281-4930

M-S STEREO RECORDING TECHNIQUES

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Placement of microphones for stereophonic recording is an art whose object is the recreation of the natural tonal balance and spatial distribution of the original sound source and its acoustic environment. There are two broad systems of stereophonic recording techniques used to attain these objectives. The time intensity system uses spaced microphones in which the stereophonic effect is due primarily to a difference in both the arrival time and magnitude of the sound reaching each microphone. The intensity difference system uses a pair of microphones mounted coincidentally i.e. on the same axis so that differences in the time of arrival at each microphone are negligible and the stereophonic effect depends solely on interchannel amplitude differences. (fig. 1.)

An acoustic source picked up by a pair of directional coincident microphones can be recorded as mid-side (M-S) or left-right (X-Y) signals (fig. 2). In the M-S system one of the microphones designated as a mid microphone has a cardioid pattern which is oriented toward the sound source. The other microphone (in the AKG C-24, the top unit) has a cosine or figure eight pattern facing sideways with the null of the figure eight pattern coinciding with the main axis of the cardioid. Thus the cardioid microphone picks up the sum of all the signals present and the figure eight microphone picks up only the left and right information. The outputs of the two microphones are then sent to a sum and difference matrix. (fig. 3) The output of the matrix is a normal left and right stereo signal. The output from the sum microphone yields a compatible monophonic signal without the phase cancellations present when spaced microphones are mixed. By attenuating either the mid or side signal before they are matrixed the width of the sound source can be increased or decreased respectively.

In the X-Y technique of intensity stereo recording, a pair of identical directional microphones are inclined to the left and right of the sound source. The principle axis of each microphone is usually set up at an angle of 45 to 60 degrees to the direction of the sound source. The polar patterns of the two microphones can be set at cardioid, figure eight, or in between depending upon the room acoustics and the properties of the sound source. The scale of width of a left - right pair can be varied by converting the output to M-S through matrixing, attenuating the M or S signal, then converting the M-S signal back to a left - right output with another matrix. In principle, both techniques of M-S and X-Y recording are equivalent and each signal can be transformed to the other by means of matrixing (sums and differences).

Figure 4a shows the polar diagrams for pairs of coincident microphones with different directional characteristics and figure 4b shows their M-S equivalents after matrixing. The polar patterns from top to bottom are figure of eight, hypercardioid, cardioid, all at 90 degrees, and cardioid at 180 degrees (back to back). Except in the case of the cardioids at 180 degrees, the M signal is relatively "dry" and the S signal contains most of the reverberation.

To show the actual results obtained from matrixing the outputs of microphones with normally used directional characteristics, a mathematical analysis is required.

The general equation for the output of a directional microphone from a sound at an angle γ expressed in polar coordinates is

$$R(\gamma) = A + B\cos(\gamma - \alpha_o) \quad (1)$$

α_o is the angle of maximum sensitivity of the microphone.

As is well known the following patterns are described when the equation is given the respective parameters

A = 0	figure eight characteristic
B = 0	omnidirectional
B/A = 1	true cardioid
B/A = 1.94	supercardioid
B/A = 3	hypercardioid

The directional characteristic can thus be seen as the result of mixing in various proportions, the output of an omnidirectional microphone A and of a figure eight microphone B.

Bringing equation (1) to standard form with B/A = a and R/A = r and setting the output of the omnidirectional microphone to 1 (A = 1) we have equation (2)

$$r(\gamma) = 1 + a \cos(\gamma - a_o) \qquad (2)$$

this equation can be transformed to

$$r(\gamma) = 1 + x \cos\gamma + y \sin\gamma \qquad (3)$$

where $a^2 = x^2 + y^2$ $\qquad a_o = \text{arctg } \frac{x}{y}$

Equation 3 shows that any general cardioid pattern can be built up from the output of an omnidirectional microphone (r = 1) and of two figure eight microphones at right angles to each other in the main axes ($r = x \cos\gamma$, $r = y \sin\gamma$)

X-Y stereophony

The equation for two crossed cardioids offset by 90 degrees to each other is from eq. 2.

$$r(\gamma)x, y = 1 + \cos(\gamma - (90 \pm \frac{\pi}{4})) \qquad a=1,\ \text{tg}a = 1$$

transformed into the form of eq 3 where $x=y=\sqrt{2}/2$, the output of the microphone is

$$r(\gamma)_{xy} = 1 + \sqrt{2}/2 \ \sin\gamma \pm \sqrt{2}/2 \cos\gamma$$

when transformed by a matrix, the sum or M signal in standard form is

$$r(\gamma)\ M = 1 + \sqrt{2}/2 \ \sin\gamma \qquad (A=2)$$

the difference or S signal in standard form is

$$r(\gamma)\ S = \sqrt{2}/2 \cos\gamma \qquad (A=2)$$

The directional characteristic of the M microphone in an equivalent MS system corresponds to a cardioid with a predominant omnidirectional share and a front to back ratio of 15 dB. In the case of the AKG C24 stereo microphone this corresponds to the position between omnidirectional and cardioid. The S signal would be that of a figure eight microphone with an output in the ratio of $\frac{1}{1+\sqrt{2}}$, that is, 7.6 dB less than the level of the M signal.

An MS microphone pair adjusted to these characteristics and levels will provide left-right signals after matrixing equal to that delivered by two

XY microphones set at $\pm$ 45 degrees and with true cardioid directional characteristics.

M-S Stereophony

In normal use a true cardioid characteristic provides the M signal and a 90 degree offset figure-of-eight pattern of identical sensitivity provides the S signal. The equation for these two characteristics according to (2) is

$$r\ (\gamma)\ M, S = 1 + \sin\gamma \pm 2\cos\gamma$$

with $x = 2$, $y = 1$, $a = \sqrt{5}$, $tg\alpha - \pm 1/2$ ($\alpha_1 = 26^\circ 36'$, $\alpha_2 = 153^\circ\ 24'$)

As a result of the formation of sums and differences (matrixing) we obtain the equation in standard form of

$$r\ (\gamma)\ XY = 1 + \sqrt{5}\cos\left(\gamma - (90^\circ \pm 63^\circ\ 24')\right)$$

which represents two cardioid shaped directional characteristics each at an angle of approximately 63 degrees to the main axis and of an approximate supercardioid shape with a ratio of omnidirectional to figure eight proportions of $1{:}\sqrt{5}$ (B/A = 2.24) this is very close to the supercardioid pattern on the S24 which has the proportions B/A = 1.94.

Thus we see that the matrixed output of an MS dual coincidence microphone will provide the same left right information as a pair of XY microphones set at an angle of 60 degrees to the main axis and having a super-cardioid directional characteristic. On the AKG C24 the two capsules would be turned $\pm$60 degrees to the axis of symmetry and the pattern selector switch set at the position between cardioid and figure eight.

A change in directional characteristics makes it possible to adjust the recording to any given room characteristics. Broadening the polar characteristics from crossed figure-eights to crossed cardioids narrows the apparent width of the sound image. At the same time it reduces the reverberation picked up from the rear. This effect is the opposite of that obtained by variation of the microphone distance since, in the latter case, moving further back narrows the source but increases the reverberation. Attenuating the M or S signal before matrixing expands or contracts the width of the image respectively with the same effects upon the reverberation as changing the directional characteristic.

Stereo requirements place a close tolerance on microphone characteristics with regard to amplitude and phase matching as well as the accuracy with which the polar response can be maintained independent of frequency. Further in using coincidence microphones, too great a distance between the two units results in time differences which lead to cancellation of certain frequencies in the compatible mono signal and time differences for sound sources above or below a point halfway between the two microphones; so that for example an actor's voice and his footsteps appear to come from different sideways points.

The C24 microphone was specifically designed for intensity stereo recording techniques. The coincident capsules are mounted with a spacing of 3.8 cm. (1½") making any differences in time between the two outputs negligible. This is crucial in maintaining separation between left and right outputs at high frequencies using the M-S technique. (Fig. 5)

Nine different directional patterns can be selected for each microphone by the pattern selector S24. These patterns are identical as to their phase relationships and sensitivity and maintain their polar characteristics independent of frequency. The patterns are omni, cardioid, figure eight and six intermediary positions. The switch on the right side of the pattern selector controls the rotatable (S) microphone system. (Fig. 6)

The stand connector is designed to facilitate rapid and accurate changeover from MS to XY stereo recording technique. A window indicates the symbol MS(2). When the stand connector(1) is rotated 45 degrees counterclockwise the symbol XY indicates the correct XY position. The upper microphone system can be rotated 180^{o} to provide any offset angle desired (Fig. 7)

See pages 9, 10, 11, 12 and 13 for technical description of AKG C-24.

Fig. 1

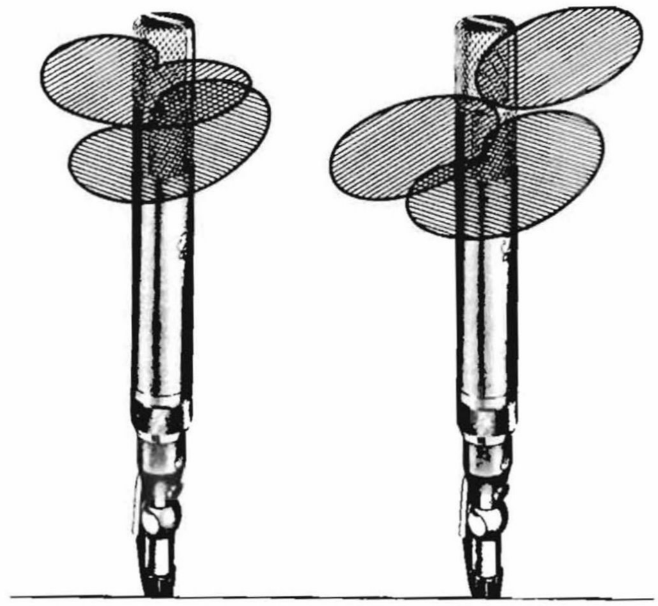
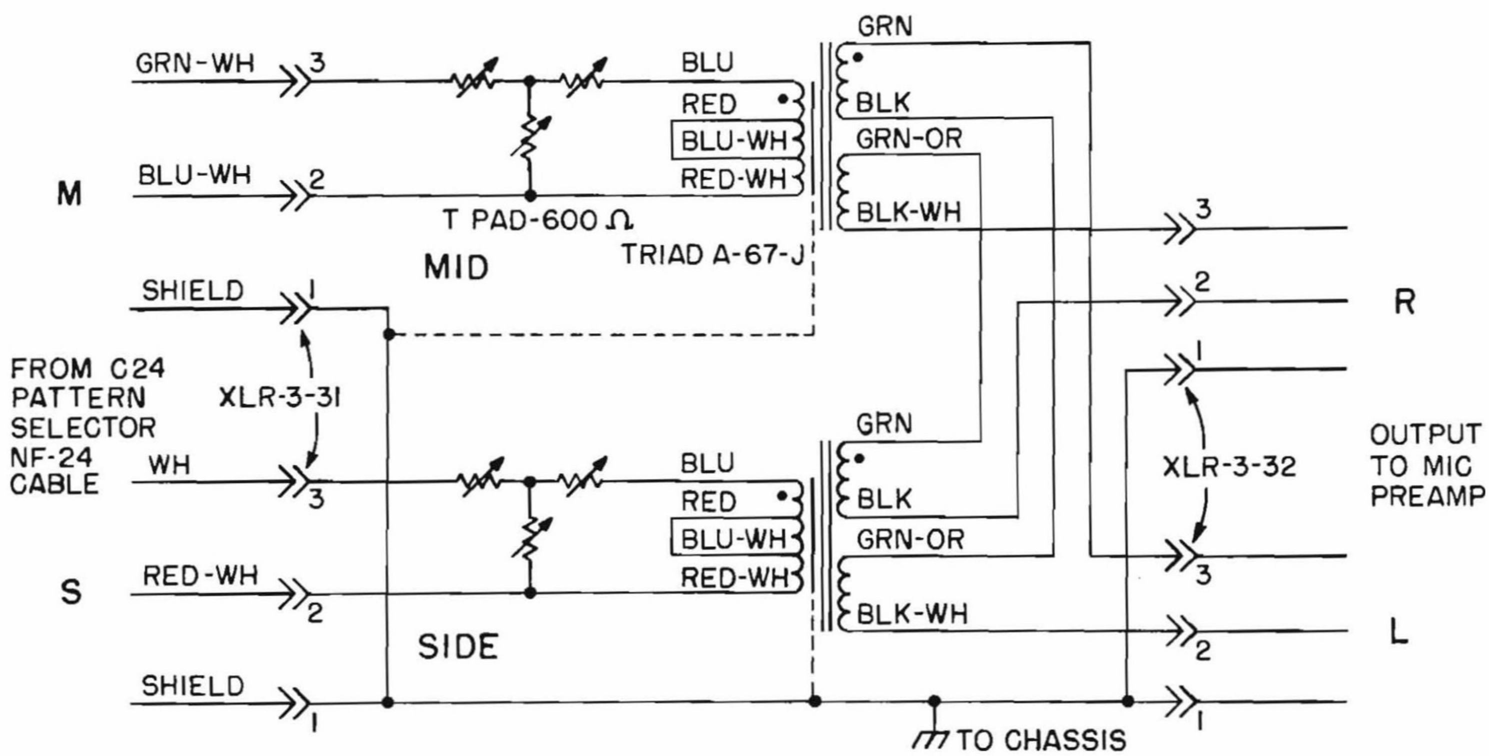
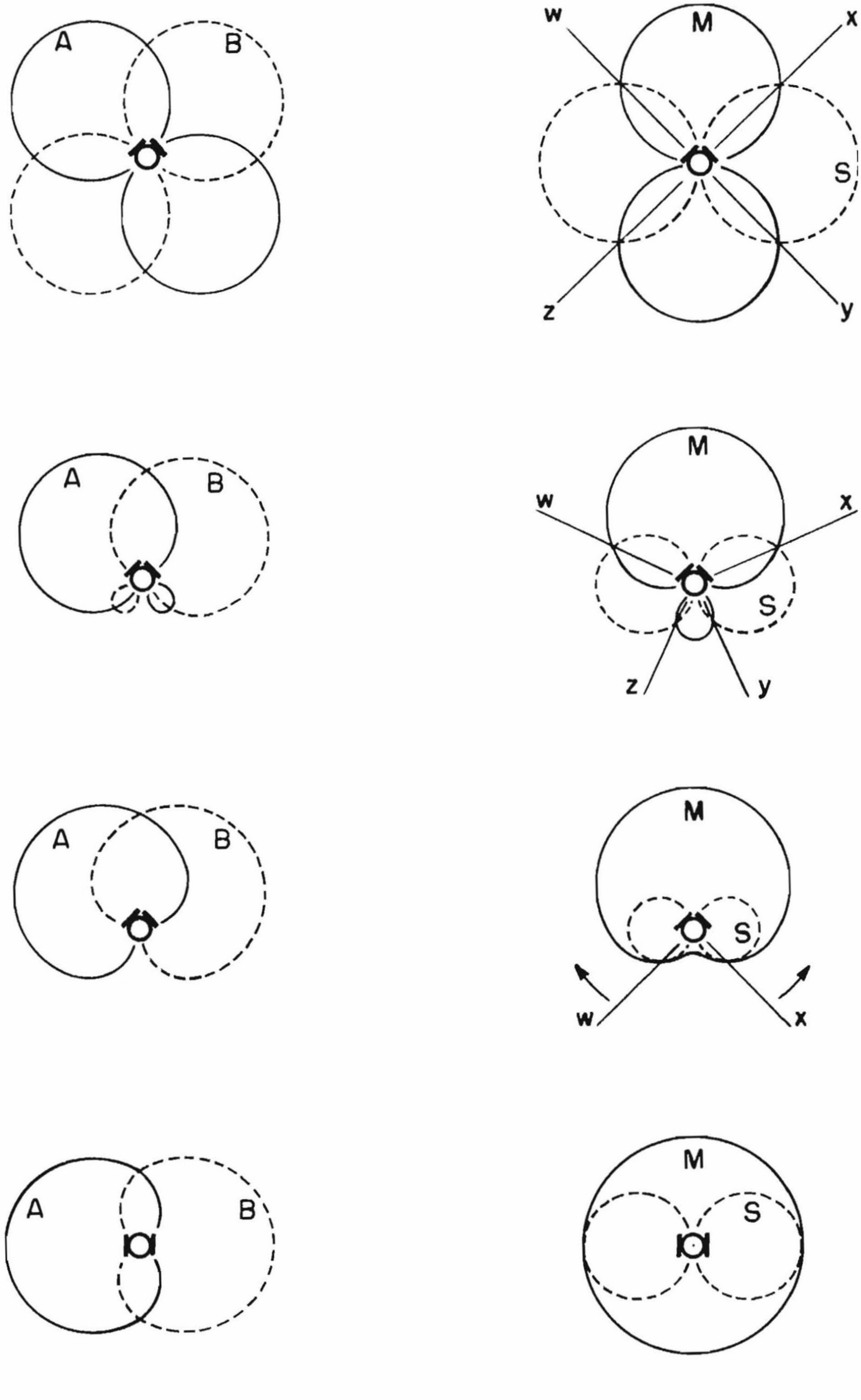


Fig. 2



MS MATRIX CIRCUIT FOR AKG C24 STEREO MICROPHONE

Fig. 3



4a Fig. 4 **4b**

Fig. 5

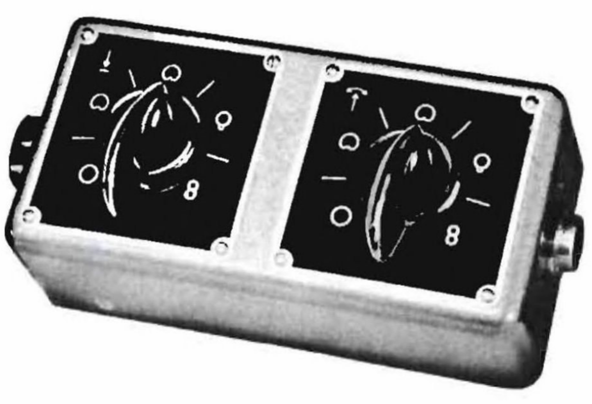


Fig. 6

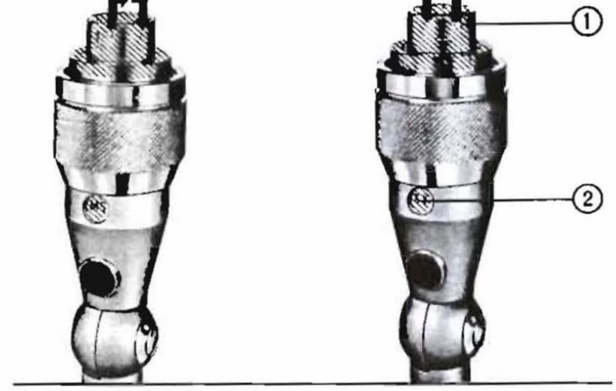


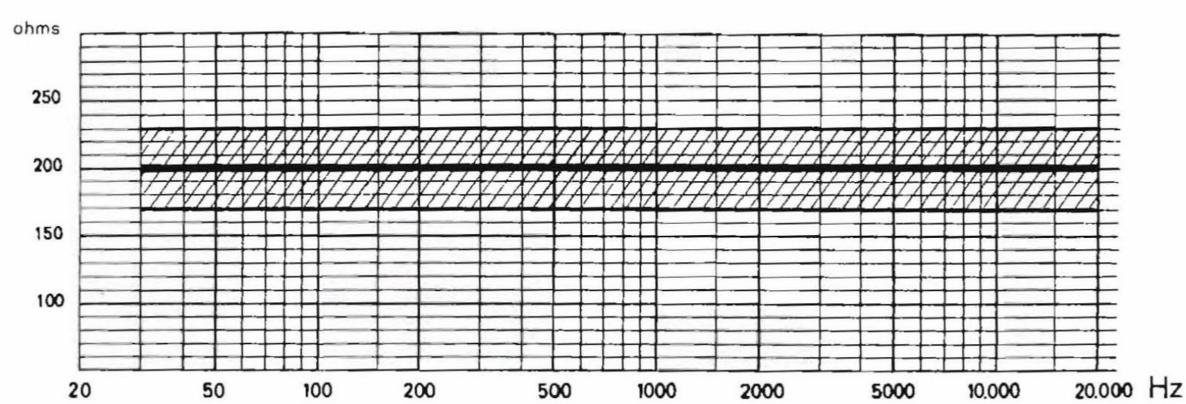
Fig. 7

TECHNICAL DATA

IMPEDANCE, VOLTAGES

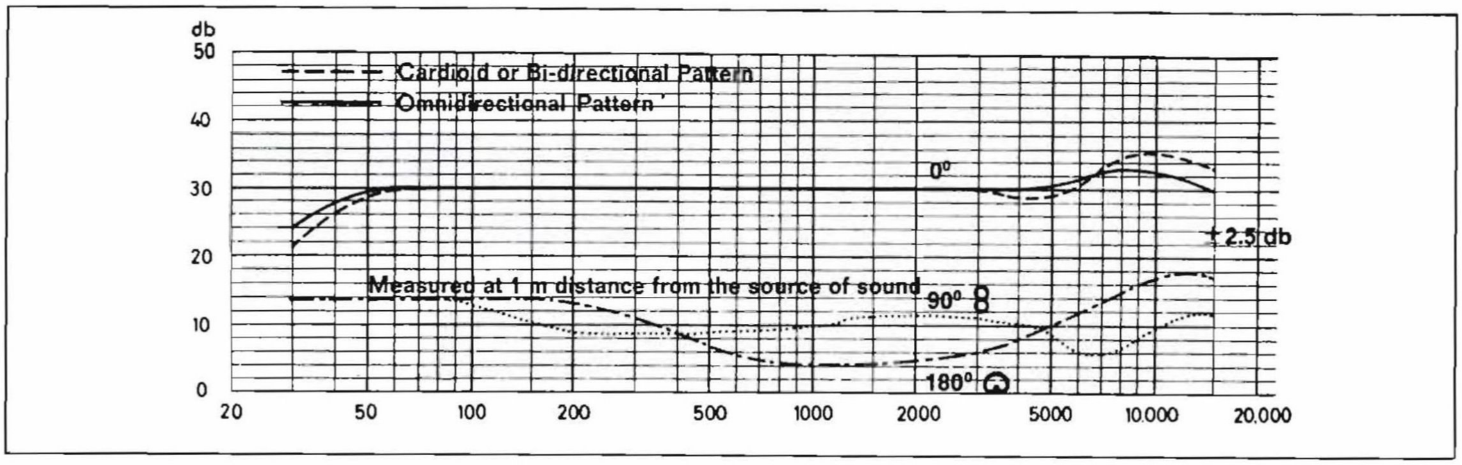
Electrical Impedance at 1000 Hz:	200 ohms ± 15%, balanced, ground-free, convertible to 50 ohms ± 15%
Impedance Response:	extremely flat over the entire frequency range
Min. Actual Load Impedance:	≧ 500 ohms (≧ 150 ohms)
Weighted Noise Level:	2.5 µveff (Filter CCIF 1954 DIN 45405)
Unweighted Noise Level:	8.0 µveff
Equivalent Noise Level:	<22 db (Filter CCIF 1954 DIN 45405)
Sensitivity to Magnetic Stray Field:	at 50 Hz: 0.06 $v/vs/m^2$ = 0.3 µv/50 m Gauss at 100 Hz: 0.5 $v/vs/m^2$ = 2.5 µv/50 m Gauss
Maximum Sound Pressure Level:	at a harmonic distortion of 0,5%: 150 µbar (117.5 db SPL)
Tube:	GE 6072
Plate Voltage:	120 v
Plate Current:	0.9 ma approx.
Filament Voltage:	12.6 v D.C.
Filament Current:	175 ma approx.
Power Supply:	220 v ± 10%, convertible to 110 v ± 10%, 50 – 60 Hz

IMPEDANCE RESPONSE

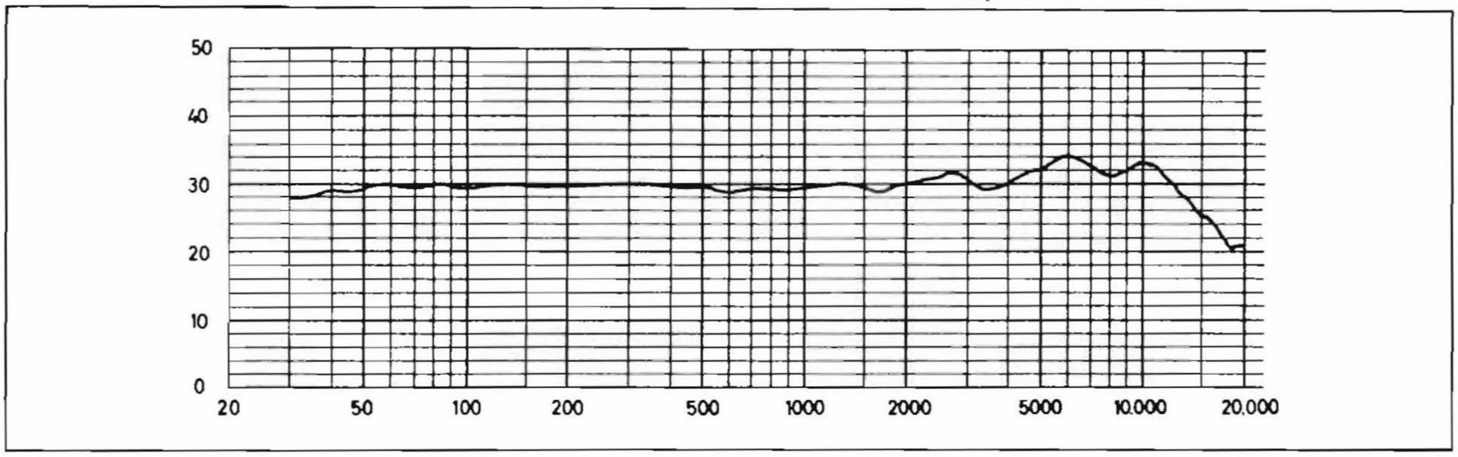


TECHNICAL DATA FREQUENCY RESPONSE CURVES:

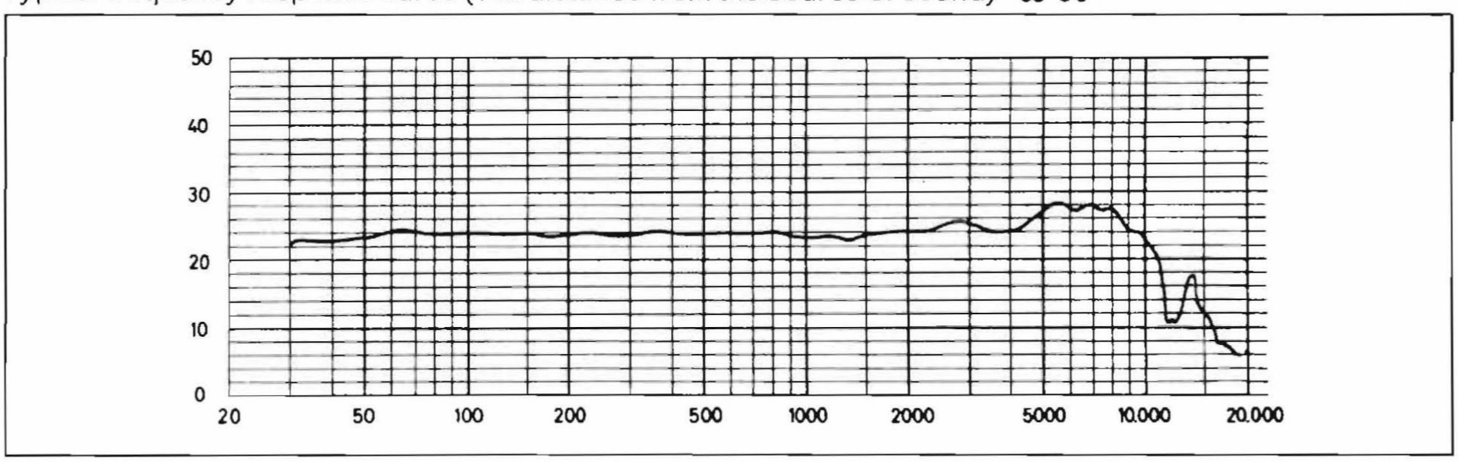
Guaranteed frequency response curve



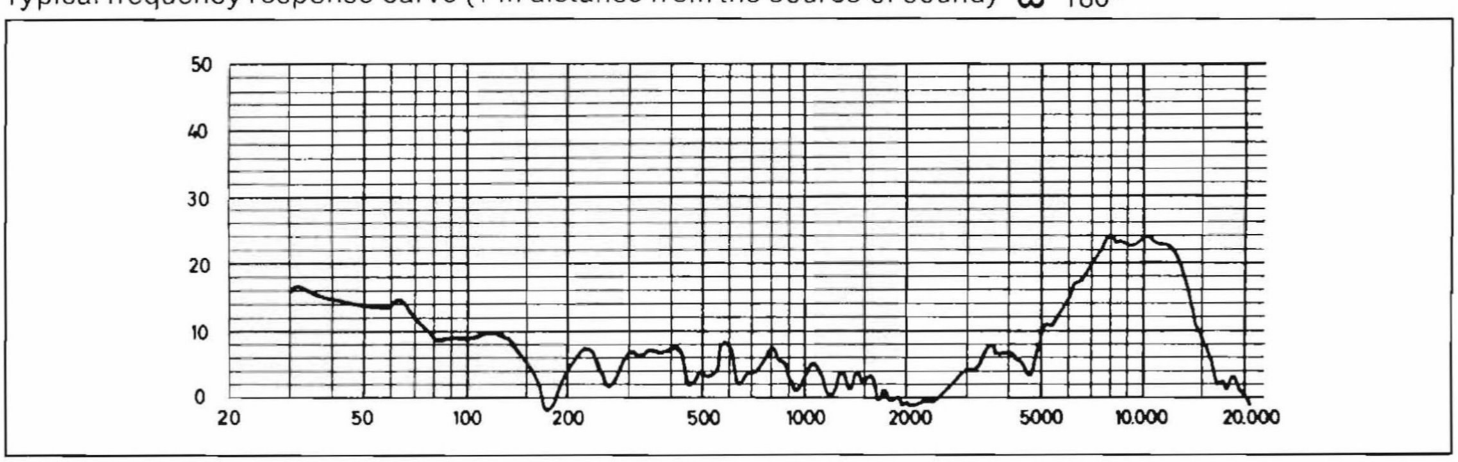
Typical frequency response curve (1 m distance from the source of sound) 0°



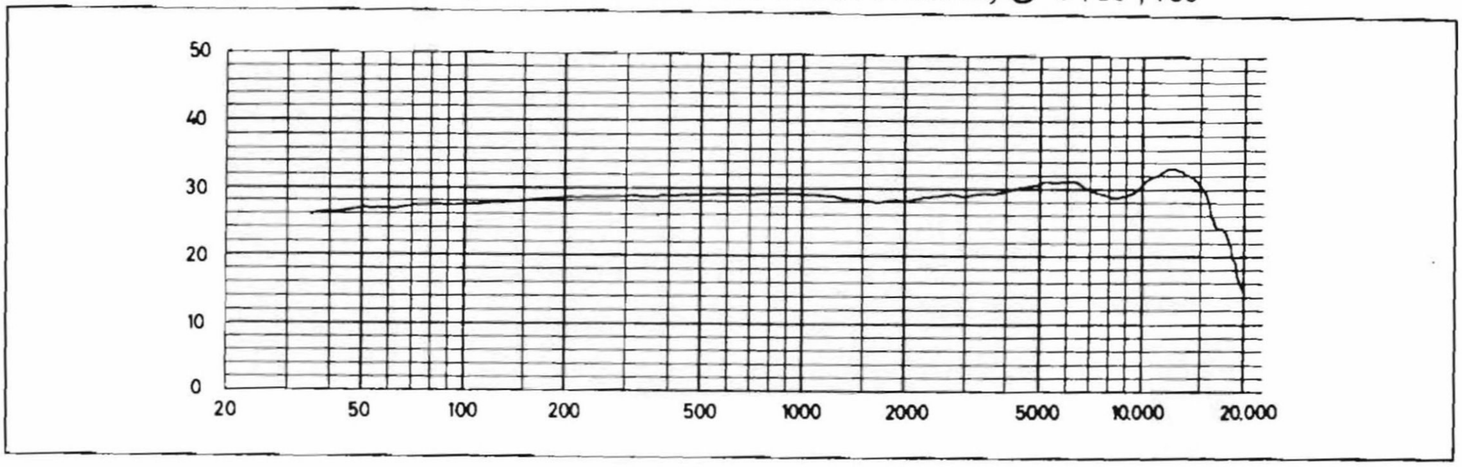
Typical frequency response curve (1 m distance from the source of sound) 90°



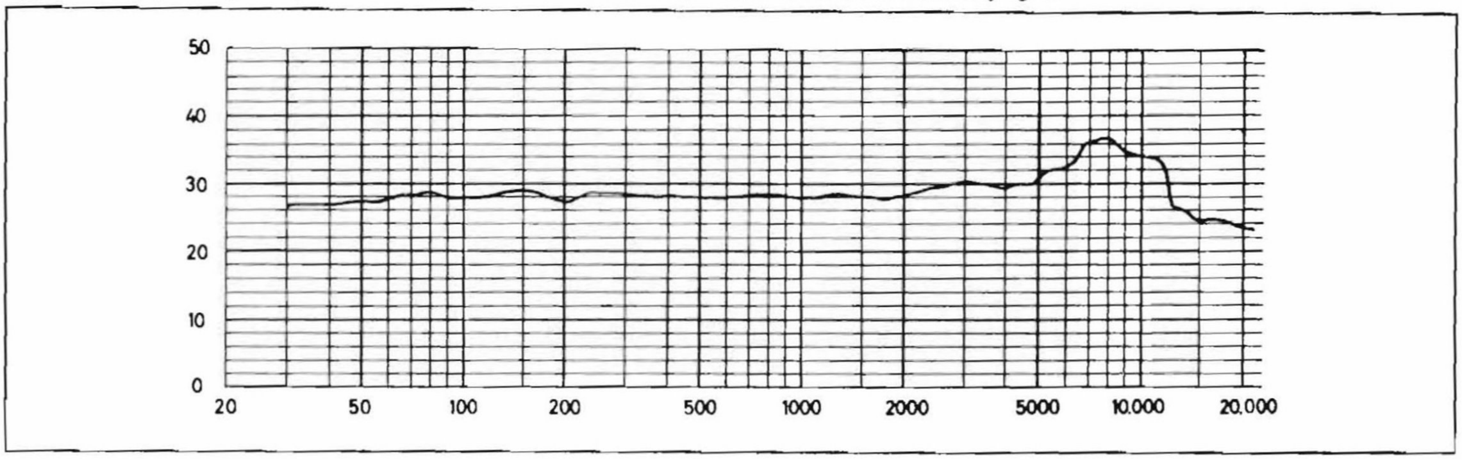
Typical frequency response curve (1 m distance from the source of sound) 180°



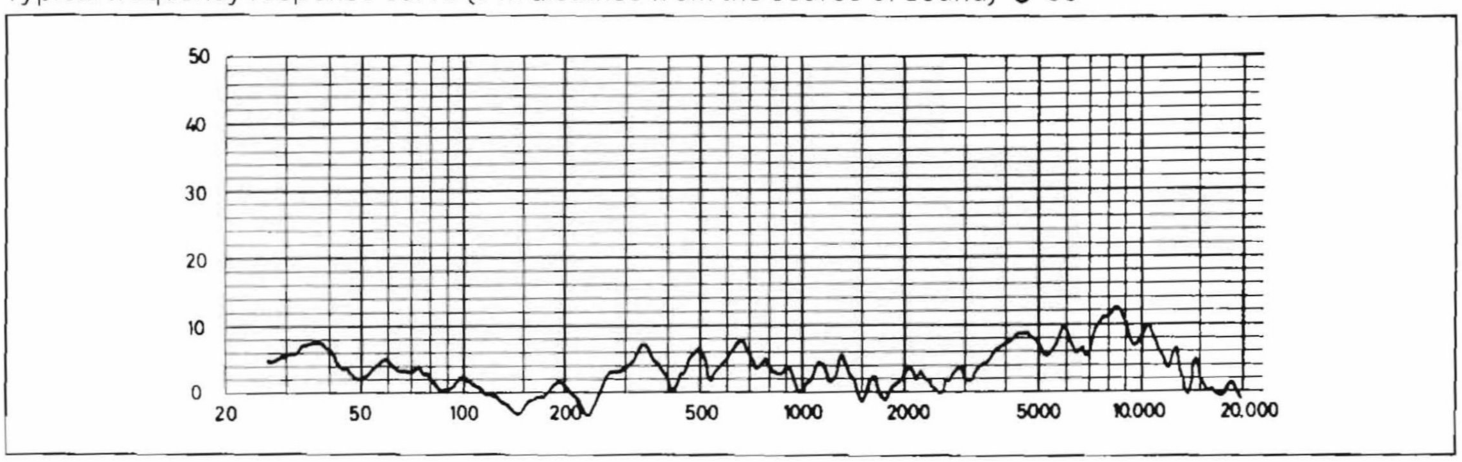
Typical frequency response curve (1 m distance fròm the source of sound) O 0°, 90°, 180°



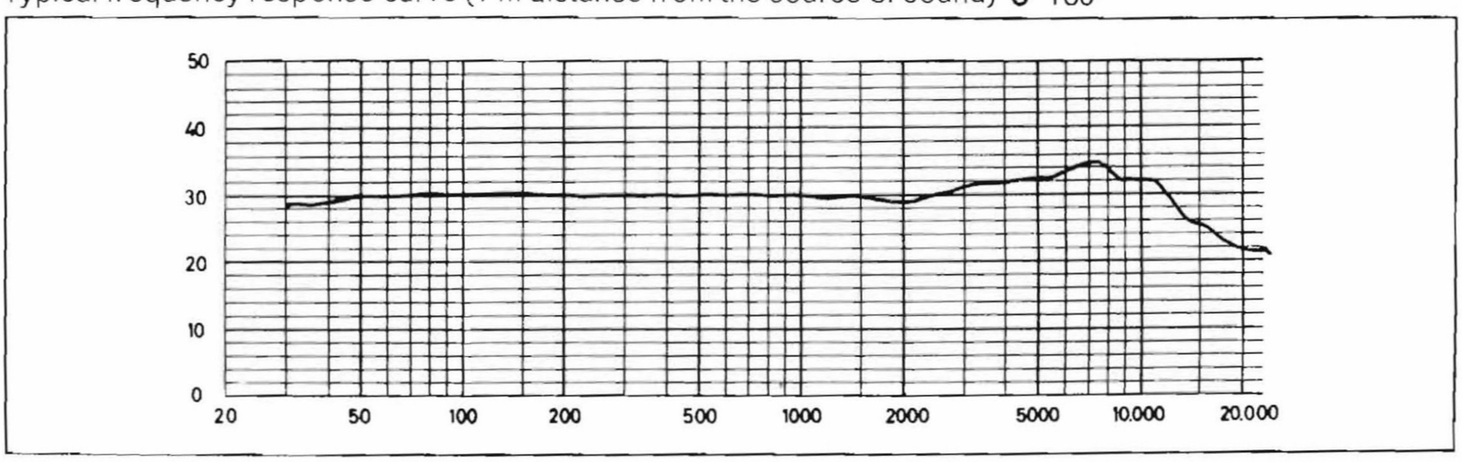
Typical frequency response curve (1 m distance from the source of sound) 8 0°



Typical frequency response curve (1 m distance from the source of sound) 8 90°



Typical frequency response curve (1 m distance from the source of sound) 8 180°



TECHNICAL DATA

SENSITIVITY, DIRECTIONAL CHARACTERISTICS:

Type: Pressure gradient receiver with low frequency circuit. For stereo recording (2 systems situated one above another)

Frequency Range: 30 . . . 20 000 Hz

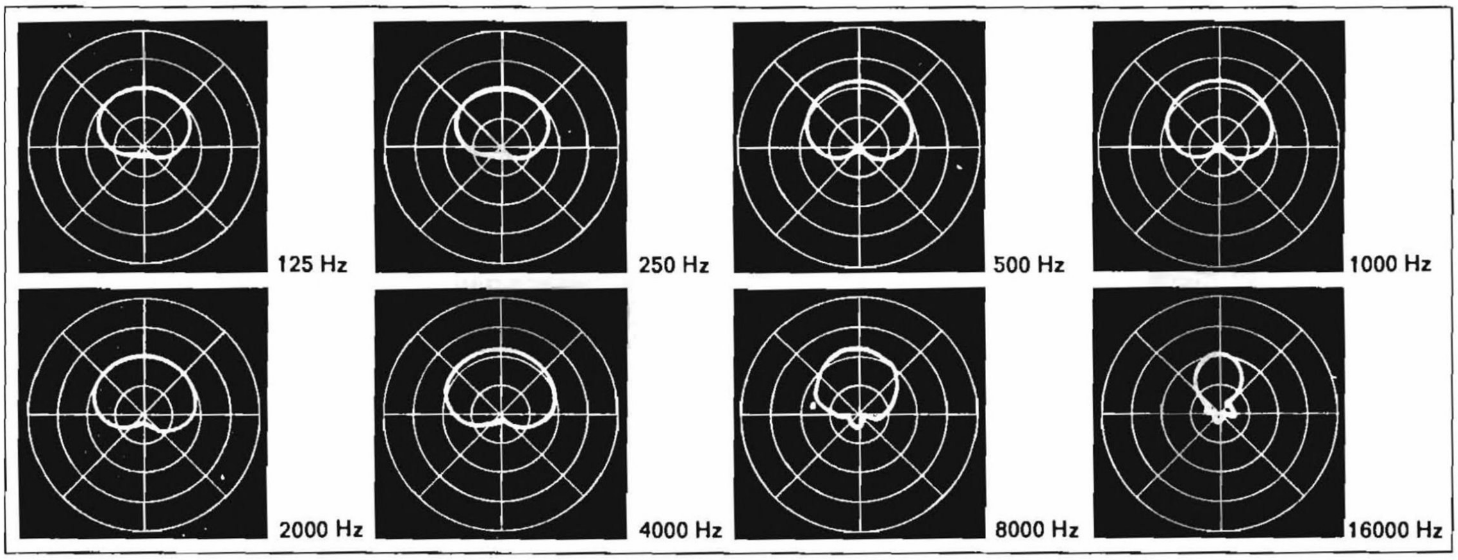
Sensitivity at 1000 Hz: 1 mv/μbar (−60 dbv) re. 1 v/dyne/cm^2

Microphone Rating: GM = −132 db; −41 db re. 1 mw/10 dyne/cm^2

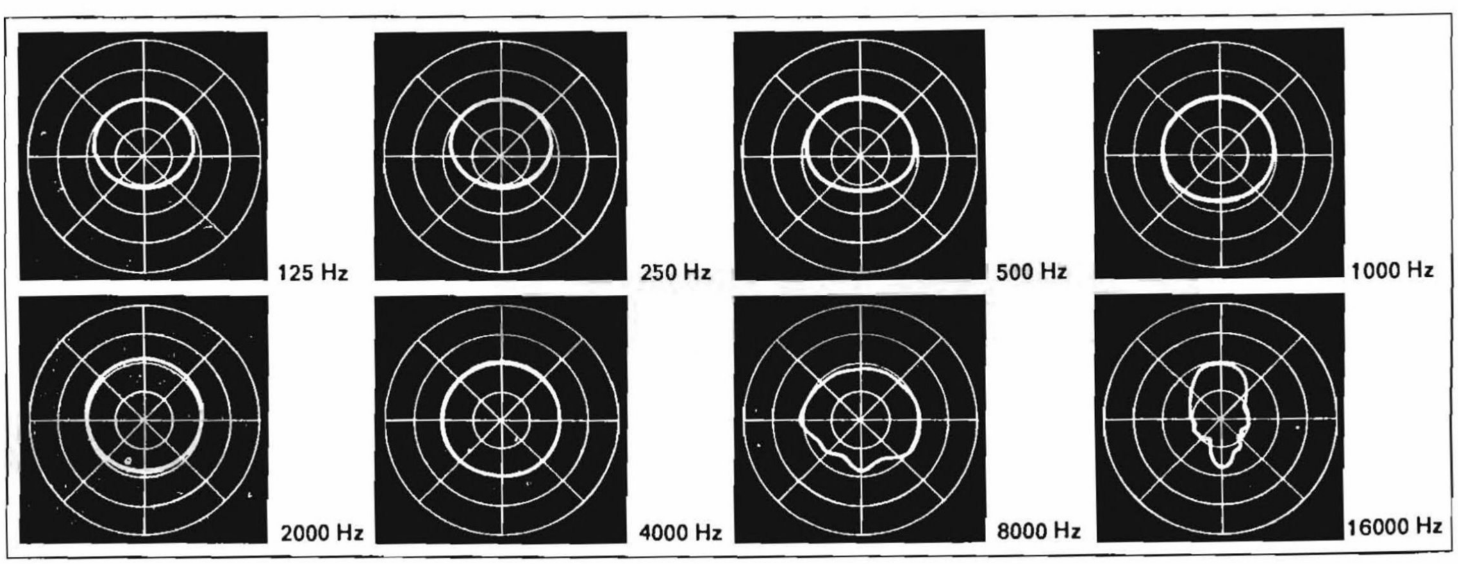
Directional Characteristics: Cardioid, Omnidirectional, Figure-of-eight and 6 intermediate positions

Cancellation at 1000 Hz: 90^0 Figure-of-eight and 180^0 Cardioid: $\geqq$ 25 db

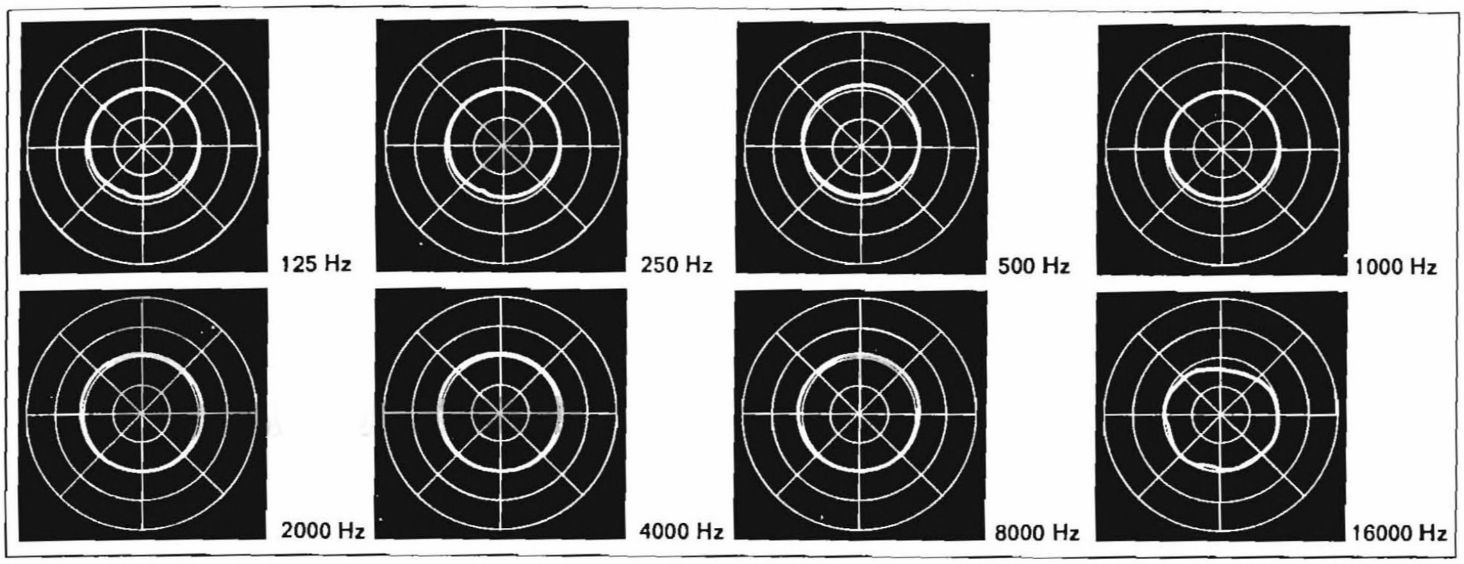
Polar diagrams (photographs), taken from 1 m distance from the source of sound.
Directional characteristic: Position "Cardioid"



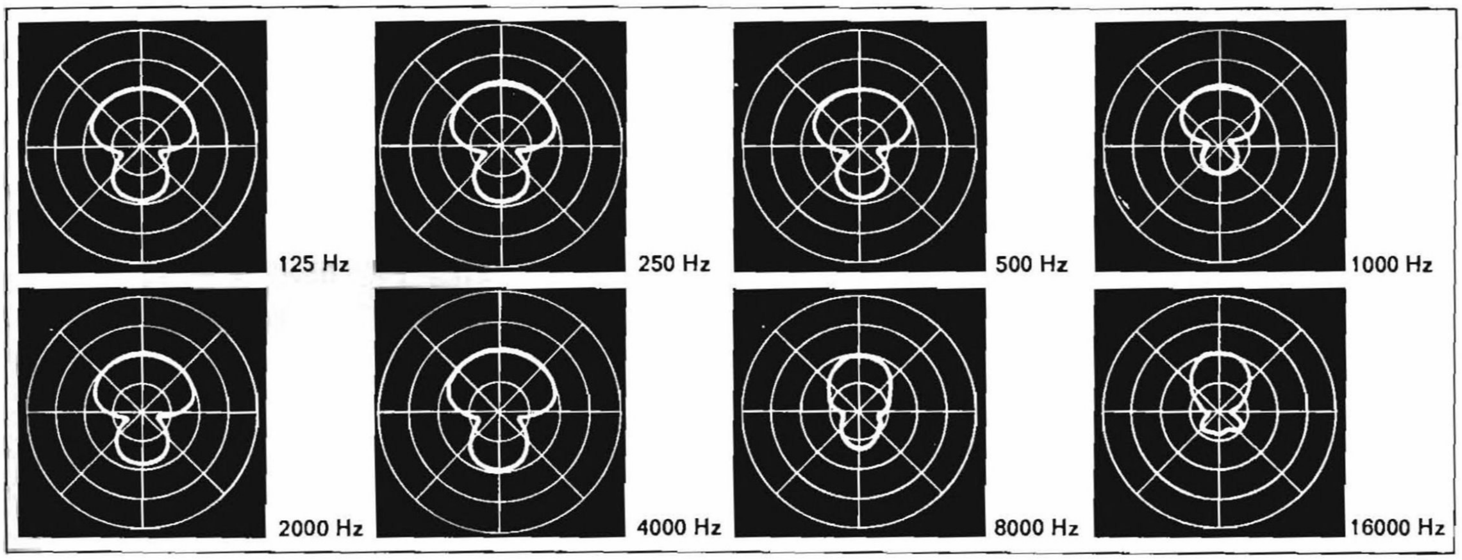
Polar diagrams (photographs), taken from 1 m distance from the source of sound.
Directional characteristic: Position between "Cardioid" and "Omnidirectional"



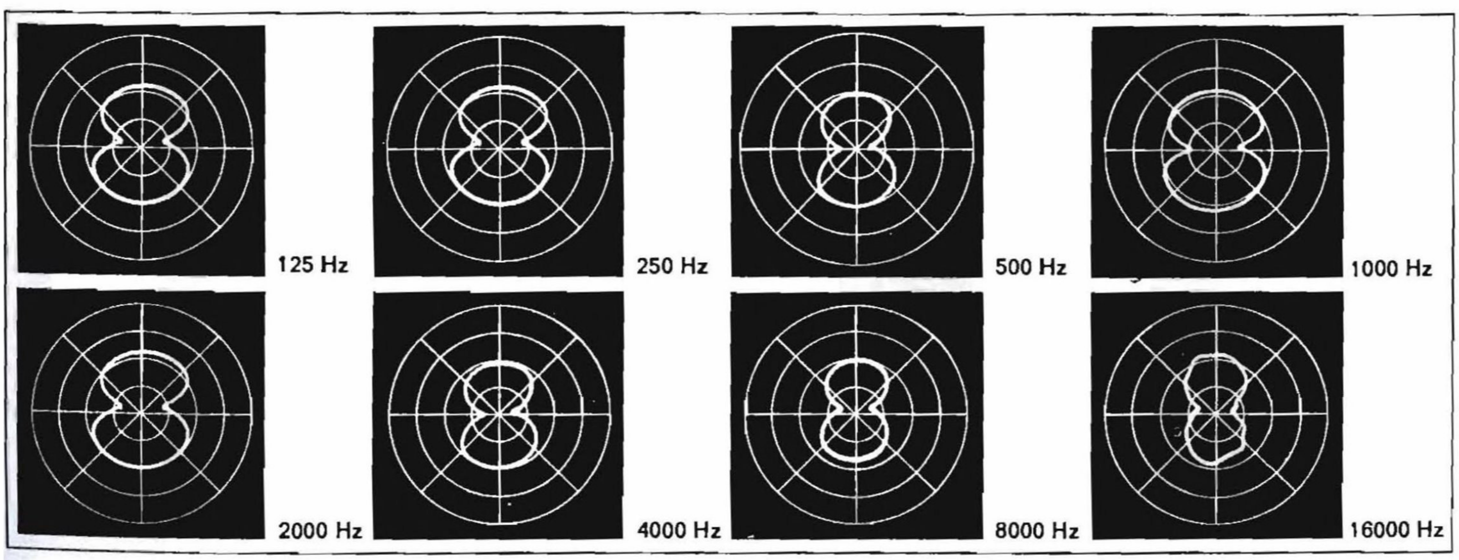
Polar diagrams (photographs), taken from 1 m distance from the source of sound.
Directional characteristic: Position "Omnidirectional"



Polar diagrams (photographs), taken from 1 m distance from the source of sound.
Directional characteristic: Position between "Cardioid" and "Figure-of-eight"



Polar diagrams (photographs), taken from 1 m distance from the source of sound.
Directional characteristic: Position "Figure-of-eight"



Recording in the MS or XY mode is also possible with two closely mounted AKG C-451E F.E.T. condenser microphones. Above illustration includes 1 C-451E, with 3-pattern capsule CK-6 set at figure eight (S) and 1 C-451E with cardioid capsule CK-1 (M). Special accessories include A-51 swivel joint to tilt capsule in proper position and H-10 stereo bar stand adapter.

Patterns described on page 7 can be obtained with C-451E by using different combinations of capsules (Details are available by requesting AKG's special "C-451E CMS" booklet).

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