keywords = Ultrasonic Industry Association sonic cavitat bubble shock wave clean immersi vapor degreas weld join bond sew seal solder insert stak drill grind machin cut extru form spin sonochemi react accelerat pollut abat toxi waste treat beneficiat remediat particl dispers disrupt homogeniz emulsif dissol degas foam defoam sparg phaco phaeco lithotript liposuc prophyla history

S. Berliner, III's Ultrasonics Page

Consultant in Ultrasonic Processing
Technical and Historical Writer, Oral Historian
Popularizer of Science and Technology
Rail, Auto, Air, Ordnance, and Model Enthusiast
Light-weight Linguist, Lay Minister, and Putative Philosopher
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S. Berliner, III
Consulting in Ultrasonic Processing

SONOCHEMISTRY * REACTION ACCELERATION * DISRUPTION HOMOGENIZATION * EMULSIFICATION * POLLUTION ABATEMENT DISSOLUTION * DEGASSING * FINE PARTICLE DISPERSION BENEFICIATION OF ORES AND MINERALS CLEANING OF SURFACES AND POROUS MATERIALS

INDEX

You might wish to go to this COURTESY HOMEPAGE:

ULTRASONIC INDUSTRY ASSOCIATION

CALL FOR CONTRIBUTIONS: I am contracted with Marcel Dekker to write a book on « High-Intensity Ultrasonic Technology and Applications », in their Mechanical Engineering series, with the assistance of Dr. Daniel R. Raichel, P.E., Professor of Mechanical Engineering and Director of the Acoustics Research Center at The Cooper Union. This will focus on the application of power (high intensity) ultrasonics, the use of ultrasonic energy to change materials. Contributions are welcome (see below).

ULTRASONICS

I shall define « ULTRASONICS » as the application of sound at extremely high intensity and high frequency (normally above human hearing, 20kHz - 20,000 cycles per second - and above) to change materials.
Such change can clean, homogenize, and accelerate both physical and chemical reactions, among many other things. In fact, using the keywords, here are just some of the many operations that are commonly performed (or faciitated) using ultrasonics:

PARTIAL LIST OF APPLICATIONS OF ULTRASONIC ENERGY

BONDING OPERATIONS:
Welding - Joining - Sewing - Sealing - Insertion - Staking - Soldering
MACHINING OPERATIONS:
Drilling - Grinding - Cutting
FORMING, FORGING, and CASTING OPERATIONS:
Extruding - Spinning - Static and Continuous Casting
CHEMICAL and PHYSICAL OPERATIONS:
Sonochemistry - Reacting (physical and chemical) - Accelerating Reactions - Pollution Abatement - Toxic Waste Treatment - Beneficiation of Ores - Remediation - Particle Handling [dispersion, agglomeration, suspension, column packing, sinters, fine ceramics, electronic insulators (resistors, capacitors), 20% volume reduction] - Disruption - Homogenization - Emulsification - Dissolution - Degassing
CLEANING OPERATIONS:
Surface Cleaning, Preparation, and Treatment - Enhancement of Surfactancy and Detergency - Vapor Degreasing -
Turbidity Measurement
MEDICAL/SURGICAL OPERATIONS:
Phaecoemulsification (cataract removal) - Dental Prophylaxis (scaling - tartar removal) - Lithotriptry (removal of liver or gall stones) - Liposuction - Debridement of Wounds - Surgery - Cautery
MEDICAL/THERAPEUTIC OPERATIONS:
« Diathermy » (deep heating) - Inhalation Therapy - Skin Cancer Treatment
AEROSOL OPERATIONS:
Humidification (lace, flour, Legionella) - Spray Drying - Evaporative Cooling - Carburetion and Combustors
MISCELLANEOUS OPERATIONS:
Levitation, Foaming (sparging) and Defoaming - Destructive and Constructive Testing (erosion, cleaning, accelerated corrosion and reaction) - Forensics and Archaeology [potsherds, bone cleaning, selective erosion (serial number restoration)]

PROCESSING

For a complete novice to technology, go first to A POPULARIZED GUIDE TO ULTRASONIC PROCESSING (A Non-Technical Explanation of a Complicated Letterhead) and then to A POPULARIZED GUIDE TO ULTRASONIC CAVITATION (A Non-Technical Explanation of « Cold Boiling »).

Those with a smattering of technical knowledge can go to CONDENSED GUIDE TO ULTRASONIC PROCESSING (A Layperson's Explanation of a Complex Letterhead).

CLEANING

MUCH MORE TO FOLLOW

ULTRASONIC PROCESSING

AL-1C CONDENSED GUIDE TO ULTRASONIC PROCESSING 4-97
(A Layperson's Explanation of a Complex Letterhead)

Ultrasonic processing applies intense, high-frequency sound to liquids, producing intimate mixing and powerful chemical and physical reactions. The process (« cavitation ») is, in effect, « cold boiling » and results from the creation and collapse of countless microbubbles in the liquid, producing shock waves. The technique is used to accelerate reactions, treat wastes, ores, and minerals, disperse fine particles and suspend slurries, disrupt biological cells and tissues, homogenize and emulsify, and clean surfaces and porous materials. This work entails « blasting » liquids, usually water, with powerful sound energy, unlike sonar, imaging, measuring, or non-destructive testing, in which the subject is not altered by the sound energy. Most such work is done at very high frequencies, far above human hearing. Processing, on the other hand, works at frequencies just above human hearing, 20 to 40kHz (20,000 to 40,000 cycles per second). In ultrasonic processing, sound is used to change materials. Some of the more significant applications:

SONOCHEMISTRY - exposing of fresh material surface to enhance reactions and even to generate new species hitherto unobtainable by classic means such as heat, electricity, light, and catalysis.

REACTION ACCELERATION - cavitation accelerates both chemical and physical reactions, such as those of surfactancy and detergency, which is why it is a preferred cleaning technique, as noted below.

BENEFICIATION OF ORES AND MINERALS - improving flotation and extraction of ores and minerals such as coal.

FINE PARTICLE DISPERSION - dispersing iron oxide for coating data processing media; enhancing analysis of particle size distribution and characterization; improving fine ceramic slurries used as insulation for electronic capacitors and to make luxury table china; making more wear-resistant sintered carbide tools; fluidization.

DISRUPTION - breaking open biological tissues and cells to extract enzymes and DNA, prepare vaccines, study intercellular components.

HOMOGENIZATION - making more uniform mixtures of liquids or liquid suspensions for CPI, biotechnology, processing of paper pulp.

EMULSIFICATION - processing foods, pharmaceuticals, and cosmetics (oil and water DO mix!); incorporating water into more efficient, cool-burning, yet stable, motor fuels; creating non-flammable jet fuels.

POLLUTION ABATEMENT - recovering oil from soils, decomposing PCBs, degrading toxic wastes, reacting pollutants.

DISSOLUTION - dissolving solids in solvents; speeding quality control of pharmaceuticals, flavors and fragrances, sheet and pelletized plastic materials.

DEGASSING - removing gases from solutions without heat or vacuum; quality control (TOD) of wines, spirits, and carbonated beverages.

CLEANING OF SURFACES AND POROUS MATERIALS - stripping away oxides and other films, emulsifying oil coatings, suspending particulates, enhancing detergency, and degreasing without hydrocarbon solvents.

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For more information, please contact S. Berliner, III.

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ULTRASONIC PROCESSING

AL-1P A POPULARIZED GUIDE TO ULTRASONIC PROCESSING 7-97 (A Non-Technical Explanation of a Complicated Letterhead)

« Ultrasonic Processing » means « blasting » liquids, usually water, with very intense sound at high frequency, producing very good mixing and powerful chemical and physical reactions. The process, called « cavitation », is sort of « cold boiling » and results from the creation and collapse of zillions of microscopic bubbles in the liquid, producing shock waves, very much like those produced by a supersonic jet plane (such as the Concorde). This makes reactions work faster, treats wastes, mixes fine particles, disrupts cells and tissue, homogenizes and emulsifies, and cleans things.

Ultrasonic processing is unlike underwater sonar, fetal imaging, thickness or level measuring, or non-destructive testing, in which the subject is not altered by the sound energy. Most such work is done at very high frequencies, far above human hearing. Processing, on the other hand, works at frequencies just above human hearing, 20 to 40kHz (20,000 to 40,000 cycles per second). Just for example, ordinary alternating (A.C.) house current pulses 60 times a second in the U.S. or 50 times a second in Europe and Japan. In ultrasonic processing, sound actually changes materials.

Some of the more significant applications:

SONOCHEMISTRY - cleaning the surface of a material to get stronger reactions with other chemicals touching that surface and even generating new kinds of chemicals which couldn’t previously be made by heating, electricity, light, and chemical reaction.

REACTION ACCELERATION - cavitation makes both chemical and physical reactions, such as the cleaning power of soaps or detergents, occur faster.

BENEFICIATION OF ORES AND MINERALS - improving the removal of ores and minerals such as coal from the rock in which they are found.

FINE PARTICLE DISPERSION - evenly separating (dispersing) tiny bits of iron oxide (rust) used to coat computer and audio/video tapes and disks; giving better analysis of fine particles floating in liquids; improving the fine ceramic particles used to make insulation for electronic capacitors and to make luxury table china; making more wear-resistant sintered carbide tools; and making better fluidized beds (quicksands).

DISRUPTION - breaking open biological tissues and cells to get out enzymes and DNA for study, to prepare vaccines, and to study the materials inside cells.

HOMOGENIZATION - mixing liquids or fine particles suspended in liquids for chmeical processing, biotechnology, and processing of paper pulp, like mixing milk and cream.

EMULSIFICATION - processing foods, pharmaceuticals, and cosmetics (oil and water DO mix!); adding water to motor fuels to make them burn more efficiently and coolly.

POLLUTION ABATEMENT - getting spilled oil from the soil, decomposing dangerous chemicals, degrading toxic waste, getting rid of pollutants.

DISSOLUTION - dissolving solids in solvents; improving quality control of pharma-ceuticals, flavors and fragrances, plastics.

DEGASSING - removing air and other gases from solutions without heat or vacuum; quality control of wines, spirits, and carbonated beverages (soda).

CLEANING OF SURFACES AND POROUS MATERIALS - removing rust, tarnish, oil, grease, and other contaminants, without solvents, and making soaps and detergents work better.

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ULTRASONIC CAVITATION

AL-1V A POPULARIZED GUIDE TO ULTRASONIC CAVITATION 4-97
(A Non-Technical Explanation of « Cold Boiling »)

« Ultrasonic Processing » means « blasting » liquids, usually water, with very intense sound at high frequency, producing very good mixing and powerful chemical and physical reactions. The process, called « cavitation », is sort of « cold boiling » and results from the creation and collapse of zillions of microscopic bubbles in the liquid.
« Cavitation » or « cold boiling » is easy to understand if you think about what the words « solid », « liquid », and « gas » mean.

A solid is something hard that you can see and touch and hold; its molecules can not move in relation to each other; they are « stuck together ».

A liquid is something you can see and touch, but it runs through your fingers if you try to hold it without a cup or a bowl; its molecules are free to move around each other but they can't move apart. That means that they are « slippery »; they can flow.

A gas is something you can touch, like the wind moving across your hand when you stick it out the window of a moving car, but you can't usually see it and you can't hold it at all without a closed can or bottle; its molecules are free to move around and together or apart from each other. They can expand or contract without limit.

The definition in physics of a solid is something whose molecules are rigidly bound together in time and space, a liquid is something whose molecules are free to move around each other at a fixed distance, and a gas is something whose molecules are free to move around each other and to move closer together or further apart.

You know you can bend a solid, like bending a branch or matchstick or toothpick. If you bend it too far, it snaps. If you bend a paper clip back and forth enough times, you can break it, too; you « fatique » the metal or wear out the bond that holds the molecules together. What you are doing in each case is called « exceeding the elastic limit »; you are bending it further than it can bend without breaking. With a hammer, you can break a brick or a small stone. With a big enough hammer or a wrecking ball, you can smash rock or boulders or concrete.

Well, you can break liquids, too! You do it every time you break glass! Glass isn't really a true solid; it is actually a very, VERY, VERY thick liquid, sort of like a super thick syrup or molasses. If you look carefully at ancient window glass, you can see that it has drooped; it has a bulge toward the bottom of the pane. That's because it is flowing downhill; gravity is pulling it down even though it's held in the window frame. « Silly Putty » is exactly the same thing, only not quite as thick; you can see it flow if you wait long enough. But hit it or snap it and it breaks.

Just as you broke the paper clip by bending it back and forth slowly, you can break water (or most other liquids) by jiggling it back and forth, only you have to do it very quickly. By sticking a vibrating object into water, if you vibrate it far enough (a tiny fraction of an inch) and fast enough (around 10,000 times a second), you can « fatigue » the water and break the bond between the water molecules. But what does that mean? What was the definition of a gas? Something whose molecules could move apart. So, if you move water molecules apart, you have a gas, and the gas of water is steam. A steam bubble is normally created by heating above the boiling point (212ºF or 100ºC). But we just did it by fast jiggling, not by heating, so we « cold boiled » the water!

Next, we now have a steam bubble wandering around in a cold liquid, and that just can't be! The steam has to condense (the way steam from a kettle or hot shower frosts a glass

or mirror) and that leaves an empty space behind, a « void » or « cavity », where the steam was. The surrounding water molecules rush in to fill that cavity; when they reach the center of the cavity, they collide with each other with great force. This is called « cavitation ». That makes the molecules bounce back, creating a « shock wave » which runs outward from the collapsed bubble just like ripples in a pond when you throw in a pebble. The shock wave can wear away metal; like the edges of an outboard motor propellor. Cavitation was discovered by investigating why propellors wear out.

Where shock waves meet each other, they can cause more steam bubbles to occur and collapse, creating even more cavitation. There, now you're an expert on cavitation!

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STERILIZATION and DISINFECTION

AM-1 ULTRASONIC STERILIZATION and DISINFECTION 16 Jul 97

For over 40 years now, there has been much made of the purported ability of ultrasound, the application of high frequency sound waves, and of ultrasonics, the application of ultrasound at high intensity, to disinfect and sterilize. Sterilization is defined as absolute killing of all disease organisms, including fungus spores. Disinfection is not as rigorously defined, and does not necessarily include inactivation of spores. Much as it pains the author to admit it, ultrasound, and even ultrasonics, do NOT sterilize, by themselves, under normal use in an ultrasonic cleaning tank such as those used by dentists in their offices. No reputable manufacturer has ever claimed any such property.

Ultrasonic equipment exists that can and routinely does disrupt all bacteria, virii, and fungus under controlled laboratory conditions, but it is a totally different type of device than an ultrasonic cleaner. Such equipment, termed high intensity probes or disruptors, under such tradenames as SONICATOR, SONIFIER, or VIBRA-CELL, focuses sound on a very small area to disrupt organisms. Such devices produce energy densities many orders of magnitude higher than that available in even the best ultrasonic cleaning tank.

One of this country's top three manufacturers of ultrasonic disruptors is Misonix Incorporated of Farmingdale (formerly Heat Systems-Ultrasonics, Inc., 1938 New highway, Farmingdale, New York 11735, tel. 516-694-9555, FAX 516-694-9412). The founder of the firm, Howard Alliger, developed the concept of ultrasonic disruption of cells and tissues, used originally primarily to release cell contents such as DNA and enzymes. Misonix's SONICATOR Ultrasonic Liquid Processor is one of the most widely used in the field.

Another Long Island firm is among a different top three firms making ultrasonic equipment, in this case Sonicor Instruments, Inc. (100 Wartburg Avenue, Copiague, New York 11726, tel. 516-842-3344, FAX 516-842-3389). Sonicor is a major manufacturer of ultrasonic cleaning tanks and accessories, both for commercial and industrial use.

A liquid product which, when used in conjunction with an ultrasonic cleaner, or even without, could sterilize instruments was developed here on Long Island by Mr. Alliger, then President of Heat Systems. In various formulations, the liquid is rated by the EPA as both a disinfectant and sterilant. For current developments, contact Mr. Alliger at Arco Research Inc., SUNY-Farmingdale, Conklin Hall, Farmingdale, New York 11735 (tel. 516-777-1420, FAX 516-777-1422).

In addition to direct disinfection and sterilization, several surprisingly successful experiments about a decade ago led to the development of a number of highly-proprietary processes in which ozone and other purificants have been introduced into chemical and wastewater flows in the presence of a cavitational field. The net result has been to greatly improve the efficiency of the chemical action and to provide purified, and even potable, water at economical costs. The author has two patents (5,032,027 dated 16 July 1991 for an Ultrasonic Fluid Processing Method and 5,026,167 dated 25 Jun 1991 for an Ultrasonic Fluid Processing System, assigned to Heat Systems/Misonix) to this end.

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Call for Contributions

For the forthcoming contracted book, « High-Intensity Ultrasonic Technology and Applications », on the application of power (high intensity) ultrasonics, the use of ultrasonic energy to change materials, I solicit input in the following forms:

1. Corporate/Organizational/Personal History.
2. Significant Technical Breakthroughs.
3. Thumbnail Biographies of Leading Innovators.
4. Photographs of Major Representative Equipment, especially of New and Unique Items.
5. Diagrams of Major Applications and Processes.

and, of course,

6. Permission to edit and reproduce the above for publication (with the style in which appropriate credit is to be given).
7. Reprints of any articles published about equipment and applications.
8. Copies of any Patents which you feel cover(ed) outstanding innovations in equipment and/or processes.

These are the gut items that will highlight, flesh out, and humanize the otherwise dry facts of ultrasonic cleaning, welding, bonding, joining, cutting, drilling, and the myriad other applications.

This will be a practical text, not so much « how-to » as « what has been done, is being done, and can be done ». I will need illustrations of standard bonding and cleaning processes and special features. If you wish those you use in your literature to be

included in the book, with appropriate credit to you or your firm (as appropriate), of course, please forward copies.

Any illustrative material (photographs and diagrams) should be in camera-ready form. Xerographic copies are not suitable. Photographs should be glossy 4 »x5 » or 8 »x10 ».

Naturally, no guarantee can be given that any material submitted will be included but I want to give a balanced picture of the industry. I ask that you be selective; please don't just « dump » catalogs on me.

Please note that a far-more detailed explanation of ultrasonic processing, as well as other technical literature, is available at no charge to consultation clients.

Updated: 25 Sep 97, 06:35 EDST

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