Similarly, we have for the radial stress

$$\sigma_r(r,t) = 4\mu u_0 St + \sum_{m=1}^{\infty} A_m k_m M_m \frac{\sin \omega_m t}{\omega_m}, \qquad 0 \le t \le t_0 \tag{48}$$

$$\sigma_r(r,t) = 4\mu u_0 St_0 + \sum_{m=1}^{\infty} A_m k_m M_m \cdot \left[\frac{\sin \omega_m t}{\omega_m} - \frac{\sin \omega_m (t - t_0)}{\omega_m}\right], \qquad t \ge t_0. \tag{49}$$

Equations (46)–(49) represent the general solution for the displacement and radial stress in a spherical head exposed to pulsed microwave radiation as a function of the microwave, thermal, elastic, and geometric parameters of the model.

Since u_0 and A_m are directly proportional to I_0, both the displacement and the radial stress are proportional to the peak absorbed power density. It is easy to see that the displacement and radial stress also depend linearly on the peak incident power density.

At the center of the sphere, $r = 0$, both (46) and (47) reduce to zero, and (48) and (49) become

$$\sigma_r = 4\mu u_0 \left[\pm \left(\frac{1}{N\pi}\right)^2 - \frac{1}{3}\right] t + \sum_{m=1}^{\infty} A_m k_m \left(\lambda + \frac{2}{3}\mu\right) \frac{\sin \omega_m t}{\omega_m}, \qquad 0 \le t \le t_0 \tag{50}$$

and

$$\sigma_r = 4\mu u_0 \left[\pm \left(\frac{1}{N\pi}\right)^2 - \frac{1}{3}\right] t_0 + \sum_{m=1}^{\infty} A_m k_m \left(\lambda + \frac{2}{3}\mu\right) \left[\frac{\sin \omega_m t}{\omega_m} - \frac{\sin \omega_m (t - t_0)}{\omega_m}\right], \qquad t \ge t_0,\ N = \begin{cases} 1,3,5,\cdots \\ 2,4,6,\cdots \end{cases} \tag{51}$$

The radial stress is therefore given by (50) and (51), and there is no displacement at the center of the model. On the other hand, at the surface ($r = a$), (43) becomes naught. The radial stress is given by the summation of the harmonic time functions alone.

III. Displacement and Sound Pressure

Using the parameters for brain matter given in Table I, we can compute the effect of microwave pulses on spherical models of the head from the solutions derived above. Fig. 5 shows the results of pressure computations in a 7-cm spherical head exposed to 918-MHz radiation with pulsewidth ranging from 0.1 to 100 μs while keeping the peak incident (or absorbed) power density constant. The relations between peak incident and absorbed power density are obtained from Figs. 2 and 3. The sound pressure amplitudes clearly depend on the pulsewidth of the impinging radiation. Moreover, there seems to be a minimum pulsewidth around 2 μs. The sound pressure amplitude rises rapidly first to a maximum and then alternates around a constant average amplitude. The dependence of sound pressure amplitude on peak powers is illustrated in Fig. 6. The pulsewidth is taken to be 20 μs. It is therefore apparent that the sound pressure amplitude depends upon peak power as well.

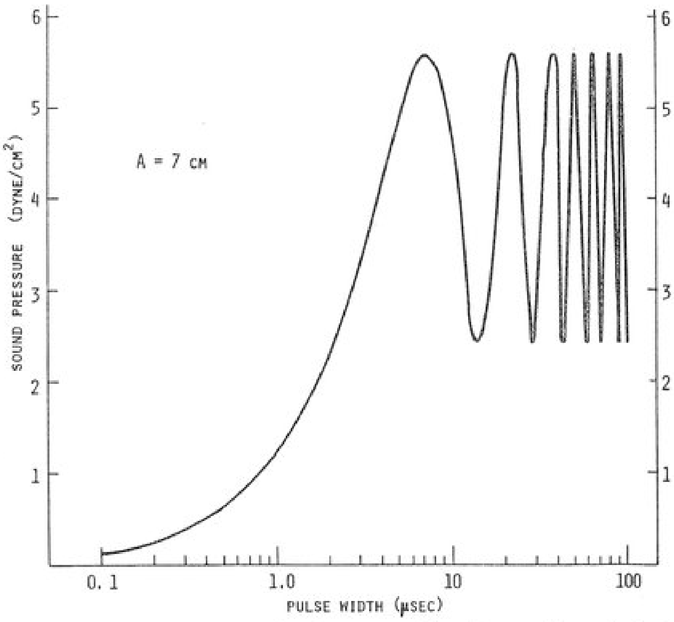

Fig. 5. Sound pressure amplitude generated in a 7-cm-radius spherical head exposed to 918-MHz plane wave as a function of pulsewidth. The peak absorbed energy is 1000 mW/cm^3.

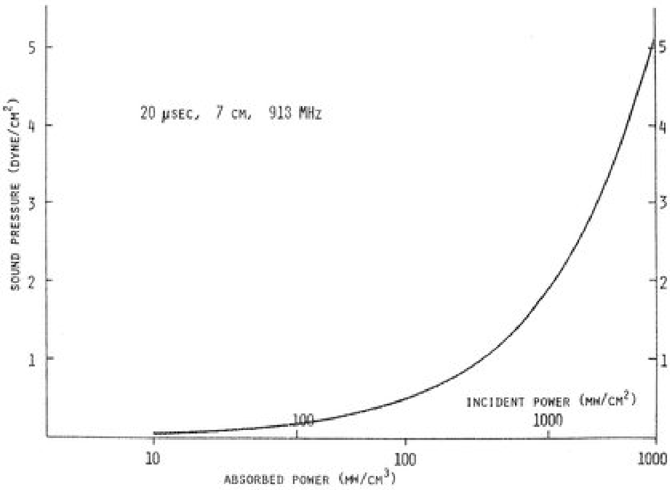

Fig. 6. The dependence sound pressure amplitude generated in a 7-cm-radius spherical head exposed to 918-MHz plane wave on peak incident and absorbed powers. The pulsewidth is taken to be 20 μs.

Fig. 7 gives the computed pressures in a 3-cm-radius sphere exposed to 2450-MHz radiation. It is readily seen that microwave-induced sound is a function of both pulsewidth and peak powers (Fig. 8). The minimum pulsewidth for efficient sound generation by 2450-MHz microwaves impinging on a 3-cm-radius spherical head is around 1 μs.

Figs. 9 and 10 depict typical displacements of brain matter in spherical models of the head exposed to pulsed microwaves. The pulsewidth used for computing Figs. 9 and 10 is 20 μs. These are representative graphs and are shown for $r = 0$, $a/2$, and a, where a is the radius of the sphere. As