THE STEREOPHONIC ZOOM : A PRACTICAL APPROACH TO DETERMINING THE CHARACTERISTICS OF A SPACED PAIR OF MICROPHONES

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THE STEREOPHONIC "ZOOM"

- A practical approach to determining the characteristics of a spaced pair of directional microphones -

The intensity and time differences for a spaced pair of cardioïde microphones can be calculated as a function of sound source position and, various spacing and angles between the microphones. This information, together with the physiological limits of the stereophonic listening situation, enables a usable angle for coherent stereophonic recording (recording angle) to be determined. For the same recording angle, different values of spacing and mic angle enable the sound engineer to choose the subjective stereophonic quality desired.

In the field of monophonic sound recording, the sound engineer has considerable freedom to choose the microphone position according to the sound quality desired. The relationship between the distance of the microphone from the sound source, its frequency response curve, and the amount of "presence" required is easily appreciated; and the different microphone directional characteristics available, also enable the ratio of direct to indirect sound to be easily optimized.

This is unfortunately not the case in stereophonic sound recording. Microphone position is generally a compromise between a good coherent stereophonic image and the required amount of presence. My aim in presenting this paper is to try and restore a certain amount of freedom of choice to the sound engineer by showing a way of varying the characteristics of a spaced pair of cardioide microphones to suit different recording situations and to show the way in which subjective stereophonic quality can also be varied independently of other factors.

Using a spaced pair of high quality condenser microphones with cardioïde polar diagrams, it is possible to calculate the Intensity Difference (ΔI) and Time Difference ($\Delta \tau$) for various positions of the sound source, as a function of the angle between the microphones and the distance between them. The relationship between intensity difference, sound source position, and microphone angle for a coincident pair of cardioïde microphones is given in the following diagram (Fig. 1).

Using a spaced pair of omnidirectional microphones the relationship between time difference and sound source position can also be determined as a function of different spacing between the microphones (Fig. 2).

If one now combines these two functions in a spaced pair of cardioide microphones, with intensity difference and time difference as a function of spacing and microphone angle, one obtains a whole series of functions. A few examples of different microphone spacings (12cm, 17cm, 22cm, 30cm and 40cm) are illustrated in Figs. 3, 4, 5, 6 and 7.

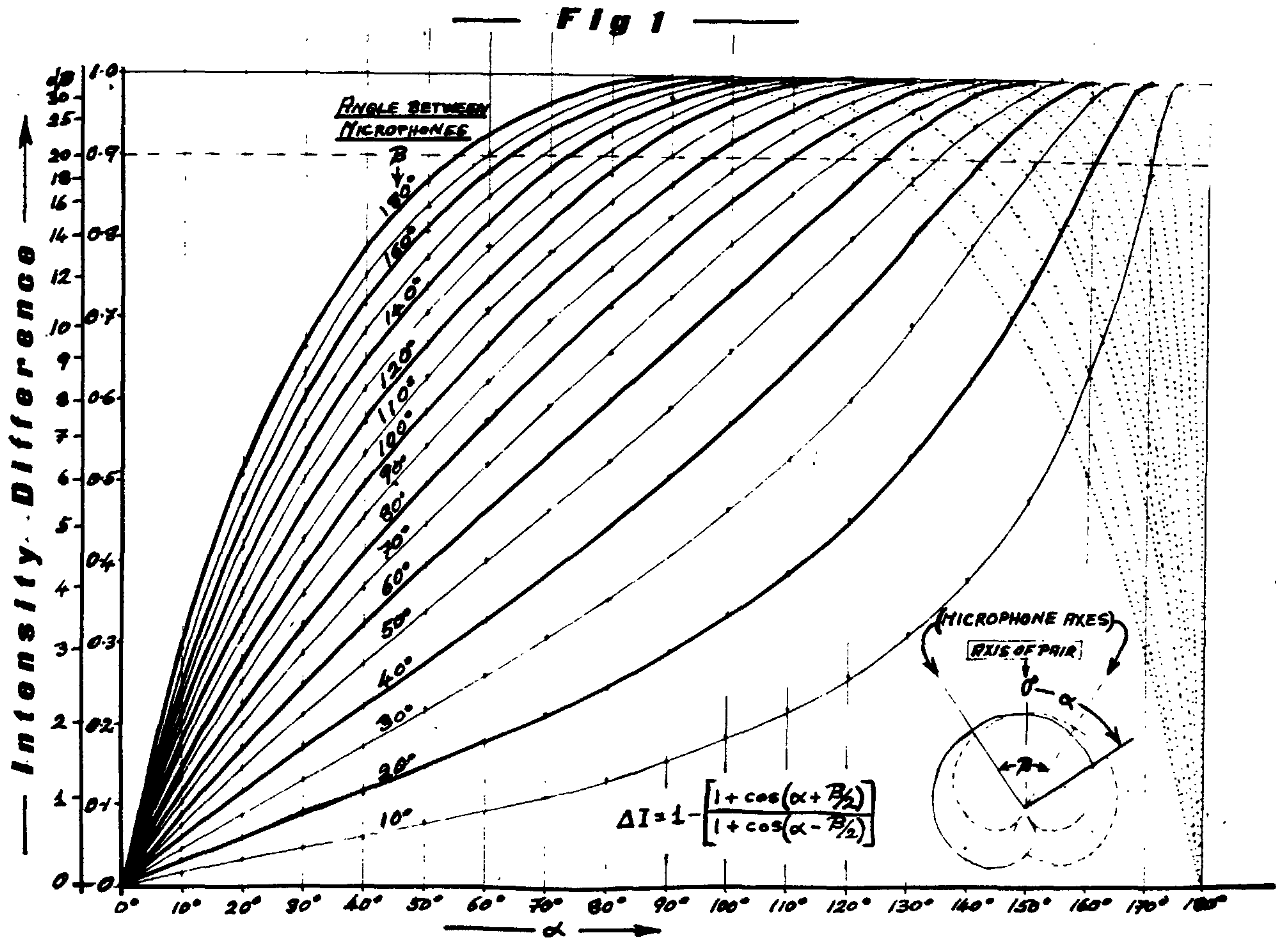
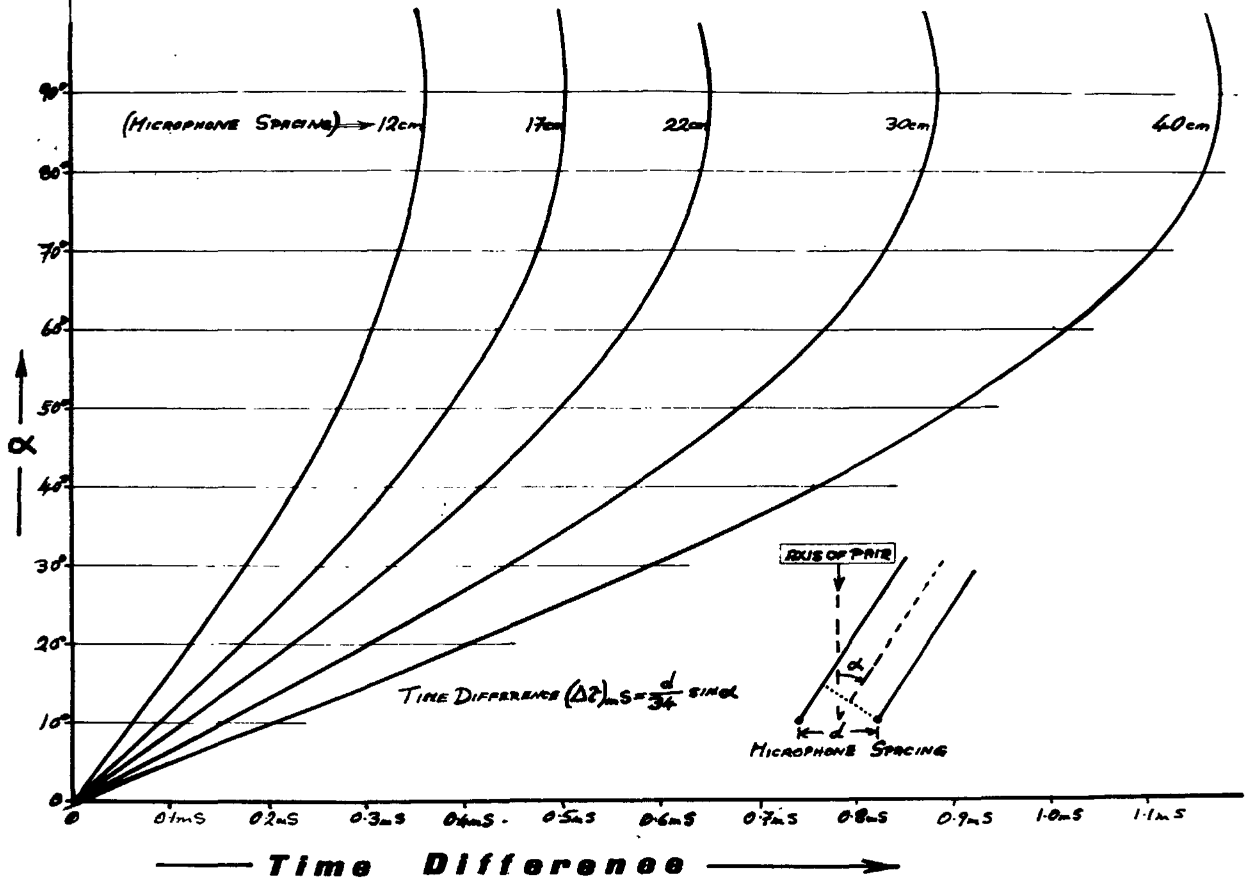
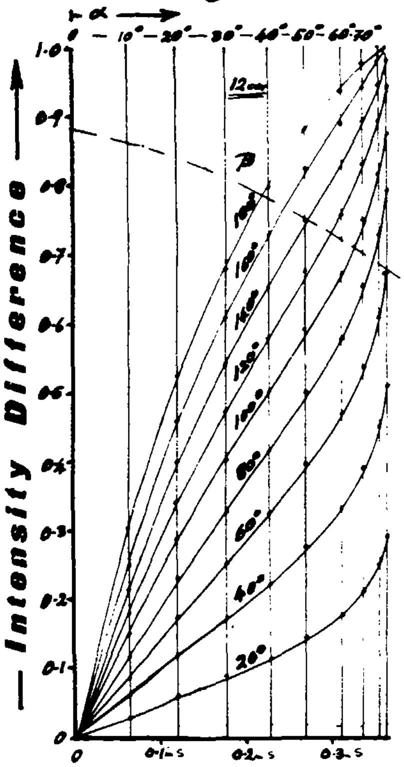


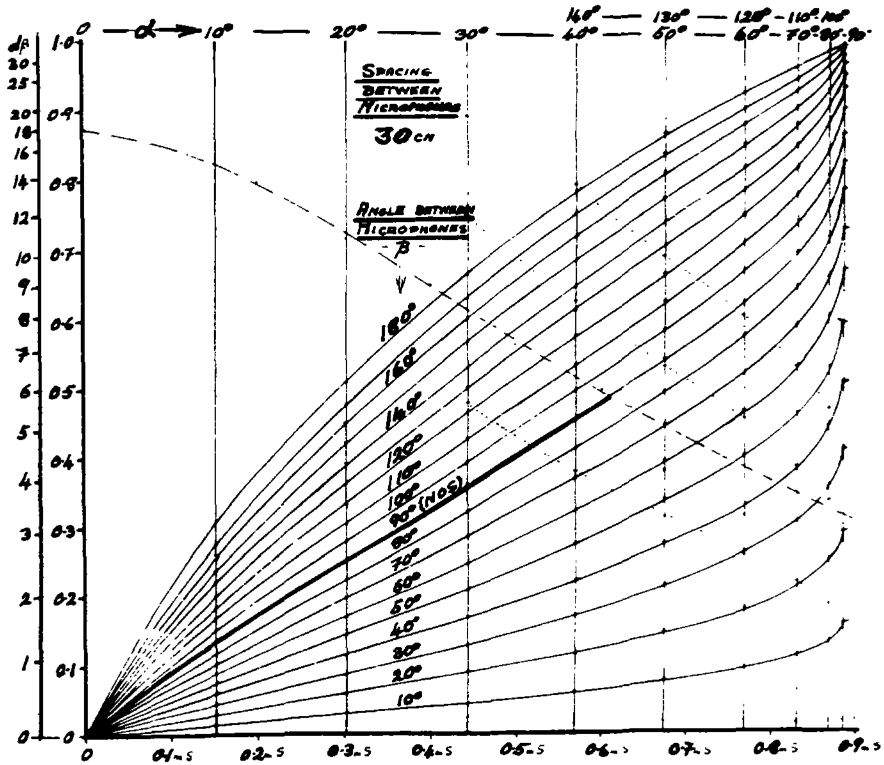
Fig 1
ANGLE BETWEEN MICROPHONES
β
180°
160°
140°
120°
110°
100°
90°
80°
70°
60°
50°
40°
30°
20°
10°
Intensity Difference
db
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
30
25
20
18
16
14
12
10
9
8
7
6
5
4
3
2
1
0
0° 10° 20° 30° 40° 50° 60° 70° 80° 90° 100° 110° 120° 130° 140° 150° 160° 170° 180°
α
MICROPHONE AXES
AXIS OF PAIR
0
α
β
$\Delta I = 1 - \left[\frac{1+\cos(\alpha + \beta/2)}{1+\cos(\alpha - \beta/2)}\right]$


(Microphone Spacing) → 12cm
17cm
22cm
30cm
40cm
90°
80°
70°
60°
50°
40°
30°
20°
10°
0
α
0
0·1mS
0·2mS
0·3mS
0·4mS
0·5mS
0·6mS
0·7mS
0·8mS
0·9mS
1·0mS
1·1mS
Time Difference (Δτ)mS = d/34 sin α
Axis of Pair
α
d
Microphone Spacing
Time Difference

— Fig 3 —

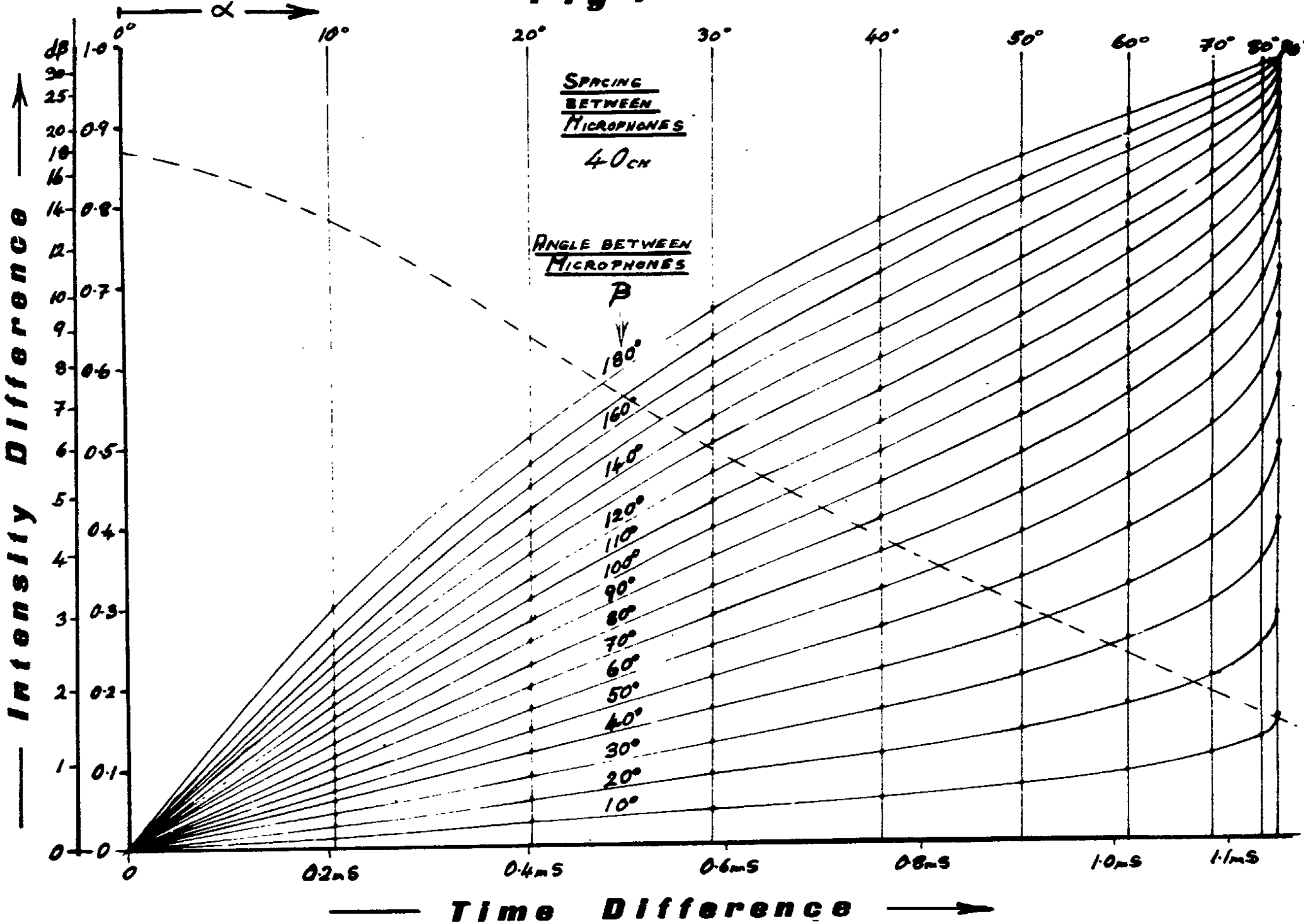
— Fig 6 —





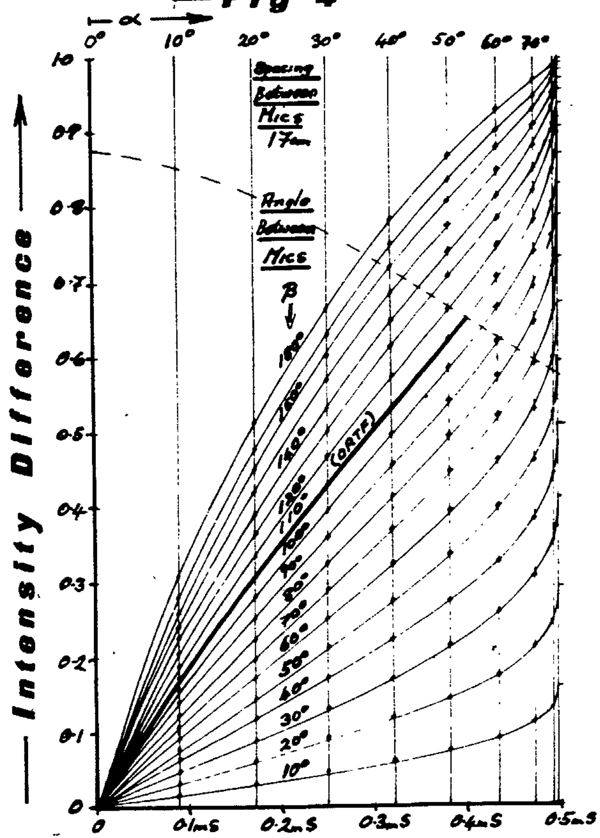
— Time Difference —

Fig 7

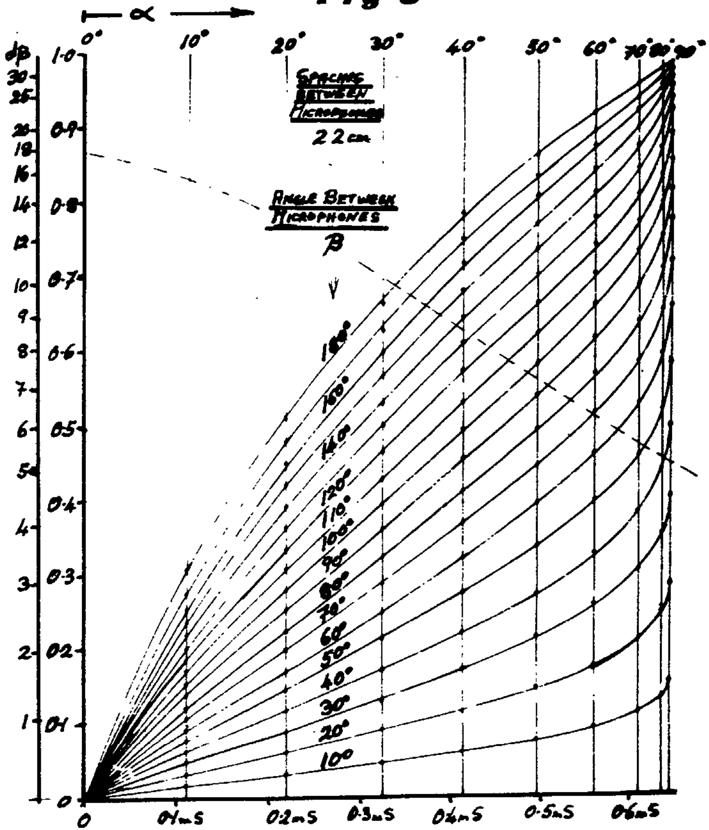


α
0° 10° 20° 30° 40° 50° 60° 70° 80° 90°
SPACING BETWEEN MICROPHONES
40 CM
ANGLE BETWEEN MICROPHONES
β
180° 160° 140° 120° 110° 100° 90° 80° 70° 60° 50° 40° 30° 20° 10°
dB
0 1 2 3 4 5 6 7 8 9 10 12 14 16 18 20 25 30
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Intensity Difference
0 0.2mS 0.4mS 0.6mS 0.8mS 1.0mS 1.1mS
Time Difference

— Fig 4 —

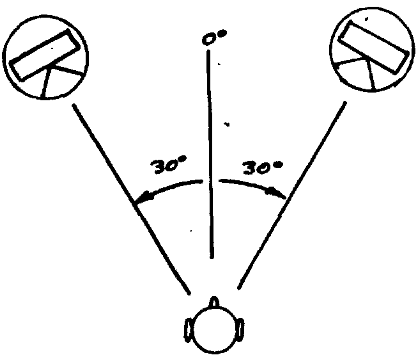


— Fig 5 —

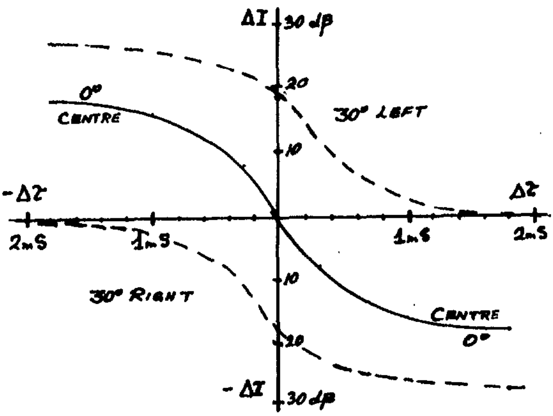


Time Difference

The dotted line in each graph represents the physiological limits of the listening situation considered (Fig. 8) i.e. the time and/or intensity difference necessary to give the impression that the sound is coming completely from one loudspeaker or the other. The complete relationship between ΔI and $\Delta\tau$ for 30° right, 30° left and mid position 0° is given in Fig. 9.



- Fig. 8 -



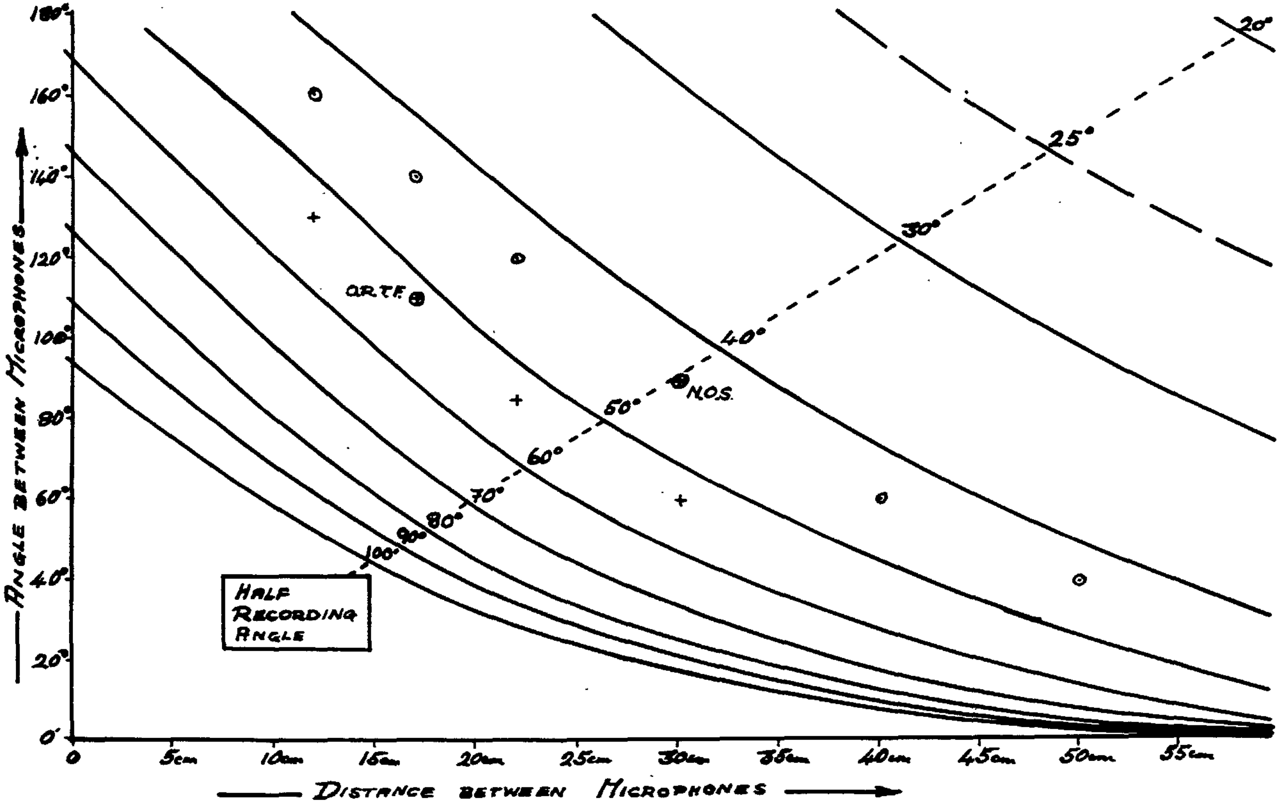
- Fig. 9 -

It is now possible to use Figs. 3 to 7 to determine the usable angle for coherent stereophonic recording (recording angle) for a spaced pair of cardioïde microphones for different distances and angles between microphones.

For instance in Fig. 4, one can see that with spacing of 17cm and 110° angle between microphones, the half recording angle is about 55°. However, the same recording angle can be obtained with 12cm 130° (Fig. 3), 22cm 80° (Fig. 5), 30cm 60° (Fig. 6), 40cm 40° (Fig. 7), etc. The relationship between this "recording angle" and the values of spacing and mic angles produces the following graphical representation (Fig. 10).

One can deduce from this graph that the "recording angle" can be varied by keeping one of the axes (α or β) constant and varying the other, or by gradually varying both. This situation is somewhat similar to the zoom lens of a television or film camera. For instance, starting with 15 cm 45° and gradually changing to 60 cm 175° one "zooms" from a total recording angle of 200° (wide angle lens) to a recording angle of 40° (narrow angle lens).

Fig 10



180°
160°
140°
120°
100°
80°
60°
40°
20°
0°
Angle between Microphones
0
5cm
10cm
15cm
20cm
25cm
30cm
35cm
40cm
45cm
50cm
55cm
Distance between Microphones
Half Recording Angle
100°
90°
80°
70°
60°
50°
40°
30°
25°
20°
O.R.T.F.
N.O.S.

A whole series of combinations of distance and mic angles are possible for a given recording angle. For instance, for a total recording angle of 90°, the following combinations are possible : 12cm 160°, 17cm 140°, 22cm 120°, 30cm 90° (NOS), 40cm 60° and 50cm 40°. For adjacent "equivalents" the difference in subjective quality is quite difficult to determine. However, if extreme equivalents (12cm 160° as against 40cm 60°) are compared, the listener can begin to feel the subjective contribution of intensity differences as against time differences. The final choice is of course a personal one and long may it remain so!

It is common practice in recording a symphony orchestra to place an additional stereophonic pair well behind the main recording microphone pair in order to "open up the sound". It is obvious that the recording angle of this additional pair must be carefully determined so as not to mix up the main stereophonic image or create a double image. For instance if a 17cm 110° pair is used (total recording angle of 100°) in its normal position in front of the orchestra and another pair is placed 8 metres further away,,it must cover a recording angle of only 60° (from Fig. 10 the values of spacing and mic angle can be determined for a recording angle of 60°), i.e. 25cm 180°, 30cm 165°, 40cm 130° or 50cm 100°.

Conclusion

In a given situation, a microphone pair can be placed at the optimum distance from the sound source. The values of spacing and mic angle can then be determined in relation to the stereophonic image to be reproduced. Desired subjective recording quality is then just a question of comparing various constant recording angle equivalents.

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