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RESEARCH DEPARTMENT

A.K.G. ELECTROSTATIC MICROPHONES TYPES C26 AND C28

Report No. L-048

(1961/12)

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

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SUMMARY

This report describes tests on two electrostatic microphones manufactured by the Akustische und Kino-Geräte Gesellschaft (A.K.G.). The first, type C26, has omnidirectional and the second, type C28, cardioid characteristics. The microphones are of small dimensions and provision is made in each case for introducing an extension piece between the capsule and the head amplifier. Two types of windshield are provided; one can be fitted over the end of the microphone itself, whilst the other is designed to protect the microphone capsule when an extension piece is used.

Measurements have been made of the microphone frequency characteristics with and without the various fittings, and the degree of interference from wind and from magnetic fields has also been determined. The quality of reproduction obtained, particularly from the type C28, is good and the degree of interference is low. The susceptibility to radio-frequency fields has also been measured and a method of reducing it has been indicated.

1. INTRODUCTION

The Akustische und Kino-Geräte Gesellschaft of Vienna has introduced two new electrostatic microphones, type C26 which has a nominally omnidirectional characteristic and type C28 with a cardioid characteristic. The same head amplifiers, mains units and interconnecting leads are used in both types, the only differences being in the internal construction of the capsules types CK26 and CK28, which have identical external dimensions. The capsule in each case is surrounded by a layer of fine wire gauze which forms part of the microphone case and affords an appreciable measure of protection against interference from wind. For more severe conditions a windshield,* type W28, is provided, which fits over the microphone head. To make the instrument less conspicuous, the portion of the case surrounding the capsule can be removed and slender extension pieces, types C29 or C30 of differing lengths, can be inserted between the capsule and head amplifier so that the latter may be concealed; when either of these extension pieces is used, a different windshield, type W17, is normally employed to protect the capsule.

The type C28 has potential applications in places such as footlights where an inconspicuous microphone having a high degree of suppression of sound from the rear

*This windshield, which bears no type number, is described by the maker as type W26 or type W28, according to the microphone with which it is supplied. Throughout this report, however, it will be referred to as the type W28.

is required. When the type C30 extension piece and the type W17 windshield are employed, the height is suitable and the size small enough to enable the microphone to be used on the stage by crooners.

The type C26 microphone might be of interest as a replacement for the Philips type EL3921/00 microphone which is now obsolete.

Two experimental models of the type C28 microphone were examined in June 1957 and another pair, incorporating improvements, in March 1958. Some minor modifications were suggested and production units were received in May 1958. At the request of S.E.S.B.'s Department, two type CK26 capsules were tested in May 1959.

The price to the B.B.C. is £90 for either the type C26 or the type C28. The approximate cost of the type C29 extension piece is £4, of the type C30 £4.10s.0d., and of the type W17 and type W28 windshields £4. 5s. 0d. and £7.13s. 0d. respectively. A case is available to house all these items and costs an additional £8.

2. DESCRIPTION

2.1. General

Fig. 1 gives an external view and dimensions of the microphone, a capsule type CK28, the two extension pieces types C29 and C30, and the windshields types W17 and W28; as previously mentioned, the type C26 instrument is externally identical. The windshields are designed to enclose the entire capsule; they are constructed of two layers of wire gauze sprayed with flock on the inside and spaced about 1/8 in. (3 mm) apart. This form of construction is quite effective but if the flock became wet it is doubtful whether the flow resistance would return, on drying, to its previous value.

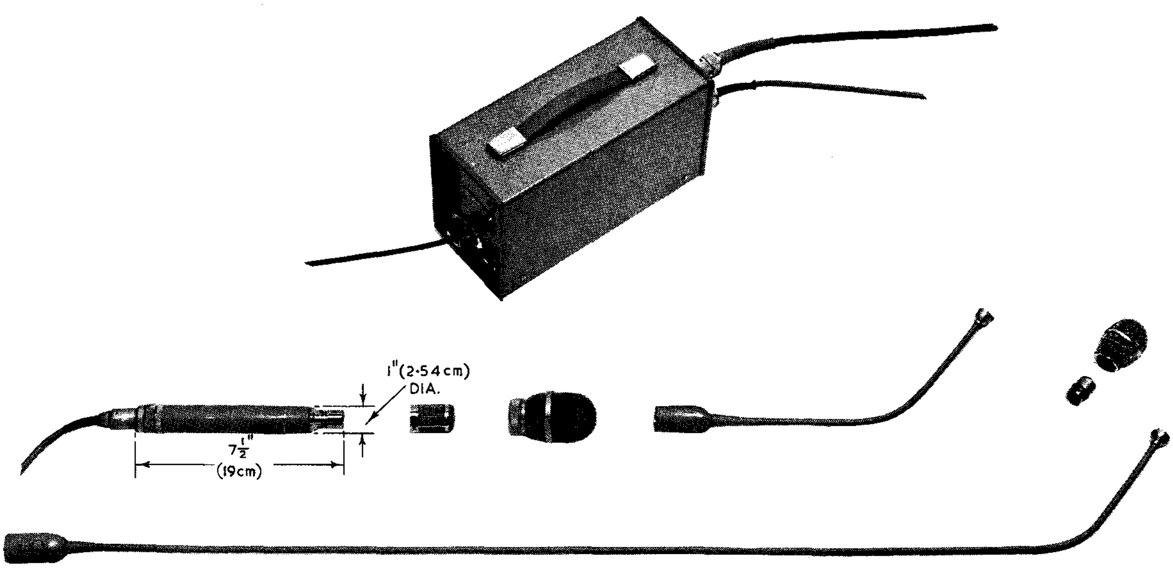

Fig. 1 - A.K.G. microphone type C28 with extension pieces types C29 and C30 and windshields types W17 and W28. External view and dimensions

2.2. Weight

The weight of either microphone without cable is ½ lb (0·2 kg) and of the mains unit 9 lb (4 kg).

2.3. Type CK26 Capsule

The construction of the pressure type capsule CK26 is on conventional lines. The size is similar to that of the Philips microphone type EL3921/00 and the directional properties are therefore similar.

2.4. Type CK28 Capsule

The design of the type CK28 capsule, which is the subject of a patent, is novel in that two apertures spaced along the capsule length are provided instead of the usual one; these communicate with different acoustic networks, each designed to operate over a different part of the frequency range. Fig. 2 shows the main constructional details. Sound can reach the rear of the diaphragm either through aperture 1 and network 1a, 1b, 1c and 1d, or through apertures 2 and network 2a, 2b, 2c, 2d, 2e and 2f. It is claimed that each of the elements forming these networks may be adjusted separately to give the desired directional characteristics. This

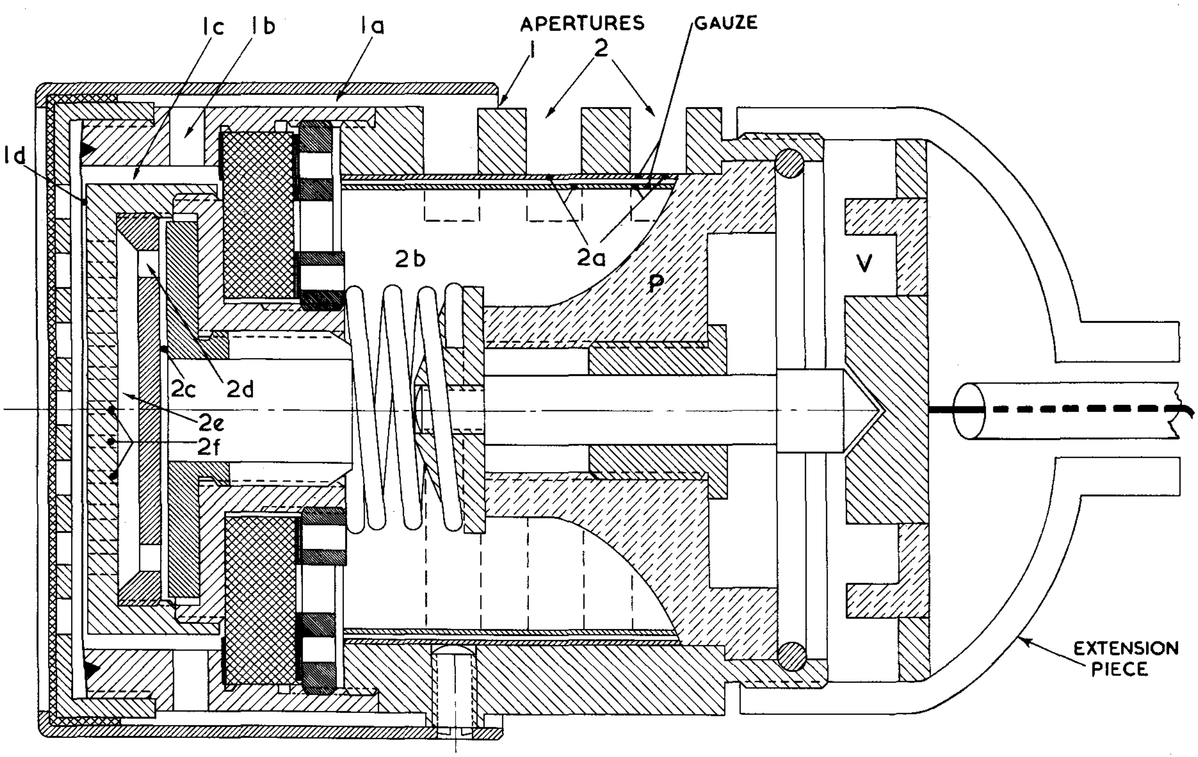

Fig. 2 - A.K.G. microphone type C28. Constructional details of capsule type CK28

arrangement has advantages over the usual construction since if only one rear sound aperture is employed it is difficult to design a microphone which maintains a constant cardioid characteristic over the whole audio-frequency range.

In the prototype CK28 capsules, holes were formed in the plate P and these, together with the enclosed volume of air, V, affected the phase of the sound pressure at apertures 1 and 2 and therefore the directional characteristics. As this fact had not been appreciated by the designer, and as the volume V in the different extension pieces had not been closely controlled in production, the directional characteristic was dependent on the particular fitting used. In the production models, however, this variation was prevented by eliminating the holes in the plate P. The type C28 response curves which are given later in the report all refer to capsules modified in this way.

2.5. Amplifier and Cables

Fig. 3 shows the electrical circuit diagram of the head amplifier. The transformer may be connected to give a nominal output impedance of 50 or 200 ohms; the manufacturer suggests that the change from one output impedance to the other should only be undertaken in the factory.

The microphone is connected by a plug and 65 ft (20 m) of cable to the mains unit type N28K, from which the audio-frequency output is taken through a 3-pin plug and socket. In an emergency a faulty mains unit may be replaced by one of the type N12K normally used for the A.K.G. type C12 microphone.

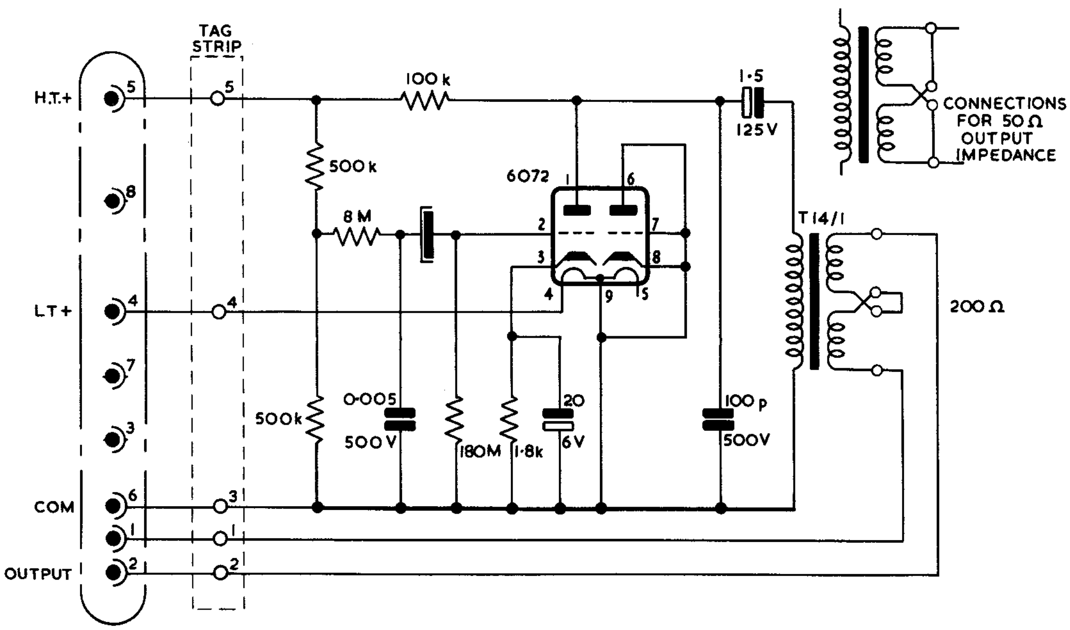

Fig. 3 - A.K.G. microphone type C28. Circuit diagram of head amplifier

3. PERFORMANCE

3.1. Method of Measurement

All the frequency characteristics of the type C26 microphone and those of the type C28 microphone above 200 c/s were measured by comparison with a pressure standard in a dead room. The characteristics of the type C28 microphone at frequencies below 200 c/s were measured in a travelling-wave duct by comparison with the same standard; the characteristics of the type C28 microphone with the type C29 extension piece were obtained in a similar manner. Generally the accuracy of comparison is ± ½ dB; errors of ± 1 dB are, however, possible in the measurements of the types C28 and C29 instruments for sound incident at angles greater than 90°.

All the characteristics given in this section were measured with the transformer connected to give a nominal output impedance of 200 ohms.

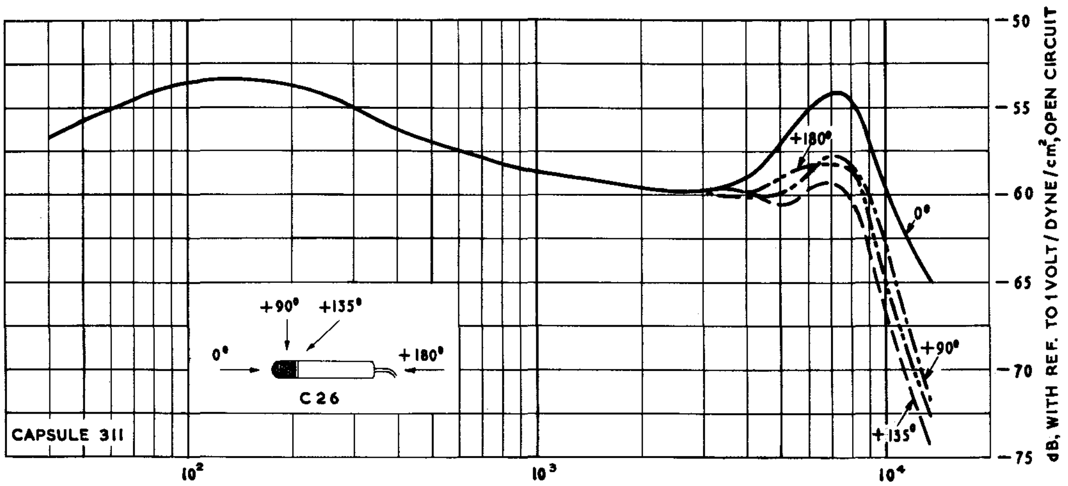

Fig. 4 - A.K.G. microphone type C26. Frequency characteristics measured at 200-ohm connection for sound incident at various angles

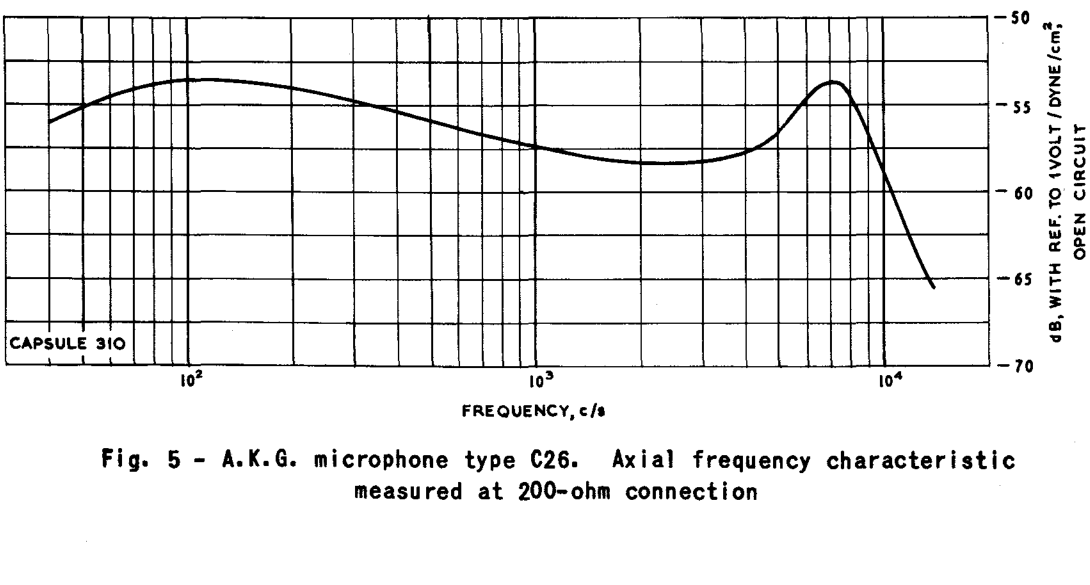

Fig. 5 - A.K.G. microphone type C26. Axial frequency characteristic measured at 200-ohm connection

3.2. Frequency Characteristics

Fig. 4 shows the open-circuit frequency characteristics of a type C26 microphone for sound incident at various angles, and Fig. 5 the axial response when fitted with another type CK26 capsule. For comparison, Fig. 6, taken from Research Department Technical Memorandum M.1008, shows the corresponding curves for a Philips microphone type EL3921/00. If the windshield type W28 is fitted to the type C26 microphone the overall frequency response is not changed by more than ± 1 dB. When the microphone capsule is mounted on either the type C29 or the type C30 extension piece so that the smaller windshield type W17 has to be used, the change in response, shown in Fig. 7, is slightly greater.

Fig. 8 shows the open-circuit frequency characteristics of a type C28 microphone for sound incident at various angles, and Fig. 9 the difference in axial frequency response of three capsules. The change in response caused by the type W28 windshield is remarkably small for a microphone with a cardioid polar characteristic and is not more than ± ½ dB for sound incident at 0° and 90° and 2 dB at 180°. Fig. 10 shows the response of the capsule referred to in Fig. 8 when mounted on the type C29 extension piece; when the longer extension piece type C30 is employed, the same frequency response is obtained. Fig. 11 shows the response of a microphone with and without the type W17 windshield; it will be noted that although the shield does

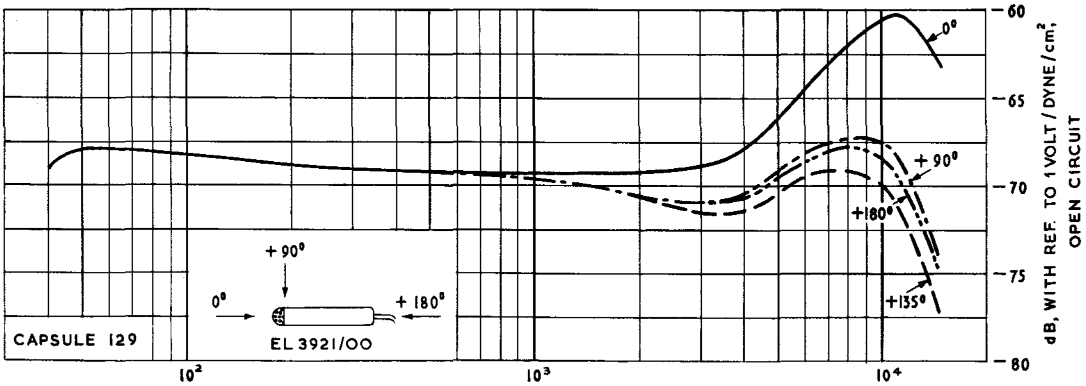

Fig. 6 - Philips microphone type EL3921/00. Frequency characteristics measured at 200-ohm connection for sound incident at various angles

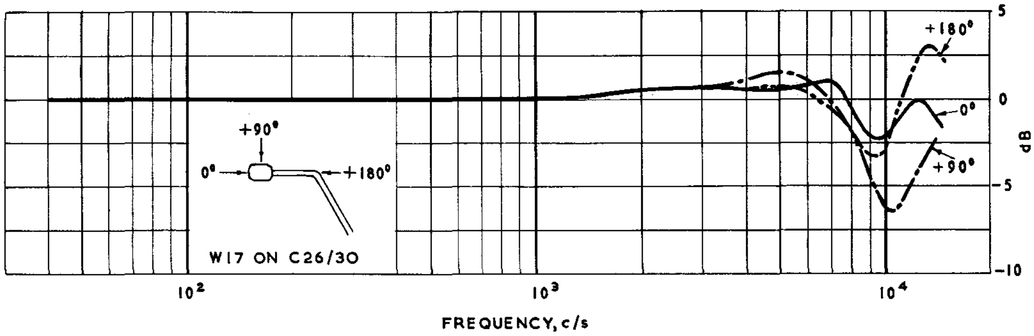

Fig. 7 - A.K.G. microphone type C26/C30. Change in response produced by windshield type W17 for sound incident at various angles

not greatly change the axial frequency response, it does appreciably degrade the directional characteristics at low frequencies.

The above figures refer to early production models. However, measurements made on current microphones show a loss at low frequencies, varying from −5 dB to −10 dB at 50 c/s, much greater than that shown in Fig. 9. In addition there is some evidence that under service conditions the bass response decreases still further with time. This matter is being further investigated.

3.3. Impedance

The mid-band output impedance of the microphone tested, when using the 200 ohms transformer connection, lies between 160 ohms and 240 ohms and is thus

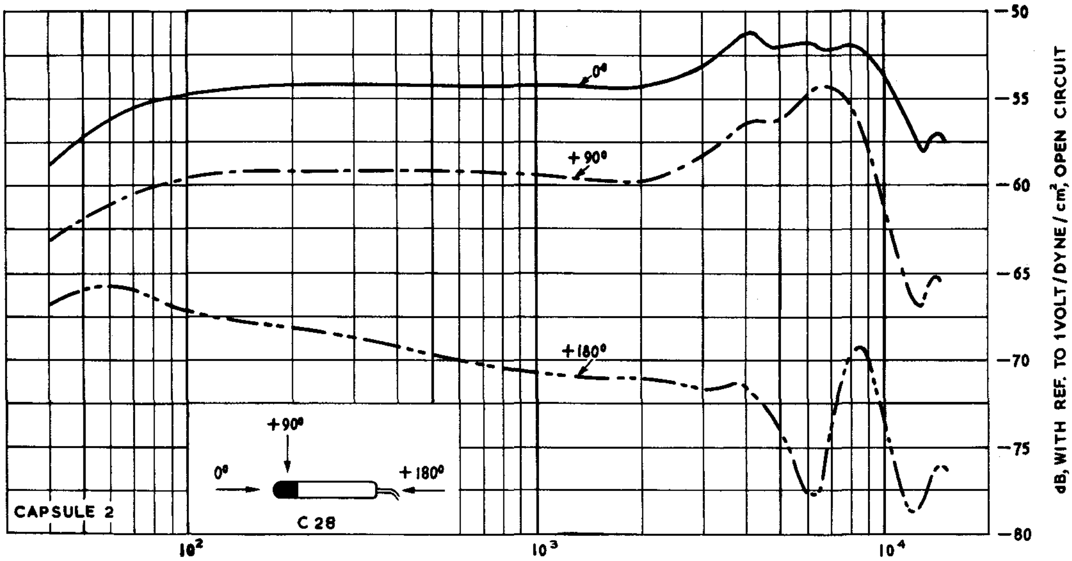

Fig. 8 - A.K.G. microphone type C28. Frequency characteristics measured at 200-ohm connection for sound incident at various angles

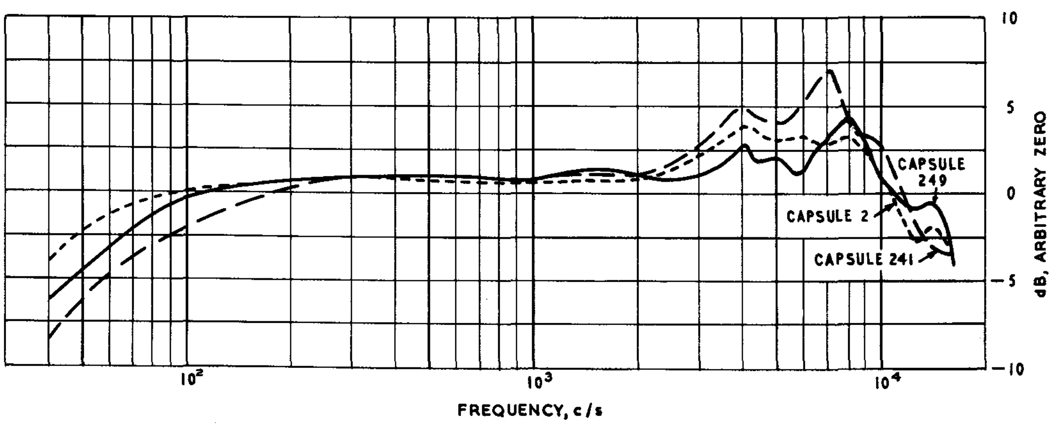

Fig. 9 - A.K.G. microphone type C28. Axial frequency measured at 200-ohm connection for three capsules

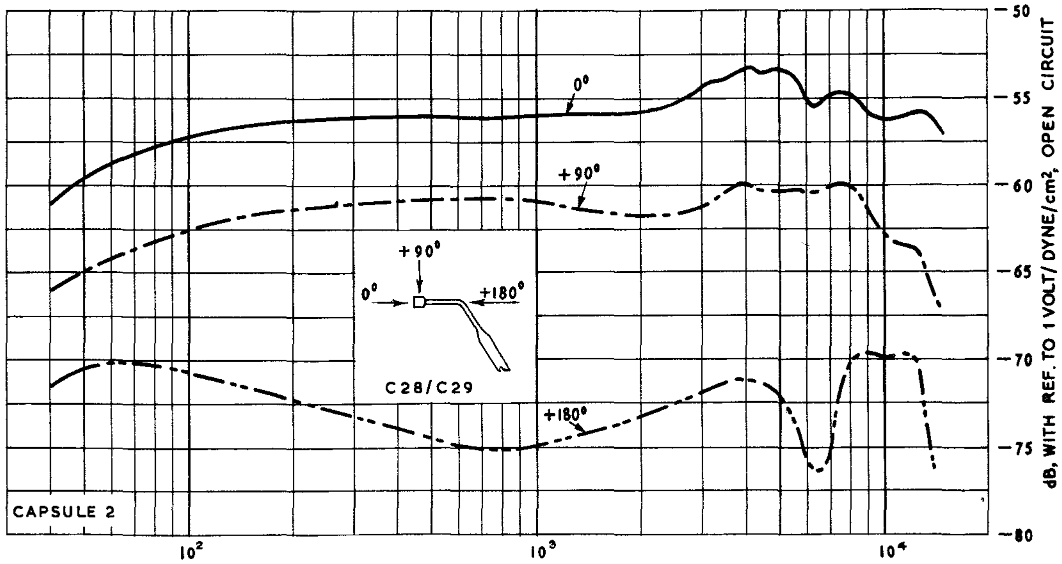

Fig. 10 - A.K.G. microphone type C28/C29. Frequency characteristics measured at 200-ohm connection for sound incident at various angles

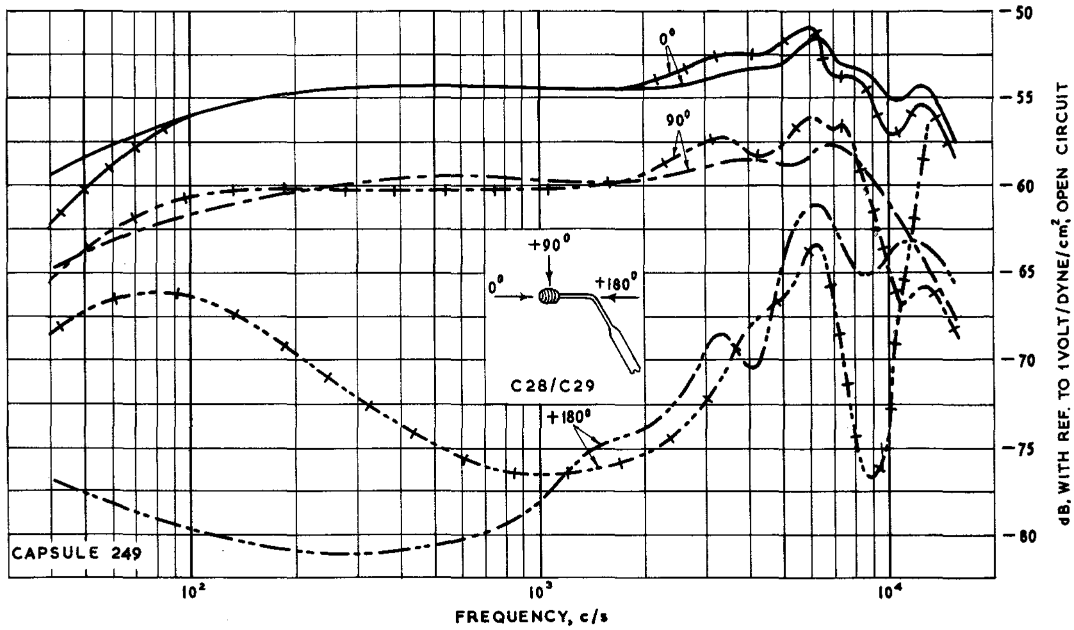

Fig. 11 - A.K.G. microphone type C28/C29. Frequency characteristics measured at 200-ohm connection for sound incident at various angles showing effect of windshield

Without windshield		With W17 windshield
————	0°	—+—+—+—+—
—— – ——	90°	—+— – —+—
—— - - ——	180°	—+— - - —+—

outside the maker's tolerance of ± 10%; the value of this impedance is affected to some extent by feedback through the grid-anode capacitance of the valve, which forms a potential divider with the capacitance of the particular capsule and extension piece in use. The impedance is, however, substantially constant over the whole audio-frequency band so that the on-load frequency characteristics do not differ significantly from those shown.

3.4. Sensitivity

The high tension supply from the mains unit is unstabilised and as a result the capsule polarising potential, and therefore the microphone sensitivity, changes with the voltage of the mains supply. For nominal mains voltage the open-circuit sensitivity of the type C26 microphone in the mid-band region is −56 dB with reference to 1 volt/dyne/cm^2 when using capsule No. 310 and −57 dB for capsule No. 311; the maker's figure is stated to be "about 1·3 mV", i.e. −57·5 dB.

Four type CK28 capsules were tested in the same head amplifier; the microphone open-circuit sensitivity lay between −54 dB and −55 dB with reference to 1 volt/dyne/cm^2, the maker's figure again specifying approximately −57·5 dB. When the type C29 and C30 extension pieces are used, the capacitance-to-earth of the additional length of lead involved shunts the signal from the capsule, and the sensitivity of the microphone is thereby reduced. The loss for the type C29 extension piece is 1 dB and for the type C30 approximately 3 dB; the maker does not appear to have appreciated this effect as the same sensitivity is quoted for all three conditions.

4. NOISE

4.1. Internally Generated Noise

The internally generated noise appearing at the output of the microphone is a combination of flicker effect in the valve and of thermal agitation in the resistive component of the grid circuit impedance.

The open-circuit noise when weighted by an aural sensitivity network type ASN/3 is −105 dB with reference to 1 volt both for the type C26 and for the type C28. The mid-band sound pressures required to give the same output levels are +25 dB and +23 dB respectively with reference to 0·0002 dyne/cm^2; if the rise in axial response of the type C26 microphone at high frequencies were equalised, the noise level would be somewhat reduced. For comparison, the weighted noise figure for the Philips type EL3921/00 microphone is +27 dB.

It appears that the noise figure for the types C26 and C28 microphones is not as good as it could be, because the head amplifier employs a triode operating under conditions of high gain producing a large effective input capacitance — about 65 $\mu\mu$F; as the type CK28 capsule has a capacitance of about 25 $\mu\mu$F, the signal at the valve grid is reduced to some 11 dB below the open-circuit output, resulting in an appreciable reduction in signal-to-noise ratio. The level delivered by the amplifier is too high to mix directly with that from most other types of microphone used in the Corporation; hence an attenuator of about 15 dB, designated AT.2/6 and provided by

Equipment Department, is normally fitted in series with the output. It seems probable that if, instead of using external attenuation, the amplifier gain, and thus the input capacitance, were reduced, the same effect would be achieved but with a better signal-to-noise ratio.

4.2. Interference from Magnetic Fields

Measurements were made of the maximum open-circuit voltage induced in the microphone by a uniform magnetic field. The unweighted mid-band sound levels, with reference to 0·0002 dyne/cm^2, required to give an output equivalent to that produced by uniform fields of 1 milligauss at 50 c/s, 1 kc/s and 10 kc/s are +1 dB, +13 dB and +23 dB for the type C26 microphone using capsule No. 311, and −2 dB, +10 dB and +20 dB for the type C28 using capsule No. 2. These levels are regarded as extremely low and should cause no trouble under normal studio conditions.

4.3. Interference from Radio-Frequency Signals

As with many electrostatic microphones, radio-frequency signals may be picked up and demodulated in the head amplifier. Although the manufacturer has endeavoured to reduce this effect to a minimum, considerable interference has been experienced on some occasions. An investigation carried out by Research Department[1] revealed the means by which the radio-frequency currents enter the amplifier screening and by paying careful attention to the method of earthing the microphone case the interference has been very considerably reduced. Details of the modification have already been issued as a memorandum by S.E.S.B. on 9th June 1960. It is carried out by connecting together the two tags shown in Fig. 12. However, when these microphones are to be used in places where appreciable radio-frequency fields are known to exist, tests should still be made in advance to ensure that interference is not likely to be troublesome.

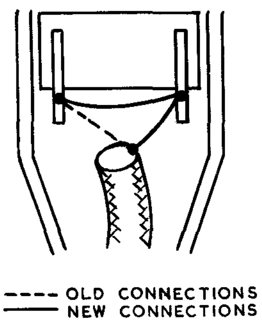

Fig. 12 - Wiring modification to reduce radio-frequency interference

4.4. Wind Noise

Measurements were made of the wind noise generated when the microphone was placed at various angles to a streamlined air flow of 10 m.p.h. both for the normal condition and when equalised so that the axial response was uniform from 1 kc/s down to 50 c/s. The open-circuit noise was weighted by the standard A.S.A.* network and measured by a V.U. meter; the results are given in the following table in terms of the level, with respect to 0·0002 dyne/cm^2, of a 1 kc/s tone calculated to give an equal signal.

*American Standards Association, Standard Z.24.3 — 1944, "Sound Level Meters for Measurement of Noise and Other Sounds".

TABLE 1

Microphone condition	Angle				
	0°	45°	90°	135°	180°
	dB	dB	dB	dB	dB
Normal C28: Capsule No. 216. Amplifier No. 352					
Unequalised	92	85	85	96	83
Equalised	102	96	97	107	96
With W28 windshield, unequalised	77	61	59	79	64
With W28 windshield, equalised	84	77	75	98	81
Bare on C29 extension, unequalised	106	100	98	96	87
Bare on C29 extension, equalised	117	112	111	108	101
On C29 extension with W17 windshield, unequalised	70	69	70	71	76
On C29 extension with W17 windshield, equalised	85	86	88	91	90
Normal C26: Capsule No. 311. Amplifier No. 352					
Unequalised	50	47	45	50	51
Equalised	49	43	43	46	49
With W28 windshield, unequalised	52	38	38	37	37
With W28 windshield, equalised	50	38	38	37	37
Bare on C29 extension, unequalised	76	63	66	60	53
Bare on C29 extension, equalised	71	58	57	60	51
On C29 extension with W17 windshield, unequalised	55	40	40	42	48
On C29 extension with W17 windshield, equalised	51	38	36	39	45

The wind noise levels with the types W17 and W28 windshields measured without bass equalisation are low for both types of microphone.

4.5. Interpretation of Noise Measurements

In applying these results it should be remembered that the aural sensitivity weighting where used is intended to give an indication only of the loudness of the noise. The subjective assessment of the annoyance caused depends on such factors as the degree to which it may blend with the studio "atmosphere" and other background noises.

4.6. Listening Tests

Listening tests were carried out on speech from non-reverberant surroundings. The results obtained were in agreement with the objective tests.

5. CONCLUSIONS

The type C26 microphone appears to be a reasonable replacement for the Philips type EL3921/00. The electrical noise is a little lower and the microphone is slightly less directional at high frequencies; as with the Philips microphone, a certain amount of equalisation is desirable.

The axial frequency response of the type C28 microphone is free from serious irregularities and is well maintained over the frequency band. The directional characteristic is also nearly independent of frequency. The electrical noise is low but could probably be made even lower by a modification of the head amplifier.

The facility of mounting the type CK28 capsule on one of the extension pieces types C29 or C30 has proved useful on occasion. The windshields provided are effective with both the types CK26 and CK28 capsules and produce appreciably less degradation in the frequency characteristics than is usual with commercial shields.

6. REFERENCE

1. B.B.C. Research Department Report No. L-047, "Radio-Frequency Interference in Electrostatic Microphones".

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