EV THE PA BIBLE

ADDITION NUMBER ONE
DRIVERS AND HORNS

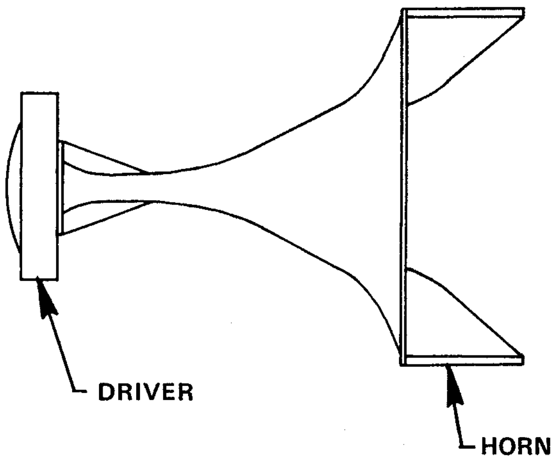

FIGURE 1 – Simple Driver and Horn View

No, this is not about a traffic jam in downtown Buchanan. This is the first supplement to the Electro-Voice "PA Bible." Although it is not absolutely necessary to have read the "Bible" to understand the following material, we believe you will find answers to many of your acoustics application problems in it. In the following material we will deal with the nature of horn drivers, the horns they must be attached to, and, most importantly, how to choose reasonable gear of this type for your sound system.

DRIVER INTRODUCTION

The driver, sometimes called a compression driver, high-frequency driver, or midrange driver, is the device attached to a horn which converts amplifier power into sound. See Figure 1.

The driver can produce sound without a horn, but it will sound bad and not be very loud. The horn "couples" the minute motion of the small diaphragm to the air, producing the characteristic high efficiency of the horn-type speaker. This means that a relatively high proportion of your amp's power is turned into the **acoustic** power your ears hear. Drivers are engineered to work best when connected to a suitable horn of the same connecting hole size.

In the material to follow, drivers will be split into two basic classes. These are "PA" or "midrange" units and "high-performance" units. In general, these two types are defined by the ability to reproduce frequencies above 5000-8000 Hertz. The high-performance units have usable response above this frequency range and represent a class of very sophisticated and difficult-to-design audio devices.

The Diaphragm

The heart of the driver is its "diaphragm," the surface which actually moves back and forth to produce the sound you hear. It is attached to, and moved by, the "voice coil" which is what gets connected to your amp. See Figure 2.

The diaphragm is often made of phenolic impregnated cloth on PA or midrange type drivers or aluminum on high-performance or wide-range type drivers. The phenolic diaphragms are usually more durable. However, they often weigh more than their aluminum counterparts and are not as mechanically rigid. This tends to produce limited high-frequency performance, most appropriate for police sirens, factory paging speakers and other places where the primary goal is intelligible voice communication.

Aluminum diaphragms are often used in high-performance drivers because their light weight enables them to reproduce a more extended frequency range than their phenolic counterparts. Some high-performance driver diaphragms are of "composite" construction with the main central part of the diaphragm made of aluminum and the outer suspension part (which allows movement to occur) made from a more durable material. This permits durability to be optimized while still retaining the desirable properties of the aluminum in the main part of the diaphragm. On a sophisticated high-performance driver the diaphragm and its associated voice coil can have a weight on the order of 1/30 of an ounce and yet it can sustain input powers of the order of 30 watts!

The Phasing Plug

In order to maximize efficiency and effectively permit energy originating at the diaphragm to reach the horn attached to the driver, a device called a "phasing plug" is an integral part of driver design. (See Figure 2 again.) The phasing plug in a PA type driver is a simple device which has a small number of openings or channels that will only allow proper channeling of frequencies up to the 5000-8000 Hz range. In a high-performance driver, the phasing plug becomes more complex in design with many openings which allow high-frequency performance to extend to as high as 20,000 Hertz.

High-Frequency Output Roll-off

It should be noted that even though high-performance class drivers may be very sophisticated in concept and design, they cannot produce a constant output of acoustic power at very high frequencies relative to the lower frequencies. This condition is masked by response curves run with the drivers connected to horns of a type which becomes more directive with increasing frequency. However, a high-frequency roll-off will be evident on response curves obtained on terminated acoustic tubes (a semi-standard way of measuring total driver output versus frequency, without the distorting effects of a horn) or (more important for you, the user) on horns which have the desirable characteristic of uniform directivity as frequency increases.

Under these conditions smooth high-frequency power response roll-offs will begin to take place above the 3000-6000 Hertz range. This condition is natural and is caused

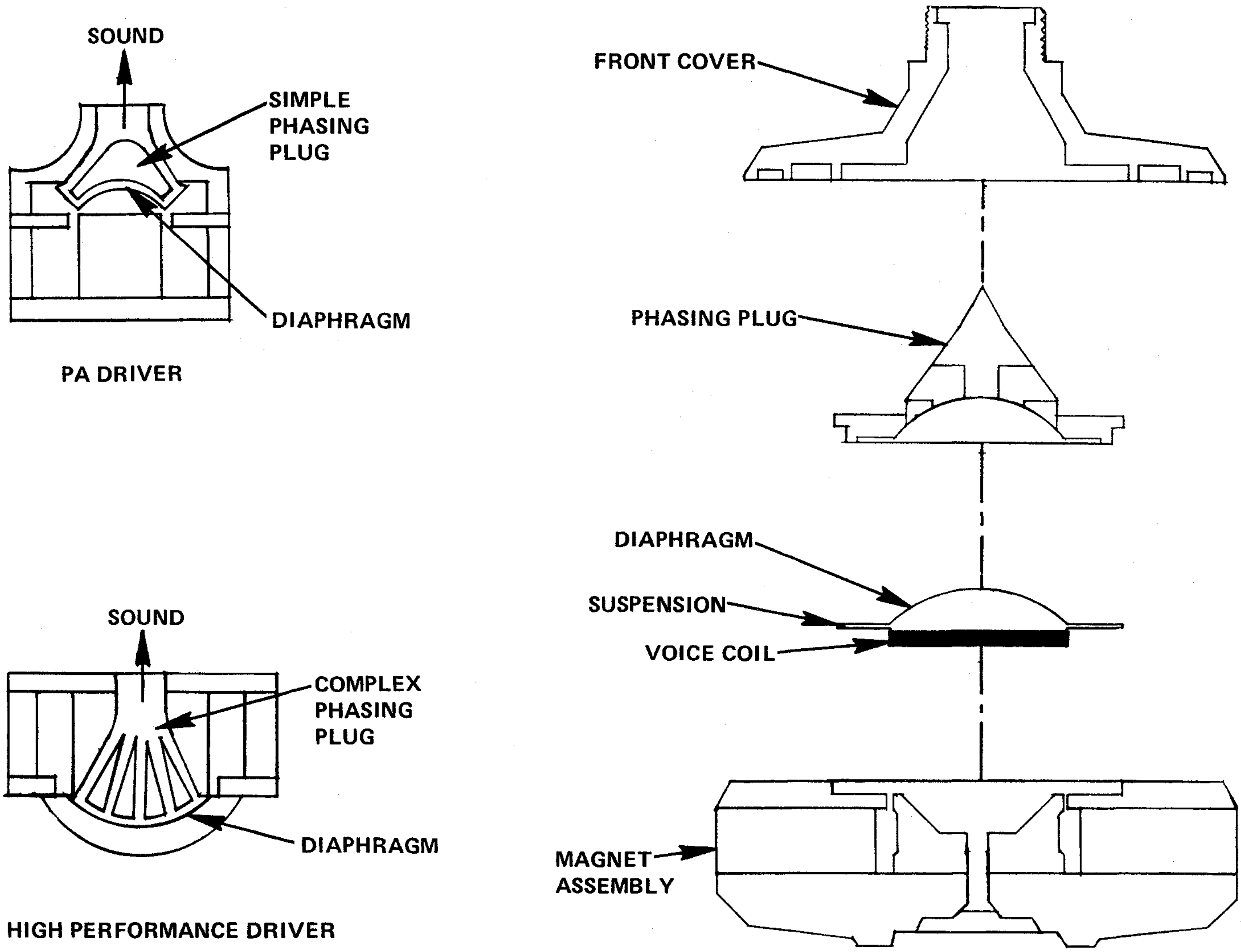

FIGURE 2 – Parts of a Driver
(actual geometry can vary on specific units)

chiefly by the extreme difficulty of making the mass of what must be a durable diaphragm vanishingly small. In practice the natural power roll-off, if smooth, can easily be compensated for by electrical equalization in the form of high-frequency boost. Most well designed drivers are electrically durable enough to take this measure in stride.

Choosing Your High-Performance Driver

You can now see why high-performance drivers are highly desirable for full-range music reproduction. (Two E-V drivers which are high-performance types are the DH1012 and DH1506.) A puzzling matter to many users considering the use of high-performance drivers is how to select an appropriate unit from several offerings. Many driver lineups can be subdivided into large and small units in terms of diaphragm diameter and driver weight (occasionally with the option of all-phenolic or all-aluminum diaphragm construction on a given driver.) A general rule of thumb is that the larger units will be usable to lower frequencies, handle more power, and have more restricted high-frequency output than the smaller models. These characteristics are a consequence of the basic design trade-offs made when the driver was conceived. If low crossover frequencies and/or brute acoustic output are of paramount importance, then the larger driver is probably the best choice. If extended high-frequency output is of more importance relative to the other matters, then the smaller driver is probably indicated. Individual manufacturers' data needs to be consulted in order to make an intelligent selection in any case. In the case of E-V high-performance drivers the significant performance matters are displayed in Table 1.

From these features you can see that the DH1012 is a somewhat more durable driver which is capable of going lower in frequency at the expense of some very-high-frequency output. This does not mean that the DH1012 cannot be crossed over at 800 Hertz or higher. A good rule of thumb is that the highest crossover frequency that will do the job is preferable in order to maximize driver durability in actual usage.

The high-performance drivers are the best choice for maximum efficiency systems which are two way. A two-way system is one which uses the driver to cover the mid and high frequencies (such as 800 Hertz to 20,000 Hertz) with a woofer covering the low frequencies (such as 75 Hertz to 800 Hertz). Although we have not primarily concentrated on this type of unit in this paper, drivers with phenolic diaphragms and simple phasing plugs (such as the Electro-Voice 1824M) are good choices for midrange devices in three-way systems where higher frequencies are handled by a separate tweeter.

Recommended Minimum Crossover Frequency,
DH1012:
500 Hz
DH1506:
800 Hz
Power Handling Capacity (see spec sheet of driver)
DH1012:
40 watts
DH1506:
30 watts
Horn Mounting Method,
DH1012:
Bolt-on
DH1506:
Screw-on
Highest Usable Frequency,
DH1012:
10,000 Hz
DH1506:
20,000 Hz

Table 1 – Major Specifications for "Sorting" Drivers (E-V)

HORN INTRODUCTION

A horn is a device which performs the function of acoustically coupling sound generated from a driver to the air. Horns are necessary in order to form a complete horn-type transducer.

Horns, unlike direct radiators (cone speakers on a flat baffle), have the unique property of being able to control directionality. By this we mean that it is possible, over a fairly wide range of frequencies, to have the zone of coverage of the energy eminating from the horn to be uniform and controlled. This can be a very useful characteristic in the design of high-quality systems especially when articulate and natural reproduction of the human voice is of importance. (See the "Bible" for more particulars on complete system design.) Horns can be designed to provide various coverage angles such as 90° horizontal by 40° vertical (E-V HR9040A and HR90 horns).

Basic Forms of Horns

The most rudimentary horn designs take advantage of the high efficiency characteristic inherent in horns and have little or no coverage control. These horns are usually relatively small, simple-appearing units which have been designed primarily to perform the basic function of attaining high efficiency. It should be noted that even in the case of simple horns it is possible to do limited forms of directional control – especially if they are intended for midrange frequencies only. Such control is in the form of fairly uniform wide-angle coverage if careful thought is given during the design process. However, control over a wide frequency band, especially for narrow coverage zones, can only be practically achieved through more sophisticated and larger horn structures.

An additional embellishment of the simple design incorporates some directional control in addition to providing the basic horn function. One of the earliest attempts which can still be seen today is the multicell horn (see Figure 3). The multicell horn is usually quite large and is made up of several (sometimes 10 or more) small exponential horns. This is a method of attempting to obtain controlled directionality. This works fairly well at low to mid frequencies, but it creates many finger-like "lobes" at high frequencies as each small section has its own "beaming" problem which eventually shows up at high frequencies.

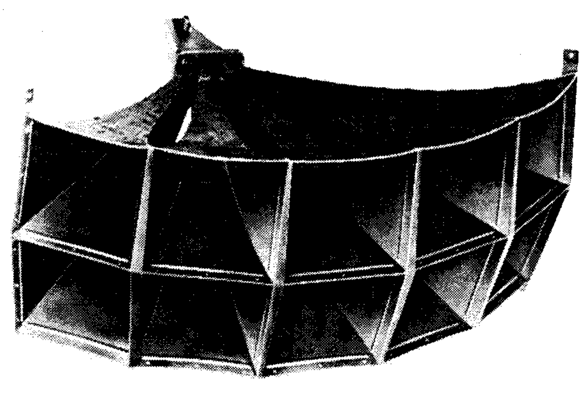

FIGURE 3 – Multicell Horn

Another form of horn is the **simple** sectoral (sometimes called radial) type shown in two views in Figure 4. This horn is made in the form of a sector (like a piece of pie) in the top view. The angle of the sector is intended to define a coverage zone for the horn in a horizontal direction. (In practice this can happen with reasonable precision – especially if care is taken in important secondary design details involving particular attention to the size and shape of the small and large end.) In the other view (side view) the shape is typically determined by some mathematical formula (there are several) which spells out the rate at which the horn flares out in going from the small (driver) end to the big (mouth) end. Because of this, the horn surfaces shown in the side view take on the shape of a smooth curve. The curved surface is not conducive to controlling the coverage angle of the horn in the vertical (up-and-down) direction with the result usually being that in this direction the coverage angle changes depending on what frequency the horn is handling. The coverage angle decreases with increasing frequency. Because of this the potential uniform coverage in the horizontal direction is not matched by uniform coverage in the vertical direction.

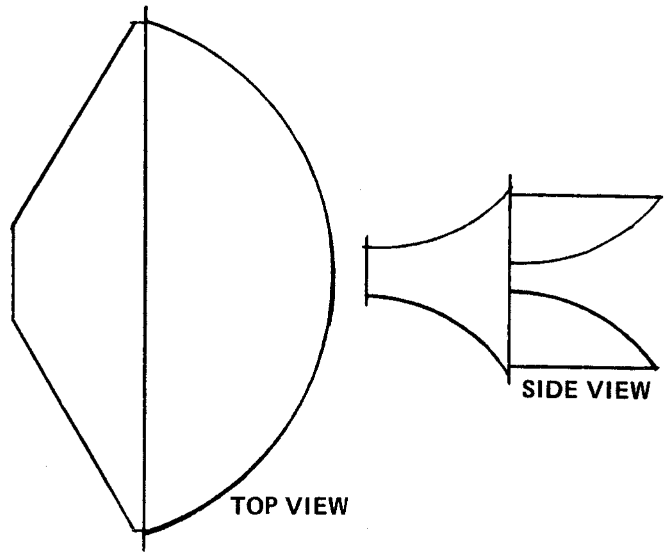

FIGURE 4 – Simple Sectoral Horn

Constant-Directivity Horns

It is possible to achieve more uniform directional control in both the horizontal and vertical directions by using a combination of flare rates. In doing this, enough of the horn must have an appropriate shape so as to preserve the basic function of assuring that the high-efficiency characteristic of the horn (mentioned in the section of rudimentary horns) is maintained over an appropriate range of frequencies. Additional flared sections can then be incorporated to assure tighter directional control in both directions of interest. Horns designed by these techniques can offer well-controlled directionality characteristics that can be an important part of predictable, sophisticated system design for specific application. A product example is the E-V HR series which in 1974 introduced the concept of constant directivity and which uses combinations of exponential and conical flares (U.S. patent number 407112).

Selecting Your Horn

The E-V HR series horns are offered in seven varieties and which one to use for a specific application is a question. Examining one feature will quickly break the group into two categories:

Recommended Crossover Frequency
(Beamwidth Limited)

Models	**Crossover**
HR9040A, HR6040A, HR4020A	500 Hertz
HR120, HR90, HR60, HR40	800 Hertz

Note that the "beamwidth limited" determines the recommended crossover point. What this means is that because of their relatively small physical size the HR120, HR90, etc., are not capable of controlling their coverage patterns below 800 Hertz. The large HR horns (HR9040A, etc.) can maintain their coverage angles (especially in the vertical plane) approximately one octave lower in frequency. This makes the large horns the best choice for highly refined systems where their size is acceptable.

Note, however, that the small HR horns do provide proper driver diaphragm loading down to 500 Hz so they can be crossed over at 500 Hertz if the decreased pattern control can be tolerated and the driver itself has capabilities down to that frequency.

Appropriate horn coverage angles depend on the application. If long-throw, "tight" patterns are needed to project sound to the back of a large room (consult the "PA Bible" for more particulars about this important matter), the HR40 or HR4020A (40° x 20°) would be recommended. For very wide coverage, the HR120, HR90, or HR9040A (90°/120° x 40°) would be a good choice. For medium-size rooms where some projection is necessary, the HR60 or HR6040A (60° x 40°) would perhaps be indicated. Obviously, this relatively brief discussion will not tell you everything to consider when choosing a horn, but some evaluation of the room (or rooms) you play in and the appropriate specification sheets and, perhaps most importantly a copy of the E-V "PA Bible" can guide you along the right path.

SPECIAL NOTE TO THE READER

The E-V "PA Bible" and this addition have been prepared to help you solve your PA problems. Let us know if you have any other areas in mind for us to tackle.

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