Auditory System Response to Radio Frequency Energy

Technical Note

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CLASSICALLY, the auditory and visual systems have been distinguished in part by the "fact" that the two systems respond to different types of energy, acoustic and electromagnetic, respectively. Our Laboratory, however, has obtained data which suggests that this fact may not be correct.

The textbooks state that sound energy is generated only by vibrating bodies and is transmitted by wave motion in a material medium, i.e., air, water, wood. In contrast to this, the visual system responds to electromagnetic energy. This energy is not transmitted by molecular motion in a material medium and does not need a material medium for propagation.

Our data to date indicate that the human auditory system can respond to electromagnetic energy in at least a portion of the radio frequency (RF) spectrum. Further, this response is instantaneous and occurs at low power densities, densities which are well below that necessary for biological damage. For example, the effect has been induced with power densities 1/160 of the standard maximum safe level for continuous exposure.

We have been collecting two lines of data on this effect in human subjects. One approach involves finding people who believe they have experienced this effect, interviewing them, evaluating their reports, and collating this information about a variety of RF transmitters. This type of information provides clues as to the nature of the effect and suggests experiments. The other line of data collection involves direct experimentation and is summarized in this paper.

In our experiments to date we have used the two transmitters having the pertinent parameters shown in Table I.

TABLE I. TRANSMITTER PARAMETERS

	Transmitter A	Transmitter B
Frequency	1310 megacycles	2982 megacycles
Wavelength	22.9 cm.	10.4 cm.
PPS	244	400
Pulse width	6 microseconds	1 microsecond
Duty cycle	.0015	.0004

It should be noted that the auditory system responds to frequencies at least as low as 200 megacycles and at least as high as 3000 megacycles. In other words, transmitters broadcasting in P, L, and S bands have elicited responses.

The response of the auditory system to irradiation with transmitters A and B results in the subject reporting that he hears a buzzing sound. This perceived sound is referred to as the *RF sound*. The RF sounds induced by the two transmitters appear to be similar, but may not be identical. We have not yet been able to determine whether the perceived sounds are identical. With other transmitters, a knocking sound has been reported.

Eight points of experimental evidence are summarized:

1. It has frequently been reported that some people can detect radio programs through fillings in their teeth. To check this possibility, shields were interposed between the subject and RF source. When the lower half of the head was covered, including the maxillary dental area, the RF sound was per-

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ceived. When the top half was covered the RF sound ceased.

2. With the transmitter's antenna enclosed in a radome and thus not visible to the subjects, the antenna was rotated at various rates. Thus, the RF beam swept by the subject several times a minute. On each sweep, he heard the RF sound for a few seconds and reported it. This report was compared with the needle deflection of our meters which the subject could not see. The subjects invariably perceived when they were swept by the RF beam. In fact, they responded a moment before the instruments since the mechanism of the instruments has a slight lag time. These subjects were over 100 feet from the radome and could hear no sound from it.

3. Subjects have been blindfolded with tight-fitting blacked-out goggles and have been placed in the RF beam. The beam was then broken repeatedly in an irregular fashion by interposing a screen shield between the source and subject. The reports of subjects indicating when the sound was "on" and "off" correlated perfectly with the unshielded and shielded conditions.

4. Subjects were placed in pairs in the RF beam. A screen shield was placed between the source and head of one member of each pair. The RF sound immediately ceased for the shielded member of the pair but continued for the unshielded member.

5. The typical ambient noise level was 70 to 80 db. Earplugs rated to attenuate sound an average of 30 db were placed in the ears of subjects in the RF beam. The subjects reported a reduction in ambient noise level and an increase in the level of the RF sound. The latter observation was probably relative.

6. A deaf subject had an average air conduction loss of 50 db. Bone conduction was good. He could hear the RF sound with power densities approximating those needed for threshold perception in normal subjects.

7. When a screen shield was placed so that RF energy which had passed the subject was reflected back on the subject, he reported an increase in the volume of the RF sound.

8. With usual sounds, subjects localized the source quite well if given an opportunity to rotate their body freely. With the RF sound, this was not the case. The subjects typically reported, when asked to localize the source of the RF sound, that the apparent source was a short distance behind their head. No matter how they rotate in the RF field, they localize the source in the same place.

With consideration of these eight experimental observations, it was difficult to accept the concept that the perception of RF sound was induced by acoustic energy external to the tympanic membrane.

Threshold Detection.—Transmitter A. The ambient noise level was approximately 70 db. Earplugs found to attenuate tones between 125 cycles and 8000 cycles 25 to 30 db were placed in the ears of eight subjects.

Th average field was measured with a Polarad C.A.-L antenna together with an attenuator, a type #50 A.I.L. RF power bridge and a Hewlett-Packard type 477 thermister mount. The accuracy of this instrument was checked by having an independent measurement of the RF field. In these measurements a crystal rectifier-microammeter, a broad band instrument to detect signals, was used. Then the average field strength for transmitter A's frequency was ascertained with a Sperry gyroscope type #84C microwave wattmeter together with a Hewlett-Packard #477B thermister mount and a loop having a 1 cm.^{2} area. The threshold for eight subjects was approximately 400 microwatts/cm^2.

Transmitter B. The ambient noise level was approximately 80 db. The earplugs described above were used. The average field strength was determined with a DeMornay Bonardi horn type G-520 together with a Hewlett-Packard variable attenuator type X357A, and a Narda power meter type 440. The threshold for seven subjects was approximately 2 milliwatts/cm^2.

Matching to Audio.—The subjects refused to try to match RF sounds to a sine wave. They would try a few seconds and find it impossible.

A white noise generator with a variable bandpass filter was more acceptable to the subjects but not very satisfactory. Consistent matching could not be achieved.

The speaker was connected with the variable bandpass filter to the pulser of the transmitter and the subjects found this arrangement more acceptable than white noise, but were still not satisfied. They indicated that more high harmonics would be desirable for adequate comparison or matching. The speaker response may have been the limitation in this arrangement.

With this arrangement, however, the subjects invariably set the filter to cut out all frequencies below about 5KC audio and wanted maximum bandwidth to the high end.

Deaf Subjects: Only transmitter A was used with this series.

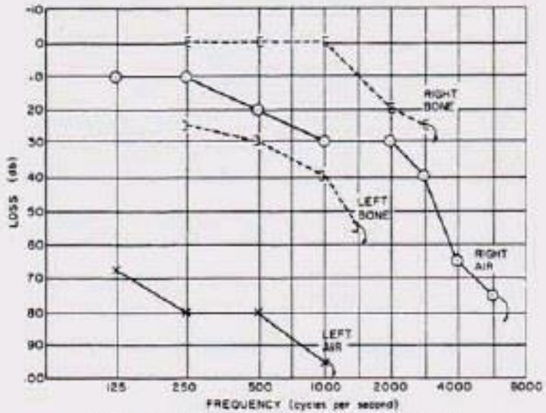

Fig. 1. Hearing loss in Subject 1.

Subject 1. The right ear was moderately scarred and thickened (Fig. 1). The left ear showed a clean radical mastoidectomy cavity. Subject 1 did not hear the RF sound even when the power density was 30 times that needed for the normal threshold.

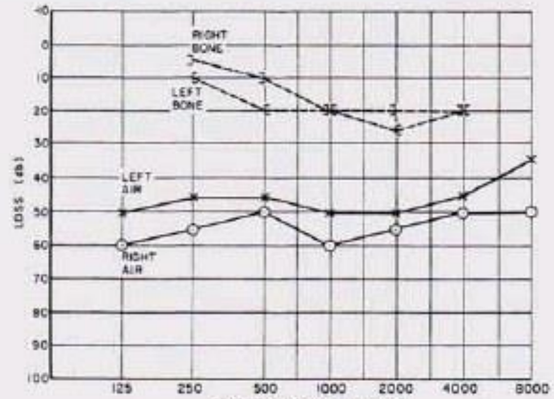

Fig. 2. Hearing loss in Subject 2.

Subject 2. This person (Fig. 2) showed manifestations of otosclerosis.

He heard the RF sound at approximately the same power density level needed to induce threshold perception in normal subjects.

Subject 3. The diagnosis for this person was nerve deafness as a result of treating hepatitis with intravenous neomycin. A tinnitus persisted and was described as sounding like the hiss of escaping gas.

The subject (Fig. 3) did not hear the RF sound.

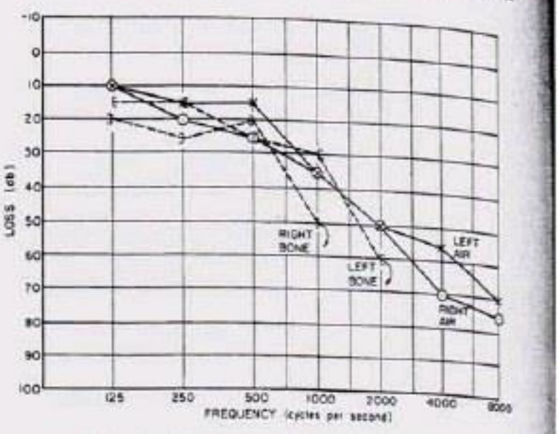

Fig. 3. Hearing loss in Subject 3.

Subject 4. This subject was not a clinical case and had normal hearing. He accompanied the investigator as an observer and participant in the experiment. He reported that he could not hear the RF sound. An audiometer check revealed the results (Fig. 4).

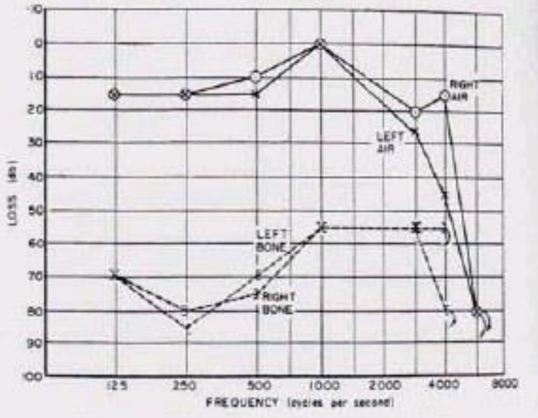

Fig. 4. Hearing loss in Subject 4.

It appeared from this series that a necessary condition for perceiving the RF sound was the ability to perceive audio above approximately 5KC, although not necessarily by air conduction.

Shielding.—Our preliminary studies indicated that the entire head, but for the temporal areas, can be shielded without attenuating the RF sound. If other areas are exposed, but the areas over the temples shielded, the RF sound is not heard.