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LOCALIZATION OF LATERAL PHANTOM-SOURCES

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LOCALIZATION OF LATERAL PHANTOM-SOURCES

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Introduction

More research has been conducted recently to determine which phantom source locations, using the usual loudspeaker arrangement "Δ", can be applied to quadrophony: reminiscent for example of the groundwork done by Ratliff (1) which was presented to the A.E.S. Conference in London in 1975. This research which extented only to loudspeaker arrangements symmetric to the median plane or ear axis, resulted in the conclusion that an 'all round effect' cannot be produced with the usual quadrophonic loudspeaker arrangement. This is proved clearly by the result of Ratliff's experiment (fig.1).

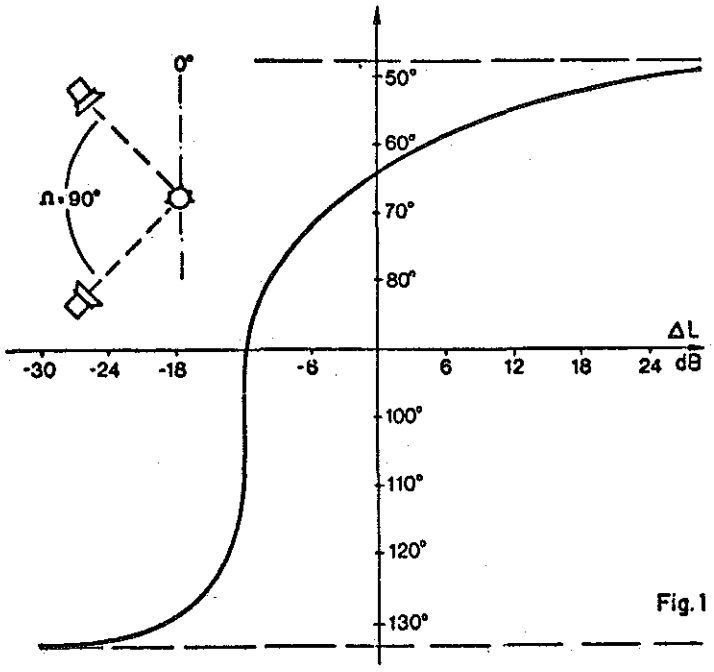


Fig.1

It shows that an uniform distribution of phantom sources lateral to the listener, with the loudspeakers $L_F + L_R$ and $R_F + R_R$ respectively, is not possible. It shows that even small level differences between the loudspeakers lead to large angle changes and that localization jumps here and there between the loudspeakers at the front and at the back.

Design of experiments

As it is not possible to achieve the desired 'all round effect' with the usual positioning of the loudspeakers, a divergent solution had to be investigated. Beforehand however, it had to be thoroughly examined which phantom sources result in loudspeaker arrangements which are asymmetrical to the median plane.

In doing so the following limitations were made in the research programme:

1) Signal differences between the loudspeakers were differences in level, the time differences were consciously omitted as they do not occur in the usual stereo/quadrophony recording process (Intensity Stereophony).

2) The level differences always refer to the total signal. Frequency dependent differences were not examined.

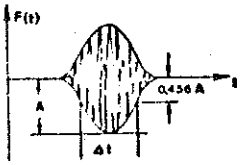
3) The number of loudspeaker wad limited to two.

4) The loudspeaker aperture was always $\Omega = 60^{o}$, corresponding to the optimal value in two chanel stereophony. Larger angles lead to inadmissable angles of elevation of the phantom source, smaller angles lead to a too large number of loudspeaker (> 6) when trying to achieve an 'all round effect'.

5) The lateral displacements of base centre were $\delta = 0^{o}$ (control value) 20^{o}, 40^{o}, 60^{o}, 80^{o}, 90^{o}, (lateral, ear axis), 100^{o}, 120^{o} (ref. 0^{o} straight ahead)

6) It was taken that the results were equal for left and right (symmetric to the median plane) and for back and front.

7) The signals were either Gaussian noise impulses, band limited noise 0,6 - 10 KHz, or continuous speech.



8) The loudspea kers were always two metres distant from the observer.

9) The measurments were taken in an echo free room.

Method

To elucidate, Fig. 2 shows a typical arrangement (lateral displacement of base centre $\delta = 40^{o}$). The determination of sound sensation (position of phantom sources) was made with the help of an asoustic indicator. A variable angle of incidence of a reference signal (noise impulse) was varied until the direction of sound sensation to be measured agreed with the direction of sound sensation of the reference signal. This method has the advantage that only the aural sense is required and so mistakes made through the introduction of other senses, such as are made in the 'Report Method', - indicating with the finger or arm, nodding the head or body in the direction being listened to, etc., are avoided. It is also possible to include the area behind the listener by using the purely acoustical method. A requirement is a dardened room.

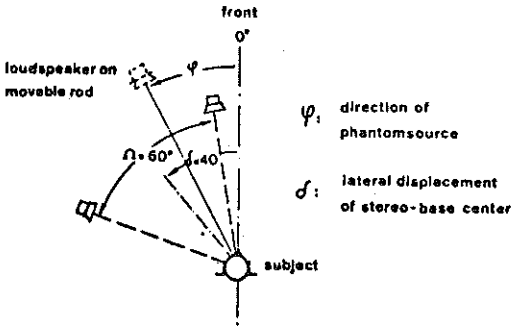


Fig. 2

The location of the phantom source is dependent on whether or not the head of the listener is fixed. In order to exclude all other acoustical influences which could occur when the subjects head is held still in one position, the subjects were askes to look at a light source through two slits in a mask. Even by a tiny movement of the eye or head, the source could only be seen from one eye or not at all.

The loudspeaker pairs with differing lateral displacements of base centres were given the subjects in random order, as were the level differences ΔL between the loudspeakers. These had the values of 0dB to $\pm$ 18 dB in steps of 3 dB and $\pm$ ∞ (real sources, one loudspeaker).

Results

The diagrams 3 - 7 show results of the measurements taken. Shown are the median values and the quartils. Diagram 3 shows a comparison of the already known values for normal stereo arrangement $\delta = 0^0$ after Mertens (2), Wendt (3) and Ratliff (1) and our own control measurments. Inspite of the different signals, the results are very similar.

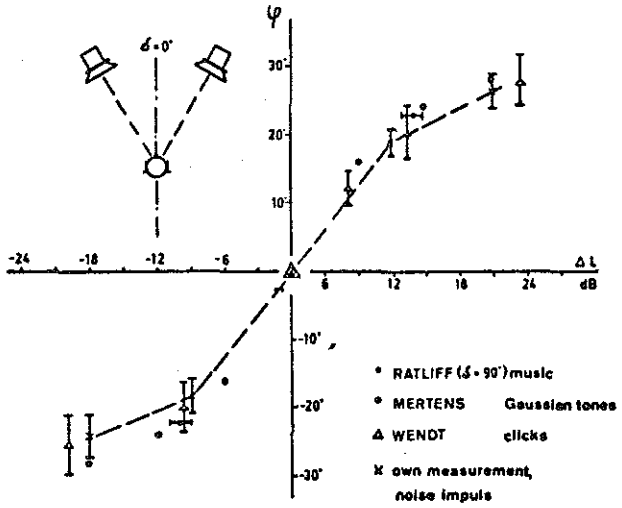


Fig.3 Direction of phantomsource

The diagrams 4 - 6 show the results for $\delta = 40^0, 60^0, 80^0$.

One can see that :

1) The level difference $\Delta L = 0$ does not produce a phantom source located at base centre.
2) The slope of curve increases with $\delta \rightarrow 90^0$, i.e. the production of the sound sensation between the loudspeakers became more difficult as a larger area of angle with smaller level differences had to be covered.
3) The quartils, that ist the interindividual variations, become larger with $\delta \rightarrow 90^0$.

Finally, diag. 7 shows the results for $\delta = 90^0$. The variations are extremely large, as is the slope of the curve. 6 dB level differential led, by an aperture of 60^0, to an angle displacement of over 40^0, with $\delta = 0^0$ 6 dB causes about 14^0 displacement.

The conclusion to be drawn from the last result for $\delta = 90^0$ is that in the search for a loudspeaker arrangement which allows an 'all round effect' the directions right and left on the lateral (90^0) must be represented trough real sources. From this it can be seen that if an aperture of up to 60^0 for the pair of loudspeaker is allowed there

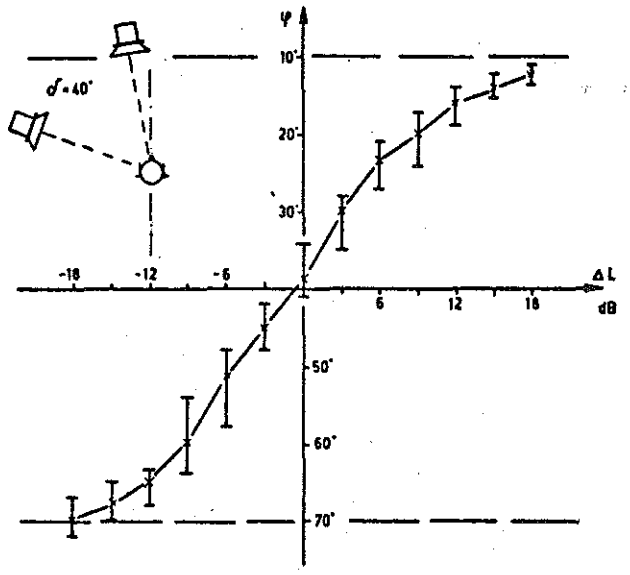


Fig. 4

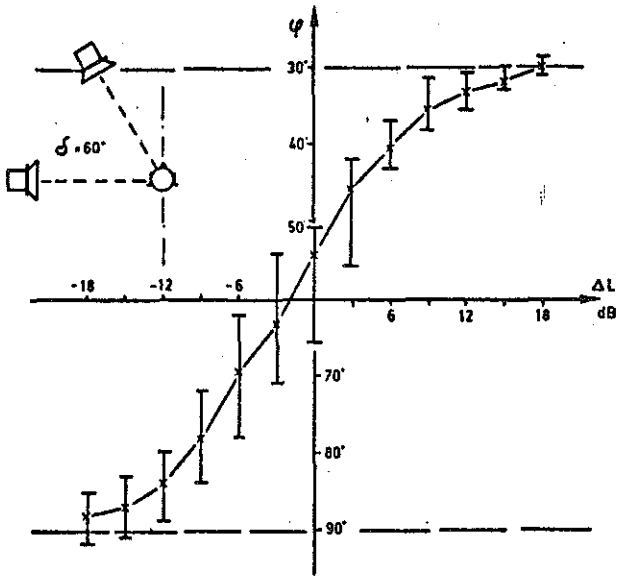


Fig. 5

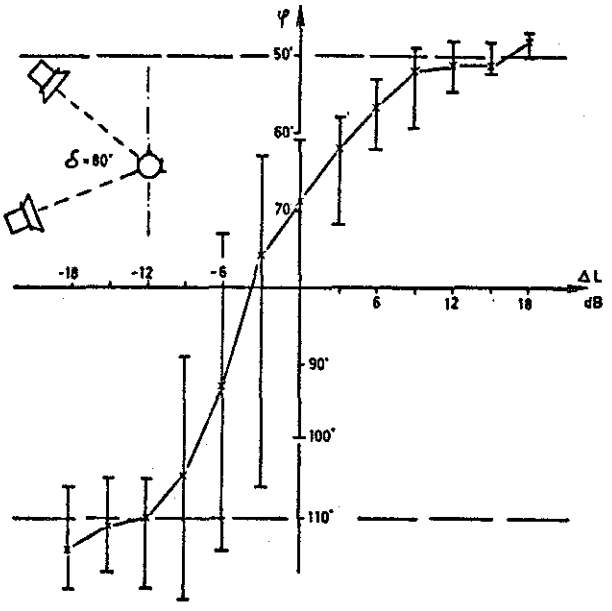


Fig. 6

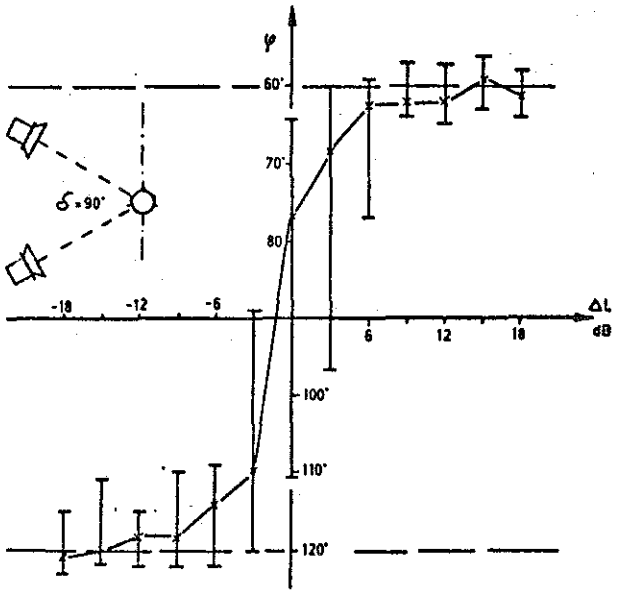


Fig. 7

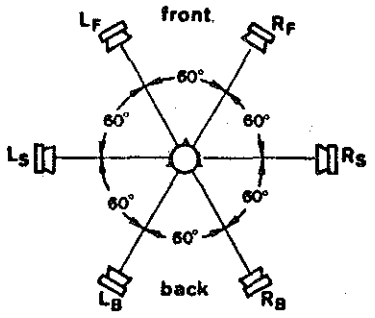


Fig. 8

results the following arrangement: (fig.8). Together with that the localization values in the suggested loudspeaker arrangement should be examined. Those localization curves necessary for the production of the 13 sound sensations 0^0, 15^0, 30^0, 45^0, ... 180^0 were taken from those chanel level differences of $\delta = 0^0$, 60^0, 120^0, 180^0.

φ desired	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
δ	0°	0°	0°	60°	60°	60°	60°	120°	120°	120°	120°	180°	180°
ΔL [dB]	0	-7	-∞	+4	-2	-8	-∞	+9	+5	-1	-∞	-7	0

These settings should be offered to the subject and, in addition to the signal used in the first experiment (noise Δf = 0,6...10 kHz), speech.

The table shows clearly once again:

1) That only for the direction $\varphi = 0^0$ and $\varphi = 180^0$, (base centres) the level differences are equal ΔL = 0dB.
2) For the other base centres varying values apply (-2 dB d + 5 dB); the localization of the lateral phantom sources occur asymmetric in relation to the ear axis.

In this experiment the acoustic indicator was not used but the subjects were asked to note the percives sound direction on a printed sheet of paper (Fig. 9). The loudspeaker were hidden by an acoustically permeable curtain. This method also provided well reproducable results, as the research by Plenge et al.(4) had already shown.
The results are shown in diagram 10 for noise impulses. Diag.11 shows those for male speech.

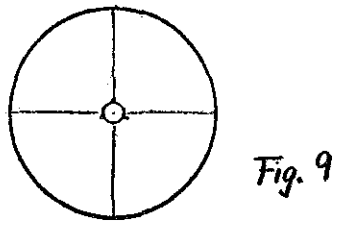


Fig. 9

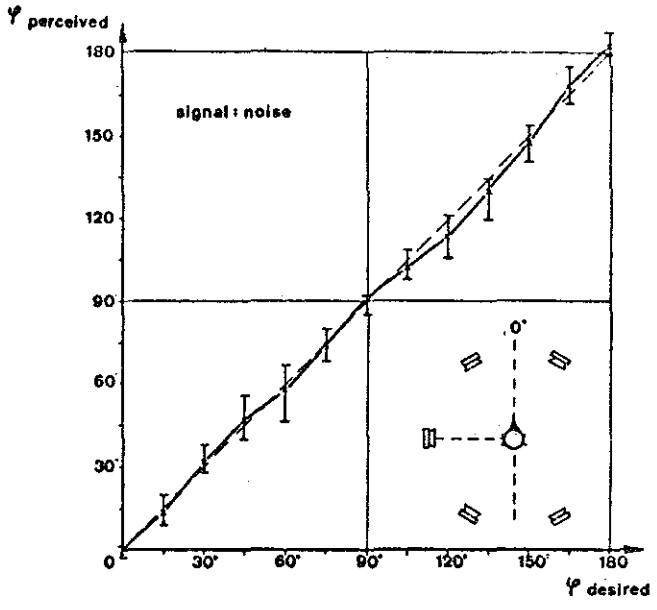


Fig. 10

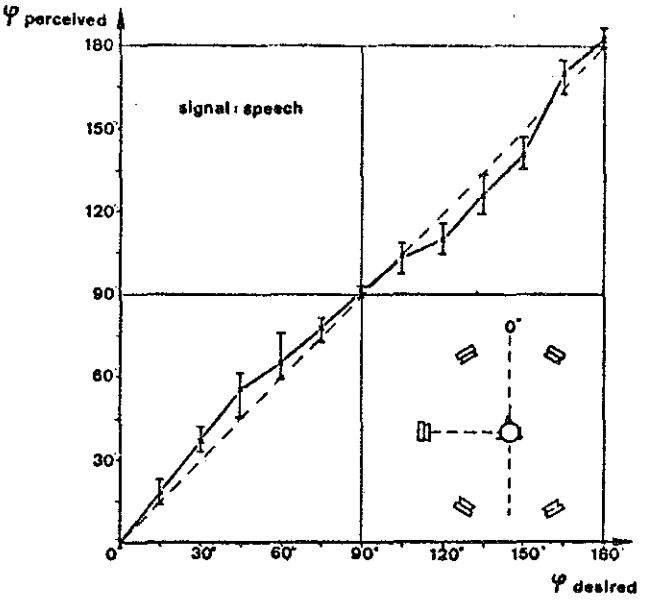


Fig. 11

The application of this loudspeaker arrangement for quadrophony could occur in the following manner without increasing the number of channels for transmission and storage and without loss of information by means of a matrix process.

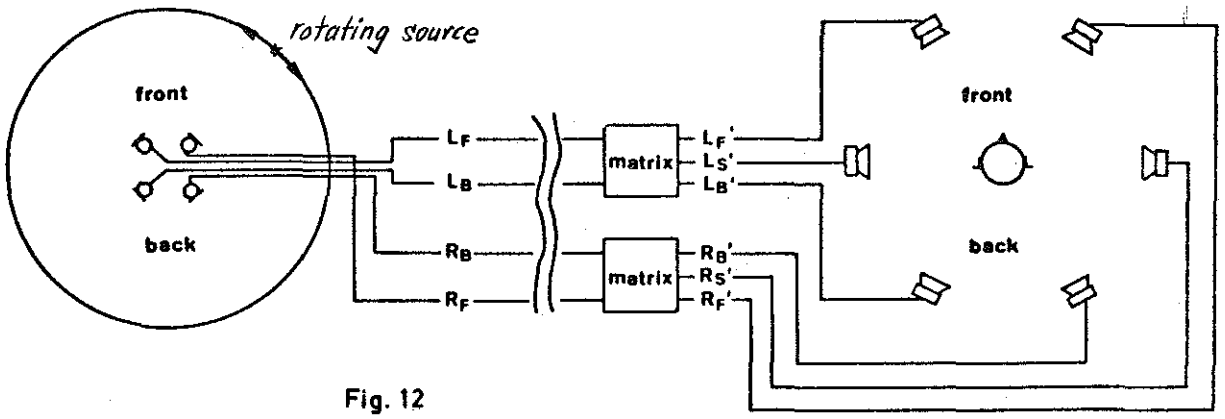


Fig. 12

Each of the front and back transmission channels of one side are led into a matrix, which isolates the coherent signal parts dependent on their level relation. At full coherence and level equality (lateral source 90°) the signal pair L_F / L_B and R_F / R_B respectively are blended out of the transmission channels; they appear completely in the lateral support chanels L_S' and R_S' respectively. The support signal appears so much weaker the smaller the coherence or the larger the level difference. This happens in the case of coherence corresponding the localization curves for $\delta = 60^0$ and $\delta = 120^0$.

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