

PHYSICS

Silent Sound

Ultrasonics has found countless applications in research, medicine and industry; despite its already widespread use, its potential is far greater.

By RICHARD LITELL

► SOUNDS PITCHED so high that you cannot hear them are finding applications in almost every science and industry in the nation. Despite the widespread public attention focused on the latest developments in nuclear energy and the conquest of space, ultrasonics remains one of the magic words in 20th century science.

Ultrasonics refers to the study and use of high-frequency, inaudible sound waves. These waves have been referred to as "silent sound" or high-frequency vibrations, for how can they be sound when there is no sound to hear?

Call them what you will, these ultrasonic waves have been used to tenderize meat, make facial creams, clean and degrease precision tools, mow lawns, age whisky, detect submarines and cut jewels. And that is not all. They have also been used in industrial drilling and grinding, in speeding up chemical reactions, in emulsifying and homogenizing materials, in removing barnacles from the hulls of ships, and in burglar alarms, to say nothing of numerous applications in medicine and dentistry. And that is still not all. One could go on all day listing applications of ultrasonics.

A look at the nature of sound waves as related to the human ear may lead to a better understanding of ultrasonic waves.

Basically, sound consists of a series of alternate increases and decreases in pressure, similar to the ripples caused by throwing a stone into a still pond. The frequency, or pitch, is determined by the number of times the pressure increases or decreases; it is measured in cycles per second. Intensity, on the other hand, expresses the varying strengths of this pressure, and is measured in decibels.

Speeds and Vibrations

The word supersonic, often used interchangeably with ultrasonic, more correctly applies in current usage to speeds higher than the speed of sound. Sound travels at about 741 miles per hour at 32 degrees Fahrenheit at sea level. Ultrasonic, on the other hand, refers to frequency of sound waves.

The average person cannot hear frequencies of less than 16 vibrations a second or more than 15,000 to 20,000 vibrations a second. Similarly, the human detection range of intensity is from zero to 120 decibels. That is, any intensity above 120 decibels becomes painful.

No matter how loud a sound is, it cannot be heard unless it lies in the audible frequency range, because the limit of audi-

bility is set by the frequency and not by the intensity. Thus it is possible to have silent, inaudible sound of very high intensity.

Try moving your hand rapidly back and forth in front of your face. You are now setting up vibrations in the air, yet you do not hear them. This is because the vibrations are too slow, less than 16 a second.

If you could vibrate something in front of you at a frequency greater than approximately 17,000 vibrations a second, you would not hear anything either, because the sound would be at the other extreme of inaudibility to the human ear.

To take an everyday example of ultrasonics, consider the dog whistle that can be heard by a dog but not by any person. The vibration frequency of the whistle is pitched too high for the human ear to detect it. But a dog, which can detect frequencies up to about 35,000 per second, both hears and responds.

For ultrasonics' surprising ability to accomplish easily formerly difficult tasks, it is necessary to obtain a sound intensity sufficiently high to produce a secondary effect known as cavitation. This is essentially the creation and collapse of millions of tiny vapor bubbles in the medium through which the sound is traveling.

In cavitation, instantaneous pressures as high as 75,000 pounds per square inch, 5,000 times greater than normal atmospheric pressure, can be created. Along with these pressures are localized temperatures as high as 20,000 degrees Fahrenheit—above that of the sun's surface. A thin aluminum foil subjected to cavitation in ordinary tap water can be literally chewed to pieces within a few seconds.

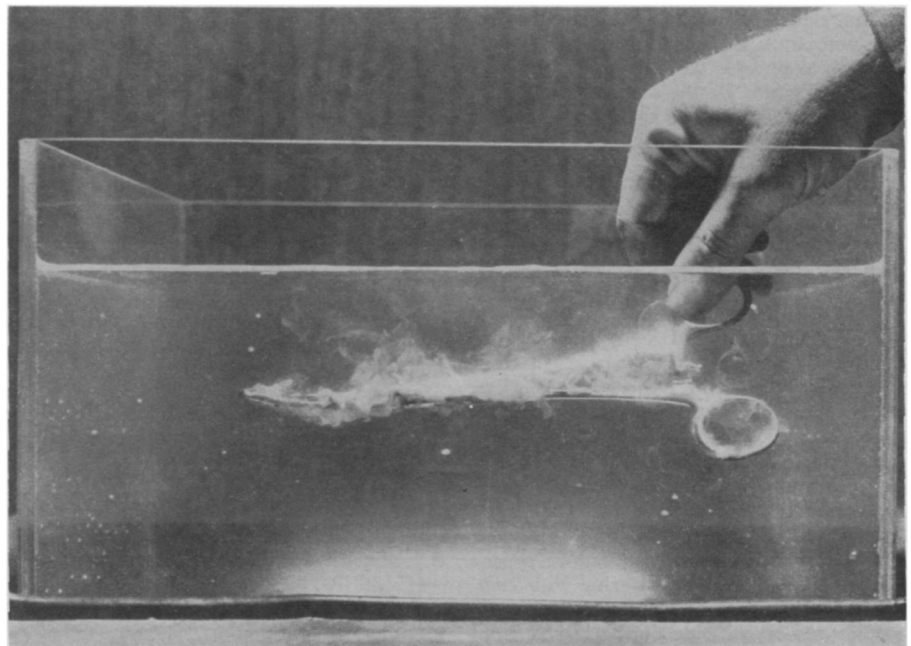
In order to produce ultrasonic waves, electrical energy must be changed into mechanical sound vibrations by such devices as quartz crystals or transducers. With quartz crystal vibrators, sounds a thousand times as intense as a violent crack of thunder have been produced.

Applications of Ultrasonics

By using frequencies between 35,000 and 50,000 vibrations a second, cosmetic manufacturers can surround a particle of water with oil to make a cleansing cream, or surround a particle of oil with water to produce a vanishing cream.

An ultrasonic tenderizing process that breaks up tough fibers in frozen foods is said to cause no taste or color change in meat, fish, fruits or vegetables. The frozen food is immersed in a brine-filled tank and then subjected to vibrations varying from 1,000 to 1,000,000 cycles a second through the use of a transducer. The freezing guarantees retention of the original shape and natural juice of the food.

An ultrasonic washing machine for cleaning soiled surgical instruments far more



ULTRASONIC WASHING—Dried blood and other soils fly away from this surgical instrument immersed in a tank of ultrasonically radiated water. Cavitation effect of powerful, inaudible sound waves does a faster, easier and more thorough job than conventional hand brush and scrubbing.

speedily and thoroughly than ever before is probably the forerunner of an ultrasonic home dishwasher. Within such washing machines, the penetrating energy of high-pitched waves loosens and disintegrates dirt, dried blood, bits of tissue and other foreign material, even that packed into microscopic holes. One hospital has reported an 80% saving in time for cleaning instruments with ultrasonic washing machines. Experimental models of ultrasonic kitchen sinks have also been demonstrated.

Minute particles of soot from industrial stacks, normally too tiny to be caught by ordinary collection methods, have been made to form into large clumps and subsequently captured by sound vibration of high frequency. In this way the carbon is saved and the countryside freed of soot.

In a similar manner, ultrasonic waves have been made to condense fog by causing the tiny water droplets to gather together and fall as water.

Applications that perhaps affect the public most directly are the medical ones. For example, ultrasonic energy has been successfully used to diagnose lumps in the human breast and tumors in the brain. When a narrow sound beam encounters human tissue, a pattern of echoes is returned, converted into electronic signals and displayed on a television picture tube. Irregularities such as cancer, nonmalignant solid tumors and liquid-filled cysts can thus be recognized from their characteristic pictures, and appropriate treatment can be initiated.

Sound Waves Take Pictures

Ultrasound may also supplement X-rays as a diagnostic aid. High-pitched sound waves have been used to take pictures of bones and other body parts. The device used consists of a plastic tank filled with water in which the object to be viewed is suspended, crystals to direct ultrasonic beams onto the object and a sonic lens that forms a sound image of the object on another crystal. The image can be formed either by reflected sound waves or by those that have passed through the object.

A recently developed technique makes it possible to examine areas of the eye which were formerly too difficult to reach. Now ultrasonics makes possible a cross-sectional view of the eye and the areas behind the eye.

Medical applications of ultrasonics, however, are still not too widespread as much remains to be learned about the effects of high-pitched waves on animal tissue. The same range of frequencies that makes cleansing creams and vanishing creams, for example, also can clot blood.

Though the future of ultrasonics in medicine seems much more likely to be directed to saving human lives than toward destroying them, the fact remains that ultrasonic waves improperly used can be death-dealing. A great deal must still be learned about their effect on body tissues before they can be used extensively in all their promising applications.

Today, despite its tremendous potential and already widespread use, ultrasonics is only beginning to assume the important role that many foresee for it in industry, research and in the home.

Science News Letter, January 17, 1959

NEW! CENCO® Mobile Laboratory



For science teacher demonstrations in different locations, any vantage point. Moves quickly. Equipped with gas, electric and water services, support rods and pegboard display panel. Roomy storage area. In attractive colors, large Formica top. Write for full details.



EACH \$29500

Cenco, the leading manufacturer of instruments for laboratories

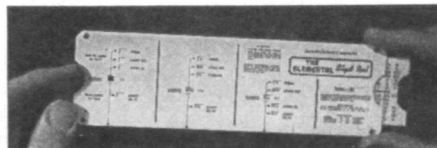
CENTRAL SCIENTIFIC CO.

1718-V Irving Park Road • Chicago 13, Illinois
Branches and Warehouses—Mountainside, N. J.
Boston • Birmingham • Santa Clara • Los Angeles • Tulsa
Houston • Toronto • Montreal • Vancouver • Ottawa

MAKE MONEY WRITING .. short paragraphs!

You don't have to be a trained author to make money writing. Hundreds now making money every day on short paragraphs. I tell you what to write, where and how to sell; and supply big list of editors who buy from beginners. Lots of small checks in a hurry bring cash that adds up quickly. No tedious study. Write to sell, right away. Send for free facts. **BENSON BARRETT**, Dept. 163-A 7464 N. Clark St., Chicago 26, Ill.

800 ELEMENT FACTS AT YOUR FINGERTIPS



The Elemental Sloyd-Rul tells you, at a glance, symbol, weight, density, number, valences, color, melting and boiling point in °C for the 98 elements. An ideal educational aid for science, physics and chemistry students. \$1 postpaid. Student rate: 12 or more, 75¢ ea. Money-back guarantee. The Sloyd-Rul Co., Canaan, N.Y.

ELECTROSTATIC GENERATORS

(Van de Graaff Type)



500,000 VOLTS. This model available in kit form is over 3 feet tall and has a 15" diameter spherical charge collector. Kit includes 15" hemispheres, plastic tube, pulleys, bearings, belt, frame, and assembly directions. \$25.80 f.o.b. Buffalo, N. Y.

200,000 VOLTS. This model (shown at left) is 17" high and has a 6 1/2" diameter spheroidal charge collector. Operates on 110 volt AC. Fully assembled, postpaid \$29.50. Kit form \$19.50. Write for free specification sheets.

MORRIS AND LEE, 439 Elm St., Buffalo 3, N. Y.

AMAZING ELECTRONICS DISCOVERY!

Portable, Transistorized Tape Recorder Costs LESS Than Down Payment on Many Standard Recorders!



Here's the new, low-priced, battery-operated tape recorder you've been waiting for! Powered by ordinary flashlight batteries and transistors—a finely engineered instrument—not a toy! It is multi-staged utilizing transistors for superb tone clarity. Truly portable—weighs less than 2 lbs.

CAN SAVE YOU MANY TIMES ITS COST THE VERY FIRST TIME YOU USE IT!

You'll find a thousand and one uses for this amazing tape recorder. Use it as a dictating machine—to cut your office and home work in half. Use it to record sales meetings, interviews, group discussions, on the spot reactions wherever you go! Use it for wonderful new fun with your children and family—to store up memories that will never grow dim! It makes the perfect gift to give or get!

\$37⁵⁰ Complete with Microphone-Listening Device, Private Listener, Sample Reel of Tape, Deluxe Fitted Attache Type, Simulated Leather Carrying Case, Set of Batteries
FREE! Extra 225 ft. Reel of Recording Tape!

LET SOME OF AMERICA'S OUTSTANDING PRESTIGE MAGAZINES TELL YOU WHAT THEY THINK ABOUT IT!

American Legion—"While miniature tape recorders have been available for years, their price has kept them out of the mass market. Most of them sell for close to \$300, but now a machine is being sold for one-tenth of that!"

Scholastic Teacher—"Recording is quite audible and easily understandable. Fine for small student group, interviewing community leaders."

Mademoiselle—"Very happy to report that anyone can afford it—and anyone can operate it!"

V.F.W. Magazine—"Imagine a precision-made, battery-operated tape recorder that weighs only two pounds, yet sells for this amazing low price."

Cosmopolitan—"The Last Word!... Capture baby's first words or a memorable family occasion. Dictate letters, reports, speeches. You can even re-record phono discs and radio and TV shows!"

Popular Mechanics—"Provides low cost, variable speed recording and playback."

Send Check or Money Order.
If COD—send \$3.00 deposit.

FILNOR PRODUCTS INC., Dept. M-57—101 W. 31st., New York 1, N. Y.