Developments in Microphones

A review of recent innovations in design

by H. D. Harwood, B.Sc.*

THERE has been a considerable amount of work on microphones during the last few years, resulting in improved frequency characteristics, better signal-to-noise ratio and smaller size. It is difficult to say at this stage whether all the variations are likely to endure or whether some will eventually predominate on the grounds of simplicity or price, but at the moment the spate of innovations shows no signs of slackening.†

Capacitor Microphones

Perhaps the class of microphone which has changed most generally over the past few years is the capacitor type. Most of these changes are associated with the design of the head amplifiers and biasing.

Circuit Design.—For many years the capsule of a capacitor microphone operated into a triode valve and special quiet valves have been designed which achieve the very high input impedance required for this purpose; however, in practice, the valves became noisy after a period of time and the reputation of capacitor microphones has suffered accordingly. When the field effect transistor, with its very high input impedance, was developed, one of the first obvious applications was to this problem, provided the necessary requirements could be met. The electrical noise from a capacitor microphone consists of three bands, at low, middle and high frequencies respectively. The low frequency portion is that generated by the resistive component of the gate input impedance. This consists of the capsule and input capacitances in shunt with the resistance of the gate input circuit and has a "red" noise spectrum falling at 6 dB per octave with respect to white noise. The middle frequency portion consists of the pink noise from the f.e.t., while the upper frequency portion consists of white noise from the f.e.t. The position is thus strictly analogous to that obtaining with a triode, and the problem is one of securing adequately low noise levels and a high degree of reliability. The red low frequency noise can be reduced to an insignificant level by increasing the input resistance of the amplifier; f.e.ts do not present any difficulty in this respect and the other two sources of noise therefore remain the main problem. The pink and white noise levels vary considerably from type to type, and although special low-noise f.e.ts are now made, it is usually necessary to resort to selection in order to find quiet enough specimens; this involves considerable expense.

One potential source of trouble which so far has not proved serious is dampness of the capsule, resulting in lowered resistance across the capsule terminals. In the old designs, with a valve close to the capsule, the heat was sufficient to dry the insulation but with the advent of f.e.ts fears were expressed that dampness would prove a problem. It is to the credit of the designers that because of the use of improved insulating materials and other measures no trouble seems to have been met. One disadvantage with some types of f.e.t. however, is that the gain appears to wander over a period of time. Users requiring extreme stability of gain should therefore check this feature.

It is a pleasure to be able to record that the first microphone employing f.e.ts was made in this country by Standard Telephones and Cables, and this microphone, the type 4126, also has the claim of being the smallest on the market. The output is comparable with that of dynamic microphones. A later version, type 4136, has a higher output and uses a cable with only two conductors instead of the multicore cable required for the earlier model. This arrangement, which is, of course, operationally more convenient and reliable, has been adopted by the Neumann company with their whole range of f.e.t. operated microphones, (an example of which, type KM76, is illustrated). In this case the power is supplied down the lead, either direct to the microphone or via a d.c. converter built into the microphone itself. In either case the power requirements are low and can be supplied by batteries, especially for the direct supply condition for which a typical life is said to be 200 hours.

A.K.G. of Vienna have also entered this field with their model C451.

The noise levels claimed for capacitor microphones with f.e.ts are rather difficult to assess, as various weighting curves are in use in different countries (a matter which

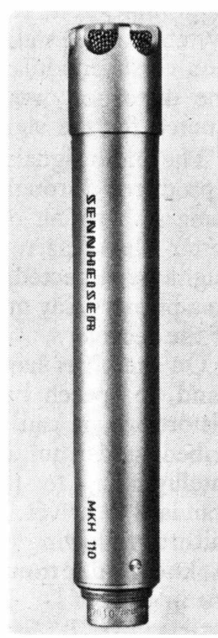
* B.B.C. Research Department.

† It has been necessary from time to time to refer to specific makes as illustrations of trends, but it should be clearly understood that these are mentioned solely because they have some particular item of interest, and no comment on their performance is intended; on the other hand the exclusion of any make or type is not intended to reflect on its excellence in its own particular field.

Capacitor microphone incorporating an f.e.t. head amplifier (Standard Telephones and Cables type 4126).

(Left) Capacitor microphone with f.e.t head amplifier made by Neumann (type KM76).

(Right) Pressure type capacitor microphone, MKH110, mad by Sennheiser.



the I.E.C. could well look into), but at their best they appear to be slightly better than their nearest valve equivalents. With the continued development of transistors it may be expected that noise levels will decrease still further and that f.e.ts will prove themselves to be more reliable than valves.

The second revolution which has taken place in capacitor microphones has been the reintroduction of radio-frequency biasing. It is interesting to note that in the early 1920s when it was difficult to obtain high input impedance amplifiers this form of biasing was used in various ways. Today it is usual to employ some form of bridge circuit and an r.f. of the order of 5 MHz.

In the absence of an acoustic signal the bridge should be balanced, and therefore if it is necessary to change the capsule the bridge must be rebalanced. On the other hand it is noteworthy that very low electrical noise levels are quoted by A.K.G. and Sennheiser for this form of circuit; the noise level claimed for the Sennheiser MKH104 and 105 omnidirectional microphones is so low that the air impedance is stated to affect the value obtained. Very efficient r.f. filtering is used to ensure that none of the carrier frequency is transmitted outside the microphone case. At these frequencies the impedance of the capsule is relatively low, of the order of 1kΩ, and it has been found necessary to gold-plate the capsule contacts to ensure that oxide contamination does not contribute to the noise level.

Capsules.—Progress has also been made in the design of capsules to go with the improved circuits. The axial frequency range has been extended and the directional properties made more constant with frequency. For example, the Neumann KM74 cardioid type is claimed to have a directional characteristic constant with frequency out to an angle of 135° from the forward axial direction. This feature is useful not only in widening the angle within which direct pick-up can be obtained but also in ensuring that the reverberation is not coloured so as to sound different from the direct pick-up.

The front-to-back ratio of cardioid type capsules has also improved and there is not now such a tendency for this to fall off at the bass. One manufacturer, S.T.C., actually claims a front-to-back ratio of 32 dB but it must require facilities of a very high order to measure this, let alone maintain it in production.

A very interesting capsule is used by Sennheiser in the type MKH110. This is of the pressure type but has been made with such a low time constant that the sensitivity is uniform down to about 0.1 Hz. As it uses the r.f. biasing system described earlier, which operates efficiently down to d.c., the full capabilities of the capsule can be exploited and it should be ideal for studying sounds such as sonic bangs which have prominent low-frequency spectral components.

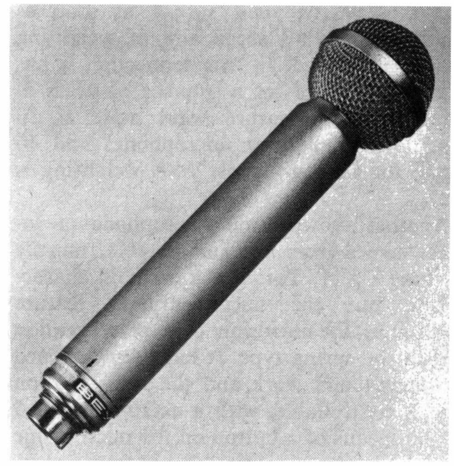
Ribbon Microphones

Development work still proceeds on ribbon microphones, these having the advantage that their characteristics can be more accurately duplicated than can those of any other type of microphone. The Japanese broadcasting authority's (NHK) research laboratories have brought out the NHK RVI-A, an instrument which is a modern version of an old R.C.A. device. It incorporates a ribbon, the rear of which is partially covered by a tube leading to an acoustic labyrinth. Omnidirectional, figure-of-eight and cardioid characteristics are available. Although much smaller than the old R.C.A. device, it is still fairly large by present-day standards, but on the other hand the performance is stated to be of very high quality.

Also worthy of note as the smallest unidirectional ribbon microphone on the market is the Beyer M160. The directional characteristic is of the hyper-cardioid type and an interesting point is that to achieve a higher sensitivity two parallel ribbons are used in the air gap; although this device has been suggested before, this is the only microphone in production in which it is used. It has significant advantages over using a ribbon of twice the thickness in that a lower resonance frequency and better control of the ribbon overtones can be obtained, but, of course, it raises a number of problems in production as the ribbons must never be allowed to touch each other.

The other ribbon microphone of interest is also from the NHK laboratories. This is the "group talk" microphone and appears to be an embodiment of patent No. 2,539,671 taken out by Olson in 1951. It consists of two figure-of-eight microphones at right angles to each other, the outputs of which are combined through a quadrature network. The polar diagram is in the form of a toroid generated by rotating a figure-of-eight about an axis at right angles to the principal axis. The object is to provide a device which is suitable for discussion groups while maintaining some directional properties in the vertical plane. However, the directivity index is of necessity low, $\frac{2}{3}$ or -1.8 dB, as would be expected from a combination of two figures-of-eight, and it remains to be seen whether in practice it proves to be more useful than a cardioid with the acoustic axis vertical.

Ribbon microphone incorporating an acoustic labyrinth, type NHK RV1-A, developed by the Japanese broadcasting authority's research laboratories.

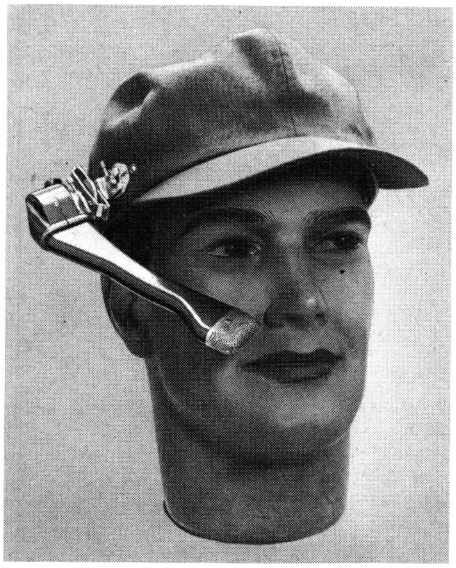


Smallest unidirectional ribbon microphone on the market, the Beyer type M160, uses two parallel ribbons.

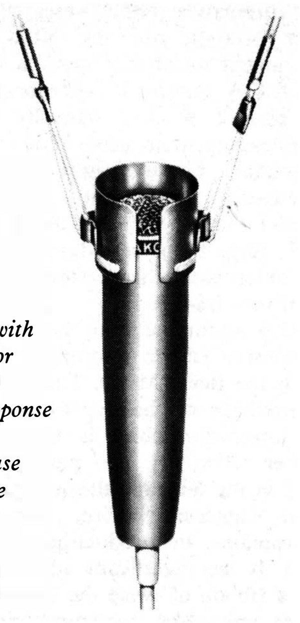
Moving Coil Microphones

The most interesting new moving coil microphone is a two-unit cardioid device, type D202, made by A.K.G. This is a development of the variable distance microphones introduced by the same firm and by Electrovoice in America. One unit is used for the low frequency end of the spectrum and another for the high frequencies. In this way it is possible to employ a much greater front-to-back path difference (about 14 cm) for the low-frequency unit than if it had to cover the whole frequency range and therefore the acoustic driving force is correspondingly greater. For this reason the susceptibility to mechanical vibration and wind noise is much less and so is the effect of close talking. The crossover frequency between the two units is at 500 Hz, and the front-to-back path for the high-frequency unit is only 1.2 cm, thus enabling a wide high-frequency range to be maintained; it is also claimed that the ±90° curves run parallel to the axial curve. The

This moving-coil microphone made by A.K.G. (type D202) contains two units, one for low and the other for high frequencies.



Noise cancelling moving-coil microphone for commentators, using two spaced tubes to pick up the sound (NHK/Sankon type ML/1).



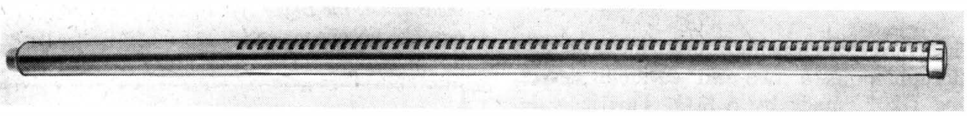
Lavalier microphone with sliding clip for altering the frequency response for different positions of use (A.K.G. type D109).

models 200 and 224, designed for p.a. and studio use, complete the range of this type. It is interesting to note that for the first time the specification for this microphone quotes a value for the wind noise, and it is hoped that this practice will spread as soon as standards of wind speed and of weighting curves are agreed. In this connection it has been the practice for a number of years in the B.B.C. to measure wind noise at 10 m.p.h. for studio-type microphones and 40 m.p.h. for outdoor types; ASA weighting is used.

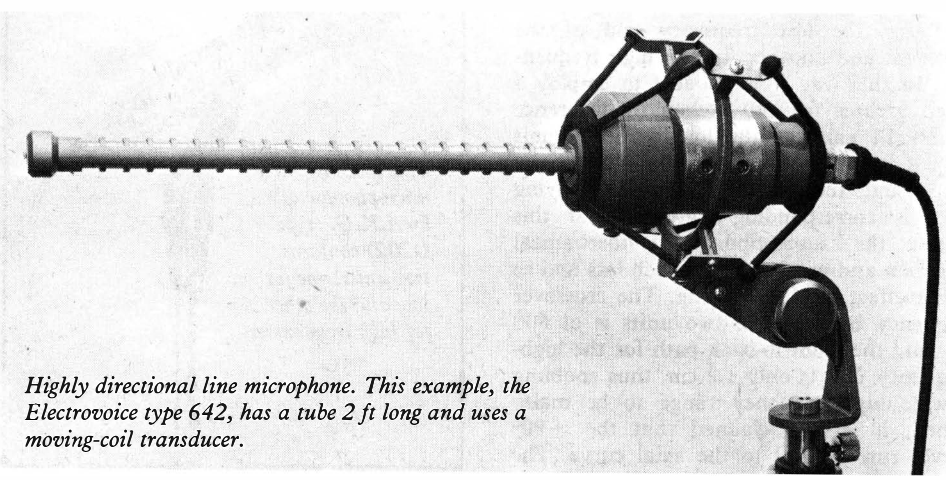
Another moving coil microphone of interest comes from the same stable, namely the type DX11. This has a cardioid characteristic but the unconventional feature about it is the inclusion of a reverberation unit of the spring type. It has been designed for dance band work and the reverberation time is controllable, with a maximum of 2.5 sec, by means of a button on the microphone handle. The associated transistors are powered by batteries located in the microphone handle.

The NHK/Sankon type ML/1 moving-coil microphone is of a different kind. This is a so-called noise cancelling type designed for use at the Olympic Games in 1964. The object was to produce a commentator's microphone which leaves the user with both hands free for writing or holding field glasses and this has been achieved by mounting the microphone on a peaked cap. Sound is picked up by two tubes, the ends of which are about 2 cm apart and placed at the side of the head at a level between the nose and mouth. The tubes are each terminated acoustically at the entrance and communicate with a moving-coil element mounted near the user's ear. The tubes are on anti-vibration mountings and a wind shield can be fitted over the openings. The whole device is very light but the necessity of wearing the cap limits the use on many occasions.

The last kind of moving-coil microphone to be considered is the Lavalier type which has now become very popular. This type was first developed in the U.S.A., where R.C.A. have carried out a considerable amount of development work in this direction, producing some very small models having an axial response designed to compensate for the lack of high frequencies at chest level. However, miniaturization can carry with it high manufacturing costs, and the latest models from this company are rather expensive. Another approach to the problem has been made by A.K.G. who have produced a model, type D109, which is nearly as small as the latest R.C.A. device. The D109 carries a sliding clip which is depressed when the instrument is held in the hand and raised when used as a Lavalier microphone. In the first instance the axial frequency response is said to be almost uniform, while raising the clip has the effect of giving an appreciable increase in response at the higher frequencies, thus compensating for the reduction of this frequency band when used in the hanging position.



Line microphone with capacitor transducer and r.f. biasing (Sennheiser type MKH804).



Highly directional line microphone. This example, the Electrovoice type 642, has a tube 2 ft long and uses a moving-coil transducer.

Line Microphones

Finally, we come to the highly directional line microphone. With a simple microphone of this type the directivity varies with frequency and approximates to that of a cardioid when the wavelength of the incident sound is twice the length of the tube. Modern line microphones, therefore, have transducers with cardioid characteristics at the bass so that the directional characteristic never becomes more omnidirectional than this.

Two examples of this design are the Electrovoice types 642 and 643, with lengths of approximately 2ft and 6ft respectively. Each uses a moving coil transducer with a very large magnet and the correspondingly high signal to electrical noise ratio enables the directional properties to be fully exploited.

A third example is the Sennheiser type MKH804. This is unusual in that while the directional characteristic degenerates into a cardioid at the bass, that of the higher frequencies does not become progressively sharper with frequency but reaches a figure of about −10 dB at 90° away from the axis and maintains this over a wide frequency band. In this case the transducer is of the capacitor type and a good signal-to-electrical noise ratio is achieved by the use of the r.f. biasing circuit described earlier; this construction makes for a very light instrument.

A fourth type due to appear soon is made by A.K.G. as an attachment to the C451 f.e.t. microphone. The tube is about 2ft long and the directivity varies with frequency. A lightweight version of each type will thus be available and it will be interesting to see which proves the more popular.

A feature common to all line microphones is the fact that they have an inherently good signal-to-wind-noise ratio, as the wind-noise at each opening adds up in an r.m.s. manner whilst the signal adds up linearly. Wind shields are provided but these are unnecessary except for use in high winds.