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WHARFEDALE DIAMOND IV SPEAKER

Manufacturer's Specifications
System Type: Two-way, vented mini-monitor system.
Drivers: 5-in. (120-mm) metal-cone woofer and ¾-in. (19-mm) metal-dome tweeter.
Frequency Response: 50 Hz to 25 kHz, ±3 dB.
Sensitivity: 86 dB SPL for 1 watt input at 1 meter.
Crossover Frequency: 3.5 kHz.
Impedance: 8 ohms nominal, 6.4 ohms minimum.
Power Handling: 100 watts.
Dimensions: 10½ in. H × 7¼ in. W × 7¼ in. D (26.7 cm × 18.4 cm × 18.4 cm).
Weight: 17⅝ lbs. (8 kg) per pair.
Price: $300 per pair, not including stands.
Company Address: 1940 Blake St., Suite 101, Denver, Colo. 80202.
For literature, circle No. 91

Quick: Think of an American loudspeaker company that has been in operation for nearly 60 years operating under the same name. You're right, there aren't any! There is one in the U.K., however, and that's Wharfedale. Gilbert Briggs founded the company in 1932 by building his first loudspeaker in the basement of his home in the town of Ilkley, county of Wharfedale (love those British names!). Loudspeaker production by Wharfedale Wireless Works increased quickly to 4,600 speakers per year by 1934. Today, Wharfedale, with its driver, cabinet, and R&D facilities in Leeds, England, exports to more than 43 countries and is a very significant competitor in the consumer loudspeaker market worldwide.

Historically, Wharfedale has been at the forefront of innovative research and production techniques. It was the first speaker company to successfully use laser interferometry to create a contour map of a moving speaker diaphragm with a technique called SCALP (Scanned Laser Plot). Wharfedale also applies SCALP when measuring cabinet side-wall vibration. (The British Celestion is another company that makes extensive use of laser interferometry.)

The Diamond IV is the smallest in a line of five systems in Wharfedale's economically priced Performance Series, which range in price from the Diamond IVs at $300 per pair up to $950 per pair for the Model 440. The four larger systems, Models 410 to 440, are all essentially two-way designs, with the two largest containing dual 8-inch woofers. All use drivers designed and manufactured by Wharfedale.

The Diamond IV is quite small and light, with a footprint of only about 7 × 7 inches. A single system can comfortably be held in one hand with your arm outstretched. Even though light in weight, the box has side walls that are quite rigid and stiff. The only available finish in the Performance Series is an attractive black ash. The appearance and build quality of my review samples were first-rate. As with other mini-monitors, the low-frequency performance of the speakers does not compete with that of larger systems.

The tweeters of the Performance Series use hardened, anodized-aluminum diaphragms, with Ferrofluid-cooled voice-coils, which Wharfedale claims operate as perfect pistons to beyond 35 kHz. According to the literature, this results not from "brute-force application of exotic (expensive) materials, but by the good design and engineering only possible with long experience with the tools for investigating diaphragm behavior. . . ." The bass drivers use diaphragms made of Wharfedale's proprietary plastic material called MFHP2, a mineral-filled polypropylene with high stiffness, relatively low mass, and high self-damping. It is claimed to greatly reduce colorations as compared to other plastic cone materials.

The tooled plastic grille assembly of the Diamond IV actually fits around the front of the cabinet and snaps into grooves on either side of the front panel. This mounting method minimizes diffraction and, in addition, looks quite good. Without the grille, the speaker is also quite attractive, due to Wharfedale's use of tapered, hard-rubber rings around each driver. The ring around the woofer is not completely round but extends to, and terminates at, the top of the enclosure. The tapered rings minimize diffraction in addition to very efficiently hiding the driver mounting hardware.

The side edges of the front panel are rounded, while the top is bevelled and contains the raised letters of the manufacturer's name—a nice touch! These boxes do not have the mundane look of typical low-cost, high-volume, vinyl-wrapped cabinets. I preferred the look of the systems without the grilles and used them that way for most of my review activities.

The box is fitted with a tube, 1 inch in diameter and 4¼ inches long, mounted at the top rear of the enclosure and having a rounded entry. An outside visual inspection of the tube's interior showed damping material placed right up against its inside end. This presumably deliberate condition had a large impact on the low-frequency performance of the system. (See my comments in the "Measurements" section of this review.)

A recessed input-terminal panel is mounted in the center of the box's rear and contains two heavy-duty, double-banana jacks mounted on ¾-inch centers. The wire insertion holes in these jacks are nearly 3/16 inch in diameter and can easily handle 10- or 12-gauge wire, if desired. Although not gold-plated, they serve their purpose very well and are quite accessible. Bi-wire capability is not supported.

Measurements

The anechoic frequency response, for a 2.83-V rms input, is shown in Fig. 1, smoothed with a tenth-octave filter. The curve was taken at a distance of 1 meter, normal to the enclosure's front surface, with the microphone midway between the woofer and tweeter. The grille caused less than a 1-dB variation in the response below 10 kHz; at higher frequencies it provided increasing attenuation, but with a maximum loss of only about 2 dB at 20 kHz. All the following measurements were taken with the grille off.

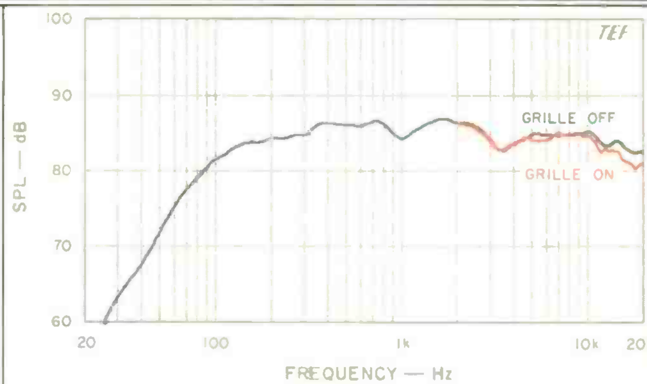

Fig. 1—One-meter, on-axis frequency response.

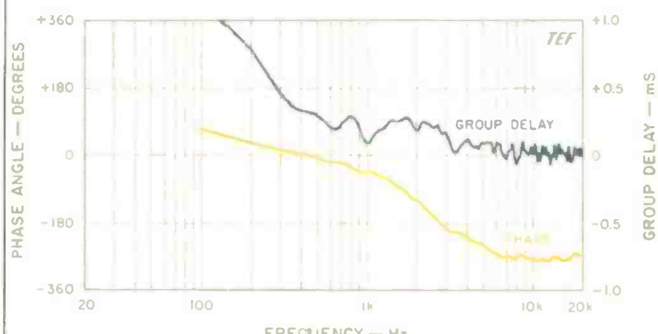

Fig. 2—Phase angle and group delay.

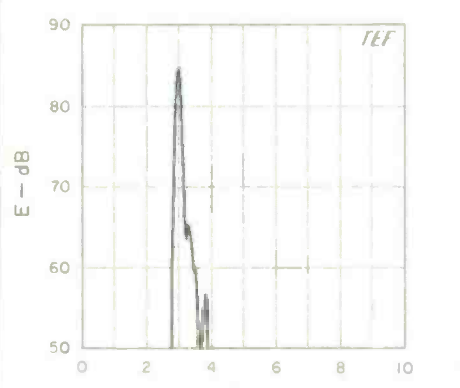

Fig. 3—One-meter, on-axis energy/time curve.

The hybrid closed/vented design reduces the woofer's excursion without causing a rapid roll-off below the box's cutoff frequency.

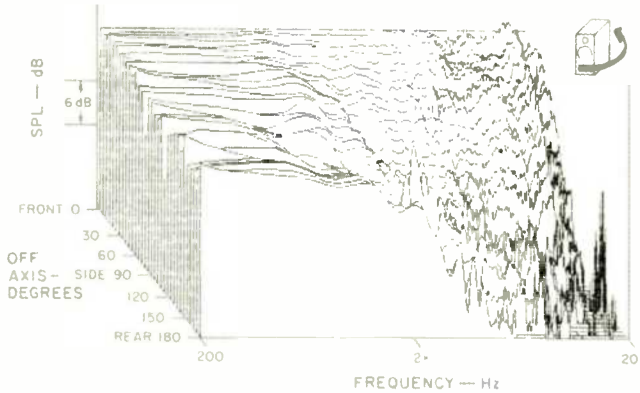

Fig. 4—Horizontal off-axis response, normalized to the on-axis response.

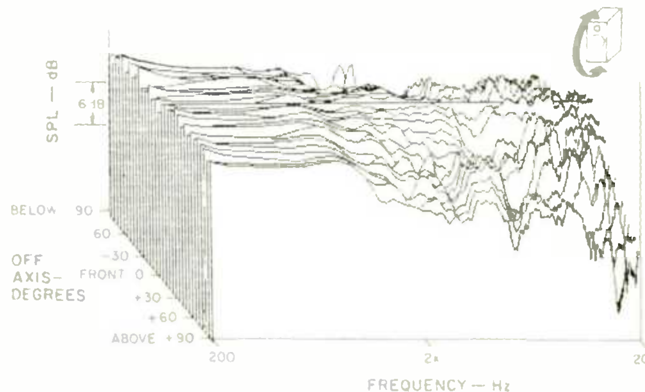

Fig. 5—Vertical off-axis response, normalized to the on-axis response.

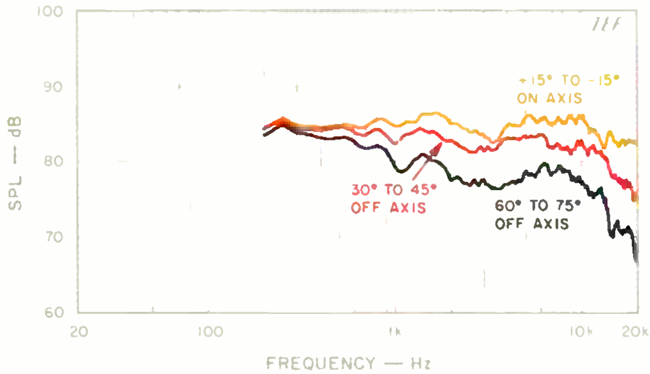

Fig. 6—Mean horizontal responses derived from data of Fig. 4.

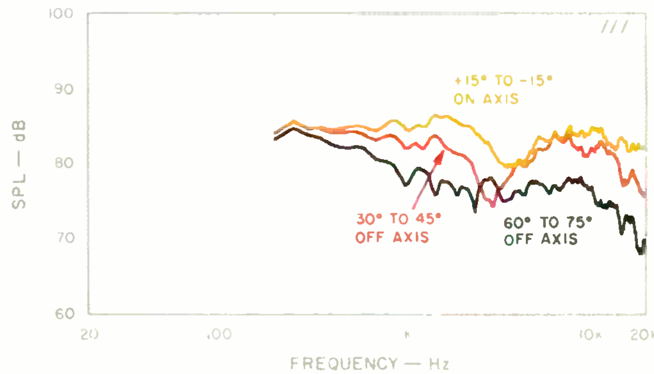

Fig. 7—Mean vertical responses derived from data of Fig. 5.

The response curve fits within a ±3.0 dB envelope from 95 Hz to 20 kHz. Above 120 Hz, the curve fits a commendably tighter ±2.0 dB envelope. No major irregularities are exhibited except for a slight dip at the 3.5-kHz crossover. Below 80 Hz, the response falls at 12 dB/octave, typical of closed-box systems (but unlike vented-box systems, whose response drops at 24 dB/octave!). Averaging the axial response over the range from 250 Hz to 4 kHz yielded a sensitivity of 85.8 dB, equalling the manufacturer's rating of 86 dB SPL. The systems were matched quite closely, measuring within ±0.75 dB in the range from 100 Hz to 20 kHz. A high-frequency measurement up to 32 kHz revealed no tweeter resonances.

The axial phase and group-delay measurements of the system, corrected for the tweeter's arrival, are shown in Fig. 2. The phase response exhibits a total rotation of only about 230° between 1 and 20 kHz. Group delay is fairly well behaved above 1 kHz, and the curve shows that the woofer/midrange lags the tweeter by about 0.20 mS. This is about three-fourths of a wavelength at the 3.5-kHz crossover.

The 1-meter, on-axis, 2.83-V rms energy/time curve (ETC) of the Diamond IV is shown in Fig. 3, for a test signal swept from 200 Hz to 10 kHz. The main arrival, at 3 mS, is notably compact and well behaved, with only slight broadening at levels 20 dB below the peak. Note that under these test conditions, a perfect energy/time curve would appear as a single sharp spike centered at 3 mS, with a width of about 1 mS at the base (50-dB line) and tapering to a rounded point at the top.

Removal of the woofer and rear terminal panel revealed a very well-constructed box with tight fit and close tolerances. The front panel is made from a hefty, ⅞-inch-thick material which seemed denser than medium-density fiberboard, as it is identified by Wharfedale. The remaining walls are ½ inch thick. The very dense front-panel material allows accurate routing for the very unusual driver-mounting method employed for the Diamond IV. The drivers are deeply recessed into the front panel and covered with a tooled, tapered hard-rubber ring which minimizes front-panel edge diffraction and greatly improves the cosmetics of the system.

The small diameter of the Diamond IV's tweeter gives it broader high-frequency coverage than can be had from larger tweeters.

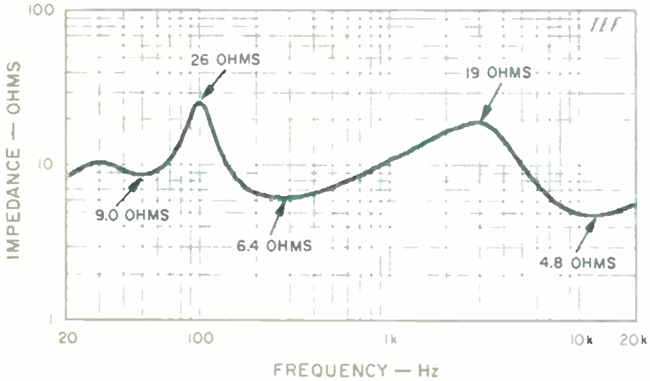

Fig. 8—Impedance.

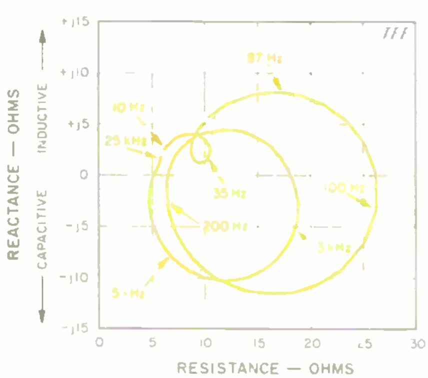

Fig. 9—Complex impedance, showing reactance and resistance vs. frequency.

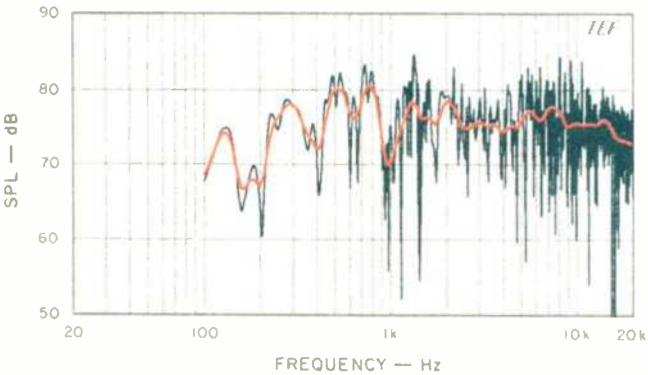

Fig. 10—Three-meter room response, showing both raw and smoothed data.

To damp internal reflections, white batting (apparently cotton) is used inside the box, rather than fiberglass. The batting was positioned up against the inner end of the vent tube, changing the system from a pure vented-box design into a leakage-damped closed-box system. This hybrid design is functionally equivalent to Dynaudio's Variovent design used in the Special One system (*Audio*, December 1990). The vent, rather than acting as a mass of air to resonate with the air trapped inside the cabinet, acts primarily as a resistance to the flow of air into and out of the box. This technique somewhat reduces the woofer excursion compared to that of a conventional closed box of the same size, but does not bring with it the vented box's rapid roll-off below cutoff. An additional benefit of the design is a significant reduction in air-rush and wind noises often associated with vented-box systems having small-diameter vents.

A high-level, low-frequency sine-wave sweep revealed no significant cabinet side-wall resonances. A comparison of the woofer's excursion, with the port open and closed (covered by my hand), revealed that the port reduced the woofer's excursion over a broad range from 35 to 95 Hz, reaching a maximum reduction of about 25% at 55 Hz. The woofer did not exhibit any detectable effects of dynamic offset. At 13-V rms input at 55 Hz (about 20 watts), wind noises were minimal; however, when the batting was pushed away from the inside end of the port tube, wind noises increased dramatically.

The woofer overloaded gracefully at high levels, with no objectionable noises. The effective piston diameter of the woofer is about 4½ inches (as measured from the middle of the surround on one side to the middle of the surround on the other). The woofer's linear excursion capability was about ¼ inch, peak to peak, with an excursion limit of about 0.35 inch, peak to peak.

The crossover network of the Diamond IV consists of five parts: Two inductors, two capacitors, and one resistor, forming essentially a 12-dB/octave electrical design. The crossover's p.c. board is mounted on the rear of the cabinet, just below the input-terminal panel. The woofer's inductor is of iron-core design, while the tweeter is air core. Nonpolarized electrolytic capacitors are used. All internal wiring is stranded 18 or 20 gauge, with push-on terminal clips.

Measurements of the drivers' separate acoustic responses, connected to the crossover, revealed that the actual electroacoustic response is effectively 12 dB/octave through the region. The drivers were in phase with each other below and up to about 4 kHz, one-sixth octave above the crossover, and rapidly went out of phase at higher frequencies. The mainly in-phase condition of the drivers' responses minimizes lobing. However, some lobing is expected above crossover, because the drivers' phase responses are not the same. The individual responses also revealed that the drivers' output levels were somewhat low through the crossover region, causing the previously noted dip in the on-axis response.

The normalized, horizontal, "3-D" off-axis curves of the Diamond IV are shown in Fig. 4. The curves are quite well behaved and indicate even horizontal coverage, which is required for good lateral localization and imaging. Figure 5 shows the vertical off-axis curves. These curves are also

Small as the Diamond IVs are, their sensitivity and efficiency equal those of much larger systems.

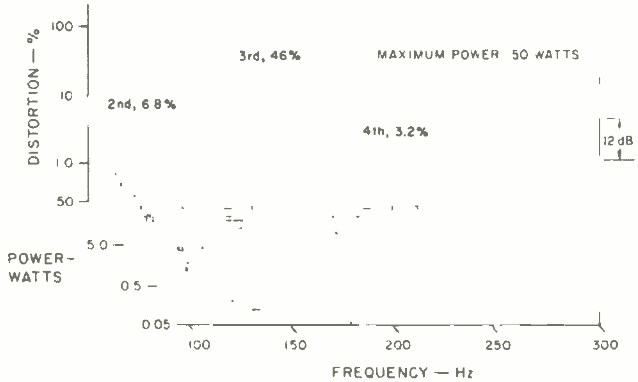

Fig. 11—Harmonic distortion products for the musical tone B_1 (61.7 Hz).

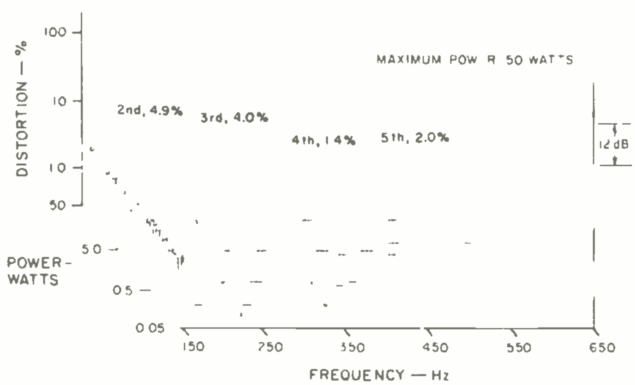

Fig. 12—Harmonic distortion products for the musical tone A_2 (110 Hz).

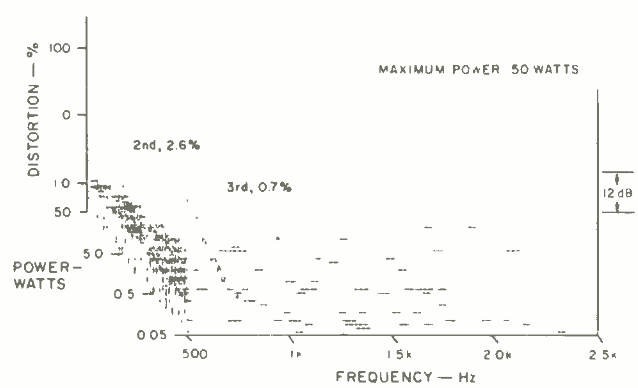

Fig. 13—Harmonic distortion products for the musical tone A_4 (440 Hz).

quite well behaved and reasonably symmetrical above and below axis, which indicates minimal response changes with shifts in vertical listening position.

The NRC-style, mean horizontal and vertical on- and off-axis response curves of the Diamond IV are shown in Figs. 6 and 7, respectively. The horizontal axial response curve in Fig. 6 is quite smooth and extended except for a slight crossover dip at 3.5 kHz. The off-axis response from 30° to 45° is also well behaved and extended, and begins to roll off only above 15 kHz. The response from 60° to 75° off axis is smooth above 2 kHz and rolls off above 13 kHz. The small-diameter (¾-inch) tweeter contributes to the Diamond IV's high-frequency coverage. Most other systems, with larger tweeters, maintain coverage only up to about 10 kHz at extreme off-axis angles.

The mean vertical responses of the Diamond IV are shown in Fig. 7 The averaged axial curve exhibits an octave-wide response depression at crossover, which also carries over to the 30° to 45° averaged response. The somewhat low level of the drivers in the crossover region, as noted before, and the woofer/tweeter driver spacing contribute to the energy loss in the crossover region. With the exception of the response through crossover, all the curves are quite smooth and extended.

Figure 8 shows the Diamond IV's impedance plotted from 20 Hz to 20 kHz. The system had a measured low of 4.8 ohms at 12 kHz and a high of 26 ohms at 100 Hz. This is a fairly easy load for most amplifiers. The characteristic double-humped impedance response of the vented-box enclosure is evident between 20 and 150 Hz, but with the upper peak significantly higher than the lower peak. However, the shallow dip at 50 Hz indicates only slight loading at the Helmholtz box resonance. The system's minimum impedance of 4.8 ohms, coupled with its minimum-to-maximum variation ratio of 5.4 (26 divided by 4.8), makes the Diamond IV somewhat sensitive to cable resistance. To keep cable-drop effects from causing response peaks and dips greater than 0.1 dB, cable series resistance must be limited to a maximum of about 68 milliohms.

Figure 9 shows a well-behaved complex impedance from 10 Hz to 25 kHz. The phase angle of the impedance (not shown) reached a maximum of +31° at 77 Hz and a minimum of −49° at 5 kHz.

The system's 3-meter room curve, with both raw and sixth-octave smoothed responses, can be seen in Fig. 10. The Diamond IV was in the right-hand stereo position, mounted on its stand and aimed at the listening location; the test microphone was placed at ear height (36 inches), at the listener's position on the sofa. The system was swept from 100 Hz to 20 kHz with a 2.83-V rms, sine-wave signal (which corresponds to 1 watt into the rated 8-ohm load). The parameters of the TDS sweep were chosen to include the direct sound plus 13 mS of the room's reverberation. The curve is reasonably well behaved and extended except for some response roughness below 1.5 kHz, mostly due to room effects. Above 2.5 kHz, the curve is quite smooth and extended, all the way to 20 kHz.

An additional room curve was taken with the system mounted in a bookshelf, where a typical listener might put it for casual listening. The curve (not shown) was very much

Although the Diamond IVs don't have extended bass, they do have above-average resistance to bass overload.

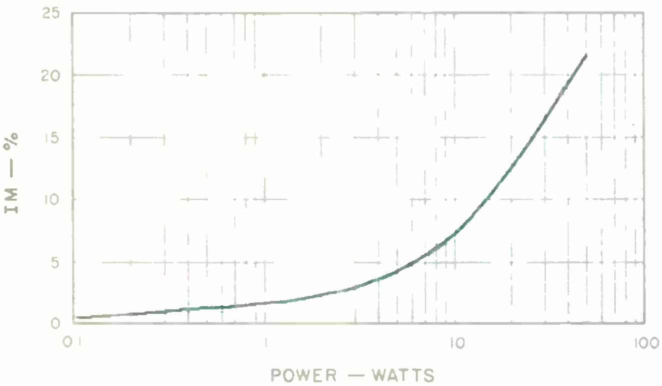

Fig. 14—IM distortion on 440 Hz (A_4) produced by 61.7 Hz (B_1) when mixed in one-to-one proportion.

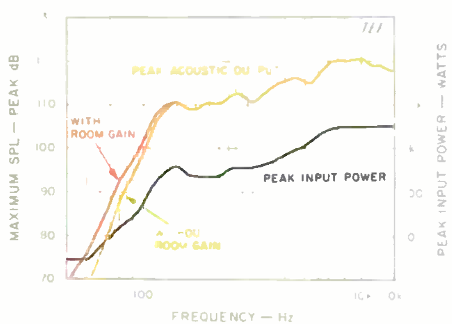

Fig. 15—Maximum peak sound output, measured at 1 meter on axis, and corresponding maximum peak input power levels.

rougher, with large peaks and dips in the response due to close-in reflections. A separately measured ETC (also not shown) confirmed that this mounting location caused a large number of high-amplitude, early-energy returns that were not evident in the normal mounting position, which places the system a significant distance from any close reflecting surfaces.

The distortion spectra of applied single-frequency tones versus power level for the musical notes of B_1 (61.7 Hz), A_2 (110 Hz), and A_4 (440 Hz) are shown in Figs. 11, 12, and 13. These measurements indicate the level of harmonic distortion generated by the system with the application of a single-frequency sine wave at power levels from 0.05 to 50 watts (–13 to 17 dBW, a 30-dB dynamic range) in steps of 1 dB. The power levels were computed using the rated system impedance of 8 ohms (20 V rms equals 50 watts, etc.).

Figure 11 shows the B_1 (61.7-Hz) harmonic distortion data. The higher tone, B_1, was used instead of the customary E_1 (41.2 Hz), because E_1 generated excessive distortion (126% third harmonic at 50 watts!). Even using B_1, the distortion at 50 watts reaches a high 46% third harmonic. At 50 watts, the system generates 94 dB SPL at 1 meter.

At A_2 (110-Hz) harmonic data is shown in Fig. 12. The second harmonic reaches a moderate level of about 4.9% at full power, while the third reaches 4%. The fourth and fifth harmonics are only 2% or lower at full power. At 110 Hz, the system generates about 100 dB SPL at 50 watts at 1 meter.

The A_4 (440-Hz) harmonic measurements, shown in Fig. 13, are quite low, reaching only 2.6% for the second harmonic at full power, where the system generates 104 dB SPL at full power at 1 meter.

The IM distortion shown in Fig. 14 was created by mixing 440-Hz (A_4) and 61.7-Hz (B_1) tones at equal input power levels. The higher, B_1, tone was used for the lower modulating frequency because the usual E_1 tone generated excessive distortion. Even using B_1, the IM distortion reached a fairly high 22% at full power.

Figure 15 shows the system's short-term, peak-power input and output capabilities as a function of frequency, measured with a tone burst of third-octave bandwidth. The peak input power was calculated by assuming that the measured peak voltage was applied across the rated 8-ohm impedance. The maximum power handling of the Diamond IV is shown in the lower curve. At 30 Hz and below, the peak power must be limited to about 3 watts or less to prevent excessive distortion and intermodulation. Above 30 Hz, the power handling rises gradually, reaching a plateau of about 300 peak watts (about 50 V peak) between 200 and 630 Hz. Above 630 Hz, the power handling again rises gradually, reaching a maximum of 3.2 kW above 6.3 kHz. The power handling in the range from 125 Hz to 1 kHz is somewhat low compared to other systems I have measured. (That is, if you judge 300 to 400 peak watts as being low! This corresponds roughly to the peak output of an amplifier rated at 150 to 200 watts continuous.) Evidence leads me to believe that the metal-core inductor in the crossover's woofer leg is responsible.

The upper curve in Fig. 15 represents the peak sound pressure levels the system can generate at a distance of 1 meter on axis for the levels shown in the lower curve. Also shown on the upper curve is the "room gain" of a typical listening room at low frequencies, which adds about 3 dB to the response at 80 Hz and adds 9 dB at 20 Hz. The peak output rises with frequency up to 200 Hz, where a plateau of about 110 dB is reached. Above 1 kHz, the maximum output rises to about 120 dB above 6.4 kHz. With room gain, a single Diamond IV can generate peaks in excess of 110 dB SPL (but only above 160 Hz) and of 100 dB above 90 Hz. Below 160 Hz, the low-frequency output rolls off at about 18 dB/octave. A pair of these systems, operating with mono bass, will be able to generate bass levels some 3 to 9 dB higher, particularly if they are set up near wall boundaries.

Use and Listening Tests

I listened to the Diamond IVs primarily in my customary location, placing them on stands so that the tweeter was approximately at ear height. This location positioned them a significant distance from any reflecting surfaces that might interfere with imaging, localization, and midrange smoothness, but they were at a clear disadvantage with respect to any beneficial boundary reinforcement that would tend to augment their low-frequency output.

The Wharfedales' quality and musical honesty would befit systems costing far more than their price of $300 per pair.

Even though the Diamond IVs are quite small, their sensitivity and efficiency equal those of much larger systems. The laws of loudspeaker physics dictate that their low-frequency efficiency and output will be much less than those of larger systems. (Assuming the same efficiency, an octave lower extension of low-frequency performance requires an eightfold increase in enclosure volume!) In other words, to compete unaided with larger loudspeakers, very small systems need to be placed close to reflective boundaries to enhance their low-frequency performance. This, unfortunately, often impairs higher frequency performance because of the detrimental effect of high-amplitude reflections which closely follow the system's direct sound.

I chose to evaluate the Diamond IVs as stand-alone systems for serious critical listening—putting more emphasis on higher frequency performance parameters such as smoothness, imaging, and accuracy—rather than as systems that might be used for casual applications such as background music reproduction. In the latter situation, sound reproduction is not as important as other considerations, such as size and ease of placement, although the Diamond IVs can be used for this application as well.

So as not to be biased by the lack of low end in some of my listening tests, I requested that Wharfedale send me a three-piece satellite/subwoofer system that they currently market (the System 2130) so that I could experiment with the subwoofer as an adjunct to the Diamond IVs. Before you cry foul, let me add that I did a great amount of listening to the IVs both with and without the subwoofer. I greatly appreciated its augmentation in the octave from 40 to 80 Hz in many cases. When the subwoofer was in use, I hooked the Diamond IVs directly to the power amplifier and did not use the 2130's internal, high-pass crossover output. I simply added the subwoofer in parallel with the IVs (the 2130 has dual internal woofers connected separately to right and left channels) and depended on its internal, low-pass filtering to roll off its own higher frequency response. When I used this subwoofer with the Diamond IVs, I placed it in the front of my room to approximate the overall low-end balance of my reference systems. It was an easy matter to connect and disconnect the added bass system.

Driving equipment included an Onkyo Grand Integra DX-G10 CD player and a recently acquired Enlightened Audio Designs (EAD) "Ultra" modified Rotel RCD-855 CD player, along with Jeff Rowland Design Group's Consummate preamplifier and two Jeff Rowland Model 7 power amplifiers. Hookup was with Straight Wire Maestro interconnects and speaker cables. I did most of the listening before the measurements.

As mentioned, most listening was done with the Diamond IVs placed on stands and aimed at my head. They were about 6 feet away from the short rear wall, separated by 8 feet, and with a side-wall spacing of about 4 feet. I sat on the sofa, about 10 feet away, which placed my ears about 36 inches high. The System 2130's subwoofer, when used, was placed on the floor in front of the bookshelves at the front of the room, offset laterally by a couple of feet.

First impressions of the Diamond IVs were very positive; these speakers have a balance and sensitivity very close to my reference systems (the B & W 801 Matrix Series 2) except for a much-attenuated low end. There was a slight loss of energy in the upper mids as compared to my reference, but it was not all that objectionable. The balance and response in the top two octaves were nearly indistinguishable from the reference, which indicates a very smooth, extended top end.

Reproduction of male voices on the CD *Jack Lemmon Tells the Musical Tale of Peter and the Wolf* by Prokofiev (LaserLight 15 386) was very balanced and even, with no tubbyness, and created a very believable center image. (Here the subwoofer was not needed, as it only added some unwanted upper bass emphasis.) The high-frequency sound effects on the same disc, in Mozart's Children's Symphony, were re-created outstandingly.

The choral music on *J. S. Bach: The Motets, BWV 225-229* (Sony Classical SK 45859) was portrayed with excellent vocal separation and delineation of the different choir sections. The instruments on *Vivaldi: 6 Double Concertos* (flute, violin, strings, and harpsichord, Sony Classical SK 45867) demonstrated the clarity and smoothness of the Diamond IV's midrange.

Although the Diamond IVs do not have extended low-end capabilities, they exhibited above-average resistance to below-band bass overload. The organ passage that caused IM problems in the Monitor Audio Studio 10 speakers (see July issue) was handled acceptably, i.e., you could hear the IM distortion, but it was not as objectionable.

The Diamond IV loudspeakers exhibited a reasonable amount of upper-mid tonality changes on the pink-noise, stand-up/sit-down test. When I was sitting or partially standing, the Diamond IVs sounded quite similar to my reference B & Ws, but when I stood up fully, there were noticeable tonal changes. On third-octave band-limited pink noise, the systems' output dropped quickly below 80 Hz. At 40 Hz and below, the output was unusable. However, when the Wharfedales were mounted in the bookshelves at the end of the room, the low end held up well to below 50 Hz, although this was coupled with unacceptable upper-frequency tonal changes. The addition of the 2130 bass module corrected most of these bass deficiencies, except for the output at 32 Hz and below. The additional bass module did cause some unwanted emphasis in the region from 80 to 125 Hz, which presumably would be corrected by fully using the 2130's internal crossover.

On the jazz-fusion CD *The Pugh–Taylor Project* (dmp CD-448), the Diamond IVs could be played quite loudly, with only slight harshness. The very dissonant sound of the dual trombone pairing of Pugh and Taylor on track 2 was maintained up to quite loud levels, with minimal changes in tonal character.

I am quite pleased with the overall performance of the Diamond IVs. Their quality and musical honesty befit systems of much greater cost. At $300 a pair, they are a genuine value and can compete sonically with systems way above their price bracket. Their small size and price may just fit your audio budget. As small monitors, however, their bass performance is lacking compared to that of larger systems. Coupled with a high-performance subwoofer and associated electronics, they could form an accurate, relatively inexpensive, near high-end system. *D. B. Keele, Jr.*