THE PA BIBLE

ADDITION NUMBER THIRTEEN
THE ELECTRIC GUITAR LOUDSPEAKER, A UNIQUE DESIGN

In this addition of the PA Bible, we will discuss the development of loudspeakers for electric guitars to illustrate the special character of these unique speakers.

Electric guitar amplifier designs of the early 60's depended upon hi-fi and general purpose loudspeakers that were then available. These loudspeakers were found to be deficient in two characteristics: they failed when driven with high power, and the tonal characteristics did not enhance the guitar sound.

Engineering efforts to overcome these weaknesses, including extensive power testing and new materials searches, have resulted in unique designs, with special tonal characteristics and power handling capabilities unheard of prior to their development.

The Guitar Sound Approach

A significant part of the design specialization has been the recognition that electric guitar speakers are part of the instrument; that these speakers must be developed expressly for the electric guitarist; and that these speakers are designed with the guitar note in mind, not for playing records.

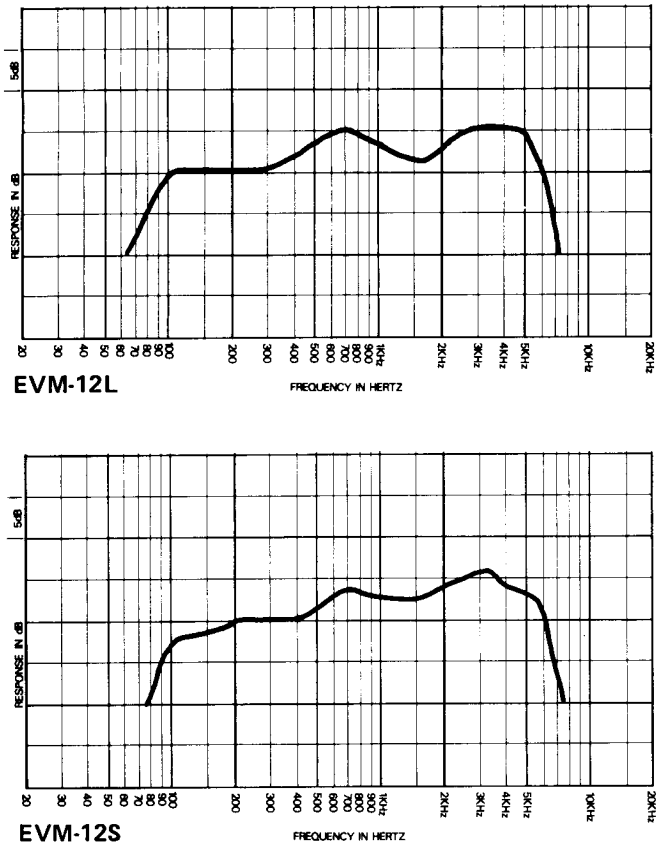

FIGURE 1 - Frequency Response

Individual preference is very much a part of this process, as it is with musical instruments.

The Electro-Voice EVM-12L and EVM®-12S have found wide acceptance as quality electric guitar speakers and their characteristics will be referenced to illustrate the special character of the guitar speaker design.

The Special Tone Quality

The **special tonal characteristics of electric guitar loudspeakers result** from **the selection of cone materials and shape, voice coil materials and size,** cone suspension details, magnetic gap geometry and venting.

Because electric guitars are normally played at very high sound levels, their characteristic sound can only be fully described by listening to the instrument. Lower level frequency response measurements, however, are indicative of the overall character, and are useful in controlling the consistency of manufacture.

The tonal characteristics of the Electro-Voice EVM-12L and EVM-12S are thus indicated in the response curves shown in Figure 1, with the curves showing a 2000 Hz to 4000 Hz frequency rise which **adds a brilliance or presence** to the sound, with the EVM-12S having a brighter sound as indicated by the greater output in 1000 Hz to 3000 Hz.

To achieve this special response, the guitar loudspeaker designer must carefully select the size, shape and composition of the materials used in the cone, coil, dome and gap structure of the loudspeaker.

Cone

The selection of a single-piece felted paper curved-sided cone constructed of a proprietary pulp mixture, when driven by the correct coil size, results in the sound of the EVM-12L and EVM-12S, the sound preferred by most electric guitarists. By contrast, an inexpensive seamed, straight-sided cone tends towards the uneven tonal characteristic illustrated in Figure 2.

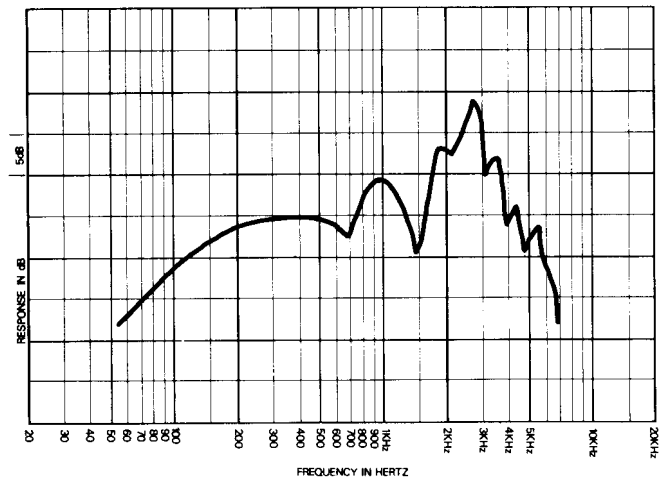

FIGURE 2
Inexpensive Small Coil 12 in. Guitar Speaker with Flat, Folded Paper Cone

Coil

The selection of a 2.5 inch diameter coil for the EVM-12L and EVM-12S is supported by the tendency of smaller diameter coils to dip in the region of 1500 Hz, as illustrated in Figure 3; and, conversely, by the lack of a high-frequency rise when larger coils are used (see Figure 4).

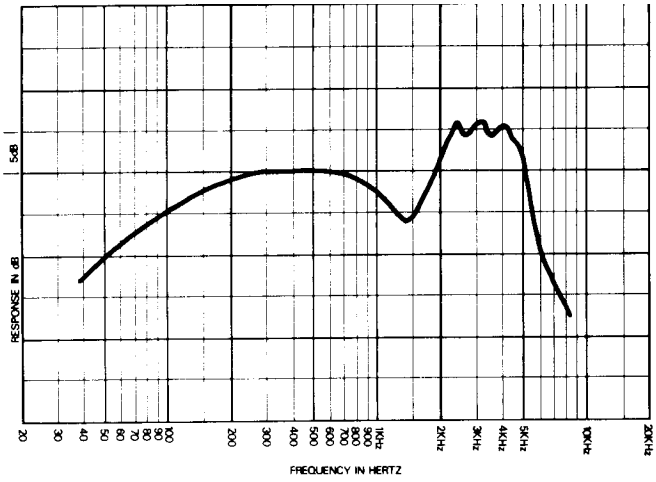

FIGURE 3 - Small Coil (1.75 in.) 12 in. Guitar Speaker

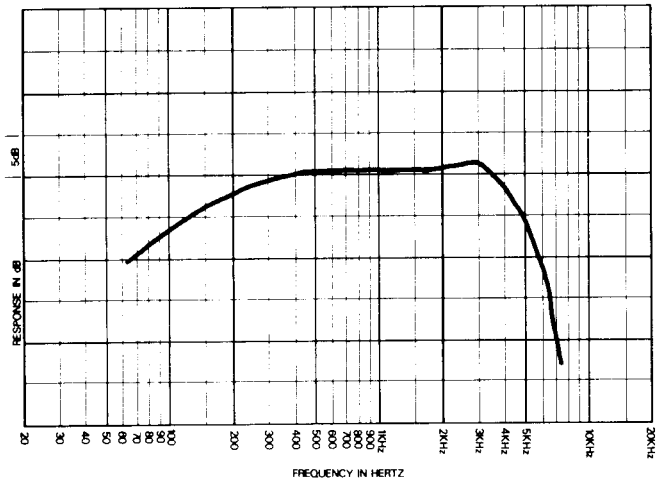

FIGURE 4 - Large Coil (4 in.) 12 in. Guitar Speaker

Dome

While the smooth, rising frequency response of the EVM-12L and EVM-12S are indicative of their tonal quality, other features add to the character of the sound. For example, a paper dome is used in the EVM's to avoid the harshness caused by the high-frequency breakup of aluminum domes.

Gap Structure

The use of an asymmetrical gap structure, and a coil height equal to the height of the pole piece, (see Figure 5) particularly illustrate the special character of the EVM electric guitar loudspeaker.

Symmetrical magnetic gap structures have been promoted as desirable in a guitar speaker. We have found this to be a fallacy. When driven at very high power, the coil. which is made to fill the gap height to obtain high efficiency, will be driven out of the gap. When so driven,

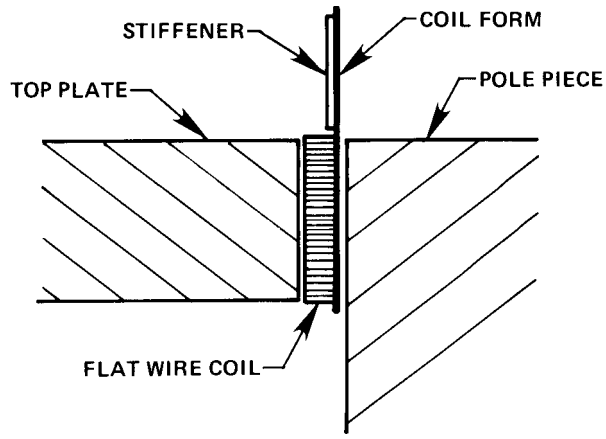

FIGURE 5 - Gap Structure

the coil motion in a symmetrical magnetic gap structure will produce only odd harmonics due to the non-linear magnetic field. A coil moving in an asymmetrical magnetic gap, conversely, will generate a mixture of odd and even harmonics resulting in a more complex, richer sound, with the additional benefit of lower coil temperature resulting from the longer time that the coil spends adjacent to the pole piece.

Thus, the special tonal characteristics of the EVM-12L and EVM-12S are the result of careful choices during the design process, choices specifically tied to the guitar sound.

Power Handling Capacity

Electric guitars are normally played at very high sound pressures, requiring a loudspeaker that is both efficient and capable of handling very high electrical power input. The EV EVM-12L and EVM-12S, for example, are designed to withstand 200 watts long term and 800 watts short term peak power.

To design loudspeakers that can withstand these power levels, two failure mechanisms must be eliminated. These are (1) material failure due to high temperatures, and (2) mechanical failure due to large displacements of the coil.

The heat rise of the voice coil at high power levels is substantial (see Figure 6) and requires special materials and construction to survive and control these temperatures. The wire insulation and coil support should be made from a material capable of withstanding temperatures in excess of 400 degrees fahrenheit. For example, the EVM-12s use a specially treated polyimide material for both the wire insulation and coil support. Special high temperature adhesives must be used on all adhesive joints. In the EVM-12s a special high temperature epoxy is used to secure the coil to the form, and this assembly then to the cone. The coil should be spaced very close to the pole piece and top plate to optimize the heat transfer from the coil assembly. The EVM-12's coil structure is spaced within thousands of an inch of the pole piece and top plate; and, further, the EVM structure uses a straight pole piece which tests show lowers the coil temperature 17 degrees F for 200 watts input. In addition, the aluminum frame used in the EVM-12s provides heat conduction away from the magnetic structure that is superior to stamped steel frames.

To prevent destruction during the high coil excursion, special materials are required to withstand the resultant stresses. The EVM-12s use special high strength rolls and spiders, and a special Kapton° stiffener to strengthen the coil form.

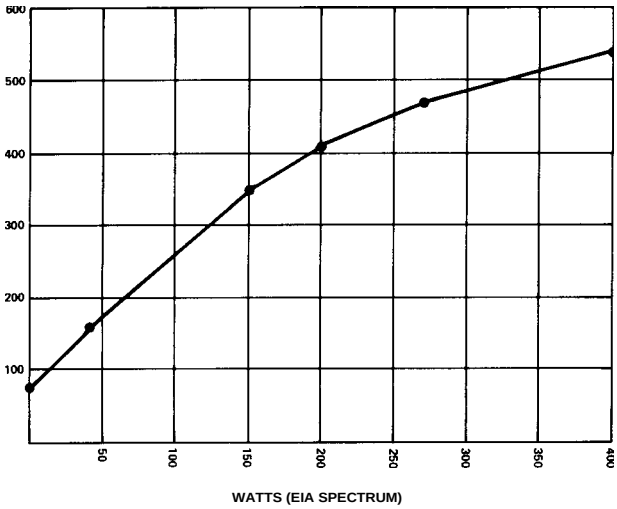

FIGURE 6 - Voice Coil Heat Rise

Power Test

The test used to determine the power handling capacity of an electric guitar loudspeaker is very important, and can mean the difference between long life and catastrophic failure. The test specified in EIA Standard 426A, which includes instantaneous peak powers that are four times the continuous (rated) power, more closely resembles the character of the guitar signal than does a sine wave; and, consequently, is a superior test for guitar speakers. EVM speakers are required to pass the eight hour test specified in EIA Standard 426A.

The reliability provided in these high power designs is enhanced by the use of an aluminum frame. These die cast frames provide a stable, stiff support for the cone and heavy magnetic structure; and, in addition, provide a major heat loss mechanism due to the excellent heat conductivity of aluminum. Aluminum is also light weight, non-magnetic and non-corrosive; and, is further enhanced by a reliable, chemical-resistant baked epoxy finish.

Venting

Unless special precautions are taken, air trapped between spider and top plate, and between the dome and pole piece, is forced through the air gap. Because of the physical restriction in the gap, high velocity turbulent air causes noise and an increase in the system stiffness. To eliminate this problem the EVM speakers use vent holes in the coil support, and, also, use porous spiders to vent the heated air entrapped beneath the spider.

Cabinets

The EVM-12L and EVM-12S will work well in open back, sealed or vented cabinets. We recommend the use of vented enclosures for the optimum size and bass response combination. The bass responses (see Figure 1) were measured with the speakers mounted in a 1.3 cu. ft. vented box, the TL806. Details on the TL806 design and construction may be obtained from Electro-Voice by requesting "TL806 Builder Plans," Form 1544-523.

Conclusion

In conclusion, it is apparent that a special, premium grade loudspeaker is required for the best electric guitar performance, including the details highlighted in Figure 7. This premium design, which includes special materials and special production processes, results in a product that sells at a premium price.

Recently, other alternatives have become available. For example, the EV FORCE loudspeakers, which use cast aluminum frames, and the same cone and magnetic gap design as the EVM speakers, are priced only slightly higher than hi fi or general purpose speakers, but with performance characteristics only slightly lower than the EVM speakers.

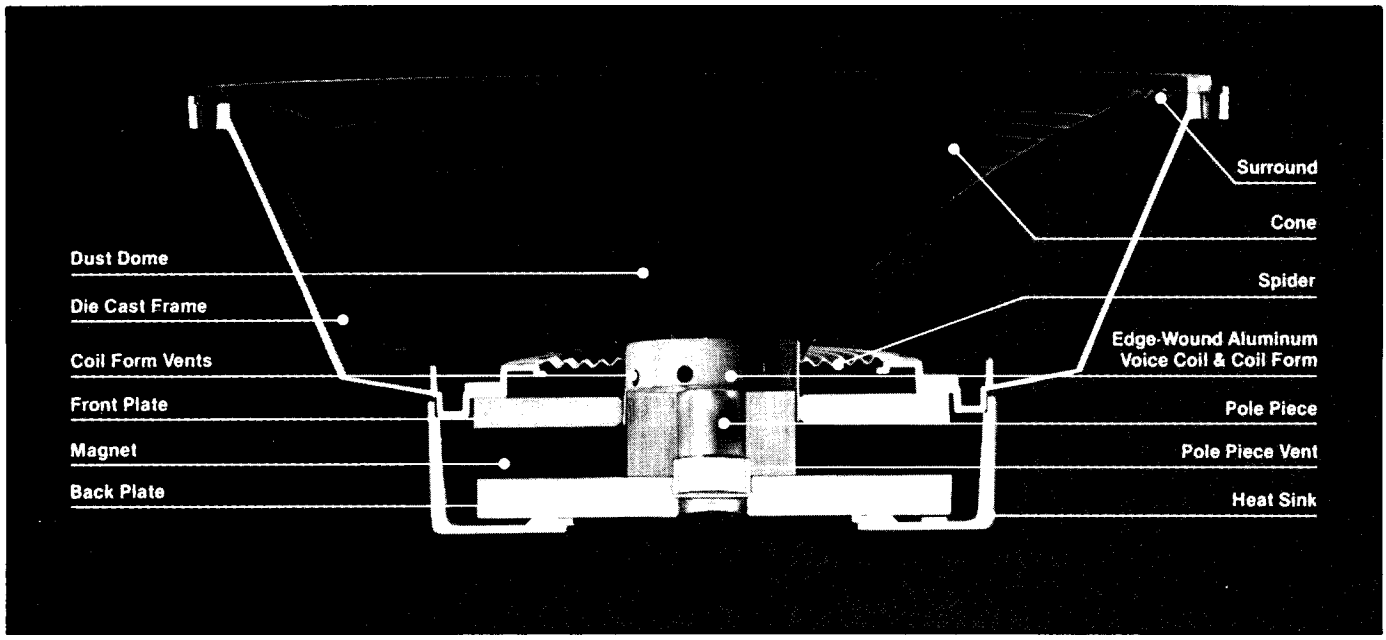

FIGURE 7 - EVM Cutaway