

Dear HOT ROD,  
I'm not here to criticize Ray Bohacz' article "Passing Gas" (Oct. '00); it was an excellent overview on modern theories and methods of power production via exhaust modifications. But guys! Exhaust is not about power; it's about sound. Everyone has a set of pipes they want to be heard! Why not forget about the power and do a tech piece on how to produce a gorgeous burble or bark?

Samuel Veccharella  
Rochdale, MA

Sam, this one's for you.—Ed.

It's fascinating how the various aspects of technology impact each of us differently. The vast majority simply let technology lead them along while they use it with delight. However, there are those who spend a good part of their time turning creative energy into technological advances.

"Taking a daily fact of life and making it part of technology is one of the ways we advance as a society," says Ray Flugger of Flowmaster.

"One of the things I want is the data to create perfect exhaust tones by using advanced scientific methods to quantify the research. Our customers love the Flowmaster exhaust tone as much as the performance the system brings, and we are now building a scientific bandwidth (a range within a band of wavelengths, frequencies, or energies) database to assure our grasp of this sound technology."

The brain processes sensory input from the environ-

Flugger explains, "I realized years ago that the exhaust system is more than waste gas from an internal combustion engine. It is an interactive system that can build horsepower, lose horsepower, make too much noise, or make the sweetest sounds on earth."

Flugger is no newcomer to technological advances. In 1973, the military was designing a new high-speed attack helicopter and had issues with its detection by heat-seeking missiles. They wanted to know if Flugger's technology could help to make the helicopter "invisible." He created a muffled-heat-management exhaust design that worked like a charm, and the basic elements of this system are still used on our most advanced stealth aircraft. After 40 years in the exhaust products business, bringing some of the most innovative street and race exhaust technologies to fruition, Flugger is now reaching into the

future with some fascinating research and engineering in exhaust technology.

"The quality of the exhaust sound has always been part of our concept. Years ago, I realized how important the sound quality is when asked to create a "mood for an exhaust system. Back in the '60s, I did my first experiment with exhaust tone quality by installing a dual system with glass-pack mufflers of different lengths, an 18-inch on one side and a 24-inch on the other. This created two frequencies and produced a two-note  
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which gave a smooth sound with a cruiser warble. People just loved that exhaust tone, and it made me realize that no matter how well the exhaust system was built, it also had to sound right."

Racer and engineer Dick Guldstrand had a substantial impact on Flugger's thinking. Guldstrand is noted for his development work on virtually every model of Corvette, and he maintains that the brain can only concentrate on one thing at a time, so he trains race car drivers for acute concentration. An exhaust system that reverberates with a disturbing sound is a distraction the driver should

ment and determines the way it processes sound via the emotional reaction of pleasure, annoyance, or pain. These subconscious emotions can profoundly change how our bodies function, thus having significant implications for our health or vulnerability to illness... and can defeat our ability to function normally. In other words, adverse sounds often cause stress.

HOW SOUND MAKES YOU FEEL  
EVEN

BY DAVID FETHERSTON



not have to endure.

There are many factors that affect horsepower and torque as well as sound quality. Research shows that there is a direct correlation between pipe diameters, the number of bends, and how the exhaust reversion and reactive wave flows the gases and the heat, as well as the sound that results from it. For instance, a stainless steel tip with a straight-cut edge amplifies sounds quite differently than one with a rolled edge, and the same applies to the length of the tip. Similarly, the same sounds generated inside the vehicle that are annoying to the body can be very pleasing when generated only on the outside of the vehicle.

Flugger: "A research program we did for one of Detroit's Big Three showed that the length of the OEM tailpipe robbed the engine of 15 horsepower. We did a little tweaking, added an extra bend to stop resonance, shortened the system by 7 inches, and picked up the 15 horses. With this kind of thoroughly tested research, we've perfected the Flowmaster tone that so many people love.

"We have recently begun research on how sound quantity and quality impact human physiology by using electrophysiological monitoring. Both quantity and quality affect mood—the first can bring pain while the other can bring pleasure. Our aim is to discover what sound bandwidths the brain loves and which ones it doesn't. This research is delving into how sound can affect the brain, nervous system, heart, circulatory system, and skeletal muscles—and whether it is interpreted as pleasure or pain.

"The research we've conducted to date indicates that we are on the right track. With the help of Dr. Peter Madill of 3R Company, who has designed the research protocols and is conducting the research with Flowmaster, we are producing ground-breaking data for human interaction with sound. We are looking towards creating exhaust products which

produce power, yet retain the distinct Flowmaster tone without producing stress reactions."

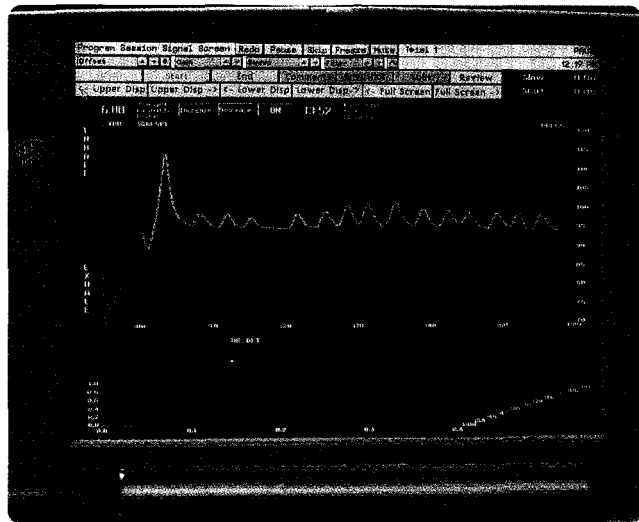
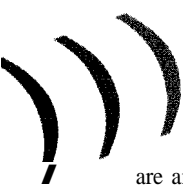
This research began one and a half years ago when Flugger and Dr. Madill adapted the use of proprietary electrophysiological monitoring technology for the 3R Company's "Wellness in the Workplace" program. The objective of this program is to improve comfort and safety, to lessen the vulnerability to work-related repetitive motion injuries, and to enable employees to leave work with enough energy to enjoy their off-work lives. Initial efforts focused on the untapped potential of this technology to improve the ergonomic design of various human operator interfaces peculiar to Flowmaster's unique production machinery.

Another aspect of this research addresses the adverse effects of too much noise. Just as there has been increased interest and concern among governmental regulatory agencies regarding workplace injuries, so has there been concern about the potential adverse impact of noise on hearing and the ability to concentrate.

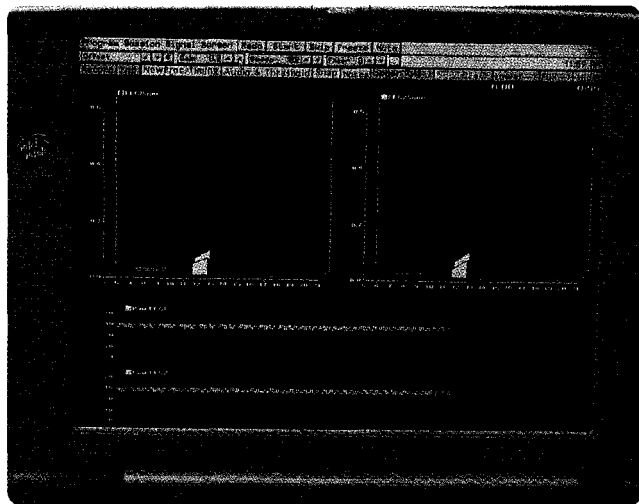
With the implementation of 3R's Exhaust Sound Research Program, studies determine the different brain and body responses to the sound of a muffled and unmuffled exhaust. According to Dr. Madill, "This technology traces the body's reaction to noise and enables us to study the brain's reaction as well. Once we have established our baselines, we can then use this data to further evolve and refine Flowmaster's patented exhaust designs."

For instance, it wasn't long ago that Indy Light cars were driving fans from the stands because of their high dB frequency exhaust. To solve the problem, Indy Light Series brought Flowmaster onboard, and within a few months had a new muffler that did all the right things with the power curve... and lured fans back to the stands.

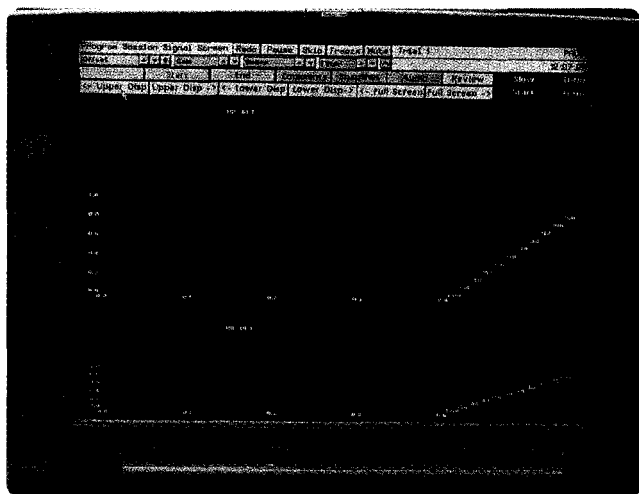
Research indicates that damage to hearing arises from the loudness of the sound and the frequency of the various sound elements that make up the "composite sound." Thus, different sounds are described as



The screen depicts the tracings of Ro's breathing, pulse variance, and heart rate analysis. Dr. Madill has found that they provide the most measurable data for recording what the brain downloads to the body.



This graph represents the right and left hemispheric brain functions. The left forebrain responds to events and excitement, while the right forebrain issues warnings which become downloaded stress responses for the body to prepare itself for fight or flight syndrome.



A 3D heart rate variability graph shows the pattern of the stress response as it is translated into a more balanced response.

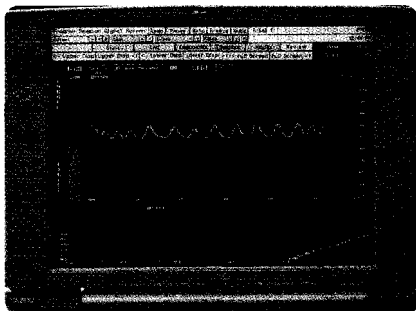
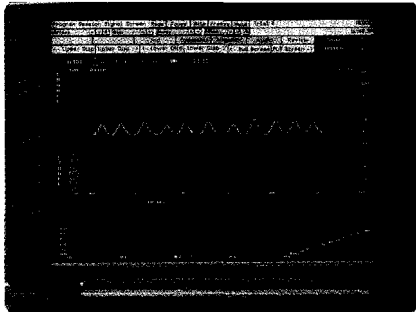
having very low, low, mid-range, and high frequencies. The human ear hears a relatively limited range of lower and mid-range frequencies, and it is the combination of these frequencies that is particularly damaging to the auditory system.

The classic Flowmaster tone involves very specific frequencies and is achieved by eliminating the damaging sounds through sound spectral analysis on the dynamometer. This pioneering work proves that there is enormous potential for implementing further change in race car "noise" at the racetrack for the benefit of driver and race fan alike. A thundering Pro Street car with Flowmaster mufflers may rumble the ground and grandstands, but it won't hurt your hearing because of the frequency bandwidth it produces.

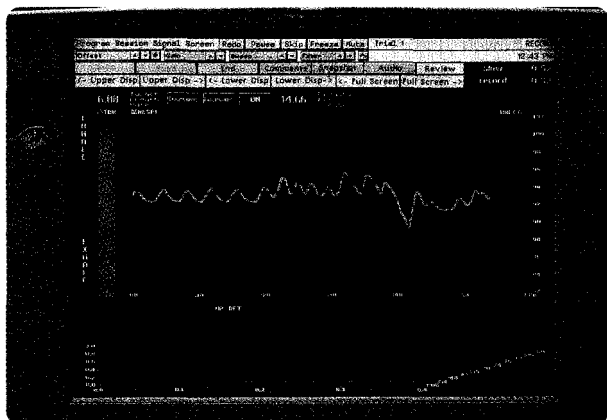
Dr. Madill explains the body response process: "When we experience stress, our bodies mobilize a two-phase response mechanism. The first component is the rapid acting electrical system called the autonomic nervous system. It has two divisions: The 'activating mobilizing sympathetic' and the 'calming relaxing parasympathetic' divisions. In a way, they are like the accelerator and the brake in your automobile. Typically, the sympathetic division kicks in if we are suddenly threatened. We experience fear in the abdomen and butterflies in the stomach, indicating the sudden flood of adrenaline readying the body for the flight or fight syndrome. Alternatively, we might respond to a different threat with anger, but once again the sympathetic nervous system mobilizes the body in preparation to take action consistent with anger. In this instance, we experience pressure and tightness in the chest, blood rushing to the head, and a marked narrowing of awareness."

In order to maintain cool concentration, a racer or any other athlete must master these reactions. It's what the pros call "being in the zone." Head games racers play in the staging lanes or pits are much more powerful than you might think, a drifting thought or other distraction at the wrong moment can cost you a race or even your life.

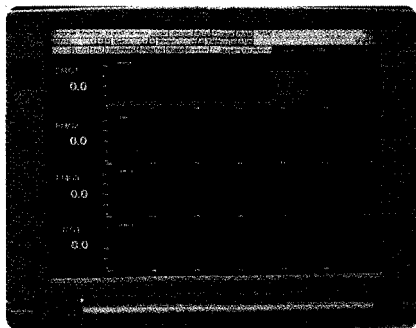
If our fear- or anger-based stress reaction persists and we are incapable of defusing the reaction, then the second component of the stress mechanisms is mobilized by a slower but longer-acting component which we call the "messenger molecule" or "neuro-hormonal component." Primarily, the brain sends chemical messengers to the adrenal



This shows breathing pulse rate variability and a mounting stress response to a sound that is not particularly pleasing to the brain.



The transition of listening to Flowmaster mufflers and then to the competitors' mufflers. The brain is manifesting a significant stress response to the competitors' sounds, as indicated by the change in heart rate.



The transition from listening to Flowmaster to the competitors' mufflers using electro-physiological responses to display and record the marked increase in muscle tone (or contraction) as the sound is switched (Flowmaster on the left, competitor's muffler on the right).

gland, and it stimulates the release of cortisol into the bloodstream. Cortisol influences a wide variety of physiological and metabolic processes. The end result substantially raises the odds of surviving a major threat, such as an assault by a predator or exposure to a prolonged period of physical stress such as severe cold or overexertion.

Knowledge of the stress response mechanism is important for three reasons. First, these mechanisms were designed by nature to promote survival during critical injury to the body. Today, however, our stress response mechanisms are commonly mobilized by an ever-widening array of stressors of a social or psychological nature, while few represent physical threat to our survival.

The second reason revolves around the new high-tech world in which our mechanisms are exposed to a slew of environmental stresses. These are often so subtle and complicated that we have little awareness of the impact. Though the sound of a fingernail on a chalk board has very low dB reading, it will probably put our defense mechanisms on higher alert than a Funny Car blasting down the track. Other prominent examples are the discordant sounds from a poorly designed exhaust system, or even worse, the sounds of race engines running.

The third reason is perhaps the most important of all. Excessive mobilization of the stress response mechanisms can suppress the immune system, leading to the promotion of a greater vulnerability to disease. We can become addicted to the unregulated function of our stress response mechanisms, and the reaction begins to feel normal. In effect, we become adrenaline junkies. Acquiring the ability to consciously monitor and voluntarily regulate the activity of our stress response mechanism is vital to well being. Obviously, this data impacts the race fan, race driver, and the manufacturing workplace. Madill and Flugger know that Flowmaster's unique sound helps minimize excessive response of the body's stress mechanisms as compared to other aftermarket exhaust products.

According to Flugger, "This extensive research and its resulting engineering will allow us to be right on the cutting edge of dealing with both Federal and State regulators who govern so much of motorsport and high-performance events. Flowmaster is creating a formula to scientifically engineer the perfect tone for future product lines while still gaining free horsepower. In the future, this research will hopefully be able to match the character of the driver and the car to the tone the exhaust produces." **HR**

## Sources

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