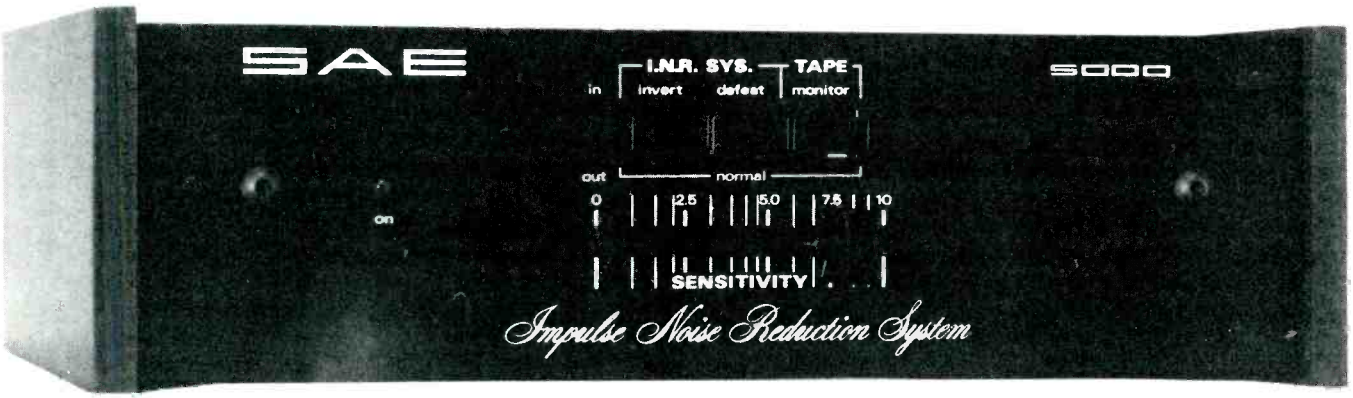
SAE Model 5000 Impulse Noise Reduction System



MANUFACTURER'S SPECIFICATIONS

Rated Output: 2.5 volts rms.
Frequency Response: 20 Hz to 20 kHz ±1 dB.
Output at Clipping: Greater than 9.0 volts into 10 kilohms.
Input Impedance: 75 kilohms.
Output Impedance: 600 ohms.
Insertion Loss: Less than 1.0 dB.
S/N: Greater than 90 dB below rated output.
THD (at any level up to rated output): Less than 0.1 per cent.
IM Distortion: Less than 0.1 per cent.
Power Requirements: 120 V a.c., 50/60 Hz, 7 watts.
Dimensions: 10 ¾ in. (26.7 cm) W x 3 in. (7.62 cm) H x 9 ¼ in. (23.5 cm) D.
Weight: 8 lbs (3.6 kg).
Price: $200.00.

Don't throw away those scratched records, dear readers, at least not before you read about an incredible new "black box" developed by Scientific Audio Electronics, Inc. of California. As the descriptive name of the Model 5000 suggests, it is a device designed to eliminate impulse noise (or to reduce it significantly). Impulse noise should *not* be confused with random hiss, surface noise of a wideband nature, hum, or other disturbances that plague our audio systems and interfere with our listening pleasure. Impulse noise, in reference to phonograph discs, means those clicks and pops which arise through the mishandling of discs, inadvertantly allowing the stylus to scrape across a disc after you drop the tone arm, etc.

The SAE Model 5000, then, was designed (invented, would really be a more apt term) to reduce the audible effect of those infamous pops and clicks. It not only works, but works so amazingly well that we find ourselves still sort of shaking our head in disbelief. More about why and how it works in a moment. First, let's examine this newest "add-on" box which, as you might have guessed, can be easily plugged into any hi-fi component system via those ever-handy tape monitor out and in jacks, or between your preamp and power amp, if you happen to own such separate components.

The front panel of the 5000 is, appropriately enough, finished in black, with white lettered control designations. The three pushbuttons at top center are labeled *Tape Monitor* (for duplicating that function which may have been used up on your present equipment when you connected the device itself), *Defeat* (which allows for easy comparison between pop-laden and pop-free reproduction results), and *Invert*, a button whose function will be described shortly. A slider control, calibrated from 0 (the "off" position) to 10, is identified as a sensitivity control and its setting is adjusted under actual listening conditions for the most effective impulse noise reduction.

The rear panel is fitted with pairs of input and output jacks plus the tape-out and tape-in jacks mentioned earlier. A fuseholder is also mounted on the rear panel.

Design Approach and How It Works

According to the SAE 5000 inventor, Jack Sacks, several properties of impulse noise were first investigated and those unique to impulse noise were isolated. Impulse noise was found to have an extremely fast attack and decay time. While some music also contains fast attack times, decay is usually slower. Impulse noise was also found to contain essentially out-of-phase information. A logic circuit was developed, based upon this research, which can detect the presence of impulse noise even under the most demanding musical conditions that will minimize false "triggering" of the noise elimination circuits.

Since the noise pulse occurs during such a short time, the noise removal circuit of the 5000 actually shuts down the music during its occurrence. But, to ensure program continuity (the human ear would readily detect even such short absences of sound), a "reconstruction" circuit is also activated. Program material prior to and after the impulse noise is evaluated, and extrapolated prior-impulse program material replaces the impulse noise that was removed. Through this approach, musical continuity is maintained and impulse noise is removed without dynamic enhancement or bandwidth modification techniques. The entire process described takes less than one-thousandth of a second from deterioration to complete removal.

Use of The Sensitivity and Invert Controls

In actual use with a phonograph record that has impulse noises in its grooves, one pushes the *Invert* button on the front panel. One then hears not the music, but the pops and clicks that the unit is "removing". The sensitivity control is then moved towards the right until some of the peaks of the music begin to be heard (as a sort of rasping, break-through kind of sound). The sensitivity control is then backed off slightly, the *Invert* button is released and presto! The music comes through and the pops and clicks don't. The operation is truly uncanny! In our tests, we took a pocket knife and deliberately "laid down" a gouge across the entire radius of a

Fig. 1—With the sensitivity control in the *Off* position and pseudo-impulse noise fed to the input, the Model 5000 produces signals shown in the lower trace at the outputs.

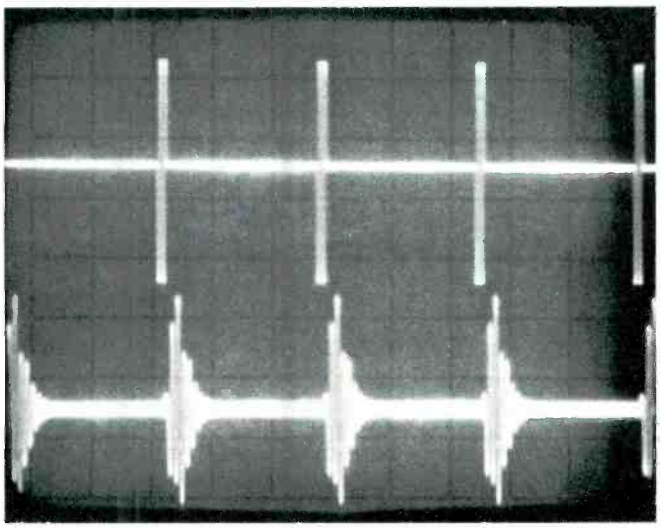
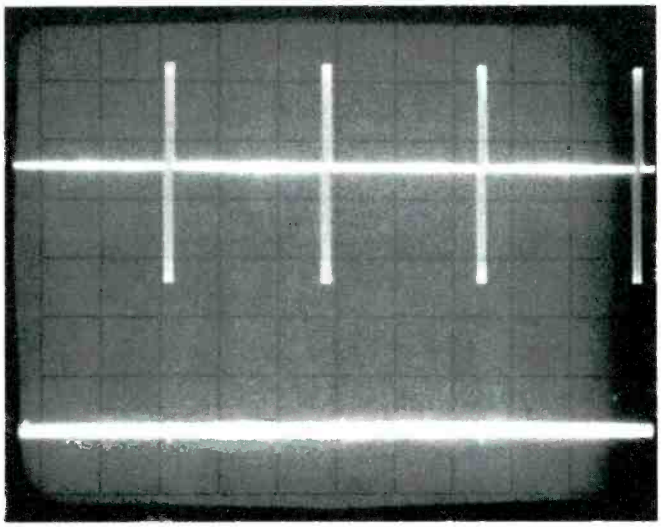


Fig. 2—After proper adjustment of the sensitivity control, noise signals are effectively eliminated at the output.



record (one which we were ready to discard because of its musical content anyway). All we can report is that after playing this disc through the SAE 5000 we have had second thoughts about relegating it to the trash can, and the disc remains part of our record library!

In reporting about this unit, we thought it would be nice if we could demonstrate graphically (rather than by our verbal description) how effectively it does the job for which it was designed. After some experimenting, we developed a repetitive signal which came close to that of impulse noise and which the unit would recognize and process as such. The signal consisted of two cycles worth of 25 kHz bursts, repeated several times per second, as illustrated in the top trace of the 'scope photo of Fig. 1. Interestingly, trying to use lower frequencies than 25 kHz to represent impulse noise failed, suggesting that the 5000 cannot be easily fooled when presented with high frequency musical content within the audio range.

In any event, with the sensitivity control set to its "zero" position (noise impulse reducing circuit not operating), the output waveform from the unit looked as shown in the lower trace of Fig. 1. However, when the sensitivity control was advanced beyond the "3" setting, suddenly the output all but disappeared, as shown in the lower trace of Fig. 2 (the upper trace still represents our artificially created "impulse" signal). If you examine the lower trace very carefully, you will see very tiny "glitches" where the pulses would have come through to the output. With the very same setting of the sensitivity control, feeding in even 20 kHz of continuous sine wave signals resulted in an output that was identical to the input.

Basic Measurements

All the advantages of a unit like the SAE Model 5000 would be of little use if the unit itself introduced high levels of distortion, altered frequency response of the total system with which it is used, or degraded system signal-to-noise ratio. Our remaining test measurements were therefore concerned with some of the more basic performance parameters of the unit. Since rated output for the unit is listed as 2.5 volts rms, our THD and noise measurements were made with respect to that output level.

Total harmonic distortion with an input signal of 1 kHz measured a very low 0.005 per cent. At the frequency extremes of 20 Hz and 20 kHz, THD was 0.01 and 0.05—all considerably lower than the 0.1 per cent claimed by the manufacturer. IM distortion for the same equivalent output level measured 0.019 per cent. Frequency response was flat within 1 dB from 18 Hz to 21.1 kHz. There is a sharp drop-off beyond that high frequency extreme, however, no doubt a requirement of this device which must not "mistake" music for impulse noise. Insertion loss on our sample measured 0.5 dB, while signal-to-noise ratio, referred to 2.5 volts output, measured 96 dB.

It should be noted that a relatively high input level is required if such high S/N ratios are to be maintained, and it seemed to us that a user would be better advised to insert the unit between a preamp and an amp (or, if one's receiver is equipped with preamp-out/main amp in terminals, at that point) rather than at the usual tape-out/monitor in jacks. Levels at most tape out jacks are of the order of 100 to 150 mV, and while the unit would operate perfectly well at these lower input levels, S/N ratio capability would be degraded from its high reading of 96 dB to around 71 dB or so and might, in some systems, become a "limiting factor." (Editor's Note: SAE comments that when the unit is placed between preamp and amp, adjustment of the preamp's volume control makes necessary further adjustment of the 5000's sensitivity control. Their data shows that typical rms levels for tape outputs are between 0.5 and 1.0 V, so that S/N would not be so seriously degraded. They therefore recommend the unit be placed in the tape loop.)

Whether or not a serious audiophile is prepared to spend an extra $200 to restore "pop and click" laden records to usability will, of course, depend upon how many such records are owned and how important they are in a record collection. We, however, having heard the SAE 5000 in action, can only compliment its designer and the company that manufactures the device for having come up with a truly innovative and effective solution to an age-old problem that besets all disc collectors. *Leonard Feldman*