Tactile Sound 101: Technical Manual

Chapter One: Introduction To Tactile Sound

A New Entertainment Product Class

Remember the scene in the original Jurassic Park, when all the Land Rovers sputtered and stalled during the park tour? The rain was drumming hard on the roofs of the vehicles and tension began to rise. Slowly, the camera zoomed onto the surface of a still glass of water, and the surface began to ripple.
Here, Spielberg was trying to give the sense of something big about to happen. Because he was unable to shake the theater floor, he used the next best thing: a visual effect of water rippling.

However, suppose he could shake the entire theater floor, and shake it the way a nearby 20-ton stomping T-Rex would. That would raise a few goose bumps, would it not? Well, maybe the local theater can't do it, but you can at home with Clark Synthesis Tactile Transducers.

Tactile transducers are electromechanical devices designed to drive large surfaces, such as seats and floors, with auditory information ranging from 1hz to 800hz. These are powerful devices, intentionally installed and calibrated to subtly add the tactile sense that is missing from music and movie soundtracks. The result is nothing short of engrossing. Anyone who has experienced tactile sound will tell you that it adds another dimension to home entertainment.

Tactile sound reproduction has a solid basis in psychophysiological research and is used extensively in military and other applications. Clark Synthesis is the first and only company to bring the excitement of Full-Range, Full-Fidelity, Full Contact Audio® Tactile Sound to the home entertainment industry.

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Chapter Two: The Psychophysiology of Sound

Reality Compared To Sound Perceived In A Sound System

Many people conceptualize ”sound” as the perception our brain produces when auditory energy travels through air and stimulates our ears. This is reinforced by the audio/video industry; because loudspeakers, the industry’s standard sound reproduction device, do just that. Loudspeakers are designed to push air molecules closest to the drivers, creating longitudinal waves that eventually reach our ears. The result is what we call “sound.”

However, this is a one-dimensional way to look at our perception of sound, because the phenomenon of sound involves many more facets. In fact, there are several other pathways that acoustic energy travels to us that reinforce our perception of sound, even though it does not enter our ears the standard way—through our ear canals.

To better understand the physiology of sound, let’s take a look at the launching of a space shuttle mission.

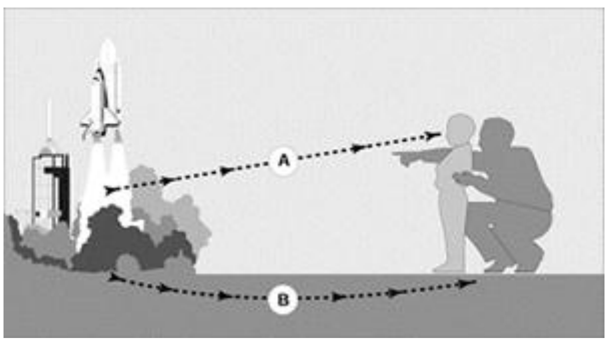

Figure 1

This illustration shows a man and his son watching a liftoff. The sonic impact of this event on our observers involves two distinct pathways and a variety of psychophysiological mechanisms. First, let’s examine the event itself. When the space shuttle’s engines are initially ignited, a tremendous blast occurs at the launch site. The enormous energy released travels through the earth and is transferred to our two observers via the ground they stand on. This energy is felt almost immediately, because sound waves travel rapidly through solid media. Next, after several seconds, the actual sound of the shuttle reaches our observers in a thundering roar. By this time, both father and son have goose bumps covering their entire bodies due to the overlapping of five different perceptual phenomena.

The Five Pathways To Perceiving Sound

In the following section, you will see the five ways pulsations can be perceived in the human body in the auditory frequency range. Each of these sensory pathways has a different mechanism, but all of them can reinforce the sounds that come in through our ears. The general term adopted for these additional four pathways is “tactile sound.” The range of tactile sound, as identified by Clark Synthesis, is from approximately 1Hz to 800Hz. This is quite a bit higher than what subwoofers deliver, and extends into the lower registers of the human vocal frequency ranges.

Tactile sound reproduction can be utilized for many purposes. Of primary interest is the addition of tactile frequencies to the production of recorded music and movie soundtracks, which provides dramatic effects.

Participants often refer to the experience as being thoroughly engaging, and describe a feeling “that encompasses a sixth sense.” That sixth sense is the increased realism obtained when tactile cues are added to conventional air-transmitted sounds. In addition to standard entertainment venues, tactile sound transducers find their way into other venues. These devices are one of the only ways the profoundly deaf can experience external sounds. Tactile transducers have been used under portable stage floors (risers) at concerts for the hearing impaired, and many participants have described the results as "a miracle".

1. Hearing Via Air Transmission

(Energy Pathway A in Figure 1)

The standard way we perceive acoustic energy is through our ears. The mechanism is simple. Vibrating air molecules enter the ear canal and push against the eardrum. This energy is transmitted to the Cochlea through the inner ear bones. The Cochlea is a fluid-filled sense organ in which small hairs, Cilia, convert mechanical vibrations into the perception of sound.

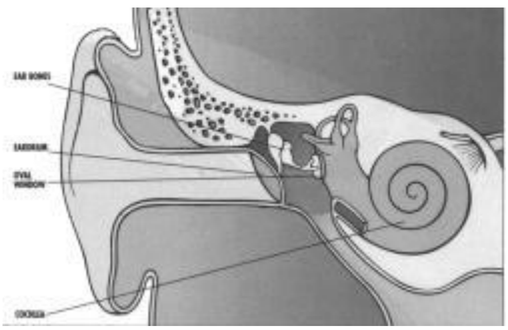

Figure 2: Diagram of The Inner Ear

Sound waves push on the eardrum, which mechanically stimulates the three ear bones. These push on the oval window of the Cochlea and create the sensation of sound

2. Feeling Via Deep Tissue Movement

(Energy Pathway B in Figure 1)

The ground vibrating almost imperceptibly beneath our observers is stimulating nerve endings in deep tissues and muscle mass. This sense is called “kinesthetic.” It comes from the Greek word kinos, which means, “to move.” These kinesthetic sensations are the gut feelings that occur when powerful objects excite the ground near us.

3. Feeling Via Skeletal Joint Movement

(Energy Pathway B in Figure 1)

The ground vibrating beneath our observers is also stimulating nerve endings in skeletal joints and deep tissues (Figure 3). This sense is called “haptic.” It comes from the Greek word haptein, which means, “to touch.”

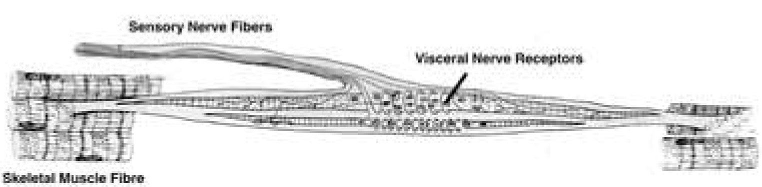

Figure 3

4. Feeling Via Tactile Stimulation

(Energy Pathway B in Figure 1)

The ground moving beneath our friends is also stimulating nerve endings just under the outer layer of skin (Figure 4). This sense should be familiar to you; it is your sense of touch. Ordinarily, the sense of touch does not come into effect with acoustic events except in situations where excessively loud noises are produced. It also comes into effect for musicians who hold their instruments close to their bodies when playing.

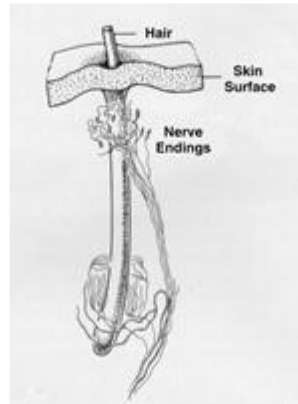

Figure 4

5. Feeling Via Bone Conduction

(Energy Pathway B in Figure 1)

If you look at the diagram (Figure 2) of the inner ear on the previous page, you will see that the Cochlea, the sense organ that takes the mechanical movements of acoustic energy and translates them into nerve impulses, is firmly encased in the skull bone. This bony protection allows a secondary pathway for sound waves to reach the Cochlea; directly through the bone mass itself. The phenomena of bone conduction is well known and has been exploited by many people. For example, in cases of structural hearing loss where the eardrum or inner ears bones are damaged beyond repair, various companies manufacture bone conducting "hearing aids." These devices clamp onto the back of the ear, or are actually implanted into the skull, to directly stimulate the Cochlea via local bone conduction

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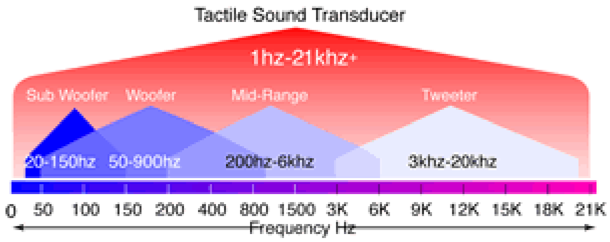
Chapter Three: Tactile Sound Applied

As we covered in the previous section, there are five ways pulsations in the auditory frequency range can be perceived by the human body. Each of these sensory pathways has a different mechanism, but all can reinforce the sounds that come in through our ears. The general term adopted for all these additional four pathways is "tactile sound."

The range of tactile sound, as identified by Clark Synthesis, is from approximately 1Hz to 800Hz. As you can see, this is quite a bit lower than what subwoofers typically deliver, and extends up into the lower registers of the human vocal ranges.



The Clark Tactile Sound Transducer (TST) is essentially a special loudspeaker driver designed to vibrate a large, heavy structure—such as a chair or a floor—instead of a small, light speaker diaphragm. TSTs are not designed to replace conventional speakers and subwoofers, but to supplement them. A Clark Synthesis TST is a full-range device (in contrast to ordinary "bass shakers"), it supplements them in two ways: first, it delivers physical vibrations that you both feel and hear through bone conduction; and second, it forms what amounts to a very large speaker, wherein the resonant structure to which it is attached actually generates audible sound. We have found that some people who install a TST in a chair or couch for use with movies, video games, or music prefer to limit its range to the lower frequencies; that is, vibrations you mainly feel, rather than hear. This can be achieved by using a low-pass filter on the signal, or as a last resort supplying the TST with the LFE / Sub (Low Frequency Effects) channel of a surround-sound signal (see the Clark Synthesis Tactile Sound installation manual for more details).

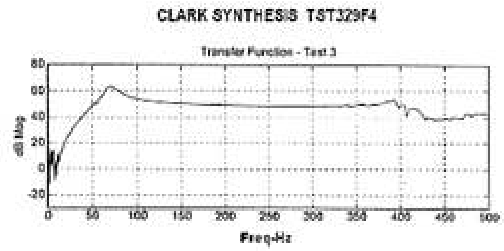
It must be noted, however, that allowing higher frequencies in the mix improves the intelligibility of movie dialog, and clarity in general. Indeed, this is one of the principal benefits of bone conduction. The trade-off, however, is the rare probability that you will hear voices in a mono-soundtrack or an off camera scene coming from the seat of your chair! Should this occur, try adjusting the volume of the TST's amplifier and the low-pass filter setting until an acceptable balance is achieved. Another easy way to fine-tune this is to use an equalizer to filter out the imposing frequencies. An equalizer added to the system allows wide bandwidth effect experience compared to a crossover. (Note that "chair sound" is not an issue when you wear headphones. In fact, this is an especially great way to experience video games.)

Car seats are a different matter. The full range sound can assist in lifting the sound stage to head height and clearly define center stage imaging. The TST can bring out details that standard speakers cannot produce. With the use of tactile sound the hearing paths improve the in-car experience like no other component can. ***If you plan to install a TST in your car, Clark Synthesis highly recommends that you contact a car audio installation specialist.***

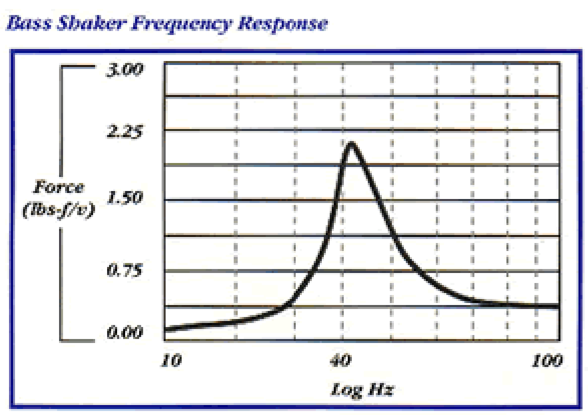
When TSTs are used beneath floors, stages, or wood decks, full-range reproduction is desirable. This is because the TSTs are being used both to generate tactile sensations and to supply audible sound via the coupling surface that supplements the main speakers. A popular application for the all-weather TSTs is under wood decks for music. In such cases, the deck must be constructed in such a way that it performs well as a giant speaker diaphragm!

There Is a Difference Between Shakers and Tactile Sound Transducers

Great confusion has been generated regarding the difference between Tactile Sound Transducers and shakers. The difference is simply a factor of bandwidth and fidelity. Clark Synthesis manufactures the world's only Tactile Sound Transducers that deliver high output full-fidelity and full-bandwidth thus the term Full Contact Audio®. Tactile Sound Transducers make complete use of the four ways tactile sound is perceived, and can also be used audibly to achieve all five paths of sound perception. Shakers, by design, have limited bandwidth and lack fidelity. This lack of either or both elements reduces the quality of the experience. Using shakers, the perception and intelligibility of a soundtrack is greatly compromised. The shaker's lack of fidelity in sound enhancement applications, such as home theater and sound monitoring by musicians, is simply the wrong application of those devices. When compared to a Clark Synthesis Tactile Sound product, the results are dramatic.



Let us revisit the shuttle blast and compare the effects between Products A, B, and C (Clark Synthesis). With Product A, the blast-off at its peak would feel as if a person was sitting behind you kicking the back of your seat. If you have experienced this in a commercial theater, it is distracting and irritating. Although Product B has great output, it is vague and sloppy. The blast-off would feel more like being on a boat and feeling the waves: the audible sound would not mesh with the shaker's output, and a kind of seasickness or time slur could result. Of greater concern is the solenoid design in Product B, which is inherently the wrong technology to use in audio, since the mass of the solenoid cannot stop when the sound does. This is commonly called "ringing" in speaker terminology, where the unit keeps playing after signal has stopped. This is an undesirable distortion, and is unacceptable by anyone's audio criteria for sound. Power handling and efficiency is another criteria to consider. Product A handles low power—about 25 to 50 watts—and has little output. Product B needs upwards of 1000 watts, although they recommend using more. It is inefficient and offers inferior fidelity due to the simple solenoid design. Both A and B are, by their own admission, shakers. (Refer to Appendix B to see Product A's spec sheet, which lists their printed bandwidth of 43Hz.) Clark Synthesis established the Tactile Sound standard many years ago. Newer companies that have come on the scene since have tried to make claims that a shaker just cannot achieve.



What Musicians Have To Say About Tactile Sound

One of the earliest groups to embrace the use of tactile sound transducers is musicians. To understand this requires a look at the physical mechanisms at work in a live performance. Let's take a violinist, for example:

When you listen to the recording of a violinist, you attempt to recreate the exact perceptions one feels during a live performance. It may surprise you to realize that what you feel and what the violinist feels are two different things. Here's why: when a violinist performs, he/she is drawing a slightly abrasive set of strings (the bow) across a set of finely tuned strings. This excites the strings, which resonate, and we hear these vibrations through our ears. However, consider our performer, who also feels these sounds. This feeling is direct in the fullest sense of the word, right up from the chin piece into the violinist's body. The three main sensation mechanisms for a musician are:

1. Through the ears via air-transmission.
2. Through the skin via tactile sound reception.
3. Through the Cochlea via bone conduction.

In short, musicians experience music quite differently while playing than we do as passive listeners. When musicians hear tactile sound for the first time they're usually ecstatic!

A Famous Conductor Experiences Tactile Sound Reproduction...
This anecdote was related to us and has been a fun one to share here at Clark Synthesis: During a reception, the conductor for the Denver Symphony Orchestra stepped onto a cedar deck that was playing a Bach orchestral piece via Clark Synthesis transducers. After several minutes, he exclaimed that he had never heard orchestral music reproduced so clearly and with such feeling. He exclaimed that he could hear and feel each instrument individually. Soon, he was sprawled out on the deck with his eyes closed and a grin on his face.

Musicians do, indeed have a different frame of reference. If you want to experience a performance the way musicians do all that is required is a Tactile Sound Transducer installed properly in the listening environment.

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Chapter Four: Applications for TSTs

The original environment for tactile sound transducers was in military simulators, where they are used to generate motion cues and simulation soundtracks. These low-frequency cues are necessary to impart realism into flight and tank simulators. At the same time the TST produced the full range sound of the actual craft to increase its realism.

Theme and amusement parks use hundreds of tactile transducers in conventional rides and simulation rides. Theme park engineers call Clark Synthesis Tactile Sound Transducers one of their favorite building blocks as they design new attractions. Tactile sound really brings the fun to life.

Professional musicians have taken the technology on the road to save their hearing, lighten the load, push their performance and improve the sound for the audience. Used with in-ear monitors, tactile monitoring can replace up to four 18-inch subs in a folded horn design. With Clark transducers, drummers can play better and the roadies have a lot less to load and tear down without the massive sub cabinet.

Universities have procured many TSTs to use in medical research varying from Fibro Myalgia to Alzheimer's disease. It is our hope that tactile sound transducer will be a key component in helping people lead normal lives.

Home and car entertainment applications are a natural part of raising the level in either in car video and gaming or any home theater. Applying the same life-like effects that theme parks and the simulation companies use.

Here is a general list of applications:

- Studio and Stage Instrument Monitoring
- Home Theater
- Commercial Theater
- Virtual Reality and Gaming
- Flight and Warfare Simulators
- Pools and Underwater Sound (Aquasonic® speaker line)
- Health and Wellness (physiotones, etc.)
- Theme and Amusement Parks
- Automotive Sound
- Outdoor Decks
- Stage Monitoring
- Hearing Impaired and People With Special Needs