Chapter 11

Horn-Type Enclosures

Historical Note

The horn is perhaps the oldest type of baffle in the art of acoustic reproduction. Edison's early phonograph had a short conical horn to "amplify" the sound coming from the mechanically energized diaphragm. Later versions of this instrument sprouted the "morning glory" type of horn; and just before the advent of the electro-acoustic reproducer the console-type acoustic phonographs so well known in the living room and parlor of the 1920's boasted well-designed folded horns for "concert-hall reproduction." This type of horn gave good reproduction for the recorded material with which it had to work, and for the acoustic "tone box" feeding it.

When the day of electro-acoustic reproduction dawned upon us, it was only natural that the horn be used again. The most remembered types were offshoots of the "morning glory" variety, coupled to a large heavy driver unit on the table beside the radio. These driver units were actually overgrown models of telephone receivers. In fact, the unit was commonly referred to as a "loud speaking telephone." From that derivation we were left with the term "loudspeaker" for any device that makes sound loud enough so that the reproducer does not have to be held up to the ear for the sound to be heard. Despite the fact that the horn is of ancient vintage, it is a highly efficient device, acoustically speaking. With the modern studies that have been made of horn theory and design and the improvements in their driver units, the acoustic horn has taken a firm foothold in the high fidelity art.

Horn Provides High Acoustic Efficiency

The acoustic horn is an acoustic transformer, *not an amplifier,* despite the fact that a source of sound appears louder when a horn is applied to it. The reason for the increase in sound output from a driver when it is coupled to a horn is that the horn, through its transformer action, creates a better impedance match between the driver and the

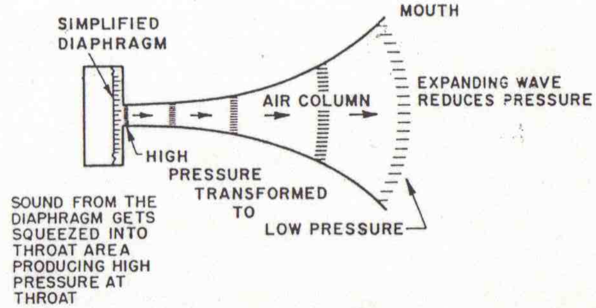

Fig. 11-1. Simplified horn structure illustrating transformation of high pressure at throat to low pressure at mouth.

air. With improved impedance matching of the driver unit to the air comes improved power output and efficiency of operation.

Horns may take many shapes, but they have one characteristic in common. They expand from a narrow opening called the throat to a larger opening called the mouth. (See Fig. 11-1.) The intervening space is called the "air column." When the horn is coupled to a driver unit at its throat, all the sound from the driver unit must travel into the throat area. This means that if the diaphragm of the driver unit located at the throat of the horn is five times larger than the area of the throat, the sound coming from the surface of the diaphragm must be compressed in a five-to-one ratio. As a result, the sound pressure at the throat of the horn is high.

As the sound wave progresses along the horn toward the mouth, it finds its confining walls continually expanding. This allows the high pressure wave to spread out over a larger and larger surface. As it spreads out, the pressure per unit area decreases. Finally, at the mouth of the horn, the sound wave breaks away from the mouth of the horn and is propagated into space. Thus the horn has acted as a transformer;

it has changed the acoustic flow of energy from a high pressure condition at the throat to a low pressure condition at the mouth.

Horn Couples High Throat Impedance to Low Mouth Impedance

This statement should now be interpreted in terms of impedance because it is the impedance into which something works that determines the power that is developed. We know that in electrical transmission systems or electrical coupling systems carrying a given power.

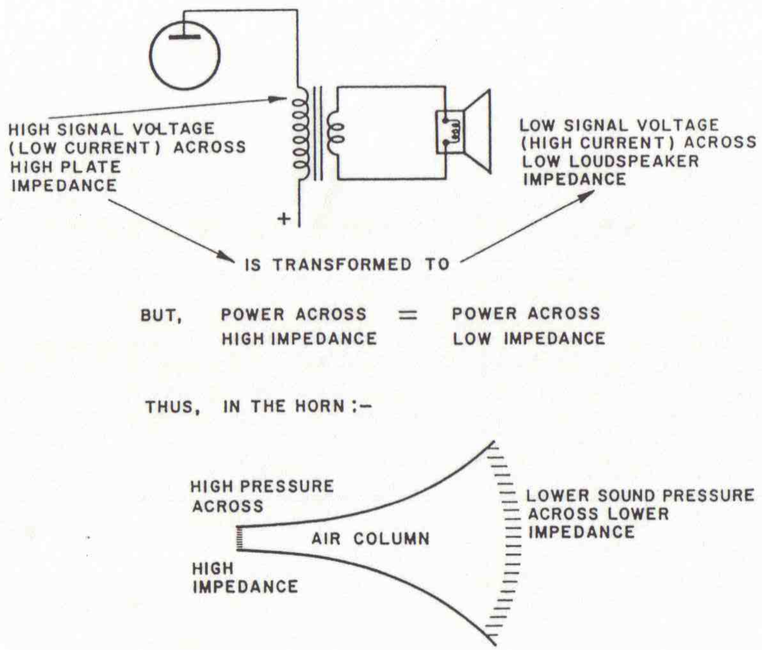

Fig. 11-2. Analogy showing the impedance transformation function of a horn.

if we have high voltage at one portion of the circuit and low voltage at another, the *high voltage exists across the high impedance portion of the circuit and the low voltage appears across the low impedance portion.* Take for example the output transformer in Fig. 11-2. The primary side of the transformer, which is connected to the high signal

output plate voltage (at low current) is of high impedance, while the secondary, which connects to the loudspeaker, is of low impedance, across which there is low signal voltage (at high current).

Sound pressure is analogous to voltage. Voltage drives the current through the circuit; sound pressure imparts the "volume velocity" to the sound wave. Thus, in an *acoustic transformer,* high sound pressure exists across high acoustic impedance, and low sound pressure exists across low acoustic impedance. What happens in the acoustic horn is that the gradually tapering column of air is a means of matching the relatively low loading impedance of the nebulous outside air to the relatively high mechanical impedance of the comparatively massive vibrating piston. When this impedance match is properly made, the combined driver and horn system may operate at considerably higher efficiency.

Putting it in simple terms, the direct radiator type of loudspeaker used in a simple baffle must "grab hold" of the entire air merely through the air with which the surface of the diaphragm itself comes in direct contact. Because the diaphragm size is always relatively small compared to "all the air," the impedance match is a poor one and the efficiency of the direct radiator system is correspondingly low. In the case of the horn, however, the diaphragm is allowed to contact a "surface" of air much larger than its own area by means of the much larger horn mouth, which is *directly coupled to the diaphragm through the horn.* The larger the mouth of the horn, the better the impedance match between "all the air" and the diaphragm, and the more efficiently the diaphragm can grab hold of the air. As a consequence, the horn system has high efficiency, somewhat in the order of 40 to 50 percent, whereas direct radiator efficiency is in the order of 10 percent or less.

The mouth of the horn may be considered to be an actual vibrating piston by itself. If reference is made to Fig. 10-1, it will readily be seen that by making the mouth of the horn large for a given low frequency a much larger radiation resistance may be presented to the relatively small diaphragm driving the large mouthed horn. This is illustrated in Fig. 11-3.

High System Efficiency Reflects Itself in Cleaner Reproduction

Because of the high order of efficiency of the horn-loaded system, it is possible to obtain much more linear low frequency response than