HISS OF THE FIREBALL

EARTH

By Pamela Weintraub

It was November 13, 1833, and the East Coast was in the midst of perhaps the most spectacular meteor shower of all time. While dozens of glowing fireballs streaked through the atmosphere, people on the ground detected a distinctive hiss. Minutes after, they heard the roar of the meteors' dive to Earth.

Some 150 years later, in November 1984, Ben and Jeannette Killingsworth watched from their rural Galveston County, Texas, home as the space shuttle *Discovery* approached Earth. Streaking across the predawn sky, the craft seemed to emit an unmistakable swish. The *expected* sound of reentry—the sonic boom—came several minutes later.

Over the centuries, there have been hundreds of similar reports. People watching large, moving objects like meteoric fireballs have routinely reported swishes, whooshes, crackles, and hisses. And according to Danish meteorologist Vagn Buchwald, animals have long appeared to detect such sounds as well. Since light waves travel thousands of times faster than sound waves do, light radiating from such far-off objects should reach the witness seconds *before* the sound. But in case after case, witnesses have perceived both sound and image at the same time.

This anomaly has been the subject of scientific inquiry ever since the 1780s, when Sir Charles Blagdon, secretary of the Royal Society of London, studied a large fireball that reportedly hissed as it made its descent more than 50 miles from observers on the ground.

Blagdon was convinced by the sincerity of his witnesses, but he could not explain their perceptions. Instead, he declared, he would leave the mystery "as a point to be cleared up by future observers."

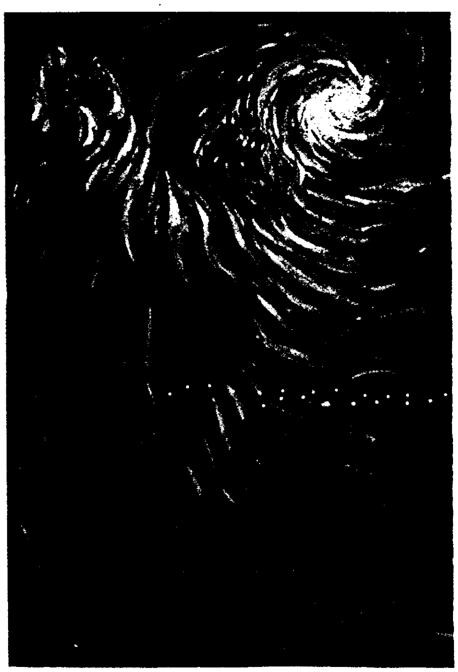
Future observers did indeed contemplate the phenomenon, proposing one theory after another. One scientist, for instance, suggested that energy emitted by the fireball stimulated the brain directly, bypassing the normal hearing apparatus in the ear. Another proposed that the sounds were produced when tiny particles blasted off the meteor and flew close to the observer on Earth.

In general, though, these explanations were shunned. Hiss, crackle, or whoosh, most scientists said, the noise *had* to be psychological, stimulated by the awe-inspiring sight of a fireball trailing brilliant flames of light through the sky.

Then, on April 7, 1978, two hours before sunrise, a huge fireball crossed the skies of Sydney and New Castle, Australia. Seen by hundreds of people, the blazing meteor made front-page news in the local papers. And it didn't take long for word of the fireball to reach local meteor specialist Colin Keay, a physicist at the University of New Castle, in New South Wales. Keay was especially intrigued by a particular aspect of the reports: Though the fireball had landed 70 kilometers out to sea, many witnesses claimed that they had actually *heard* it descend.

"At first," Keay says, "I, like my colleagues throughout history, dismissed these reports as psychological. But in interviewing witnesses, I was struck by their sincerity, so much so that I decided to go back and search the literature."

The search, he explains, convinced him that delusion was not the case. "Report after report," says Keay, "paralleled the claims of my own witnesses in Australia. If the reports were mere fantasy, how could the phenomenon occur again and again at such widely divergent times and places around the world? Something more had to be going on."



To figure out that something, Keay took a three-month leave of absence from his job, heading for the National Research Council, in Ottawa, Ontario.

Getting down to work, he theorized that the mysterious phenomenon could occur only if sound were somehow traveling as fast as light. Since light is made of electromagnetic energy, the sound was probably induced by a form of electromagnetic energy as well. Electromagnetic energy, of course, cannot produce sound directly. But as any radio engineer knows, Keay reasoned, electromagnetic energy can certainly be *converted* to acoustical energy by a loudspeaker or some other transducer. Natural objects in proximity to the observer, he knew, could serve that function well.

This embryonic theory in place, Keay dug out an article by Arizona physicist and fireball expert Doug ReVelle. ReVelle reported that when giant fireballs penetrated the atmosphere, they produced a hot gas, or plasma, generating tremendous turbulence in their rapid descent to Earth.

Latching onto ReVelle's information, Keay proposed that the plasma was turbulent enough to literally trap the earth's magnetic field. But during the fireball's descent, the plasma would dissipate, releasing the magnetic field in the form of very low frequency electromagnetic radiation. That radiation would travel to Earth at the speed of light, causing objects in the vicinity of the observer to vibrate.

Testing his hypothesis, Keay placed subjects beneath an electrode that emitted radiation similar to that given off by the fireball. In a few instances, subjects heard a whooshing sound. And those with loose clothing, steel-rimmed glasses, or frizzy hair, which all vibrate readily, were most susceptible of all.

Keay's recent results are strengthened

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GAMES

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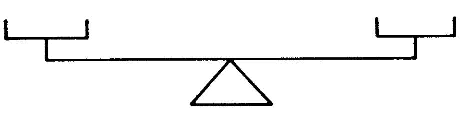
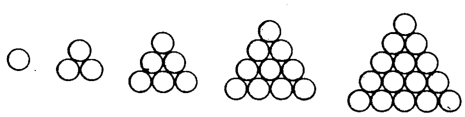
be showing on the top surfaces of the two dice after each throw. If a player gets the sum 13 or 23 on his first throw (a natural), he wins. If he gets the sum 2, 3, or 24 (craps), he loses. If he gets any other sum (his point), he must throw both dice again. On this or any subsequent throw, the player loses if he gets the sum 13 and wins if he gets his point but must throw both dice again if any other sum appears. The player continues until he either wins or loses. To the nearest percent, what is the probability at the start of any game that the dice thrower will win?

38. Illustrated below is a simple scale for weighing objects. The scale consists of a lever resting on a fulcrum with weighing pans at each end of the lever equidistant from the fulcrum. Suppose that the objects to be weighed may range in weight from 1 pound to 100 pounds at one-pound intervals: 1, 2, 3, . . . , 98, 99, 100. After placing one such object on either of the two weighing pans, one or more precalibrated weights is then placed in either or both pans until a balance is achieved, thus determining the weight of the object. If the relative positions of the lever, fulcrum, and pans may not be changed and if one may not add to the initial set of precalibrated weights, what is the minimum number of such precalibrated weights that would be sufficient to bring into balance any of these objects?

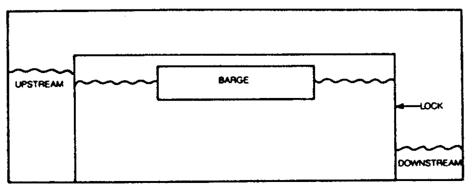


39. A crystal consists of 100,000,000 layers of atoms such that there is 1 atom in the first layer, 3 in the second, 6 in the third, 10 in the fourth, 15 in the fifth, and so forth, as illustrated below. Exactly how many atoms are there in the entire crystal?



40. To the nearest percent, the probability that any one person selected at random was born on Monday is 14 percent. What is the probability, to the nearest percent, that of any seven persons chosen at random, exactly one was born on Monday?

41. A certain lock for raising and lowering barges from one river level to another is a rectangular parallelepiped 200 meters long, 50 wide, and 20 deep. A barge is floating in the lock that is also a rectangular parallelepiped measuring 80 meters long, 25 wide, and 5 deep. The barge, containing 3,000 barrels of toxic chemicals, displaces 8,000 long tons of water. The water has a density of one long ton per cubic meter. Each barrel of chemicals is watertight, with a volume of one cubic meter and a weight of two long tons. A group of terrorists render the lock inoperable and attach a time bomb to the side of the barge set to go off in three hours. The barge contains elevators for moving barrels quickly to the deck, but the crew is too shorthanded to roll the heavy barrels up an inclined plane in the time allotted. The deck is only ten centimeters below the top edge of the lock, from which the barrels could be rolled to dry land. If no water is entering or leaving the lock, how many barrels, at a minimum, would need to be rolled into the water in the lock in order to raise the level of the barge so that its deck would be even with or slightly above the top edge of the lock so that the remaining barrels could be rolled to dry land?

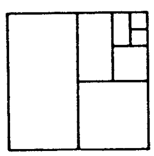


42. As one can see from the diagram below, the sum of the infinite series

$\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \dots$

is 1. What is the sum of the infinite series

$\frac{1}{3} + \frac{1}{9} + \frac{1}{27} + \frac{1}{81} + \dots ?$



For each of the following number series, what number should come next? For example, in the series 1 4 9 16 25 36 ? the best answer would be 49.

43. 15 52 99 144 175 180 147 ?
44. 3 23 229 2869 43531 ?
45. 0 5 8 8 2 3 5 2 9 4 ?
46. 14 21 13 2 5 18 0 19 5 18 9 5 ?
47. 6 8 5 8 4 0 7 3 4 6 ?
48. 1 3 8 22 65 209 732 2780 ?

This concludes the test.

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by the work of Allen Frey, a biophysicist and technical director of Randomline Inc., a basic-research and consulting firm in Huntington Valley, Pennsylvania. Frey has been studying sounds generated not by giant fireballs but by the relatively weak electromagnetic fields associated with radar, microwaves, and radio waves.

Applying his physiology background to the problem, Frey discovered that such fields, while too weak to cause vibration in the outside environment, somehow stimulate the inner ear itself. Although unsure of the *exact* mechanism involved, Frey suggests that these very weak fields might be affecting the chemical bath that surrounds the ear's acoustically sensitive membrane. Somehow that electrochemical reaction may be translated to sound.

While Keay's theory about vibration of the surrounding environment makes sense, Frey adds, giant fireballs are most probably stimulating the internal environment—the inner-ear membrane—as well as the external one. "You don't have an either/or situation," he notes. "The sources of the sound will vary depending upon the exact frequency of the electromagnetic wave."

Both Frey and Keay insist that better understanding of the phenomenon will have a sizable payoff. Learning exactly how electromagnetism reacts with the ear, says Frey, will give us greater insight into the human auditory system.

And understanding how fireballs generate sound, says Keay, could open new vistas for scientists studying geophysics, electromagnetism, and astronomy. And perhaps even more important, current work could conceivably help researchers perfect a promising new energy technology known as *magnetohydrodynamics,* in which hot plasma, like that created by the fireball, generates electromagnetic power.

In the past, Keay notes, a concerted study of the fireball hiss has been almost impossible. At any given site around the world, there are only three or four giant meteors a century. It's impossible to know when one of these projectiles will arrive, and there simply aren't enough of them to justify a long-term wait, complete with recording equipment and a trained scientific staff.

But that issue, he adds, may now be academic. A new, predictable kind of fireball—the space shuttle—produces as much plasma and noise as do fireballs dropping in from the cosmos.

"The space shuttle offers a golden opportunity for any young researcher with a tape recorder, an amplifier, and a bit of time," Keay contends. "Scientists who know when it will pass can simply lie in wait for its arrival. By getting the whooshes and hisses of the electromagnetic signal on tape, we can learn *exactly* how this kind of energy is converted to sound. We'd be solving a mystery that's haunted us for two hundred years."