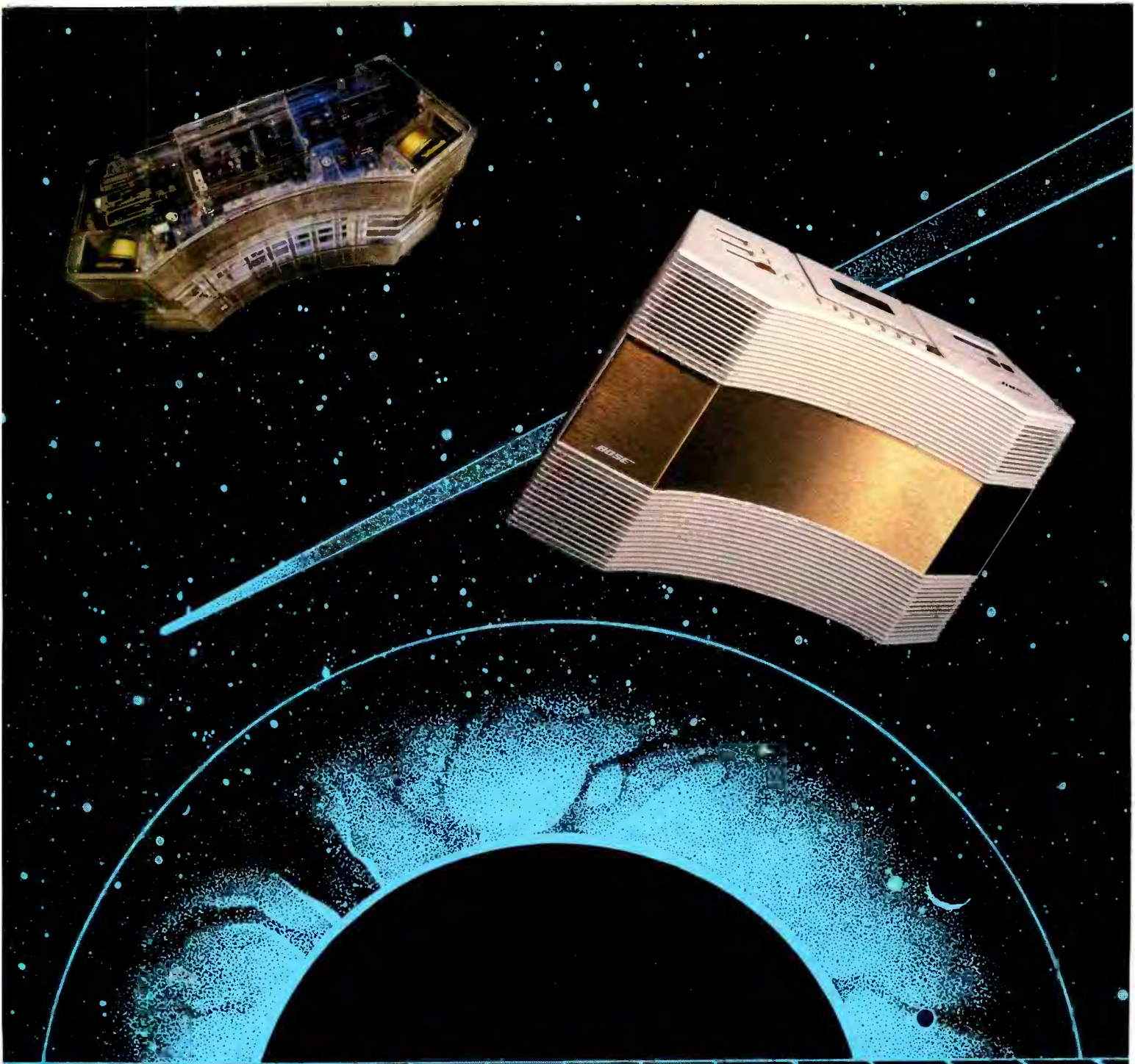


New Speaker Design Breaks Size Barrier

Bose's "Acoustic Wave" speaker development is combined with a receiver and tape deck for an exceptionally compact stereo system with powerful bass response.

By Len Feldman

Until more recent years, speaker-system designing was as much an art as a science. The Bose Corporation was among the pioneer science-ordered speaker developers, led by Dr. Amar Bose, an MIT professor. Moreover, the company has a history of breaking with traditional designs. So it was with a heightened sense of expectation that I traveled to the company's headquarters at the invitation of Dr. Bose to learn about its newest product.

Seated in one of Bose's audio/visual presentation rooms, together with a group of reporters, a spectacular slide-sound show unfolded. The room-filling sound associated with the presentation appeared to be coming from four Bose 901 speakers—no surprise, since these speaker systems, in their latest incarnation, are still the mainstay of the Bose line of direct-reflecting systems. At the conclusion of the meeting, however, hollow covers designed to simulate Model 901 enclosures were lifted away, unmasking an altogether different product—high fidelity component systems packaged in a unitary form.

Each system contained an AM/Stereo FM tuner, a cassette tape deck and the new product development, a speaker system dubbed an "Acoustic Wave Sound System." The entire stereo system surprisingly occupies less space than a single 901 speaker system, measuring only 18"W × 6"D (max.) × 11"H. It weighs around 18 lbs. and, when fitted in an optional carrying case that contains a set of batteries, can be operated solely from this power source. The system carries a suggested retail price of $650.

Design Philosophy

A thrust of Bose's design quest over the years has been to achieve realistic sound with properly reproduced low bass tones from a small speaker enclosure. Coupled with this, he reasoned that true high-fidelity components hadn't penetrated a high percentage of households due to the large size of such systems on the market. With the advent of integrated-circuit technology, the electronic section of a system no longer posed a problem.

To develop a satisfactory compact system, therefore, only the speaker system stood in the way. To meet this criterion, Dr. Bose and his staff pursued new speaker-design approaches, resulting in the Acoustic Wave™ Music System introduced recently and discussed here. The name of the system is based upon the waveguide technology that it uses. Combined with a receiver and a cassette tape deck, the small system modifies our thinking about the relationship of size to sound-reproduction quality.

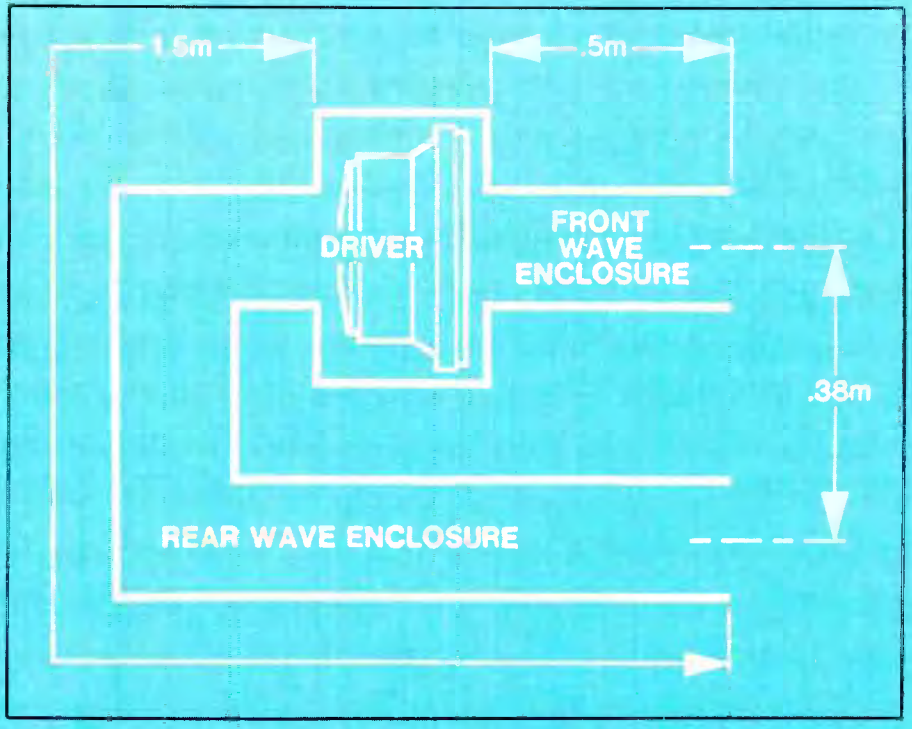
The Acoustic Wave Principle

Waveguide technology, normally employed for transmission of super-high-frequency radio waves in the Gigahertz frequency region, is fundamentally different from that of "lumped parameter" designs such as those used in the design of bass reflex or acoustic suspension (sealed box) speaker enclosure designs. Inside the waveguide, air does not behave as a single, lumped mass or compliance. Instead, the system is designed so that standing waves are *deliberately* developed.

These standing waves act to improve efficiency and to reduce required speaker cone motion over a wide frequency range. The higher efficiency results in lower amplifier power requirements, while the reduced cone motion results in greater acoustic power output combined with lower distortion.

In its simplest form, a waveguide enclosure consists of two chambers or acoustic "waveguides," with the speaker driver itself located at a precisely calculated point between the two waveguides. The front and rear waveguides operate so that the sys-

Fig. 1. This is an illustration of the Bose AWMS-1 system enclosure.



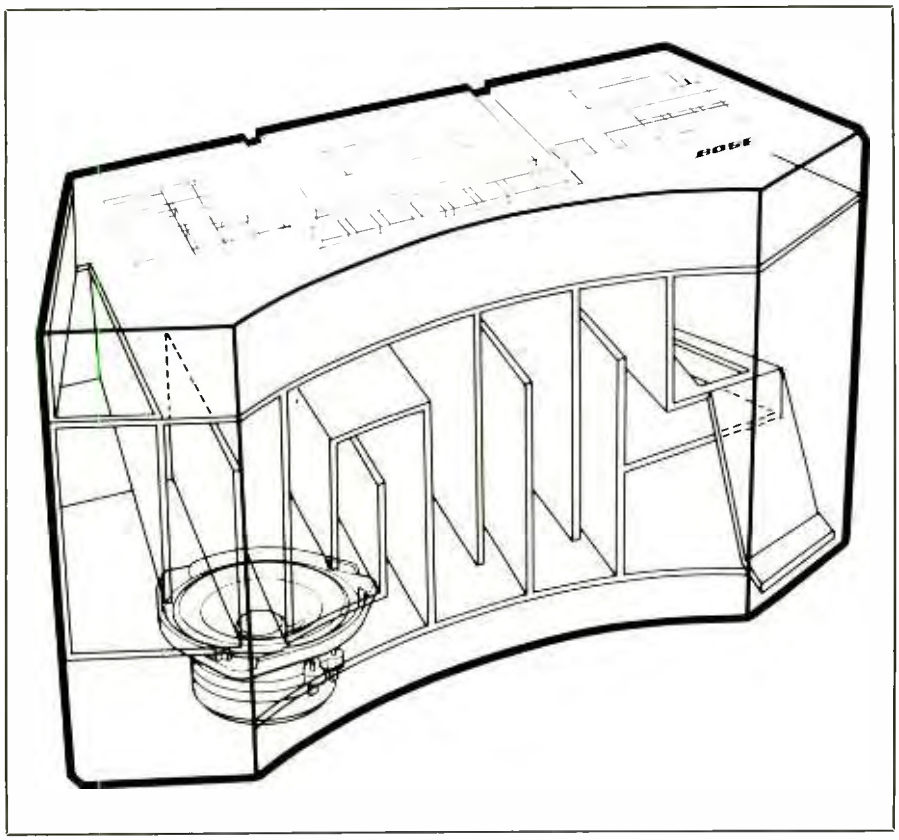
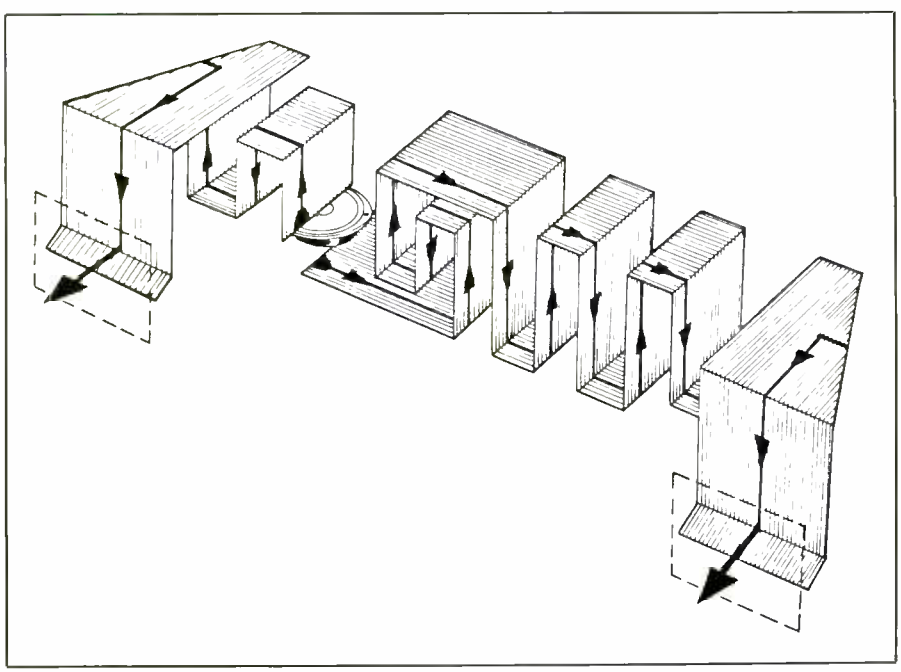


Fig. 2. This diagram illustrates, in simplified form, the actual waveguide structure used in the Bose Acoustic Wave Music System.

Fig. 3. Shown here is the approximate path followed by sound waves in the AWMS-1 as they reflect from each wall of the waveguide structure.



tem can accomplish cone velocity amplification and cone motion reduction over a wide frequency range.

Another way of looking at the principle is to think of a pipe organ. In that instrument, each of the pipes is "tuned" to a specific frequency. When a small volume of air is passed over the opening of each pipe, the resonance effect of that pipe "amplifies" the note to which the pipe is tuned. As a result, a large volume of air (and hence a loud sound) is set in motion at the output of the paper. An electrical analogy is the familiar "resonant circuit" that's used to "tune" radios to incoming r-f signals and to sustain oscillations in oscillator circuits of all kinds. Another familiar analogy, from the world of mechanics, is the clock pendulum. Resonant organ pipes, resonant electrical circuits, and mechanical pendulums all produce a large amount of energy compared with the energy required to *sustain* their oscillation.

Unfortunately, each of these devices can produce only *one* frequency. Their "amplification" effect is known, technically, as their "Q," and all of these devices have high "Q" numbers. If you want to have these devices respond to a broader range of frequencies, you would have to lower the Q, thereby losing the amplification effect. What Dr. Bose and his engineers discovered is that, contrary to earlier theory, it is possible to have a "high-Q" pipe that is, at the same time, broadband in its frequency characteristics. In other words, it's like creating a single organ pipe that is responsive not just to one note, but to perhaps as many as three or four octaves worth of frequencies!

The simple waveguide just described requires additional features if it is to be used in music reproduction applications. First, the length of the two waveguides must be in the precise ratio of 3:1. The ends of the two waveguides must be at the proper distance from each other to provide proper radiation impedance at each

opening, as illustrated in Fig. 1. Higher-frequency modes must be suppressed by appropriate shaping of the waveguides. Finally, speaker driver parameters must be precisely calculated so that as the waveguides develop "standing waves" that amplify diaphragm or cone velocity, the diaphragm motion itself is automatically and proportionately reduced. This reduced diaphragm motion compensates for the cone velocity amplification, and results in uniform power radiation with changing frequencies.

The actual waveguide structure used in the Acoustic Wave Music System is shown in simplified form in Fig. 2. Each waveguide section has been folded to meet the requirements outlined earlier, and the speaker driver itself has been positioned so that the two waveguide sections are in the required 3:1 length ratio. Figure 3 shows the approximate path followed by sound waves from each side of the following.

In the waveguide system, the wave reflects almost perfectly from the opening and travels back toward the speaker cone. Since there is virtually no damping in the structure, a standing wave is built up. Therefore, what you have are waves in both waveguides traveling in both directions (away from the cone and towards it) at all frequencies at which the system operates. These standing waves provide the velocity gain and the reduction in cone motion that enables the system to perform as it does.

The Rest of The System

Good bass alone does not a high-fidelity system make. The waveguide enclosure in the actual system now being offered by Bose works for frequencies up to 500 Hz. Mid-high frequency drivers are used for the remainder of the audio spectrum, and each of these mid-high frequency drivers is powered by its own small amplifier, separate from the single low-frequency driver. This is shown in the block diagram of Fig. 4. The use of an electronic crossover minimizes phase and amplitude matching problems normally associated with passive crossover networks. The acoustic waveguide functions as a low-pass filter, thereby reducing radiation of distortion by the low-frequency driver, and no low-frequency energy needs to be handled by the high-frequency amps and speakers.

Despite the small size of the system and the use of a single driver for bass frequencies, stereo effect obtained with the AWMS-1 (the model num-

AN AUDIO PIONEER

The chairman of Bose Corporation, Amar Bose, has set the audio community on its end more than once since he introduced his revolutionary 901 Direct/Reflecting® speaker system in 1968. Around that time I remember being seated next to him at an annual Audio Engineering Society convention dinner (Ray Dolby, inventor of the Dolby noise-reduction system, was at my other side). He told me about his work as a professor at world-famous M.I.T., where he taught acoustics and was involved deeply in psychoacoustics, which he had applied to the design of his new speaker system.

He talked about creativity, inventiveness, and his deep interest in music. Dolby, whose professional noise-reduction system I had just covered editorially in a series of articles in *Audio*, was drawn into the conversation. Both men regaled me with more information than I could ever digest about their products, of course, and I wondered if their enthusiasm would carry over to some degree of business success. As history has shown, it obviously did.

Some years later I visited Bose in his new headquarters atop a high hill called "The Mountain" in Framingham, MA. The facilities were extraordinarily impressive, down to the tranquil, pastoral scene below.

Obviously research-oriented by training (Sc.D. in Electrical Engineering from M.I.T., and supervising graduate and undergraduate thesis students at M.I.T. where he's a Professor of Electrical Engineering and Computer Science) and industry research work (such as for a prosthetics project at Massachusetts General Hospital that led to the Boston Arm), his company gathered one of the most advanced acoustical engineering groups in the world, it is said.

Using electronics to compensate for deficiencies in loudspeakers, he carved out new audio paths. This concept was extended in 1982 when, in a joint effort with General Motors and Delco Electronics, the first automotive sound system where speakers and amplifiers were acoustically customized to individual car models was introduced . . . to critical acclaim.

Bolstering the foregoing, Bose formed the Bose Music Society to offer audiophile-quality prerecorded cassette tapes, which includes a Private Performances Collection for car stereo owners.

Breaking new audio ground once again with the Acoustic Wave™ small music system discussed in the main article, adds another important technical innovation to the credit of this audio industry pioneer.—*Art Salsberg.*

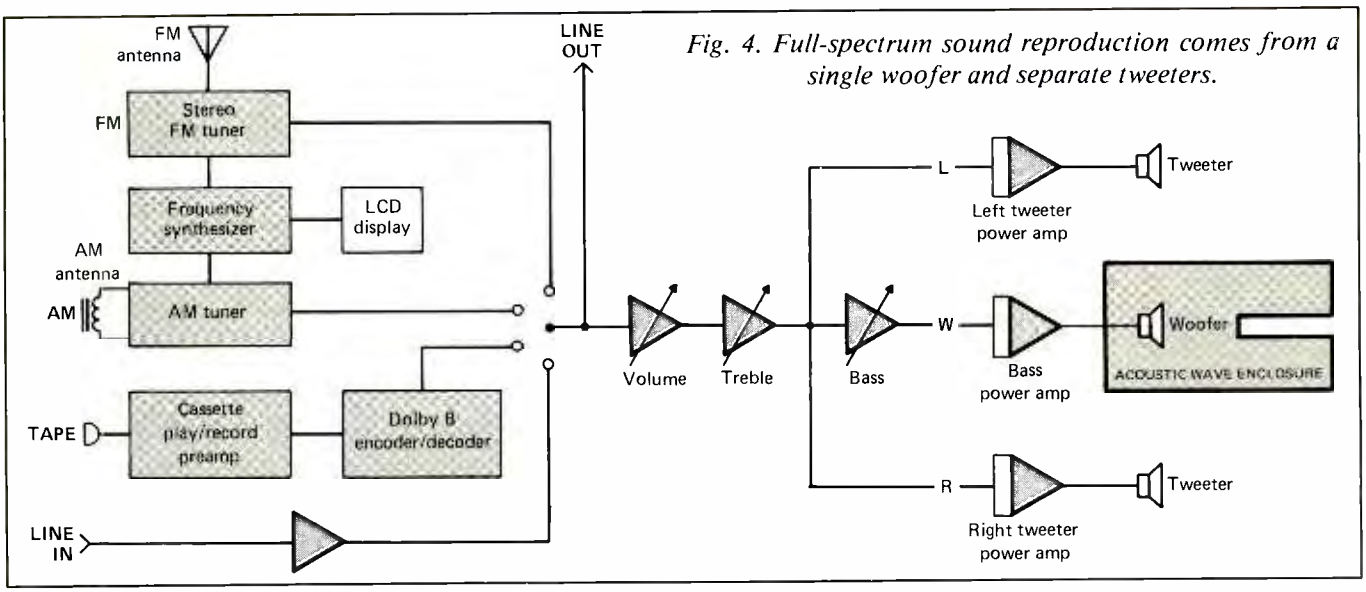


Fig. 4. Full-spectrum sound reproduction comes from a single woofer and separate tweeters.

ber given to this first product employing the new principle) is quite satisfactory. This is due in part to the fact that low frequencies are virtually non-directional in any case, and also to the positioning and outboard angling of the mid-high drivers.

Controls have been simplified to the utmost, in keeping with the original goal of creating a system that would not intimidate the typical music lover who wants good sound without complexity of operation. Dynamic equalization provides proper tonal balance at all listening levels. Tape playback equalization is automatic, thanks to internal sensing of tape type being played. The built-in cassette recording capability has been optimized for type II (chrome or chrome equivalent) cassette tape with Dolby noise reduction always active. The tuner is a quartz frequency synthesized type, with provision for presetting 10 favorite station frequencies (5 AM and 5 FM) for recall.

There are auxiliary line input and line output jacks on the unit, for connection of additional program sources such as a Compact Disc player or another tape deck, if desired. In addition to being able to operate the system when it is powered from an optional battery pack, it can also be powered by a car battery. Maximum acoustic output is in excess of 100 dB SPL (Sound Pressure Level)—more than enough to enjoy music at home at lifelike loudness levels.

Conclusion

The only relevant specifications that Bose reveals concerning the AWMS-1 are its maximum acoustic output (which, as previously stated, is better than 100 dB SPL) and that the system will operate for about 10 hours when it is powered by alkaline flashlight batteries.

The notable absence of technical specifications is consistent with Bose's original goal of creating a music reproducing system that will appeal to non-technical music lovers who have, up to now, resisted buying conventional audio components because the process of purchasing and assembling was overly complex.

Aside from this, Dr. Bose has always decried raw technical specifications as not accurately representing the quality of high-fidelity equipment, to the consternation of many audio equipment reviewers.

Nonetheless, technical tests can be made on any equipment, if numbers are the name of the game. In the case of the new AWMS-1, the speaker system goes very smoothly down to a respectable 50 Hz, which is remarkable for a system its size. The overall sound quality it reproduces is immensely satisfying. Its stereophonic effect is fairly good, given the limits of the speakers' fixed positions.

Aside from its music-reproducing capability, this is a highly versatile product. For example, the integrated entertainment center can be used virtually anywhere one wishes to enjoy high-performance stereo. Since it's about the size of the proverbial breadbox, the modernistic-looking all-in-one system can even fit comfortably on a kitchen counter. It can also be used in a vehicle or boat with an adapter. Furthermore, the AWMS will serve well outdoors when armed with an optional battery pack. And since it can be easily transported, it's inviting to use this portability.

In essence, then, Bose's new Acoustic Wave Sound System may well be the answer to the mass of music lovers who want excellent sound reproduction from a system that occupies little space and who will give up the flexibility of separate components and that extra measure of performance issued by larger, more costly equipment. **ME**