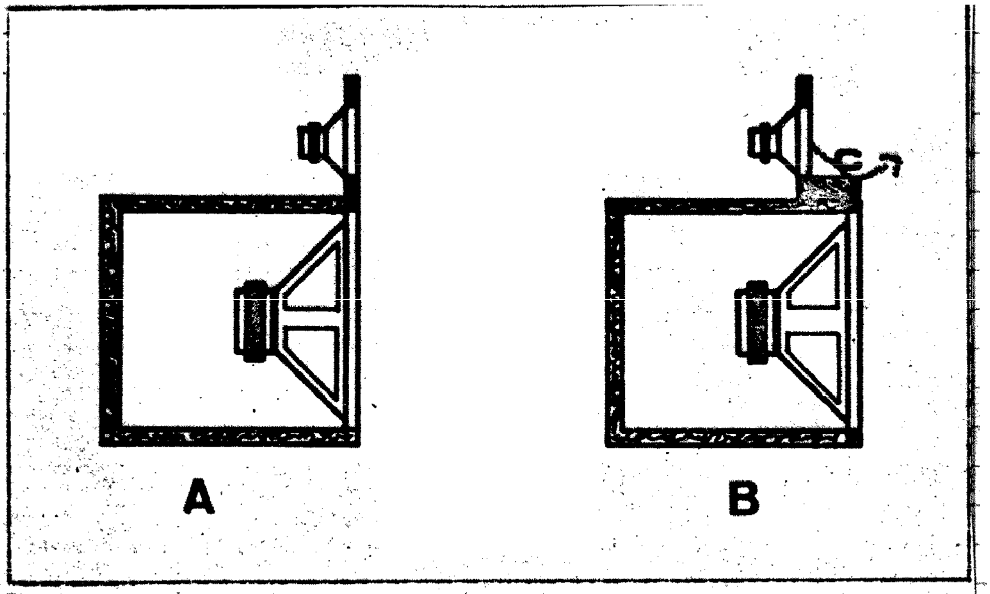


Fig. 1
Disposizione del woofer e del tweeter nelle due casse, in fase (B) e non in fase (A). Un pannello di materiale fonoassorbente (C) serve ad evitare dannose riflessioni.

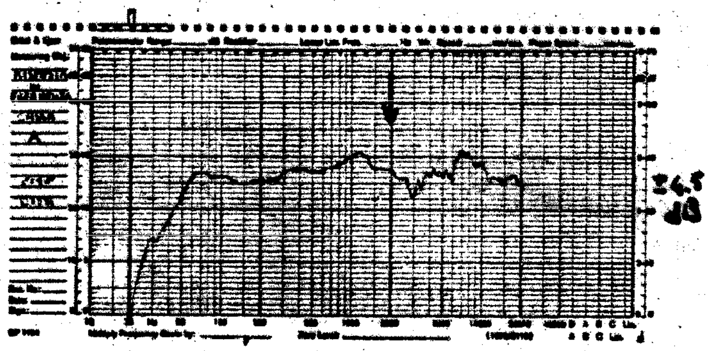


Fig. 2
Curva di risposta, in camera anecoica, della cassa non in fase (A).

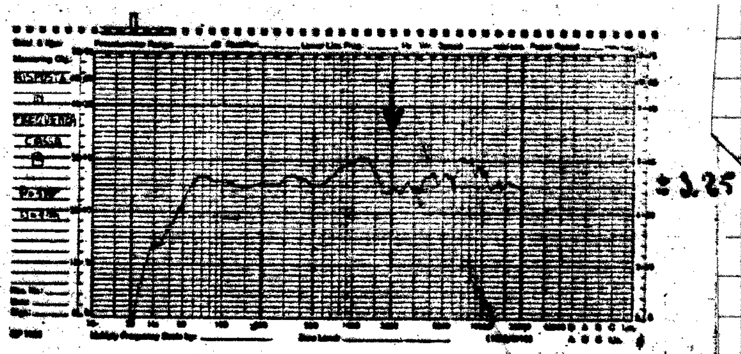


Fig. 3
Curva di risposta della cassa in fase (B). Si può notare la grande somiglianza con la curva della cassa A.

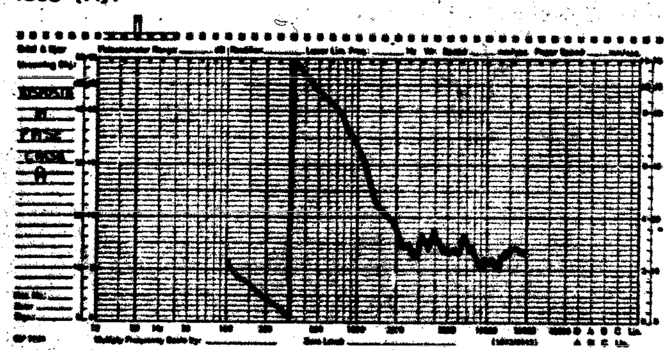


Fig. 4
Risposta in fase della cassa A: si vede chiaramente che il woofer è in « ritardo » a causa della disposizione in linea degli altoparlanti sul frontale.

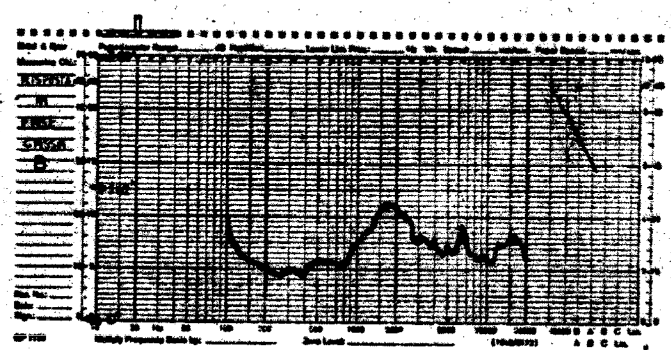


Fig. 5
Risposta in fase della cassa B. Si riesce ad avere una risposta compresa entro ± 40° tra 100 Hz e 20 KHz, l'irregolarità in prossimità del punto di crossover è dovuta al fatto di aver cercato di ottenere due risposte in ampiezza quasi identiche.

Tratto da: Giancarlo Gandolfi: Le prove nelle casse acustiche – parte sesta
(Suono Marzo 1976)

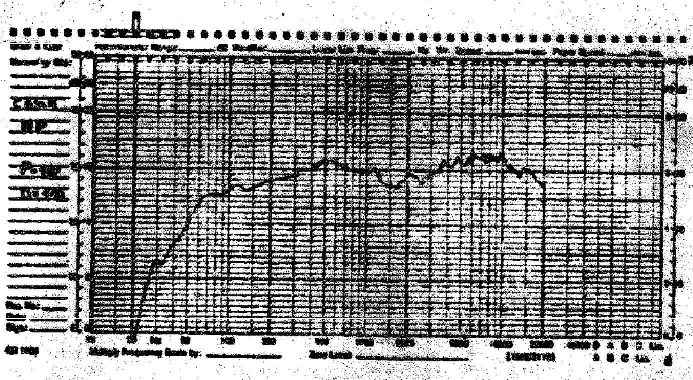


Fig. 6
Curva di risposta di una buona cassa a tre vie con i componenti montati sul pannello anteriore in maniera tradizionale.

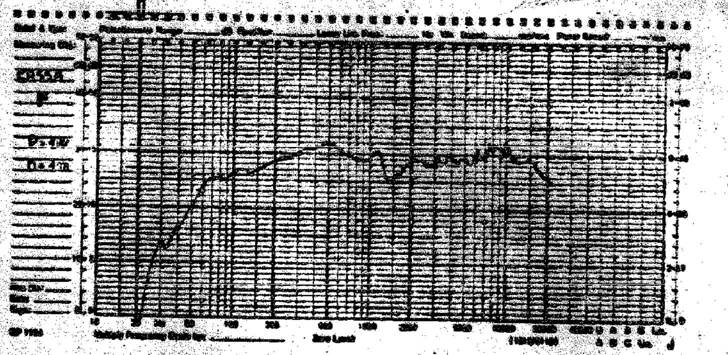


Fig. 7
Risposta della stessa cassa di fig. 6 ma con il tweeter messo in fase corretta con il midrange.

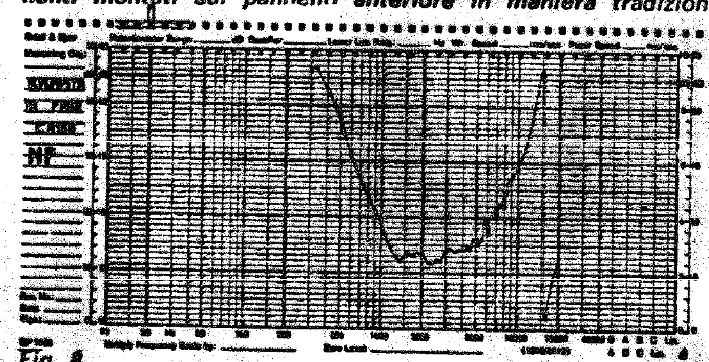


Fig. 8
Risposta in fase della cassa tradizionale: si vede, come ormai è ben noto, che il tweeter è in « anticipo » sul midrange, mentre il woofer è in « ritardo ».

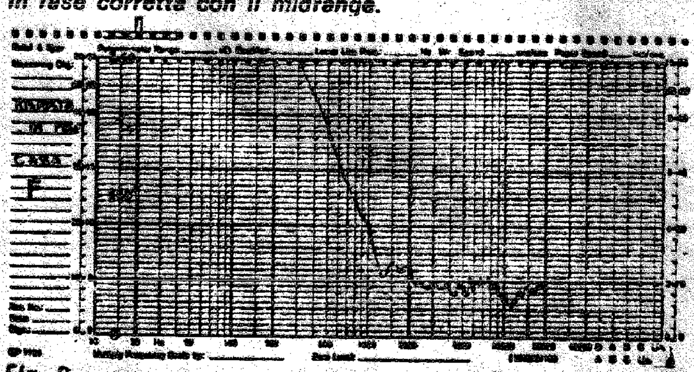
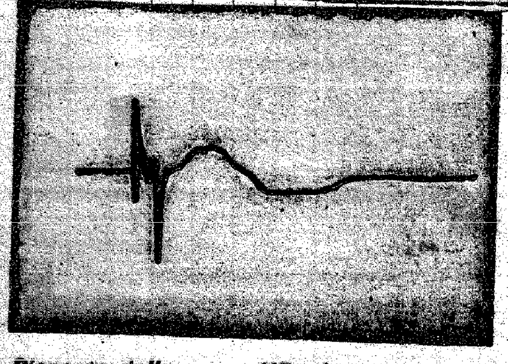
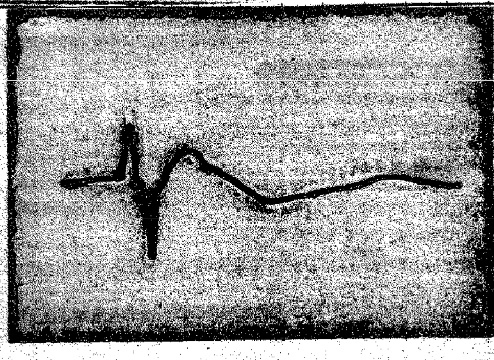


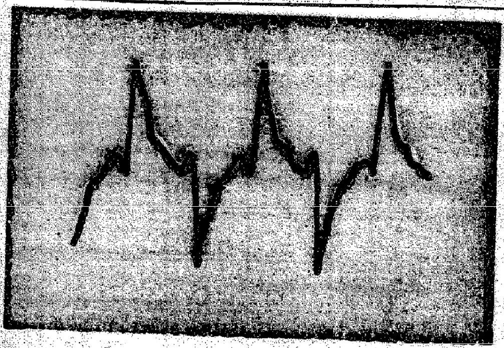
Fig. 9
Risposta in fase della stessa cassa di fig. 7.



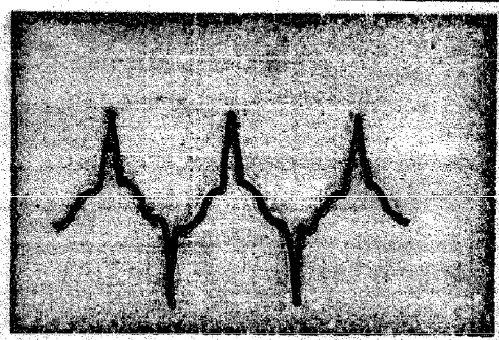
Risposta della cassa NF ad un impulso di 0,25 ms.



Risposta della cassa F ad un impulso di 0,25 ms.



Risposta all'onda quadra a 2000 Hz della cassa NF.



Risposta all'onda quadra a 2000 Hz della cassa F.

L'ascolto dei due diffusori ha confermato le perplessità apparse all'esame delle figure dell'oscilloscopio: la qualità di riproduzione del diffusore rimane sostanzialmente inalterata anche disponendo il tweeter in fase e, solo durante l'ascolto di alcuni segnali artificiali è parso ad alcuni ascoltatori di avvertire una qualche differenza di riproduzione tra i due sistemi.

... in un diffusore acustico una corretta risposta in fase provoca sempre un miglioramento della risposta ai segnali transitori che però diventa evidente all'ascolto solo dopo che sono state annullate, o per lo meno fortemente ridotte, tutte le altre forme di distorsione.

D) Una corretta risposta in fase è più importante quando si ascolta un programma stereofonico in un ambiente riverberante, ma è percettibile anche in monofonia, ascoltata in camera anecoica.

Dopo aver concluso che l'orecchio è sensibile alla fase, dobbiamo però ammettere che, durante queste lunghe ricerche, ci siamo resi conto che le altre forme di distorsione presenti negli altoparlanti sono in genere assai più facilmente avvertibili.

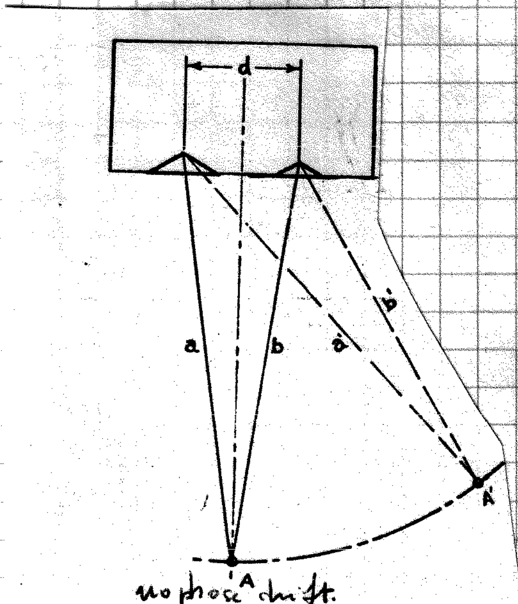


Fig. 6—Adjacent mounting of woofer and tweeter results in large difference in path lengths *a'* and *b'*.

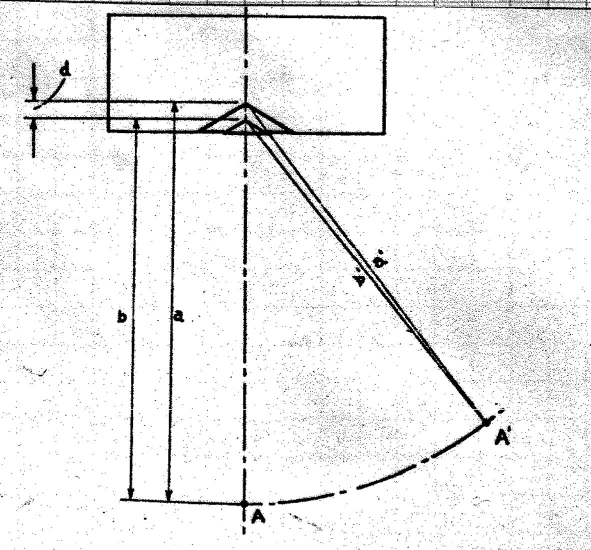


Fig. 7—Coaxial mounting of woofer and tweeter results in small difference in path lengths *a'* and *b'*.

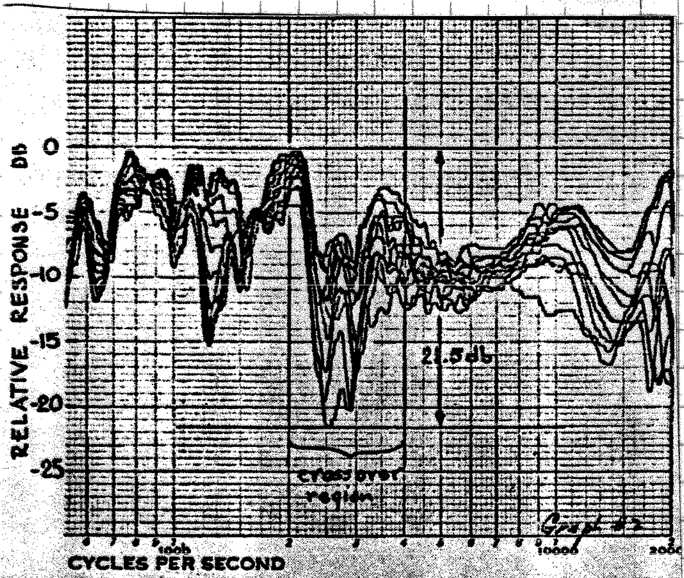


Fig. 8—Adjacent mounting of woofer and tweeter. Curves taken in 5° intervals from +30° to −30° fell within 21.5 db boundaries in the crossover region.

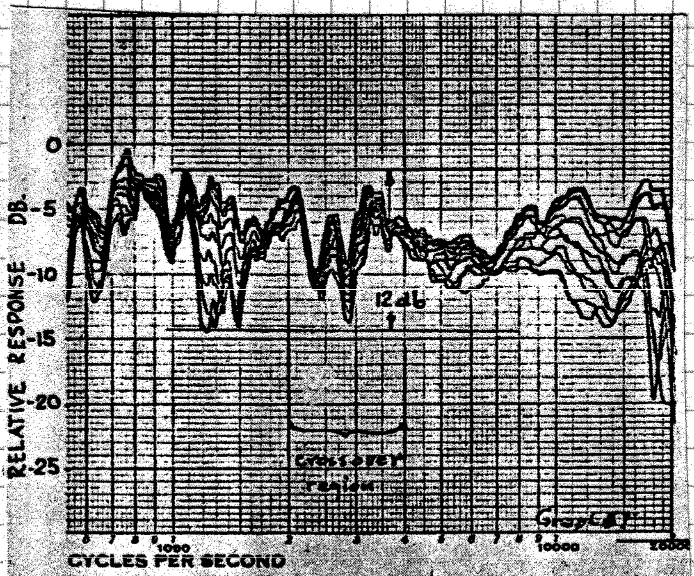


Fig. 9—Coaxial mounting of woofer and tweeter. Curves taken in 5° intervals from +30° to −30° fell within 21.5 db boundaries in the crossover region.

Experimental verification of this analysis was made by the use of an 8 inch woofer and a 1 inch tweeter mounted side-by-side at a distance *d* equal to 8 inches and by a coaxial arrangement where the tweeter diaphragm was mounted 2¼ inches from the woofer cone anchoring plane. The actual displacement *d* of the tweeter diaphragm with respect to the mean effective radiating portion of the woofer at 3000 cps was about 1.5 inches or somewhat more than one-quarter wavelengths. Both systems were made to cross over at 3000 cps with a simple L-C network. The two speakers were connected in phase in the adjacent mounting, out of phase in the coaxial mounting. Both woofer and tweeter had fairly sharp cutoff characteristics outside the crossover region.

Fig. 8 shows the polar response of the system with adjacent mounting. Response curves were taken at intervals of 5° from +30° to −30°.

AUDIO:
MINIMIZING INTERFERENS EFFECTS IN TWEETERS and TWEETER-WOOFER COMBINATION_

of JOEL JULIE - Senior member, IEEE

Summary—Point-source vs large-area tweeters are analyzed in terms of phase interference. Theoretical analysis shows that the desired upper frequency limit as well as the dispersion angle place a limit on the maximum dimension of a tweeter diaphragm. Also, phase interference is analyzed in the crossover region in woofer-tweeter combinations. This interference is shown to be a function of the physical displacement of the woofer diaphragm with respect to that of the tweeter. Theoretical findings are substantiated with experimental results.

The distance d which is the separation of the two radiation centers, determines the maximum angle over which flat response can be maintained when the upper frequency limit is given. θ is the angular separation of the two mean sound paths l_1 and l_2. With conventional, direct-radiator tweeters and a listener distance greater than ten feet, this angle is in the order of magnitude of one degree. If we were to make sure that no major interference takes place within a given listener angle α, the difference in path length l_1' and l_2' should never be larger than one-half wavelength at the highest frequency of interest. This can be written as:

$$l_1' - l_2' \le \frac{\lambda}{2}.$$

The path length l_1' can be obtained from the relationship:

$$l_1' = \sqrt{(l_2')^2 + d^2 + 2l_2'd\cos\beta}$$

where β is the parallelogram angle which, for practical purposes, is nearly equal to the listener angle α when this angle is comparatively large.

Actually, there is a much simpler way of finding the path length difference $\Delta = l_1' - l_2'$. For normal listening distances (usually over 10 feet) an arc drawn through point D (Fig. 2) with the origin at point A' can be considered a straight line over the portion DE. Furthermore, triangle CDE can be considered a right-angle triangle of equal sides to a very close approximation when $\alpha = 45°$ and listening distances are in the order of magnitude of 10 feet or greater. Under these conditions

$$d = \sqrt{2\Delta^2} = \sqrt{2\left(\frac{\lambda}{2}\right)^2} = \sqrt{\frac{\lambda^2}{2}}.$$

In the case of a minimum required response of 10 kc at 45° listener angle, maximum displacement d permissible is about 0.95 inch or a diaphragm width no greater and preferably less than 1.9 inch. If the response is to be extended to 20 kc, the diaphragm width should not be greater than 0.95 inch. The diaphragm dimensions in the vertical direction can be considerably larger due to the smaller angular dispersion requirement.

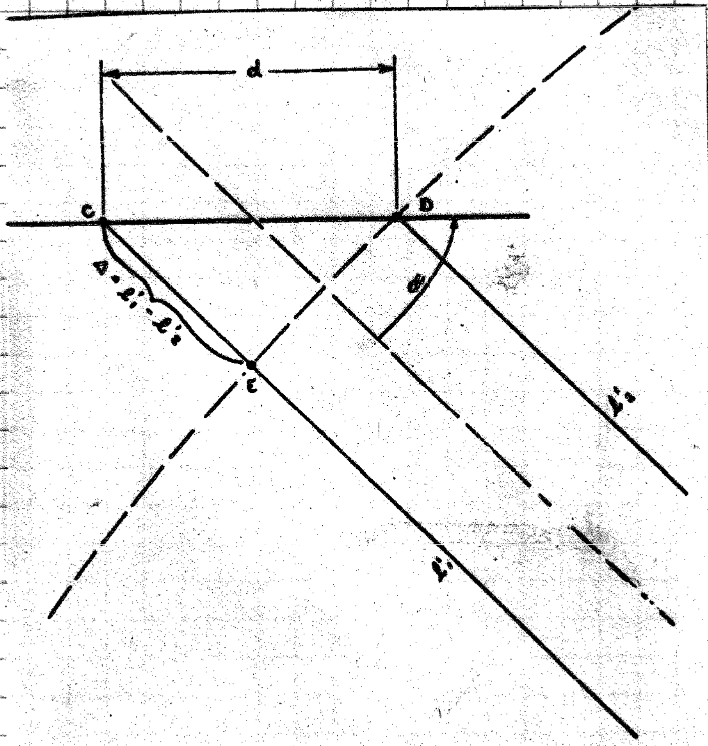


Fig. 2—Diagram illustrating approximate method for evaluating path length difference.

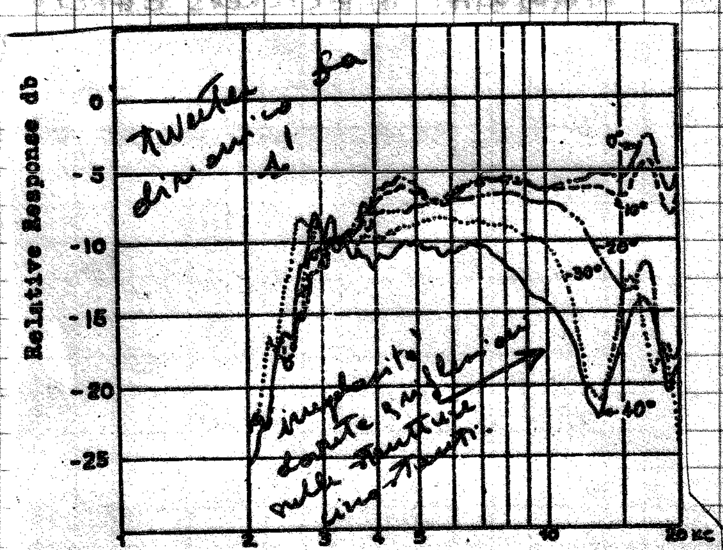


Fig. 4—Polar response, 1 inch dia ("point-source") tweeter.

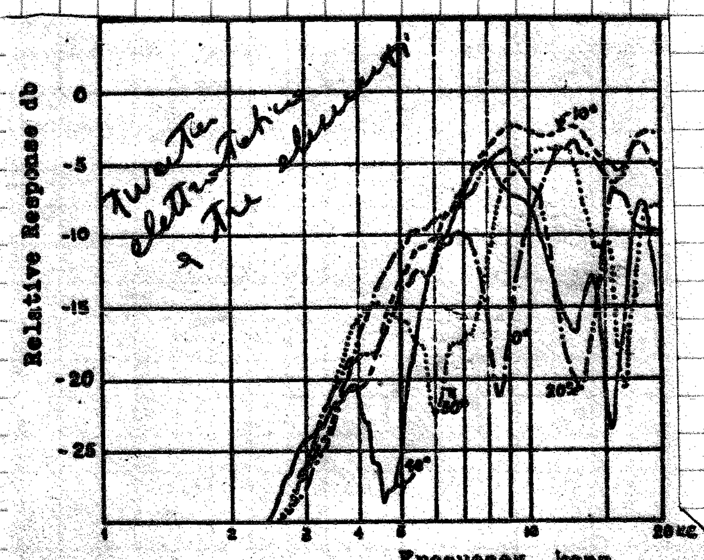


Fig. 3—Polar response, three-element electrostatic loudspeaker.