noncircular metal plate between the ceramic and the diaphragm (Fig. 1).

C. The directivity

Figure 6 shows the directivity of the radiated sound of the electromagnetic horn (a) and the piezoelectric ceramic horn (b). The ceramic horn has a similar directivity with the electromagnetic horn, but results in a slightly narrower beam.

III. CONCLUSION

It has been shown that the newly developed piezoelectric ceramic horn driven with an amplitude modulated signal to a sound-pressure level higher than 110 dB *re*: 1 μPa works well up to 80 °C. Since the horn has already come up to the standards for automobile component parts, including the standard for reliability, it is highly promising that the horn's practical applications will be found. One of the authors, in fact, has had it mounted to his car for more than two years without any faults or failures.

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Absorption of ultrasound by mammalian ovaries

K. I. Carnes and F. Dunn
Bioacoustics Research Laboratory, Department of Electrical and Computer Engineering, University of Illinois, 1406 W. Green Street, Urbana, Illinois 61801

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The transient thermoelectric method was employed to determine the ultrasonic absorption coefficient of excised bovine, canine, feline, murine, ovine, and porcine ovaries at 1 MHz. The dynamics of the organ yields significant variations with physiological stage and structure. Values ranged from 0.017 cm^{-1} for the follicle to 0.050 cm^{-1} for the corpus luteum, largely reflecting macromolecular content. Little interspecies variation was observed.

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INTRODUCTION

The use of ultrasound as a therapeutic tool became widespread more than a quarter century ago and usage has remained global. The use of ultrasound as a diagnostic tool in human and veterinary medicine has increased significantly over the past several decades (Nyborg and Ziskin, 1985) and a huge literature describes the multiplicity of such purposes (White *et al.*, 1982, 1987). There is a belief among radiologists and therapists that exposure to ultrasound is without harmful effects (Nyborg *et al.*, 1983). However, there have been reports describing ultrasonically induced biological alterations, in *in vitro* preparations, produced by clinical imaging systems (Stewart *et al.*, 1985), and some have been examined critically (AIUM, 1984). A physical mechanism known to be responsible for producing biological effects, under suitable conditions, is associated with the absorption of ultrasound in the body of the specimen with concomitant increase in temperature to possibly damaging levels (Dunn *et al.*, 1969). Knowledge of the absorption coefficient enables estimates to be made of temperature increases accompanying ultrasound exposure.

Exposure to ultrasound of the mammalian ovary, especially the human ovary, from both diagnostic and therapeutic medical equipment has been increasing rapidly. The introduction of endovaginal imaging (Vilaro *et al.*, 1987) suggests that the ultrasonic properties of the ovary should be available so that estimate of potential bioeffects can be made. The ovary appears not to have been a subject of investigation for ultrasound properties as reports of measurements of the absorption coefficient have not appeared in the literature (Goss *et al.*, 1978, 1980). The present study was undertaken to establish a catalog of absorption coefficient values for nonpathological ovarian structures from a variety of species. In addition to serving as a basis for furthering the understanding of the interaction of ultrasound with the ovary, it is hoped that these values will provide a standard to which pathological specimens can be compared.

I. THE MAMMALIAN OVARY

The mammalian ovary is physiologically complex and dynamic, and, as seen herein, acoustically heterogeneous, consisting of several distinct structures, some of which

change as the estrous cycle progresses. The size, number, and lifespan of these structures vary with species, but the basic macromolecular content is similar.

The matrix of the ovary consists of the outer cortex layer and the inner medullary area. The cortex is a tough connective tissue layer containing the follicles and corpora lutea and is covered by the germinal epithelium. The medulla is also composed of connective tissue and contains the blood vessels and nerves that support the ovary (Bloom and Fawcett, 1975). The extent of these two layers varies with species, e.g., the porcine ovary contains little medullary tissue whereas the medulla is extensive and well delineated in the bovine ovary.

The follicle, a principal cortical structure, is the site of growth and development of the oocyte and can be divided into four different categories as it undergoes oogenesis and folliculogenesis. (1) The primordial follicle consists of the oocyte and one layer of flat follicle cells. (2) The primary follicle consists of the growing oocyte and one or more layers of follicle cells that are now cuboidal and known as granulosa cells. (3) The antral follicles also contain the enlarging oocyte and granulosa cells, as well as the antral space and the follicular fluid that occupies it. (4) Just prior to the ovulation, the preovulatory or Graafian follicle is at its maximum volume of cells and fluid (Bloom and Fawcett, 1975).

Following ovulation and expulsion of the oocyte, the granulosa cells undergo hypertrophy, hyperplasia, and biochemical changes to become the luteal cells of the corpus luteum. As the corpus luteum evolves, it becomes highly vascularized and connective tissue develops. The luteal cells accumulate large amounts of lipid as they age. If the animal is not pregnant following ovulation, the corpus luteum involutes and degenerates to become a scar, viz., the corpus albicans. If pregnancy is established, the corpus luteum persists until parturition and then undergoes rapid involution and regression.

II. MATERIALS AND METHODS

Absorption coefficient measurements were determined using the transient thermoelectric technique, which has been described in detail previously (Dunn *et al.*, 1969). Chromel-constantan thermocouples were used as the detectors. The 0.003-in. wire ends were acid-etched and lap-soldered such that the junction was approximately 13 μm in diameter in order to reduce the effect of viscous heating at the junction (Goss *et al.*, 1977). The tissue to be measured was secured in a holder, which did not interfere with the plane traveling acoustic field, and the thermocouple inserted to a depth of 2 mm at the selected site, with the aid of a 30-gauge hypodermic needle. The entire assembly was supported in a Plexiglas® tank filled with degassed mammalian Ringers' solution, maintained at 37 °C. A 1-in., 1-MHz focussed transducer, which had been calibrated using the ball radiometer technique (Dunn *et al.*, 1977), was then aligned such that the focal point of the beam was at the approximate position of the thermocouple junction. The beam profile was then obtained, to determine the position of the junction, along the two axes normal to the direction of sound propagation, to within 0.1 mm.

Measurements, under computer control, were made at spatial-peak, temporal-average (SPTA) acoustic intensities of 1–10 W/cm^2 in each specimen (half-power beamwidth 5 mm). A 1-s exposure was utilized and data points from the straight-line portion of the temperature increase versus time curve were used to derive the absorption coefficient value according to the equation

$$\alpha = \frac{\rho c}{2I}\left(\frac{dT}{dt}\right)_0,$$

where ρc is the heat capacity/unit volume in J/cm^3 °C, I is the SPTA acoustic intensity in W/cm^2, and $(dT/dt)_0$ is the initial time rate of change of temperature in °C/s (Dunn, 1962). The computation of the absorption coefficient value includes an iterative procedure that corrects the intensity value for depth of the thermocouple junction in the tissue. Following the measurement procedure, the entire assembly was removed from the tank. With the tissue and thermocouple still secured in the holder, an incision was made over the junction and, with the aid of a dissecting microscope, the ovarian structure in which the junction was located was confirmed.

Tissues were obtained from a variety of sources, including slaughter house, laboratory animals, veterinarians, etc. All were nonpathological and excised either from live animals or from fresh-killed animals (within 15 min). Those specimens not measured immediately after dissection were stored at − 20 °C, some for as long as one month. On the day of measurement, those tissues were thawed and allowed to warm to 37 °C in the tank of Ringers' solution prior to measurement. The species chosen represent wide variation in reproductive cycles of mammals, i.e., litter bearers (canine, porcine) versus single-bearing species (bovine, ovine), spontaneous ovulators (porcine, murine) versus induced ovulators (feline), long cycle (canine), short cycle (murine), seasonal breeders (ovine), and nonseasonal breeders (bovine).

III. RESULTS AND DISCUSSION

The absorption coefficient values determined in this study are shown in Table I. The entries represent the mean value of the measurements, with the coefficient of variation (cv, the standard deviation expressed as a percentage of the mean) shown in parenthesis. Lack of entries for the cv implies too few samples measured for meaningful calculation. The total number of specimens studied was 60. No difference was seen in the absorption coefficient values of tissues measured immediately after the animal had been killed and those tissues that had been frozen, thawed, and measured.

The data suggest little interspecies variation of the absorption coefficient values for similar structures, despite the wide variation in estrous cycle, i.e., for all species studied, the absorption coefficient of cortex tissue is greater than that of medulla, the follicle exhibits the least value, etc. This similarity supports studies that have shown absorption coefficient values to be partially dependent on the macromolecu-

TABLE I. Ultrasonic absorption coefficient (cm^{-1}) of ovarian structures. The asterisk indicates the mean value (coefficient of variation).

Species	Stroma	Follicle	Corpora lutea
Bovine	Cortex 0.045 (2%)* Medulla 0.044 (15%)	0.017 (11%)	Active CL 0.046(9%) Active CL 0.043 (42%) Old CL 0.034 (23%)
Feline	Cortex 0.048 Medulla 0.038 (15%)	0.022 (8%)	
Canine	Medulla 0.022		CL of pregnancy 0.050
Ovine	Cortex 0.041 (12%) Medulla 0.032 (30%)	0.019 (21%)	New CL 0.048 Active CL 0.050
Murine	Diestrus 0.034 (5%) Proestrus 0.041 (7%) Postestrus 0.025 (15%)		
Porcine		0.023	New CL 0.028 Active CL 0.044 (18%) Old CL 0.033

lar content, particularly that of protein and water (Goss *et al.*, 1979), as the cortex is high in collagen (Bloom and Fawcett, 1975) and low in water content, while the follicle is high in water content and relatively low in macromolecular content (McNatty, 1978).

The follicles studied were the large antral or preovulatory follicles that contain large amounts of follicular fluid, a thick viscous liquid containing a variety of substances including protein and steroid hormones, electrolytes, sugars, and lactic and citric acids (McNatty, 1978). The follicle absorption coefficient values, shown in Table I, are low and similar to those of other body fluids such as amniotic fluid, blood plasma, and cerebral spinal fluid (Goss *et al.*, 1978, 1980), possibly reflecting the high water content. It would be expected that preantral, or follicles containing small antra, would have greater absorption coefficient values due to the lesser fluid content.

Absorption coefficient values for the corpora lutea also reflect the macromolecular content changes as they progress through their life cycles. The values are lower for the recently formed corpora lutea, when connective tissue is forming and the cells have little lipid accumulation. The values increase with corpora lutea development, which includes increases in lipid content and vascularization, after which they decrease as the corpora lutea regress. The corpus luteum of pregnancy exhibited the greatest measured value, which is expected since it is larger than the corpus luteum of the nonpregnant ovary and contains more lipid and vasculature (Bloom and Fawcett, 1975).

The absorption coefficient values for cortex and medulla reflect the species variation in amount. Data in Table I indicate that the cortex, except for the bovine, has a higher absorption coefficient value than the medulla. The table does not include a porcine entry as neither structure is present in sufficient amounts for measurement. The stage of the estrous cycle, presence or absence of interstitial gland cells, and age of the animal from which the specimen was taken are all factors affecting the macromolecular content and, hence, the absorption coefficient value.

Because of the small size of the mouse ovary, the absorption coefficient values were categorized according to the stage of estrous cycle rather than the specific structure, though the cycle stage does reflect the structural features of the ovary. For instance, the postestrus values are low because the recently ovulated follicles are beginning to luteinize and much fluid remains. The absorption coefficient is high during proestrus since it is at this stage that the corpora lutea from the previous cycle are at their peak of development and are beginning to regress. Diestrus, which occurs between postestrus and proestrus, is a period of growth and lipid accumulation. It is seen in Table I that the absorption coefficient value lies between that of the post- and proestrus ovary.

IV. CONCLUSIONS

It is apparent from this study that a single absorption coefficient value for the mammalian ovary cannot be given, as has been possible for other mammalian tissues and organs. Indeed, a single value cannot even be given for any of the species studied due to the dynamic physiology of the ovary. The observed values range, for some species, over nearly a factor of 3 from stroma to follicle. To give a single value would involve an estimation of the fraction of the ovarian volume each structure occupies. Because the luteal tissues have the highest absorption coefficient value, and, therefore, require lesser exposure to produce thermal damage, and since ovarian absorption coefficient values vary so greatly, it would appear to be prudent always to consider the absorption coefficient of the corpora lutea when making calculations to determine exposure conditions.

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Comment on "Air absorption of motor vehicle noise" [J. Acoust. Soc. Am. 80, 561–568 (1986)]

Hugo P. Verhas[a)]
Vrije Universiteit Brussels, Faculteit TW-WERK, Brussels, Belgium

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It is found that Makarewicz' article "Air absorption of motor vehicle noise" [J. Acoust. Soc. Am. **80**, 561–568 (1986)] is confusing: Quantities like reception time t, emission time t', observed frequency f', and emitted frequency f are not well defined and have various meanings; for instance, t and t' in Fig. 1, respectively Fig. 1(a). Revised equations are presented. The revision reveals that the computations in Makarewicz' article produce overestimated results and it is found that the content of the article is misleading. Corrections to these computations are presented.

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INTRODUCTION

This letter does not relate to the basic lines of Makarewicz' model of propagation[1] but to the development and the computation of the contribution of the source motion to sound exposure as it follows from the model.

In the next paragraphs, it is first pointed out where, in my opinion, Makarewicz' derivation goes wrong, and then Makarewicz' concepts, within the terms of the definitions given by Makarewicz, are worked out to show that the results are overestimating the problem.

In my argumentation, it is understood that the results refer to a coordinate system with respect to a receiver at rest and with no mean flow of the atmosphere. Convective effects in the strict sense, i.e., convective effects due to the relative movement of the source and the air, are not considered. On the other hand, the effect of the relative movement of the source and the receiver on the received energy can be regarded as some form of convective effect. Although, to distinguish among both phenomena, the latter is further indicated as *convective effects*.

I. REVISIONS

The situation to be considered: The source, i.e., the motor vehicle, is moving while the receiver is at rest with respect to the air. It means that a sudden frequency shift occurs at the moment the signal leaves the source and starts propagating through the atmosphere. The atmospheric absorption coefficient is $\alpha(f)$, regardless of whether the signal is a Doppler-shifted signal or not.

Makarewicz, however, defines the air absorption of the Doppler-shifted wave by the term $\alpha(f')$, where f' is the observed frequency and is defined by $f' = f/(1 - M)$. So, α becomes a time- and frequency-dependent quantity.

Makarewicz then presents an expression for the mean-squared pressure in the form, $\bar{p}_A^2 = \int_0^\infty W(f')p^2(f')\,df'$, and produces a solution through the following manipulation that I summarize as follows:

a) Address for correspondence: Noise and Vibration Consultancy, H. P. Verhas, Welvaartstraat 96, B-9300 Aalst, Belgium.