IDEAS FROM ABROAD

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In *Electron* (NL) Oct'90, **Herbert L Rutgers, PA0SU** explains the *directional characteristics* of communication microphones with emphasis on ***noise cancelling microphones***. Some suggestions for experimentation are included; the only instruments you will need are your ears.

SPEECH FREQUENCY fidelity is very important for a communication microphone, but so is its directional pattern. If you use an omnidirectional mike, it often picks up noises other than your speech. That is why some mikes are made *directional*, ie their sensitivity depends on the direction from which sound arrives.

Fig 1 shows three common directional diagrams. They look similar to antenna patterns, reasonably so as the same mathematics apply to both microphones and wideband antennas. **Fig 1a** needs little explanation. This omnidirectional mike consists of a capsule in a closed tube stuffed with sound damping material. The lowest frequency to which this mike responds is determined by the diameter of the capsule's membrane and the volume of the tube.

Fig 1b shows a figure-8 pattern which applies to now-obsolete condenser and ribbon microphones. The pattern of **Fig 1c** is called *cardioid* (heartshaped). It is obtained by also admitting sound to the back of the membrane. The way this is done, and especially the shape of the housing, determine the *front-to-back ratio*, which is never more than 2:1. Cardioid mikes are used in PA systems in halls, where they help to avoid the howl caused by sound from the speakers feeding back into the microphone.

FREQUENCY RESPONSE

UNFORTUNATELY FOR AMATEUR use, the frequency response of directional microphones depends on the distance between source and mike. We generally speak with the mike less than 30cm (12") from our mouth and the closer we come, the more the bass frequencies are favoured. Bass roll-off in the mike amplifier helps, but the voice quality remains a function of the mike-to-mouth distance.

With spurious noise sources in the shack, eg fans in power amplifiers, there are two approaches: use a directional mike and keep it at least 30cm away, or use an omnidirectional mike within a few cm (an inch or two) from your mouth. In either case, transmission of background noises will be limited.

Did you say you had no background noise? Even your own voice generates some due to echoes within your shack. That is most noticeable if a speech processor is used. Of these two approaches I prefer the closely held omnidirectional mike, but if a microphone could reject sounds from all sources further than, say, 15cm (6") away, that would be ideal.

NOISE CANCELLING MICROPHONES

POP SINGERS' MICROPHONES need to reject the ear-splitting noises from other members of the group; megaphones, those mike-amp-speaker combinations used to address large crowds, need them to avoid howl. I use one in my shack because of the noisy fan in my linear amp. If I switch from an omnidirectional to the noise cancelling mike taken from a megaphone, either held about 3cm (1.2") from my mouth, background noise drops by 15dB.

How is this done? By mounting two omnidirectional mike capsules typically 3.5cm (1.4") apart in a common housing so that the two capsules and the mouth are in line (**Fig 2**). Note that the two capsules are connected anti-parallel, ie in opposite phase. We now apply the law that the output from a microphone capsule is inversely proportional to the square of its distance from the source of the sound. If the source comes twice as close, the output voltage from the capsule goes up four times. Apply this to the two-capsule assembly. Sound from a far-away source has to travel practically the same distance to either capsule; their outputs are almost equal and opposite, so they largely cancel.

The voice of an operator who holds the microphone 3cm from his lips has to travel about twice as far to the furthest capsule than to the nearest; only the four times smaller output from the furthest capsule subtracts from that of the nearest, and little cancellation occurs. This assumes that the two capsules are identical. My megaphone mike has two dynamic capsules in housings so small that only frequencies above 300Hz are reproduced.

PHASE PROBLEMS

THE ABOVE REASONING assumes a sound wave arriving at the two capsules with equal phase. This is not true, however, if the distance between the capsules, typically 3.5cm, is a significant fraction of a sound wavelength (λ). If that distance were $\lambda/2$, the two outputs would be of opposite phase and, being connected anti-parallel, would add rather than subtract.

Sound travels through air at 340m/s, so λ=340/f (m). Accordingly, 3.5cm is $\frac{1}{2}\lambda$ @ 5kHz. This, fortunately, is outside the SSB voice frequency range. At 3kHz, the upper limit of that range, deterioration of noise cancellation is noticeable but in practice is not too bad.

TRY IT YOURSELF

FIND TWO SMALL, identical microphone capsules. Miniature dynamic capsules are suitable and so are electrets. The latter are inexpensive and have smooth frequency characteristics, but even supposedly identical ones have a wide spread of sensitivity which must and can be equalized further down the chain. Connect them, *not* in antiphase, to the L and R inputs of a stereo amplifier, which must be suitable for the chosen capsules.

Combine the amplifier *outputs* in anti-phase, eg by connecting monaural headphones between the 'hot' L and R output terminals. Stereo headphones can be used by connecting only to the 'tip' and 'ring' of their plug and leaving the 'barrel' floating. Adjust the stereo balance control for minimum background noise in the headphones.

If your noise cancelling microphone is to be used on the air, all the usual measures must be taken to keep RF out of the audio inputs.

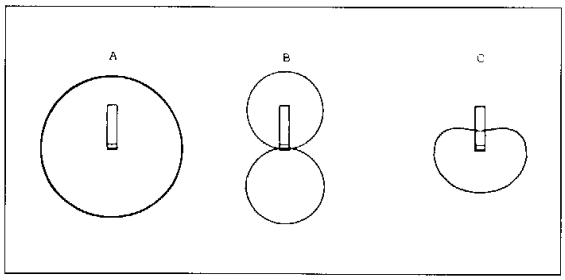

Fig 1: Three common directional patterns: a) omni-directional, b) figure-8, c) cardioid

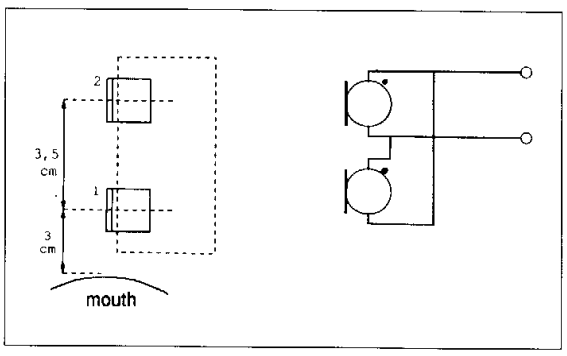

Fig 2: Location and hook-up of capsules for noise cancellation.