Microphones, Tape Recorders Public Address.... and all that

These days, enthusiasts are able to choose from a wide variety of microphones for non-professional tape recording, public address, amateur radio and other such activities. Not all, however, understand the limitations of inexpensive units, nor the problems of using microphones of any description in typical situations. This article discusses the subject at enthusiast level.

by NEVILLE WILLIAMS – PART ONE

To many enthusiasts, a microphone is a microphone! If it picks up sound and looks the part, they are not overconscious of its other attributes.

In fact, microphones vary enormously in their quality of workmanship, the principles on which they operate and their suitability for different applications. More than that they vary enormously in their fidelity characteristics, or the faithfulness with which they can translate sound into an equivalent electrical signal for amplification and/or recording.

As with any other product, there is some variation in value-for-money but, by and large, the overall quality is linked with selling price.

Typically the class of microphone supplied with inexpensive tape recorders has a unit value in the region of $5 to $10. Microphones used for professional public address, or outdoor TV and radio interviews may cost several times this figure. Microphones used for broadcasting, television and recording studios are commonly priced in hundreds of dollars. Therefore the enthusiast who acquires a microphone for a few dollars must realise that, appearance and description notwithstanding, it will fall well short of true high fidelity standards.

He will face an up-hill battle in trying to make recordings which will bear any comparison with those made on expensive equipment operating in a carefully selected acoustic environment. There is certainly everything to be said for trying but some disappointment should be expected.

The overall performance of a microphone depends on a variety of characteristics of which the most important is probably its frequency response.

For a high quality microphone, the frequency response will normally be substantially flat over the entire audible spectrum. In general terms this means that, for a given sound intensity, the electrical output will not vary by more than about 20 per cent from a median value, for any frequency between the lower and upper limits of audibility. In more technical language, such a microphone would be described as flat within plus and minus 1.5 decibels between 30 and 15,000Hz.

In practice, a wide, smooth frequency response comes only with meticulous design and an order of control over quality, assembly and testing which is not easily accommodated in an ordinary mass-production line.

Where the objective is to produce a microphone which will sell cheaply and (most likely) stand up to rough handling, performance and consistency both tend to suffer.

Cheaper, poorer quality microphones may exhibit a frequency response which falls away at the low frequency end (typically below 150Hz) or at the high frequency end (typically above 5000Hz). Many, in fact, exhibit a loss at both ends of the spectrum leaving them with what may variously be described as a "rounded" or a "peaky" response curve.

If a microphone is deficient only at the bass end, speech will contain plenty of sibilants but lack "body"; music will contain normal brilliance and overtones but lack the "weight" provided by the deep notes of the piano, organ, double bass, &c.

If a microphone is deficient only at the treble end, speech will lack sibilants and music will sound muffled.

A lack of both bass and treble and a predominance of "middles" tends to produce a somewhat "metallic" quality in both speech and music; the more pronounced the middle-frequency peak, the more metallic and unnatural speech and music will sound.

A notable example of this latter effect is to be heard any day on the "open line" radio programs, where voices originate from an ordinary telephone microphone inset. The speech is usually clear enough – a prime requirement of a telephone circuit – but the voices have a quality which, for lack of a better word, has been described as "metallic".

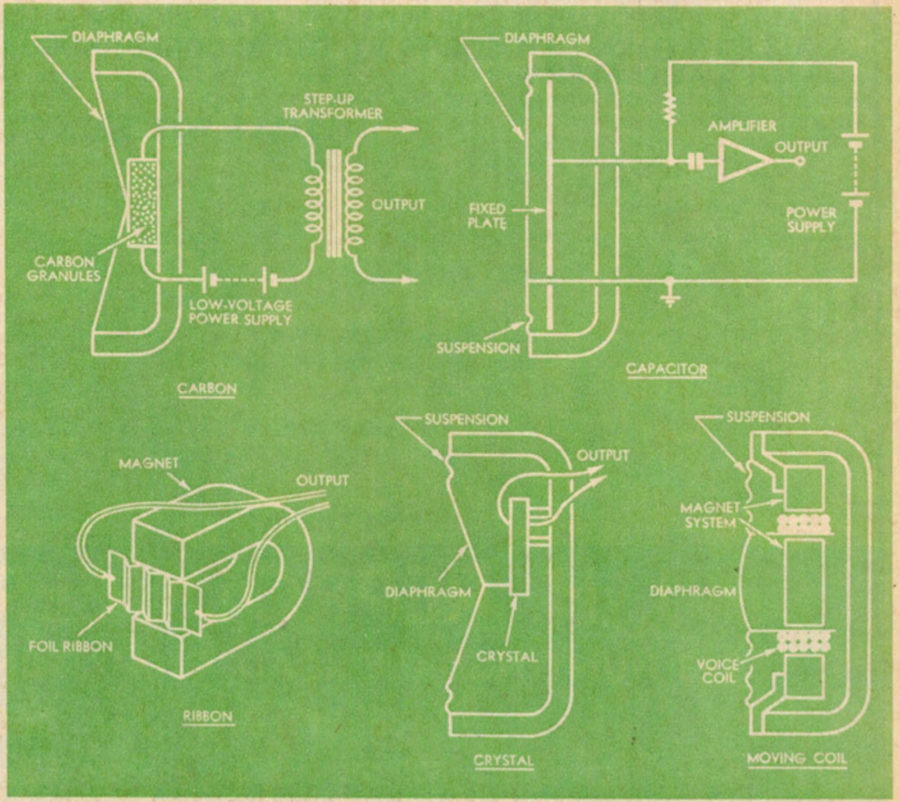

Figure 1: Basic principles of five different types of microphone. Carbon types are restricted mainly to telephone usage. Capacitor (or condenser) and ribbon microphones are widely used for professional work. Crystal (piezo) types were once very popular for non-professional applications but have now largely been displaced by moving coil (or dynamic) units.

Another important characteristic of microphones has to do with the possible introduction of harmonic and intermodulation distortion. This is evident when the electrical output signal contains frequency components which are not present in the original sound, but which have been created within the microphone itself Good quality microphones are substantially free from this effect and the sound, as finally reproduced, has a clean, unrestricted quality.

On the other hand, when some harmonic and intermodulation distortion is present, the sound takes on a somewhat "edgy" or "rough" quality. With a higher distortion content, the sound becomes noticeably harsh, noticeably muddled and, in an extreme case, it acquires a "choking" quality. The telephone again provides a familiar example where the sound quality may range from somewhat rough to a positively "choking" sound; this is what often prompts the invitation to "give your handset a good, hard bash!"

A number of other characteristics have an important bearing on the performance of microphones and their suitability for various applications. These were, in fact, covered in a general article in our September 1970 issue, to which readers may care to refer. For the present, we shall have a look at the kinds of microphone which have been – or are – most commonly available to enthusiasts, mentioning other characteristics as we come to them.

Before tape recorders transformed microphones virtually into a mass-produced consumer product, enthusiasts who needed such an item either had to make do with some highly unsuitable unit or contrive their own. Many an amateur station went on the air with the operator calling CQ through an old telephone carbon insert, complete with peaky response curve, high distortion content and high noise from the carbon granules. More enterprising operators might have been found with a "Reiss" transverse-current carbon microphone, exhibiting rather better response, lower distortion and lower noise.

At the time, manufacturers sought to meet the obvious but limited need with a variety of commercial microphones which attempted to translate basic principles into units that would work well but (hopefully) not be unduly expensive. Ribbon, moving coil, capacitor and piezoelectric microphones all made their appearance, each with their individual advantages and limitations, but none of them really cheap.

In terms of price, a notable breakthrough came with the emergence of microphone cartridges using a slab of rochelle salt crystal to translate the sound energy into electrical signals. In itself the crystal or "piezo" idea was not new but mass-production techniques resulted in cartridges which sold for something in the region $2 to $4. Mounted in various utility or decorative housings, they became the almost universal choice for mobile radio systems, amateur radio stations, economy public address and hobbyists.

In fact, the first wave of domestic tape recorders came complete with crystal microphones of this general type and thousands of them are doubtless still in use.

How does their performance rate?

Most such inexpensive crystal cartridges (or microphones) used a diaphragm of metal or bakelised paper, coupled by a small metal rod to a slab of rochelle salt crystal. While they were undoubtedly convenient from the viewpoint of equipment design, their performance was mediocre.

In saying this, it is only fair to point out that some crystal microphones were produced offering an order of performance ranging up to professional standards. They were most commonly described as "sound cell" types. However, they enjoyed only limited popularity because their cost put them outside the enthusiast market, while their impedance characteristics complicated their use in professional situations.

Piezo-type microphones have also been produced using a ceramic element (as in ceramic pickups) instead of rochelle salt. However, they have not had a significant impact on the Australian market.

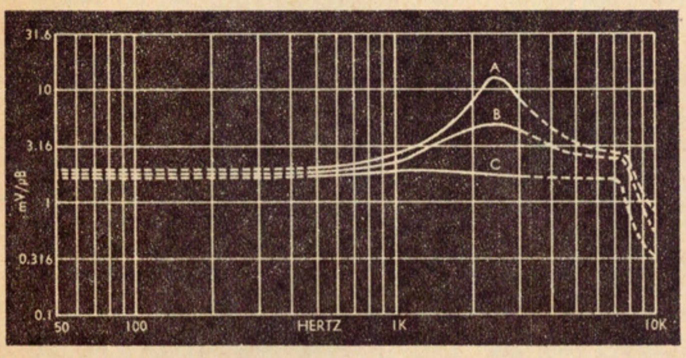

Figure 2: Frequency response curves for typical diaphragm type crystal inserts and crystal microphones. Only the more expensive units with an acoustic filter in front of the diaphragm could approach the response as in curve "C".

Figure 2 shows the frequency response curves for a range of inexpensive crystal cartridges widely distributed on the Australian market both as separate cartridges and as inserts in fully fabricated microphones. They are typical of their class.

The vertical scale is in terms of millivolts of output per microbars of sound pressure but it is so drawn that the major divisions can be interpreted as 10dB steps.

A separate rating quotes the output at 1000Hz as 2.6mV/uB, the level of 1uB being roughly equal to the sound pressure which results from conversational speech 1ft from the microphone. A 4:1 reduction in distance to 3in would increase the sound pressure by about 16:1, giving a typical output of 40mV for close talking conditions into the recommended 5-megohm load. These output figures are typical of diaphragm-type crystal microphones and are about four times the output figures for the sound cell-type crystals mentioned earlier.

In cartridge "A" the diaphragm resonance is largely undamped, producing the highest electrical output but exhibiting a pronounced peak around 2500Hz. Cartridges of this type were popular with operators of mobile radio systems and amateur radio stations because their exaggeration of "voice" frequencies concentrated the transmitter modulation in the frequency range where it would do the most good.

For public address applications, paging systems and reasonable quality tape recorders, cartridge "C" would be a much better choice giving reasonably well balanced speech and passable results on music. The curve might seem to warrant rather more generous adjectives than these but it was taken from a sales brochure and the writer's impression is that, in reality, the bass was not sustained quite as well as depicted, nor was the treble sustained quite as neatly by a plateau above the diaphragm resonance.

A point that should be made is that, in the first generation of tape recorders, it was something of an accomplishment to achieve a frequency response which extended to a figure in kilohertz equal to the tape speed in inches. (7.5KHz for 7.5ips, 3.75KHz for 3.75ips, 1.75KHz for 1.75ips.)

With such a tape recorder, microphone "C" would produce a reasonably smooth recording at a tape of 7½ips, but would sound dull at 3.75ips and positively muffled at 1.75ips.

In fact, at 1.75ips, microphone "A" would give a much clearer sound because it would help counteract the roll-off in the recorder characteristic. But, at 7.5ips, microphone "A" would sound very peaky on speech and quite unacceptable on music.

In a case like this, the tape recorder manufacturer may well have decided to supply a microphone like example "B", on the grounds that it would be the best all-round compromise, brightening the recording to some extent at the lower speeds, without introducing too horrible a peak at 7.5ips!

If you have an inexpensive crystal microphone which produces fairly natural recordings of speech and live music at a tape speed of 7½ips, its frequency response, at best, may be something like curve "C" in figure 2.

If, on the other hand, the recording has a metallic or a peaky quality, the response is more likely to resemble curves "B" or "A" – either because that is how the microphone happened to be or because the recorder manufacturer was deliberately trying to prop up the overall performance at the lower tape speeds.

During the past 10 years or so, inexpensive crystal microphones have largely been displaced by inexpensive moving coil or "dynamic" microphones – most of them manufactured in Japan. Various factors have been responsible for the change:

RELIABILITY: Rochelle salt crystals, as used in most piezo microphones, can be destroyed by excessive heat and humidity, both common hazards with portable equipment. Dynamic microphones are free from this problem.

LOAD RESISTANCE: Crystal microphones need to be terminated by a load resistance of the order 2 to 5 megohms. This requirement has presented difficulties with transistorised equipment. Dynamic microphones can operate into much lower loads, commonly of the order of 0.1 megohm.

FREQUENCY RESPONSE: By its very nature, the moving coil assembly in a modern miniature dynamic microphone is inherently more free of prominent peaks than the conventional piezo system of relatively stout diaphragm driving a relatively stiff slab of crystal. The evolution of recorders giving wider frequency response at all speeds, has further encouraged the production of microphones with a smooth response. The average, inexpensive dynamic would at least match curve "C" of figure 2, while those approaching the $20 mark would offer a marked improvement at both ends of the range.

DISTORTION: No figures are to hand but, price for price, dynamic units would compare more than favourably with crystals, particularly at high levels of input sound.

MANUFACTURE: This is straightforward enough to permit a wide selection of dynamic units to be offered within the range $5 to $20.

The vast majority of dynamic microphones are currently being sold as complete units and, as often as not, are packaged with a desk stand and an adaptor to suit a full-length floor stand. However, a few dynamic cartridges are to be found on dealers' shelves selling for between $4 and $10. These could conceivably be mounted in existing cases, although the potential savings by so doing are not great.

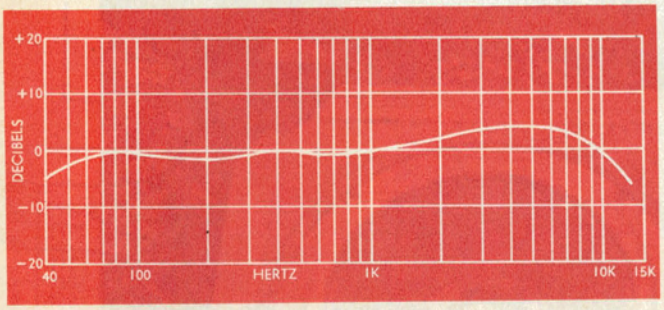

Figure 3: The kind of frequency response that can be expected from dynamic microphones in the $15-$25 bracket. More expensive units would have smoother, wider response; cheaper units, the reverse.

As with a dynamic loudspeaker, the voice coil has a relatively low impedance in itself. In the inexpensive units dynamic currently available, 50 ohms seems to be the most common impedance, although higher and lower values may be encountered. If leads from the voice coil are brought out directly, usually via a twin shielded pair, the microphone is normally marked in terms of impedance and, in general terms, described as a "low impedance" dynamic.

The signal voltage available across a coil of such relatively low impedance is insufficient for convenient application to valve or transistor amplifiers and it is common practise to pass the voice coil signal through a step-up transformer, which raises the signal voltage to a figure more appropriate to the needs of a preamplifier stage. An inevitable effect of using such a transformer is that the effective impedance is stepped up also.

In most microphones intended for non-professional use (tape recorders, paging systems, amateur radio, &c) the step-up transformer is included in the body of the microphone. The primary winding connects internally to the microphone voice coil while the secondary connects to 6ft or more of shielded output lead. One side of the secondary is common to microphone case, braid and chassis earth; the other side joins to the shielded "hot" lead.

A dynamic microphone fitted up in this way is commonly known as a "high impedance" unit; it may or may not carry some endorsement in terms of ohms.

At first glance, it might seem that the step-up transformers could be wound to give extremely high orders of voltage gain. In practise, very high ratios would necessitate secondary windings having a large number of turns of very fine wire, increasing cost, reducing reliability and emphasising problems of high frequency loss, due to internal and external shunt capacitance.

From the rather scattered evidence that is available, it would appear that the majority of step-up transformers have a ratio in the range 15:1 to 30:1. This is equivalent to an impedance step-up in the range 225:1 and 900:1. Related to a 50-ohm voice coil it would represent nominal secondary impedances falling in the range 10,000 to 50,000ohms. There is occasional reference to turns ratios as high as 45:1.

The exact significance of impedance figures, either calculated or marked on the microphone itself, is rather vague. The safest thing to assume is that a microphone should not be connected into an amplifier system having an input impedance lower than the nominal value. It is usually preferable to have the input impedance to the amplifier, recorder, &c, higher than the rated impedance of the microphone.

In valve-type equipment and in the more modern solid-state equipment, input impedance should present no problem for the average high impedance dynamic microphone.

Limited input impedance could be a problem with some solid-state circuitry, however, and microphones with transformers in the lower ratio bracket could have a potential advantage in this context.

Placing the step-up transformer inside the microphone case is undoubtedly a convenient arrangement for simple applications, since the microphone can be provided with a shielded output lead ready for direct attachment to the active input circuit of the amplifying equipment.

There is another, more subtle reason: Connected to the input of a high-gain amplifier system, a step-up transformer is likely to pick up hum from nearby power transformers, drive motors, &c. By fashioning the microphone case from ferrous metal, the transformer can be placed inside it and shielded "free"; in addition, the microphone will normally be operated several feet away from the troublesome magnetic fields.

The actual signal output voltage from a high-impedance dynamic microphone depends on many factors, including the design of the magnetic system, the ratio of the step-up transformer and, of course, the loudness and proximity of the sound source.

In general terms, the signal output from the majority of economical high-impedance dynamics appears to be only slightly less than that from the diaphragm type crystal units mentioned earlier. Therefore, dynamic microphones can usually be substituted for crystal types provided the equipment, when operated with crystal microphones did not need the level control "flat out".

In most cases the substitution of a modern dynamic microphone for an older style crystal type will make possible a much smoother type sound, whether for recording or public address. In fact, dynamic types selling in the $20-$30 bracket can provide very acceptable sound, via recorder or amplifier. They are free from obvious peaks and troughs in the frequency range and are not easily overloaded by loud sounds.

(To be continued)