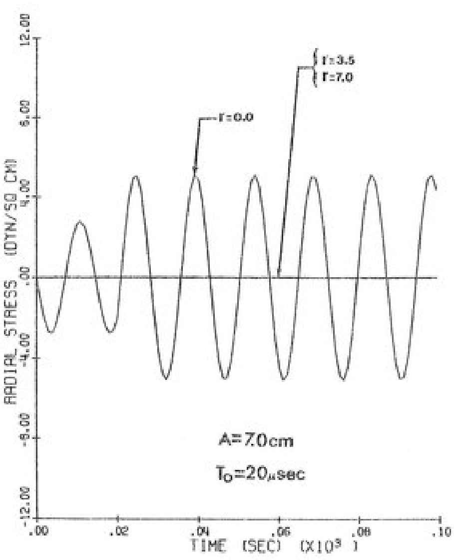

Fig. 11. Radial stress (sound pressure) generated in a 7-cm-radius spherical head exposed to 918-MHz plane wave. The peak absorption is 1000 mW/cm^3.

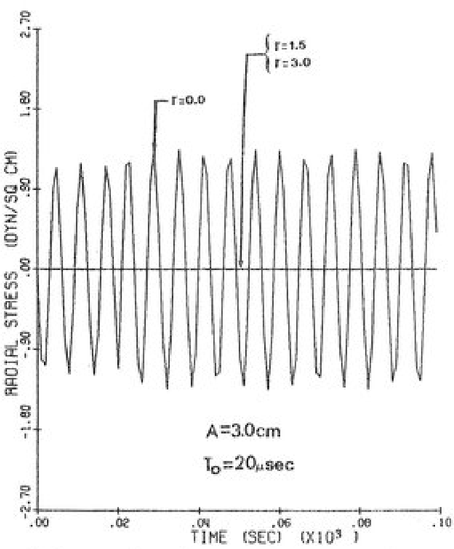

Fig. 12. Radial stress (sound pressure) generated in a 3-cm-radius spherical head exposed to 2450-MHz plane wave. The peak absorption is 1000 mW/cm^3.

wave pulses impinging on a semi-infinite medium of absorbing material has been given previously [25], [26].

TABLE II
SOUND PRESSURE IN A MAN-SIZED (a = 7 cm) SPHERICAL HEAD EXPOSED TO 918-MHz RADIATION

Pulse width (μs)	Incident power mW/cm^2	Absorbed power mW/cm^3	Pressure (dyne/cm^2)	db re 0.0002 dyne/cm^2
0.1	2200	1000	0.12	55.5
0.5	2200	1000	0.60	69.5
1.0	2200	1000	1.19	75.5
5.0	2200	1000	4.90	87.8
10.0	2200	1000	4.70	87.4
20.0	2200	1000	5.10	88.1
30.0	2200	1000	2.80	82.9
40.0	2200	1000	4.10	86.2
50.0	2200	1000	5.40	88.6

TABLE III
SOUND PRESSURE IN A CAT-SIZED (a = 3 cm) SPHERICAL HEAD EXPOSED TO 2450-MHz RADIATION

Pulse width (μs)	Incident power (mW/cm^2)	Absorbed power (mW/cm^3)	Pressure (dyne/cm^2)	db re 0.0002 dyne/cm^2
0.1	600	1000	0.12	55.6
0.5	600	1000	0.59	69.4
1.0	600	1000	1.15	75.2
5.0	600	1000	1.40	76.9
10.0	600	1000	2.30	81.2
20.0	600	1000	1.35	76.6
30.0	600	1000	1.50	77.5
40.0	600	1000	2.2	80.8
50.0	600	1000	1.2	75.6

Examination of the numerical results given in the last section indicates that pulsed microwave-induced sound pressure amplitude depends upon both pulsewidth and peak power density. In addition, there is apparently an optimal pulsewidth for maximum sound pressure generation which varies according to the sphere size and the frequency of the impinging radiation. As shown in Tables II and III, for a peak absorbed power density of 1000 mW/cm^3 (which corresponds to 600 mW/cm^2 incident power at 2450 MHz impinging on a 3-cm spherical head, and to 2200 mW/cm^2 incident power at 918 MHz impinging on a 7-cm spherical head), the pressure amplitudes generated at the center of the sphere are 15–30 dB above the reported threshold of hearing by bone conduction (60 dB, Re 0.0002 dyne/cm^2, 5–10 kHz) [27], [28] for pulses between 1 and 50 μs wide. The incident power required compares favorably with that reported previously [2], [4], [5]. At an absorbed power density of 1000 mW/cm^3, the corresponding rate of temperature rise at the center of both spheres, $r = 0$, is 0.258°C/s in the absence of heat conduction. The temperature rise in 20 μs is 5.2×10^{-6}°C.

Estimations of the fundamental sound frequency generated inside the head show that the frequency varies from about 8 kHz for a man-sized sphere to approximately 80 kHz for a small animal's, such as a mouse's, head. Assuming an equivalent radius of 1.5 cm for the brain of a guinea pig, Fig. 4 indicates a fundamental sound frequency of 48 kHz, which is in reasonably good agreement with the 50-kHz cochlea microphonic oscillations recorded from the round window of guinea pigs [6], which also happens to be the only available data in the literature.

Finally, it should be mentioned that the numerical results presented in this paper should be interpreted as giving estimates of the sound waves expected to be produced in mammalian heads by microwave pulses, subject to our ability to describe microwave, thermal, elastic, and geometric properties of mammalian cranial structures. In general, the results of this analysis indicate that thermoelastically generated stresses, resulting from microwave absorptive heating inside the head, represent a highly possible mechanism for sound generation.

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