approximately 16 Hz, which is the lower audible limit of human hearing, this frequency was selected as the design target of the LFR. Many experiments and considerable research determined the optimum relationship among cabinet volume, the orifice area, and the weight and rigidity of the closed-cell foam-plastic panels. The flexible airtight sealing strips were made as compliant as practical with available foam-rubber compounds of the necessary strength and durability. The wood rib-inserts in the panels are not for appearance alone; they prevent unwanted flexing of the panels. The particular hardwood used for inserts was selected for the best stiffness-to-weight ratio.

The compliance of the enclosed air can be modified in loudspeaker enclosures by the addition of sound-absorbent linings or fill. Absorbents also effect considerable attenuation of higher-frequency energy available to the orifice or port. Ten 3-inch cross-alternated layers of fiberglass fill are necessary for the LFR to achieve the desired characteristics.

Drivers and Crossovers

Good response curves were obtained with each of several 15-inch drivers, and tolerable results with one of the 12-inch units from the previous experiment installed in this enclosure. A high-efficiency unit with a lightweight and very rigid cone, with a long-throw voice coil and with a very low free-air resonance frequency is recommended. Drivers with added mass in their moving systems are unnecessary.

There seems to be less tendency for voice-coil rubbing with the vertical voice-coil motion utilized here, so clearance between voice coil and pole pieces could be safely reduced somewhat for increased efficiency. The free-air resonance of the driver designed for this enclosure should be made very low by making the suspension more compliant, rather than by mass added to the cone or voice-coil former. This lighter, more compliant moving system would not only further increase efficiency, but would increase the electrical damping available to the driver used with the system.

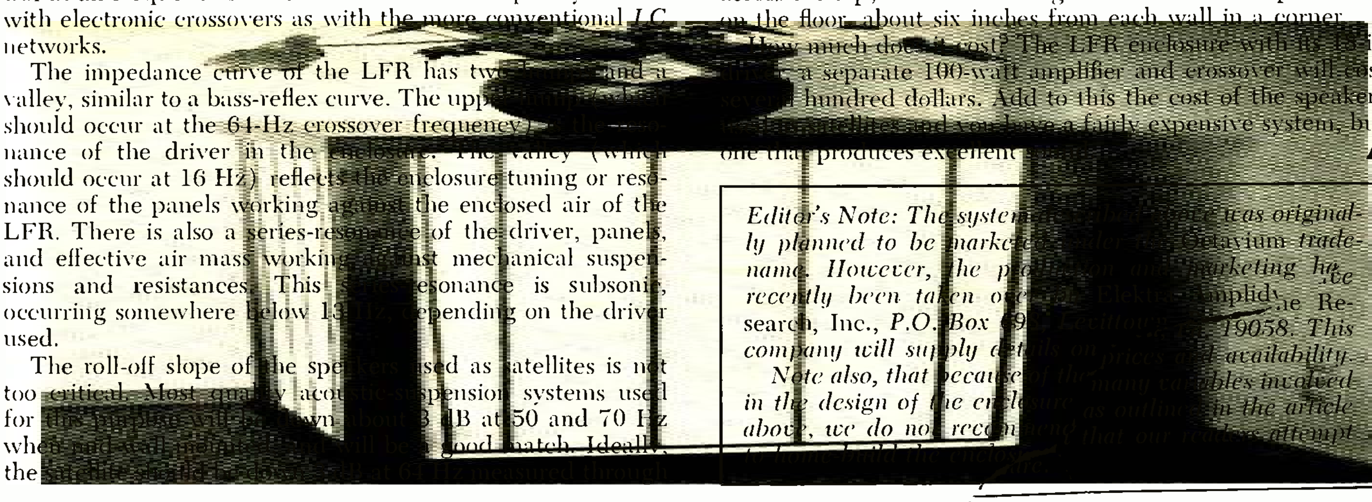
We were successful in locating a manufacturer to produce a 100-watt continuous-power-rated 18-inch driver that met the above criteria. This unit has a free-air resonance of 15 Hz, a 3-inch voice-coil diameter, and 5¼ lb ceramic ring magnet with total flux of 285,000 maxwells.

An 18-dB/octave crossover slope is the minimum that should be used with the LFR. A 64-Hz crossover frequency is used and all frequencies below this value from both stereo channels are combined and applied to a single LFR unit. Higher frequencies are fed separately to two spaced satellite speaker systems.

Although *LC* crossover networks can be used, the more sophisticated approach is to use electronic crossovers ahead of multiple driving amplifiers. With this approach, the high damping factor of the modern solid-state amplifier can be utilized to best advantage to keep the driver cone under control at all frequencies. The same crossover frequency is used with electronic crossovers as with the more conventional *LC* networks.

The impedance curve of the LFR has two humps and a valley, similar to a bass-reflex curve. The upper hump (which should occur at the 64-Hz crossover frequency) is the resonance of the driver in the enclosure. The valley (which should occur at 16 Hz) reflects the enclosure tuning or resonance of the panels working against the enclosed air of the LFR. There is also a series-resonance of the driver, panels, and effective air mass working against mechanical suspensions and resistances. This series resonance is subsonic, occurring somewhere below 13 Hz, depending on the driver used.

The roll-off slope of the speakers used as satellites is not too critical. Most quality acoustic-suspension systems used for this purpose will be down about 3 dB at 50 and 70 Hz when mid-wall mounted and will be a good match. Ideally, the satellite should be down 3 dB at 64 Hz measured through the crossover network. A few decibels one way or the other is inaudible.



Low-frequency reproducer shown in proper corner placement.

We have tried several pairs of good-quality two-way and three-way speaker systems of the sealed-enclosure type, on the floor, on shelves, and hanging from the walls of our living room. We have also tried two full-range electrostatic types coupled to our low-frequency reproducer. Together with the LFR, any two of these units can reproduce sound in our living room more like the original in frequency response, intensity, and dynamic range—and with less noticeable distortion or coloration from speaker or amplifier.

How does this enclosed unit compare with the standard? They are almost identical in sound, although the LFR required approximately four times the low-frequency power for the same output. Ten watts was adequate for the standard woofer. The LFR enclosure with 15-inch driver and two satellites needs 50 watts per channel, or 100 watts total input—and this power should be available at the lowest frequency. The 18-inch unit needs 100 watts for the LFR alone.

What is its size? The prototype enclosure is 20¾" × 20¾" across the top; it stands 37" high over-all. Its ideal position is on the floor, about six inches from each wall in a corner.

How much does it cost? The LFR enclosure with its 15-in driver, a separate 100-watt amplifier and crossover will cost several hundred dollars. Add to this the cost of the speakers used as satellites and you have a fairly expensive system, but one that produces excellent sound. ▲

Editor's Note: The system described above was originally planned to be marketed under the Octavium tradename. However, the production and marketing have recently been taken over by Elektra-Amplidyne Research, Inc., P.O. Box [illegible], Levittown, [illegible] 19058. This company will supply details on prices and availability.

Note also, that because of the many variables involved in the design of the enclosure as outlined in the article above, we do not recommend that our readers attempt to home-build the enclosure.