood, cutting notches in them, and winding eighty feet of eighteen-gauge wire around them to form simple but effective antennas. They are powerful enough to receive sferics. I simply plugged the antennas into a battery-operated cassette tape recorder. All I had to do was match the impedance of the antennas with that of the microphone inputs of the recorder.

I drove up to the top of a mountain in Colorado, one night in late August 1980, to get away from power lines. A few weeks before I had called up the Atmospheric Lab in Boulder and asked someone if he thought I would get a stereo effect if I used a pair of antennas instead of only one. He wasn't sure but thought I would have to position them a thousand miles apart. I started to think how to synchronize the signals over such a long distance. I had a friend in Australia. Perhaps we could figure out a way to do it.

I set up my antennas, leaning them up against a couple of bushes, turned on my tape recorder and, lo and behold, I heard sferics as clear as day (night, actually) through a pair of headphones. I discovered that by simply spreading the two antennas twenty or thirty feet apart and aiming them in different directions I could get a beautiful stereo sound field. Every time I changed the tape I would randomly re-orient the antennas, shifting their positions a little, thereby shifting the spatial quality of the stereo field. I got a faint whistler at around 11:30 P.M., then a series of them just before dawn.

A few years later I installed *Sferics* once more in El Morro, New Mexico, as part of an Earth Watch project. We set up a small array of antennas on the top of a mesa. Visitors could come and

sit in camp chairs and hear sferics in real time. One night there was a distant lightning storm. You could see lightning and hear loud bonks simultaneously. They were manifestations of the same event. Ionospheric disturbances are happening all the time. The ionosphere lies about eighty to three hundred miles above the earth. It merges with the magnetosphere, part of the Van Allen Belt. It becomes active at night. At dawn it quiets down. It's so beautiful up in the mountains to watch dawn come up as the atmospherics sparse out. It's ironic, too, that you have to go out into the wilderness to make the recording. There's a lovely crunching sound near the end. I have no idea what caused it. It's much more interesting to listen for whistlers in real time than to hear them on tape.

Angels and Insects

There's a beautiful recording of underwater sounds by David Dunn called *Angels and Insects*. Beneath the water's surface are a variety of plants and insects. While the sounds above water are comfortable and familiar those occurring under the surface are shocking. Their alien variety seems unprecedented as if controlled by a mysterious spirit. The minutiae that produced these audible rasps and sputters remain mostly unseen among plants and layers of silt. Each contributes to a sonic universe. The timbres of these sounds are magnificent, a tiny orchestra of percussion players, seemingly intoxicated. Bio-acousticians have hypothesized that every location on earth inhabited by living organisms has a unique acoustical bio-spectrum. They're not just uttering random sounds, there's logic to it. The chorus of sounds that comprise these biospectra may provide information about the dynamics of a resonant ecosystem—I almost said echo system—such that status information about their collective ecology is transmitted to its coexisting organisms. It seems as if they are all informing each other as to what their situation is. David Dunn made these

wonderful recordings in freshwater ponds in North America and Africa using underwater microphones. In many instances he has had to lower and slow down the sounds to get them into the human range of audibility. They are simply too high for us to hear. If *Angels and Insects* were a piece of electronic music, you'd be impressed by how beautiful and complex it would be.

A Sound Map of the Hudson River

Annea Lockwood's *A Sound Map of the Hudson River* is such a simple idea. She recorded the sounds of the Hudson River at various points, from its source in the Adirondacks to New York Harbor. I remember hearing portions of this recording on Minnesota Public Radio in the Eighties. There was a festival of New Music America in Minneapolis–Saint Paul, and National Public Radio gave Lockwood fifteen minutes every noon to play her recordings of river sounds. I'd drive from St. Paul to Minneapolis, and turn on the radio to hear the beautiful sound of a river. It was the perfect thing to hear on the radio in Minnesota. There was no advertising, no talking, just fifteen minutes of natural flowing water sound. That's something radio can do, it can be environmental—you just turn your radio on and hear sounds of the environment. In a sense this piece as well as *Sferics* and *Angels and Insects* are permanent installations in the world of nature. Each geographical location provokes a different state of mind. You feel a little bit differently about it. It may be determined by the weather, the terrain. I fish a great deal in Colorado. As you walk the streams, you hear different resonances as the water flows in different places, around sunken logs, under grassy banks, and so forth. It's sonically so rich. There's no music that can emulate that complexity. When people say that noise in music isn't natural, you can point to noise in nature. The waveforms are complex and aperiodic. Nature is very noisy.