A New Concept in Sound Radiation

by

D.C. Belz

It has been shown that 2 radiators of 6 inch diameter will exhibit the same radiation as a single radiator of 12 inch diameter [1].

Pursuing this step by step to its logical conclusion, a further subdivision by 2 would result in 4 diaphragms of 3 inch diameter, and so on. Thus if D is the original diameter, 12 inches in the example, this be be divided by 2, 4, 8, 16 --- 2^n and the number of diaphragms multiplied by the same factors 2, 4, 8 --- 2^n. Since the impedance per unit area is established by Rayleigh [2] and the Bessels Functions are available in published reference works [3], it follows that any subdivision of radiation surface may be explicitly defined.

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1. Joseph Marshall "Multiple Speakers", Radio Electronics Vol. XXVI No. 9, pp 100, 102, 105, 106, 108, September 1955.

2. Lord Rayleigh "Theory of Sound", Macmillan and Co. London, England, 1898, Vol. 2 pp 162-169.

3. Jahnke and Emde "Funkionentafln", Teubner, Leipsig, 1933; Zylinderfunktionen pp 126-130 (Ed. 1943 Rev.)

The area of each individual diaphram becomes

$$A_j = (D \times 2^{-n})^2 \ (\pi/4) = D^2 \ 2^{-2n} \ (\pi/4) \text{-------(1)}$$

and the number of diaphragms becomes 2^n. The total area of the coupled array is therefore

$$Ac = D^2 2^{-2n} \ (\pi/4) \times 2^n = D^2 (\pi/4) \ 2^{-n}. \text{ -------(2)}$$

and the original area is $D^2 \ (\pi/4)$. Thus the resultant area is smaller than the original area, the factor of reduction being 2^{-n}. If the value of n is some quantity like 2, it is not immediately evident the advantage to be gained. But suppose we make n = 10, so that 2^n becomes 1028 and 2^{-n} is 0.0097273 (very approximately). This is to say that for the original 12 inch speaker we now have 1028 minute radiators, each only 0.00097273 feet (roughly 0.0117 inch) in diameter.

This formidible array may look like an expensive approach, but, again, let us go one step further. The total area of this new array, from equation 2, n = 10,

$Ac = 12^2 (\pi/4) \ 2^{-10} = 0.10099$ square inches, or exactly 1/1028 as much as the original area.

Now still one more step. Since the 1028 individual small radiators are coupled, by the original postulate, they may be combined into a single radiating surface and driven by a single voice coil. Whence it follows Quod Error Demonstradum that the original function of the 12 inch cone speaker may be accomplished by the much smaller (0.1099 square inches) area provided by a 0.3315 inch square cone or a round one 0.4225 inches in diameter.

Note the further reduction in size afforded by the square cone or pyramidoidic frustratum superfacium.

Obviously the value of n may be made any convenient value; slide rules may be made any length. If n is made large without limit 2^{-n} becomes vanishingly small; on reaching infinitesimal values it may be ignored altogether, and the speaker omitted entirely. Erstwhile advocates of large and expensive speakers in sound reproduction systems thus become relegated to an era already passed.

Laboratory corroboration of the basic theory was enlightening. For the experiment n was taken as 6 and 32 radiators of 0.03125 foot diameter were driven by 0.015625 inch diameter voice coils removed from as many shortvalve VI model stereococci pickout heads at the retail price of $250. each. Recognition a posteriori of the economy of the common voice coil did not relieve the a priori expense.

The pressure-response curve divided by n corresponded within irrational standard deviations with the frequencies. Expressed in decibels, the factor of correlation was n where n is the same n used in equations (1) and (2). Obviously with an increase in values of n the reduction may be extended to the point where the pressure-response curve may be eliminated completely, and total reliance placed on published data.

5 April 1958

Mr. Harvey Gernsback
Editorial Director
RADIO-ELECTRONICS
154 W 14th Street
New York 11, N.Y.

Dear Harvey:

Nothing comes of our correspondence of November 1955, but I find the article in question being quoted as truth.

Enclosed is a "paper"; I dare you to print it.

Sincerely,

Paul W. Klipsch

KLIPSCH & ASSOCIATES

PWK/tm

enc: Paper "A new Concept in Sound Radiation by D.C. Belz".

cc: Woodlee

Radio-Electronics
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April 17,1958

Mr. Paul W. Klipsch
Klipsch and Associates
Hope, Arkansas

Dear Paul:

The dare is accepted. We shall be happy to print your brother-in-law's paper. It is an excellent job. However, we would like to know whether it would be permissible to asterisk Mr. Belz's byline to a footnote, indicating that he is from Hope, Arkansas.

We would also like your permission to add a new footnote #2 following your (oops, I mean Mr. Belz's) footnote #1. This footnote would be as follows:

> F. Langford-Smith, "The Use of Multiple Small Loudspeakers," Radiotronics Vol. 19, No. 8, August 1954, pp 85 - 89.

Then the following footnotes would be renumbered accordingly.

We'd like to include this one because Langford-Smith has considerably more standing than Joe Marshall. Incidentally, we sent you a copy of this paper back on January 20,1956, but you never commented on it.

I note in your letter of April 7th, you wonder whether a word of explanation should follow Mr. Belz's paper. If such an explanation were added, would you wish your name to be associated with it?

Sincerely yours,

RADIO-ELECTRONICS

Harvey

M. Harvey Gernsback
Editorial Director

MHG:eg