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THE RCA "UNIAXIAL" MICROPHONE TYPE BK-5A

Report No. L-040

(1958/16)

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

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SUMMARY

The RCA type BK-5A is a ribbon microphone which was originally claimed to possess unusual directional properties. A sample has been tested and the polar response curve found to differ only slightly from a cardioid.

The open-circuit response is fairly uniform over most of the audio-frequency band; the impedance, however, varies so widely with frequency that when the microphone is used with the standard B.B.C. type of amplifier having a resistance-loaded input, equalisation is necessary to restore the frequency characteristic. The quality then obtained is better than that from most existing ribbon or moving-coil cardioid microphones.

1. INTRODUCTION

A prototype model of the RCA BK-5A "Uniaxial" ribbon microphone was first described in March 1953[1], and was then claimed to have a directivity pattern independent of frequency and similar in shape to a cardioid, but with a substantially narrower front lobe. The constructional features said to be responsible for this unusual performance include two rear sound apertures spaced apart along the length of the microphone instead of the single inlet provided in microphones of this type. The mode of operation of the internal phase-shifting network is obscure and the theoretical explanation given seems of doubtful validity. Analysis of an equivalent electrical network was said to give a response approximately proportional to $0{\cdot}3 + 0{\cdot}7 \cos\theta \cos\theta/3$, where θ is the angle between the microphone axis and the direction of incidence. This expression does indeed yield a result which is in fair agreement with the published polar response for values of θ from $0°$ to $180°$ but is grossly in error at greater angles; for example, substituting $\theta = 0°$ and $\theta = 360°$ produces two different values.

Difficulties appear to have been encountered in the production of this microphone and a specimen ordered in 1953 was not received until the beginning of 1957. In the meantime, however, a further publication[2] in May 1955 described the polar pattern as "essentially a cardioid", although in a still later article[3], dealing with the use of two BK-5A microphones for second-order gradient operation, the original claims were repeated. Finally, in a brochure received with the microphone in 1957 the response at $90°$ is shown as only about 1 dB less than that of a cardioid, a difference which can easily be produced by a slight variation of the phase shift in a conventional type of microphone.

As the original promise of high directivity was not fulfilled, the microphone can be compared directly with existing cardioid types.

2. DESCRIPTION

The BK-5A "Uniaxial" microphone derives its name from the fact that the acoustic axis and the major mechanical axis coincide; this description could, however, be applied with equal justification to existing microphones such as the Neumann KM54 and the Hiller M59. Fig. 1(a) gives an external view and the dimensions of the BK-5A microphone, and Fig. 1(b) a simplified diagram showing the internal construction. The

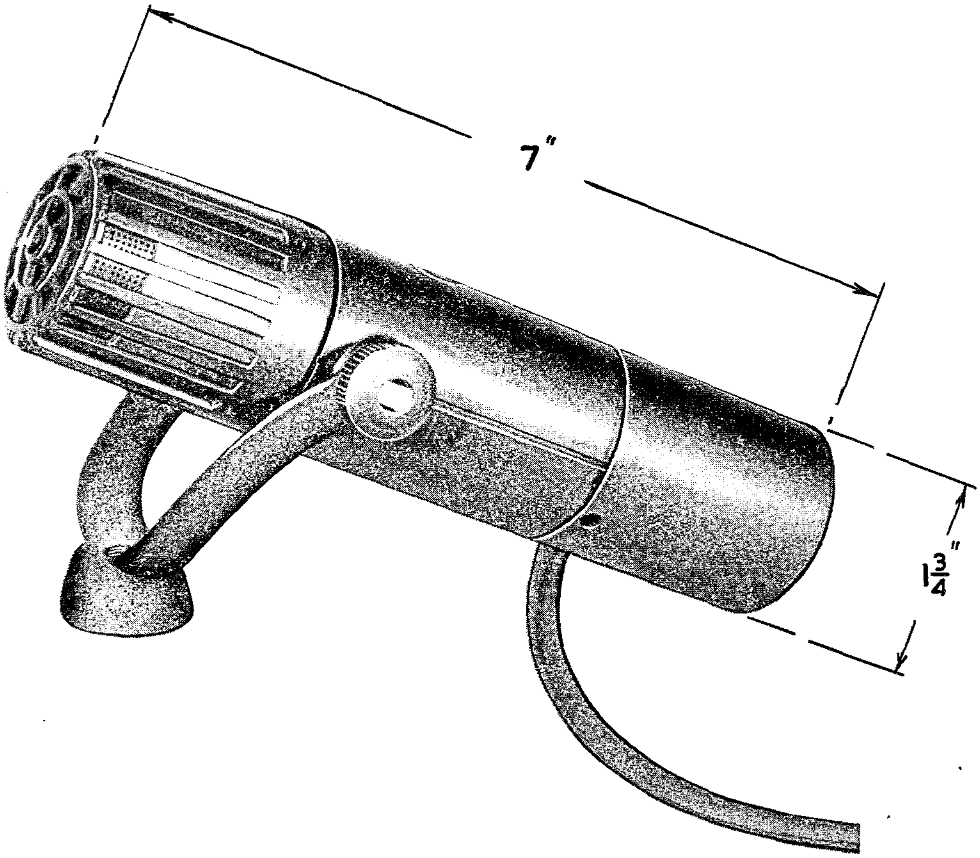

Fig. (1a) - Microphone type BK-5A; external view

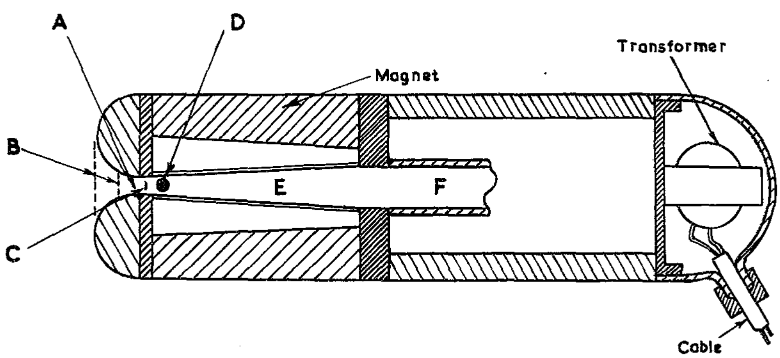

Fig. 1(b) - Microphone type BK-5A internal construction (simplified) front of the microphone is recessed at A in such a way as to improve the high frequency response; cloth screens, B, are provided for protection against the effects of blast. The ribbon, C, is mounted behind the screens and is approximately 1 in. (2·54 cm) long by 0·1 in. (0·25 cm) wide; judging by the irregularities in the response curves, its thickness is considerably greater than that used in B.B.C. microphones. Behind the ribbon is the phase-shifting network responsible for the directional properties. It consists essentially of two cloth-covered apertures of which one is shown at D, connected by a tube E of tapering cross-section to a coiled acoustic labyrinth F about 30 in. (76 cm) long. The flux density in the air gap is unusually high, a figure of over 11,000 gauss being claimed. The resulting high electro-mechanical efficiency unfortunately involves a considerable rise in electrical output impedance at low frequencies and the microphone should preferably operate into open circuit.

A tapped ribbon-to-line transformer provides nominal output impedances of 250, 150 or 30 ohms; the output cable is permanently attached. The low-impedance wiring of the ribbon circuit is stated to be balanced against external magnetic fields. Two degrees of bass cut can be obtained by means of a shunt choke connected to a switch at the rear of the microphone.

The weight of the microphone without cable is 1·7 lb (772 gm). The price in 1957 was £96. 10s.

3. PERFORMANCE

3.1. Method of Measurement

Frequency characteristics above 200 c/s were measured by comparison with a pressure standard in a dead room. Below 200 c/s measurements were made in a travelling wave duct by comparison with a pressure-gradient substandard. The accuracy of comparison for sound incident at 0°, 45° and 90° is ±½ dB, but for greater angles errors up to ±1 dB are possible. The characteristics of the standard and substandard are known to within ±½ dB.

3.2. Frequency Characteristics

All the characteristics given in this section were measured at the 250 ohms connection.

Figs. 2, 3 and 4 show the open-circuit frequency characteristics of the microphone for sound incident at various angles in the horizontal and vertical planes. Fig. 5 shows the axial response for the three positions of the bass cut switch. Fig. 6(a) shows the departure from open-circuit performance which occurs when the microphone is connected to a 300 ohm load; it will be seen that there is a considerable low-frequency loss. Figs. 7 and 8 show the makers' curves corresponding to Figs. 2 and 3; it will be seen that the agreement is reasonable. It is particularly to be noted that the response at 90° shown in the makers' curves is not much more than 6 dB below the axial response, i.e. that the directivity pattern now claimed is little different from a cardioid; in fact, a slightly narrower lobe is obtained on the sample tested.

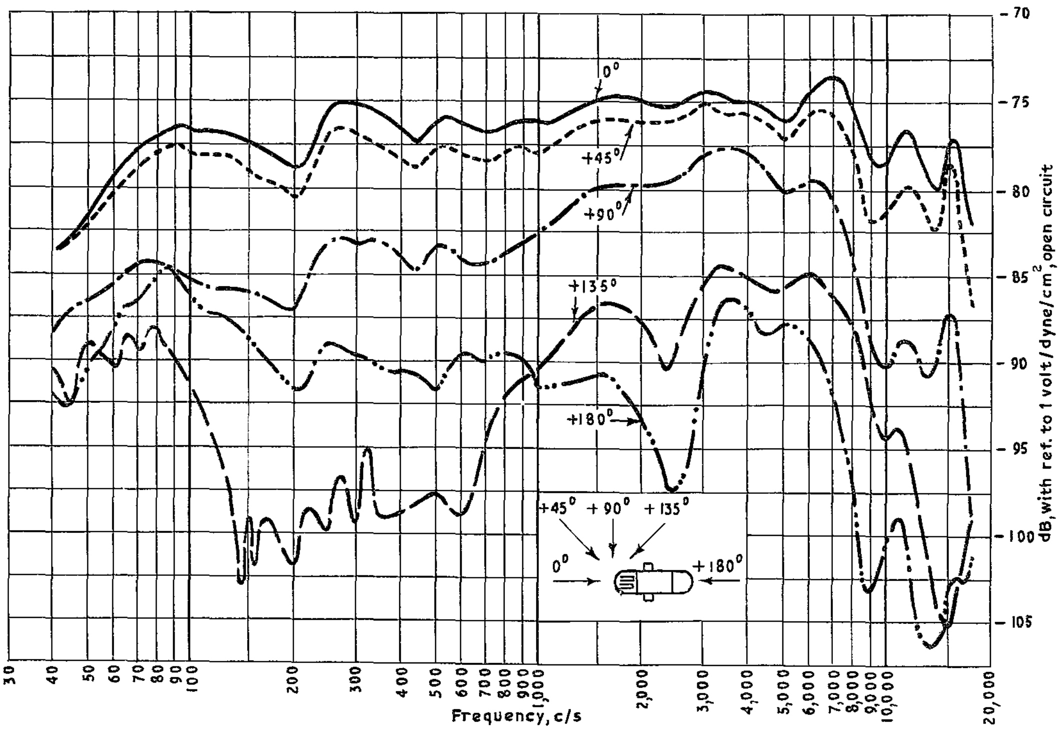

Fig. 2 - Frequency characteristics in horizontal plane, measured with 250 ohm connection

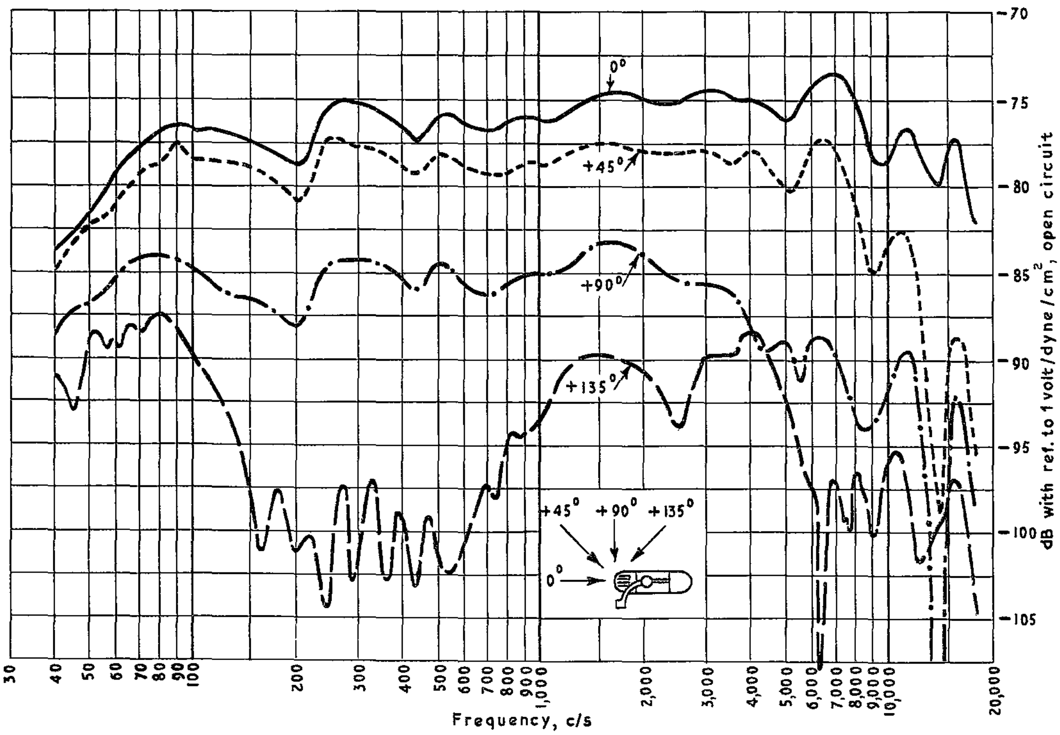

Fig. 3 - Frequency characteristics in vertical plane above axis, measured with 250 ohm connection

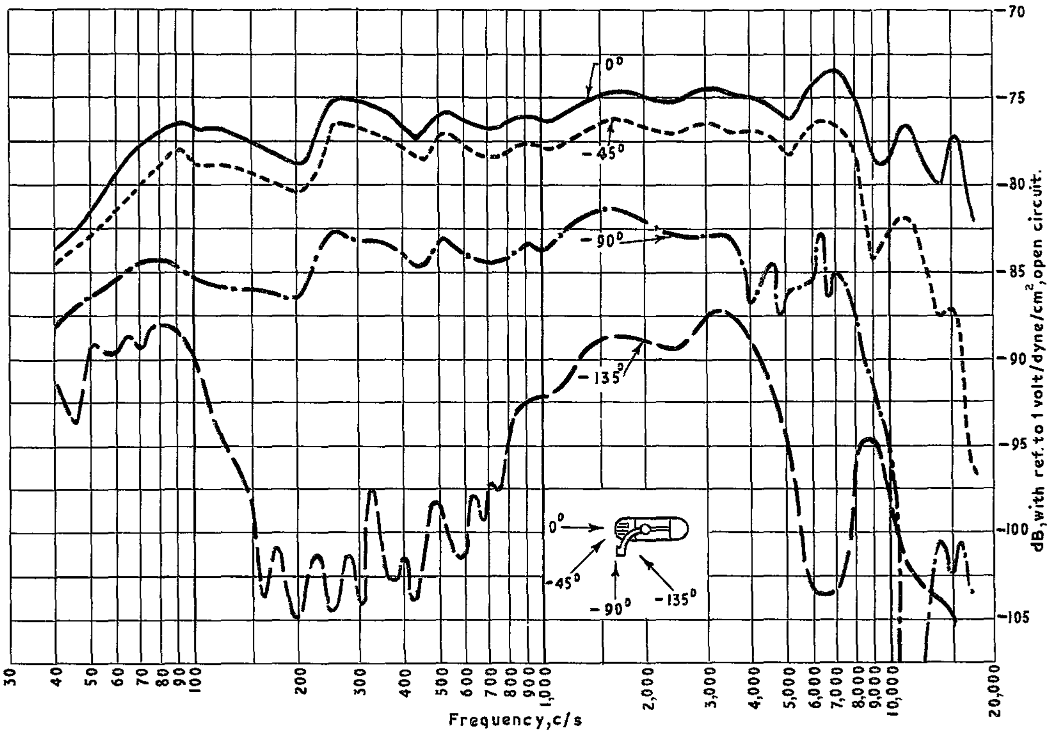

Fig. 4 - Frequency characteristics in vertical plane below axis, measured with 250 ohm connection

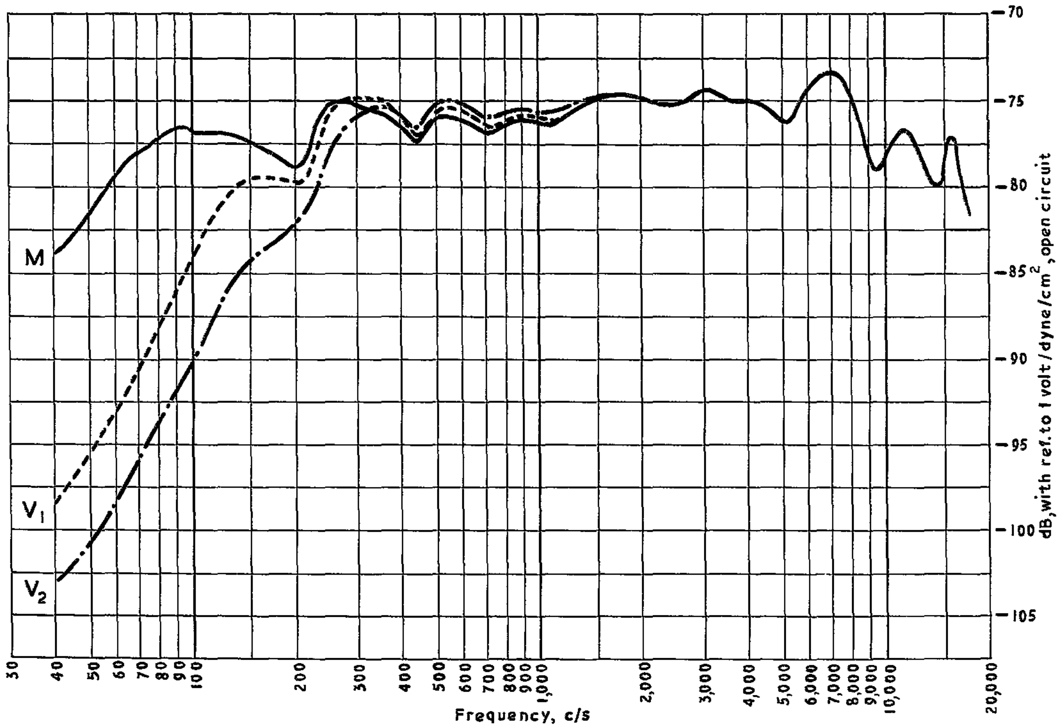

Fig. 5- Axial response with bass-cut switch set to position shown, measured with 250 ohm connection

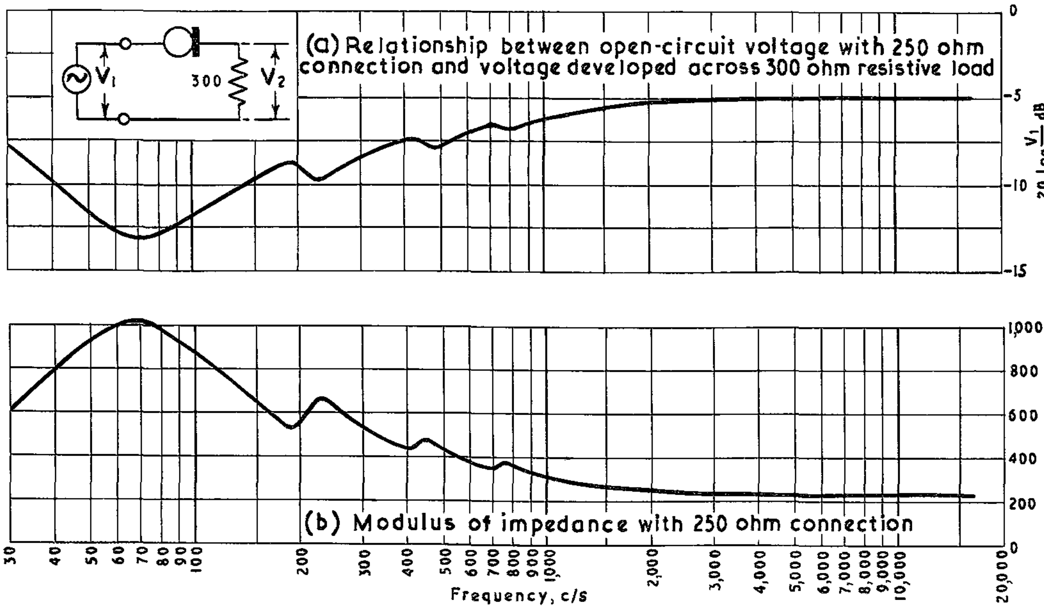

Fig. 6

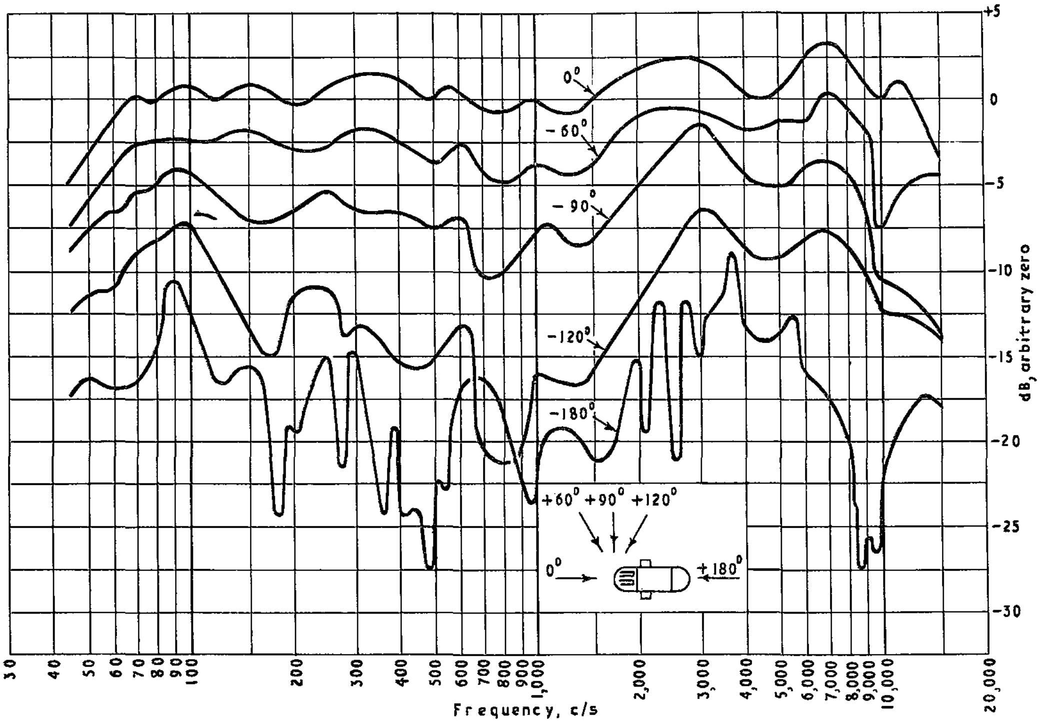

Fig. 7 - Makers' published curves of frequency characteristics in horizontal plane, measured with 250 ohm connection

The irregularities in the low-frequency response are doubtless caused by transverse ribbon resonances. Because of the high degree of electro-mechanical coupling, a slightly smoother response is obtained when the microphone is loaded by 300 ohms, the ribbon resonances being then partially damped; this point is also illustrated by Fig. 6(a).

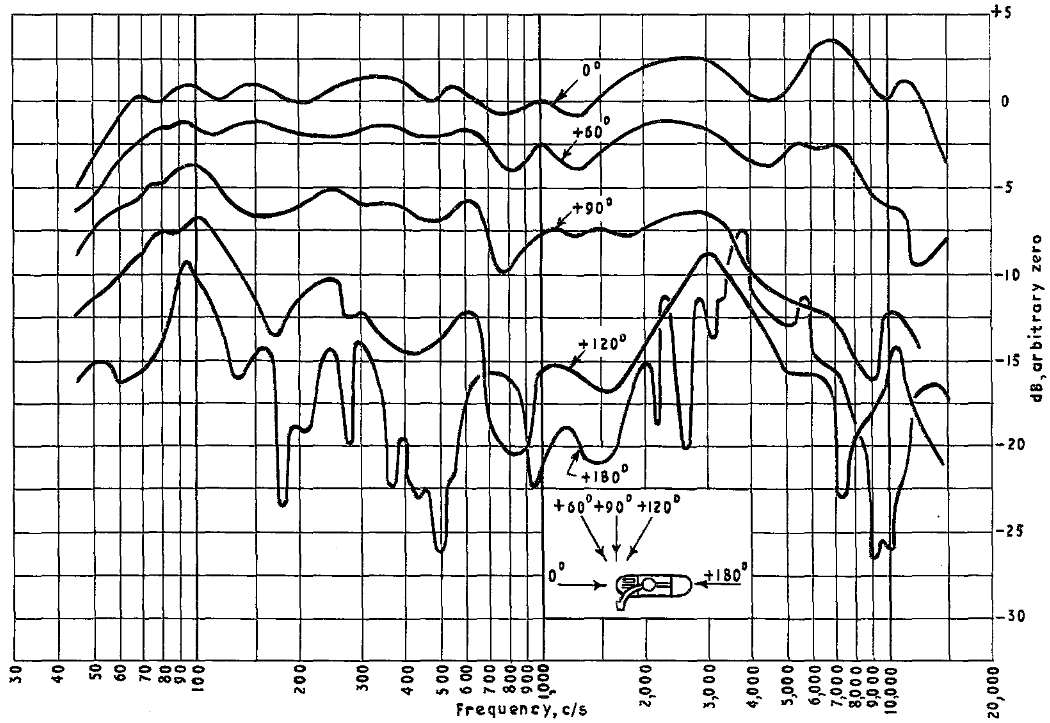

Fig. 8 - Makers' published curves of frequency characteristics in vertical plane above axis, measured with 250 ohm connection

3.3. Transient Response

The transient response of the microphone on open circuit was tested by driving the ribbon electrically with pulses of tone and watching the decay on an oscilloscope. Evidence of resonance was observed at 225, 470, 800 and 1350 c/s. These frequencies appear to coincide with ribbon resonances shown in Fig. 2.

4. SENSITIVITY

The mid-band axial sensitivity of the specimen, measured at the 250 ohm tapping, is in agreement with the makers' figure of −76 dB with respect to 1 volt/dyne/cm² open circuit; this is only 1 dB below that of the type PGS/1. If the BK-5A microphone is operated into a 300 ohm resistive load, equalisation is required to correct the low-frequency response; this process involves a mid-band loss of about 8 dB and should therefore be carried out after the first amplifier.

5. IMPEDANCE

Fig. 6(b) shows the modulus of the microphone impedance when the output connection is taken to the 250 ohm tapping. The increase in impedance at low frequencies is caused by the motional impedance of the ribbon.

6. NOISE

6.1. General

In the absence of interference from external sources the electrical noise output of the microphone is caused by thermal agitation in the resistive portion of its impedance. The open-circuit noise level is −134 dB with reference to 1 volt and −128 dB when weighted by the aural sensitivity network type ASN/3. The mid-band sound pressure required to give a signal equivalent to the weighted level is +23 dB with reference to 0·0002 dyne/cm^2. The corresponding figure for the B.B.C. type PGS is +22 dB.

6.2. Interference from Magnetic Fields

Measurements were made of the maximum voltage generated in the microphone by external alternating magnetic fields.

Fields of 1 milligauss at 50 c/s, 1 kc/s and 10 kc/s give outputs equivalent to those produced by mid-band sound levels of +11 dB, +42 dB and +46 dB respectively. These levels represent a low degree of induction and should cause little trouble under normal studio conditions.

7. LISTENING TESTS

Listening tests were carried out on speech from dead surroundings and also, with the aid of the Sound Broadcasting Engineering Department, on music in studios. In each case the microphone was operated in the on-load condition and an equaliser was used in a high-level part of the circuit to compensate for the falling low-frequency response. In addition, comparisons were made with the cardioid microphones M59 and 4033A at present used in studios. The results are in agreement with the objective tests; with the exception of a certain degree of harshness, possibly due to ribbon resonances, the quality obtained from the BK-5A is very good, being comparable with that from the M59 and better than that from the 4033A.

The type BK-5A has been on field trial in television studios and has been used several times on transmission; the following extracts are from a report from Technical Operations Television Studios.

"... The quality of the BK-5A in association with the Research Department equaliser appears to be better for vocal purposes than the S.T. and C. 4033, but not so good as the 4038 or KM54A.

Discrimination against sounds at angles approaching 180° from the normal is better than the 4033 and the quality cleaner.

The sensitivity ... appears to be adequate ..."

8. CONCLUSIONS

The type BK-5A microphone is technically interesting and, although its directional properties fall short of those originally claimed, it gives a very good performance for its size. To keep the dimensions of a microphone of this type small, it is necessary to employ rather thick ribbon; this results in some irregularity in frequency response. A very high magnetic field is necessary to obtain a reasonable sensitivity and has led to a large increase in impedance at low frequencies; as a result, high-level equalisation is essential if the microphone is used with standard B.B.C. amplifiers. The directional properties are well maintained throughout the whole frequency range. The sound quality is the best so far obtained from a ribbon or moving-coil cardioid microphone.

9. REFERENCES

1. Olson, Harry F., Preston, John and Bleazey, John C., "The Uniaxial Microphone", RCA Review, Vol. XIV, No. 1, March 1953.

2. O'Neill, J.W. and Carrell, R.M., "The New BK-5A Uniaxial Microphone", RCA Broadcast News, Vol. 83, May 1955.

3. Olson, Harry F., Preston, John and Bleazey, John C., "Bigradient Uniaxial Microphone", RCA Review, Vol. XVII, No. 4, December 1956.

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