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RESEARCH DEPARTMENT

THE SENNHEISER MKH 404 AND AKG 628 MICROPHONES

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SUMMARY

Two new capacitor microphones, the Sennheiser type MKH 404 and the Akustische und Kino Geräte type 628, have been produced which employ transistor circuits and radio-frequency polarizing of the capsule; both have a cardioid directional characteristic and are of the end-fire type.

Measurements of the frequency characteristics have been carried out for sound incident at various angles; the degree of self-generated noise and interference from wind and magnetic fields have also been determined.

The frequency characteristics of the Sennheiser type MKH 404 microphone vary more than usual with angle of sound incidence but the level of internally generated noise is extremely low.

The axial response of the AKG type 628 microphone extends to about 15 kHz (kc/s) but the back suppression is poor between 3 kHz and 8 kHz; on the other hand, the self-generated noise level is the lowest so far met with in a capacitor type microphone. The specimen tested was a pre-production model; the production version will be coded C600, C601 or C602 according to the power supply arrangements.

1. INTRODUCTION

Recently a great deal of interest has been shown in the application of transistors to capacitor microphones, and in particular to the revival of an old idea, namely the use of radio-frequency polarizing of the capsule. The advantages claimed for this form of polarizing over the usual d.c. form are two-fold, firstly a lower level of electrical noise in the microphone output, and secondly the ability to operate under conditions of high humidity. The reason for this latter advantage is that at radio frequencies the capsule has a much lower impedance than at audio frequencies and therefore there is no need to maintain such an extremely high insulation resistance. It is also probable that transistors will prove to be more reliable than valves have been. There is one disadvantage of the system, however, in that it is not possible to replace a capsule on the microphone without readjusting the electrical circuit, but it is to be hoped that in practice this limitation will not prove to be serious.

The two latest microphones to employ these techniques are the type MKH 404 made by Sennheiser in Germany and the type 628 manufactured by Akustische und Kino Geräte in Vienna, and it is therefore convenient to report on them together.

2. DESCRIPTION

Both microphones nominally have a cardioid directional characteristic; the external appearance and dimensions are shown in Figs. 1 and 2. The weights of the instruments are 100 g for the type MKH 404 and 60 g for the type 628 microphone.

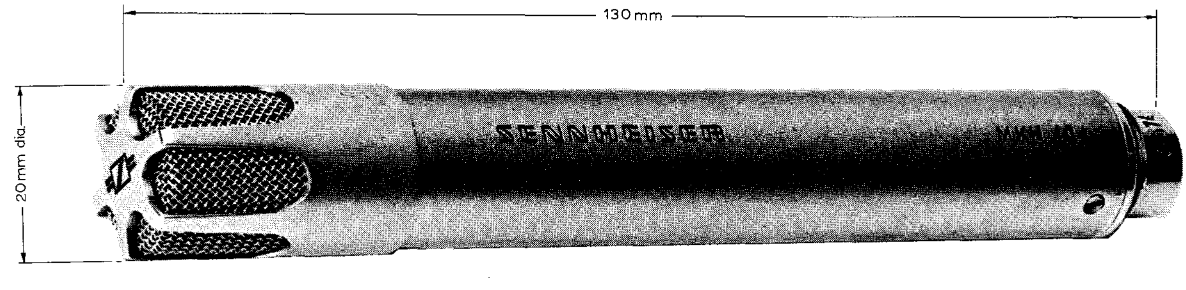

Fig. 1 - External appearance and dimensions of Sennheiser microphone type MKH 404

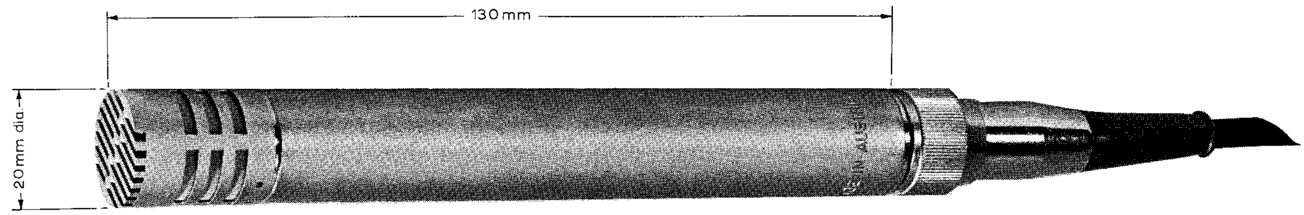

Fig. 2 - External appearance and dimensions of AKG microphone type 628

The Sennheiser microphone is provided with batteries of the Mallory type, the battery case screwing directly on to the microphone; the additional length is 76 mm and the additional weight 85 g.

The AKG type 628 microphone is a pre-production model and was supplied with 4·2V from a Neumann mains type NKM, but in production three separate models will be provided and the type numbers will be C600, C601 and C602 respectively. Of these, the type C600 will have an external supply phantom fed along the output leads, the type C601 will also have an external supply and in addition will contain internal batteries which will normally be floating across this supply but which can be employed independently when desired. Type C602 will be supplied from a Neumann mains unit and will contain an extra smoothing circuit to make this arrangement practicable.

The capsule of the AKG microphone is stated by the designers to be similar to that supplied with their type C60 microphone.

3. CIRCUIT DETAILS

The circuits employed are shown in Figs. 3 and 4 for the type MKH 404 and the type 628 microphones respectively. The circuit for the Sennheiser microphone has been described in the literature[1] to which reference should be made for detailed information. The microphone capsule M (see middle of Fig. 3) is connected in a bridge circuit and tuned with an inductance, L_2, there being a corresponding resonant circuit, L_1, and C_1 in the opposing arm; the bridge is supplied with a carrier signal at about 8 MHz from the oscillator T_1. The bridge output, in the form of an amplitude modulated signal, is obtained from diodes D_1 and D_2 of the phase-sensitive detector.

Fig. 4 shows the circuit for the type 628 microphone. Once again a bridge circuit is employed and is driven by oscillator T_1; the balancing capacitance is formed by C_6 and C_2 in parallel. The bridge unbalance signal is amplified and demodulated by the remainder of the circuit and a transformer output is provided.

In both circuits it is necessary to rebalance the bridge if the capsule is replaced and in Fig. 4, capacitor C_6 is made variable for this purpose. The makers state that C_6 should be adjusted for minimum distortion; this adjustment is difficult to carry out in studio premises but it is stated that if C_6 is adjusted for minimum feed current, this procedure gives a close approximation to the optimum setting. No corresponding adjustment is provided to C_1 in

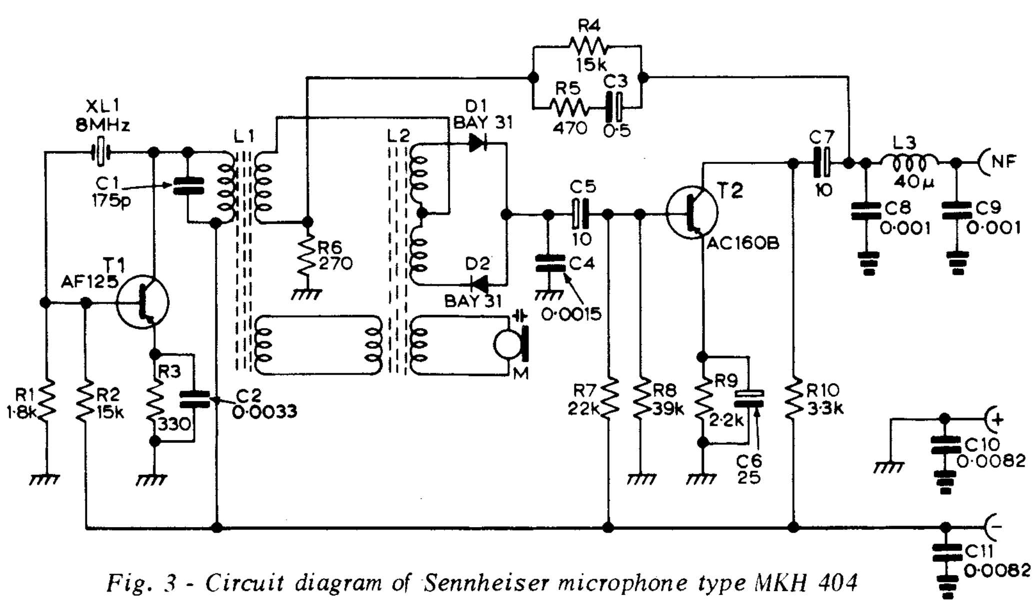

Fig. 3 - Circuit diagram of Sennheiser microphone type MKH 404

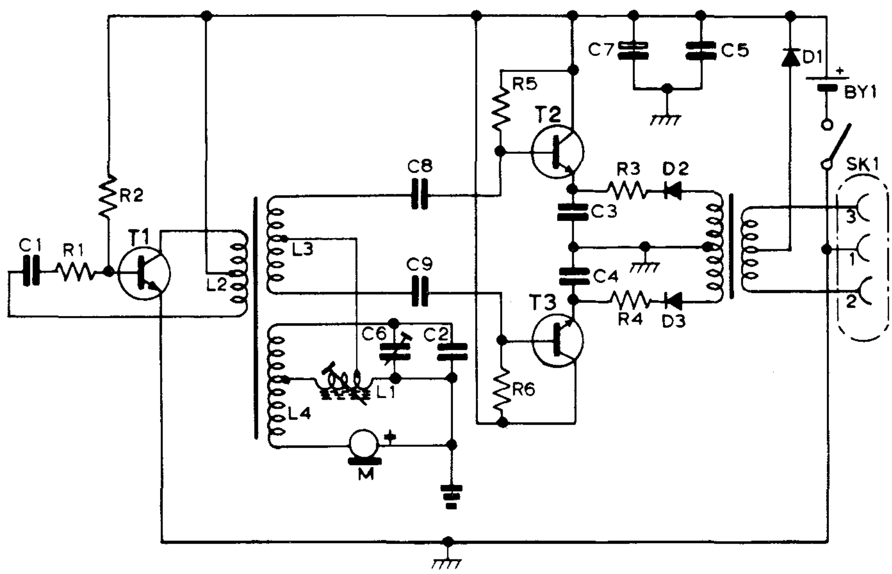

Fig. 4 - Circuit diagram of AKG microphone type 628

Fig. 3 and the microphone must presumably be returned to the makers whenever a new capsule is to be fitted. For the type MKH 404 the makers estimate(1) that the capacity variation in the capsule for a sound level approaching the overload point is only one part in 500 and it is clear that static capacity unbalance must be held to a small fraction of this; it has been necessary, therefore, for both capsule and compensating capacitor to be specially constructed with a temperature coefficient which is both low and similar for each component. If, however, the microphone is placed in a powerful source of radiant heat, e.g. in the beam of an arc lamp, it is probable that the capsule will change capacity much more quickly than the compensating capacitor, since the latter is inside the head amplifier and therefore shielded from the heat; the working point of the system will then be displaced along the transfer characteristic and the overload point will be temporarily reduced.

4. PERFORMANCE

4.1. Method of Measurement

The frequency characteristics above 200 Hz were measured by comparison with a pressure standard in a free-field room; below 200 Hz measurements were carried out in a travelling-wave duct against a similar standard. Generally the accuracy of comparison is ±½ dB but errors of ±1 dB can occur for sound incident at angles greater than 90°.

4.2. Frequency Characteristics

Fig. 5 shows the open-circuit frequency characteristics of the Sennheiser type MKH 404 microphone. It will be noted that the response is somewhat irregular on the axis and is different at +90° from that at -90° and again for +135° and -135°. Such a difference is not unknown but it is unusual to find it extending over such a wide frequency range. Apart from this the directional properties are well maintained down to the lowest frequencies.

Fig. 6 shows the open-circuit frequency characteristics of the AKG type 628 microphone; in this case the characteristics are symmetrical about the axis. It will be seen that although the axial response is maintained up to 15 kHz the response for sound incident at 90° falls off rapidly above 5 kHz; furthermore, the 180° curve is only about 5 dB below the axial curve at 6 kHz. The makers state, however, that this will be corrected in the production models.

4.3. Impedance

The nominal impedance of the Sennheiser type MKH 404 microphone is 800 ohms and according to the makers it should be loaded with not less than 1000 ohms. The measured modulus of the impedance is given in Fig. 7 from which it will be observed that in fact it varies considerably with frequency. If, however, the microphone is connected to an amplifier of 300 ohms input impedance via an LGG/2S transformer which has an impedance ratio of 13 : 1, the voltage developed across the amplifier input for constant output from the microphone is substantially independent of frequency, so that the on-load characteristics do not differ significantly from those shown.

The impedance of the AKG type 628 microphone is approximately 230 ohms and is largely independent of frequency.

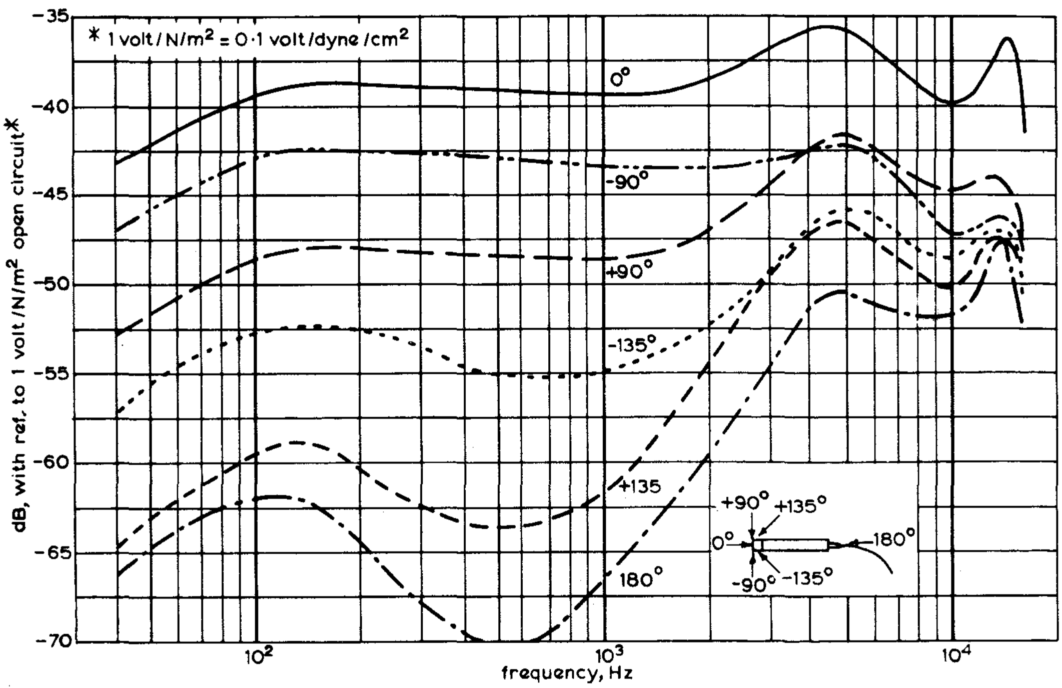

Fig. 5 - Frequency characteristics of Sennheiser microphone type MKH 404, Serial No. 64674

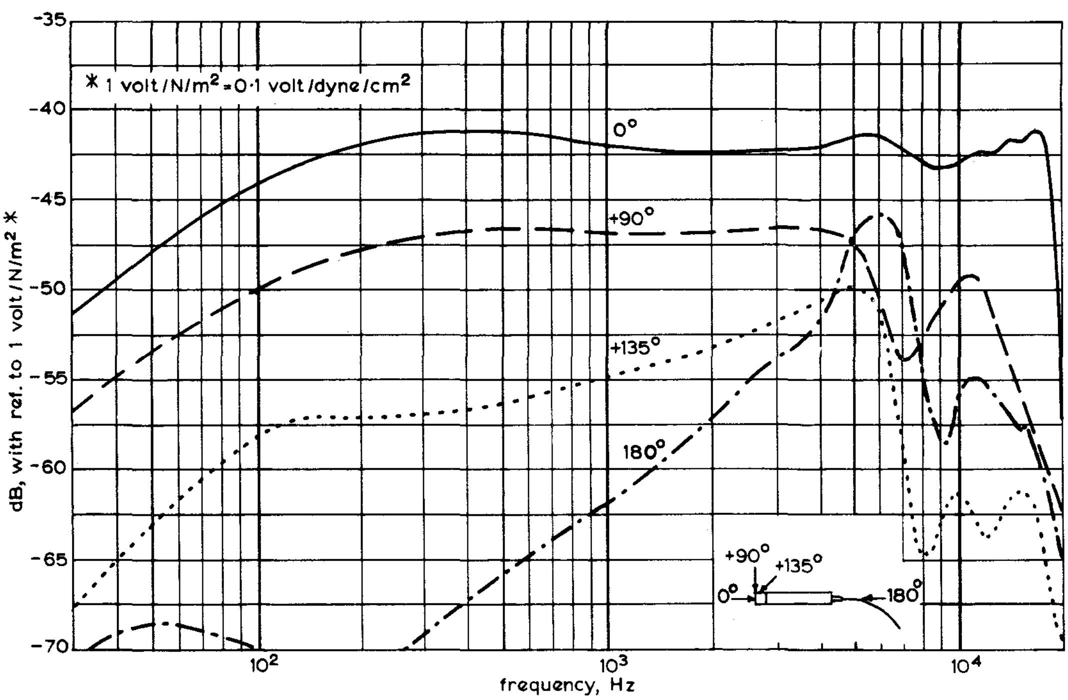

Fig. 6 - Frequency characteristics of AKG microphone type 628, Serial No. 009

4.4. Sensitivity

For the Sennheiser type MKH 404 microphone the radio-frequency voltage applied to the capsule, and hence the sensitivity, will vary with the battery voltage. With new batteries the mid-band sensitivity is -39 dB with reference to 1 volt/N/m².* The mid-band sensitivity of the AKG type 628 microphone, when connected to the Neumann mains unit type NKM, is -41·5 dB with reference to 1 volt/N/m².

* 1 Newton/metre² = 10 dynes/cm².

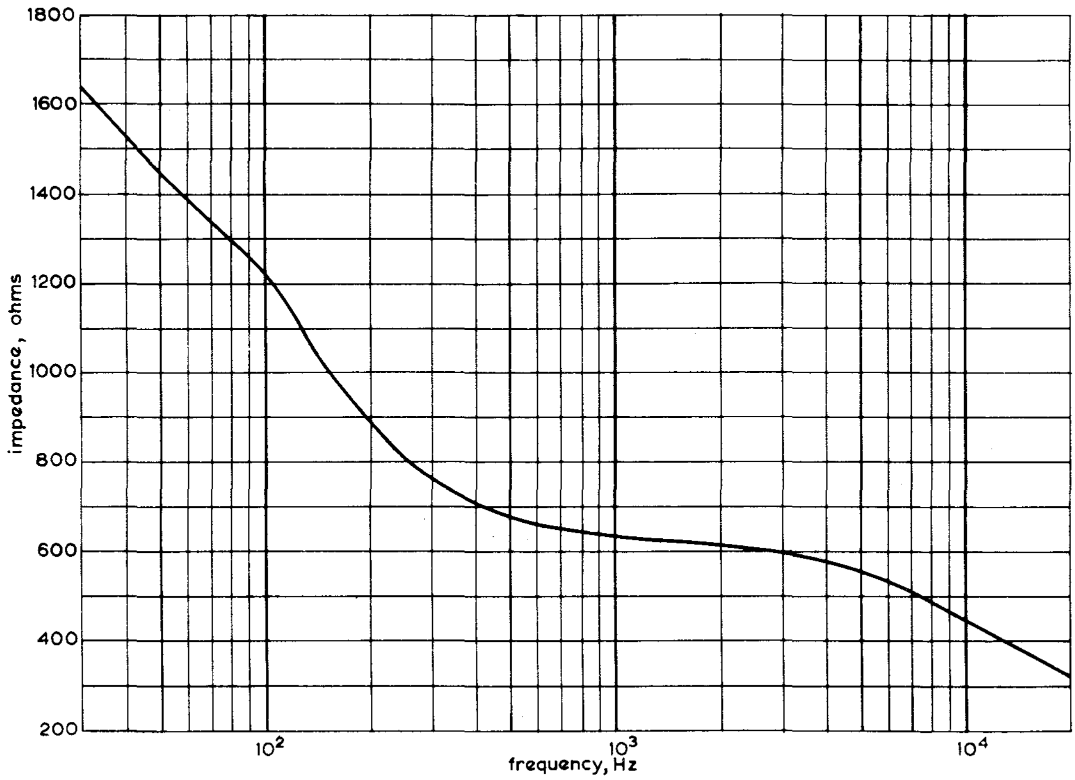

Fig. 7 - Modulus of impedance of Sennheiser microphone type MKH 404, Serial No. 64674

5. NOISE

5.1. Internally Generated Noise

The internally generated noise appearing at the output of the microphone is a combination of transistor noise, diode noise and thermal agitation noise in the resistive component of the base circuit impedance.

The open circuit noise when weighted by an aural sensitivity network type ASN/3 is -133 dB with reference to 1 volt/N/m^2 for the type MKH 404 microphone and -138 dB for the type 628. The mid-band sound levels required to give the same output levels are +20 dB and +17 dB respectively with reference to 20μN/m^2. It will be noted that these sound levels are very low, indeed the value for the type 628 is the lowest so far measured for a capacitor type microphone. It is not, however, possible to state whether the fact that a lower noise level is obtained from the type 628 than from the type MKH 404 instrument is due to a higher sensitivity capsule or whether the associated circuit is less noisy.

5.2. Interference from Magnetic Fields

Measurements were made of the maximum open-circuit voltage induced in the microphones by a uniform magnetic field. The unweighted mid-band sound levels, with reference to 20μN/m^2, required to give an output equivalent to that produced by a uniform field of 1 microtesla * at 50 Hz, 1 kHz and 10 kHz, are +22 dB, +28 dB and +53 dB for the type MKH 404, and +27 dB, +33 dB and +47 dB for the type 628 microphone respectively. These levels are regarded as extremely low and should cause no trouble under normal studio conditions.

5.3. Wind Noise

Measurements were made of the wind noise generated when the microphones were placed at various angles to a streamlined airflow of 16 km/h. To permit comparison with other microphones having a different frequency characteristic at the bass, the measurements were repeated with the microphones electrically equalised so that the axial response was uniform within ±1 dB from 1 kHz down to 40 Hz; below 400 Hz the response was attenuated by a high-pass filter. The open-circuit noise was weighted by the standard ASA** network and measured by a V.U. Meter; the results are given in the following table in terms of the sound level at 1 kHz which would give the same r.m.s. output from the microphone.

The wind noise levels for both microphones are seen to be substantially the same but they are about 3 decibels higher than for the average capacitor microphone.

* 1 microtesla = 10 milligauss.

** 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°
	Sound level dB with ref. to 20μN/m^2				
Unequalised Sennheiser MKH 404	+97	+95	+97	+104	+92
Equalised Sennheiser MKH 404	+104	+100	+104	+108	+97
Unequalised AKG 628	+98	+98	+97	+101	+97
Equalised AKG 628	+104	+100	+101	+107	+101

5.4. 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 concerned. The subjective assessment of the annoyance caused by the noise depends on such factors as the degree to which blending may take place with studio "atmosphere" and other background noises.

6. CONCLUSIONS

In both the Sennheiser MKH 404 and the AKG 628 microphones, a very low level of electrical noise has been achieved by the use of radio-frequency polarizing, that of the type 628 being the lowest so far measured on a capacitor microphone.

The axial frequency characteristic of the Sennheiser microphone is somewhat irregular at high frequencies whilst the directional properties vary with angle around the instrument.

The axial frequency characteristic of the type 628 is smooth and extensive but the front-to-back ratio is very low around 6 kHz.

7. REFERENCE

1. GRIESE, H.J. 1964. Circuits of transistorized r.f. condenser microphones. *J.Audio Engng Soc.*, 1965. **13**, 1, pp. 17 - 22.

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