A SUBMINIATURE CONDENSER MICROPHONE

USING ELECTRET TECHNOLOGY

BY ELMER V. CARLSON

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■ In 1885 Oliver Heaviside coined the word Electret for what he saw as the electrostatic analog of the Magnet and speculated that solid insulators could be made into Electrets with "a greater or less amount of permanency." What he envisoned was a solid dielectric which could be electrically stressed and have those stresses locked into the structure of the material after the stressing means was removed. Thirty-five years later, in 1920, Eguchi independently recoined the word and demonstrated the existence of relatively permanent Electrets. After another fallow period of about 40 years with some sporadic attention, the Electret has again emerged as a subject of serious scientific and engineering study.

Since the idea of the electret is at least 88 years old and reasonably permanent electrets better than 50 years old, it is reasonable to wonder why the practical electret condenser microphone suitable for hearing aid use should emerge at this time. The idea is not new, as an electret condenser microphone patent was filed at least as early as 1931, however, the device has remained little known and little used until recently.

It was necessary for several important advances in technology to occur before today's device became possible:

The first development critical to this possibility was the very low noise Field Effect Transistor (FET). The availability of this device first made the miniature ceramic microphone successful. The wide-band smooth frequency response of the ceramic microphone had been technically possible using bi-polar transistors at least five years earlier but the background noise was a serious problem. Alternatively it would have been theoretically possible to widen the frequency bandwidth of the magnetic type of microphone, but at the expense of such a large reduction in sensitivity that this approach was unattractive. It was the availability of suitable FET's that made it possible to expand the bandwidth by reverting to the piezoelectric type of transducer. Prior to the introduction of the transistor, hearing aid microphones had used Rochelle salt piezoelectric crystals. The development of ceramic materials had not yet evolved sufficiently to have a large impact on hearing aids at the time the transistor supplanted the vacuum tube. The several years of field experience using the FET amplifiers in piezoelectric microphones was useful background for the still higher impedance amplifiers needed in the condenser microphones.

Next, the introduction of new improved dielectric materials made it possible to seriously think of substituting an electret condenser transducing element for the piezoelectric element. In the early 1960's, experimenters at Bell Telephone Laboratories observed that some thin film plastic insulating materials exhibited electret-like characteristics of reasonable permanence. Since then other materials having more improved characteristics have been found and studied. With these two technological advances, it has been practical to introduce miniature electret condenser microphones having the same wide band characteristic as the ceramic microphone.

Heaviside's analogy of the magnet with electret is still relevant today as it is applied in hearing aid components. The long time standard, since the introduction of the transistor, has been the Magnetic Microphone in which a magnet supplies an internal polarizing field. In the electret condenser microphones that have recently been made available, the electret also supplies an internal polarizing field. In both devices the microphone structure, by redirecting this field, transforms the acoustical energy into electrical energy which is amplified by the hearing aid amplifier.

The electret device is used to polarize a condenser microphone transducer element. To understand this, study the two microphones that are shown schematically in Fig. 1. The illustration on the right is a conventional condenser microphone having a diaphragm electrode at the top (1), a back-plate (second electrode) (2), in a housing (3), a load resistor (4) and a polarizing battery (5). In operation an electrostatic

Elmer V. Carlson is manager, Development Engineering, Knowles Electronics, Inc.