RESEARCH DEPARTMENT

The Neumann Microphone Type U 47

Report No. M.020

Serial No. 1954/23

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

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SUMMARY

A new directional electrostatic microphone, type U 47, produced by the firm of Neumann in Berlin, incorporates the capsule originally designed for the type M 49 microphone but uses a cheaper form of head amplifier. The U 47 microphone is designed to give either cardioid or omnidirectional polar response. Frequency characteristics, sensitivity and noise have been measured on a single specimen for both conditions.

The response of the microphone capsule in the cardioid condition is very good, but the overall performance is spoilt by the obstacle effect of the large head amplifier. The signal-to-noise ratio is unusually high.

In the omnidirectional condition the microphone is of no special interest.

1. INTRODUCTION.

The U 47 is a recent addition to the series of directional electrostatic microphones manufactured by Messrs. Neumann in Berlin and has lately been described in the technical press*. Omnidirectional or cardioid polar characteristics can be selected by a switch mounted on the head amplifier. The microphone is stated by the manufacturers to be a less costly version of the M 49, using the same capsule with a different amplifier and mains unit. The quality of reproduction compares very favourably with that obtained with other electrostatic microphones. A specimen has been in use for several months and performance tests on this instrument were undertaken at the request of S.S.E., H.S.B.

The price of the microphone complete with cables and mains unit is £100.

2. DESCRIPTION OF MICROPHONE.

2.1. General.

Fig. 1 shows the appearance and dimensions of the instrument, together with the location of the main components in the head amplifier. The microphone casing is plated; the central portion surrounding the amplifier has a matt finish, the remain-

*Bauch, "New high-grade condenser microphones", Wireless World, No. 59, March 1953, pp. 111-14.

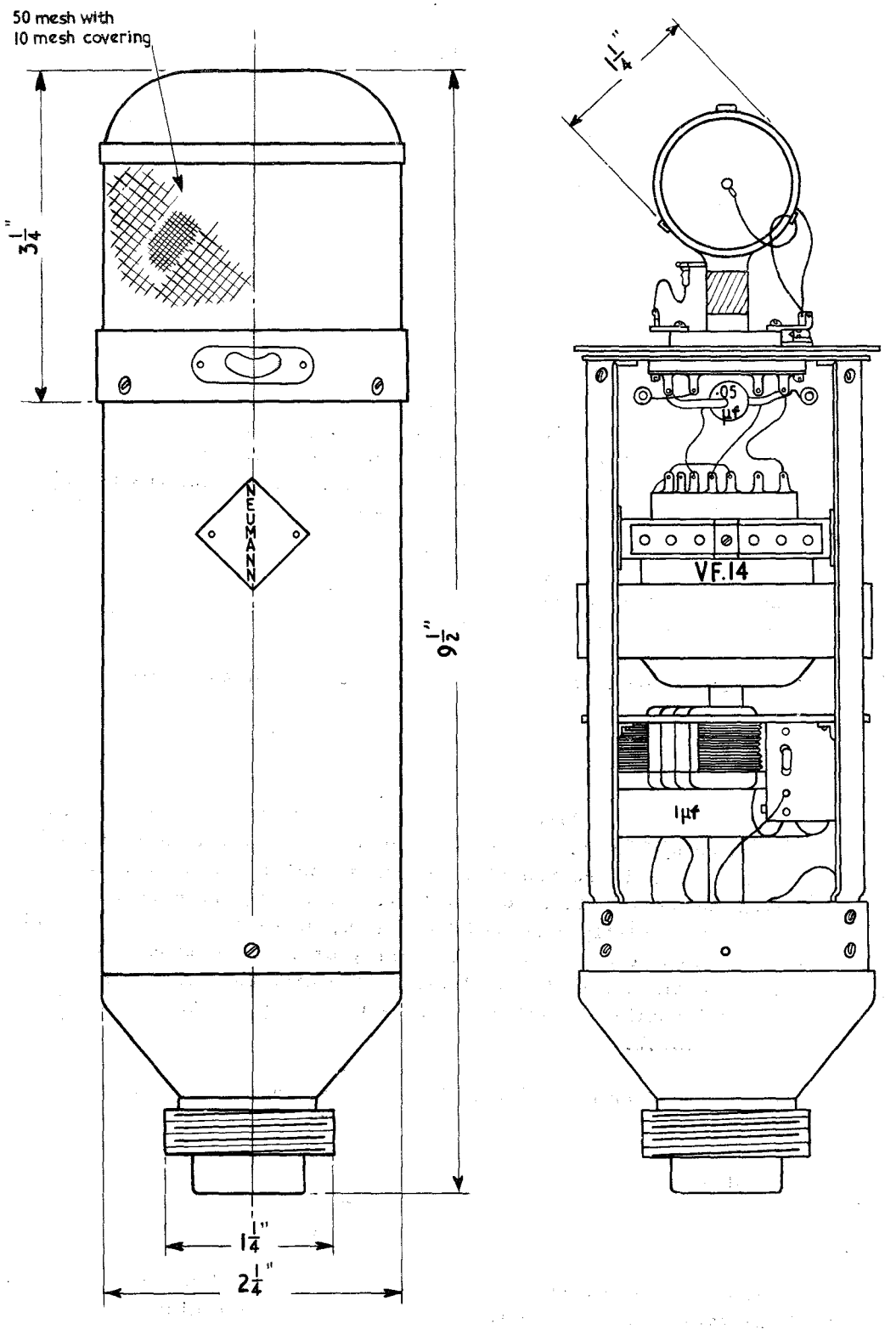

Fig. 1. Neumann condenser microphone type U.47

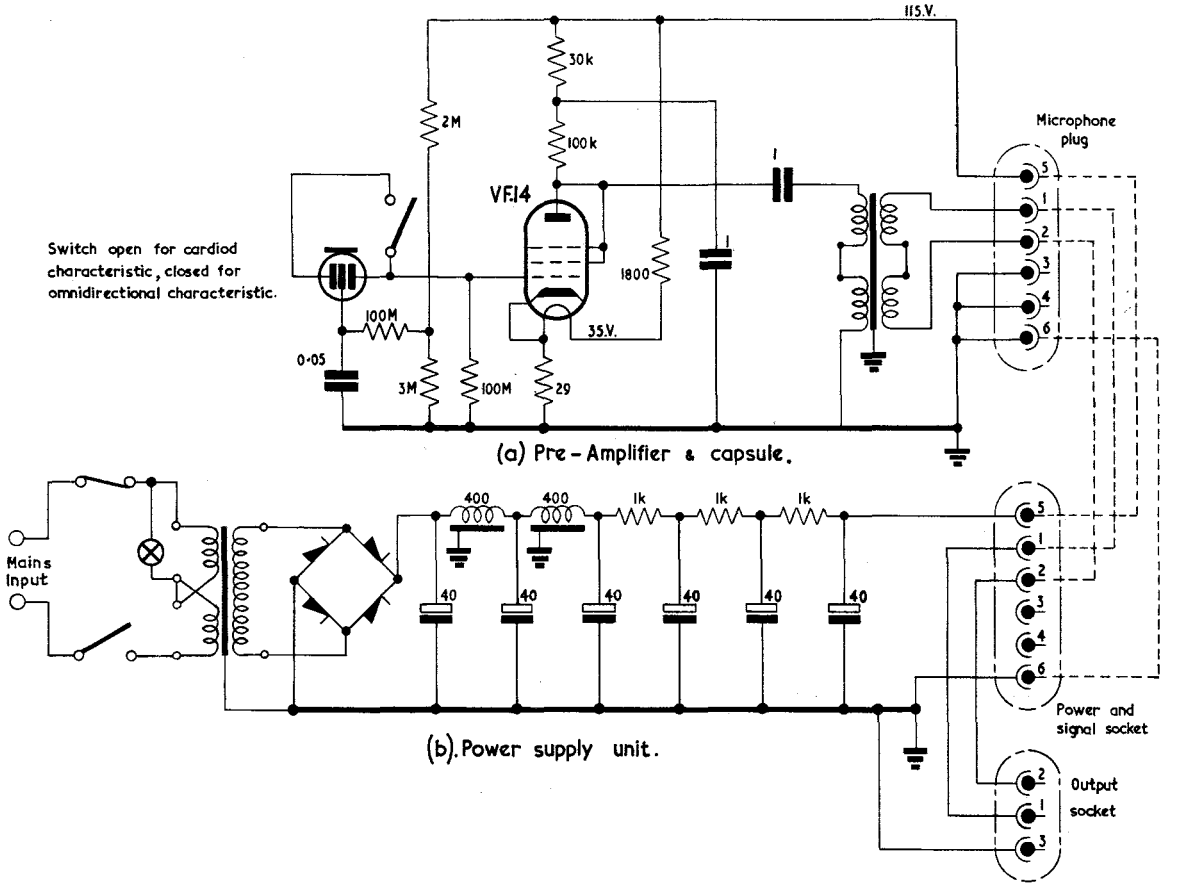

Fig. 2. Circuit diagram.

der being polished. The circuit diagram, Fig. 2, shows two unusual features. The valve used has a high-voltage heater, the current for which is taken from the H.T. supply through a voltage dropping resistance. The heater current, amounting to some 40 mA, returns to earth through a 29 ohm resistor included in the cathode circuit and thus provides the necessary bias; no by-pass condenser is necessary since the cathode resistance is too small to produce appreciable feedback or noise.

The microphone capsule is attached to the top of the amplifier by a rubber stalk which provides a certain degree of insulation against vibration. Mechanical protection and electrical screening are afforded by an outer case of 50 mesh wire gauze sandwiched between two layers of 10 mesh gauze. By modern standards the head amplifier is unnecessarily large. Even though no miniature components are used the size could easily have been reduced.

The microphone is connected by a 6 pin plug and cable to a mains unit, 4 in. × 4 in. × 8½ in. (102 mm × 102 mm × 216 mm) long. The audio-frequency output is

taken from the mains unit through a 3 pin plug; the nominal output impedance is 200 ohms.

2.2. Weight.

The weight of the microphone is 1·5 lb (0·68 Kg), and of the mains unit, 6·2 lb (2·8 Kg).

3. PERFORMANCE.

3.1. Methods of Measurement.

The frequency characteristics were measured by comparison with a pressure standard in a dead room except in the cardioid condition at frequencies below 200 c/s, for which the measurements were made in a plane-wave duct. The accuracy of comparison with the standard was in general ± ½ db, except for cardioid operation at angles of incidence greater than ± 90°, in which case errors up to ± 1 db would be possible. The characteristics of the standard are known to within ± ½ db.

3.2. Frequency Characteristics.

Figs. 3, 4 and 5 show the open-circuit frequency characteristics of the microphone in the omnidirectional condition for sound incident at various angles in the horizontal and vertical planes. Figs. 6, 7 and 8 show corresponding plane-wave characteristics for the microphone in the cardioid condition. In Figs. 4 and 7 the irregular nature of the curves at frequencies above 2 kc/s for sound incident at 90° is due to interference between the direct wave and the wave reflected from the head amplifier.

Throughout the audio-frequency band the impedance of the microphone is so close to the nominal 200 ohms that the on-load frequency characteristics do not differ significantly from those shown.

Figs. 9(a) and 9(b) show the manufacturers' curves for the omnidirectional and cardioid conditions respectively.

3.3. Sensitivity.

In the mid-band region the open-circuit sensitivity of the microphone is − 57 db relative to 1 volt/dyne/cm^2 for the omnidirectional and − 51 db for the cardioid condition; these values agree closely with those given by the makers. If an ideal transformer were used to raise the output impedance to 300 ohms, the sensitivity measured at the output terminals would be − 55 db and − 49 db relative to 1 volt/dyne/cm^2 respectively. The corresponding figure for the type AXBT microphone is − 71 db.

3.4. Noise.

3.4.1. General: In the absence of interference the noise output of the microphone is a combination of flicker effect in the valve and thermal agitation in the resistive component of the grid circuit impedance. In the present case both

sources have a similar spectrum, the noise having roughly constant power per octave throughout the audio-frequency band.

For the omnidirectional and cardioid conditions the open-circuit noise levels, when weighted by an aural sensitivity network ASN/3, are respectively - 110 db and - 108 db relative to 1 volt. The mid-band sound pressures required to give the same output levels are + 20 db and + 16 db relative to 0·0002 dyne/cm^2. For comparison, the corresponding sound pressure for the AXBT microphone is + 18 db. For the U 47 microphone the makers claim an equivalent noise figure of less than 18 "phons"; it is not stated whether this figure refers to the omnidirectional or cardioid condition and no indication is given of the type of weighting used.

3.4.2. Interference from Magnetic Fields: The open-circuit pick-up in the microphone generated by a uniform magnetic field was measured at 50 c/s, 1 kc/s and 10 kc/s. The table shows the pick-up for the orientation which gives the maximum output at each frequency, together with the sound level in the mid-band region necessary to give an equivalent output. For comparison, corresponding figures for a typical AXBT microphone are also included.

4. LISTENING TESTS.

Speech tests were carried out using male voices in acoustically dead surroundings. In the omnidirectional condition the accentuation of high frequencies caused by the rise in response in the region of 8 kc/s to 10 kc/s was clearly audible and the effect was possibly increased by the fall in response for frequencies between 4 kc/s and 6 kc/s. In the cardioid condition a slight bass loss was noticeable but the peak at 10 kc/s was not prominent. The signal-to-noise ratio was extremely good.

Further listening tests, using orchestral music, were carried out by S.S.E., H.S.B.'s Department; the results of these tests are given in the Appendix.

5. CONCLUSIONS.

The signal-to-noise ratio of the microphone is very good, especially in the cardioid condition. The falling off in the low-frequency response in this condition is noticeable on speech from a non-reverberant room although it seems, from the comments of S.S.E., H.S.B.'s Department, that the bass response in reverberant surroundings is adequate; in view of the poor directional properties in this frequency band it is not certain that equalisation would bring about an improvement in quality. The polar characteristics are good in the mid-band region but deteriorate at high frequencies, particularly for angles in the vertical plane, and the response at frequencies between 9 kc/s and 12 kc/s could with advantage be reduced.

In the omnidirectional condition the frequency response is good apart from a sharp rise in the 8 kc/s to 10 kc/s region.

The interference caused by extraneous magnetic fields is extremely low and should not give rise to any trouble.

In the cardioid condition the microphone capsule is one of the best of its type tested. It is therefore regrettable that the response has been degraded by the use of such a bulky head amplifier. In the omnidirectional condition the microphone does not appear to have any specially commendable properties.

TABLE 1

OPEN-CIRCUIT VOLTAGE AT 300 OHM OUTPUT DUE TO MAGNETIC PICK-UP IN A FIELD OF ONE MILLIGAUSS

Zero = 1 volt

FREQUENCY	(a) U 47 omnidirectional*	(b) U 47 cardioid*	(c) AXBT†
c/s	db	db	db
50	−126	−126	−133
1,000	−124	−124	−121
10,000	−110	−110	−107

TABLE 2

SOUND LEVEL IN MID-BAND REGION TO GIVE OPEN-CIRCUIT OUTPUT SHOWN IN TABLE 1

Zero = 2×10^{-4} dyne/cm^2

	(a) U 47 omnidirectional*	(b) U 47 cardioid*	(c) AXBT†
	db	db	db
50	+3	−3	+12
1,000	+5	−1	+24
10,000	+19	+13	+38

*At terminals of ideal 200 : 300 ohm transformer.

†Figures given represent a typical microphone.

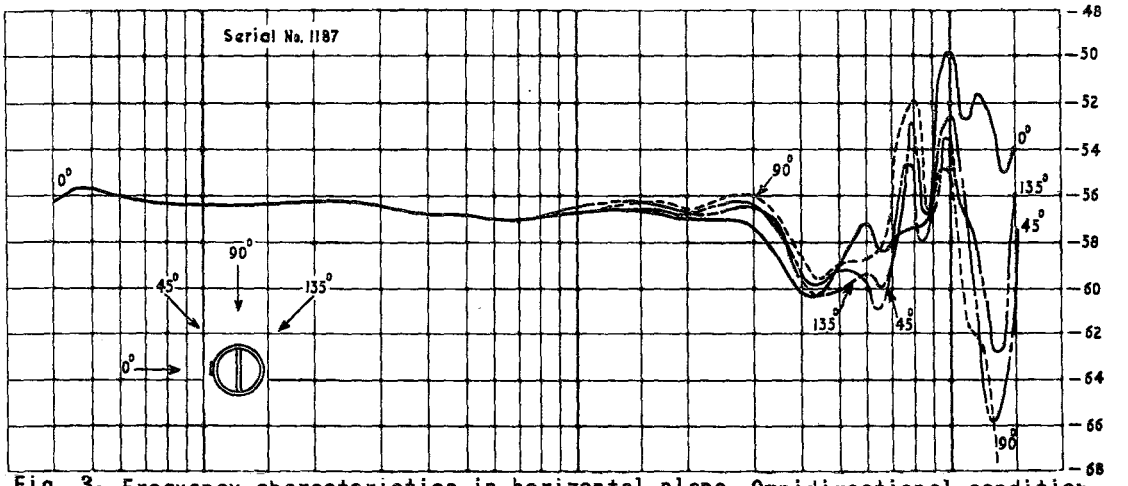

Fig. 3. Frequency characteristics in horizontal plane. Omnidirectional condition.

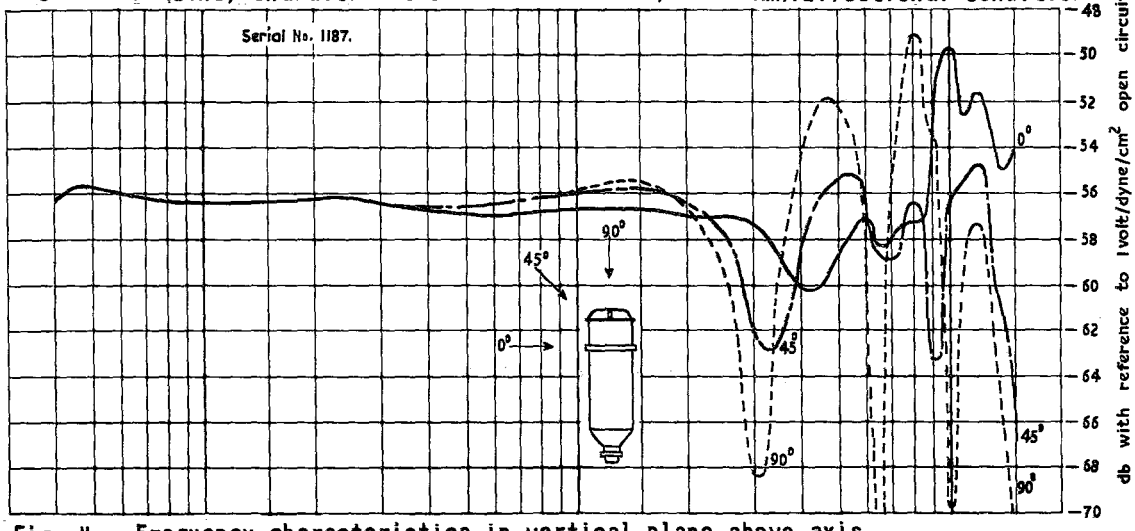

Fig. 4. Frequency characteristics in vertical plane above axis.
Omnidirectional condition.

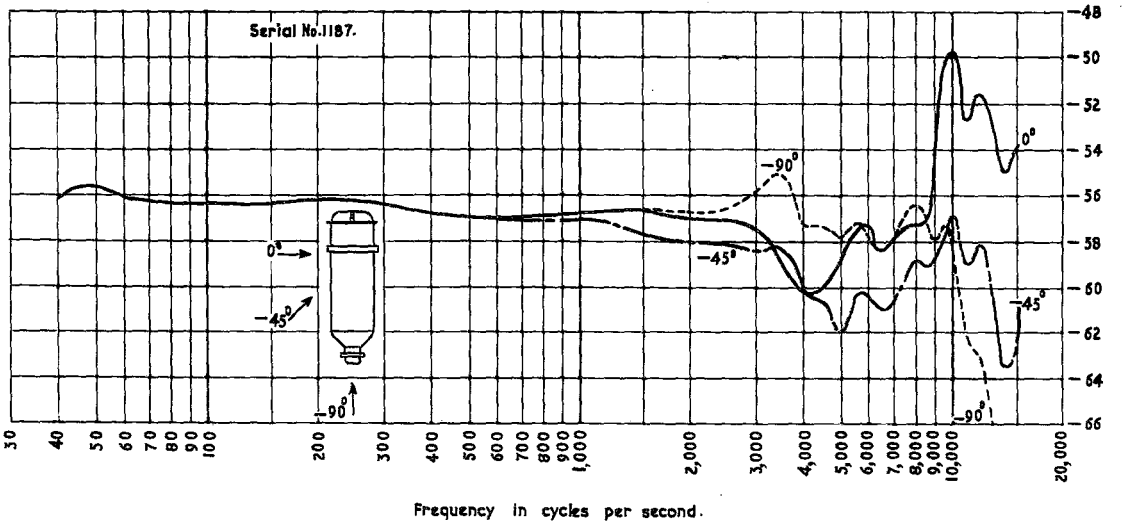

Fig. 5. Frequency characteristics in vertical plane below axis.
Omnidirectional condition.

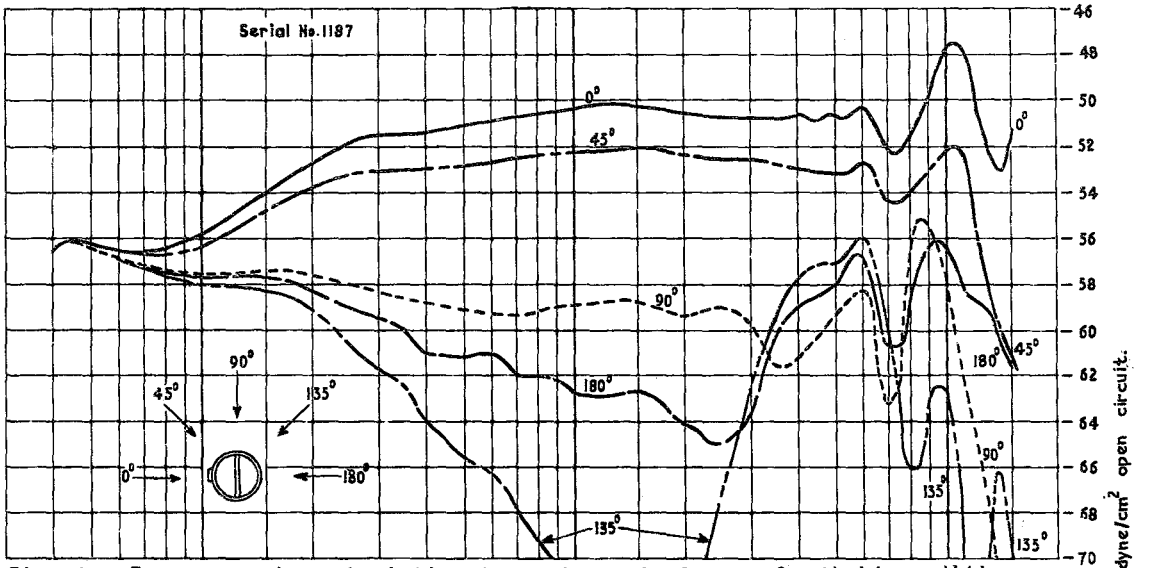

Fig. 6. Frequency characteristics in horizontal plane. Cardioid condition.

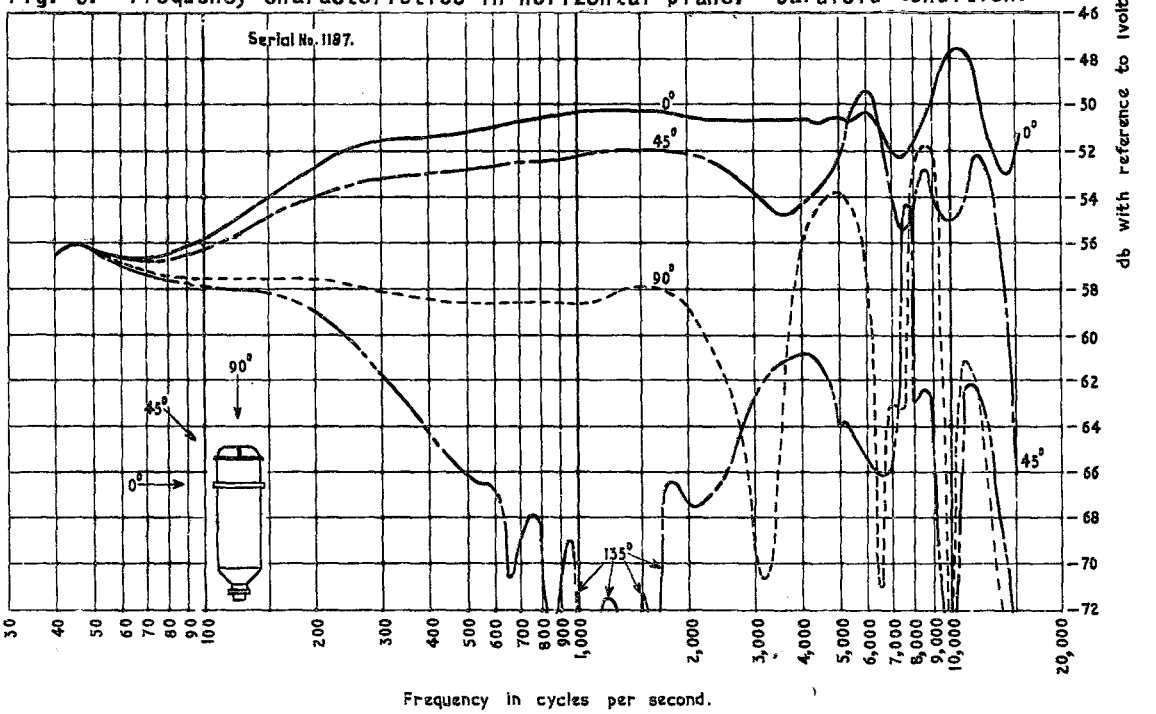

Fig. 7. Frequency characteristics in vertical plane above axis. Cardioid condition.

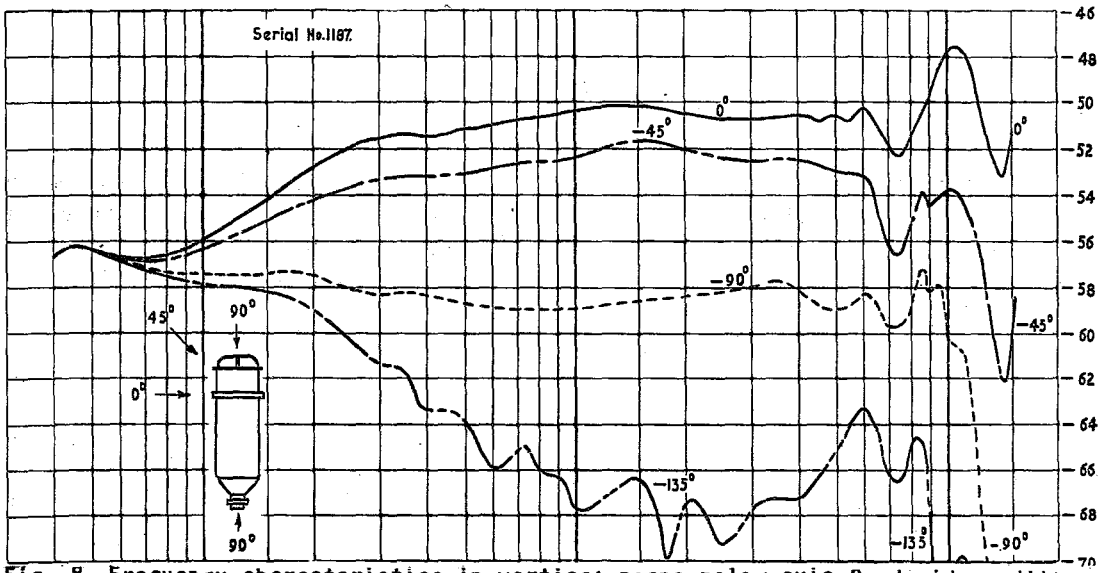

Fig. 8. Frequency characteristics in vertical plane below axis. Cardioid condition

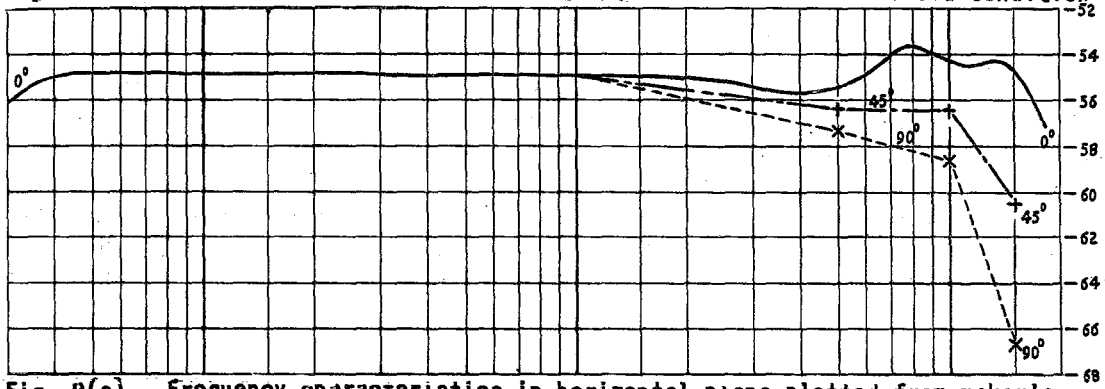

Fig. 9(a). Frequency characteristics in horizontal plane plotted from maker's data. Omnidirectional condition.

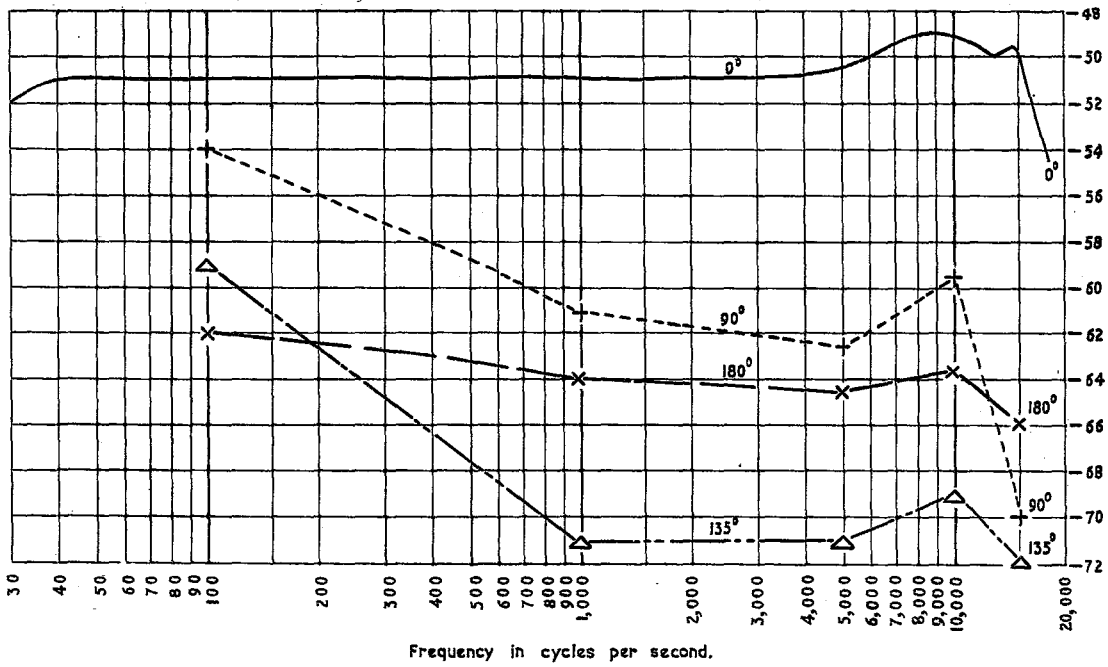

Fig. 9(b). Frequency characteristics in horizontal plane plotted from maker's data. Cardioid condition.

APPENDIX

The following comments are taken from a memorandum, dated 9th September, 1953, from Mr. Gundry to S.S.E., H.S.B., describing a test, carried out with orchestral music, in which the U 47 was compared with other types of microphone. The instrument referred to as "the Philips condenser microphone" is the Philips type EL 3921/00.

"..... In the omnidirectional condition this [the U 47 microphone] was compared with the Philips condenser microphone. It was definitely preferred to the Philips, having negligible colouration at very high frequencies and being otherwise at least as good. Further comparison with the PGD ribbon microphone showed that in general the tonal quality of these two was almost identical, though the extreme bass seemed slightly better defined on the U 47. The U 47 was then switched to cardioid polar diagram. Again, tonally it differed little from the PGD, but the slight superiority in bass definition persisted. These tests confirmed the impression gained when using the U 47 that it gives the best tonal quality of any condenser microphone we have yet tested, and is markedly preferable to that obtained from the three M 49 specimens in our possession. Moreover, it has sufficient bass output without equalisation. No tests have been carried out on its front-to-back ratio as a cardioid at low frequencies, where the M 49 is unsatisfactory.

In all the above tests the condenser microphones were used without correction; the PGD had approximately 3·5 db top lift at 10,000 c/s. All microphones were side by side, regardless of polar diagram and at about the normal working distance for a ribbon microphone.....

.....The U 47 microphone is an excellent microphone of simple construction, the mains unit containing no valves, though the valve in the head-amplifier is a special Telefunken type. However, it is considerably larger than the Philips, and Telefunken omnidirectional microphones, and therefore not suitable for certain purposes, such as the Royal Festival Hall....."