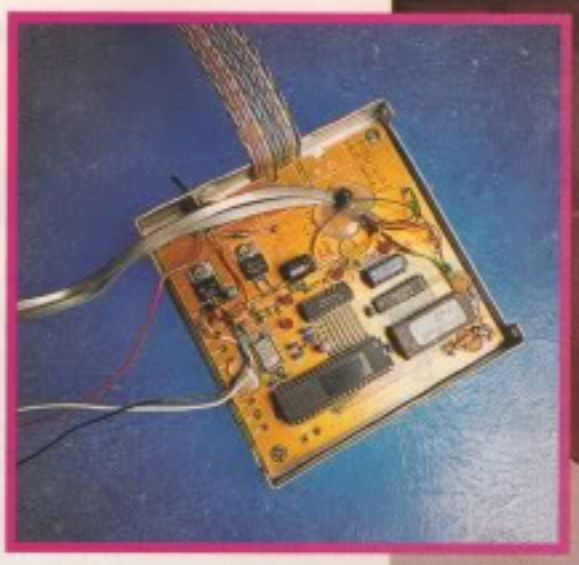


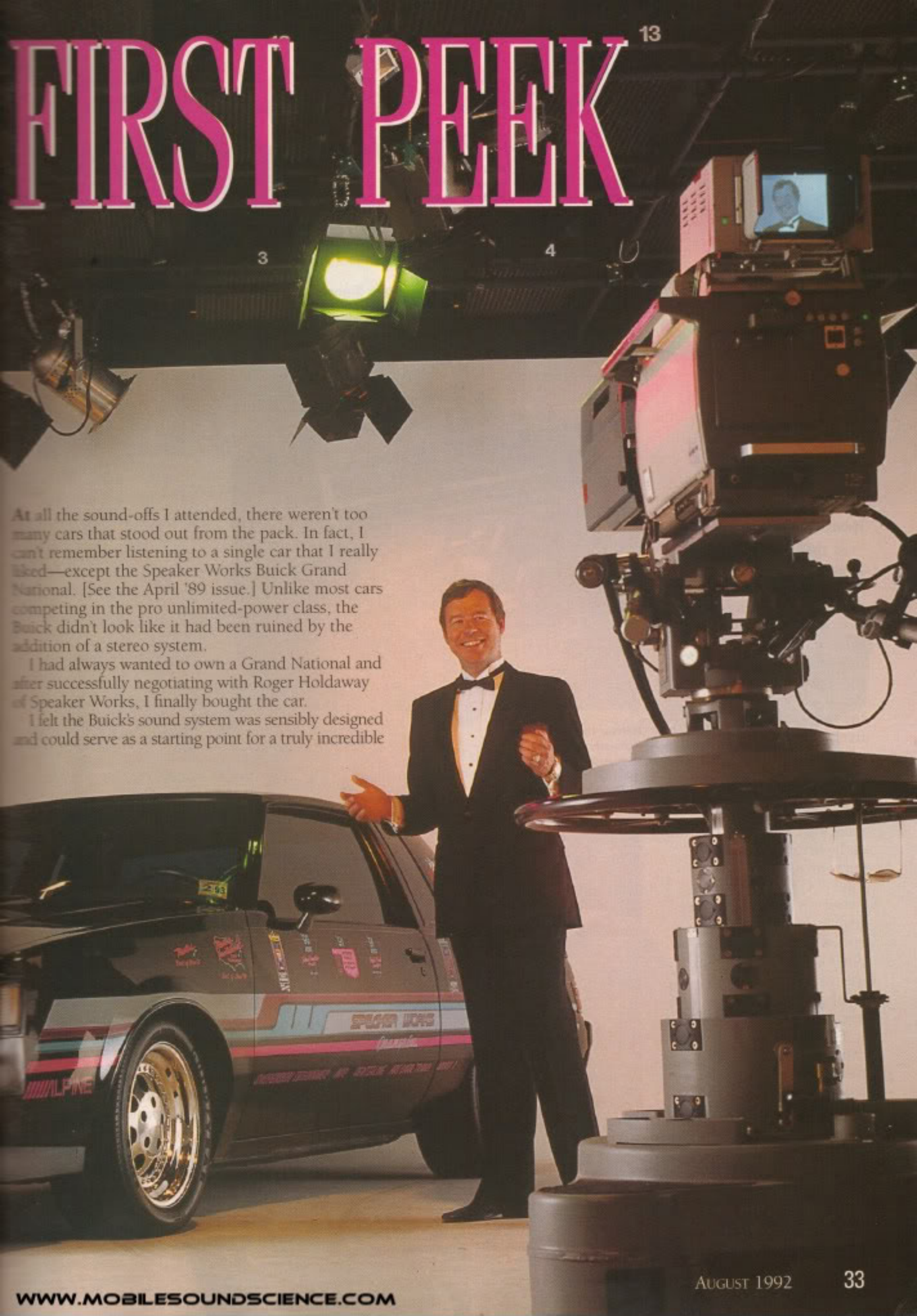
An Intel 80C32 microprocessor controls the operation of the system.

The Alpine 7909 CD tuner (above) retracts into the dash and a factory delete-option panel covers it (left).

Sound-off champ Richard Clark gives an exclusive tour behind the scenes in his Buick Grand National.

BY RICHARD CLARK
PHOTOGRAPHY BY JOHN SKALICKY

FIRST PEEK

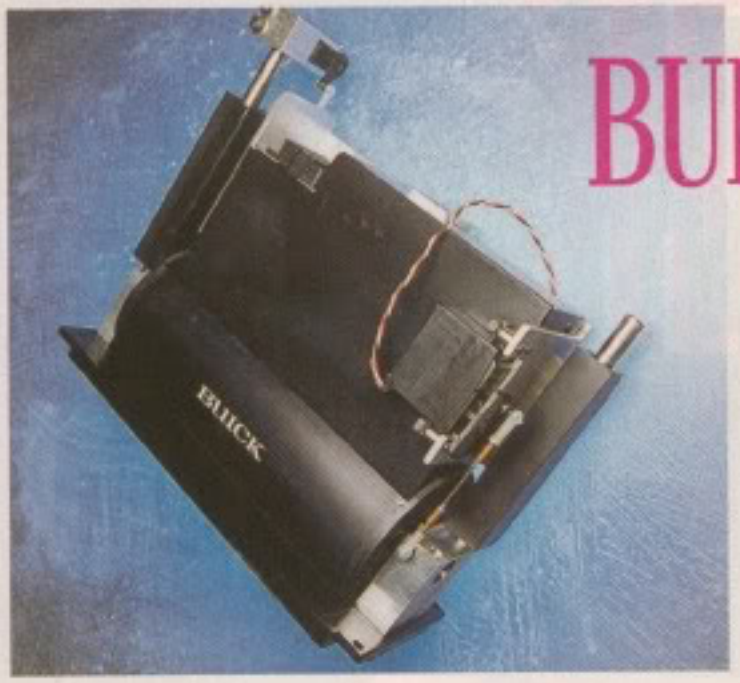


At all the sound-offs I attended, there weren't too many cars that stood out from the pack. In fact, I can't remember listening to a single car that I really liked—except the Speaker Works Buick Grand National. [See the April '89 issue.] Unlike most cars competing in the pro unlimited-power class, the Buick didn't look like it had been ruined by the addition of a stereo system.

I had always wanted to own a Grand National and after successfully negotiating with Roger Holdaway of Speaker Works, I finally bought the car.

I felt the Buick's sound system was sensibly designed and could serve as a starting point for a truly incredible

BUICK GRAND NATIONAL



Left: Head unit removed from the dash to show the servo motor and carriage.

Right: Signal processor and servo controller in aperiodic subwoofer enclosure.

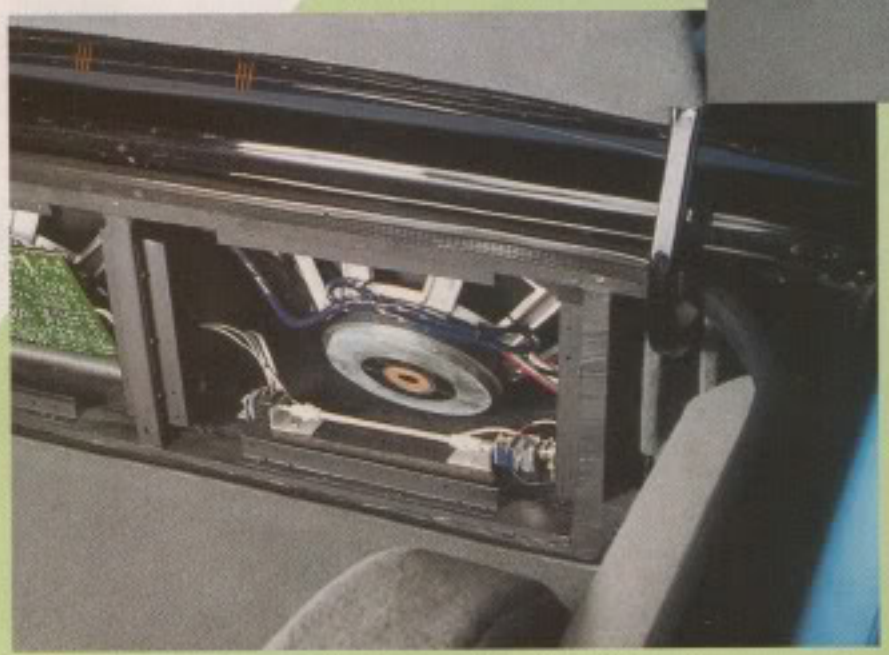
vehicle. Many aspects of the installation have remained similar—the purpose of this article is to focus on the upgrades.

Heart Of The Upgrade

At the heart of the upgrade is an Intel 80C32 microprocessor. From my previous installation experience, I discovered that it is extremely difficult to implement complex control features without the aid of a computer. When the tasks require a relatively high level of complexity, a computer can be used to simplify many control functions.

For instance, all of the relay logic related to the audio system was eliminated and assigned to the Intel 80C32. Component power-up and power-down sequencing were particularly well suited to computer control. A program was written to perform this function in a noise-free manner.

The microprocessor also controls a cooling system that utilizes temperature sensors in an amplifier-cooling tunnel for the five Alpine 3545 amplifiers in the trunk, as well as in each amplifier. The microprocessor monitors these sensors so that preprogrammed thermal limits can be precisely maintained.



Below the woofer are volume servos that automatically adjust the gain at various points in the signal chain.

Left: The 12-inch midbass speaker in each rear side panel uses a very light carbon-fiber composite cone.

Below: Absorption material was added to almost all upholstered interior surfaces.

The speed of over a dozen cooling fans is regulated so they never have to run any faster than necessary. This keeps noise from the fans to an absolute minimum.

Servo Control

One of the more elaborate uses for the computer is the control of electromechanical servos, allowing precise control and logical functioning of all the motorized accessories. One example of this is the head unit, which was designed to retract into the dash when the stereo is not operating.

A cover that looks exactly like the Buick delete-option panel moves into place to hide the head unit. This way, it actually appears as if the car was ordered from the factory without a radio. When in operation, the door retracts completely out of sight and there is no evidence of it or its slides.

The movement of the door and the head unit is performed by a precision Futaba gear-driven servo motor. The pulse-width-modulated control signal is generated by the computer. Sensors were installed to tell if there's a finger in the

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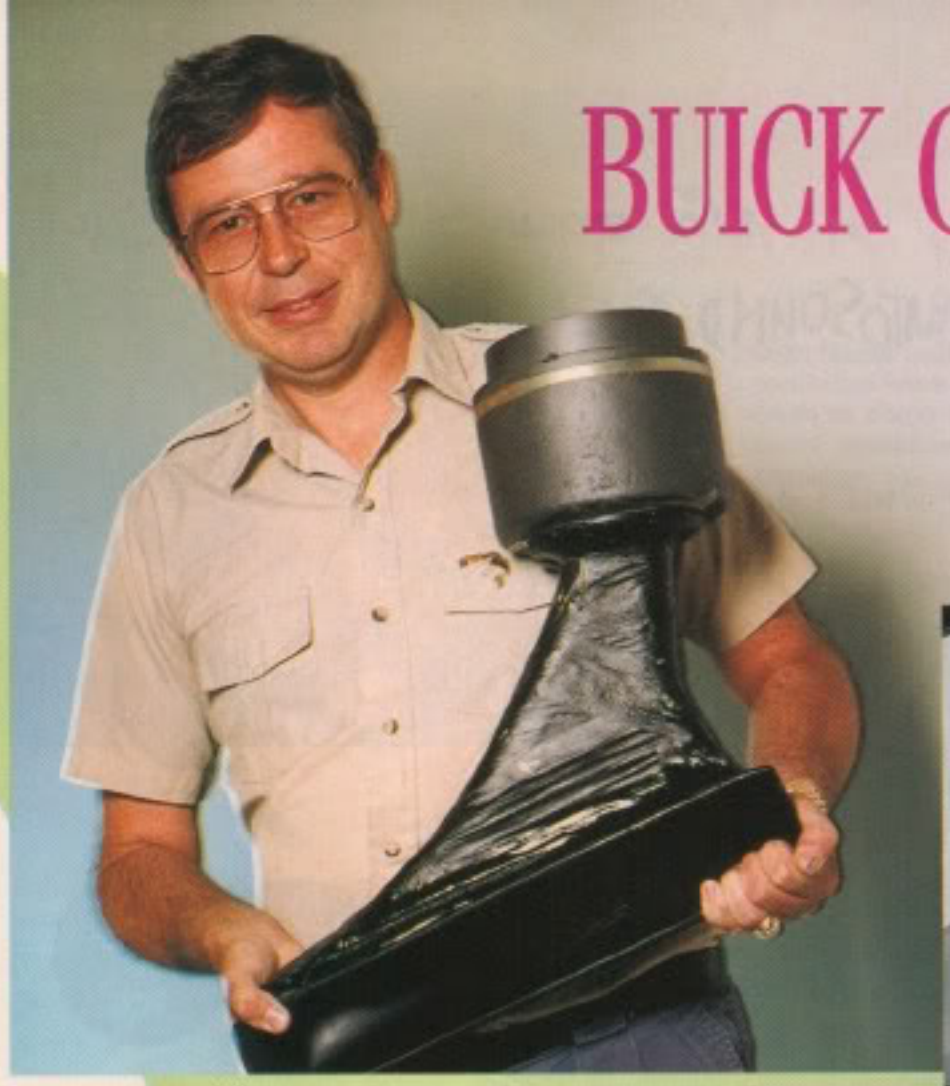

Left: Clark displays one of the massive waveguide tweeters mounted under the dash.

Below: Sound from tweeters enters the car interior through grilles below each side of the dash.

way, which would stop all movement immediately.

Temperature Gauge

Gauges in the instrument cluster were rearranged so a special temperature gauge could be added. This gauge serves two functions. When the audio system is off, the gauge displays the outside air temperature from 0 to 100 degrees centigrade. However, when the stereo is operating, the gauge shows the sound system's volume setting from 0% (off) to 100% (full volume). This is a very handy feature for competing—much like the way a tachometer functions for a race-car driver.

I also added a volume-control function to the steering-wheel controls that Speaker Works had devised. This easy-to-operate rocker switch controls the operation of four multistage volume servos. The servos all track together and adjust the gain at the head unit, equalizer, crossover, and amplifiers simultaneously. This allows extremely high output while maintaining an excellent signal-to-noise ratio.

Clark replaced the Alpine 7909's D/A converter with this Apogee unit from a recording studio.

Absorption Material

Absorption material was added to almost all the upholstered interior surfaces. Unlike mass damping, which only prevents resonance, the absorption material that I chose also reduces unwanted reflections inside the car. These reflections can cause secondary imaging cues. A special dense foam of various thicknesses was used for this purpose.

Extra mass was also added to the front seat uprights to minimize vibration. Such vibrations sometimes give sensory localization cues to very low frequencies that normally would be directionless in a car.

Servo-Controlled Sub

To increase the performance of the aperiodic low-frequency system that Speaker Works originally installed in the Buick, a special servo system was designed for use with two 15-inch USD subwoofers. In this system, the speaker itself is inserted into the corrective feedback loop of the amplifier, allowing the amplifier to compensate for the speaker's nonlinearity.

This way, the movement of the speaker is no longer dependent on its mechanical and electrical parameters alone. The amplifier can compensate for the inability of the speakers to reproduce the signal accurately—especially on transients. This creates an extremely tight, well-defined sound.

The custom-built 12-inch midbass speakers mounted in the Buick's rear side panels were upgraded to a type with

a very light carbon-fiber composite cone. These speakers also have a vented voicecoil gap designed to eliminate any change in performance that might be caused by a rise in voicecoil temperature.

Huge Tweeters

The high-frequency speakers that Speaker Works originally installed under the dash were replaced with a new type of custom-built

analog converter and line output driver were replaced with an Apogee unit from a recording studio.

This unit provides an ultra-high-voltage balanced output. In order for the rest of the system to operate at this level, the power supplies of all the signal processors were upgraded to bipolar ±20 volts. The internal circuitry of the processors was upgraded with special high-voltage

operational amplifiers designed to work with 40-volt rails. This upgrade in maximum output level was complemented at the other operating extreme by a specially designed noise gate that works at extremely low levels.

Noise Gate And Delay

Unable to find a noise gate to work to my satisfaction, I was left with no alternative but to design

one. The prototype featured a digital controller that became the basis for the Clark Audio 823A noise gate. Another device that grew out of necessity was a digital delay. The delays that were in the Buick were extremely limited in capacity and utility. These analog all-pass devices were replaced with custom-designed digital prototypes.

This permitted precision time alignment of speakers, as well as the capability to utilize the psychoacoustic phenomenon known as the Haas effect. This allows the apparent source of a sound to be manipulated by controlling its arrival time.

Such extra control of the time domain is probably the area of greatest sophistication in the Buick. Not only can the apparent source of a sound be controlled, but the high definition that is a result of waveform coherency can only be achieved in multiple-driver systems with this technology. Different parts of a sound containing various frequencies arrive at your ears as one sound rather than being noticeably divided between various speakers.

Acoustical Measurement

In order to achieve a truly realistic sound stage,

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motor assembly. This assembly uses a special type of Alnico magnet that weighs nearly 50 pounds. The huge magnetic assembly is necessary because the tweeter diaphragm is nearly four inches in diameter.

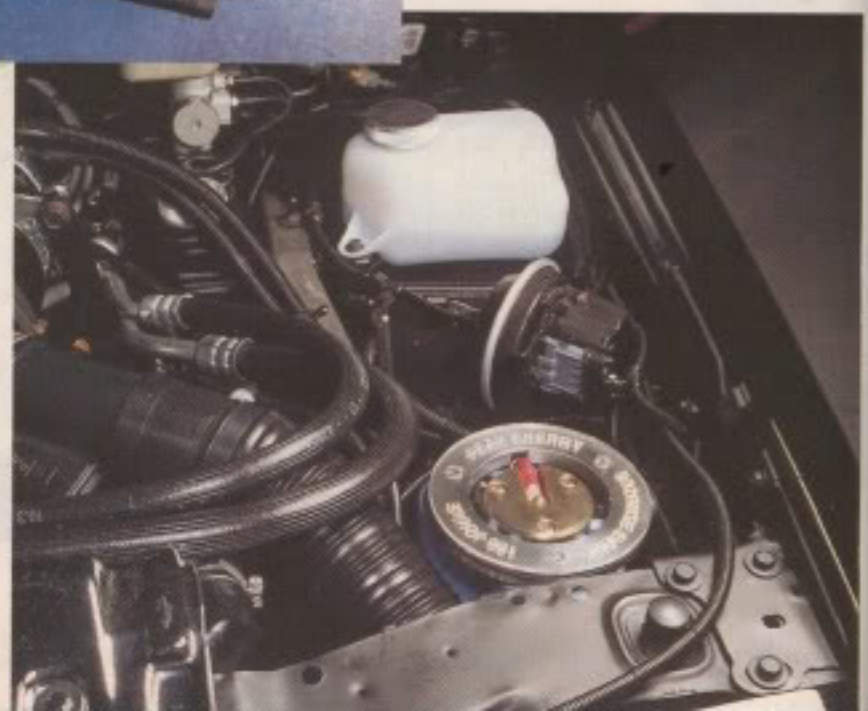
This ultra-lightweight diaphragm is constructed of a special "sandwich" composition with a very thin aluminum base created by chemical etching. A layer of diamond crystal was grown onto the aluminum, using a special low-temperature process originally designed for NASA.

These super-lightweight devices exhibit great clarity, exceptional high-frequency response, and low distortion—but at a price of several thousand dollars each. These massive tweeters can operate from 400 Hz to well over 20,000 Hz. They are mounted on 2-inch wave guides with an acoustic path length to the listener's ears of nearly six feet.

D/A Converter

The component upgrade began with the Alpine 7909 CD tuner. The digital-to-

Above: Clark designed his own noise gate for the Buick's system, the Clark Audio 823A.



A bank of three 800,000-microfarad capacitors was installed under the hood.

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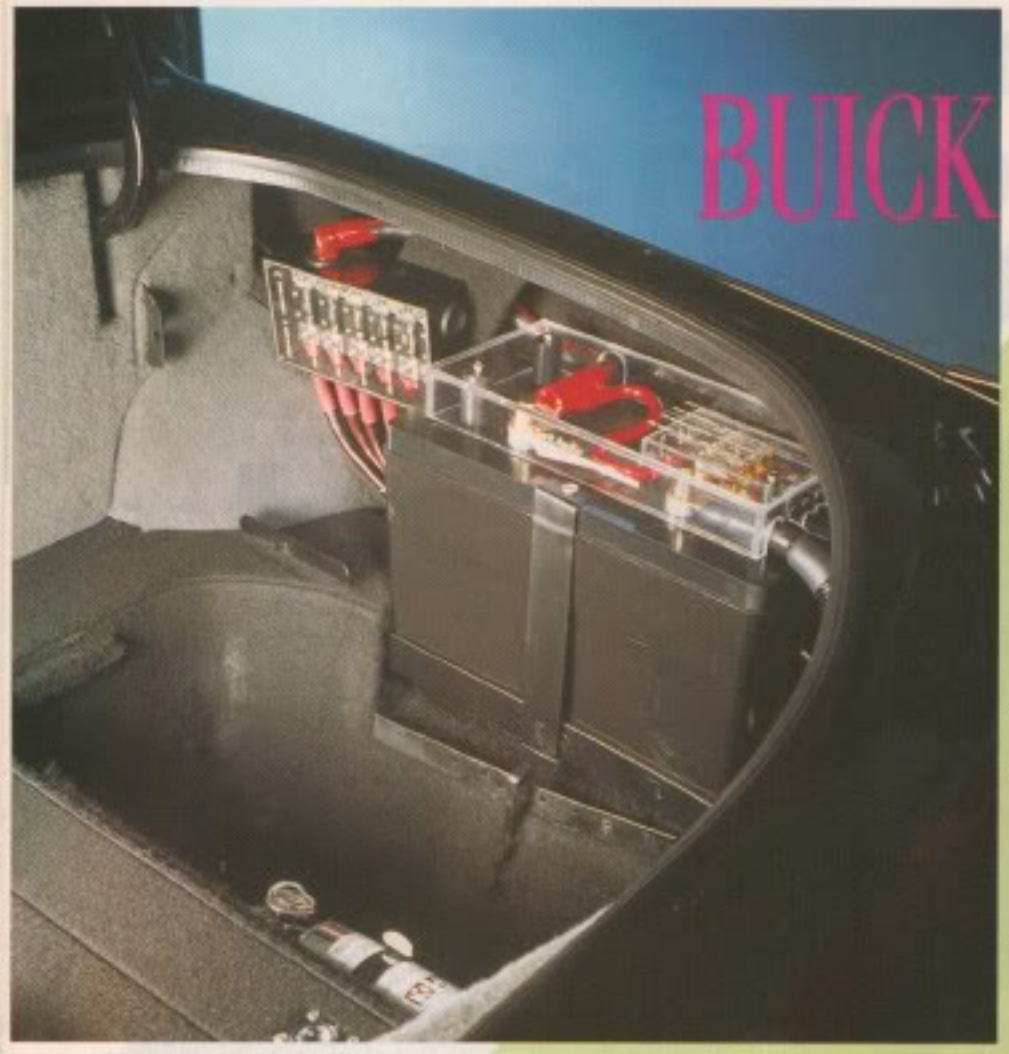

Top: The "active battery system" is a combination battery and power supply.

Bottom: Snap-in liners cover amplifiers and other components mounted in the trunk.

a lot of time was spent in the car doing measurements with a process known as TDS or Time Delay Spectrometry. This process is considered to be the most advanced form of acoustical measurement available today.

I also designed and installed a unique processor capable of making minor transfer-function modifications, manipulating the signal to make it sound as if it was coming from somewhere else. This takes advantage of our hearing process and the way we localize and perceive music. These signal modifications are used primarily to improve the imaging perception in the median listening plane. They take advantage of the fact that we hear left to right better than we hear up and down.

Electrical System Changes

To ensure that all this equipment would perform at its very best, the Buick's electrical system experienced many upgrades. First of all, a bank of three 800,000-microfarad capacitors was installed to ensure that peak current would always be available.

In addition, an active battery system was installed in the rear of the car to supply pre-regulated power to all the components. An active battery is a combination battery/power supply that converts the battery voltage to a constant 15 volts. This prototype device powers all the audio components in the car except the power amplifiers.

Special overvoltage and reverse-polarity protection are included as part of this power system, and a high-current solenoid isolates this system from the car's original electrical system. High-temperature Nomex covers, which proved far superior to the original plastic loom, protect all large cables routed close to potential hazards.

The engine compartment benefits from the addition of added chrome and performance parts, but the appearance of the trunk has changed very little from the Speaker Works days. Removing snap-in liners reveals cosmetic changes such as Lexan security covers with multicolor silk-screening. A custom-built hideaway spare was made to match the original wheels.

A New Season

After three years of serious competing, I have decided, for now, to retire from active competition. This does not mean I have lost interest. I am just as involved and interested in high-end car audio and competition as ever.

Together with CAR AUDIO AND ELECTRONICS technical consultant David Navone, I am publishing a highly technical newsletter, *Autosound 2000 Tech Briefs*. We have also been conducting seminars and workshops around the world.

These ventures have been keeping me even busier than when I was actively competing. Now, rather than concentrating on a single car, I am directly involved with hundreds of high-end cars and thousands of serious enthusiasts.

And what is the Buick up to? She has been traveling around the country on exhibition at trade shows and IASCA key events. This summer, the Buick is also slated to travel to England, Germany, and Asia. Don't miss an opportunity to see it when it comes to town. ▲

Richard Clark thanks:

Ellen Threatt, mastering engineer
Patrick Poovey, student, NC State
Drey Johnson, tool-and-die maker
Paul Demint, computer programmer
Howard Hoyt, analog engineer
Andrew Isakson, digital engineer
Jeff Dodson, Buick mechanic
Ronnie Stallings, chemical engineer
Don Richardson, engineer, AT&T
And special thanks to Speaker Works.

Clark performs Time Delay Spectrometry measurements (TDS) using a Time-Energy-Frequency (TEF) analyzer.