Fig. 4.

![Graph showing response in dB above 0.0002 dynes/cm² versus frequency (kHz)]

Fig. 5.

![Graph showing frequency in cycles per second (2 Hz to 2 kHz)]

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The present invention relates to high frequency loudspeakers commonly termed "tweeters," and more particularly to the horn throat structure of such loudspeakers.

In high fidelity reproducing systems, it is common to use a plurality of reproducers, each being specifically designed for reproduction of a particular frequency band. These reproducers are combined in the system with a suitable electrical network which allows each reproducer to receive only signal energy of its own specific bandwidth. Such a system allows for special design of each reproducer which results in extended and more uniform frequency response. It has been found, however, that the dynamic tweeters commonly employed in such systems show a marked drop in response in the vicinity of 13,000 cycles and above. This has led to some investigation and theorizing on the operation of the present type high frequency loudspeakers, which has resulted in a construction which gives a good response through 20,000 cycles and response as high as 40,000 cycles.

In accordance with the present invention, an assumption was made that the prior art high frequency dynamic loudspeakers at some frequency above 12,000 cycles encounter an action of the diaphragm which no longer is a piston action as has been assumed for many years. If this were the case, interference of the air mass adjacent the diaphragm might bring about a particle motion in the air which would result in cancellation or no resultant particle motion at the horn throat even though the energy from the voice coil is not affected.

In Figure 2 is a diagrammatic top view of the horn, a cover for the dynamic unit, and the dynamic diaphragm; Figure 3 is a diagrammatic top view of the horn, cover and diaphragm shown in Figure 2; Figure 4 is a response curve of an ultra high frequency loudspeaker unit embodying the teachings of the present invention.

Reference now may be had to Figure 2, which is a diagrammatic representation of the horn, a cover and the diaphragm of the type embodying the present invention, and which was illustrated in Figure 1. The representation in Figure 2 by the elimination of certain mechanical details provides a better basis for the explanation of the structure and its relation to other parts of the loudspeaker unit. It will be noted in Figure 2 that there has been shown a dome shaped diaphragm 19 which is clamped between two washers 21 in a portion of the cover housing 14 engaging the magnetic circuit member 22. A central magnetic circuit member 23, which generally is of cylindrical shape, provides an air gap for receiving the voice coil 24 depending from the dome shaped structure 19 of the diaphragm. In a particular embodiment, such as that illustrated in Figure 2, the permanent magnet structure comprising the members 23 and 22 has a flux density so as to provide from 18,000 to 20,000 gauss in the air gap. The diaphragm 19 in this particular embodiment has a domed structure which is about one inch in diameter and is clamped approximately one inch off center from the voice coil to place the primary resonance of the electromechanical system including the diaphragm at approximately 4,000 cycles. The voice coil 24 is seventy-sixty-fourths of an inch long formed so as to be self-supporting out of round No. 38 aluminum wire.

It will be noted in Figures 2 and 3 that various dimensions have been indicated by letters. Typical measurements for these dimensions are given in the following table:

<table>
<thead>
<tr>
<th>Character</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.670</td>
</tr>
<tr>
<td>B</td>
<td>0.729</td>
</tr>
<tr>
<td>C</td>
<td>0.093</td>
</tr>
<tr>
<td>D</td>
<td>0.312</td>
</tr>
<tr>
<td>E</td>
<td>0.010</td>
</tr>
<tr>
<td>F</td>
<td>0.234</td>
</tr>
<tr>
<td>G</td>
<td>0.175</td>
</tr>
<tr>
<td>H</td>
<td>0.734</td>
</tr>
<tr>
<td>I</td>
<td>0.906</td>
</tr>
<tr>
<td>J</td>
<td>1.031</td>
</tr>
</tbody>
</table>

The response curve in Figure 5 shows the operation from three to forty kilocycles. Excellent response is obtained through twenty kilocycles, and, while the energy...
output from twenty to forty kilocycles is much lower, it
evertheless is believed to be useful in the operation of
the improved very high frequency loudspeaker. When
a device having the characteristics shown in Figure 4 is
combined with other loudspeaker units in a system with
a network and mounted in a suitable enclosure, it will be
noticed that the curve B is much smoother and greatly ex-
tended over the curve A, which shows the same compo-
ents with the exception that the prior type of tweeter
was employed.

While the invention is not to be limited thereby, the
structure arrived at was based upon certain assumptions
which can best be understood by referring to Figures 6
and 7. Previous theories of operation of dynamic dia-
phragms have assumed that the entire domed structure
moved back and forth like a piston. Reproduction curves
and direct visual observation of the exposed diaphragm
without any loading structure, however, indicated that no
high frequency energy was translated into sound at and
above 12,000 or 13,000 cycles. This absence of sound
energy was assumed to be due to a change in the oper-
ation of the dome shaped diaphragm structure from a
piston to one where the peripheral portions might be
moving forwardly while intermediate or central portions
might be moving in the opposite direction, thus causing
to exist a phase angle difference of 180 degrees between
the velocities of these two portions of the diaphragm.
Thus, in the representation in Figures 6 and 7 the arrows
C show the peripheral portion of the diaphragm moving
downwardly, while an intermediate or central portion is
moving upwardly as indicated by the arrows D. This
would tend to cause a motion of the air beneath the load-
ing plug in Figure 6 so that in effect there is little or no
particle motion at the horn throat and hence no sound
energy produced. In both Figures 6 and 7 the magni-
tudes of the arrows A and B show relatively the magni-
tudes of particle displacement. If this were the case,
the operation in Figure 7 illustrates that air masses could
be moved in different directions as shown through mul-
tiple paths of sufficiently differing lengths so as to result
in zero phase angle difference of the velocities at points
X where the multiple sound paths converge to enter the
horn with the result that the higher frequencies, namely
those above about 12,000 cycles, could be produced by
the non-piston action of the diaphragm. Thus, in accord-
ance with the present invention the conventional loading
plug has been replaced by a phasing structure or throat
structure having a particular relation to the components
so as to produce the improved overall response charac-
teristic shown in Figure 4 and to greatly improve network
operation illustrated in Figure 5.

While for the purpose of illustrating and describing the
present invention a particular embodiment has been illus-
trated in the drawings, it is to be understood that the
invention is not to be limited thereby since such varia-
tions are contemplated as may be commensurate with
the spirit and scope of the invention set forth in the accom-
paingy claims.

I claim as my invention:

1. In a high frequency loudspeaker having a diaphragm
with a spherical convex outer surface, a horn for said
diaphragm, and a multi-path throat structure for said
horn adjacent said diaphragm comprising a cylindrical
member having a flat end and a concave end, said concave
end having a surface parallel to the convex surface of said
diaphragm, said cylindrical member having an axial hole,
and a second member comprising a section of a sphere
having a plane surface parallel to the flat end of said
cylindrical member.

2. The loudspeaker of claim 1 wherein said cylindrical
member has a diameter less than the horn throat diam-
eter, and said second member has a diameter less than
said cylindrical member.

3. In a high frequency loudspeaker having a diaphragm
with a convex outer surface, a horn for said diaphragm,
and a coaxial throat structure for said horn adjacent said
diaphragm comprising a cylindrical member having a
flat end and a concave end, said concave end having a sur-
f ace parallel to the convex surface of said diaphragm,
said cylindrical member having an axial opening, and
a second coaxial member having a plane surface parallel
to the flat end of said cylindrical member and a coaxial
convex surface intersecting said plane surface.

4. The loudspeaker of claim 3 wherein the radius of
the diaphragm convex outer surface is substantially twice
the radius of the convex surface of said second member.

5. The loudspeaker of claim 3 wherein the opening is
not more than one-fifth of the diameter of said cylindrical
member.