EQUIPMENT **PROFILE**

CELESTION 300 LOUDSPEAKER

Celestion, founded in the early 1920s, fills roughly the same niche in England that JBL does in the United States. Although not as large, Celestion has been around for a long time, has an excellent reputation, and has extensive home and professional loudspeaker lines.

The Model 300 extends Celestion's efforts in the no-compromise mini-monitor market that started over a decade ago with the well-received SL6. The floor-standing 300 and the smaller, stand-mounted 100 are cost-effective systems with high-end performance that take advantage of Celestion's experience in designing and manufacturing small high-performance loudspeakers. The 100 is a closed-box design, while the 300 uses a transmission line in a tall, slim cabinet to provide extended bass response.

Both speakers, however, share the same drivers, front plates, and crossovers. The drivers are flush-mounted within the cabinet by the use of zinc die-cast plates that hold the drivers in place and provide a good-looking, low-diffraction front surface. The high-frequency driver is an evolution of Celestion's 1¼-inch, one-piece, aluminum-dome tweeter, developed through laser interferometry research. Its voice-coil is wound directly on the dome to maintain mechanical integrity and improve thermal power handling. The bass driver is a long-throw unit with a 6½-inch Cobex plastic cone and a dual half-roll cone surround, in a die-cast frame. The design is said to maximize bass precision while minimizing cone surface waves and reflections that detrimentally affect midrange detail.

The crossover, a third-order Butterworth design, has relatively simple topology and uses a minimum of components: Two resistors, three capacitors, and two inductors. All parts are high quality, including polypropylene capacitors, air-core inductors, and inductors with cores of compressed powdered iron. Bi-wiring is supported through the use of dual gold-plated

SPECS

System Type: Two-way, floor-standing, transmission-line system.
Drivers: 6½-in. cone woofer and 1¼-in. aluminum-dome tweeter.
Low-Frequency Performance: –3 dB at 48 Hz and –6 dB at 26 Hz (free-space conditions).
Sensitivity: 84 dB SPL at 1 watt/1 meter.
Crossover Frequencies and Filter Slopes: 2.2 kHz, third-order Butterworth.
Impedance: 8 ohms.
Recommended Amplifier Power: 25 to 120 watts per channel.
Dimensions: 38 3/16 in. H × 8¼ in. W × 12 13/16 in. D (97 cm × 21 cm × 32.5 cm).
Weight: 43.4 lbs. (19.7 kg) each.
Price: $1,799 per pair; available in black oak, walnut, and mahogany wood veneers.
Company Address: 89 Doug Brown Way, Holliston, Mass. 01746.
For literature, circle No. 91

five-way binding posts at the top rear of the system. All driver connections are soldered.

The transmission-line bass configuration of the 300 utilizes the results of original research at Celestion by research engineer Martin Roberts. While designers of closed-box and vented systems have long been able to make heavy use of computers, transmission-line systems up to now have been mostly designed by cut-and-try methods. Transmission-line systems are more complicated to design because of their inherent distributed-parameter nature. (Sealed and vented systems can be treated as much simpler, lumped-parameter acoustic systems.) Also, there is very little research literature to guide the designer. To optimize the design, Roberts used some of the latest computer simulation techniques to coordinate the many variables of transmission-line loading.

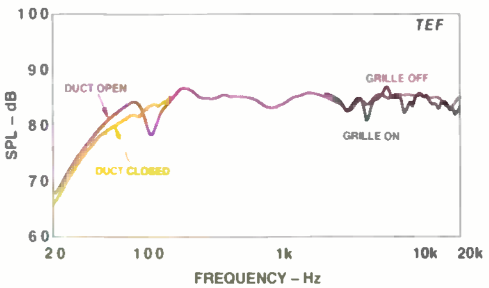

Fig. 1—One-meter, on-axis frequency response.

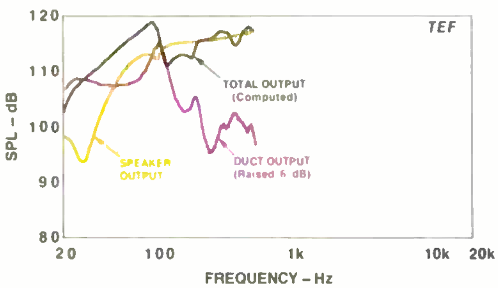

Fig. 2—Near-field response; see text.

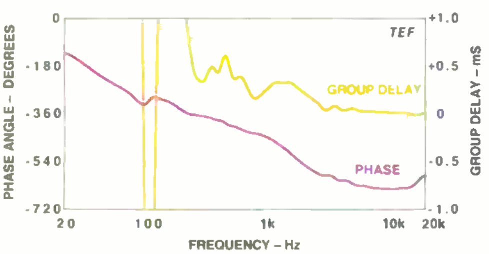

Fig. 3—On-axis phase response and group delay.

Transmission-line systems come in two basic flavors: Absorptive closed end and resonant open end. The open-end version has been more common, because the acoustic output of the line can be used to enhance the output of the main speaker. The open-end transmission line depends on organ-pipe-like resonances to load and enhance the system's output. Unfortunately, the line's output does not only beneficially load and add to the output of speaker, but can also detrimentally subtract as well! The trick is to utilize the line's beneficial output at the first quarter-wave resonance, but not to utilize the line's output at all of the detrimental higher order resonances, which occur at odd integer multiples of the quarter-wave resonance. These higher order resonances can cause severe peaks and dips in the response if left to radiate unhindered from the open end of the line.

One conventional way of suppressing the higher order line resonances is to use a large amount of absorption to fill the line. Unfortunately, the added damping reduces the line's beneficial output at the fundamental resonance in addition to reducing the detrimental higher order resonant modes.

Another method, discovered and investigated by Roberts, is to use an acoustic low-pass filter between the speaker and the line to roll off the drive to the line at higher frequencies. An acoustic low-pass filter can take the form of an expansion chamber or a restriction in an acoustic transmission line. The expansion-chamber approach was chosen for the 300. The driver's rear radiates into a chamber that connects to the input of the line, whose open end radiates to the outside. This is not the whole story of the 300's transmission-line system, however; much additional effort, simulation, and experimentation went into selecting many other variables in the design. These variables include just how much and what kind of damping to include and where it should be placed, the configuration and folding of the line, driver characteristics, etc.

Measurements

The on-axis frequency response of the Model 300 is shown in Fig. 1. Also shown are the effect of the grille on high-frequency response and the effect on low-frequency response of blocking the transmission line's duct. Measurements were taken at a distance of 1 meter on the tweeter's axis, with 2.83 V rms applied. The response below 800 Hz was derived from 2-meter ground-plane measurements, using an input of 2.83 V rms (rather than 5.66 V rms) to compensate for the ground plane's 6-dB boost.

Aside from a dip at 100 Hz, the response is fairly smooth and flat and fits a compact window of ± 2 dB from 60 Hz to 20 kHz, referenced to 1 kHz. Above 2 kHz, the grille causes moderate interference in the response, as shown by slight dips at about 4, 8, and 14 kHz.

The major feature of the response below 200 Hz is a 7-dB dip at 100 Hz, one-half octave wide. This is caused by the transmission line, as can be seen by the dip's disappearance from the response curve I made after closing off the line's exit duct. When the exit is blocked, the 300's low-frequency output, in the range from 20 to 80 Hz, is reduced by about 2 to 3 dB. The transmission line thus increases system output over a broad range below 90 Hz but decreases the output between 90 and 150 Hz.

THIS TRANSMISSION LINE WAS OPTIMIZED WITH A COMPUTER, NOT JUST BY CUT-AND-TRY METHODS.

According to Roberts, the 100-Hz dip is caused by the line's second major resonance, which occurs at the frequency where a line is three-quarters of a wavelength long. At this frequency, the line's output is 180° out of phase with the driver's output. Apparently, his scheme of adding an acoustic low-pass filter to the line to minimize the effects of higher frequency line resonances is not as effective as it could be at the second, 100-Hz, resonance. At higher frequencies, however, the low pass is quite effective, as there are no discernible ripples in the response.

To further investigate the contribution of the transmission line to the system's output, I ran individual 1-V rms near-field curves of the woofer's and transmission line's outputs. This was done by placing the measurement mike close to the speaker's cone and to the exit of the transmission line, to measure their individual contributions. These curves are shown in Fig. 2 along with a computed total output, calculated by doing a vector summation of the individual outputs.

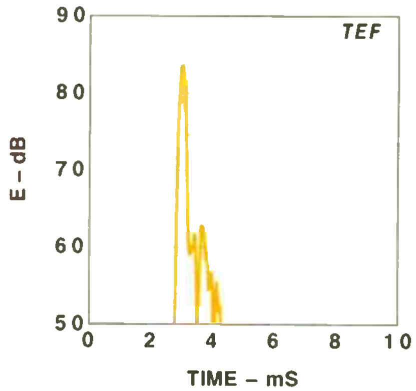

Fig. 4—Energy/time response.

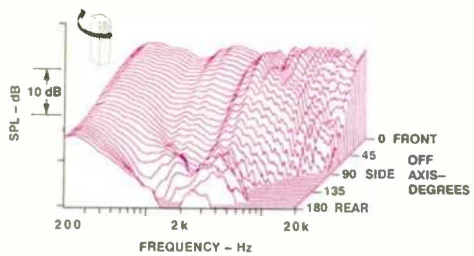

Fig. 5—Horizontal off-axis frequency responses.

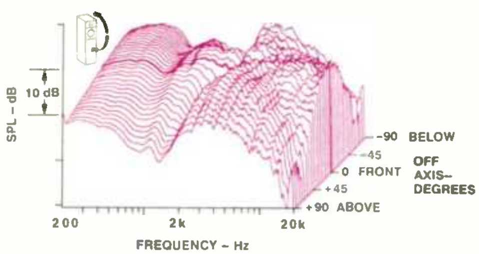

Fig. 6—Vertical off-axis frequency responses.

Between 20 and 50 Hz, the transmission line provides most of the system's output. The line's loading reaches a maximum at 29 Hz, where the driver's output is at its minimum and the line's output almost at its maximum. It is at this frequency, for which the transmission line is a quarter of a wavelength long, that the line provides most of its beneficial effects. Above 90 Hz, the line's output goes rapidly out of phase with the cone's output, thus causing a dip in the total output. The duct output also exhibits secondary resonance peaks above 150 Hz, which show up in the computed total curve. A comparison of the computed total output curve of Fig. 2 with the on-axis curve of Fig. 1 shows that the axial response is even smoother than the predicted total output. This is presumably due to the fact that the duct is at the bottom rear of the cabinet, and thus its higher frequency output is attenuated.

Above 20 kHz (data not shown), the response had a high-Q, 14-dB peak at 25.3 kHz, presumably due to the breakup resonance of the aluminum-dome tweeter. Averaging the response over the range from 250 Hz to 4 kHz yielded a sensitivity of 84.8 dB, slightly higher than the Celestion's 84-dB rating. The right and left systems matched within a close ±0.5 dB, and should provide stable lateral imaging.

Figure 3 shows the phase and group-delay responses of the 300, referenced to the tweeter's arrival time. Between 1 and 10 kHz, the phase curve rotates 180°, a relatively small amount. The group-delay excursions just above and below 100 Hz coincide with the dip in the axial response and the change in phase slope, indicating a possible minimum-phase aberration. If the response were equalized flat in this region, the phase and group-delay responses would also be much smoother.

Figure 4 shows the energy/time response measured at 1 meter on axis for a 2.83-V rms signal. The test parameters were chosen to emphasize response in the region from 1 to 10 kHz, which includes the crossover. Except for some delayed responses about 20 dB down from the peak, the time response is quite compact and sharp.

Figure 5 shows the 300's horizontal off-axis responses. The curve at the rear of the graph is the on-axis response. In the primary lateral listening window, ±15° of the axis, the coverage is extremely uniform.

IN AN OPEN-END TRANSMISSION LINE, THE TRICK IS TO USE THE GOOD RESONANCES YET SUPPRESS THE BAD ONES.

Even out to 45° off axis, not much high-frequency roll-off is evident. It's not clearly seen in the curves, but in the range from 2.5 to 4 kHz the off-axis response is actually about 1 to 2 dB higher than the on-axis response. This broadening of polar response may be due to diffraction effects related to the cabinet's width.

Figure 6 shows the vertical off-axis curves. The Celestion 300 was measured at 1 meter from the tweeter, with the tweeter the center of rotation. The bold curve in the center of the graph (front to rear) is the on-axis response. In the crossover region from 1.5 to 3 kHz, the curves from +15° to –15° show that the response is significantly flatter for downward angles than upward angles. As the listening angle is raised from 0°, a progressively sharper dip appears at about 2.2 kHz (not visible), reaching about 17 dB at +15°. These vertical-coverage asymmetries indicate substantial lobing as a result of phase differences between the tweeter and woofer through the crossover range.

The 300's impedance, plotted over the wider range of 10 Hz to 20 kHz, is shown in Fig. 7. A minimum impedance of 6.3 ohms occurs at 160 Hz and a maximum of 46 ohms at 56 Hz. The low-frequency impedance curve, which has two peaks straddling a dip, looks exactly like that of a typical vented-box system, with the box tuning occuring at the 29-Hz impedance dip. A secondary, much smaller peak and dip is observed at about 100 Hz, which coincides with the second line resonance. Even though the curve has a high max/min variation of about 7.3 to 1 (46 divided by 6.3), the 300 will not be very sensitive to cable resistance because the minimum impedance is on the high side. Cable series resistance should be limited to a maximum of about 0.085 ohm to keep cable-drop effects from causing response peaks and dips greater than 0.1 dB. For a typical run of about 10 feet, 16-gauge or heavier wire should be used.

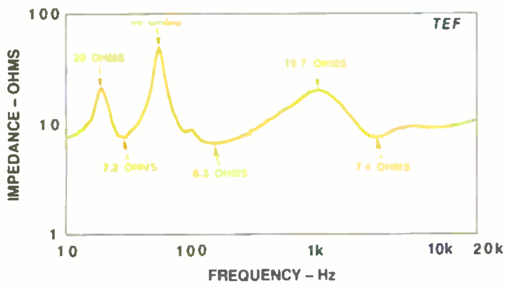

Fig. 7—Impedance.

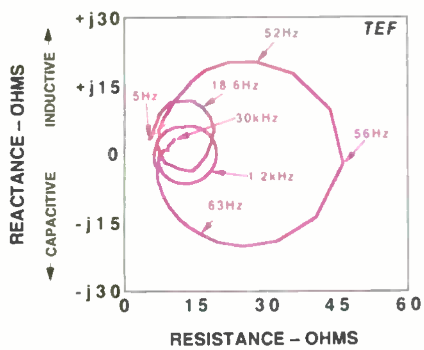

Fig. 8—Complex impedance.

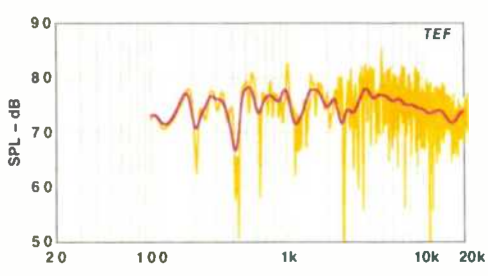

Fig. 9—Three-meter room response.

In Fig. 8, the Model 300's complex impedance is plotted over the range from 5 Hz to 30 kHz on 60-ohm impedance scales. The large circle in the plot is the 56-Hz impedance peak (the flattened sides of the circle are due to my measuring gear). The impedance phase (not shown) reached a maximum angle of +49° (inductive) at 16.9 Hz and a minimum angle of –51° (capacitive) at 67 Hz. The moderate phase values and relatively high impedance of the 300 make it an easy load for any amplifier.

No significant cabinet resonances were evident when the Celestion speaker was subjected to a high-level, low-frequency sine-wave sweep. However, there was some minor activity of the top and sides from 420 to 430 Hz. The cabinet of the 300 is quite solidly constructed and is well braced due to the internal construction of the transmission line. A sharp minimum of woofer excursion occurred at 29 Hz, the primary quarter-wave resonance of the transmission line. Peak excursion occurred between 45 and 50 Hz, where levels above about 8 V rms (8 watts) caused audible distortion. The 300's excursion versus frequency characteristic appeared the same as that of a well-operating vented-box system.

The peak linear excursion of the 6½-inch woofer was about 0.4 inch, peak to peak, with further higher distortion travel to about 0.6 inch, peak to peak. No bad sounds were generated when the woofer was overloaded, and no dynamic offset effects were exhibited. The effective diameter of the woofer is 5¼ inches, measured from the center of the surround on one side to the center of the surround on the other.

The 3-meter room curve of the 300, with both raw and sixth-octave smoothed responses, is shown in Fig. 9. The Celestion was in the right-hand stereo position, aimed at the listening location, and the test microphone was at ear height (36 inches), at the listener's position on the sofa. The system was driven with a swept sine-wave signal of 2.83 V rms (corresponding to 1 watt into the rated 8-ohm load). The direct sound plus 13 mS of the room's reverberation are included. Excluding a room-effect dip at 410 Hz, the averaged curve fits a relatively tight 7-dB (±3.5 dB) window from 100 Hz to 20 kHz. The only marked feature of the curve is a gradual roll-off of high-frequency response above 5 kHz of about 2.5 dB/octave. This roll-off is presumably caused by the 300's increased directivity at higher frequencies due to the relatively large, 1¼-inch dome tweeter.

The single-frequency harmonic distortion spectra for the musical notes of E_1 (41.2 Hz), A_2 (110 Hz), and A_4 (440 Hz) are shown in Figs. 10 to 12. The power levels were computed using the rated system impedance of 8 ohms. A maximum power of 50 watts (20 V rms) was set as the upper limit, due to the high distortion at the E_1 tone.

Figure 10 shows the E_1 (41.2-Hz) harmonic distortion. Even though the power was limited to 50 watts, the distortion at maximum power level rose to a high 46% third harmonic, with generous amounts of higher order harmonics. The second harmonic rose to an intermediate peak of about 15% at 6 watts, fell, and then attained 15.5% at 50 watts. Unfortunately, the E_1 tone falls approximately at the Model 300's maximum excursion point within its low-frequency passband. The

YOU DON'T USUALLY HEAR THIS MUCH USABLE 32-Hz BASS FROM A 6½-INCH WOOFER!

harmonic distortion at the much lower frequency of 29 Hz, where the transmission-line loading is maximum, is actually significantly lower than at 41.2 Hz. At 41.2 Hz with an input of 50 watts, the Celestion generates a not very loud 96 dB SPL at 1 meter, in free space.

Figure 11 shows the A_2 (110-Hz) harmonic data. The second harmonic reached the low value of only 2.4% at 50 watts, with negligible amounts of higher order harmonics. However, at 110 Hz with an input of 50 watts, the 300 generates only 96 dB SPL at 1 meter. The maximum level is low because the A_2 tone coincides with the dip in the 300's response curve caused by the out-of-phase condition of the transmission line's output.

Figure 12 shows the low-value A_4 (440-Hz) harmonic data. The second harmonic reached only 1.9% at 50 watts, and the third harmonic was only 1.6%. The higher harmonics were below the threshold of my measuring gear. At 440 Hz with a 50-watt input, this speaker generates a usable 102 dB SPL at 1 meter.

Figure 13 displays the IM created by tones of 440 Hz (A_4) and 41.2 Hz (E_1) of equal input power. The IM distortion rises

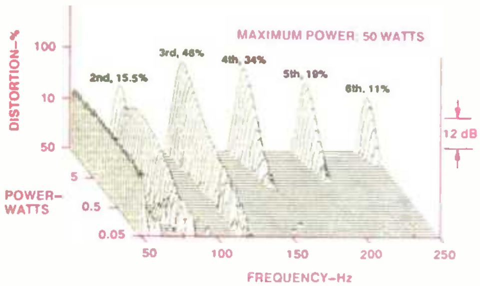

Fig. 10—Harmonic distortion for E_1 (41.2 Hz).

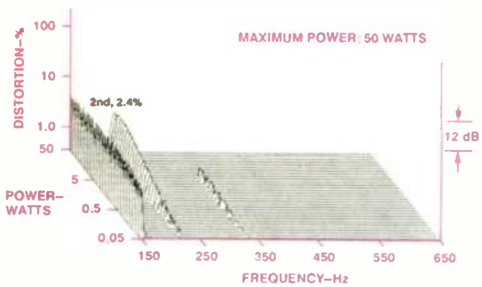

Fig. 11—Harmonic distortion for A_2 (110 Hz).

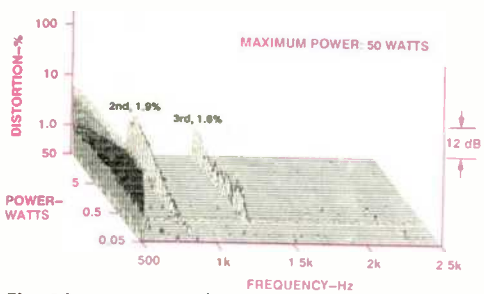

Fig. 12—Harmonic distortion for A_4 (440 Hz).

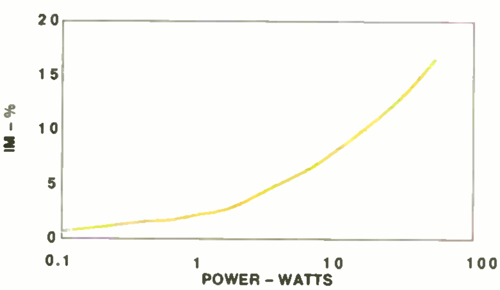

Fig. 13—IM for A_4 (440 Hz) and E_1 (41.2 Hz).

to a fairly high 16% at full power. The Celestion's 6½-inch woofer handles both frequencies of this IM test.

Figure 14 shows the short-term peak-power input and output capabilities of the 300 when the speaker was reproducing 6.5-cycle third-octave tone bursts. The peak input power was calculated by assuming the rated 8-ohm impedance.

The peak input power starts at 10 watts at 20 Hz, rises to 100 watts at 32 Hz, falls to 30 watts at 50 Hz, and then rises smoothly to 4 kW above 1 kHz. The peak acoustic output rises rapidly to a small peak at 32 Hz, fluctuates, and then attains levels in the 120-dB range above 300 Hz. Also shown is the "room gain" of a typical listening room at low frequencies, which adds about 3 dB to the response at 80 Hz and 9 dB at 20 Hz. With room gain, the Celestion can generate 110 dB SPL only above 120 Hz, and 120 dB above 350 Hz. However, the 300 can generate usable levels of 100 dB and higher at frequencies above 30 Hz. With two systems playing bass signals common to both channels, levels may be in the quite usable range of 105 to 106 dB.

Use and Listening Tests

Although the 300s are supplied with two sets of quite robust double-banana binding posts, for conventional and bi-wiring connections, they aren't arranged the way you might expect. Instead of pairing positive and negative terminals for easy use of a standard double-banana plug, Celestion has paired the two negative terminals close together and paired the two positive terminals some distance away. As a result, either bare wire ends or individual banana plugs must be used. The generously sized holes in the posts accept quite large cables. The terminal pairs are normally connected by short, golden wires which must be removed for bi-wiring. I left these supplied jumpers in place for all my listening tests.

The speakers are supplied with carpet-piercing spikes but can be used without them on bare wood floors. My review samples were finished in a quite attractive-looking mahogany; black oak and walnut are also available. The systems are designed to be used both with and without the grille and look very good either way. In fact, when I first received these speakers, I thought they were designed without grilles; there was no obvious way to attach the grilles, and the systems looked quite good without them. Grilles are supplied, of course (I found them when I went back and looked through the packing material!). They attach with four flat projections on the rear, which mate with corresponding rubber-filled slots on the four corners of the driver mounting plate.

The 300 comes with a well-written six-page manual (actually a 25-page manual, if you count its English, French, German, Italian, and Spanish translations!). It covers the usual topics of conventional and bi-wire connections, room positioning, and power handling. Celestion recommends placing the speakers about 8 to 10 feet apart and 18 to 24 inches from the back wall, with a 30° toe-in aimed at the listener. I did most of my listening in my usual review position, which is much farther out in the room. I did experiment by placing the 300s

THE CELESTION IS A SOLID COMBINATION OF LOOKS, BASS EXTENSION, AND WIDE-RANGE ACCURACY.

closer to the rear wall but experienced a moderate loss in imaging along with the expected increase of bass.

My equipment lineup includes some new amplification: Krell's new remote-controlled KRC preamplifier and the Krell KSA-250 power amplifier (which develops 250 watts per channel into 8 ohms, 500 watts into 4 ohms, 1 kW into 2 ohms, and 2 kW into 1 ohm!). I enjoy the preamp's remote-control capability, which extends even to the tape monitor, and its real volume-control knob for making those infrequent manual adjustments. Other equipment remains the same: Onkyo and

Rotel CD players, B & W 801 Matrix Series 2 speakers, and Straight Wire cabling.

First perceptions of the Celestion 300s were that they had a bright, open, and airy sound with sufficient but not thunderous bass. Imaging and clarity were first-class. Low/high spectral balance was quite satisfying, without any of the usual "small speaker" sound character.

Occasionally, however, it was easy to overload the Celestions on material having high-level bass. This included tracks 7 and 13 of Mickey Hart's *Planet Drum* (Rykodisc RCD 10206), an excellent demo CD with lots of rhythm and percussion. The 300s also exhibited good dynamics and impact on this disc. I did notice some major midrange spectral differences between the 300s and my reference systems when reproducing the tom-tom on track 4; the tom-tom was more prominent on the B & Ws.

I noticed some definite tonal differences on pink noise compared to my references. The 300s' evenness of vertical coverage on pink noise was only average on the stand-up/sit-down test; they exhibited moderate upper midrange spectral changes between the two listening positions.

On the low-frequency, third-octave pink-noise test, the 300s did quite well on the 25-, 32, and 63-Hz and higher bands but had a tendency to overload and distort on the 20-, 40-, and 50-Hz bands at high input levels. You must realize, however, that the band-limited third-octave test material is *very demanding* and not like typical program material, whose higher frequency spectral information can mask lower frequency distortion. On wide-range program material having low bass, the 300s made a good account of themselves because of their usable response to below 30 Hz and their relatively graceful overload characteristics. Even when the 300s were moderately overloaded, on wide-range program material the audible effect was not too obvious or objectionable.

On other, less bass-demanding, acoustic instrument sounds—such as the flute, guitar, dulcimer, and fiddle played by the Helicon group on *Horizons: Traditional Music from Around the World* (Dorian Discovery DIS-80103)—the 300s did an excellent job of reproducing the fine nuances of the material, providing great realism and a detailed and open soundstage. (This recording is particularly impressive, not only because of the fine performance, music, and recording techniques but because, when played back in a typical room with average reverberation on a top-grade system, the relatively dry recorded instrument parts sound *very realistic*, with a you-are-there sound quality.)

The 300s also did very well reproducing such other material as symphonic, piano, and chamber music, where their well-balanced and wide-range neutral response was quite welcome. Only on rock music and pipe organ material with heavy bass, played at high levels, did their low sensitivity and relatively limited bass output act as a major obstacle. Even on this demanding material, at moderate levels the 300s did justice to the music. The bass output of the 300 is low only when compared to loudspeakers having 10- or 12-inch woofers. Compared to systems with a single 6- or even 8-inch woofer, the 300's bass output is quite impressive. After all, you don't often hear much usable 32-Hz bass from a speaker with a 6½-inch woofer!

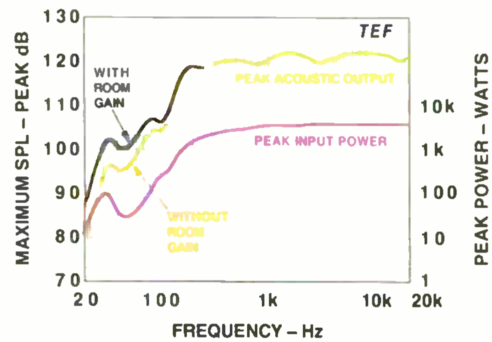

Fig. 14—Maximum peak input power and sound output.

Only when you compare the 300s to larger systems with bigger woofers, at similar prices, do they come up short. For small systems, the 300s have a solid combination of excellent appearance, high technology, extended bass, and wide-ranging accurate response. They would be a welcome addition to any home setup. *D. B. Keele, Jr.*