news

Do you hear what I hear?

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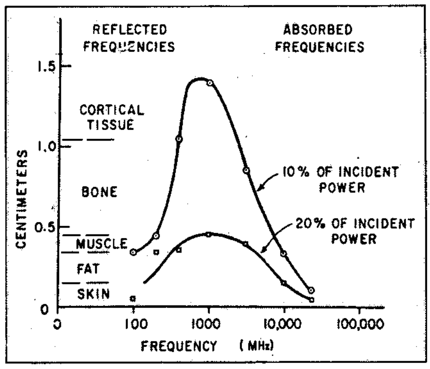
Contributing Editor

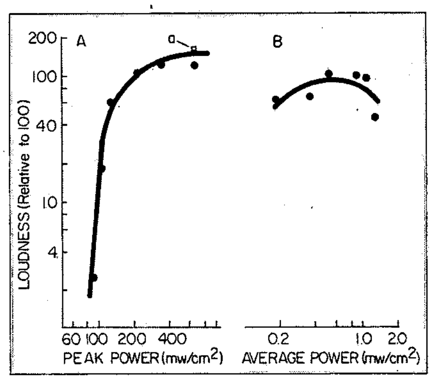
"My ears are buzzing—somebody is talking about me," may have to be changed to "I hear a buzz—someone is transmitting." Why? Because field tests with radar have indicated that humans perceive low-power, pulse-modulated energy in the 0.3 to 3 GHz band. The effect is not acoustical, but electromagnetic in nature. Even deaf people can hear rf "sounds." The "buzzes" and "hisses" perceived were dependent primarily on peak power and secondarily on pulse width. Average power was a second-order effect. In addition, pitch and timbre effects could be stimulated by varying the modulation.

This phenomēna has been observed in experiments conducted by Allan H. Frey and Rodman Messenger, Jr. of Randomline, Inc., Willow Grove, PA, under a U.S. Office of Naval Research and U. S. Army contract. Frey, the senior investigator, has been doing work on the psychophysical effects of low-power microwave radiation for many years. His experiments were performed with humans placed in an rf anechoic chamber. Typical data was taken at 1.245 GHz. The energy was conveyed from the transmitter to a waveguide-to-coaxial adapter and then to a standard gain horn placed inside the chamber. The pulse repetition rate was chosen so that the test subjects reported the perception of a sound like "buzzing."

Rf energy measurements, Fig. 1, were made with a half-wave dipole (connected to an rf power meter) placed where the subject's head would normally be. Vertical polarization was used, but horizontal polarization gave the same results. During the test, cables and supporting structures were arranged for minimum field disturbance. The field distortion of the measuring instruments and the human head were taken into account as much as possible. "All you saw, if you looked inside the chamber, was a person sitting with nothing attached at all," Frey says.



1. **Power absorption chart** shows the calculated penetration of microwave energy into the head as a function of frequency. Resonance effects and multiple reflection were neglected. The curves indicate only the overall trends.



2. **The data for each subject** consisted of three repetitions for each particular set of rf parameters. In (A), average power was held constant. In (B), pulse width was increased with peak power held constant.

It sounds like—

Test persons were chosen with normal hearing and were trained to estimate the perceived "loudness" of the buzz heard. All data was referenced to an arbitrary loudness of 100 for a given known rf signal. A radomized order of peak power, average power, pulse width and pulse repetition rates were used and all precautions were taken to eliminate false data. The results in Fig. 2 represent average response from many tests.

"It's interesting to note," says Frey, "that once a minimum pulse width is achieved, perceived loudness is a function of peak power only. When pulse width is held constant and average power changes by varying the PRF, the "sounds" perceived vary in timbre and pitch."

The threshold for perception in the rf chamber was a peak power of about 80 mw/cm^2.

Understanding the mechanism

"Unfortunately, we mostly know what the mechanism isn't," claims Frey. The results indicate there is no transduction from microwave to acoustic energy by teeth fillings. Nor does the data support the idea of radiation pressure against the skin conveyed by bone conduction to the ear. Radiation pressure against the ear's tympanic membrane can also be dismissed.

"Much of our work is concentrated on understanding just how the sound arises since the results obtained can be related to other reports of sensory and behavioral phenomena associated with incident low-level microwaves."

It's important to understand just what is going on because properly modulated microwave energy may be useful in understanding the human nervous system. The brain is stimulated by the functioning of neurons—those ubiquitous conductors of everything electrical. One theory holds that the brain may well be the detection mechanism. Evidence has been presented concerning the existence of electrostatic and magnetic fields around neurons. It is reasonable to suspect that the microwave electromagnetic field could interact with the neural field.

What's to be done?

Much work has been done in establishing the phenomena is real and of biological significance. Remaining questions include the examination of what types of deafness preclude hearing the sounds (some do—some don't), the mechanism of detection by the human and test animals, other possible (harmful?) effects of low-level microwave radiation and so on.

Frey notes that "the phenomena has a number of implications which might be of significance in several fields. For example, it might provide us with information that could be of use in communications systems or it could provide information on techniques for helping the deaf. Also, research could lead to advances in our understanding of the functioning of the nervous system."

Laser fusion: an alternative energy source?

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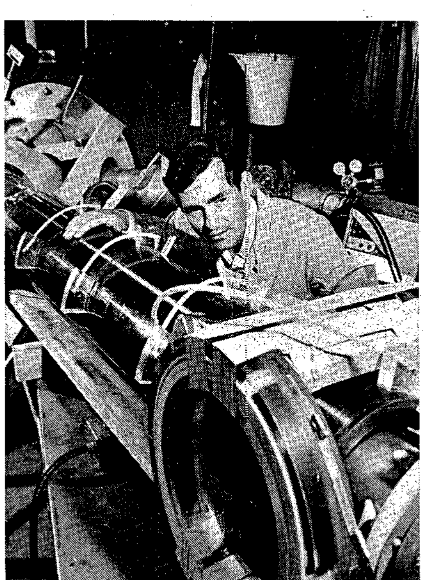
The time when atomic reactors could be driven by lasers drew another step closer when researchers at Sandia Laboratories in Albuquerque, NM, pulsed a hydrogen-fluoride laser to a record level. Excited by a 55-kA, 2-MV electron beam, the HF laser produced 228-joules of energy in a 55-ns pulse—a power output of about four billion watts.

"This is about 45 times greater than the maximum energy level previously confirmed for an HF laser," claims Edward L. Patterson, a staff member at Sandia, who believes that this breakthrough is an important step toward laser fusion.

In laser fusion, multiple laser beams simultaneously irradiate a pellet of deuterium-tritium, imploding the target to 10^4 times liquid density. The vast quantity of energy released when the heat of this laser bombardment causes the deuterium nuclei to undergo fusion could be used to generate electric power.

The laser is triggered by firing a high-energy beam of electrons formed by a relativistic electron beam accelerator into a 6-inch diameter, 40-inch long lucite tube containing a 10:1 mixture of sulfur-hexafluoride (SF_6) and ethane (C_2H_6). The 22-liter volume of gas is held at slightly less than one atmosphere of pressure. At one end of the tube, a 2-mil mylar diaphram serves as an output window, transmitting about 65% of the laser energy. Magnetic field coils circling the tube act to focus and direct the electron beam.



1. **This 22-liter HF laser** is fired by an electron-beam accelerator visible in the background.

When the electrons are shot into one end of the tube, they collide with the SF_6 molecules detaching fluorine atoms. These highly-reactive free fluorine atoms extract hydrogen atoms from the C_2H_6 forming highly excited HF molecules.

As the HF molecules return to a normal energy state, they emit infrared energy in the wavelength region from 2.65 to 2.95 microns.

Problems to be solved

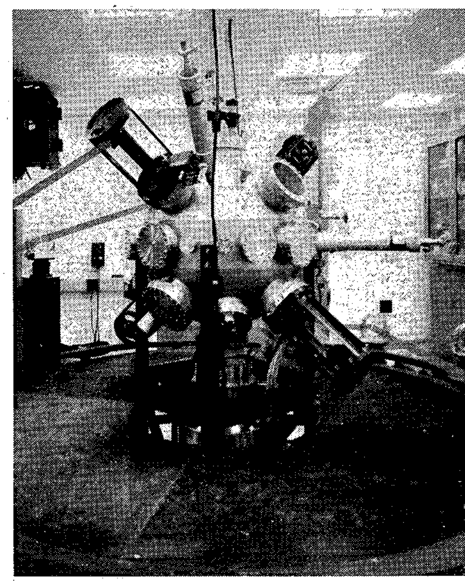
"Although there is a possibility of using this laser for fusion, there are still several problems to be solved," cautions Patterson.

Calculations by Sandia experimenters point to laser efficiency as a critically important parameter to consider when evaluating the feasibility of laser fusion. Their figures indicate that a fusion power plant using a laser displaying 10% efficiency would require about 10^5 joules of laser energy to produce a net output energy 10% greater than the input energy.

Patterson says that the maximum efficiency of the HF laser to date is about 8%, but indicates that experiments are currently underway to increase this figure toward a theoretical maximum of 24%.

The experiments involve introducing the electron beam into the side of the laser tube and placing mirrors at both ends of the tube creating an optical resonator.

At present, scientists believe that 10^3 to 10^4 joules of energy applied in subnanosecond pulses would be sufficient to fuse enough deuterium nuclei to produce break-even power—the amount of energy created by fusion equaling the amount of energy deposited in the pellet by laser light. While Sandia researchers believe that they can



2. **The evacuated test chamber** shown here houses the target pellet. Cw alignment beams illustrate the paths taken by the four firing pulses.

increase the output of HF lasers to more than 10^3 joules using higher-energy electron beams and optical resonators, they anticipate problems in decreasing the pulse length.

"The pulse length for most efficient use of energy is on the order of hundreds of picoseconds. The shortest pulse that we've seen from th HF laser is 38 ns," Patterson says.

"Unless you get some kind of destruction mechanism, the laser pulse-length will depend on the excitation pulse," he continues.

A 70 ns excitation pulse-length is now being used.

Other problems with using the HF laser for fusion include poor coherence in the six-inch laser beam and high gain.

In a laser, gain relates to the time that the gas molecules remain in an excited state before decaying back to a normal ground state. For the HF laser, this lifetime is too short; the photons are emitted too soon to produce the energy build-up necessary to create a short, intense pulse of light.

According to Patterson, there is a trade-off with the HF gas.

"When the HF gain is reduced,

(continued on p. 12)