Updated: 29 Jan 2004, 21:50 ET
[Ref: This is us-clean.html (URL http://home.att.net/~Berliner-Ultrasonics/us-clean.html)]

S. Berliner, III's

Ultrasonic Cleaning Page

Consultant in Ultrasonic Processing
"changing materials with high-intensity sound"

Technical and Historical Writer, Oral Historian
Popularizer of Science and Technology

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

[See "Keywords (Applications) Index" on Page 3.]

Specializing in brainstorming and devil's disciplery for new products and reverse engineering and product improvement for existing products.

{"Imagineering"}

[consultation is on a fee basis]

MEMBER
Board of Directors

[New 2000 Logo -
all rights reserved to UIA.]

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PLEASE NOTE: If some of the internal links on this page refuse to work, please click on Back and scroll down.

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TUBULAR HORNS (Radial Radiators).

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What's New?

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APPLICATION PAPER AP-3 - SPECIAL INSTRUCTIONS FOR CLEANING JEWELRY, CLOISONNÉ, ETC., IN HOME AND HOBBY USE.

On the ULTRASONICS GLOSSARY page:

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ULTRASONICS BIBLIOGRAPHY

Ultrasonic Bibliography Page 1 - Reference Books on Acoustics, Vibration, and Sound.
Ultrasonic Bibliography Page 2 - Sonochemistry.
Ultrasonic Bibliography Page 3 - Selected Articles.

You are invited to visit the ULTRASONIC INDUSTRY ASSOCIATION home page.

CALL FOR CONTRIBUTIONS: I am working on a book for Marcel Dekker on "***High-Intensity Ultrasonic Technology and Applications***" (in their "*Mechanical Engineering Series*", edited by Profs. Lynn L. Faulkner and S. Bradford Menkes). This book will focus on the practical application of power (high-intensity) ultrasonics, the use of ultrasonic energy to change materials. **Contributions** are welcome.

ULTRASONIC CLEANING

{this is a work in process}

I shall define "***ULTRASONIC CLEANING***" 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 surfaces**, i.e.: to clean them.

The term "***MEGASONICS***" is now being used to describe frequencies of **1,000,000Hz** (1,000kHz) and above.

Such cleaning is accomplished by accelerating both physical and chemical reactions at the surface.

CLEANING OPERATIONS include:

Surface Cleaning, Preparation, and Treatment - Enhancement of Surfactancy and Detergency - Vapor Degreasing - Turbidity Measurement, etc.

ULTRASONIC CLEANING

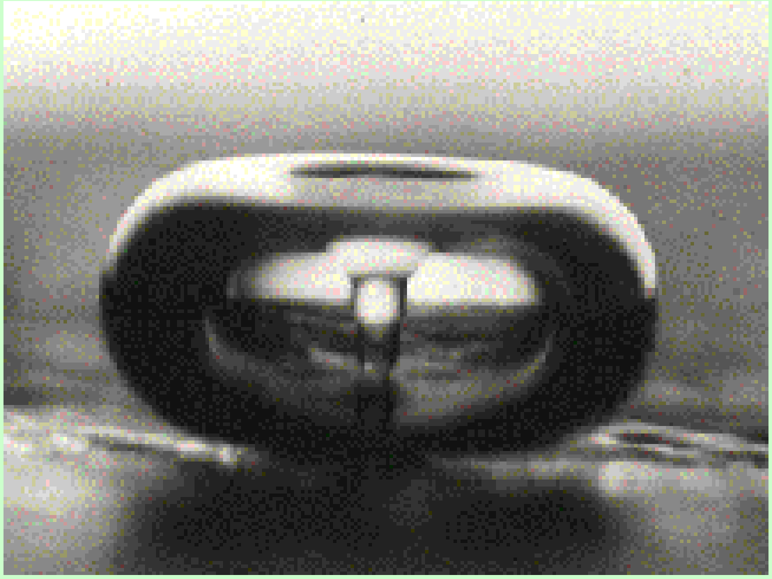
Ultrasonic cleaning involves changing the surface of materials by the application of ultrasonics, thereby removing contaminants; it is primarily the removal of contaminant from surfaces of materials through the action of ultrasonically-induced cavitation. Refer to the main ULTRASONICS page, et seq., and the GLOSSARY for more-rigorous descriptions of ultrasonics and cavitation.

The action may occur in plain water but is often enhanced by the addition of surfactants and even detergents. Cavitation can also be induced in solvents, such as hydrocarbons and chlorofluorocarbons (CFCs), but these also have drawbacks of environmental and flammability hazards.

Any bath that is in some way activated by ultrasonics to produce cavitation is thus by definition an **ultrasonic cleaner**. There is a semantic problem, however, in that the term "**cleaner**" has two meanings in industry; one, the less technical usage, is a **chemical compound** used in cleaning, whereas the other, more technical, usage is the **bath** or **tank** in which ultrasonic cleaning takes place For the purposes of this text, we shall use the latter; an **ultrasonic cleaner** shall mean an ultrasonically-activated container or tank (the other usage shall be referred to as a cleaning agent or compound).

Cavitation is the sequential formation and collapse of vapor bubbles and voids in a liquid subjected to acoustic energy at high frequency and intensity. This action is analgous to thermal boiling but without the associated rise in temperature of the mass of liquid, although localized temperatures on the molecular level can be extremely high. The volume within a bath in which active cavitation is generated by a radiating surface is called the cavitation field. Multiple transducers mounted to a radiating surface can generate multiple cavitation fields and the interaction and interference of these fields is a major design problem.

A typical cavitation bubble with the liquid jet, a jet of liquid moving at extreme velocity, resulting from the assymetrical implosion of the bubble in close proximity to the surface to be cleaned, is clearly shown in this dramatic high-speed motion micrograph:



[image from University of Washington, Applied Physics Laboratory (Lawrence Crum, Ph.D.)
- bubble diameter approximately 1mm]

Cavitation initiates most readily at, and proceeds radially outward from, discontinuities (voids, contaminant particles, and such) in the liquid, where bonds between adjacent particles are weakest. Theoretically, a completely pure liquid (an unlikely happenstance) would be virtually inmpossible to cavitate. However, somewhat conversely, once cavitation initiates, any gas bubbles in the bath absorb energy to no avail and must be removed before effective cleaning can proceed; this is normally done by running the tank (**degassing** it) for a few minutes until free bubbling (see Cavitation) ceases. Probe sonication is at so much higher an energy intensity that this procedure is not normally necessary in that procedure.

Further, a minute amount of surfactant must be present in most cases to assist in wetting the surfaces; unwetted surfaces will **NOT** be acted upon. Ordinary soaps and detergents are the normal source of surfactancy. As a rule of thumb (this is a very bad pun, as you will see), add only enough surfactant such that the liquid only just begins to feel slippery between the thumb and forefinger. Adding too much surfactant (soap, detergent) will be deleterious to good cleaning.

In addition, any surface with a concavity which could trap air or other gases and prevent full wetting of the surface will prevent activity on the that surface. Not only must the surface be wetted, it must be wholly submerged in the liquid, not merely wet. To effect such, the object to be cleaned must be rotated, completely under the surface, if necessary, to discharge any pockets of air or gas such that the gas rises out of the bath.

**It is imperative in critical cleaning processes
to assure that there are NO pocketed gases
on the surfaces (internal or external) of the item**.

"**Blanketing**" is a limiting phenomenon in the cavitation field in which the density of the bubble cloud is so great that no further cavitation can take place when additional energy is introduced (analgous to the phenomenon at the temperature of thermal boiling, above which no further change of state occurs ("blanketing" is a term coined by Berliner). The "blanketing threshold" is that intensity of cavitation at which the blanketing phenomenon occurs; for practical purposes, the blanketing threshold may be considered a relative term based on the efficiency of conversion from increased radiated energy to increased cavitation ("blanketing threshold" is also a term coined by Berliner).

The bubble cloud, a cloud of cavitation bubbles which hovers in front of an activated radiating surface, is strongest when the bath has deen degassed first; this entails running a tank for a few minutes until dissolved and suspended air and other gases are driven out by cavitation. Not doing so allows energy to be dissipated in the degassing phenomenon and not to be available for the cleaning process.

Radiation of energy into the bath is done through a diaphragm; this is usually the bottom of the tank, but may also be the side or end wall of the tank or the front surface of an immersible transducer or other radiating acoustic device that transmits ultrasonic energy from the stack or transducer into the liquid (analagous to the diaphragm in an early telephone), in effect thus forming the radiating surface (use of term "diaphragm" in this fashion coined by Berliner).

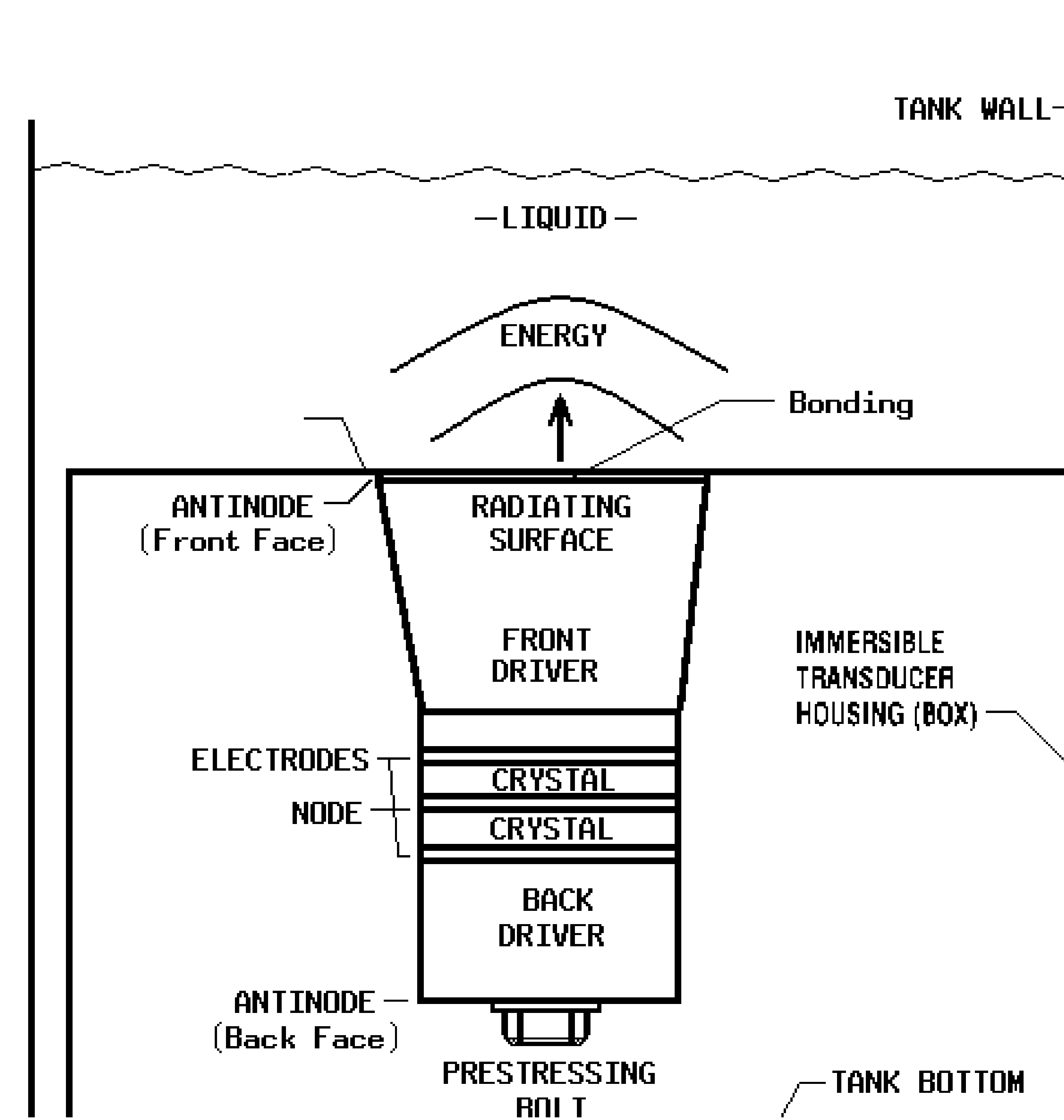
A tank is considered **active** if it is fitted with transducers and can be activated to produce cavitation; it is considered a **still** tank (terms coined by Berliner) if it has not (yet) been activated to produce cavitation or has not been fitted with ultrasonic transducers. A still tank can be activated by insertion of an immersible transducer into the bath.

ACTIVE TANKS

The more common method of inducing cavitation in a cleaning tank is to fasten transducers to the outer surface of the bottom or sides (or both) of a tank and thus to energize the inner surfaces of that tank, thereby transmitting ultrasonic vibration into a liquid bath contained in the tank. Cavitation in the tank creates shock waves and cleans surfaces of parts and assemblies by accelerating detergency of cleaning agents in the bath and by mechanically blasting contaminants off the surfaces. There are generally two styles of such tanks, small, self-contained models primarily for home and laboratory use, and larger units consisting of two (or more) modules, a tank and one or more generators, intended for industrial uses. There is a sizeable overlap in sizes and applications for the two styles. Off-the-shelf unitized models range in size and capacity from ½-pint (1 liter) measuring 5" by 5" by 3" deep (127 x 127 x 76mm) or smaller to 10 U.S. gallons (39 liters) measuring 16" by 14" by 11" deep (406 x 356 x 279mm) and larger. Stock industrial units with a tank and one or more separate generators are available in sizes and capacities from 3½-pints (13 liters) measuring 10" by 8" by 10" deep (254 x 334 x 254mm) or smaller to 46 U.S. gallons (167 liters) measuring 24" by 18" by 24" deep (610 x 457 x 610mm) and larger. Special extra-deep pipette cleaning models at 13 U.S. gallons (50 liters) measuring 12" by 10" by 25" deep (305 x 254 x 635mm) are also stocked. Larger units are generally custom built.

IMMERSIBLE TRANSDUCERS

An immersible transducer is a radiating device sealed in a housing (usually stainless steel), the forward or front surface of which is the radiating surface, and which can be submerged under the surface of a liquid bath to energize the liquid to produce cavitation. An immersible transducer placed in a still tank turns that tank into an ultrasonic cleaner. The immersible transducer is, in effect, a standard tank everted (turned inside out) with the radiating surface on the outside and the transducers on the inside, as can be seen from the diagrammatic sketch, below:



Immersible Transducer

Immersibles can have one transducer stack (radiator), or two or more stacks in a row or an array, depending on the size tank to be energized and the power to be transmitted. The sketch does NOTshow the method by which electrical energy is transmitted to the electrodes; it must go through or over the tank wall or up through the tank bottom and then through the housing (box), with all interfaces completely water/liquid tight. A common way to simplify this is to use a piece of stainless steel conduit hanging over the rim of the tank; in that way only the entry into the housing (box) need be liquid-tight. The cable can also be in a flexible conduit, usually at extra charge. REV'D (29 Jan 04)

- the following paragraphs are only "teasers"; they are here as advisory items for which more work needs to be done and illustrations need to be added.

Ultrasonic Vapor Degreasing

A **vapor degreaser** is a cleaning tank in which solvent is evaporated and cleaning and drying are done sequentially by immersing the part(s) to be cleaned in the vapors above a heated solvent tank (and perhpas in the hot solvent itself) and the withdrawing it (them) into the hot atmosphere above the vapor phase to dry. An **ultrasonic vapor degreaser** adds ultrasonics to the heated tank. Because of the stress on environmentally-safe solvents, non-CFC agents have been developed to keep this useful technique from being consigned to the scrap heap of technological history.

Printed Circuit Boards and Chips

A whole separate discipline has arisen for cleaning critical **Printed Circuit Boards** and **Chips**; techniques such as **Surface Wave Technology** are used.

High-intensity Cleaning of Porous Media

This started with Pall Corporation's **HIPS**© machine of the 1960s (the **H**yper**I**ntense **P**roximal **S**canning Ultrasonic Filter Element Cleaner, on which your author cut his cavitational teeth), which cleaned reusable fluid filter elements for aircraft and submarine and other similar critical uses by exposure to cavitation in a cleaning solvent directly under a ½" x 2½" (12.7mm x 63.5mm) horn. The cleaning solvent was pumped under pressure backward through the porous filter medium, usually sintered pleated wire mesh cylinders, to flush away contaminant and the unit provided means for performing bubble testing for maximum pore size determination and differential pressure testing for cleanliness evaluation. Since then, various other devices have been developed for like use.

High-intensity Cleaning of Surfaces for NDE

Your author developed this technique (a form of turbidity measurement), in which an active ultrasonic probe tip is held in close proximity to a flooded surface, blasting contaminant away which is then measured by a particle analyzer, for an Australian steel firm ca. 1987.

High-intensity Cleaning of Deep Holes

Misonix (formerly Heat Systems) pioneered this technique, in which very thin probes and even activated wires are run into holes to blast contaminant out and, if the probe is hollow and pressurized, flush out the detritus.

For reference, **Cup Horns** (see the processing section of the main ultrasonics page) can also be used for precision cleaning of small items.

For terminology, see the Ultrasonics Glossary page.

Generators (syn. **Power Supplies**) for ultrasonic cleaners are usually rather different than those for processing and welding, having either loose frequency control or even deliberate frequency sweeping and multiple frequencies, this to avoid localized hot spots in the bath from standing wave formation.

[The author has always suspected that certain cleaning units advertising a wide range of frequencies are simply covering up really poor frequency control! There ARE some units that truly do offer multi-frequency and sweep-frequency iperation but - - - caveat emptor!]

Magnetostrictive cleaners are used especially for very high power applications and those requiring extremes of temperature.

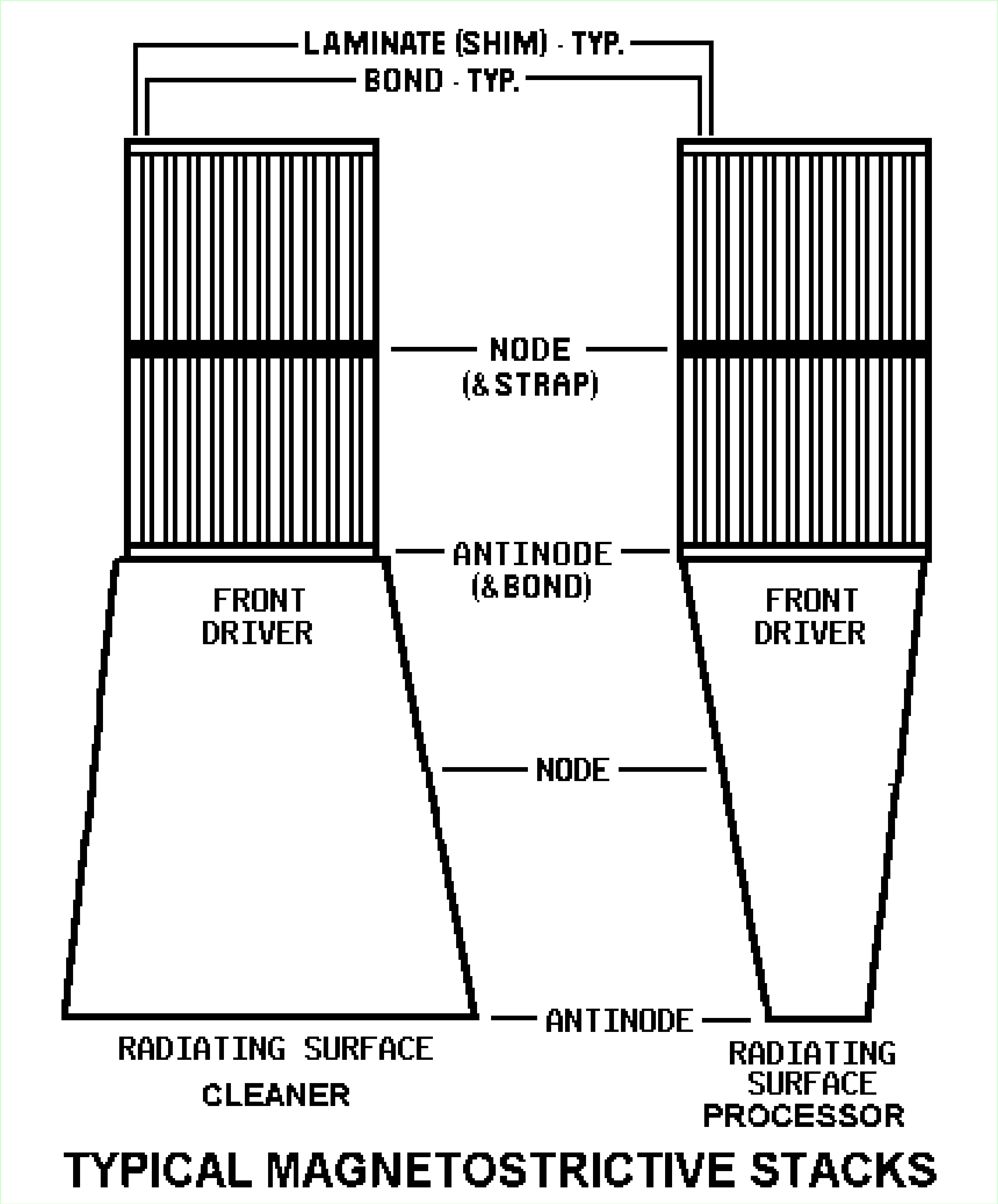
Piezoelectriccleaners are by far the most common ones in use today.

Megahertz (**MHz**) cleaners (operating at or above 1,000,000 cycles per second) have been developed, especially for microelectronics use.

> It should be noted here (as it is elsewhere on these pages) that higher frequencies yield smaller cavitation bubbles and thus give better penetration into fine holes and crevices and do less damage to components, but have less shock front energy (intensity). The trade-off is that cleaning time may have to be increased for full cleaning of items at higher frequencies.

MAGNETOSTRICTIVE TRANSDUCERS

Most cleaning and processing work currently is done with electrostrictive (crystal) transducers; however, for maximum strength, output, and temperature-resistance, **magnetostrictive** transducers are often utilized. They differ from electrostrictive transducers in that, instead of being pulsed by an alternating electrical current, they are pulsed by an alternating magnetic field. A stack of thin shim stock (usually nickel) is brazed together and surrounded by a magnetic coil; alternating the polarity of the current passed through the coil alternates the polarity of the magnetic field. Nickel (or any other magnetostrictive material) expands and contracts in altrnating magnetic fields (much as electrostrictive crystals do in an alternating electrical field). Shims are used instead of solid blocks to avoid destructive eddy currents. The stacks are usually of a high aspect ratio (long and thin) and are kept from balooning by a strap at the nodal point. In keeping with their high power ratings, magnetostrictive transducers are usually brazed together and often brazed to the tank bottom or to a block bolted to the tank. They also may require air or liquid cooling to function at high power and elevated temperature; however, there is a positive corollary. Magnetostrictive transducers, able to function at high temperatures, are ideal for use on solder pots and dip-galvanizing tanks. The magnetic coils are not shown for simplicity of description but the following illustration shows how a stack might look for cleaning and for processing devices:



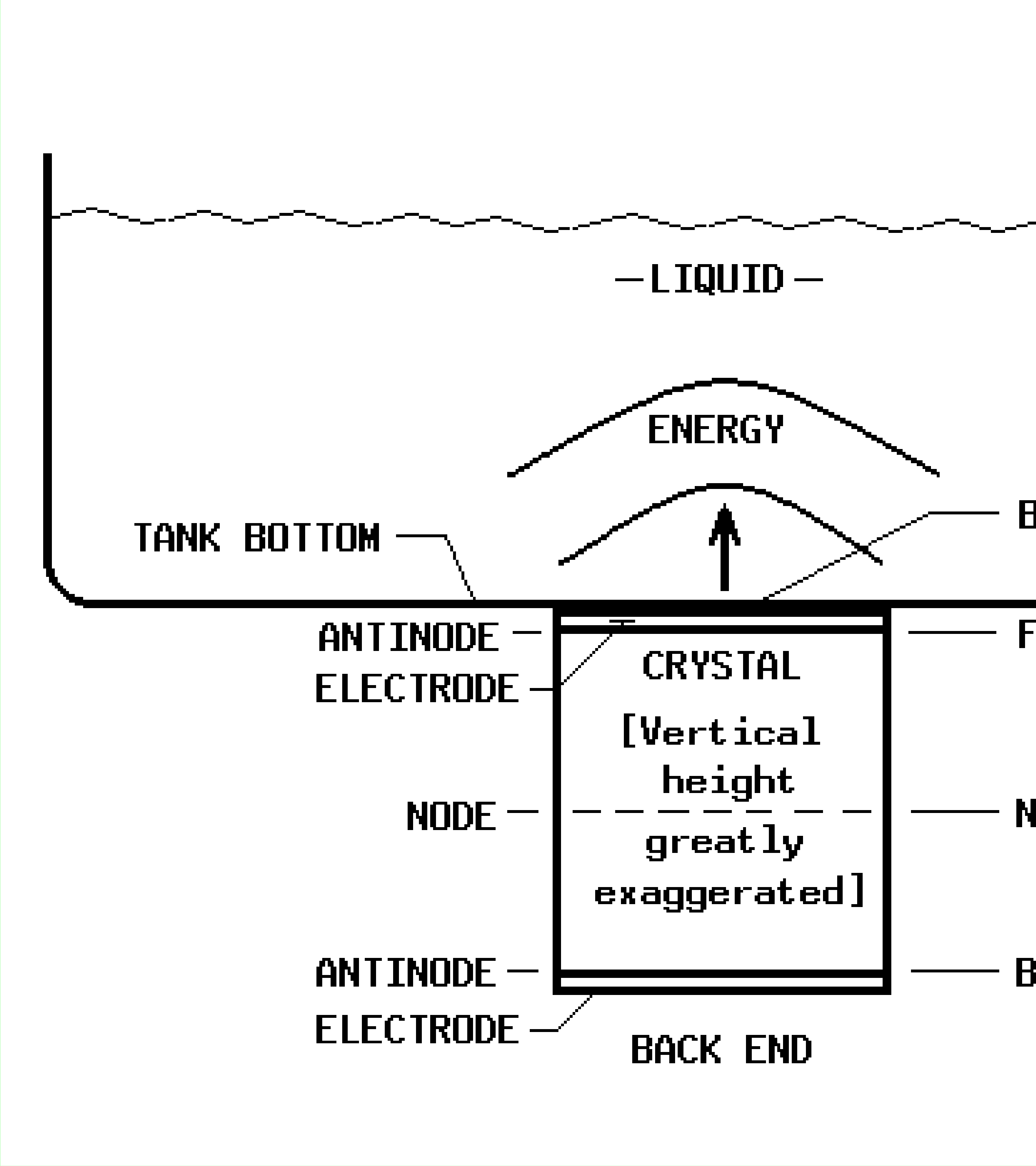
The cleaning stack is shown with a negative-gain front driver (typical or normal) while the processor stack is shown with a positive-gain (amplifying) front driver (again, typical or normal); circumstances may dictate use of simple, cylindrical drivers or even the opposite style.

You may wish to look at the website of Precision Cleaning Magazine.

WHAT'S NEW?

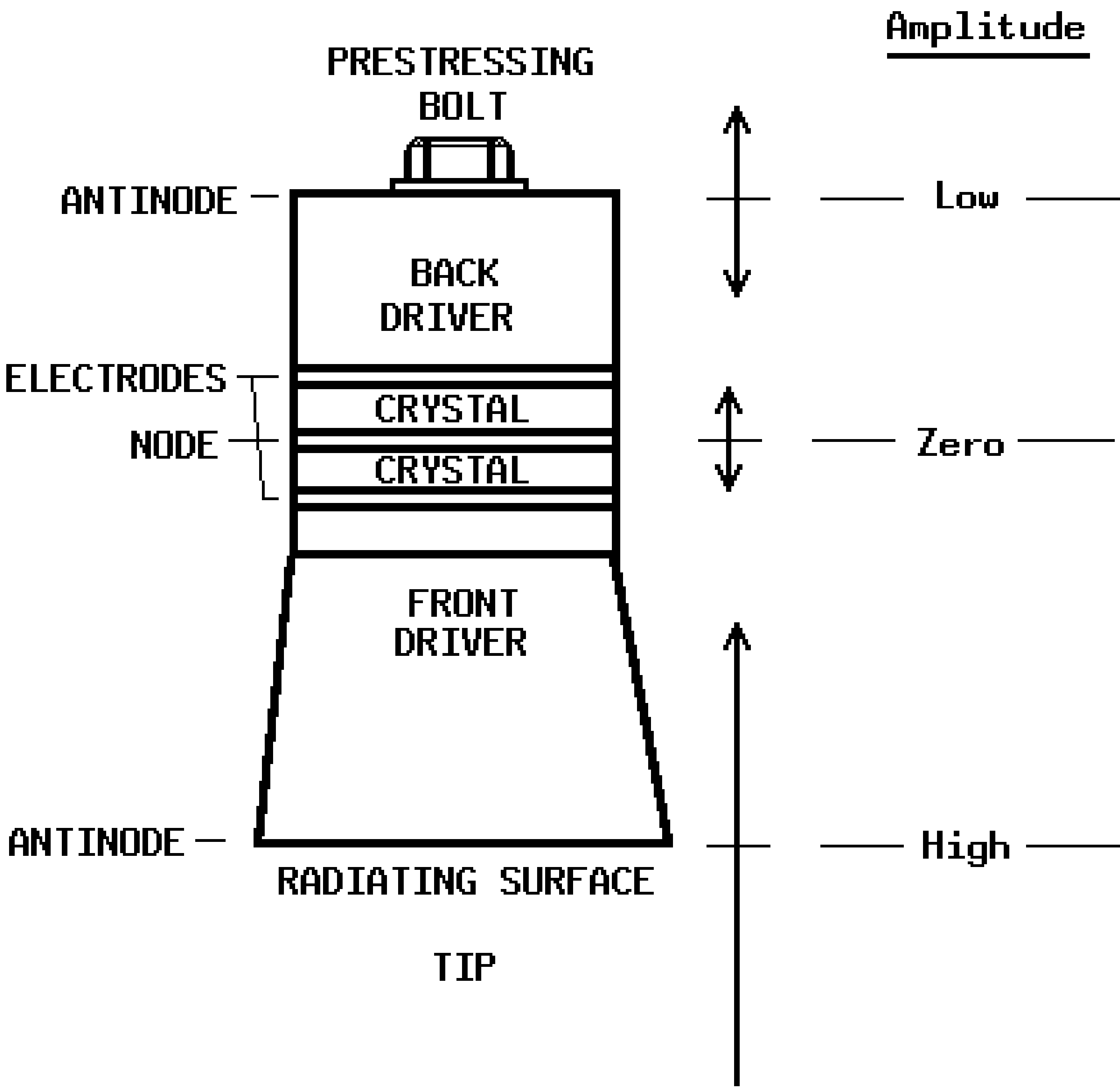
What's new is that I have put here some new illustrations for equipment that somehow never got into the preceding text.

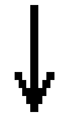
A typical low-intensity laboratory-type ultrasonic cleaning tank may have one or more transducers bonded to the bottom or side-wall of the tank to energize the wall or bottom as a diaphragm, passing vibrational energy through virtually unimpeded and cavitating the water or other liquid inside. Diagramatically, it looks like this:



Basic Ultrasonic Cleaner

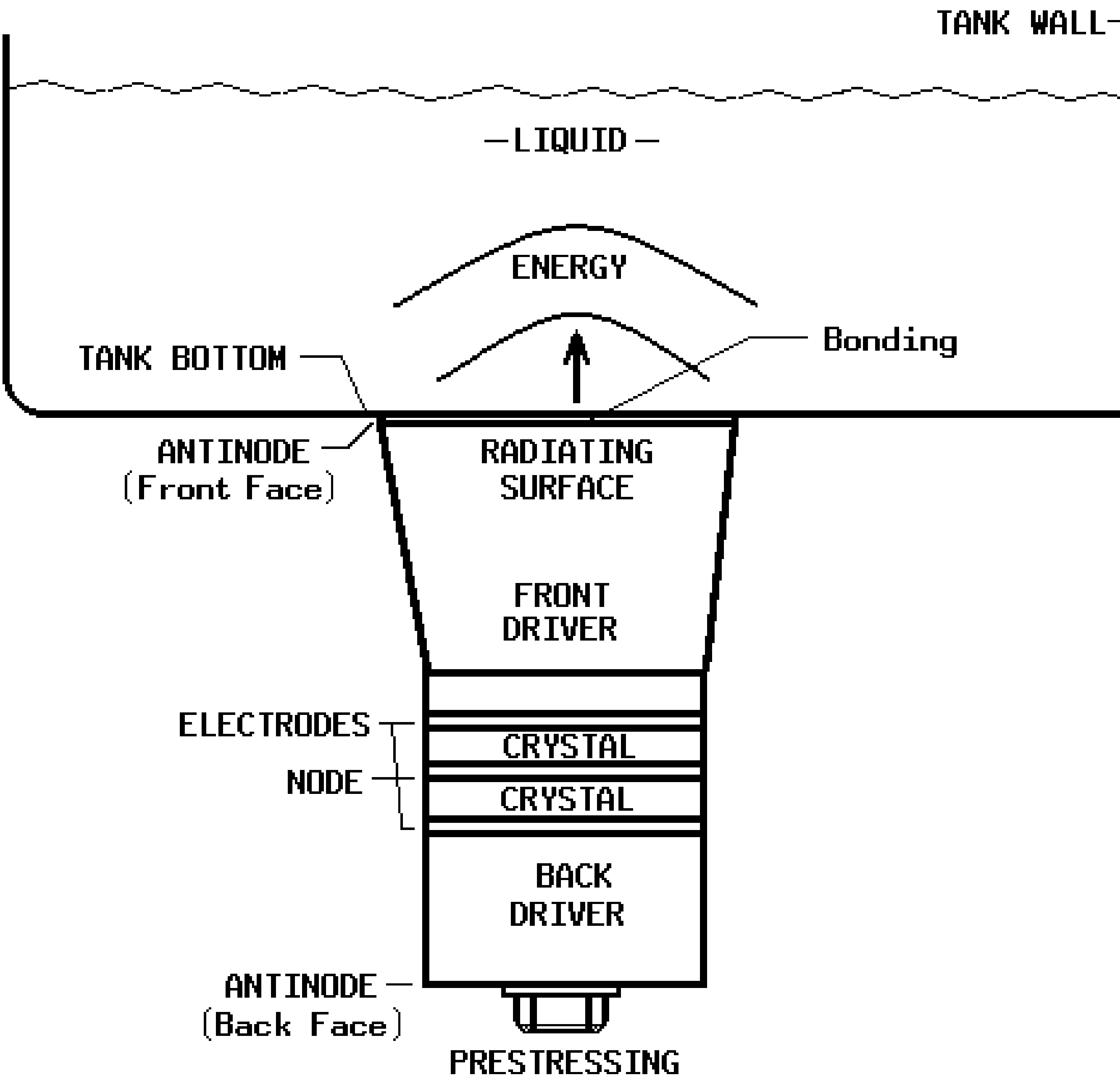
Impressing too much voltage onto a crystal bonded on in this manner can cause it to shatter. For more energy, especially in industrial usage, a **STACK** similat to that used in a high-intensity ultrasonic probe-type processor is used. You may recall that the working parts inside the CONVERTOR of a high-intensity ultrasonic probe, the **STACK**, are shown on Ultrasonics Continuation Page 3; here, for comparison, is a typical (and similar) stack used in a heavy-duty industrial cleaning tank or immersible transducer. Note how the front driver here is a negative-gain device; it' s function is to pass as much energy as possible into the wall/base of the tank at moderate amplitude (too high an amplitude and the tank will hole through from excessive cavitation and parts may be eroded):





Industrial Heavy-Duty Cleaner Stack

Now see how a cleaner stack is used with a tank:



Industrial Heavy-Duty Cleaner

These pictures will be integrated into the preceding text and more detailed explanations provided (one of these days).

Cleaning Berliner Gramophone Disk Recordings, Edison Cylinder Recordings, and the like - one should use the highest frequency commercially available (80KHz or higher, preferably much higher) and at very low energy (variable output would be desirable), to keep the cavitation implosions from eroding off the peaks of the tracks. Do NOT ask me which manufacturer makes such machines; I do not keep track *(deliberate pun)* of such.

MUCH MORE TO FOLLOW

You may wish to visit the main Ultrasonics page, et seq., as well as the Ultrasonics Glossary page {also in process}.

THUMBS UP!

THUMBS UP! - Support your local police, fire, and emergency personnel!

S. Berliner, III

To contact S. Berliner, III, please click here.

PREV.PAGE FIRST PAGE NEXT PAGE

To tour the Ultrasonics pages in sequence, the arrows take you from the main Ultrasonics Page (Ultrasonics index, Applications List, Keywords/Applications Index, and Brainstorming) to Page A ("Condensed Guide to Ultrasonic Processing" and "A Popularized Guide to Ultrasonic Processing"), Page 1 (with "A Popularized Guide to Ultrasonic Cavitation" and Tubular Horns), Page 1A ("Amplitude Measurement", Free Bubbling, Bubble Entrapment, Foaming and Aerosoling, and Extenders), Page 2 (More on Cavitation and "Ultrasonics and Fine Particles"), Page 3 ("Ultrasonic Sterilization and Disinfection","Ultrasonics, Hearing, and Health", Ultrasonics and Living Organisms, and What's New?), Glossary Page, Cleaning Page (Immersible Transducers and What's New?), Bibliography Page 1 (Reference Books on Acoustics, Vibration, and Sound), Bibliography Page 2 (Sonochemistry), and Bibliography Page 3 (Selected Articles).

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Updated: 28 Feb 2004, 11:25 ET *[Website begun 30 May 1996.]*
Update info on the top on ALL pages for your convenience.

URL http://home.att.net/~Berliner-Ultrasonics/index.html
also at http://berliner-ultrasonics.home.att.net/index.html

S. Berliner, III

Consultant in Ultrasonic Processing

"changing materials with high-intensity sound"

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DISSOLUTION * DEGASSING * FINE PARTICLE DISPERSION
BENEFICIATION OF ORES AND MINERALS
CLEANING OF SURFACES AND POROUS MATERIALS

also see Keywords (Applications) Index

consultation is on a fee basis

Technical and Historical Writer, Oral Historian
Popularizer of Science and Technology

MEMBER - Board of Directors

I've added a local search function here and on several major topic pages:

Enter Keywords:

Search

Conventions (abbreviations and such) used on this site are noted below.
NEW! (22 Jan 04)

[A new "bugaboo" has reared its ugly head - complexity of organization - see COMPLEXITY on my main index page.]

INDEX to varied professional interests classified in major areas

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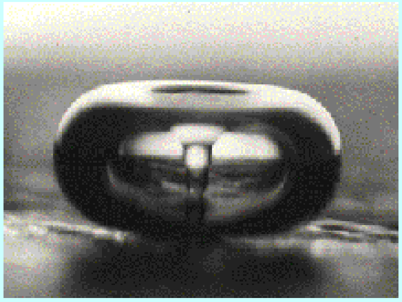
TECHNICAL and PROFESSIONAL

ULTRASONICS

ULTRASONIC PROCESSING

THE CAVITATION BUBBLE



[image from University of Washington, Applied Physics Laboratory (Lawrence Crum, Ph. D.)
- bubble diameter approximately 1mm]

Ultrasonics Index Page

[this page was added 14 Jul 2003 because the topic became so complex that the index on the main page was overloading both that page and this home page; jump there for a more detaled index.]

Main Ultrasonics Page:

Call for Contributions for Book.

For this book and other work, I am seeking information about **Narda Ultrasonics Corporation**, a firm which pioneered high-intensity application of ultrasonic energy ca. 1946-1960, and was presumably subsumed into **Narda Microwave Corporation**, which was bought out by the **Loral Corporation**, which, in turn, was acquired by **Lockheed Martin Corporation**

Ultrasonics Page 2:

More on Cavitation.

AL-2 - "ULTRASONICS AND FINE PARTICLES -
BENEFICIATION OF SLURRIES AND FINE-PARTICLE SUSPENSIONS
[CERAMICS, COAL & ORES, COATINGS, COLUMN PACKINGS,
SINTERING, SLIPS].

Ultrasonics Page 3:

AM-1 - "ULTRASONIC STERILIZATION and DISINFECTION".

UM-1 - "ULTRASONICS, HEARING, and HEALTH"

Ultrasonics and Living Organisms

What's New?

Ultrasonics Page 4:

Foaming and Aerosoling - moved 28 May 02 from Page 1A.

Ultrasonic Propulsion (Propulsive Force) - Moving Material.

Ultrasonic Fountain - Atomization, Nebulization, Humidification,
Misting, Particle Creation and Sizing.

Ultrasonics and Nuclear Fusion.

Quick Links for Ultrasonic Probe Manufacturers (moved 10 Jul 2002).

CLEANING

ULTRASONIC CLEANING {in process}.

Immersible Transducers.

What's New?

On Ultrasonics Page 4:

Foaming and Aerosoling - moved 28 May 02 from Page 1A.

Ultrasonics and Nuclear Fusion.

Ultrasonic Cleaning Continuation Page 1:

APPLICATION PAPER AP-3 - SPECIAL INSTRUCTIONS FOR CLEANING JEWELRY,
CLOISONNÉ, ETC., IN HOME AND HOBBY USE.

GLOSSARY

ULTRASONICS GLOSSARY {in process}.

ULTRASONICS BIBLIOGRAPHY

Ultrasonic Bibliography Page 1 - Reference Books on Acoustics, Vibration, and Sound.

Ultrasonic Bibliography Page 2 - Sonochemistry.

Ultrasonic Bibliography Page 3 - Selected Articles.

Major Restructuring of this Home Page - 29 Aug 99

(and restyling 20 Jul 03 courtesy of my daughter - thank you!)

All references to personal and hobby matters
have been moved to a separate index page, Home Page 2.

There is also a Semi-Alphabetical Index, et seq.
(formerly at the end of this page and now moved to a separate page
after the page list topped 100+!
(The page count is now on the Semi-Alphabetical Index Page
has topped 300, and will probably keep growing!)

In addition, a site with a private domain name now exists at:
sbiii.com
as of 12 Oct 2000; linking will maintain continuity.

To jump directly to **TECHNICAL and PROFESSIONAL** interests,
click here.

*[Please note that over the many years since this site was begun (30 May 96), I have abandoned the formal academic usage of
"the author" and "your Webmaster" in favor of the more informal first person singular "I" and "me".]*

The current Coordinated Universal (Greenwich Mean) Time (UTC),
per the U.S.Naval Observatory Master Clock, is:

(Subtract 4 for EDT, 5 for EST
Military/Euro-style 24-hour clock
00:00-12:59 = 12M-12N,
12:00-24:00 = 12N-12M)

[Note: clock runs for 30 seconds; it may skip seconds. To restart clock, click "**Reload**".]
{Your browser must be set to automatically load images or you must activate the clock image manually by right-clicking the clock image and clicking on "View image" (or equivalent).}

I try to keep these many pages up to date by adding and removing icons on a timely basis;

please bear with me if I miss a few here and there. - SB,III

[However, I shall not accept responsibility for any inconvenience due to my faulty use of such icons nor reader's misinterpretation of same.]

I should point out that I only change the date(s) on the affected page(s), not also on this home page (except when a change is made to this page).

"Incidentally"(!), I have had a major set back in that AT&T WorldNet destroyed 13 of my sites with some 2,000+ files with some 185Mb+ of data without notifying me beforehand (purportedly effective 05 Aug 2002), just after my hard drive started failing and overwrote some of my image backups, and I have to sift through my 260+ pages, finding the broken image links, then find the images (**IF** I still have them), reload them to new Websites, and then revise the links accordingly! This may just take a while and I ask your indulgence as I struggle through. I will NOT update the date or the NEW! and REV'D icons as I do this. Happily, the **Ultrasonics** pages came out relatively unscathed and are up to snuff. **IF YOU HAVE DOWNLOADED ANY OF THE MISSING IMAGES, PLEASE SEND A COPY BACK TO ME!**

NOTE! - **GREAT NEWS!** - I have successfully recovered SOME "irretrievably-lost" files from **Internet Archive!** I highly recommend this invaluable service and, further, ask that you help fund this incredible effort.

PERSONAL and HOBBY INTERESTS:

COURTESY HOME PAGES
HOBBIES and SPECIAL INTERESTS
PERSONAL
plus a Computer Page,
with credits (helpful sites), references, tips, queries, etc.

[**NOTE** - there is also a Semi-Alphabetical Index, previously at the end of this page and now on a separate page of its own.]

Please be sure to visit my REFERENCE Page - useful links (with disclaimer)

[A courtesy home page for the **Ultrasonic Industry Association** has been discontinued;
the UIA now has its own site - "http://www.ultrasonics.org" - click on the logo to go there:]

FLUID FILTRATION

OTHER TECHNICAL INTERESTS

NON-WOVEN FIBROUS MATERIALS page.

Semi-Alphabetical Index of SBIII's Site Pages

Moved to its own separate page, et seq..

CONVENTIONS (abbreviations and such) used on this site: NEW! (22 Jan 04)

Abbreviations, Contractions, etc. -
Year Format - 98, 99, 03, 04, etc. = 1998, 1999, 2003, 2004, etc.
Date Format - **22 Jan 04** = January 22, 2004.
Time Format (military time) - 12M = 00:00, 12:01AM = 00:01, 12N = 12:00, 1PM = 13:00, 12:59PM = 23:59
(page revision time stamping in 5 minute increments).

RoW = Right-of-Way (highways, railroads)
[to save space, repeated names may be initialized - LIMP = Long Island Motor Parkway].
N = North, E = East, W = West, S = South.

and so forth *[to be cont'd.]* **:-)**

@ - "VANITY" URL

As noted at the top of this page (and, similarly, on ALL my pages), my base URL is **http://home.att.net/~Berliner-Ultrasonics/**; however, to simplify listing and linking, AT&T WorldNet has come up with so-called *"Vanity URLs"* by which my pages can be accessed, which, in this particular case reads as follows:

http://berliner-ultrasonics.home.att.net

Any sub-page can be accessed by simply using that "vanity" URL followed by the normal suffix, as in the URL of this page:

http://berliner-ultrasonics.home.att.net/index.html

or **http://home.att.net/~berliner-ultrasonics/index.html**

The "vanity" URL saves a forward slash ("/") and avoids the (to some) troublesome tilde
("~" in HTML - also "%7e" in Unix Code).

LEGACY

What happens to all this when I DIE or (heaven forfend!) **lose interest?**
See LEGACY.

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This notice last updated 02 January 1999.

THUMBS UP!

THUMBS UP! - Support your local police, fire, and emergency personnel!

To contact S. Berliner, III, please click here.

[This Website was begun 30 May 1996.]

Return to Top of Page

Updated: 14 Apr 2003, 07:30 ET
[Ref: This is uson-3.html (URL http://home.att.net/~Berliner-Ultrasonics/uson-3.html)]

S. Berliner, III's

Ultrasonics
Page 3

Consultant in Ultrasonic Processing
"changing materials with high-intensity sound"

Technical and Historical Writer, Oral Historian
Popularizer of Science and Technology

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

[See "Keywords (Applications) Index" on Page 3.]

Specializing in brainstorming and devil's disciplery for new products and reverse engineering and product improvement for existing products.

{"Imagineering"}

[consultation is on a fee basis]

MEMBER
Board of Directors

[New 2000 Logo - all rights reserved to UIA.]

You may wish to visit the main page on **ultrasonics**.

NOTE: This page "evaporated" from my server (perhaps aliens abducted it?) on 13 Sep 99 and has been recreated from a back-up copy - please accept my apologies if I have inadvertently overlooked any typographical errors which might have crept in in the process of recreating the document.

INDEX

{Truncated to save space}

PLEASE NOTE: If some of the internal links on this page refuse to work,
please click on Back and scroll down.

What's New?

Continuous Flow Cells

On Ultrasonics Page 4:

Foaming and Aerosoling - moved 28 May 02 from Page 1A.

Ultrasonic Propulsion (Propulsive Force) - Moving Material.

Ultrasonic Fountains - Atomization, Nebulization, Humidification, Misting, Particle Creation and Sizing.

Ultrasonics and Nuclear Fusion.

Quick Links for Ultrasonic Probe Manufacturers (moved 10 Jul 2002).

On the Ultrasonic Cleaning page:

ULTRASONIC CLEANING {in process}.

Immersible Transducers.

What's New?

On the Ultrasonics Glossary page:

ULTRASONICS GLOSSARY {in process}.

ULTRASONICS BIBLIOGRAPHY

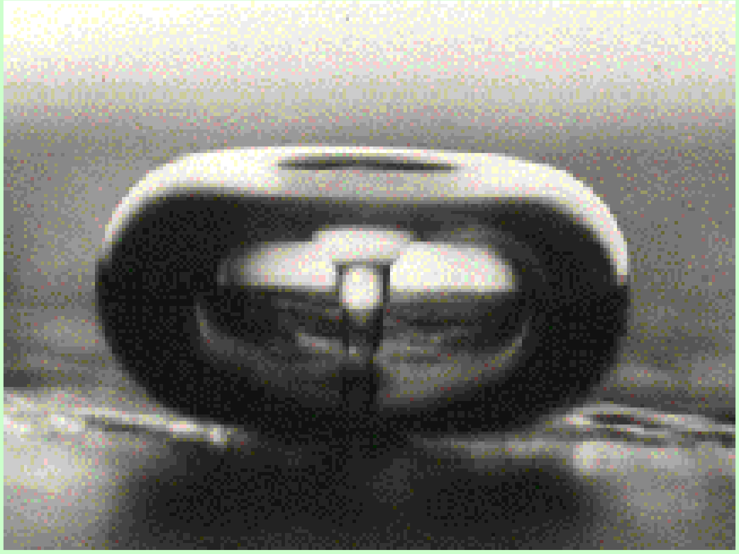
Ultrasonic Bibliography Page 1 - Reference Books on Acoustics, Vibration, and Sound.
Ultrasonic Bibliography Page 2 - Sonochemistry.
Ultrasonic Bibliography Page 3 - Selected Articles.

You are invited to visit the ULTRASONIC INDUSTRY ASSOCIATION home page.

CALL FOR CONTRIBUTIONS: I am writing a book on "***High-Intensity Ultrasonic Technology and***

Applications", on the practical application of power (high intensity) ultrasonics, the use of ultrasonic energy to change materials. **Contributions** are welcome.

THE CAVITATION BUBBLE



[image from University of Washington, Applied Physics Laboratory (Lawrence Crum, Ph.D.)
- bubble diameter approximately 1mm]

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), a major manufacturer of ultrasonic cleaning tanks and vapor degreasers.

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 Frontier Pharmaceutical Inc. (formerly Arco Research), 135 Spagnoli Road, Melville, New York 11747, (tel. 631-777-1420, FAX 631-777-1422). Mr. Alliger also founded Rx Technologies, Inc., a vaccine and diagnostic development company, also at the same address (tel. 631-777-1309, FAX 631-777-1422).

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.

 ULTRASONIC STERILIZATION and DISINFECTION - 16 Jul 97

Corporate information given above has been updated as of 28 May 1999.

Other firms producing such processing and cleaning equipment can be found through various means, especially through directory service of the Ultrasonic Industry Association.

ULTRASONICS, HEARING, and HEALTH

(preliminary)

```
UM-1              ULTRASONICS, HEARING, and HEALTH              16 Jul 99
```

[This monograph is updated from a similar one written by the author for Heat Systems (now Misonix) Inc., Farmingdale, New York, their Technical Bulletin TB-1 (Applications Note AN-10)]

Questions are sometimes raised about possible harmful effects of ultrasound generated by ultrasonic cleaning and liquid processing equipment. Available data indicates that airborne ultrasonic fields do not appear to be hazardous to humans. There are no known physiological effects from airborne ultrasound.

Ultrasonic "sickness" appears to be largely psychosomatic, engendered by apprehension or fear of the unknown. Most "awareness" of these processes is due to hearing the "high-audible" components of the noise, not ultrasound. Frequencies used range from 20kHz (20,000 cycles per second) up. The upper threshold of normal human hearing is around 18kHz. Persons able to hear 20kHz and above, including the author, report only a "sensation", rather than discomfort. It should be stressed to concerned individuals that there is no electromagnetic radiation involved, only the creation of sound waves. The acoustic energy passing through the air is at intensities far lower than those emitted by high fidelity equipment; there is no reason, for example, to fear harm to the fetus in utero.

The sound emanating from an open vessel in which an ultrasonic processing horn is being operated is radiated primarily through the air/water interface and secondarily through the walls and bottom of the vessel. Ordinary industrial ear muffs or stopples will block the greater part of this noise, which is primarily in the 5kHz to 8Khz range. Processing often takes place in a fume hood or fume enclosure which will effectively dissipate the sound energy. Special sound reduction cabinets are available to enclose the processor and vessel.

Top quality table-top ultrasonic cleaners should be listed by Underwriters Laboratories, Inc. and certified by the Canadian Standard Association. The sound emanating from ultrasonic cleaners is also primarily radiated through the air/water interface. Any minor change in temperature, depth, or surfactancy of the cleaning solution, or in the bulk of material or number of objects immersed in the tank or in the depth of immersion, will dramatically reduce such noise. The degree to which the cleaning solution has been degassed will also have a significant affect on noise output. Use of a tank cover, preferably with a elastomeric gasket between it and the tank rim, is also helpful.

It is important to isolate the processor, vessel, or cleaning tank from tables, walls, ducts, or other furnishings which could act as, or transmit vibratio ns to, resonant surfaces. Tanks and generators should be mounted on elostomeric feet. Processing convertors and cells should be held in elastomeric clamps. Tubing connections to processing cells should always be flexible, both to minimize sound transmission and to avoid interference with the resonant horn.

Proper attention to such details will prevent the possible annoyance of personnel and resultant complaints about mysterious maladies.

 ULTRASONICS, HEARING, and HEALTH - 16 July 1999

- - - * - - -

NOTE: (08 Oct 99) - Although the foregoing is clearly labelled "**preliminary**", i.e. a work-in-progress or unfinished, I was taken to task by a worker in ultrasonics who claimed to have damaged his "hearing using a 40KHz ultrasonic transducer which was putting out a **sound pressure** of about **120db**, which is a very common frequency and level for small ultrasonic transducers" and that his "hearing damage was confirmed by much testing and two audiologist"s *{emphases mine}*. He also mentioned an engineer who "designed ultrasonic cleaning equipment who also claimed his hearing was damaged by ultrasound". I do not doubt their hearing loss, but anyone who knowingly and willingly works with sound at 120 db is looking for serious trouble. I hold that ultrasonic equipment which with I am familiar and which has been properly designed, fabricated, **and**

maintained does **not** radiate at such levels.

In my response, I noted the sound escaping from an unprotected process can far exceed that and do serious damage, just as I state above. I also wondered how his damage can be so specifically traced to the ultrasonic equipment. Hearing loss is a terrible thing and I am in no way making light of his or his friend's or anyone's, but I would need absolute proof, which I frankly do not believe anyone can produce, that the acoustic output of properly-made and -maintained ultrasonic equipment itself, and not of ancillary equipment or processes, is at fault.

I should hasten to add that damaged or badly set up equipment can produce hideous sounds at appalling levels, which I am in the habit of describing as the sound of a "stuck pig" [not that I have ever (happily) heard a pig stuck]. It can be an unbearable screech, and that, in itself, should be more than adequate warning that something is very wrong and that the system should be shut down and examined. My description usually continues with an analogy to a hot houshold iron; you can test the temperature of the soleplate with your fingertip but you run the risk of a serious burn; the same holds for ultrasonic equipment. Today's analogy would better be continuing to run a computer after getting a fault warning. Safety (both of personnel **and** equipment) always depends on the application of <u>common sense</u>; if it squeals, **SHUT IT OFF!**

In mechanical operations, such as welding, the tip contact against a hard object can generate terrible levels of sound; protection must be provided.

One major source of internal sound (as opposed to that from the process) is that emanating from a loose or damaged horn or tip or from a failing stack; it can be incredibly loud and piercing (and harmful).

Similarly, I have observed many manufacturers and users of ultrasonic equipment routinely testing in open spaces without acoustic radiation protection; they put their workers at risk and are liable for the consequences. Thus, again similarly, anyone working under such conditions must either do something about it or quit (or suffer attendant/subsequent hearing loss).

The foregoing is largely based on work at from 20KHz to 120KHz. Emanations from 15KHz equipment (little-used, currently) are well within the audible range and must be very carefully damped.

- - - * - - -

I should also add that <u>unexplained</u> **inaudible** sound at very high frequencies can cause a reaction of anxiety, of unease, while that at very low frequency can cause depression; it is my understanding that these reactions do not occur when the subject is aware of the situation (this is certainly true in my own personal experience).

Ultrasonics and Living Organisms

For a very long time, I have been howling to the wind about the indiscriminate use of ultrasound and ultrasonics in humans (especially in scanning and dental prophylaxis) and now, finally, a University of Illinois conference on biophysics and bioengineering of ultrasound, focusing on Non-Thermal Bioeffects, reveals a lot more effect than we have been led to believe. I will add more on this.

These facts are of long standing and are incontrovertible; cavitation, and pre-cavitational effects, cause violent organelle motion, cell disruption, and DNA scission - PERIOD! If some medical and dental practitioners don't mind such effects occurring in live human tissue, I, for one, do not care to subject myself to their tender ministrations.

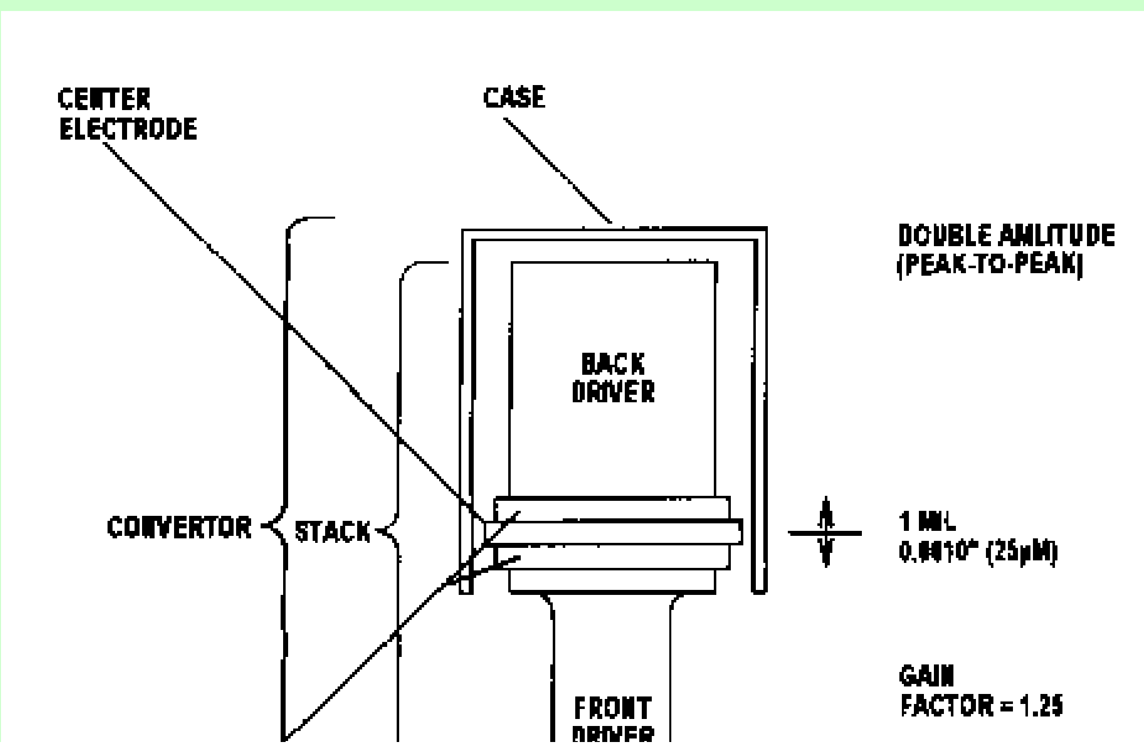
[I deny any connection with a "us-government-torture" site!]

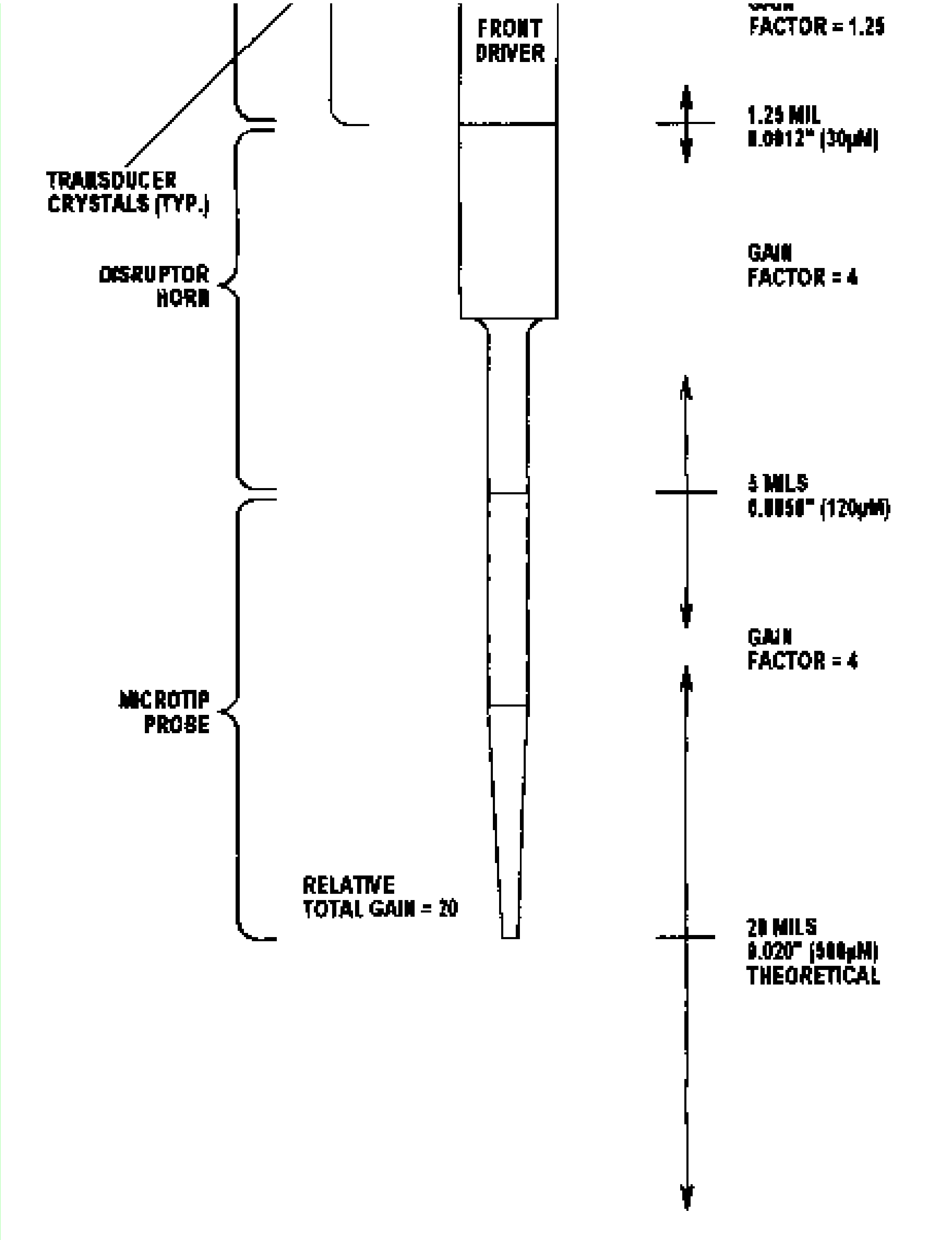
KEYWORDS (Applications) INDEX

Latest list update: 06 Jul 99
(moved to KEYWORDS on the main page from this page on 12 Feb 00)
[for hardware (non-applications), see GLOSSARY, * = added {date}]

WHAT'S NEW?

What's new is that the Ultrasonics Page 1 (the first page) has overloaded again and I'll have to reformat all these pages to have things fit logically. In the interim, here are some new illustrations for equipment and accessories that somehow never got into the preceding pages.

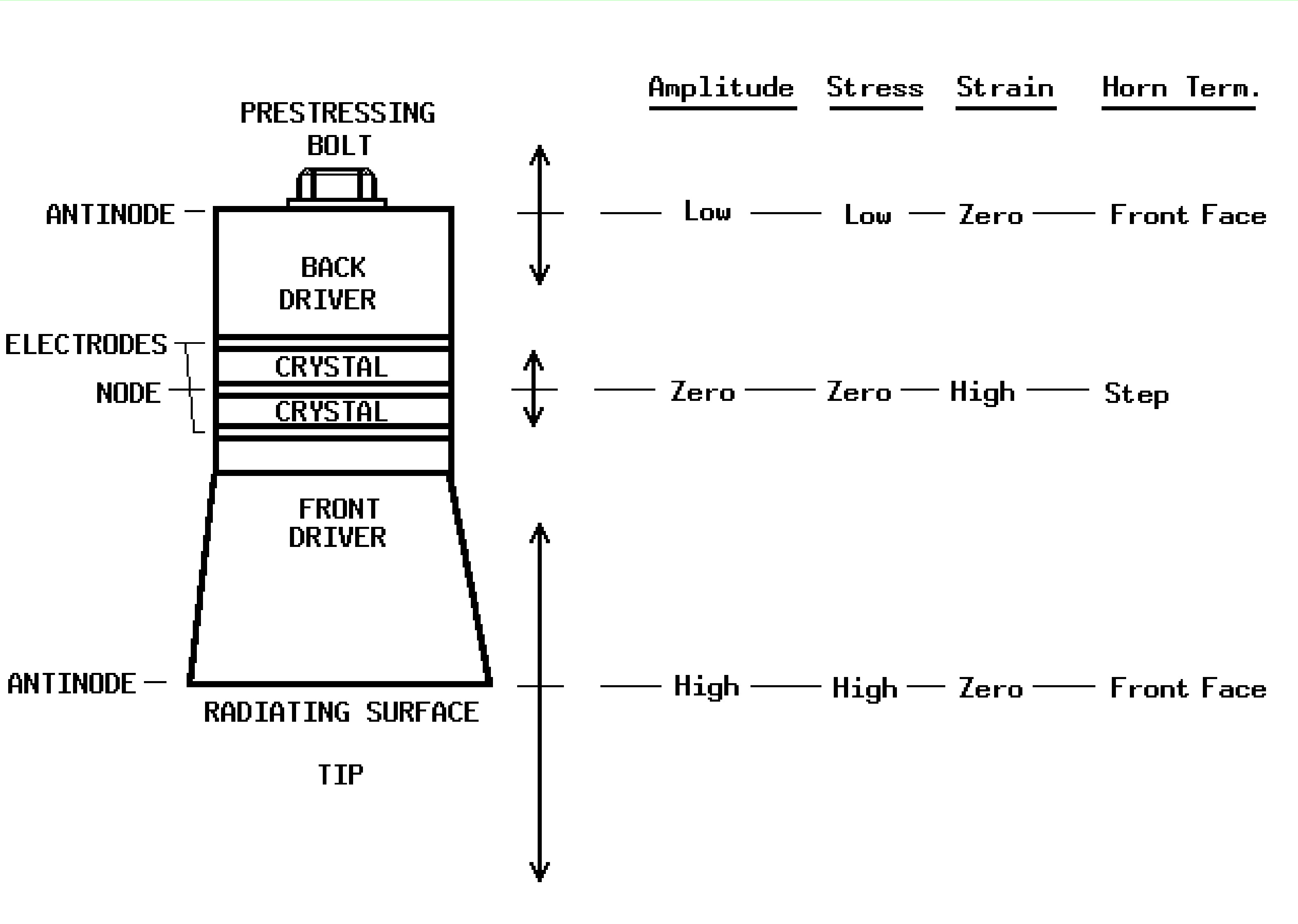




Convertor Stack

You may recall that the working parts inside the **CONVERTOR** of a high-intensity ultrasonic probe are termed the **STACK**; here is how it works in more detail. The transducer crystals (there could be only one and sometimes are more than two), with conducting **ELECTRODES**, are prisoned between a **BACK DRIVER**, in effect a counterweight, and a **FRONT DRIVER**, usually a mechanical amplifying stage, al held together by an internal stud or, as shown, an external **BOLT**, either of which prestresses the stack so that the crystals can have high-voltage impressed upon them through the electrodes to bias them to expand and contract. The stud or bolt acts as a tensioning spring, stretching as the crystals expand and pulling things back together as they relax. The stress in the stud or bolt is exceeedingly high. The horn or tool is fastened to the front driver.

For comparison, here is a typical (and similar) stack used in a heavy-duty industrial cleaning tank or immersible transducer. Note how the front driver here is a negative-gain device; it' s function is to pass as much energy as possible into the wall/base of the tank at moderate amplitude (too high an amplitude and the tank will hole through from excessive cavitation and parts may be eroded):

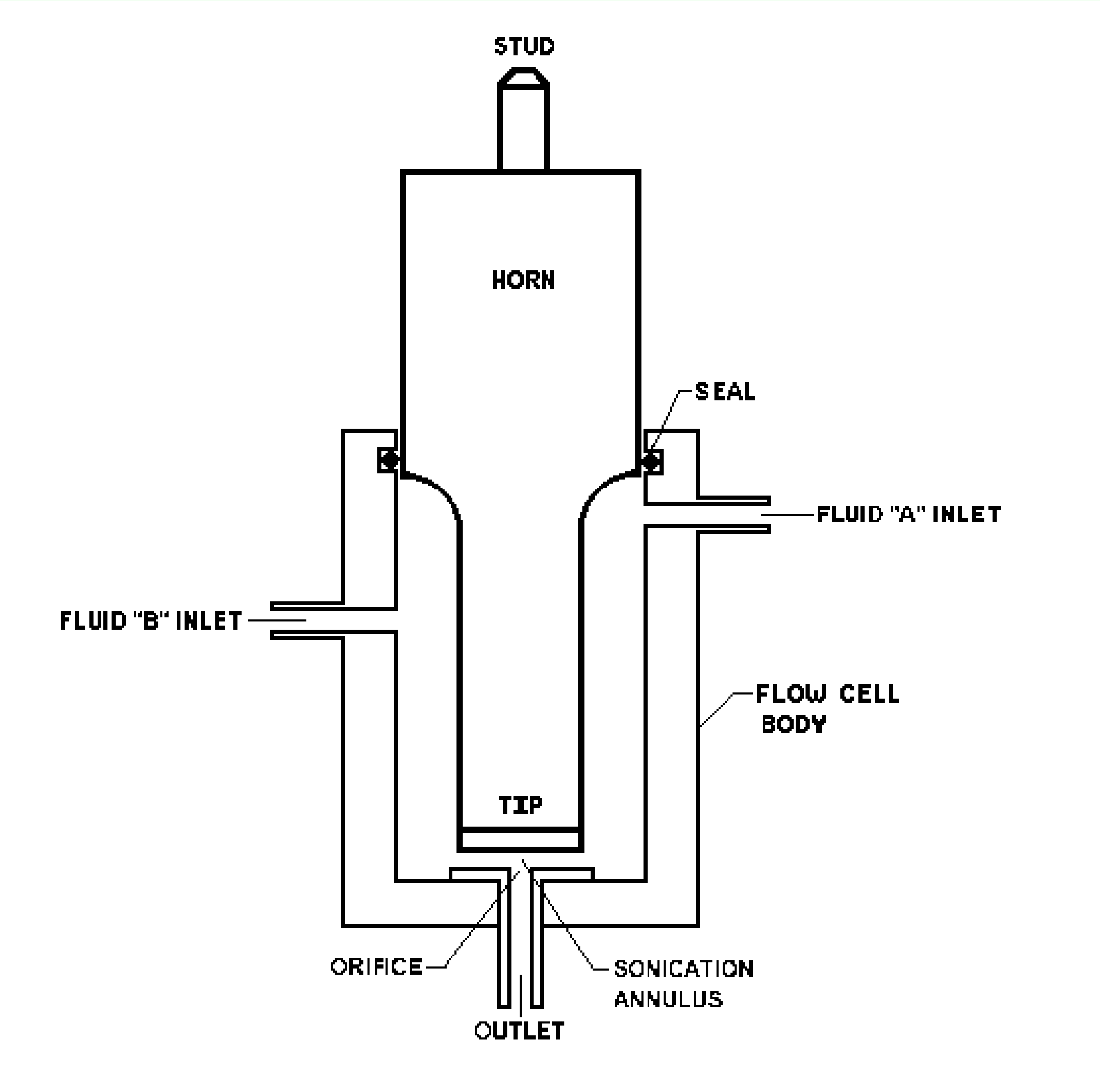


Convertor Stack

See the Ultrasonic Cleaning page for how the stack is used with a tank.

Continuous Flow Cells

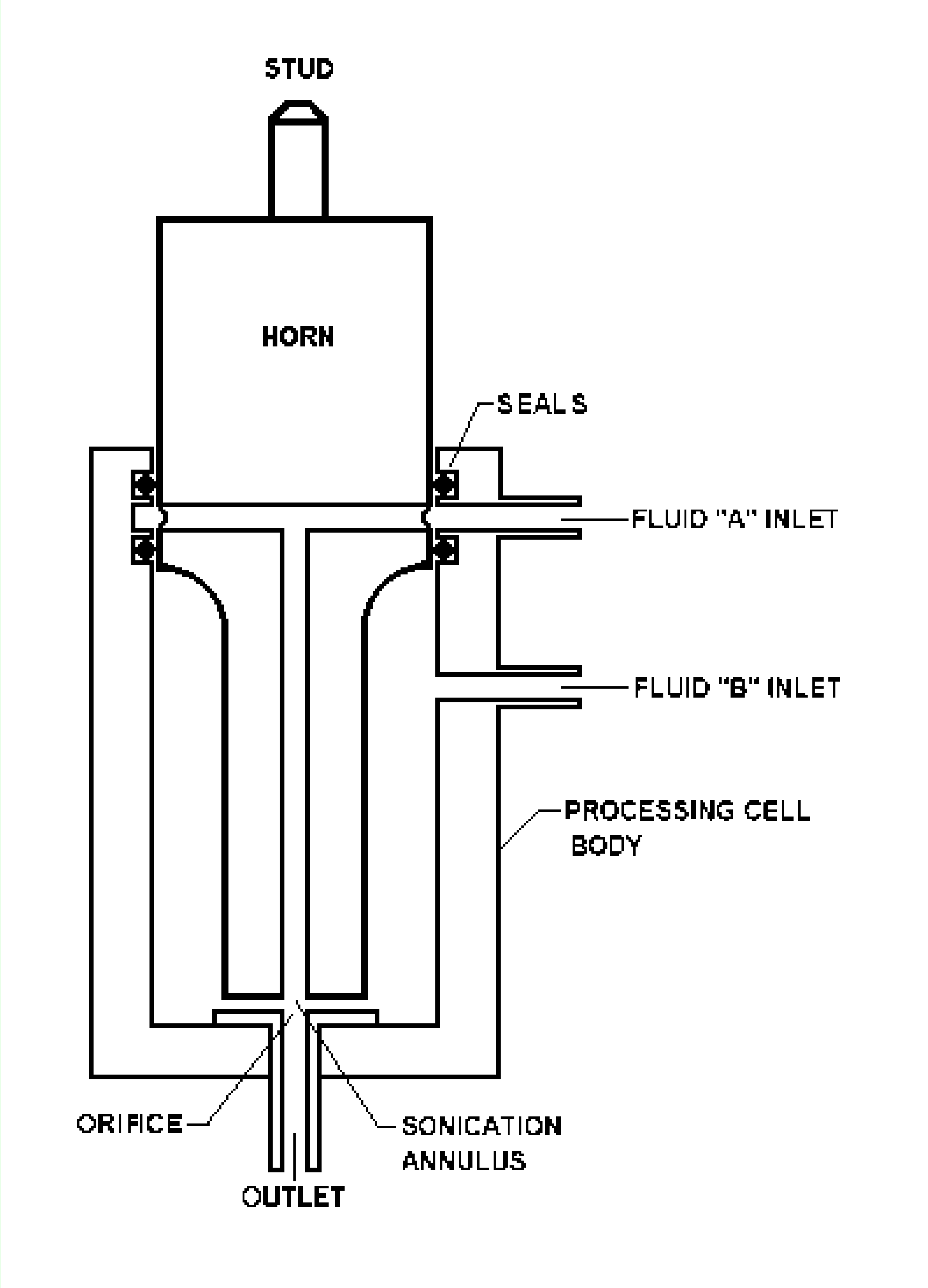
Here is a means of using a horn in a continuous flow system; one or two (or more) liquids are pumped into the "**CONTINUOUS FLOW CELL**", mix and are processed in the annulus, controlled by an adjustable orifice which can be moved in and out axially and with interchangeable orifice plates, thus giving full control over the process parameters:



Continuous Flow Cell

Note that the cell has a seal at the horn's nodal point, where there is little, if any, lateral (radial) motion; this is a critical point - restricting the horn with a clamping force throws it out of resonance, generates tremendous heat and noise, and can cause loss of seal integrity. Most flow cells are made either of polycarbonate and rated for low pressure or of stainless steel rated for 20psi. Details of threading and such are not shown here; these drawings are for concept, only.

Taking the flow cell a step further, the author combined the features of a flow cell with a so-called **FLOW-THROUGH HORN**, one which is cross and axially drilled and came up with a novel (the U. S. Patent Office agreed) means of getting guaranteed uniform mixing of two components by passing one through the horn so that the liquid (Fluid "A") exits the horn through the tip in the center of the cavitational field where it meets the other liquid coming radially inward from the body of the cell. Because the second liquid (Fluid "B") travels radially inward, all aliquots pass along a radius of equal length, thus assuring equal sonication and mix with Fluid "A" directly in the cavitation field at the end of the horn:

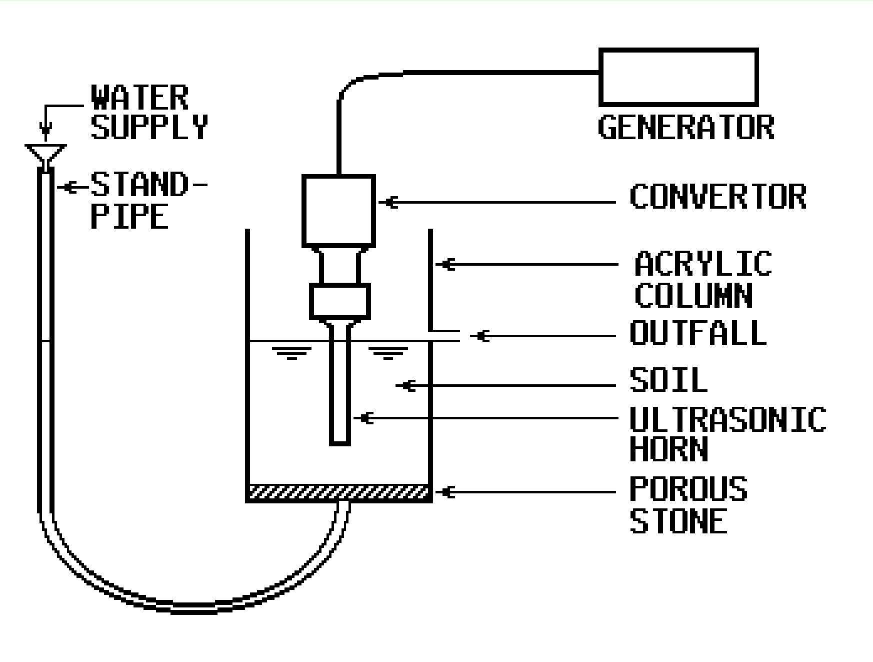


Processing Cell

The processing cell is covered by United States Patent #**5,032,027** of July 16, 1991, "Ultrasonic fluid processing method", and United States Patent # **5,026,167** of June 25, 1991, "Ultrasonic fluid processing system". Both were granted to the author (S. Berliner, III) and assigned to Heat Systems, Incorporated (now Misonix Incorporated).

In the regular flow cell, the two liquids mix randomly and aliquots can flow directly through without significant (if any) mixing.

Next, allied with AL-2*, herein, and the environmental paper co-authored with Dr. L. N. Reddi, et al., *Feasibility* *of Ultrasonic Enhancement of Flow in Clayey Sands*, Technical Note No. 3291, J. of Environmental Engineering, Environmental Engineering Div., American Society of Civil Engineers, 119, 4, 746-752 (Jul/Aug 1993)., here is the experimental setup used to activate the soil (fluidize the bed), and release bound hydrocarbons:



Soil Remediation Test Arrangement

The horn used was a 1" horn with a 1½-wave extender, projecting into the soil some 17" or so. Excellent energy dispersal was noted and good removal was achieved.

* - AL-2 - "ULTRASONICS AND FINE PARTICLES -
BENEFICIATION OF SLURRIES AND FINE-PARTICLE SUSPENSIONS
[CERAMICS, COAL & ORES, COATINGS, COLUMN PACKINGS, SINTERING, SLIPS].

These pictures will be integrated into the preceding pages and more detailed explanations provided.

There are also some new ones on the Ultrasonic Cleaning page that tie in with these.

Also new is work on altering skin permeability by ultrasonics as reported in ***Nature Medicine***, March 2000, Vol. 6 No. 3, pp 231 - 356 - "***Transdermal monitoring of glucose and other analytes using ultrasound***", pp 347 - 350, J. Kost, et al.; an outgrowth of work on varying permeability of membranes, the immediate advantage is painless taking of blood samples for diabetes monitoring.

The School of Biosciences at Cardiff University works on the use of **standing waves** for **particle separation** in suspensions. Their **Ultrasonic Bioseparations Research Group** has put up a truly excellent poster on this work.

You may wish to visit the main Ultrasonics page, Continuation Page A, Continuation Page 1, Continuation Page 2, and Continuation Page 4, with more on **ultrasonics**, as well as the Ultrasonic Cleaning page {in process} and the Ultrasonics Glossary page {also in process}.

THUMBS UP!

THUMBS UP! - Support your local police, fire, and emergency personnel!

S. Berliner, III

To contact S. Berliner, III, please click here.

PREV.PAGE FIRST PAGE NEXT PAGE

To tour the Ultrasonics pages in sequence, the arrows take you from the main Ultrasonics Page (with full index) to Pages A, 1, 1A, 2, 3, and 4, Glossary Page, Cleaning Page, and Bibliography Pages 1, 2, and 3 (see Index, above).

Return to Top of Page

Updated: 28 Feb 2004, 11:25 ET *[Website begun 30 May 1996.]*
Update info on the top on ALL pages for your convenience.

URL http://home.att.net/~Berliner-Ultrasonics/index.html
also at http://berliner-ultrasonics.home.att.net/index.html

S. Berliner, III

Consultant in Ultrasonic Processing

"changing materials with high-intensity sound"

SONOCHEMISTRY * REACTION ACCELERATION * DISRUPTION
HOMOGENIZATION * EMULSIFICATION * POLLUTION ABATEMENT
DISSOLUTION * DEGASSING * FINE PARTICLE DISPERSION
BENEFICIATION OF ORES AND MINERALS
CLEANING OF SURFACES AND POROUS MATERIALS
also see Keywords (Applications) Index

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Technical and Historical Writer, Oral Historian
Popularizer of Science and Technology

MEMBER - Board of Directors
Logo 2000 - all rights reserved to UIA.

I've added a local search function here and on several major topic pages:

Enter Keywords:

Search

Conventions (abbreviations and such) used on this site are noted below.
NEW! (22 Jan 04)

[A new "bugaboo" has reared its ugly head - complexity of organization - see COMPLEXITY on my main index page.]

INDEX to varied professional interests classified in major areas

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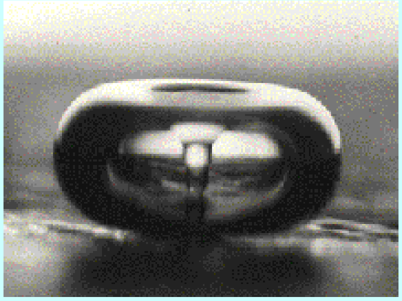
TECHNICAL and PROFESSIONAL

ULTRASONICS

ULTRASONIC PROCESSING

THE CAVITATION BUBBLE



[image from University of Washington, Applied Physics Laboratory (Lawrence Crum, Ph. D.)
- bubble diameter approximately 1mm]

Ultrasonics Index Page

[this page was added 14 Jul 2003 because the topic became so complex that the index on the main page was overloading both that page and this home page; jump there for a more detaled index.]

Main Ultrasonics Page:

Call for Contributions for Book.

For this book and other work, I am seeking information about **Narda Ultrasonics Corporation**, a firm which pioneered high-intensity application of ultrasonic energy ca. 1946-1960, and was presumably subsumed into **Narda Microwave Corporation**, which was bought out by the **Loral Corporation**, which, in turn, was acquired by **Lockheed Martin Corporation**

Ultrasonics Page 2:

More on Cavitation.

AL-2 - "ULTRASONICS AND FINE PARTICLES -
BENEFICIATION OF SLURRIES AND FINE-PARTICLE SUSPENSIONS [CERAMICS, COAL & ORES, COATINGS, COLUMN PACKINGS, SINTERING, SLIPS].

Ultrasonics Page 3:

AM-1 - "ULTRASONIC STERILIZATION and DISINFECTION".

UM-1 - "ULTRASONICS, HEARING, and HEALTH"

Ultrasonics and Living Organisms

What's New?

Ultrasonics Page 4:

Foaming and Aerosoling - moved 28 May 02 from Page 1A.

Ultrasonic Propulsion (Propulsive Force) - Moving Material.

Ultrasonic Fountain - Atomization, Nebulization, Humidification, Misting, Particle Creation and Sizing.

Ultrasonics and Nuclear Fusion.

Quick Links for Ultrasonic Probe Manufacturers (moved 10 Jul 2002).

CLEANING

ULTRASONIC CLEANING {in process}.

Immersible Transducers.

What's New?

On Ultrasonics Page 4:

Foaming and Aerosoling - moved 28 May 02 from Page 1A.

Ultrasonics and Nuclear Fusion.

Ultrasonic Cleaning Continuation Page 1:

APPLICATION PAPER AP-3 - SPECIAL INSTRUCTIONS FOR CLEANING JEWELRY,
CLOISONNÉ, ETC., IN HOME AND HOBBY USE.

GLOSSARY

ULTRASONICS GLOSSARY {in process}.

ULTRASONICS BIBLIOGRAPHY

Ultrasonic Bibliography Page 1 - Reference Books on Acoustics, Vibration, and Sound.

Ultrasonic Bibliography Page 2 - Sonochemistry.

Ultrasonic Bibliography Page 3 - Selected Articles.

Major Restructuring of this Home Page - 29 Aug 99

(and restyling 20 Jul 03 courtesy of my daughter - thank you!)

All references to personal and hobby matters
have been moved to a separate index page, Home Page 2.

There is also a Semi-Alphabetical Index, et seq.
(formerly at the end of this page and now moved to a separate page
after the page list topped 100+!
(The page count is now on the Semi-Alphabetical Index Page
has topped 300, and will probably keep growing!)

In addition, a site with a private domain name now exists at:
sbiii.com
as of 12 Oct 2000; linking will maintain continuity.

To jump directly to **TECHNICAL and PROFESSIONAL** interests,
click here.

[Please note that over the many years since this site was begun (30 May 96), I have abandoned the formal academic usage of "the author" and "your Webmaster" in favor of the more informal first person singular "I" and "me".]

The current Coordinated Universal (Greenwich Mean) Time (UTC),
per the U.S.Naval Observatory Master Clock, is:

(Subtract 4 for EDT, 5 for EST
Military/Euro-style 24-hour clock
00:00-12:59 = 12M-12N,
12:00-24:00 = 12N-12M)

[Note: clock runs for 30 seconds; it may skip seconds. To restart clock, click "**Reload**".]
{Your browser must be set to automatically load images or you must activate the clock image manually by right-clicking the clock image and clicking on "View image" (or equivalent).}

I try to keep these many pages up to date by adding and removing icons on a timely basis;

please bear with me if I miss a few here and there. - SB,III

[However, I shall not accept responsibility for any inconvenience due to my faulty use of such icons nor reader's misinterpretation of same.]

I should point out that I only change the date(s) on the affected page(s), not also on this home page (except when a change is made to this page).

"Incidentally"(!), I have had a major set back in that AT&T WorldNet destroyed 13 of my sites with some 2,000+ files with some 185Mb+ of data without notifying me beforehand (purportedly effective 05 Aug 2002), just after my hard drive started failing and overwrote some of my image backups, and I have to sift through my 260+ pages, finding the broken image links, then find the images (**IF** I still have them), reload them to new Websites, and then revise the links accordingly! This may just take a while and I ask your indulgence as I struggle through. I will NOT update the date or the NEW! and REV'D icons as I do this. Happily, the **Ultrasonics** pages came out relatively unscathed and are up to snuff. **IF YOU HAVE DOWNLOADED ANY OF THE MISSING IMAGES, PLEASE SEND A COPY BACK TO ME!**

NOTE! - **GREAT NEWS!** - I have successfully recovered SOME "irretrievably-lost" files from **Internet Archive!** I highly recommend this invaluable service and, further, ask that you help fund this incredible effort.

PERSONAL and HOBBY INTERESTS:

COURTESY HOME PAGES
HOBBIES and SPECIAL INTERESTS
PERSONAL
plus a Computer Page,
with credits (helpful sites), references, tips, queries, etc.

[**NOTE** - there is also a Semi-Alphabetical Index, previously at the end of this page and now on a separate page of its own.]

Please be sure to visit my REFERENCE Page - useful links (with disclaimer)

[A courtesy home page for the **Ultrasonic Industry Association** has been discontinued;
the UIA now has its own site - "http://www.ultrasonics.org" - click on the logo to go there:]

[New 2000 Logo - all rights reserved to UIA.]

FLUID FILTRATION

OTHER TECHNICAL INTERESTS

NON-WOVEN FIBROUS MATERIALS page.

Semi-Alphabetical Index of SBIII's Site Pages

Moved to its own separate page, et seq..

CONVENTIONS (abbreviations and such) used on this site: NEW! (22 Jan 04)

Abbreviations, Contractions, etc. -
Year Format - 98, 99, 03, 04, etc. = 1998, 1999, 2003, 2004, etc.
Date Format - **22 Jan 04** = January 22, 2004.
Time Format (military time) - 12M = 00:00, 12:01AM = 00:01, 12N = 12:00, 1PM = 13:00, 12:59PM = 23:59
(page revision time stamping in 5 minute increments).

RoW = Right-of-Way (highways, railroads)
[to save space, repeated names may be initialized - LIMP = Long Island Motor Parkway].
N = North, E = East, W = West, S = South.

and so forth *[to be cont'd.]* **:-)**

@ - "VANITY" URL

As noted at the top of this page (and, similarly, on ALL my pages), my base URL is **http://home.att.net/~Berliner-Ultrasonics/**; however, to simplify listing and linking, AT&T WorldNet has come up with so-called *"Vanity URLs"* by which my pages can be accessed, which, in this particular case reads as follows:

http://berliner-ultrasonics.home.att.net

Any sub-page can be accessed by simply using that "vanity" URL followed by the normal suffix, as in the URL of this page:

http://berliner-ultrasonics.home.att.net/index.html

or **http://home.att.net/~berliner-ultrasonics/index.html**

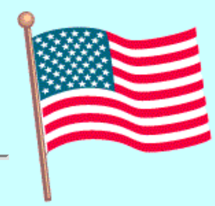
The "vanity" URL saves a forward slash ("/") and avoids the (to some) troublesome tilde
("~" in HTML - also "%7e" in Unix Code).

LEGACY

What happens to <u>all this</u> when I <u>DIE</u> or (heaven forfend!) **lose interest?**
See LEGACY.

COPYRIGHT NOTICE

THUMBS UP!



THUMBS UP! - Support your local police, fire, and emergency personnel!

To contact S. Berliner, III, please click here.

[This Website was begun 30 May 1996.]

Return to Top of Page

Updated: 17 Oct 2003, 18:25 ET
[Ref: This is u-s.html (URL http://home.att.net/~Berliner-Ultrasonics/u-s.html)]
{Please note that it may ALSO be accessed as URL
http://berliner-ultrasonics.home.att.net/u-s.html
(a so-called "*vanity*" URL.);
this also holds true for the other ultrasonics pages.}

S. Berliner, III's

Ultrasonics Page

Consultant in Ultrasonic Processing
"changing materials with high-intensity sound"

Technical and Historical Writer, Oral Historian
Popularizer of Science and Technology

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

[See "Keywords (Applications) Index" on Page 3.]

Specializing in brainstorming and devil's disciplery for new products and reverse engineering and product improvement for existing products.

{"Imagineering"}

[consultation is on a fee basis]

[Please note that I am an independent consultant, **NOT** a manufacturer;
I WAS Director of Technical Services for **Heat Systems-Ultrasonics**
(now **Misonix**) for many years, q.v.]

MEMBER
Board of Directors

[New 2000 Logo - all rights reserved to UIA.]

INDEX to ULTRASONICS

I've added a local search function:

Enter Keywords:

Search

PLEASE NOTE: If some internal links refuse to work,
please click on Back and scroll down.

[Please also note the alternative spelling of American usage "homogeni**z**e"
vis-à-vis the British usage "homogeni**s**e", etc.]

NOTE! - it was my original intention to use the main "home" or "index" page of this site for this purpose but the coverage of ultrasonics has become too extensive and complex even for me to follow; thus there is now a more-detailed index, which is in two forms. The first part is a straight-forward index of the ultrasonics pages, brought forward from the site index page and amplified. The second part is a linked alphabetical index to all or most of the terms used herein.

On the main Ultrasonics Page (this page):

Applications List.

Keywords (Applications) Index - moved from Page 3 on 12 Feb 00.

Probe-type Ultrasonic Processing Equipment.

AL-1C - "CONDENSED GUIDE TO ULTRASONIC PROCESSING"

(A Layperson's Explanation of a Complex Letterhead)
{moved to Page A on 05 Jan 02
to make more room for this ever-increasing Ultrasonics Index}.

AL-1P - "A POPULARIZED GUIDE TO ULTRASONIC PROCESSING".
(A Non-Technical Explanation of a Complicated Letterhead)
{moved to Page A on 19 Apr 01}.

AL-1V - "A POPULARIZED GUIDE TO ULTRASONIC CAVITATION"
(A Non-Technical Explanation of "Cold Boiling"
{moved to Page 1 on 12 Feb 00.

Brain Storming - bright ideas, pipe dreams, pie-in-the-sky?

On Ultrasonics Page A (the next page - created 19 Apr 01):

ULTRASONIC PROCESSING

Power vs.Intensity.

AL-1C - "CONDENSED GUIDE TO ULTRASONIC PROCESSING"
(A Layperson's Explanation of a Complex Letterhead)
moved from this page on 05 Jan 02.

AL-1P - "A POPULARIZED GUIDE TO ULTRASONIC PROCESSING".
(A Non-Technical Explanation of a Complicated Letterhead)
moved from this page on 19 Apr 01}.

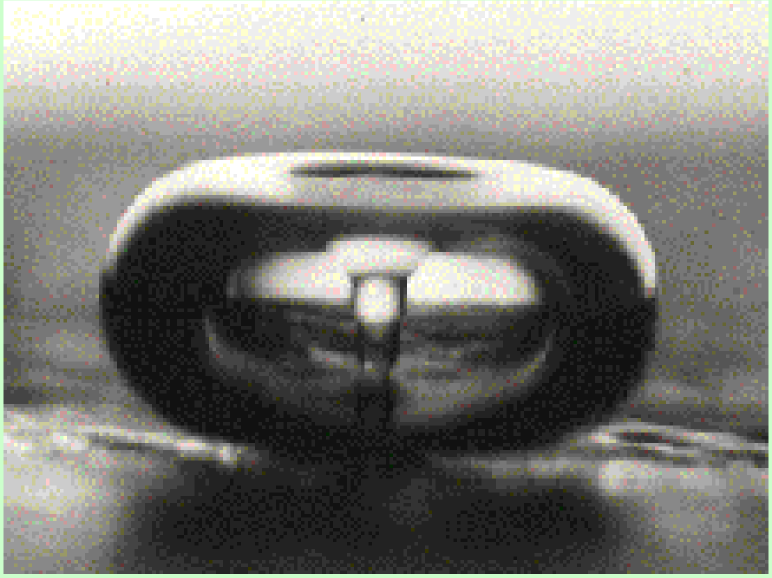
Failure Modes in Horns.

Ultrasonic Soldering, Galvanizing, etc..

You are invited to visit the ULTRASONIC INDUSTRY ASSOCIATION home page.

CALL FOR CONTRIBUTIONS: I am writing a book on "***High-Intensity Ultrasonic Technology and Applications***" (intended for Marcel Dekker's "*Mechanical Engineering Series*", edited by Profs. Lynn L. Faulkner and S. Bradford Menkes). This book will focus on the practical application of power (high intensity) ultrasonics, the use of ultrasonic energy to change materials. **Contributions** are welcome.

THE CAVITATION BUBBLE



[image from University of Washington, Applied Physics Laboratory (Lawrence Crum, Ph.D.) - bubble diameter approximately 1mm]

ULTRASONICS

[Please note that over the many years since this site was begun (30 May 96), I have abandoned the formal academic usage of "the author" and "your Webmaster" in favor of the more informal first person singular "I" and "me".]

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**. The term "***MEGASONICS***" is now being used to describe frequencies of **1,000,000Hz** (1,000kHz) and above.

There are other types of "***ULTRASOUND***", especially those used for Imaging and Sonar, Characterization of Materials and NDE (Non-Destructive Evaluation), pest-control (supposedly), and so forth; these do **NOT** change materials and are not covered herein. This series of pages is concerned only with changing materials with ultrasonics.

Such change can clean, homogenize, and accelerate both physical and chemical reactions, among many other things.

That is a key phrase worthy of repetition:

CAVITATION ACCELERATES BOTH PHYSICAL AND CHEMICAL REACTIONS.

Using the keywords, here are just some of the many operations that are commonly performed (or facilitated) using ultrasonics:

PARTIAL LIST OF APPLICATIONS OF ULTRASONIC ENERGY

=======================================

(High-intensity applications, only)

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/Sonolysis - Homogenization - Emulsification - Dissolution - Degassing - Bubble Fusion

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).

A word here about the terms "**Ultrasonic Processing**" vs. "**Ultrasonic Liquid Processing**" - the former refers to any method of changing materials using ultrasonic (high-frequency acoustical) energy; the latter refers specifically to methods of changing materials using ultrasonic (high-frequency acoustical) energy in a liquid (a liquid to be processed or the parent liquor used to carry solids to be processed). Some processing, such as drying and levitation, can be accomplished in air or other gaseous media. I have denigrated the latter term ("Ultrasonic Liquid Processing") because, while the most common form of ultrasonic processing, it is too limited in scope and too limiting for the imagination.

CLEANING

[see the Ultrasonic Cleaning page for more detail]

ACTIVE TANKS

Cleaning is most commonly accomplished by immersing objects in a tank to which are fasten transducers that energize the walls or bottom of the tank and generate cavitation in the liquid. Shock waves clean surfaces of parts and assemblies by accelerating detergency of cleaning agents in the bath and by mechanically blasting contaminants off the surfaces.

IMMERSIBLE TRANSDUCERS

An immersible transducer is a radiating device sealed in a housing which can be submerged in a liquid bath to energize the liquid to produce cavitation. An immersible transducer placed in a still tank turns that tank into an ultrasonic cleaner. The immersible transducer is, in effect, a standard tank everted (turned inside out) with the radiating surface on the outside and the transducers on the inside.

Other forms of ultrasonic cleaning include Ultrasonic **Vapor Degreasing**, Surface Wave Technology for cleaning Printed Circuit Boards, and **High-intensity Cleaning** of Porous Media, Surfaces for NDE, and Deep Holes.

KEYWORDS (Applications) INDEX

Latest list update: 06 Jul 99
(moved from Page 3 on 12 Feb 00)
[for hardware (non-applications), see GLOSSARY, * = added {date}]

- - - • - - -

APPLICATION:

abatement fine particle dispersion
acceleration fluidization (Br. fluidisation)
agglomeration food dehydration
agitation forming
atomization (Br. atomisation) fractionation
beneficiation grinding
biological cell disruption homogenization (Br. homogenisation)
bleaching insertion
blending joining
bonding levitation
catalysis liquids processing
cavitation machining
cell disruption, biological mixing
cleaning nebulization (Br. nebulisation)
compaction particle size reduction
curing pollution abatement
cutting processing
deagglomeration reflowing (hot melt adhesive)
deflocculating scission
degassing separation

degreasing size reduction
dehydration soldering
disaggregation solids processing
disintegration solubilization (Br. solubilisation)
dispersion sonocatalysis
disruption sonochemistry
dissociation sonolysis
dissolution sonoluminescence
drying staking
emulsification streaming
enhancement surface processing (as in cleaning)
erosion surgical
extraction suspension
fatigue testing tissue disruption
filtration enhancement welding (metals, plastics)

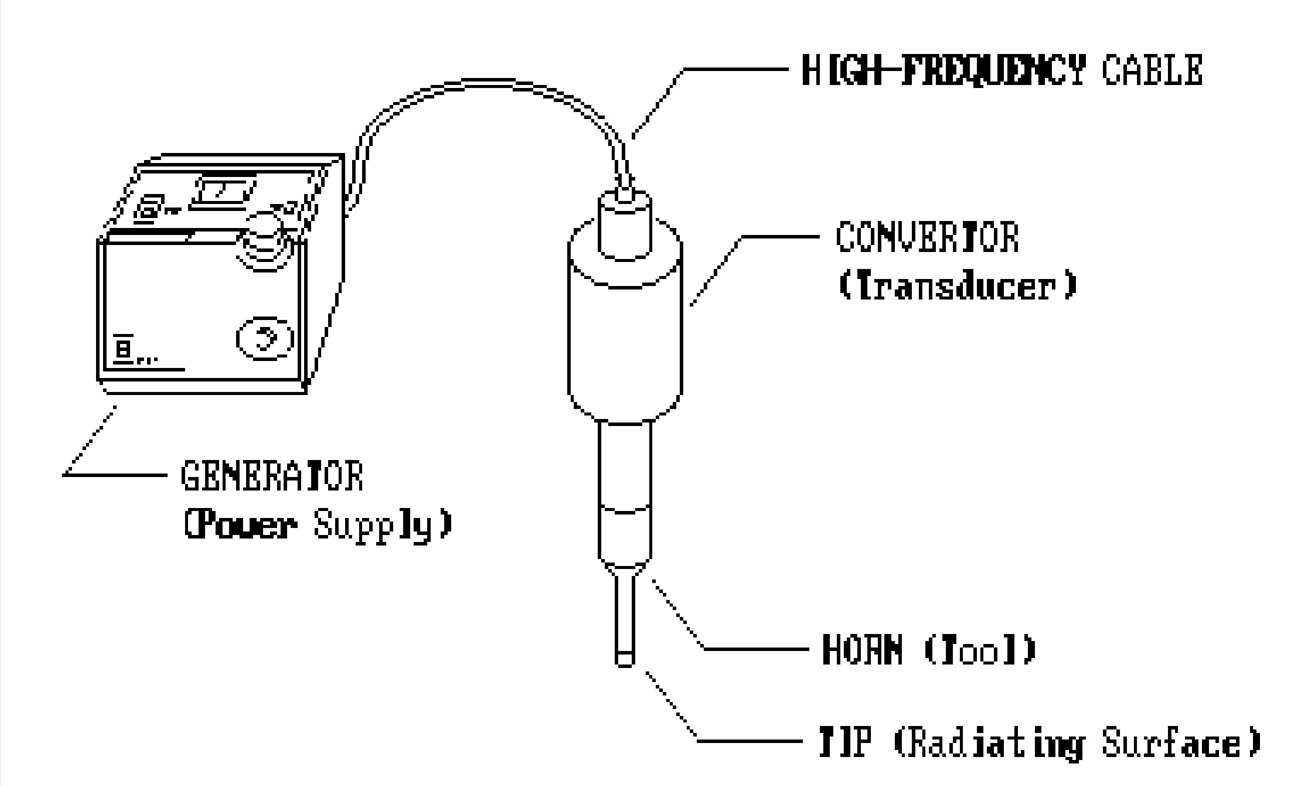
- - - • - - -

(this list will NOT be updated -see instead the alphabetical index.

Probe-type Ultrasonic Processing Equipment

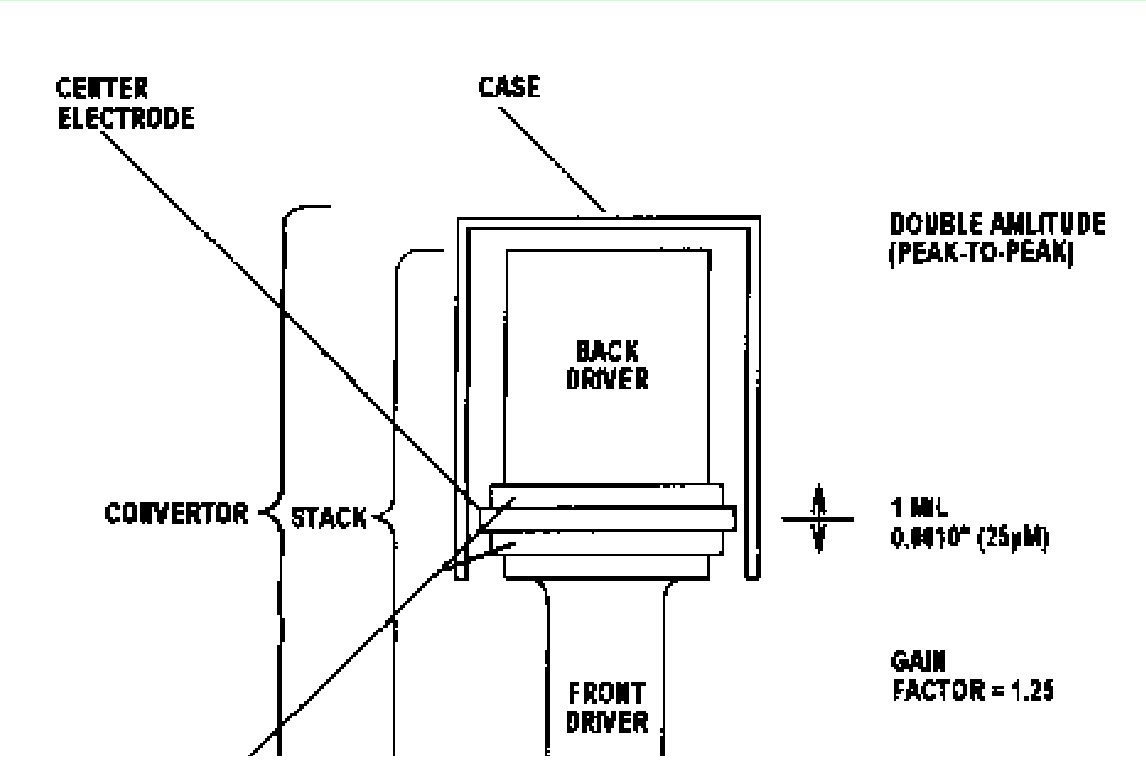
Until more illustrative material is added, let the following temporary terminology and visualization guide suffice:

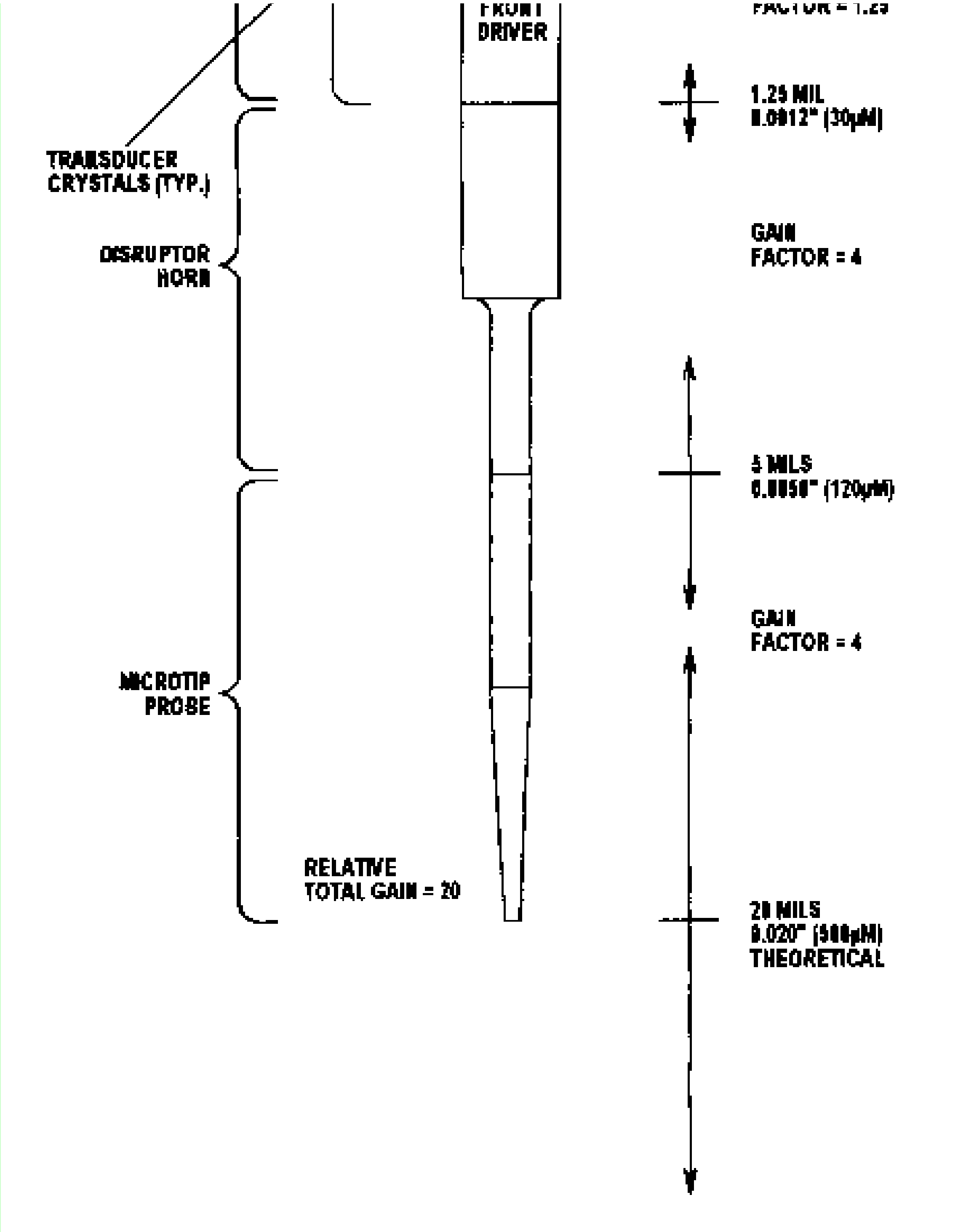
{Note that these devices are also known as "sonoprobes" or "sonotrodes" outside the U. S. and that they look quite similar to equipment used for ultrasonic welding/bonding - however, the sensing and control systems are drastically different.}



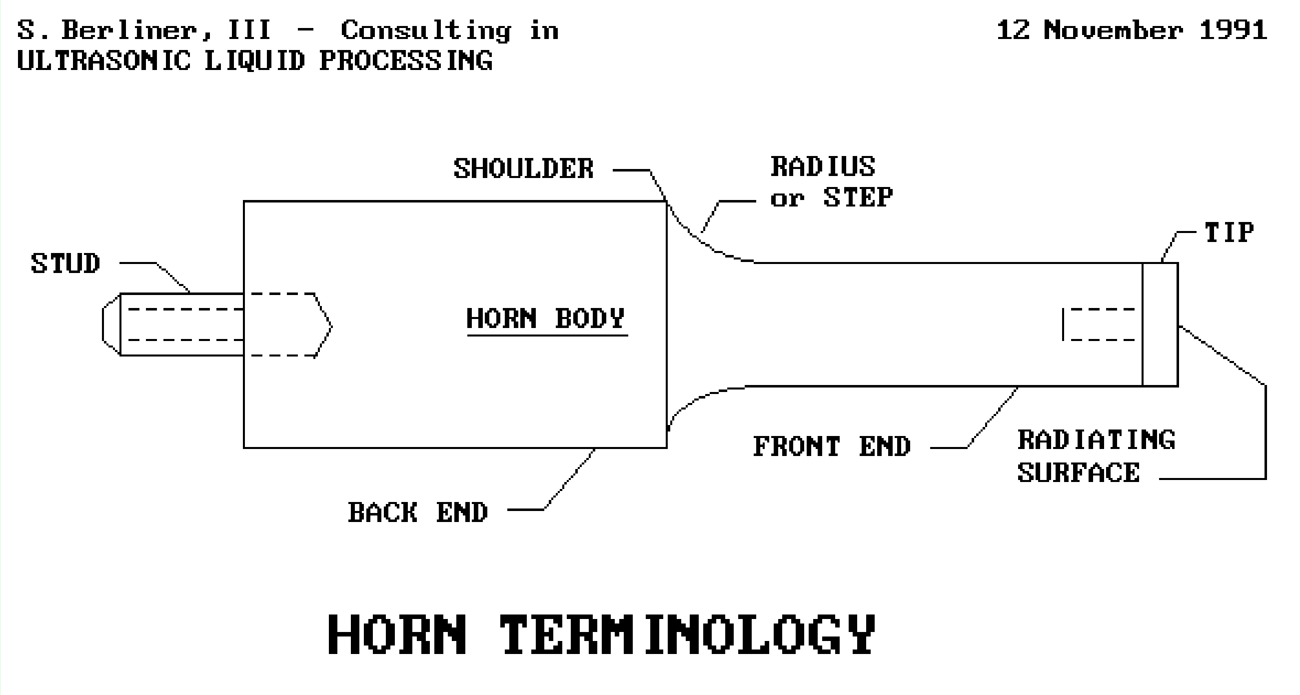
Typical Ultrasonic Processing System

The energy from the house/lab/plant lines (mains) is transformed from 110/220V AC at 60/50Hz to 20KHz (20,000 cycles per second) and controlled in the GENERATOR (or Power Supply), sent to the CONVERTOR (or Transducer) where it is changed into mechanical energy by the TRANSDUCER crystals (if electrostrictive) or TRANSDUCER Stack of laminated nickel shims (if magnetostrictive) and passed to the HORN (or tool), going through one or more amplification stages (STEPS) and ending up at the TIP (which may be integral to the HORN or removable), the end of which is the RADIATING SURFACE. This face radiates the acoustic energy into the fluid (liquid bath or gaseous sample).

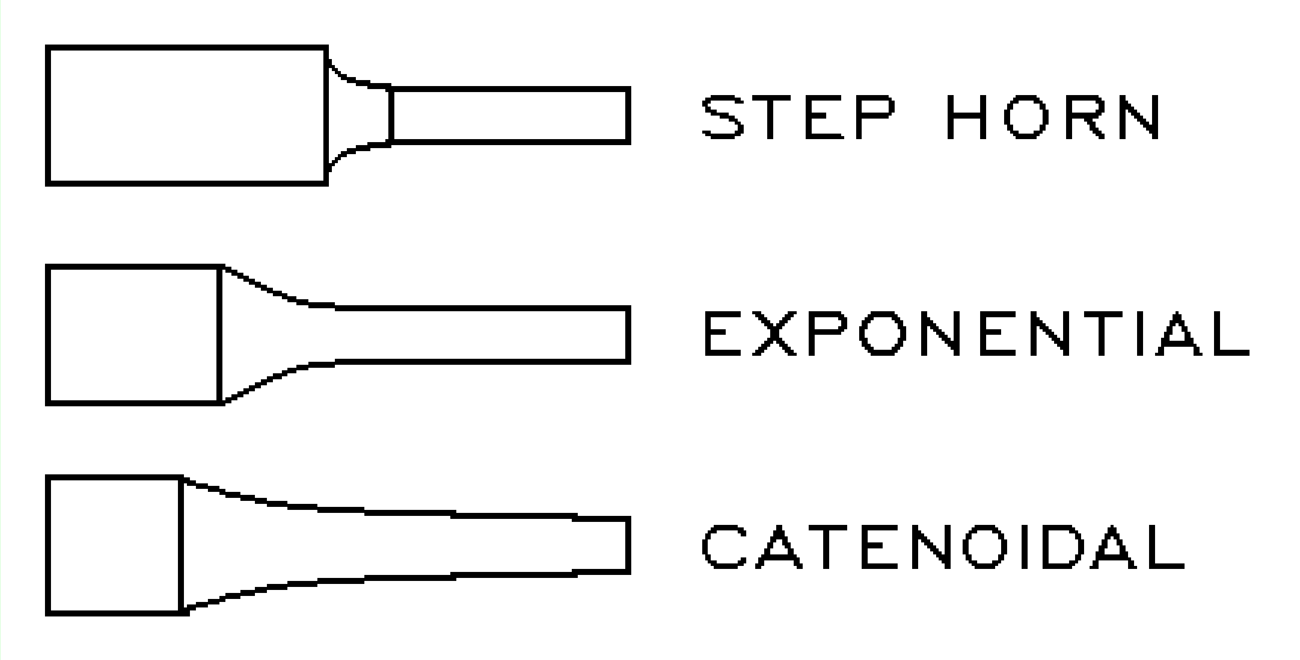




Convertor-Stack-Horn Layout
(electrostrictive shown)



Horn Terminology



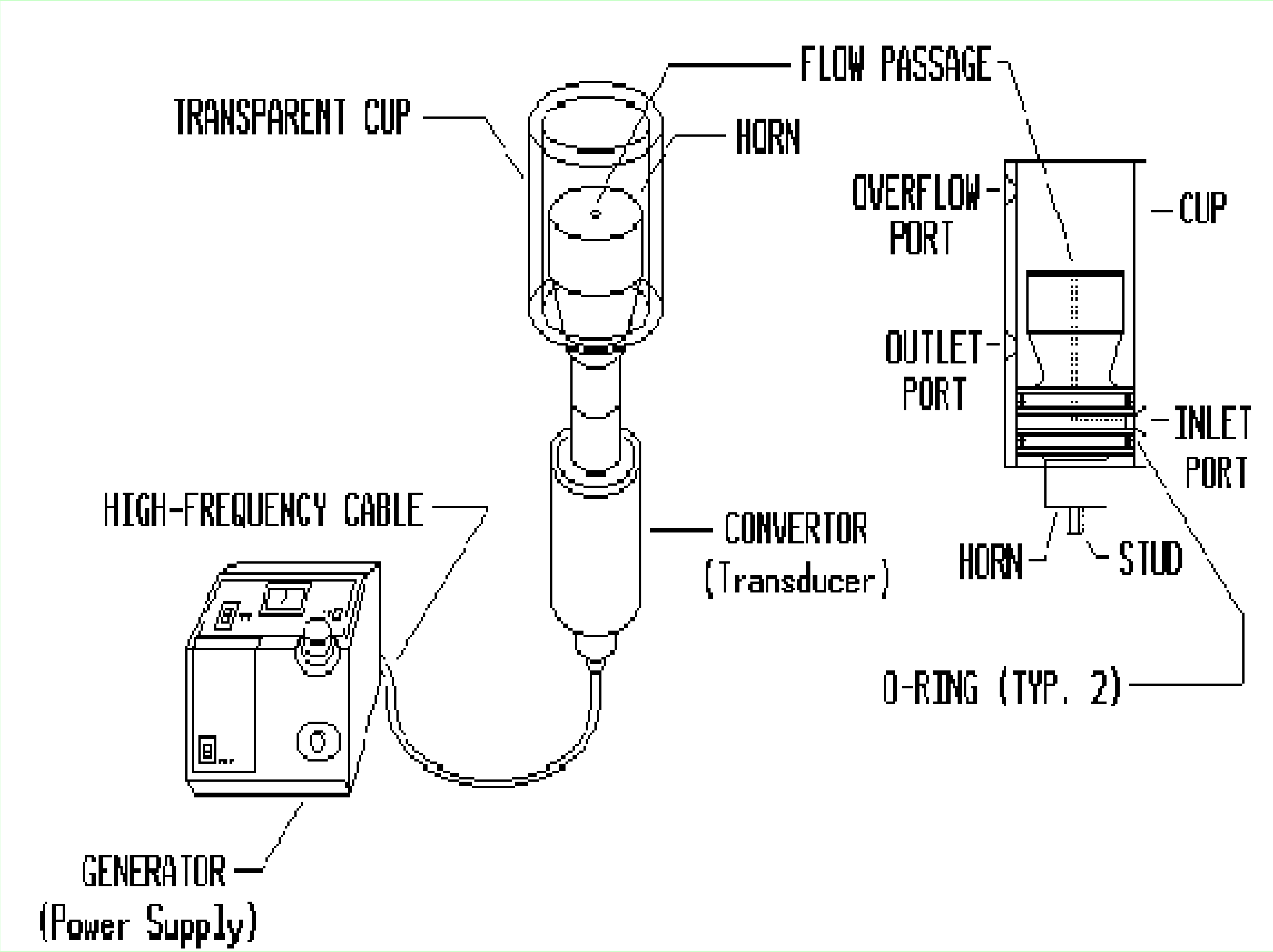
Horn Types

STEP HORNS provide maximum amplification (high gain) with high stress at the step and are used primarily in liquid processing. **EXPONENTIAL HORNS** provide moderate gain with moderate stress. **CATENOIDAL HORNS** provide low gain with low stress and are used primarily in joining.

{Note also that horns are commonly called "tools" in joining (welding, bonding, etc.) applications.}

For a brilliant (literally and figuratively) dissertation on horn design, see Don Culp's Krell Engineering site, replete with horn performance (FEA) animations.

Cup Horns



CUP HORNS are high-intensity baths used in ultrasonic liquid processing to prevent cross-contamination of samples and tips, in which the sample is placed in a test tube or small beaker placed in a transmission liquid in the cup and irradiated through the base and walls of the vessel.

Boosters (Booster Horns) are sometimes used to enhance output amplitude. NEW! (17 Oct 03)

ULTRASONIC PROCESSING - AL-1C - CONDENSED GUIDE TO ULTRASONIC PROCESSING

(A Layperson's Explanation of a Complex Letterhead) {and Business Card!}
(Moved to Ultrasonics page A on 05 Jan 2002).

ULTRASONIC PROCESSING: AL-1P, A POPULARIZED GUIDE TO ULTRASONIC PROCESSING

(A Non-Technical Explanation of a Complicated Letterhead)

(Moved to Page A on 19 Apr 2001).

AL-1V - "A POPULARIZED GUIDE TO ULTRASONIC CAVITATION"

(A Non-Technical Explanation of "Cold Boiling")

moved to Ultrasonics Continuation Page 1A on 12 Feb 00).

Quick Links to Major Ultrasonic Probe Manufacturers

For your convenience (and their benefit), I here three of the top manufacturers of ultrasonic probes for changing materials (NOT sensing probes); this list is neither exclusive nor exhaustive but represents firms with which I have dealt closely and which I can wholeheartedly recommend (moved to Ultrasonics page 4 on 10 Jul 2002).

Brain Storming -

bright ideas, pipe dreams, pie-in-the-sky?

Here is where I will put ideas that I have not tried or which have not been carried forward or for which I can not find substantiation in my capacious memory or voluminous files:

Grain refinement (grain as in crystalization, NOT food grasses) - I speak to this in a small way under ultrasonic processing of molten metals, but there is much work that might be (and may, indeed, have been) done in this area. Gradual reduction of cavitation in a melt will/should result in far better grain structure, finer dendritic formation, and smaller grain size.

Similarly, coarse ice formation in water can/should be slowed or prevented and microcrystalline or amorphous ice result.

In 1989, the idea of achieving "cold" fusion in the collapsing cavitation bubble popped into my head during the Pons/Fleischman flap but they did not resond to my suggestion; now (2002) it is under serious investigation (see Ultrasonics and Nuclear Fusion).

This is the stuff of dreams - the place of devil's disciplery - seek and ye shall find - ask away; hey, you never know (what pearls of wisdom or insight are trapped under all the decaying grey matter)!

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

Call for Contributions

For the forthcoming 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 and refer you to the new Continuation Page 1 where details of this request have been moved.

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. However, as what I believe to be a public service, I shall be adding more of my monographs on ultrasonics on this site; watch for them in the index (above).

You may wish to visit Continuation Page A, Continuation Page 1, Continuation Page 2, and Continuation Page 3 with more on **ultrasonics**, as well as the Ultrasonics Cleaning page {in process} and the Ultrasonics Glossary page {also in process}.

Those persons interested in **SONOCHEMISTRY** might wish to look at
Prof. Kenneth S. Suslick's and Shiga University's Sonochemistry pages.

The author gratefully acknowledges inclusion of these pages
in the **EEVL** -
[the Enhanced and Evaluated Virtual Library]
The Internet Guide for Engineering, Mathematics and Computing
(formerly the Edinburgh Engineering Virtual Library)
a service of the Heriot-Watt University funded by the JISC.

LEGACY

What happens to <u>all this</u> when I <u>DIE</u> or (heaven forfend!) **lose interest?** See LEGACY.

THUMBS UP!

THUMBS UP! - Support your local police, fire, and emergency personnel!

S. Berliner, III

To contact S. Berliner, III, please click here.

INDEX PAGE NEXT PAGE

To tour the Ultrasonics pages in sequence, the arrows take you from this first page (Ultrasonics index, Applications List, Keywords/Applications Index, and Brain Storming) to page A ("Condensed Guide to Ultrasonic Processing" and "A Popularized Guide to Ultrasonic Processing"), Page 1 (with "A Popularized Guide to Ultrasonic Cavitation" and Tubular Horns), Page 1A ("Amplitude Measurement", Free Bubbling, Bubble Entrapment, Foaming and Aerosoling, and Extenders), Page 2 (More on Cavitation and "Ultrasonics and Fine Particles"), Page 3 ("Ultrasonic Sterilization and Disinfection","Ultrasonics, Hearing, and Health", Ultrasonics and Living Organisms, and What's New?), Page 4 (Foaming and Aerosoling), Glossary Page, Cleaning Page (Immersible Transducers and What's New?), Bibliography Page 1 (Reference Books on Acoustics, Vibration, and Sound), Bibliography Page 2 (Sonochemistry), and Bibliography Page 3 (Selected Articles).

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Updated: 25 Oct 2002, 09:15 ET
(Created 19 Apr 2001)
[Ref: This is usonicsa.html (URL http://home.att.net/~Berliner-Ultrasonics/usonicsa.html)]

S. Berliner, III's

Ultrasonics Page A

Consultant in Ultrasonic Processing
"changing materials with high-intensity sound"

Technical and Historical Writer, Oral Historian
Popularizer of Science and Technology

S. Berliner, III

Consulting in Ultrasonic Processing

SONOCHEMISTRY * REACTION ACCELERATION * DISRUPTION
HOMOGENIZATION * EMULSIFICATION * POLLUTION ABATEMENT
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MEMBER
Board of Directors

[New 2000 Logo -

INDEX

(Truncated to save space)

PLEASE NOTE: If some internal links refuse to work,
please click on Back and scroll down.

(A Layperson's Explanation of a Complex Letterhead)
{moved from the main ultrasonics page on 05 Jan 2002}.

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

Failure Modes in Horns.

Ultrasonic Soldering, Galvanizing, etc.

On Ultrasonics Page 1 (the next page - created 12 Feb 00):

AL-1V - "A POPULARIZED GUIDE TO ULTRASONIC CAVITATION"
(A Non-Technical Explanation of "Cold Boiling").

TUBULAR HORNS (Radial Radiators).

CARE of TIPS (Radiating Faces).

ULTRASONIC DEGASSING.

On Ultrasonics Page 1A (rearranged 12 Feb 00):

AL-4 - AMPLITUDE MEASUREMENT.

Free Bubbling.

Bubble Entrapment.

Extenders.

Call for Contributions for Book.

On Ultrasonics Page 2:

More on Cavitation.

AL-2 - "ULTRASONICS AND FINE PARTICLES -
BENEFICIATION OF SLURRIES AND FINE-PARTICLE SUSPENSIONS
[CERAMICS, COAL & ORES, COATINGS, COLUMN PACKINGS,
SINTERING, SLIPS].

On Ultrasonics Page 3:

AM-1 - "ULTRASONIC STERILIZATION and DISINFECTION".

UM-1 - "ULTRASONICS, HEARING, and HEALTH".

Ultrasonics and Living Organisms.

What's New?

On Ultrasonics Page 4:

Foaming and Aerosoling - moved 28 May 02 from Page 1A.

Ultrasonic Propulsion (Propulsive Force) - Moving Material.

Ultrasonic Fountains - Atomization, Nebulization, Humidification, Misting, Particle Creation and Sizing.

Ultrasonics and Nuclear Fusion.

Quick Links for Ultrasonic Probe Manufacturers (moved 10 Jul 2002).

On the Ultrasonic Cleaning Page:

ULTRASONIC CLEANING {in process}.

Immersible Transducers.

What's New?

On the ULTRASONICS GLOSSARY page:

ULTRASONICS GLOSSARY {in process}.

ULTRASONICS BIBLIOGRAPHY

- Ultrasonic Bibliography Page 1 - Reference Books on Acoustics, Vibration, and Sound.
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- Ultrasonic Bibliography Page 3 - Selected Articles.

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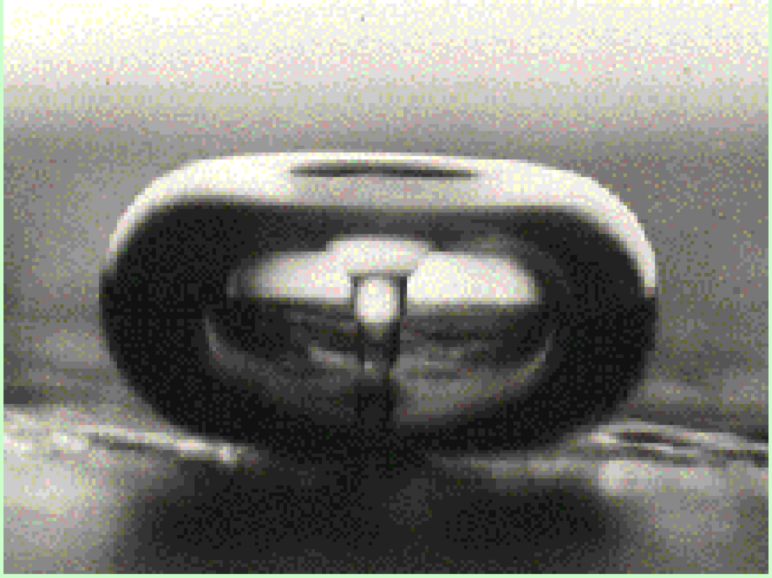
THE CAVITATION BUBBLE



[image from University of Washington, Applied Physics Laboratory (Lawrence Crum, Ph.D.) - bubble diameter approximately 1mm]

ULTRASONIC PROCESSING

(Moved from the main ultrasonics page on 05 Jan 2002)

Power vs. Intensity

As a prefatory remark, I wish to stress a point made directly earlier (on Ultrasonics Page 1, in AL-4 - AMPLITUDE MEASUREMENT) and indirectly in several other places. There it was incident to the matter at hand (measurement); it is, however, an over-arching matter. "Intensity" and "power" in probe sonication are two wholly inter-related yet different concepts. Power, measured in watts, is the energy required to move the mechanical masses used to create cavitation in a liquid. It is the energy required to drive the radiating surface of a given horn, at a specified amplitude of vibration (the excursion or stroke), against a specified load, at the fixed resonant frequency of the device. Intensity, on the other hand, is a measure of the energy available per unit volume of liquid and is directly related to amplitude. It is the intensity of cavitation that determines the effectivity of sonication, not the total power applied to the system. Intensity is directly related to the amplitude of the radiating face of the tip or horn. It is amplitude that must be provided, maintained, and monitored.

Any truly satisfactory ultrasonic liquid processor or cell disruptor must provide controlled amplitude under all varying load conditions within specifications. It does so by regulating the power output to maintain the frequency against any imposed load, usually by adjusting the voltage impressed on the piezo-electric crystals (or the magnetic coil for a magnetostrictive device). Think of the horn or probe tip as a piston, operating in a liquid cylinder. This is not as illogical as it may seem at first glance; at the frequncies involved (generally 20KHz and higher), the molecules of the liquid do not have time to restore fully after each stroke, thus generating the extremes of pressure and vacuum that are inherent in this process. The energetics are thus virtually identical to a problem in simple hydraulics; the larger the piston (radiating face) diameter, the longer the stroke (amplitude), the faster the stroke rate (frequency), the higher the static head (pressure), the more resistant and cold the liquid (viscosity), the higher the power required to move the radiating face. Similarly, the faster and the further you move the tip, the higher the energy you impart to the cavitation bubble and the greater the intensity of the energy released in the implosion of that bubble.

Thus, power drawn is dependant on the geometry of the radiator/liquid arrangements and intensity is related only to amplitude (excursion) of the radiating face. The amount of power required to provide and maintain that intensity thus is a multi-variable parameter.

Further, liquids, especially water, are a "neurotic" load. Many variables affect the efficiency of cavitation and thus the power drawn. As the load increases on the generator, the vibrating body reacts by deccelerating, slowing in frequency; it "bogs down". The generator (a well-regulated one, anyway) responds with more voltage, accelerating the motion of the radiating masses and thus increasing frequency. Once the system reaches its voltage limit, amplitude can not be increased further. In addition (from "Cleaning"), once cavitation bubbles "blanket" the radiating face, an increase in amplitude will produce no more cavitation; "**blanketing**" is a limiting phenomenon in the cavitation field in which the density of the bubble cloud is so great that no further cavitation can take place when additional energy is introduced (analgous to the phenomenon at the temperature of thermal boiling, above which no further change of state occurs). The "blanketing threshold" is that intensity of cavitation at which the blanketing phenomenon occurs; for practical purposes, the blanketing threshold may be considered a relative term based on the efficiency of conversion from increased radiated energy to increased cavitation.

It is my intention to expand upon this in an update of my seminal articles, "*Power vs. Intensity*" and

"*Application of Ultrasonic Processors (Power vs. Intensity in Sonication)*" of 1984 and previous.

AL-1C
4-97

CONDENSED GUIDE TO ULTRASONIC PROCESSING

(A Layperson's Explanation of a Complex Letterhead)

{and Business Card!}

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.

---*---

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

(Moved from the main ultrasonics page on 19 Apr 2001)

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.<[P> 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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For more information, please contact S. Berliner, III.

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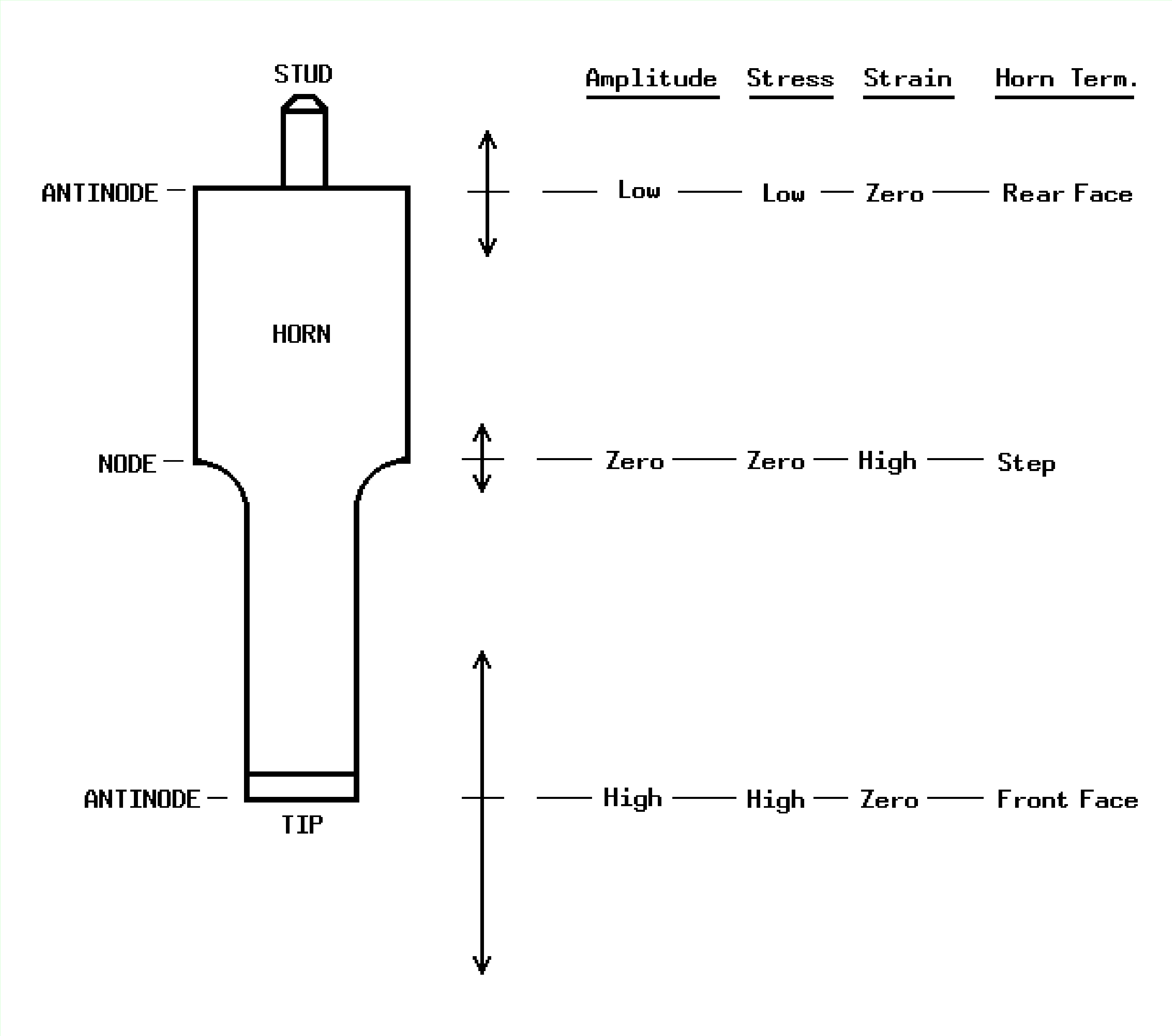
Failure Modes in Horns

Several mentions have been made of ways in which horns (and transducers and extenders and boosters) can fail. It may be well to consolidate this information in one place.

As has been noted elsewhere on this site, horns are longitudinal bells, carefully designed and crafted to resonate primarily in the axial mode. That is the critical word, though, "primarily". As with any elastic body, when it shrinks in one (or two) dimension(s), it must expand in the other(s). The analogy of a child's sausage balloon is most apt; squeeze the big end and the small end shoots (extends) 'way out. In more technical terms, use the analogy of a differential piston; a small excursion of the larger diameter will result in a greater excursion of the smaller diameter ("compounding"). Mass must be conserved. This is how the horn acts as a mechanical amplifier. Excerpting from the horn segment of the Convertor-Stack-Horn Layout drawing and the terminology of the succeeding drawing, both on the main Ultrasonic page, we can see the concepts more graphically:



The center of mass, hopefully the nodal point, where the molecules are being alternately forced together and apart, both radially and axially in opposite cycles, sees the greatest stress. Thus, the fatter the horn (the lower the aspect ratio), the more likely it is to heat and fail in the nodal point. The ends, especially the end with higher amplitude of excursion, where the molecues are primarily in alternating logitudinal tension and compression, see the highest strain. Thus, the strain is worst where the connections are made to the convertor/front driver/transducer and at the tip (if removable). Any imperfection in material or construction at either the node or the antinodes, then, will become a stress raiser, a point of likely failure.

At nodes (centers), the most critical place is the **STEP**, the transition from one diameter to another; any notch from damage or from poor design or machining is almost garanteed to cause failure, especially at high amplitudes.

Similary, at antinodes (ends), any flaw in the connecting stud, grit in the joint, non-planar mating of the opposing faces, skewed alignment, etc., will almost certainly cause heating and eventual failure. In cases of extreme extension (as in ultra-high amplitude Microtips), operating near or at the tensile limit of the material, the slightest discrepancy can cause virtually instantaneous failure.

Such failure is not catastrophic (except financially); the horn or tip or stud merely fractures and falls apart, sometimes almost instantaneously. Quite often, however, the immediate precursor and warning is a screech of tortured metal, sounding for all the world like the proverbial stuck pig (never having been "blessèd" with the dubious privilege of hearing same, I must use my perfervid imagination).

For a brilliant (literally and figuratively) dissertation on horn design, see Don Culp's Krell Engineering site, replete with horn performance (FEA) animations. NEW!

See also CARE of TIPS (Radiating Faces).

{more to follow on this topic}

Ultrasonic Soldering, Galvanizing, etc.

One of the earliest applications of power ultrasonics was ultrasonic soldering. This entails basically using a beefed-up, high-temperature version of an ultrasonic cleaning tank, often requiring one or more magnetostrictive transducers. This is basically dip-soldering, using the cleaning action of cavitation to prepare the surfaces by cleaning and deoxidizing, enhance wetting and recrystallization, and mix the solder thoroughly. Drag-out and whiskering is minimized and resultant joints are stronger.

In addition, ultrasonic processing probes have been adapted to serve as ultrasonic soldering irons; such difficult materials as aluminum, stainless steel, ceramics, and even glass can be soldered and, because such sufaces can be wetted, disparate materials can be soldered. {The author well remembers the thrill of first soldering glass.}

By extension, subject to the limitations of temperature, the same operations can be used for silver soldering and galvanizing and related processes.

A completely new field of **wave soldering** has been developed for soldering printed circuit boards and the like at megahertz frequencies, utilizing Lambda waves (lateral propagation), especialy well suited for through-hole applications, but is beyond the scope of this presentation.

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

Call for Contributions

For the forthcoming 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 and refer you to the new Continuation Page 1 where details of this request have been moved.

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. However, as what I believe to be a public service, I shall be adding more of my monographs on ultrasonics on this site; watch for them in the index (above).

You may wish to visit main ULTRASONICS page, Continuation Page 1, Continuation Page 2, and Continuation Page 3 with more on **ultrasonics**, as well as the Ultrasonics Cleaning page {in process} and the Ultrasonics Glossary page {also in process}.

Those persons interested in **SONOCHEMISTRY** might wish to look at
Prof. Kenneth S. Suslick's and Shiga University's Sonochemistry pages.

The author gratefully acknowledges inclusion of these pages
in the **EEVL**
(the Edinburgh Engineering Virtual Library),
"the UK gateway to quality engineering information on the Internet",
a service of the Heriot-Watt University funded by the JISC.

LEGACY

What happens to all this when I DIE or (heaven forfend!) **lose interest?** See LEGACY.

THUMBS UP!

THUMBS UP! - Support your local police, fire, and emergency personnel!

S. Berliner, III

To contact S. Berliner, III, please click here.

PREV.PAGE = FIRST PAGE NEXT PAGE

To tour the Ultrasonics pages in sequence, the arrows take you from the first page to this page A, pages 1, 1A, 2, 3, and, Glossary Page, Cleaning Page, and Bibliography Pages 1, 2, and 3.

Return to Top of Page

Updated: 27 Sep 2002, 06:15 ET
[Ref: This is uson-0.html (URL http://home.att.net/~Berliner-Ultrasonics/uson-0.html)]
{Please note that uson0.html is U/S Page 1 and uson1.html is U/S Page 1A. }

S. Berliner, III's

Ultrasonics Page 1

Consultant in Ultrasonic Processing
"changing materials with high-intensity sound"

Technical and Historical Writer, Oral Historian
Popularizer of Science and Technology

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

[See "Keywords (Applications) Index" on Page 3.]

Specializing in brainstorming and devil's disciplery for new products and reverse engineering and product improvement for existing products.

{"Imagineering"}

[consultation is on a fee basis]

MEMBER
Board of Directors

[New 2000 Logo - all rights reserved to UIA.]

INDEX

PLEASE NOTE: If some internal links refuse to work,
please click on Back and scroll down.

On the main Ultrasonics Page (the preceding page):

On Ultrasonics Page A (the next page - created 19 Apr 01):

On Ultrasonics Page 1 (this page):

Ultrasonic Propulsion (Propulsive Force) - Moving Material. NEW!

Ultrasonic Fountains - Atomization, Nebulization, Humidification,
Misting, Particle Creation and Sizing. NEW!

Ultrasonics and Nuclear Fusion. NEW!

Quick Links for Ultrasonic Probe Manufacturers (moved 10 Jul 2002).

On the Ultrasonic Cleaning Page:

ULTRASONIC CLEANING {in process}.

Immersible Transducers.

What's New?

On the ULTRASONICS GLOSSARY page:

ULTRASONICS GLOSSARY {in process}.

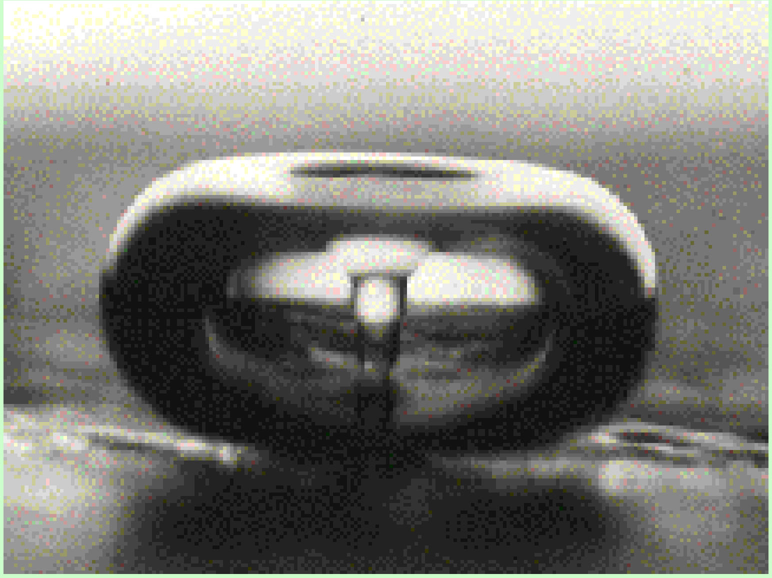
ULTRASONICS BIBLIOGRAPHY

Ultrasonic Bibliography Page 1 - Reference Books on Acoustics, Vibration, and Sound.
Ultrasonic Bibliography Page 2 - Sonochemistry.
Ultrasonic Bibliography Page 3 - Selected Articles.

You are invited to visit the ULTRASONIC INDUSTRY ASSOCIATION home page.

CALL FOR CONTRIBUTIONS: I am writing a book on "***High-Intensity Ultrasonic Technology and Applications***" (intended for Marcel Dekker's "*Mechanical Engineering Series*", edited by Profs. Lynn L. Faulkner and S. Bradford Menkes). This book will focus on the practical application of power (high intensity) ultrasonics, the use of ultrasonic energy to change materials. **Contributions** are welcome.

THE CAVITATION BUBBLE



[image from University of Washington, Applied Physics Laboratory (Lawrence Crum, Ph.D.)
- bubble diameter approximately 1mm]

ULTRASONICS - continued

ULTRASONIC CAVITATION

[See the photo of a cavitation bubble at the top of this page
and the section, More on Cavitation, on page 2]

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AL-1V              A POPULARIZED GUIDE TO ULTRASONIC CAVITATION
4-97
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(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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For more information, please contact S. Berliner, III.

Let me repeat here what I noted on a preceding page: NEW!

CAVITATION ACCELERATES BOTH CHEMICAL AND PHYSICAL REACTIONS.

This discussion continues in more technical detail
in More on Cavitation on Page 2.

AM-7 Applications Monograph - ULTRASONIC DEGASSING 3-00

NEW!

The action of cavitation induced by ultrasonic energy imparted to a liquid has been introduced in preceding application monographs. This short monograph is intended to consolidate references to ultrasonic degassing given in related documents into one convenient entity.

Cavitation requires some discontinuity in the liquid, such as gas bubbles or dust motes, about which the bubble forms. A theoretically pure liquid would require impractically high power levels to initiate cavitation. Ultrasonic degassing initially increases the efficiency of cavitation by removing air bubbles which absorb acoustic energy and damp sonication.

Ultrasonic degassing is perhaps a slight misnomer, inasmuch as gases are forced both in and out of suspension and solution by ultrasonic action. Degassing in an ultrasonic field occurs when the rapid vibration of gas bubbles occasioned by the passage of acoustic waves from the radiating surface through the liquid causes adjacent bubbles to touch and coalesce. As this action progresses with time, bubbles grow to a size sufficient to allow them to rise up through the liquid, against gravity, until they reach the surface, rise through, and pop (there may be a more elegant scientific term but I am sure the reader will understand what is meant by "pop").

A distinction should be made here between the bubbles which are formed by cavitation and those which occur naturally in the parent liquid or are induced by ultrasonic action (sparging). Cavitation bubbles, which range in size from infinitesimal to visible (40µm and up) appear only when the radiating surface is activated and vanish apparently instantaneously when the power is turned off (in actual fact, they vanish within a half cycle or 0.000025 sec. at 20KHz). Naturally-occurring bubbles of entrapped air or other gases are most evident in freshly-poured hot tap water as a cloudiness or in still water as small bubbles adhering to the undersurface and the vessel walls. Sparged bubbles, those induced mechanically by external means, such as by ultrasonic action at or near the gas-liquid interface (the surface) tend to float in the liquid and even cause foam.

Coalescing of either type of bubble is fast and quite visible in water or other clear liquids and is even visible in translucent liquids since it occurs throughout the bath and so occurs at the walls and surface where it can be viewed. The assumption is made, perhaps unwarrantedly, that the vessel is clear or provided with viewports or other means of viewing what occurs in the liquid - such visibility is a prerequisite for visual determination. Should visual examination of the process not be possible, other means of determination, such as neutron radiography, may be employed.

Because a critical factor in successful degassing is that the bubbles grow, rise, and escape through the surface, parameters such as temperature, viscosity, vapor pressures, and surface tension are also critical. The distance bubbles must travel to reach the surface thus becomes of interest and the process must be designed to allow for such transit time. In order to provide for transit, the energy may be interrupted periodically, "pulsing" the activity of the radiator. To further complicate matters, since cavitation causes both sparging and coalescence, the energy level (intensity) must be carefully selected. These are done empirically; in this area of endeavor, nothing beats cut-and-try experience, and it can be done rapidly and conveniently.

Pulsing is most commonly done by means of a pulsing circuit provided integrally in the generator of the leading brands of ultrasonic processors. These features generally interrupt the low-voltage control circuitry and allow for variation of pulse interval and pulse length. In degassing, short bursts at low to moderate intensity, followed by relatively long recovery periods to allow bubbles to rise, suffice. Time ranges might be on the order of a half a second on and ten or twenty seconds off for liter-batch quantities.

Providing a vacuum above the gas-liquid interface (surface) greatly enhances degassing and requires both a pulse-free (constant pressure) vacuum source and a means of disposing of the extracted gases if they are in any way environmentally unsafe.

NOTE: Bubbles that appear in the body of the sample liquid during sonication may also represent sonochemical degradation products or high volatiles driven out by cavitation. If these phenomena are possible, chemical analysis is recomended in critical processes.

WARNING: Flammable or explosive volatiles may be driven out by cavitation and could ignite. Virtually no sonication devices are explosion-proof and only extreme measures can render them even explosion-resistant.

In continuous flow operations, some form of standpipe must be provided to prevent pumping pressure from overcoming evacuation pressure, which might otherwise cause the process liquid to flow out the gas outlet. The height of the standpipe is determined by the weight of the liquid in it, which must exceed the process pressure and the base of the standpipe must be located directly above the cavitation field. Save such a standpipe, elaborate separation technologies must be employed.

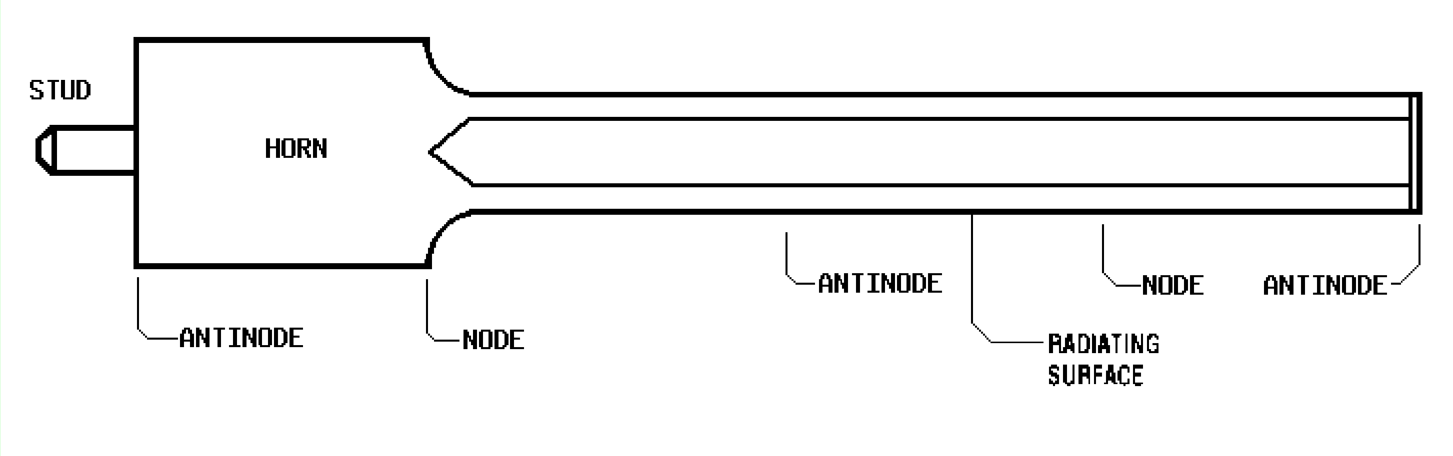
Ultrasonic degassing is a growing area of application, unfortunately held back more by details of mechanical systems (and secrecy) than by the ultrasonic equipment available. From analysis of dissolved oxygen and carbon dioxide content of soft drinks and wines and spirits to production degassing of process lines, application of ultrasonic energy holds promise of continued growth in this field.

Contact the author for more information on the above-noted applications
or other areas in which sonication might prove advantageous.

TUBULAR HORNS
(Radial Radiators)

{preliminary}

A new type of horn is now on the market; unlike standard horns which are solid cylinders of metal, the new style is hollow and it "balloons" (or"bulges") outward when activated away from the transducer crystals, returning to a simple cylindrical form on the return stroke. Thus, the horn radiates radially outward, at right angles to the longitudinal axis. This enable it to process material in a pipe placed around it, or in a beaker or other vessel in which it might be inserted. Here is a diagrammatic representation:



Tubular Horn
(One-and-a-Half Wavelength shown)

{Incorrect image replaced 20 May 00}

CARE of TIPS (Radiating Faces)

{PRELIMINARY}

DISCLAIMER: The information given here is generic and should NOT be taken as more authoritative than that contained in the instruction manual which accompanies (or should accompany) the device.

Further, the vast bulk of tips and horns are made of titanium alloy and these instructions apply specifically to that metal, as well as to monel, nickel, and similar "bell metal" alloys. Similar effects have been observed in glass, ceramic, and single-crystal radiating faces.

Another caveat - these instructions do NOT apply to bonded crystal tips, such as sapphire tips; they must be replaced by the factory.

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As explained in more detail in the Cavitation Bubble section on Ultrasonics Page 3, the very action of cavitation erodes (and, to some smaller degree, accelerates corrosion of) the radiating surface of the replaceable tip or solid horn. Performance degrades in proportion to the degree of roughness of the surface until a point is reached, if the tip does not disntegrate or stop resonating first, at which no significant energy passes into the liquid sample. Tips which are so heavily eroded (pitted) that the dendritic peaks and valleys are obvious to the unaided eye can trap air or gas bubbles in the valleys (concavities) and, in effect, stop radiating. Most manufacturers supply tips with a smooth finish (it is a waste of time and money to mirror-polish tips; the finish wlll matte almost instantly on use). The wear pattern is generally symmetrical on a round or rectangular face, with a small rim of uneroded material remaining around the edge and the balance of the face becoming gradually darker as material is eroded and the surface roughened. The exception to this is when wear occurs in an abrasive particulate suspension, in which case the impact of the particles polishes the surface even as it erodes it. Serious erosion usually occurs in concentric rings and really severe erosion can eat into the dendritic structure of the tip, even perforating through to the back end (the tip/horn joint), in which case the horn itself then becomes eroded and useless. Further, when erosion progresses so far that pitting extends into the smooth, erosion-free circumferential ring at the edge of the tip face, the tip (or solid horn) is irreparable and must be replaced.

Tip life can be best be extended by polishing the tip (the radiating face , only) with an abrasive paper or cloth; do **NOT** attempt to lathe turn the face - too much material will be removed. Remember that the tip is part of a finely-tuned resonant body (in effect, a bell) and removing material, by erosion or abrasion, shortens the length and thus raises the natural resonant frequency. Removing too much material may drive the frequency above that which the generator can accomodate and the machine may drop out of resonance. Trying to force a machine to resonate above its frequency limit could destroy the driving circuit or even cause failure of the transducer.

To properly dress a worn tip, do so BEFORE erosion progresses beyond mere matting of the finish. Hold the tip or horn absolutely perpendicular to a piece of fine carbide grit paper or emery cloth (NOT "sandpaper") placed on a hard, flat work surface and work the tip **lightly** across the grit in a circular pattern. Do **NOT** rock the tip or score it by bearing down heavily; anything that detracts from a smooth, flat finish will cause accelerated erosion. Similarly, do **NOT** try to dress a tip by hand polishing with sandpaper or a file. Stop dressing after the matte grey finish is replaced by a finely criss-crossed pattern of fine scratch marks.

Above all, do **NOT** attempt to dress a severely eroded tip! Replace it.

If the machine is old and does not have automatic tuning, or if it is a middle-generation machine that requires nominal tuning, always retune after dressing a tip.

{more to follow}

You may wish to visit the main ULTRASONICS page, Continuation Page 2, and Continuation Page 3 with more on **ultrasonics**, as well as the Ultrasonics Cleaning page {in process} and the Ultrasonics Glossary page {also in process}.

Those persons interested in **SONOCHEMISTRY** might wish to look at
Prof. Kenneth S. Suslick's and Shiga University's Sonochemistry pages.

THUMBS UP!

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S. Berliner, III

To contact S. Berliner, III, please click here.

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To tour the Ultrasonics pages in sequence, the arrows take you from the main Ultrasonics Page (Ultrasonics index, Applications List, Keywords/Applications Index, and Brainstorming) to Page A ("Condensed Guide to Ultrasonic Processing" and "A Popularized Guide to Ultrasonic Processing") to Page 1 (with "A Popularized Guide to Ultrasonic Cavitation" and Tubular Horns), Page 1A ("Amplitude Measurement", Free Bubbling, Bubble Entrapment, Foaming and Aerosoling, and Extenders), Page 2 (More on Cavitation and "Ultrasonics and Fine Particles"), Page 3 ("Ultrasonic Sterilization and Disinfection","Ultrasonics, Hearing, and Health", Ultrasonics and Living Organisms, and What's New?), Glossary Page, Cleaning Page (Immersible Transducers and What's New?), Bibliography Page 1 (Reference Books on Acoustics, Vibration, and Sound), Bibliography Page 2 (Sonochemistry), and Bibliography Page 3 (Selected Articles).

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S. Berliner, III's

Ultrasonics Page 1A

Consultant in Ultrasonic Processing
"changing materials with high-intensity sound"

Technical and Historical Writer, Oral Historian
Popularizer of Science and Technology

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

[See "Keywords (Applications) Index" on Page 3.]

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Brain Storming - bright ideas, pipe dreams, pie-in-the-sky? NEW!

On Ultrasonics Page A

AL-1C - "CONDENSED GUIDE TO ULTRASONIC PROCESSING"

(A Layperson's Explanation of a Complex Letterhead).

AL-1P - "A POPULARIZED GUIDE TO ULTRASONIC PROCESSING".

On Ultrasonics Page 1 (the preceding page):

AL-1V - "A POPULARIZED GUIDE TO ULTRASONIC CAVITATION"
(A Non-Technical Explanation of "Cold Boiling"
moved from the preceding page 12 Feb 00).

ULTRASONIC DEGASSING. NEW!

Ultrasonic Propulsion (Propulsive Force) - Moving Material. NEW!

Ultrasonic Fountains - Atomization, Nebulization, Humidification, Misting, Particle Creation and Sizing. NEW!

Ultrasonics and Nuclear Fusion.

Quick Links for Ultrasonic Probe Manufacturers (moved 10 Jul 2002).

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Immersible Transducers.

What's New?

On the ULTRASONICS GLOSSARY page:

ULTRASONICS GLOSSARY {in process}.

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Ultrasonic Bibliography Page 1 - Reference Books on Acoustics, Vibration, and Sound.
Ultrasonic Bibliography Page 2 - Sonochemistry.
Ultrasonic Bibliography Page 3 - Selected Articles.

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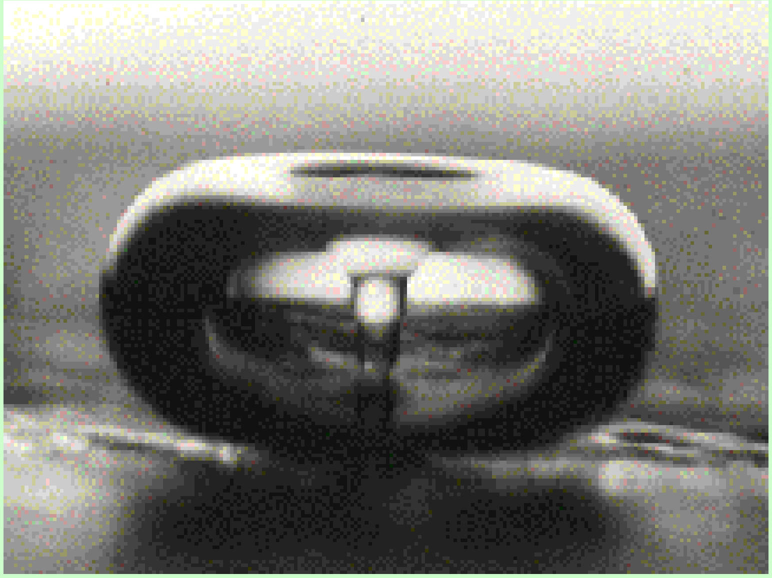
THE CAVITATION BUBBLE



[image from University of Washington, Applied Physics Laboratory (Lawrence Crum, Ph.D.)
- bubble diameter approximately 1mm]

ULTRASONICS

AL-4 AMPLITUDE MEASUREMENT Aug 99

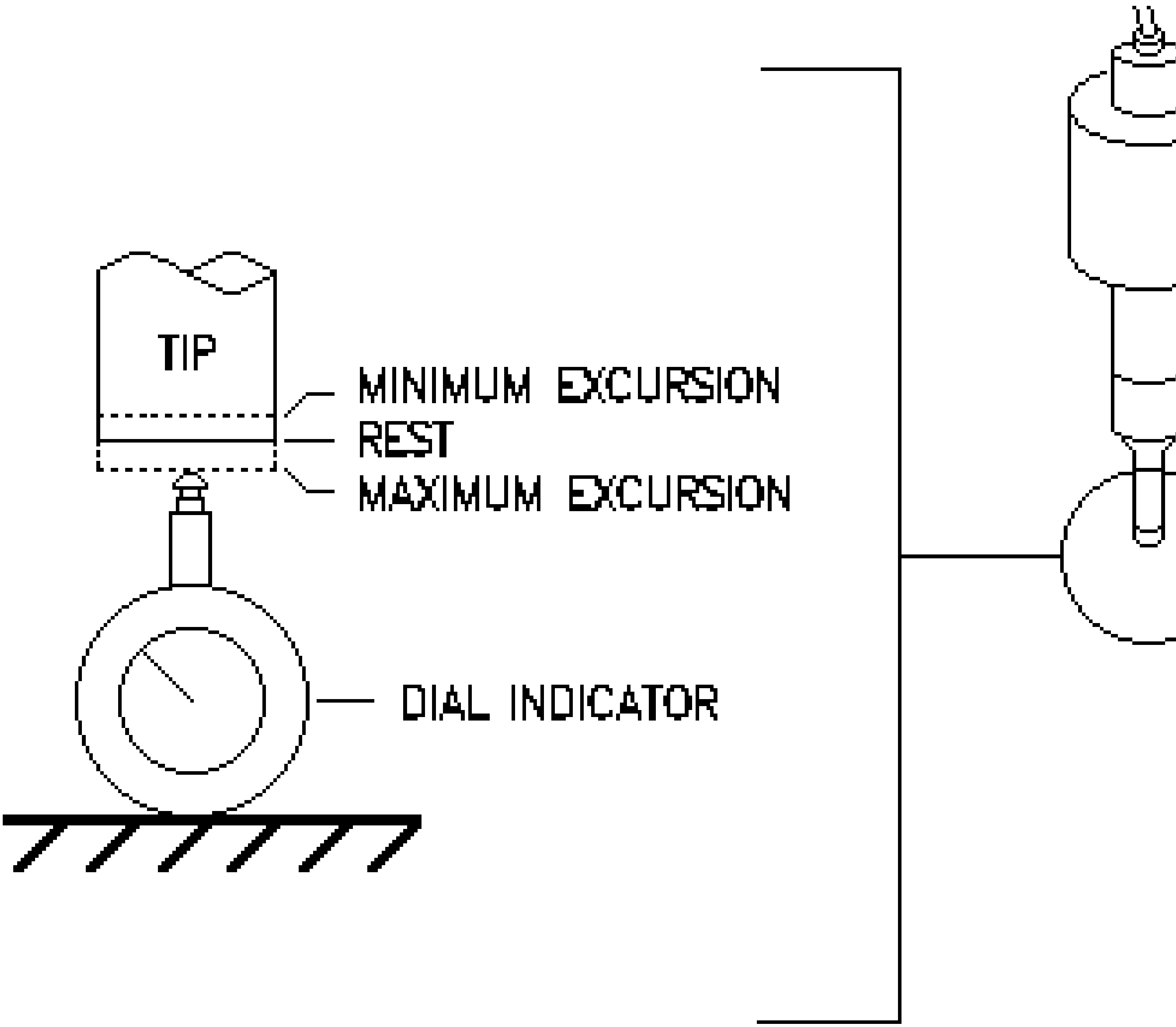
{This is a DRAFT, only; please substitute reprint PVI-2 for AP-0}

1. **GENERAL -** The difference between the terms "intensity" and "power" in probe sonication has been discussed in detail in Applications Primer AP-0, normally appended hereto, q. v. Power is measured in watts. It is the energy required to drive the radiating surface of a given horn, at a specified amplitude of vibration, the excursion or stroke, against a specified load, at the fixed resonant frequency of the device to generate cavitation in a liquid. Intensity is a measure of the energy available per unit volume of liquid and is directly related to amplitude. It is the intensity of cavitation that determines the effectivity of sonication in disrupting cells, accelerating physical and chemical reactions, degassing, mixing "immiscible" liquids, shearing DNA, disaggregating shale, and so forth, not the total power applied to the system. Intensity is directly related to the amplitude of the radiating face of the tip or horn. It is amplitude that must be provided, maintained, and monitored. Any truly satisfactory ultrasonic liquid processor or cell disruptor must provide controlled amplitude under and all varying load conditions within specifications.

1.1 Since the amplification factor of the horn is fixed by its geometry (refer to AP-0), the measurements can be taken from any surface perpendicular to the longitudinal centerline. Thus, measurements can be taken outside a sealed pressure vessel, even by direct contact, without breaching the vessel.

2. **MEASUREMENT MEANS -** Amplitude can be measured by various methods which are mechanical, optical, electrostrictive (piezoelectric or magnetostrictive), ultrasonic, etc., both directly and indirectly.

3. **MECHANICAL MEANS -** An accurate, simple, and historically least expensive means to measure tip amplitude is by direct mechanical contact. A suitably calibrated dial indicator can read amplitude directly from the radiating face.



[Illustration © S. Berliner, III - 1999]

3.1 Originally, the dial indicator was mounted alongside the horn on a fairly rigid bracket which also held an axle for a lever projecting under the radiating face. The tip and lever were under the liquid surface and the indicator above. This complexity was occasioned by the inability of early ultrasonic disruptors/ processors to maintain amplitude unloaded. With accurate constant smplitude control, these measurements can now be made in air, with the horn or tip unloaded. This technique is shown in Figure 1. The dial indicator method can be used quite effectively on large horns at moderately high amplitudes within the operating range of a dial indicator. However, the smaller the bulk of the horn and the diameter of the radiating face, the more the dial indicator gearing loads the resonant device and affects the output. In addition, too much amplitude may destroy the dial indicator bearings and gears. However, for those who wish to use this technique, the dial indicator is best nulled while the ultrasonic device is operating and the reading taken when the device is turned off. This will minimize erratic readings made while trying to null the indicator; it will prove amazing how sensitive even the most rigid indicator mounting will be. For this reason, it is absolutely critical for good results that the convertor (transducer housing) and the dial indicator be rigidly secured to a common, rigid mechanical ground. A 3" (76mm) or heavier drill press column and base, readily available from machine tool vendors, with very heavy clamps for the convertor and indicator, is recommended. If the mountings are not heavy, rigid, and secure, readings will drift.

3.2 If the rear surface of the horn projects beyond the front driver and convertor case diameter sufficiently to provide axial access for the dial indicator tip, a reading can be made directly from the top of the rear surface with the indicator upright. The horn amplification factor must be known accurately and verified. Merely taking the ratio of the square of the body and tip diameters may not be sufficently accurate for this method.

3.3 The amplitude read is that of rest-to-peak or single amplitude, which must be doubled if comparing to the parameter normally speci-fied, peak-to-peak or double amplitude. The horn tip merely pushes the indicator tip down and the inertia of the indicator gearing pre-vents it from returning under spring pressure; the net effect is that the indicator "floats" at the maximum excursion of the horn/tip face.

4. **OPTICAL MEANS -** Direct and accurate measurement of radiating face amplitude can also be made without in any way affecting the action of the ultrasonic device or the resultant process by optical means. Direct observation by microscope, indirect observation by electronically-amplified and computer-analysed image processors, interferometer measurements, and other means are available. Optical measurements may be taken both with the tip vibrating in air under no load or under clear or translucent liquid in a transparent vessel. It is even possible to "see" inside an opaque suspension.

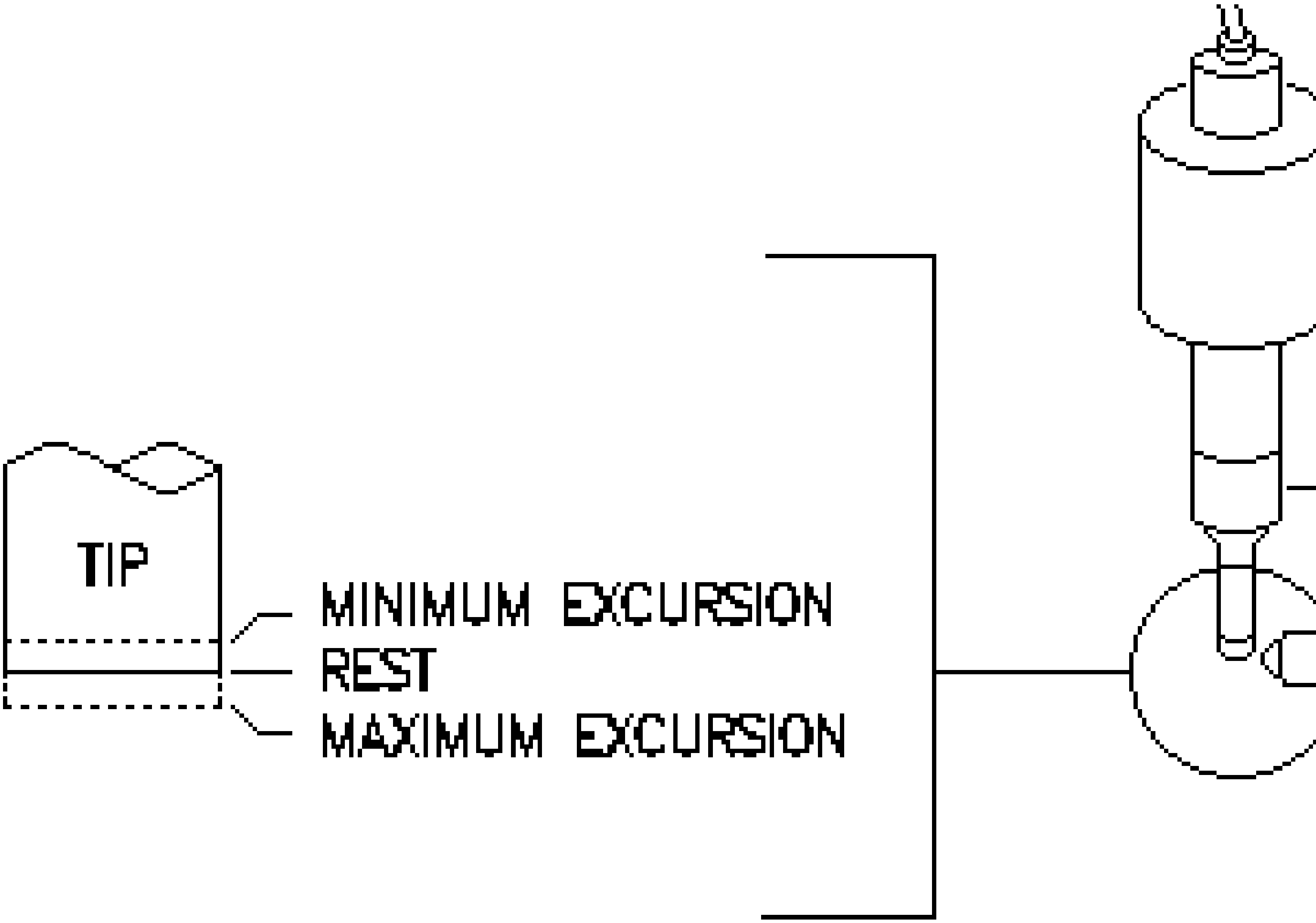


Fig. 2 - Optical Amplitude Meas

[Illustration © S. Berliner, III - 1999]

4.1 A simple, inexpensive field microscope with a calibrated reticle is the least expensive method of optical amplitude determination, as shown in Figure 2. Since the magnitude of vibration at the radiating face is usually in the order of 1 to 250 µm (micrometers) and the microscope axis is at right angles to the axis of the convertor/horn, errors due to parallax or refraction through the liquid/glass inter-face are negligible. The convertor should be set up in a rigid stand with the horn hanging free beneath it. A 100X field microscope with calibrated reticle is oriented perdendicular to the axis of the con-vertor and horn such that the reticle scale is vertical and the long-itudinal (vertical) displacement of the tip can be read directly through the calibrated eyepiece (ocular lens). The microscope is focused on, and the measuring scale is zeroed on, the horizontal image of the radiating face (or on a horizontal scratch or mark on the side of the tip immediately adjacent to the face) and the ultrasonic device activated. The observer sees the edge (or mark) blur and, because of the speed of oscillation, sees two distinct images at each end of the blur. Since the horn is a resonant body, vibrating from rest, the images seen are the peak amplitudes in the positive and negative mode; that is, the viewer sees that point at which the face stops advancing up or down and starts to return to rest. These images, then, are those of maximum positive and negative excursion from rest. The distance measured between these two images is the double amplitude, or peak-to-peak excursion, of the radiating face.

4.2 The microscope image may be electronically amplified and analysed by computerized image processors for greater accuracy and automation.

4.3 As with the mechanical dial indicator method, it is important that the microscope and convertor be rigidly mounted to a common, rigid, mechanical ground. The drill press stand noted in Para. 3.1 is useful.

[Note: It has been reported in using the optical method with magnetostrictive transducers that a line voltage can be superimposed over the driving voltage, especially under fluorescent light, possibly resulting in a blurred image, but this problem does not seem to occur with piezoelectric processors.]

5. **OTHER NON-CONTACT MEANS -** Magnetostrictive and piezoelectric sensors have been used to determine amplitude. One of the first methods was to embed a nickel or monel pin in the back surface of a horn, parallel to the axis of the horn, and place a sensing coil around it. As the pin was accelerated axially, it changed the impedance of the coil. Piezoelectric wafers can be placed in the stack (new piezoelectric polymer films just introduced at this writing may find use in this manner) and send a signal proportional to amplitude. Voltage feedback from the driving crystals may also provide a proportional signal. Laser and microwave interferometers and similar devices can be used to sense high frequency displacement. X-ray or neutron sources might be combined with interferometry to read amplitude with closed volumes. Ultrasonic sensors may also be used, provided the frequency is such that it does not interact with that of the device being measured.

6. **EQUIPMENT -** The 100-power field microscope with calibrated reticle referenced in Paragraph 4.1 for optical measurement of tip amplitude was imported from Japan by Southern Precision Instruments under their Part Number 1837 and is {was?} available as their Direct Measuring Microscope under Catalog No. N61,193 (on Page 21 in August 1, 1988, Catalog 18N7) from:

Edmund Scientific Co.   Tel.: 609-547-6250 or -3488
101 East Gloucester Pike

Barrington, NJ 08007 FAX: 609-573-6295

The dial indicator referenced in Section 3 for direct mechanical measurement of tip amplitude was made in Japan by Mitutoyo as their Model No. 2109, 6 Jewels, Shockproof, rated at 0.001 - 1 mm or Model No. 2119, Jewelled, rated at 0.001 - 5 mm. The choice of range (1 to 40 mils or 1 to 200 mils) is best determined by the expected amplitude to be measured. The Model 2109 is desirable for greater accuracy at lower amplitudes; the Model 2119 is chosen for measuring higher amplitudes. A flat indicator tip was originally used; later both cupped (concave) and broad radius (convex) tips were tried, but flat tips seem best, overall. It is important to assure perpendicularity such that the horn or sample radiating face doesn't skitter off center. One source for the dial indicator is {was?}:

MSC Industrial Co. Tel.: 800-645-7270 or 516-349-7100
Long Island Division Local: 800-645-7008 or 516-645-7270
151 Sunnyside Blvd. FAX: 800-255-5067
Plainview, NY 11803 Telex: 221719 SIDTL UR

The metric system model numbers noted did not appear in MSC's last-seen catalog; only English system indicators were listed.

Neither the specific microscope or indicators shown, nor their sources, are critical. Equivalent or better equipment will serve.

7. For information regarding any specific processor/disruptor and horn or tip, refer to the referenced primer or contact the author.

Free Bubbling

Elsewhere on this site, I use the term "**Free Bubbling**"; it is not a term of art to my knowledge. By "Free Bubbling", I mean the outgassing of air (or other gas) bubbles from the liquid in which cavitation is to (takes/has taken) place, without the application of ultrasonic energy. The difference between free bubbling and cavitation bubbles can be easily and dramatically demonstrated. Observe the bubble formation in the cavitation field in an active tank or in front of the radiating surface of an active, immersed sonicating probe. Then turn off the power. The cavitation bubbles will disappear instantly (within one half-cycle of the frequency, far too quickly for you to be misled); any bubbles which then remain and rise out of the bath are air or gas bubbles, degassed from the liquid or created at an air/liquid/object interface.

Bubble Entrapment

These pages speak to degassing of liquids by active cavitation; they have not, however, to date (29 Sep 99), dealt with the opposite phenomenon, **Bubble Entrapment**. By this is meant the forcing, by various mechanisms, of bubbles of ambient gas (usually air) under the surface of the liquid being used in treating an object or a liquid being treated. The degree to which this occurs is directly proportional to the amplitude of vibration of the probe or tank wall (or any vibrating object) at the object/gas/liquid interface (visually somewhat akin to a triple point in metallurgy), as well as inversely to the frequency.

Where a vibrating object breaks the gas/liquid interface, it can drag molecules of gas adhering to its surface under the interface (liquid surface) on the forward (downward) stroke and release them on the reverse stroke. The further and faster the excursion of the object, the greater the likelihood of entrapment. In extreme cases, usually limited to probe sonication, although not impossible in tank cleaning, this can result in foaming of the liquid and loss of transmission of ultrasonic energy.

Foaming and Aerosoling

When a foam is generated in a lab sample, it interposes bubbles between the radiating surface and the body of the liquid to be treated or in which treatment is to occur. This is somewhat akin to "blanketing" but is the result of gas bubbles, not cavitation bubbles interfering with free radiation of acoustic energy into the bath. It is a self-limiting process.

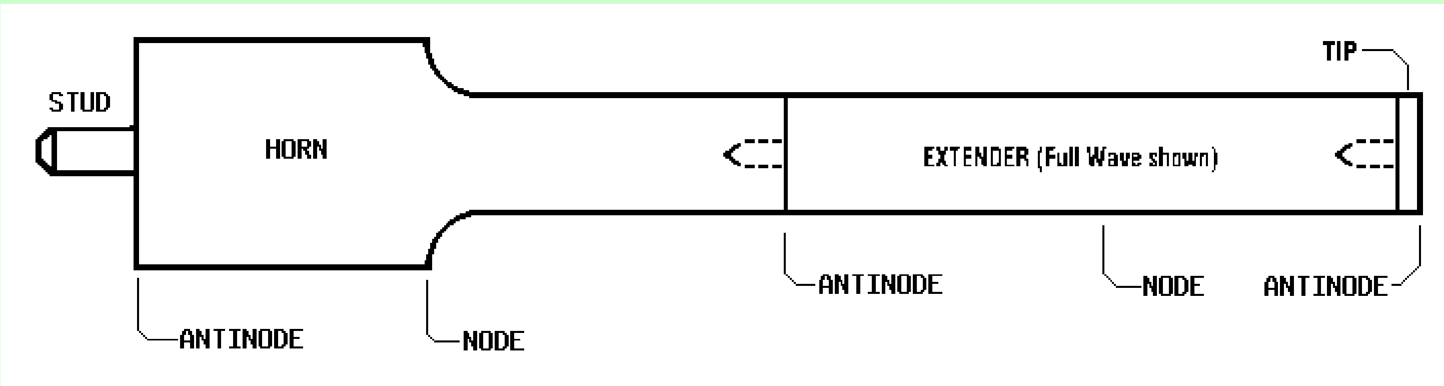
Once a foam has been created, especially in viscous liquids, it becomes necessary to stop sonication and degas the liquid. In some cases, at low viscosity, bubbles may rise against gravity and escape through the liquid surface. If, however, they persist in the bath, short bursts of energy (pulsing), with long rest times between, may be sufficient to break the foam. A fine mist of the parent liquid can be sprayed against the foam to break it; ultrasonic nozzles excel at this. In extreme cases, centrifuging and/or vacuum must be applied or the sample may even have to be discarded.

Similarly, on the reverse stroke, molecules of liquid adhering to the surface of a vibrating object may be dragged above the interface (liquid surface) and released, or even ultrasonically nebulized and driven off balistically, into the atmosphere ("**aerosoling**"). Obviously, this could pose a significant risk if the liquid is toxic or contains biohazards. Various techniques beyond the scope of this monograph are available to minimize aerosoling or prevent the escape of the aerosol.

More on this subject and its commercial applications will be found on Ultrasonics page 4.

EXTENDERS (Extender Tips)

Horns are normally made of titanium or aluminum, both of which have a half-wavelength of approximately 5"' at 20KHz. In order to reach into narrow vessels or through necks of vessels or into process streams and such, "**extenders**" (also called "extender tips") are available from some probe manufacturers. Horns are normally a half-wavelength long (~5") and extenders are usually made in "**Half Wave**" and "**Full Wave**" length increments; they are usually simple cylinders, solid or tapped for a tip. Solid extenders are actually more than a wavelength increment; they have to be fitted to tapped horns and so are longer than the wavelength increment by the length of the regular replaceable tip in order to maintain resonance. A Full Wave extender is represented graphically here:



Extender (Full Wave shown)

Call for Contributions

For the forthcoming book, "***High-Intensity Ultrasonic Technology and Applications***", on the application of power (high intensity) ultrasonics, the use of ultrasonic energy to change materials (intended for Marcel Dekker's "*Mechanical Engineering Series*", edited by Profs. Lynn L. Faulkner and S. Bradford Menkes), 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.

For this book and other work, I am seeking information about **Narda Ultrasonics Corporation**, a firm which pioneered high-intensity application of ultrasonic energy ca. 1946-1960, and was sold to **Dynasonics Corporation** of Minnesota in 1965; howver, some o=f the activities appear to have subsumed into **Narda Microwave Corporation**, which was bought out by the **Loral Corporation**, which, in turn, was acquired by **Lockheed Martin Corporation** and so to **L-3 Communications Corporation**.

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. However, as what I believe to be a public service, I shall be adding more of my monographs on ultrasonics on this site; watch for them in the index (above).

You may wish to visit the main ULTRASONICS page, et seq., with more on **ultrasonics**, as well as the Ultrasonics Cleaning page {in process} and the Ultrasonics Glossary page {also in process}.

Those persons interested in **SONOCHEMISTRY** might wish to look at the sonochemistry pages of:

Prof. Kenneth S. Suslick of the University of Illinois at Urbana-Champaign, and
Dr. Takahide Kimura at Shiga University in Japan.

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S. Berliner, III

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PREV.PAGE FIRST PAGE NEXT PAGE

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S. Berliner, III's

Ultrasonics
Page 2

Consultant in Ultrasonic Processing
"changing materials with high-intensity sound"

Technical and Historical Writer, Oral Historian
Popularizer of Science and Technology

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Consulting in Ultrasonic Processing

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[See "Keywords (Applications) Index" on Page 3.]

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You may wish to visit the preceding page on **ultrasonics**.

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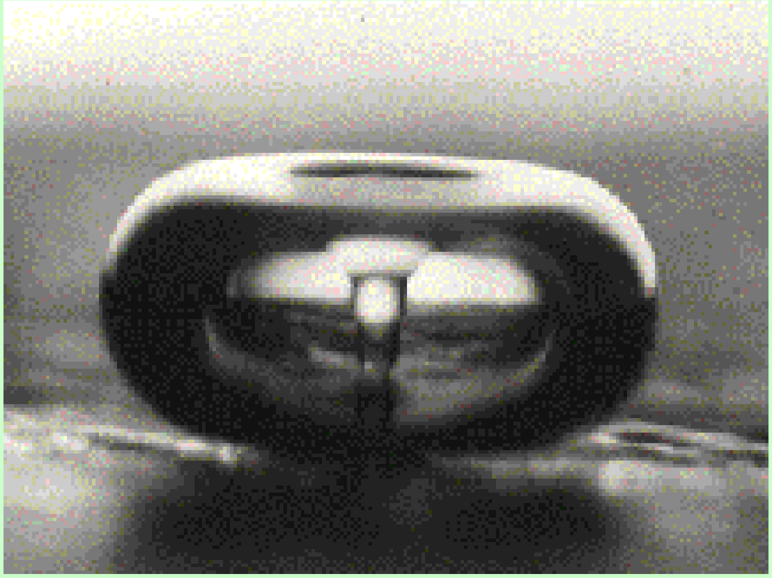
THE CAVITATION BUBBLE



[image from University of Washington, Applied Physics Laboratory (Lawrence Crum, Ph.D.)
- bubble diameter approximately 1mm]

MORE ON CAVITATION

[Continuing from AL-1V - "A POPULARIZED GUIDE TO ULTRASONIC CAVITATION"
(A Non-Technical Explanation of "Cold Boiling")]

Cavitation initiates most readily at, and proceeds radially outward from, discontinuities (voids, contaminant particles, and such) in the liquid, where bonds between adjacent particles are weakest. Theoretically, a completely pure liquid (an unlikely happenstance) would be virtually inmpossible to cavitate. However, somewhat conversely, once cavitation initiates, any gas bubbles in the liquid absorb energy to no avail and must be removed before effective processing can proceed; this is normally done by running the device (**degassing** it) for a few minutes until free bubbling ceases. This applies primarily to bath (cleaning tank) sonication. Probe sonication is at so much higher an energy intensity that this procedure is not normally necessary in that procedure. In addition, any surface with a concavity which could trap air or other gases and prevent full wetting of the surface will prevent activity on the that surface. Not only must the surface be wetted, it must be wholly submerged in the liquid, not merely wet. To effect such, the object to be cleaned (or otherwise treated) must be rotated, completely under the surface, if necessary, to discharge any pockets of air or gas such that the gas rises out of the liquid bath.

I have defined, on Page 1 "***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**. Changing materials with ultrasonics, such as to clean, homogenize, and accelerate both physical and chemical reactions, among many other things, is accomplished largely due to the action of **cavitation**. I have described in lay terms on Page 1 how the cavitation bubble is formed, even in a cold liquid ("cold boiling"), by shearing molecules just as in a solid,and the shock wave generated by the implosion which results when the bubble collapses. However, there are more actions inherent in bubble collapse which are of significance.

First, it should be noted that the term "**bubble**,in itself, could be misleading. A bubble, by definition, contains a gas or vapor. After that gas or vapor condenses, there is still a **void** or **cavity** in place until the implosion occurs. Unless otherwise stated, I shall use the term "bubble" for all three forms (bubble, void, cavity).

From Prof. Lawrence Crum of the Applied Physics Laboratory at the University of Washington in Seattle, writing about lithotriptry, in which a kidney stone is broken with ultrasonic energy, "When pressure surrounding a bubble falls below the vapor pressure of the liquid, the bubble fills with vapor and grows explosively. The bubble collapses violently when pressure returns. If the collapse occurs near a boundary, such as {a} targeted kidney stone, a high velocity liquid jet is formed that impacts the boundary with great force. These extremely violent processes are thought to play a major role in stone destruction and associated tissue damage." Going beyond lithotriptry, that same jet, a focused stream of liquid forced with extreme pressure and velocity and very similar in nature to the molten-metal jet formed in a "shaped charge" in explosive ordnance, causes a number of violent and useful effects. The jet occurs due to the non-symmetric geometry at the surface of the substrate and can be seen in formation in Professor Crum's most dramatic stop-motion microphotograph seen above. The substrate is at the bottom of the photo and the top surface of the bubble can be seen dimpling downward as the jet (remember that the background of the picture is clear liquid) begins to form and progress downward through the middle of the bubble.

When the liquid molecules at the forward (down in the photo) edge of the jet impinge on solid material (the substrate, i.e: bone, stone, ceramic, or metal), the collision breaks off the least-tightly bound surface molecules of the substrate. In the author's work, cavitation erosion of metal has been seen to propagate inward along grain boundaries and in dendritic fashion. As a point of fact of long standing, one of the earliest tests for activity in an ulltrasonic cleaning tank was to immerse aluminum foil, energize the tank, and observe the perforation of the foil by cavitation erosion. Even materials as hard as aluminum oxide (sapphire) and tungsten carbide are eroded by cavitation. The reference in AL-1V to the discovery of cavitation through the investigation of why ship/boat propellors wear away was done in the mid-19th Century by John William Strutt, Lord Rayleigh, then not yet the Nobel laureate, who wrote one of the first definitive texts on acoustics, covering this subject, "*Theory of Sound*" in 1877-78.

In addition to erosion or ablation of surfaces by the jet, cavitation causes many other actions noted at the top of this page, on Page 1, and elsewhere. Notable among these in a purely physical sense is the action of intense shock fronts generated by imploding cavitation bubbles against kidney stones (lithotriptry), gall stones, tumors, and other intrusions in the body. Some of this action can also be accomplished by direct impact of a vibrating ultrasonic tool tip, but no (or minimal) cavitation is involved. In work by Dr. Frank E. Barber of the Radiology Department at Harvard Medical School and by Prof. Crum at the University of Washington, and others, remotely-generated shock waves are focused inside the body to produce intense cavitation alongside the stone or other object, shattering it for easier removal via catheter. The source of remote energy can be from a phased array of transducers (Barber) or from an array of spark-gaps; in the latter case, a steam bubble results each time a spark passes across a gap under water.

Similar arrangements are being used to destroy cataracts, excise tumors and diseased tissue, heal wounds, close torn blood vessels, relieve benign prostatic hyperplasia, and improve absorption and transfection of drugs.

One local Long Island (New York) firm making devices for such work is Misonix Incorporated in Farmingdale (formerly Heat Systems, for which the author was Director of Technical Services - a blatant plug!).

Let me repeat here, yet again, what was stated before: NEW!

CAVITATION ACCELERATES BOTH CHEMICAL AND PHYSICAL REACTIONS.

More to follow.

ULTRASONICS AND FINE PARTICLES - BENEFICIATION OF SLURRIES AND FINE-PARTICLE SUSPENSIONS [CERAMICS, COAL & ORES, COATINGS, COLUMN PACKINGS, SINTERING, SLIPS]

```
AL-2                ULTRASONICS AND FINE PARTICLES -               Jan 98

        BENEFICIATION OF SLURRIES AND FINE-PARTICLE SUSPENSIONS

  [CERAMICS, COAL & ORES, COATINGS, COLUMN PACKINGS, SINTERING, SLIPS]

      {Also including suggestions for best mixing of batch samples -
                 "sifting solids and swirling solutions"}
```

1. GENERAL -

Sonication of suspensions of ultrafine particles provides a number of significant benefits, not the least of which is better dispersion. Ultrasonics substantially reduces particle size of ultrafine suspensions in one tenth the time of traditional ball milling methods. In addition, one can expect disaggregation and deagglomeration of clumps (particle size reduction), degassing of the carrier liquid, increased slurry flow properties, higher homogeneity, and denser castings, sinterings, or packings.

Cavitation, the formation and implosion of microbubbles in a high-intensity ultrasonic field, propagates shock waves through the liquid. This intense energy accelerates both physical and chemical reactions, enhancing surface chemistry and causing violent particle motion and generating high-velocity interparticle collisions.

Bubble formation occurs in the liquid between particles. Cavitation can not occur in air, gas, or vapor. Thus, no action is found in unwetted, gas-filled voids in a particulate mass. For an insoluble material suspended in an inert liquid, the effective viscosity of the parent liquor (that property of the suspending liquid affecting cavitation) is just that of the basic liquid, which can be quite low, and not the apparent viscosity of the suspension, which can be quite high. For this reason, it is possible to sonicate extremely dense suspensions or slurries in water or light solvents. Such thick slurries might have apparent viscosities far above the range of 5,000 to 10,000 centipoise (5 to 10 Pa.s), which is the threshold of cavitation for most simple liquids.

Wetted beds of particles can be fluidized with probes or in cup horns or even in ultrasonic cleaners for laboratory-scale experimentation.

Field experience has borne out these ideas. Several practical examples follow:

a. Ceramic insulation for resistors and capacitors benefits greatly from the homogeneity and degassing provided by sonication. Probes are used in conjunction with continuous flow cells to give on-line production capability in a number of electronics applications.

b. Iron oxides and similar disk and tape coatings are dispersed and degassed immediately prior to application in slurry form. Freedom from voids and smears provides a far superior product for manufacturers of magnetic media.

c. Clays, limes, and other fines can be compacted (dewatered) ultrasonically. Significant development work has been done in this area. Compacting of soil samples and selectively increasing or decreasing permeability are also prcticable. In addition, a phenomenon of gelling of clays, especially in the presence of petroleum- based oils, has been noted by the author.

d. Coal beneficiation and ore refining obtain greater yields and coal slurries can be made denser for better transport and improved combustion properties.

e. Pharmaceutical preparations and tablet pressing operations are also areas in which sonication of fine particle suspensions has been applied. Reduction of tablet size is a very attractive application. [Tablet producers should note that ultrasonic liquid processors are also used for dissolution of samples for faster QC analysis.]

f. Glass beads (microspheres) are commonly used as column packings for filtration and for HPLC (High Pressure Liquid Chromatography) and similar applications. Sonication of the suspended beads immediately prior to packing the column has repeatedly resulted in 20% denser packing. This allows 20%

shorter equivalent columns or a 20% higher performance in the same column length.

g. Industrial ceramics and even fine china table service can be improved by sonicating the slip prior to pouring the mold. Better slip homogeneity, fewer voids from bubbles, smoother surface finishes, and less cold jointing result. Probes can be fitted directly to slip pouring nozzles at molding stations.

h. Sintered carbide tool bits are made by suspending fine particles of tungsten or other carbides in light fluorocarbon liquid, pouring the suspension in a die cavity, evaporating (and recovering) the solvent, and pressing the particles in the cavity under extreme pressure and temperature. By sonicating the particles either immediately before pouring, or even directly in the cavity, a 20% improvement in density was found. Resultant bits are stronger, hold an edge longer, cut cleaner, and remain cooler. Thinner bits can be made, thus providing cost savings.

i. Photographic emulsion grains can be sonicated prior to coating to degas and homogenize the material and to prevent formation of voids and discontinuities.

In addition, ultrasonic processing of suspensions in chemically-reactive liquids provides greater yields through acceleration of surface chemistry. A new field, sonochemistry, has, in part, resulted from the realization of the ability of cavitation to both expose fresh surface and enhance reactions.

2. SIFTING SOLIDS AND SWIRLING SOLUTIONS

The ability of an ultrasonic liquid processor to effectively stir, mix, or agitate a batch depends to a large degree on the sample volume being appropriate for the horn and tip being used. Such sample volumes are usually indicated in manufacturers' catalogs. On occasion, however, it becomes necessary to process volumes larger than recommended. While inefficient, wasteful of tips, and time consuming, the procedure can be improved if appropriate steps are taken:

a. In any batch sonication procedure, the shape and size of the vessel can be critical. In general, beakershaped vessels are best, and round-bottomed vessels such as test tubes and boiling flasks are fair, while square-bottomed vessels or complex shapes are poor. Vessels with no free space around the tip will experience much faster temperature rise than those with ample heat sink volume and large cooling area. Approximately one to five tip diameters can be used as a first approximation for volume sizing.

b. Depth of immersion and free space under the tip are also significant factors. There is virtually no sonication alongside the tip or above it. Material floating on the surface will not be treated, nor will material taken up on foam bubble surfaces. Insufficient tip immersion will cause spattering or foaming. Empirical tests in actual samples or referee liquids are recommended.

c. Large volumes of glass beads or other particles can be suspended in liquids by direct sonication. If the solids exceed about 20% of the liquid by volume, especially in oversized vessels, the solids may be too deep in the vessel to allow full depth sonic penetration of the mass of solids. Sifting the particles in slowly while the liquid is being sonicated will greatly increase the proportion of solid to liquid, even to the extent that particles can touch all surrounding particles. In this latter case, the effect is that of creating a fluidized bed.

d. If the bulk of solids is already in the liquid or is inconvenient to sift, a mechanical or magnetic stirrer may be used in conjunction with the ultrasonic probe. For best results with a stirrer, the stir bar or impellor should be inserted far from the center of the beaker or other vessel, vertically along one side wall, with the probe/horn/tip offset 180° across the vessel along the opposite side (but NOT touching the wall). It is especially important to avoid drawing a vortex under or alongside the probe to prevent foaming.

3. MISCELLANY

In addition, there are two major areas in ultrasonic processing of fine particles which require careful attention in order to achieve best results. These have to do with the horn/tip interface and with continuous flow cells:

a. For the interface (joint) between the horn and tip and, in fact, that between the front driver of the convertor and the horn (which should never be wetted) or between horns and boosters or extenders or microtips, present operators of ultrasonic processors are referred first to the paragraph(s) on the care of horns and tips in their processor instruction manual. Normal sonication produces cavitation in liquids, the formation and collapse of microscopic vapor bubbles, generating shock waves which radiate outward and disrupt cells, homogenize and emulsify samples, degas liquids, etc. Shock waves, being radially symmetrical, attack the acoustic radiating surface of the tip or horn as well as the sample. The erosion which results reduces the efficiency of sonication in direct proportion to the degree of erosion. Certain solvents have been found to wick under replaceable flat tips and cause deterioration and early failure. Solid horns are thus recommended in lieu of tapped horns for such applications. Considerations regarding intrusion of liquids carrying ultrafines into the horn/tip joint are also covered in greater detail in Applications Leaflet AL-5, Extenders and Sapphire Tips.

b. The standard polycarbonate and stainless steel continuous flow cells, and most other accessories fitted to the body of standard horns, are manufactured with extremely fine (32-pitch) threads which can bind up or gall if accidentally contaminated with micronic or sub-micronic particles. Two solutions to this problem have been used. Larger cells use sanitary clamps and loosely fitted removable parts to avoid binding; they are, however, much more expensive. The alternative has been to make the smaller cells without threads, with customers devising a mechanical version of an optical bench, longitudinal ways in which the convertor and cell are supported laterally and moved axially (by screw jack or hydraulics) for adjustment and servicing. In this latter case, some form of gymbal mounting of the convertor is required to avoid any side-thrust on the horn.

In spite of the preceding caveat regarding entry of fine particulates into the horn/tip joint, it has been found repeatedly that sonication in suspensions of ultrafine abrasive materials retards cavitation erosion of the radiating surface. No definitive studies on this phenomenon are known to the author but it appears that the mechanism of significance is peening. Normal tip erosion proceeds as those most-loosely-bound molecules on the surface are broken loose and the form of erosion appears to follow the dendritic structure of the tip material (usually titanium alloy). Sonication in a fine abrasive slurry or suspension, such as diamond dust, clay, or tungsten carbide powder, seems to peen the surface, closing up the dendritic pores and polishing the tip as fast as it would otherwise erode. Long-term sonication will result in classic erosion patterns (concentric rings of lost material with an uneroded circumferential edge) but with a highly polished microfinish.

Contact the author for more information on the above-noted applications or other areas in which sonication might prove advantageous.

 AL-2 ULTRASONICS AND FINE PARTICLES Jan 98

- - - * - - -

NOTE re sonication and fine particles - I had the honor (and the fun) of setting up Prof. Kenneth S. Suslick's first SONICATOR disruptor at his laboratory in the Noyes Lab of the Department of Chemistry at the University of Illinois at Urbana-Champaign. Since then, Ken has become a leading light in the discipline now known as **SONOCHEMISTRY**, beginning with the production of iron carbonyls and other species that had not been amenable to creation by thermolysis, catalysis, photolysis, etc. In the 24 Jun 98 *Journal of the American Chemical Society* (as reported in Vol. 154, *Science News*, 18 Jul 98, p. 47), Ken and his colleagues announced the development of a novel method of creating ultra-small crystals of molybdenum disulfide, known to me as a super lubricant but apparently also a major catalyst to remove sulfur from petroleum. Ken, et al., uses sonication to create tiny crystals some ten times more active than the usual MoS_2, even better at catalysis than ruthenium disulfide, currently the best available. I **KNEW** that (well - I knew sonication could do it)! Ah, but Ken is a chemist and actually did it, and more power to him!

[Corporate information given above has been updated as of 01 Aug 1998]

You may wish to visit the main Ultrasonics page, et seq., as well as the Ultrasonic Cleaning page {in process} and the Ultrasonics Glossary page {also in process}.

THUMBS UP!

THUMBS UP! - Support your local police, fire, and emergency personnel!

S. Berliner, III

To contact S. Berliner, III, please click here.

PREV.PAGE FIRST PAGE NEXT PAGE

To tour the Ultrasonics pages in sequence, the arrows take you from the main Ultrasonics Page (with full index) to Pages A, 1, 1A, 2, 3, and 4, Glossary Page, Cleaning Page, and Bibliography Pages 1, 2, and 3 (see Index, above).

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Updated: 23 Feb 2004, 23:55 ET
(Created 28 May 2002)
[Ref: This is uson-4.html (URL http://home.att.net/~Berliner-Ultrasonics/uson-4.html)]

S. Berliner, III's

Ultrasonics Page 4

Consultant in Ultrasonic Processing
"changing materials with high-intensity sound"

Technical and Historical Writer, Oral Historian
Popularizer of Science and Technology

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

[See "Keywords (Applications) Index" on Page 3.]

Specializing in brainstorming and devil's disciplery for new products and reverse engineering and product improvement for existing products.

{"Imagineering"}

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INDEX

PLEASE NOTE: If some internal links refuse to work,
please click on Back and scroll down.

What's New?

On Ultrasonics Page 4 (this page):

Dissolution.

Foaming and Aerosoling - moved 28 May 02 from Page 1A.

Ultrasonic Propulsion (Propulsive Force) - Moving Material.

Ultrasonic Fountains - Atomization, Nebulization, Humidification,
Misting, Particle Creation and Sizing.

Ultrasonics and Nuclear Fusion.

Boosters (Booster Horns).

Quick Links to Major Ultrasonic Probe Manufacturers (moved to this page 10 Jul 2002).

On Ultrasonics Page 5:

Ultrasonic Whistles (Nozzles, Atomizers, Nebulizers). NEW! (23 Feb 04)

On the Ultrasonic Cleaning Page:

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What's New?

On the ULTRASONICS GLOSSARY page:

ULTRASONICS GLOSSARY {in process}.

ULTRASONICS BIBLIOGRAPHY

Ultrasonic Bibliography Page 1 - Reference Books on Acoustics, Vibration, and Sound.

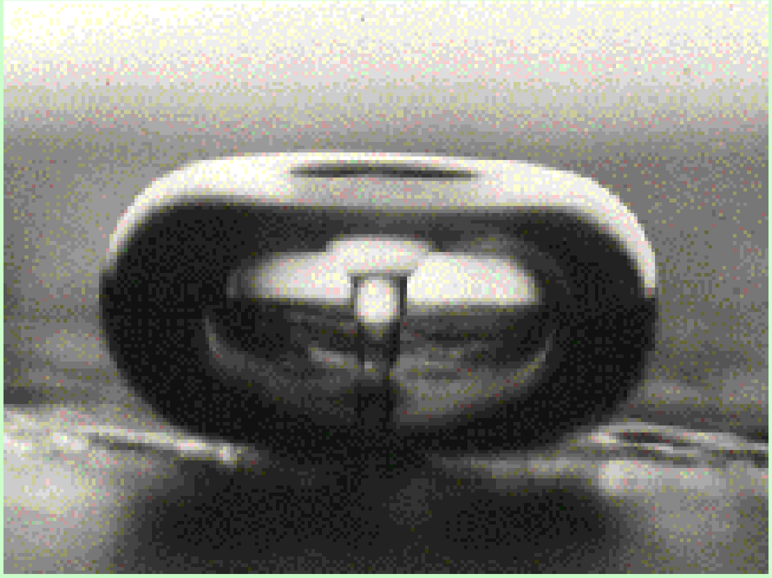
Ultrasonic Bibliography Page 2 - Sonochemistry.

Ultrasonic Bibliography Page 3 - Selected Articles.

You are invited to visit the ULTRASONIC INDUSTRY ASSOCIATION home page.

CALL FOR CONTRIBUTIONS: I am writing a book on "***High-Intensity Ultrasonic Technology and Applications***", on the practical application of power (high intensity) ultrasonics, the use of ultrasonic energy to change materials. **Contributions** are welcome (see below).

THE CAVITATION BUBBLE



[image from University of Washington, Applied Physics Laboratory (Lawrence Crum, Ph.D.) - bubble diameter approximately 1mm]

ULTRASONICS

Dissolution

Dissolution *(of samples, NOT of personalities!)*, as of tablets for quality control in pharmaceutical work, includes or overlaps many other ultrasonic operations. Among these are disruption, homogenization, emulsification, and dispersion. Dissolution can be used to enhance examination of samples in many other quality control areas, notably to dissolve coupons of polymers in solvents. The great advantage to using ultrasonics is that the dissolution progresses far faster than by other means, such as by stirring, shaking or otherwise agitating, by heating, or by washing. In coupon dissolution of plastic films, the author observed results ten or more times faster than previously tried methods, even as much as obtaining times in minutes that had taken the same number in hours.

There are three most common methods to dissolve tablets, coupons, or other samples. In all cases, care must be taken to avoid igniting or inhaling solvents.

Ultrasonic Cleaners - The simplest and often cheapest method is to use a laboratory ultrasonic cleaner (bath). The sample could be placed directly in the tank but then the entire contebts of the tank must be removed and replaced for each sample; instead, each sample can be placed in a beaker or a well of a multi-well tray and then floated or held in the bath such that energy passes through the bottom of the beaker or well into the sample. The drawback is that intensity is generally fairly low and repeatability is poor.

Ultrasonic Cup Horn - A more intense variation of the bath system is to use a Cup Horn, a bath driven by the convertor of a probe-type processor. Intensity is fairly high and repeatability good but requires careful attention to physical placemnet of sample vessel.

Ultrasonic Processor - The most intense method, in which an active probe tip is inserted into the sample vessel. Intensity is extremely high and repeatabilioty excellent but the tip must be cleaned between samples (it can clean itself).

Among the many parameter variables to be considered are the vessel (thickness, configuration, material, and quality), liquid condition (surfactant coupler, temperature, depth, degassing, impurities, etc.); sample conditions (configuration and condition in vessel, particle size, density, solubility, etc.), cleaner bath (output frequency, amplitude, regulation, power capability, temperature variations, line voltage and frequency fluctuations, etc.); and so on and on.

{to be expanded upon}

Foaming and Aerosoling

(expanded from Page 1A.)

When a foam is generated in a lab sample, it interposes bubbles between the radiating surface and the body of the liquid to be treated or in which treatment is to occur. This is somewhat akin to "blanketing" but is the result of gas bubbles, not cavitation bubbles interfering with free radiation of acoustic energy into the bath.

It is a self-limiting process.

Once a foam has been created, especially in viscous liquids, it becomes necessary to stop sonication and degas the liquid. In some cases, at low viscosity, bubbles may rise against gravity and escape through the liquid surface. If, however, they persist in the bath, short bursts of energy (pulsing), with long rest times between, may be sufficient to break the foam. A fine mist of the parent liquid can be sprayed against the foam to break it; ultrasonic nozzles excel at this. In extreme cases, centrifuging and/or vacuum must be applied or the sample may even have to be discarded.

Similarly, on the reverse stroke, molecules of liquid adhering to the surface of a vibrating object may be dragged above the interface (liquid surface) and released, or even ultrasonically nebulized and driven off ballistically, into the atmosphere ("**aerosoling**"). Obviously, this could pose a significant risk if the liquid is toxic or contains biohazards. Various techniques beyond the scope of this monograph are available to minimize aerosoling or prevent the escape of the aerosol.

There is, however, far more to this subject and its commercial applications than merely working with laboratory samples. Historically, a major effort to suppress foam, especially in beer and ale, was carried out in the 1950s and 1960s but little evidence remains.

As noted above, foam may be broken by applying ultrasonic energy from below the gas-liquid interface but another technique exists which is drawing more and more attention in which acoustical energy is driven through a gas onto the surface of the foam, much as in the '50s and '60s, but with far more effective devices.

Based largely on the work of **Prof. Juan A. Gallego-Juárez**, Research Professor of the Higher Council for Scientific Research (CSIC), and working at the Instituto de Acústica, Serrano, 144, 28006 Madrid, Spain, this technique utilizes large diameter "**plate radiators**" which are, in effect, oversized radiating faces driven by relatively "standard" horns. A graphic representation of such a device is shown:

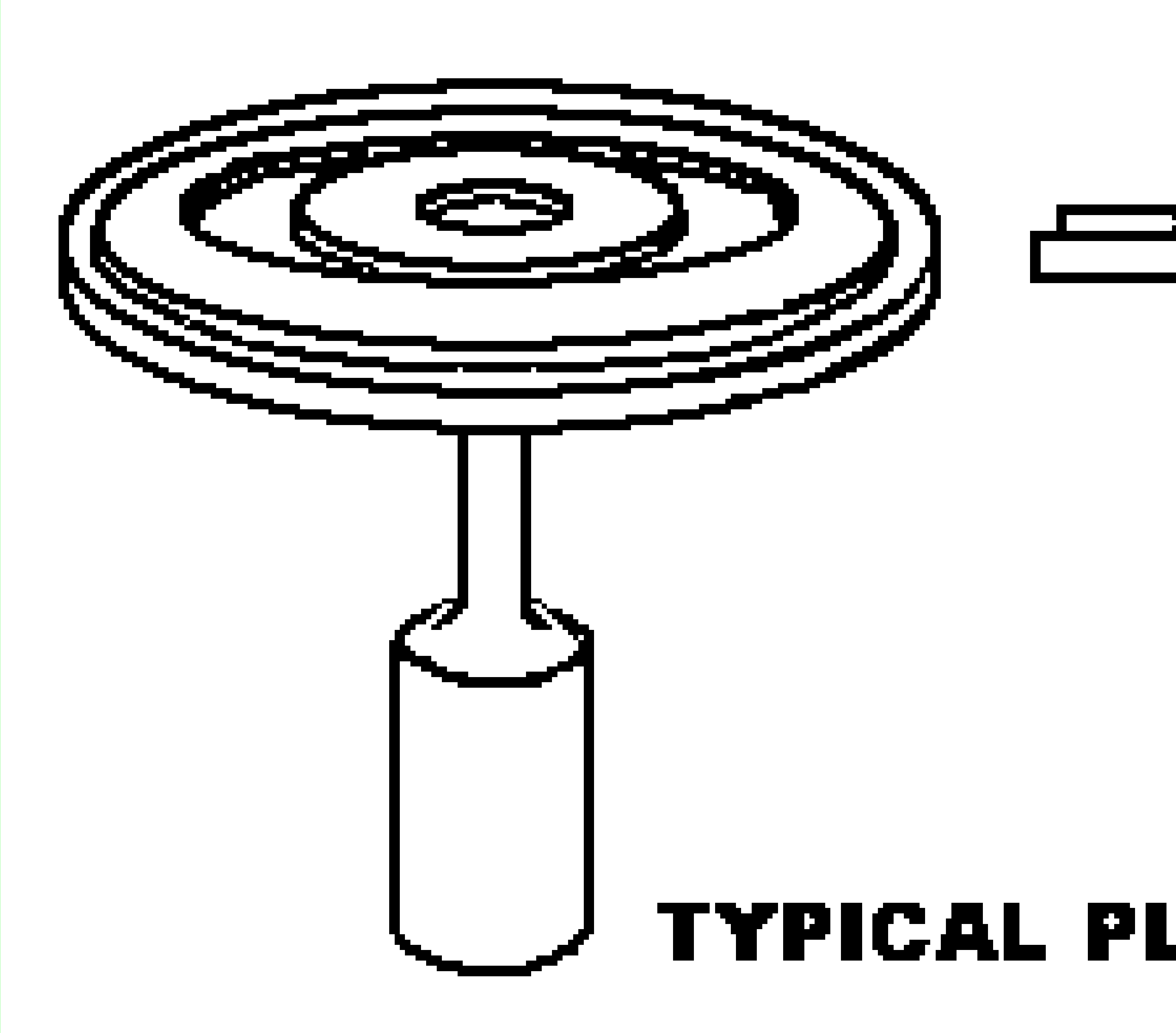
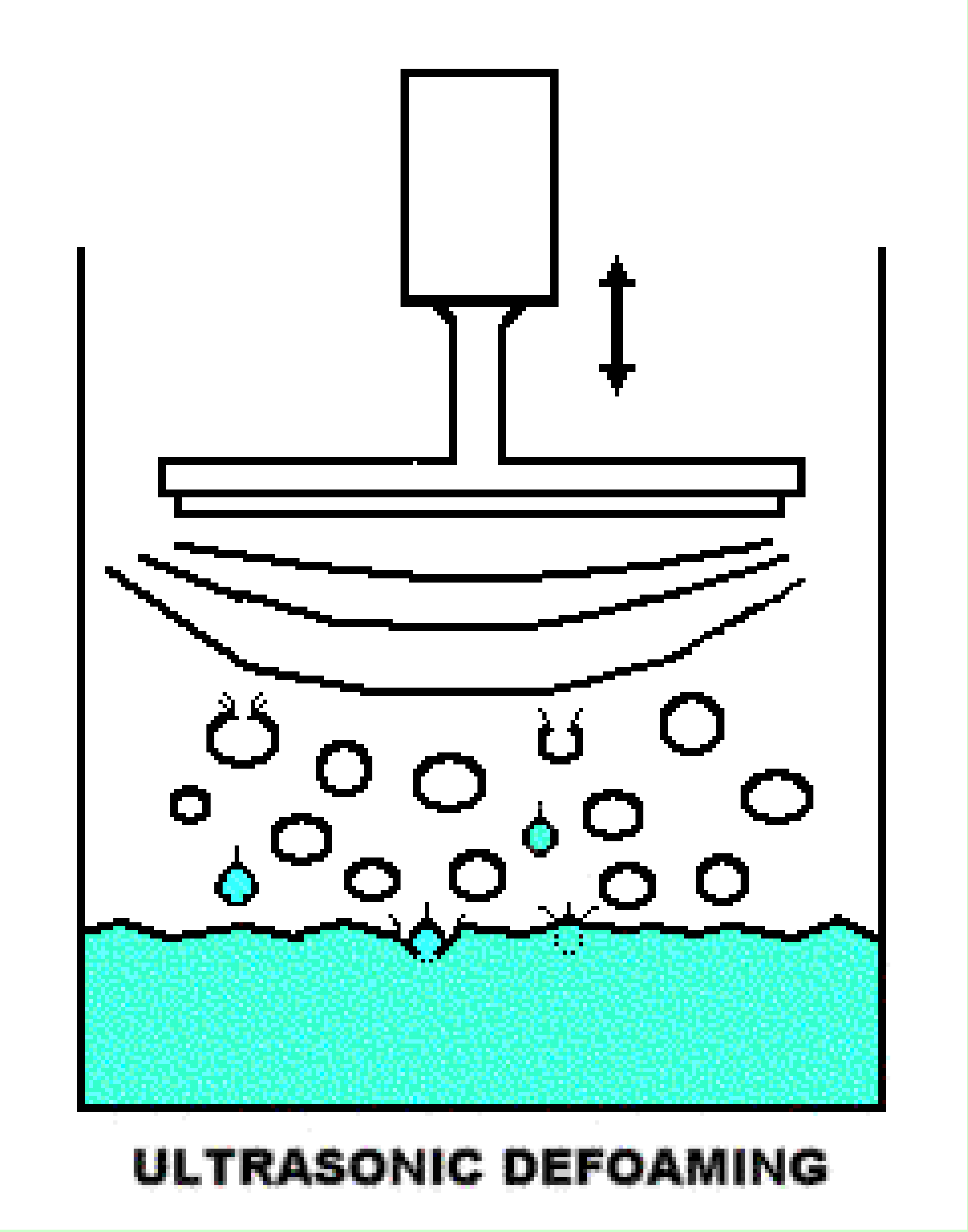


Plate Radiator

Where this device differs from previous equipment is in that it has a very high "aspect ratio", the diameter of the radiating face is quite large in proportion to its thickness and the diameter of the driving horn. Dr. Gallegos's own personal development, this device represents a break-through in design of large-diameter radiators and permits efficent transfer of acoustic radiation from a radiating surface, througn a gas, to a work surface (in this case, the gas bubbles that form the foam). Part of the success of this radiator, whereby it has a high service life without fracturing, lies in the novel multi-step design of the reverse side of the plate.

The radiator drives acoustic vibrations through the gas (air) into the foam bubbles, which are stressed beyond their elastic limit and break (pop), thus exposing the next layer of foam bubbles; the process is quite efficient and rapid:



Ultrasonic Defoaming

The substance of foam bubbles, consisting only of a thin skin of the parent liquid around a core of gas, simply runs back into the parent liquid once the skin bursts.

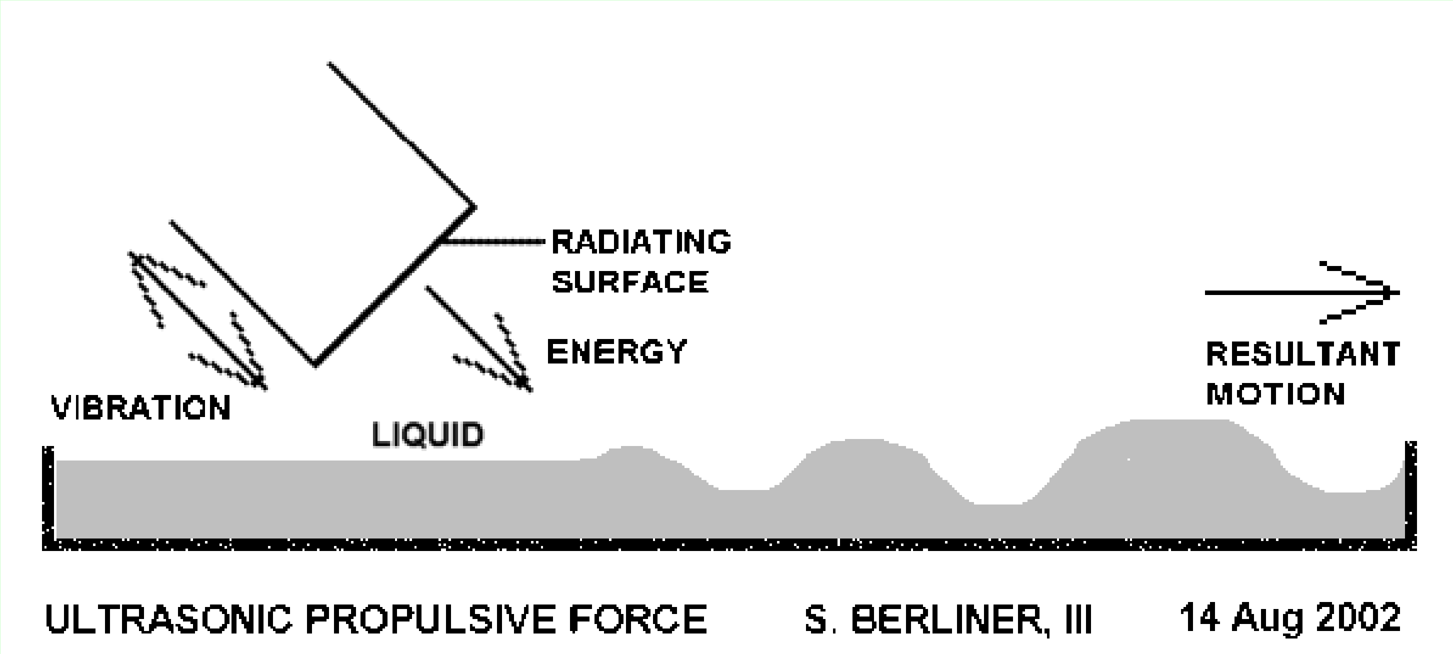
Ultrasonic Propulsion (Propulsive Force)

Moving Material

{14 Aug 2002 - preliminary}

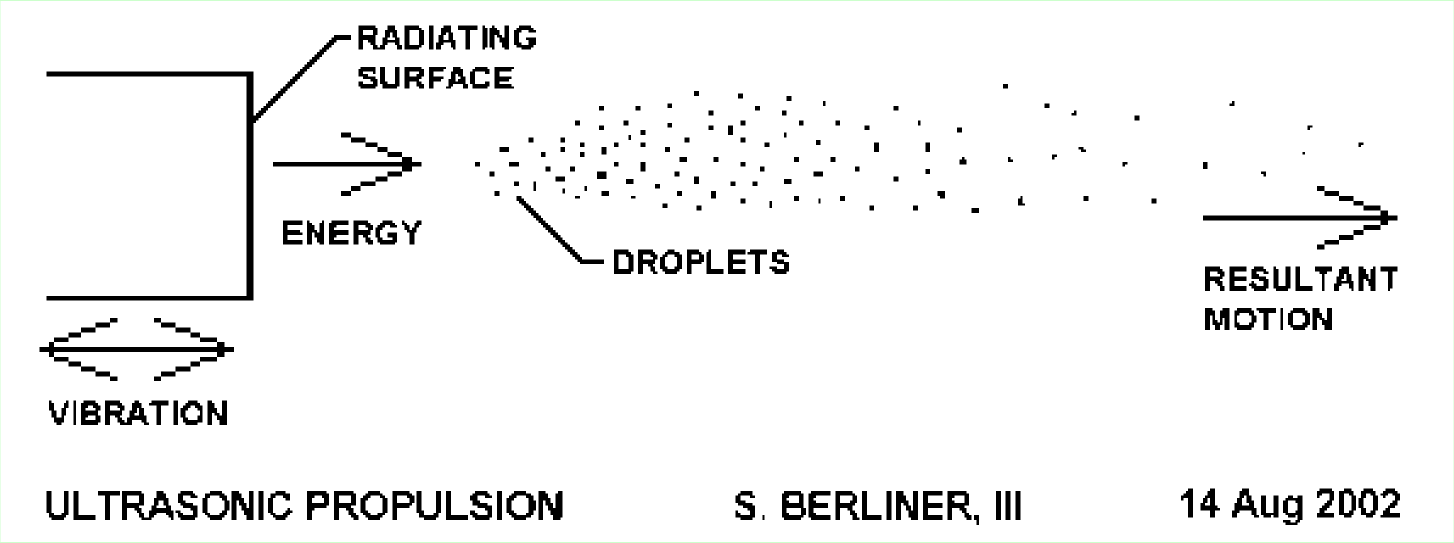
A phenomenon of ultrasonic radiation that is little-used and little-known is that of **ultrasonic propulsion**. As discussed elsewhere, when a high-intensity ultrasonic probe is energized, vibration is imparted to the gas in which it stands or the liquid in which it is immersed. Because energy leaves the horn (in the form of acoustic vibration), a physical reaction takes place such that material is pushed away from the radiating surface.

This phenomenon can most easily be seen by placing a horn tip just above a liquid and observing the waves that occur on the surface of the liquid; however, this may well cause the formation of standing waves. To visualize the propulsive force, simply turn the horn system at a slight angle and you will see the liquid being pushed away from the tip; increasing the angle will increase the propulsive effect until at over 45° there is more lateral motion than vertical motion:



(14 Aug 2002 image by and © S. Berliner, III 2002 - all rights reserved)

Taking this a step further, particulates in a gas can be moved away from the radiating surface, which leads directly to the next phenomenon, **Ultrasonic Fountains** (*Atomization, Nebulization, Humidification, Misting, Particle Creation and Sizing*):



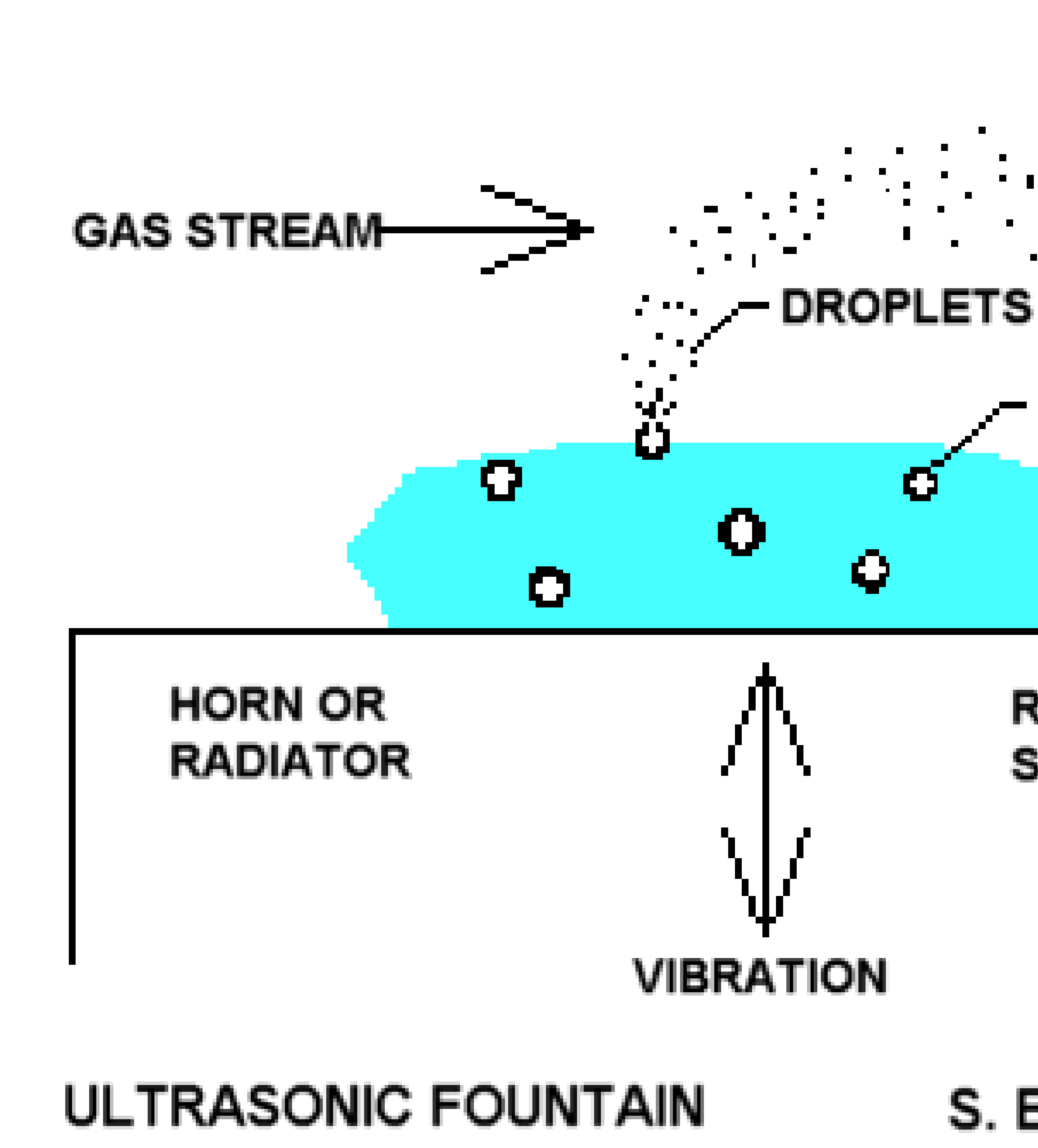
Ultrasonic Fountains

Atomization, Nebulization, Humidification,
Misting, Particle Creation and Sizing

{09 Jul 2002 - preliminary}

A phenomenon of cavitation that is commonly-used by, but little-known to, the general public is the **ultrasonic fountain**.

When cavitation is induced in a film of liquid, or at least near the surface of a body of liquid, the bubbles bursting at or very near the gas-liquid interface cause fine droplets to be driven off to some distance:



This projection of these droplets can be used for the formation of fine mists which, in turn, can be used for humidification and cooling and, in practice, is the basis for the prolific and inexpensive ultrasonic humidifiers in common use.

If either the process is inclined so that gravity has a vector at right angles to the axis of motion of the radiating face, or a gas stream is applied perpendicular to that axis, droplets will act ballistically and fall away dependent on their size. In this way, fine particulates can be produced, such as from molten metals or super-saturated solutions of precipitates, and they can be sorted or characterized by their ballistic trajectories.

> See also Ultrasonic Whistles (Nozzles, Atomizers, Nebulizers). NEW! (23 Feb 04)

Ultrasonics and Nuclear Fusion

Back in 1989, Dr. Stanley Pons of the University of Utah and Professor Martin Fleischman of Southampton University in the UK claimed they found evidence of cold fusion at room temperature in a test tube; the general derison in the scientific community was loud and overwhelming (and probably unwarranted), but I felt they were on to something and that the incredible pressures and temperatures in the collapsing cavitation bubble might well induce fusion - not "cold", but still fusion, and offered to work with them to prove concept. Nothing came of that, but, more recently, Drs. Rusi Taleyarkhan, a senior scientist in Oak Ridge National Laboratory's Engineering Science and Technology Division, and Richard T. Lahey Jr., the Edward Hood Professor of Engineering at Rensselaer Polytechnic Institute, et al, issued a press release (dated 04 Mar 2002) indicating that they may have done just that.

It will be interesting to follow the progress of this investigation.

The primary references are (from *Science*'s Website, "The report by R. P. Taleyarkhan et al. of observations of tritium decay and neutron emissions associated with the collapse of tiny bubbles in deuterated acetone and the possibility that those observations may have arisen from fusion reactions within the imploding bubbles"; the research article by Taleyarkhan et al., and three associated commentaries, a perspective by F. D. Becchetti describing the research and its significance; a news article by Charles Seife on some of the controversy stoked by the paper, and an editorial by *Science*'s Editor in Chief, Donald Kennedy, on why Science decided that 'publication is the best option'.":

> R. P. Taleyarkhan et al., *Evidence for Nuclear Emissions During Acoustic Cavitation*, Science 295, 1868 (2002) (in Research Articles)

> F. Becchetti, *Evidence for Nuclear Reactions in Imploding Bubbles*, Science 295, 1850 (2002) (in Perspectives)

> C. Seife, *"Bubble Fusion" Paper Generates a Tempest in a Beaker*, Science 295, 1808 (2002) (in News of the Week)

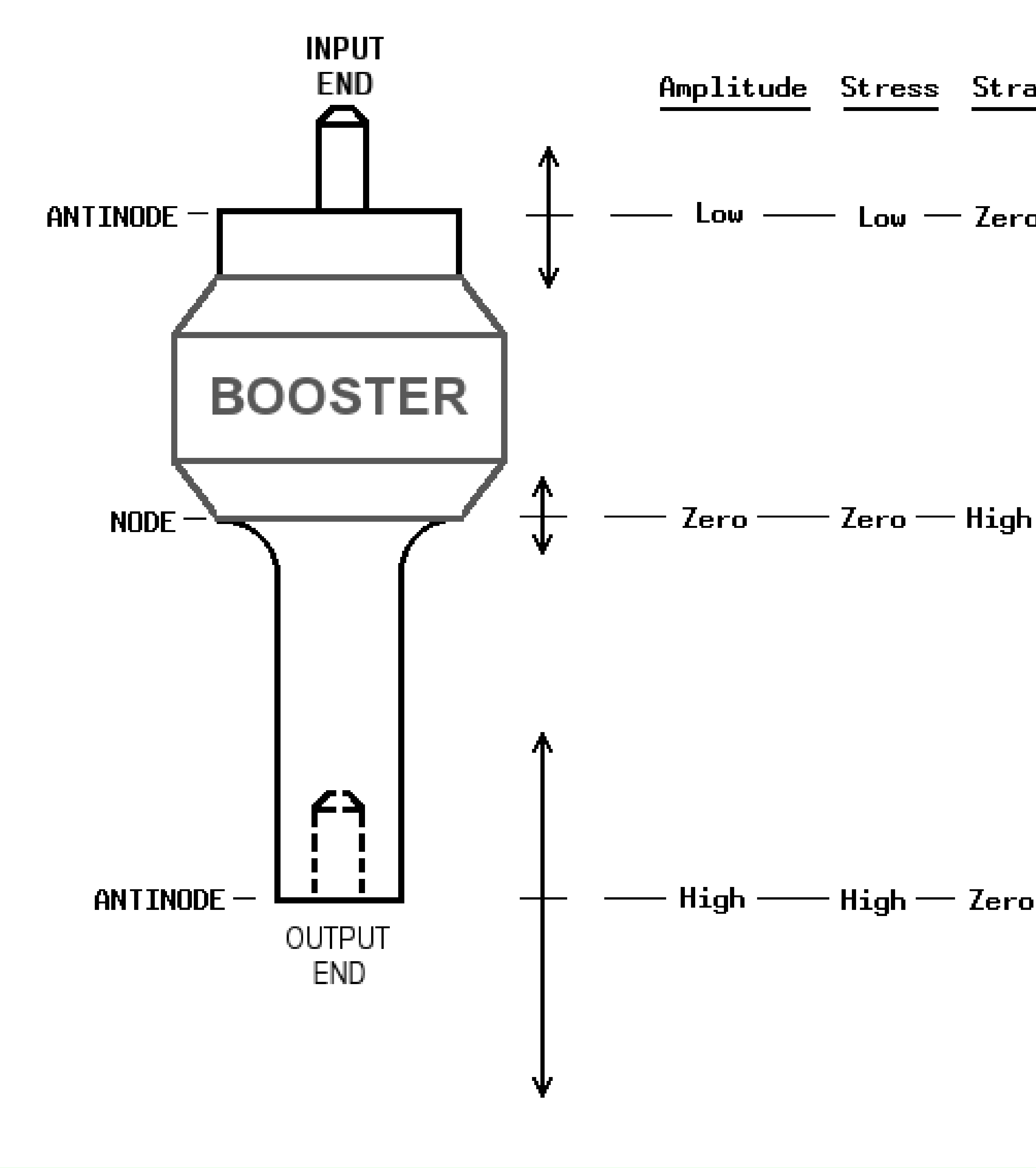
D. Kennedy, *To Publish or Not to Publish*, Science 295, 1793 (2002) (in Editorials)

The term "**Bubble Fusion**" seems to have caught on; it does help distance this process from "cold fusion". How much of this hooraw is justified and how much is a bitter legacy from 1989 is an interesting question, but, clearly, the scientific community was (or feels it was) burned and is exercising extreme caution. Unfortunately, any progress toward cold fusion is clouded in a morass of psychic and metaphysical nonsense and it is earnestly hoped that the newer work does not become so tainted.

I should be pleased to assist in this matter but probably do not have the credentials to be taken seriously (the fallout of not having taken advanced degrees).

Boosters
(Booster Horns)

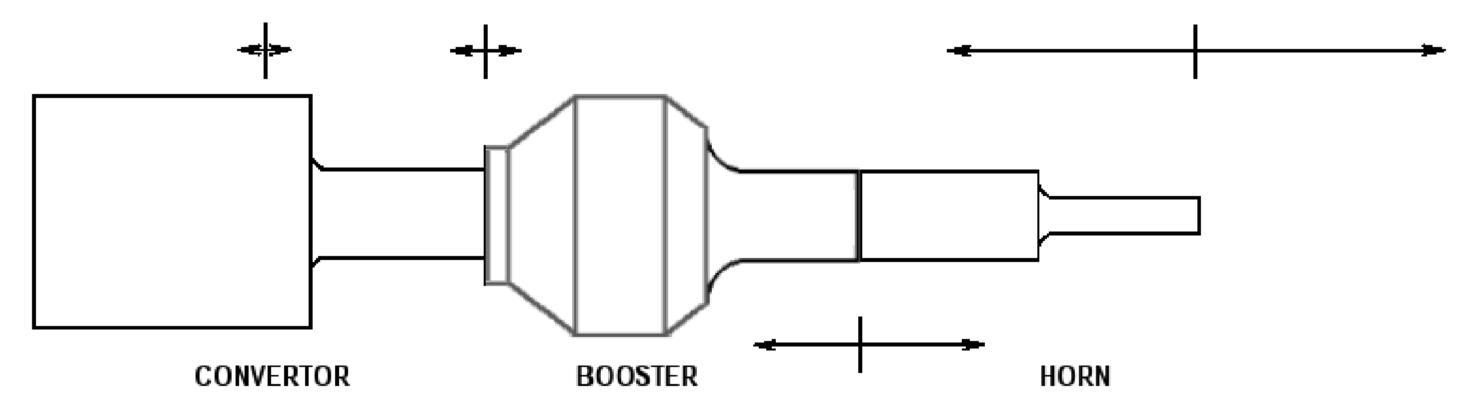
Boosters (booster horns) are additional stages of mechanical amplification inserted between the front driver of a convertor (see Equipment and Terminology on main page) and the output horn:



The standard horn serves as such for a standard MICROTIP, as does the Upper Section for the Stepped

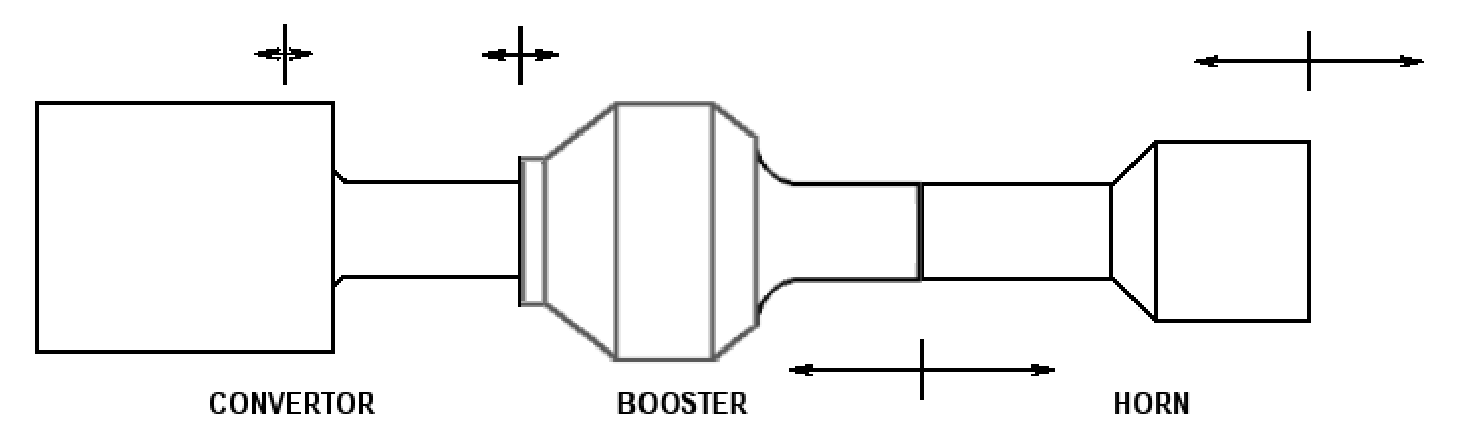
MICROTIP.

Boosters are available at various positive and negative gain factors, commonly from 3:1 to 0.5:1. A booster is, in effect, simply another horn inserted ahead of a regular horn to give the output tip (radiating face) greater amplitude:



(17 Oct 2003 image by and © 2003 S. Berliner, III - all rights reserved)

A positive-gain booster would not normally be used with a high-gain horn because the amplitude of the latter might well exceed its design limitations, causing the output horn to over-extend and fatigue and crack at the nodal point. Rather, a booster would be used with a low-gain or negative-gain horn (such as used in the Cup Horn) to give higher amplitude on a larger diameter radiating face:



(17 Oct 2003 image by and © 2003 S. Berliner, III - all rights reserved)

One exception might be when the tip of a high-gain horn is working against a very high static head. However, do NOT use positive-gain booster horns without first consulting with the manufacturer of the ouput horn!

Quick Links to Major Ultrasonic Probe Manufacturers

For your convenience (and their benefit), I list here three of the top manufacturers of ultrasonic probes for changing materials (NOT sensing probes); this list is neither exclusive nor exhaustive but represents firms with which I have dealt closely and which I can wholeheartedly recommend:

Misonix, Incorporated
http://www.misonix.com/
(formerly **Heat Systems**, Inc.)
1938 New Highway
Farmingdale, New York 11735
Phone: **631-694-9555**, 800-645-9846
FAX: 631-694-9412
e-mail: http://www.misonix.com/contact.htm

Sonicator®/**Microson**™: http://www.misonix.com/ultra.htm

Sonics & Materials, Inc.
http://www.sonicsandmaterials.com/
53 Church Hill Road
Newtown, Connecticut 06470
Phone: **203-270-4600**, 800-745-1105
FAX: 203-270-4610
e-mail: info@sonicsandmaterials.com

Vibra-Cell: http://www.sonicsandmaterials.com/home.html

Branson Ultrasonics Corporation
http://www.bransonultrasonics.com/
Precision Processing Division
http://www.bransoncleaning.com/
41 Eagle Road
Danbury, Connecticut 06813-1961
Phone: **203-796-0400**
FAX: 203-796-9813
e-mail: info@bransoncleaning.com

Sonifier™: http://www.bransoncleaning.com/Sonifier/SonifierProducts.htm

In addition to these processors, similar equipment is used for **ULTRASONIC DRILLING and MILLING and the manufacturer of such equipment as a standard product line is:**

Sonic-Mill
http://www.ceramics.com/sonic/
7500 Bluewater Road, NW

Albuquerque, New Mexico 87121-1962
Phone: 505-839-3535
FAX: 505-839--3525
e-mail: sonics@ceramics.com

[There is no guarantee made whatsoever that these listings are correct, complete, or current.]

(Tradenames are noted solely for information and remain the intellectual property of the manufacturer.)

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. However, as what I believe to be a public service, I shall be adding more of my monographs on ultrasonics on this site; watch for them in the index (above).

You may wish to visit the main ULTRASONICS page, et seq., with more on **ultrasonics**, as well as the Ultrasonics Cleaning page {in process} and the Ultrasonics Glossary page {also in process}.

Those persons interested in **SONOCHEMISTRY** might wish to look at the sonochemistry pages of:

Prof. Kenneth S. Suslick of the University of Illinois at Urbana-Champaign, and

Dr. Takahide Kimura at Shiga University in Japan.

THUMBS UP!

THUMBS UP! - Support your local police, fire, and emergency personnel!

S. Berliner, III

To contact S. Berliner, III, please click here.

PREV.PAGE FIRST PAGE NEXT PAGE

To tour the Ultrasonics pages in sequence, the arrows take you from the main Ultrasonics Page (with full index) to Pages A, 1, 1A, 2, 3, and 4, Glossary Page, Cleaning Page, and Bibliography Pages 1, 2, 3, and 4 (see Index, above).

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Updated: 14 Aug 2002, 05:45 ET
(Created 09 Apr 2002)
[Ref: This is usclean1.html (URL http://home.att.net/~Berliner-Ultrasonics/usclean1.html)]

S. Berliner, III's

Ultrasonic Cleaning
Continuation Page 1

Consultant in Ultrasonic Processing
"changing materials with high-intensity sound"

Technical and Historical Writer, Oral Historian
Popularizer of Science and Technology

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

[See "Keywords (Applications) Index" on Page 3.]

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INDEX

PLEASE NOTE: If some of the internal links on this page refuse to work, please click on Back and scroll down.

Misting, Particle Creation and Sizing.

Ultrasonics and Nuclear Fusion.

On the ULTRASONICS CLEANING page:

ULTRASONIC CLEANING {in process}.

Immersible Transducers.

What's New?

On the Ultrasonic Cleaning Continuation Page 1 (this page):

APPLICATION PAPER AP-3 - SPECIAL INSTRUCTIONS FOR CLEANING JEWELRY, CLOISONNÉ, ETC., IN HOME AND HOBBY USE.

On the ULTRASONICS GLOSSARY page:

ULTRASONICS GLOSSARY {in process}.

ULTRASONICS BIBLIOGRAPHY

Ultrasonic Bibliography Page 1 - Reference Books on Acoustics, Vibration, and Sound.
Ultrasonic Bibliography Page 2 - Sonochemistry.
Ultrasonic Bibliography Page 3 - Selected Articles.

You are invited to visit the ULTRASONIC INDUSTRY ASSOCIATION home page.

CALL FOR CONTRIBUTIONS: I am working on a book for Marcel Dekker on "***High-Intensity Ultrasonic Technology and Applications***" (in their "*Mechanical Engineering Series*", edited by Profs. Lynn L. Faulkner and S. Bradford Menkes). This book will focus on the practical application of power (high-intensity) ultrasonics, the use of ultrasonic energy to change materials. **Contributions** are welcome.

ULTRASONIC CLEANING

Continuation Page 1

{this is a work in process}

APPLICATION PAPER AP-3

Original Date: 01 Aug 1991
Rewritten: 09 Apr 2002

SPECIAL INSTRUCTIONS FOR CLEANING JEWELRY, CLOISONNÉ, ETC., IN HOME AND HOBBY USE

This information supplements the standard cleaning information supplied with general purpose ultrasonic cleaning tanks. There are certain precautions to observe and procedures to follow which will give optimum results when cleaning jewelry, cloisonné ware*, timepieces, and other like articles.

* - see Paragraph 5, below.

1. CLEANING SOLUTIONS - Low sudsing household cleaning agents, such as ammoniated **AJAX**, **MR. CLEAN**, or **JANITOR-IN-A-DRUM**, are often quite effective, easily obtained, and relatively inexpensive. Solution strength should be determined empirically. Too much or too little detergent will decrease cleaning efficiency. As a rule of "thumb", the water should feel only just slightly "slippery" when rubbed between thumb and forefinger. Decrease the concentration if the water feels slick and increase it if the feeling is more like that of plain water. Allow the solution to outgas by running each fresh batch for about 15 minutes. Use warm (not hot) water or use a heated tank. Unheated tanks will stabilize at about 110øF (43øC) and heated tanks are preset at about 140øF (60øC). This optimizes the higher detergency at elevated temperature and the greater cavitation effect of ultrasound at lower temperature.

2. DETERGENTS - A special detergent especially recommended for home use [DYNASOAP 104, formerly available from Heat Systems (now Misonix, Inc.)] was recommended in the original of this monograph. It was a highly concentrated cleaning agent, slightly alkaline, for general use, phosphate-free and biodegradeable, and held dirt in suspension, and rinsed freely in tap water. There were two other types of DYNASOAP detergents for home and hobby use. DYNASOAP 105 was an acidic cleaning agent for stain removal and for cleaning metals; it cleaned rust, oxide, and smut from all metals, especially stainless steel, chromium, and nickel (overuse might have etched aluminum). DYNASOAP 107 was an alkaline cleaning agent for cleaning glass and precious stones; it was best for oils, grease films, fingerprints, and buffing compounds. In the absence of these products, appropriate ALCONOX products could be substituted:

Alconox, Inc.
9 East 40th Street, Suite 200
New York, NY 10016
212-532-4040
FAX: 212-532-4301

e-mail: cleaning@alconox.com

URL: "http://www.alconox.com/main/mainmenu.html".

3. PRECAUTIONS -

a. Precious metals with a significant amount of copper alloying and any other materials to be cleaned should be tested before cleaning to determine the compatibility of the material with the cleaning agent.

b. NEVER clean pearls in an ultrasonic cleaner! Pearls are a natural accretion of calcium carbonate which may delaminate and dissolve in the tank!

b. NEVER clean paste jewelry in an ultrasonic cleaner! The paste may dissolve in the cleaning solution!

c. NEVER clean opals in an ultrasonic cleaner! Opals are a heavily fractured stone (the fracture planes reflect light and give the beautiful coloration for which opal is noted). Ultrasonic action (cavitation) in the tank may cause the fracture planes to extend and the stone may crumble in the tank!

d. Do not place items to be cleaned directly on the bottom of the tank. It is activately vibrating and can abrade the surface of the item. Suspend items in the bath or use a suspended beaker or the perforated tray made for the purpose.

4. SUGGESTIONS -

a. Cleaning copper, or high-copper alloys, will remove the patina and leave a bright pink pure copper color. Heating the metal in warm vegetable oil supposedly restores the darker color.

b. When cleaning old jewelry with very small stones (baguettes, chips, melée, etc.) always clean the item in a glass beaker, rather than directly in the tank. Small stones are often loose and held in place only by dried hand cream, skin oils, and soap, and may fall out when these contaminants are removed by ultrasonic cleaning. Stones may be hard to find in the large tank, but are easily seen in the bottom of a beaker.

c. To use strong acid or caustic solutions without harming the stainless steel tank, clean items in a glass beaker as indicated below, taking all necessary precautions against personal injury.

d. To clean items in the solid tray or in beakers, make up a solution of warm water to which a small amount of mild soap or detergent has been added. Fill the tank only with the amount of solution which will rise to 1" (25mm) from the tank rim when the tray or beaker is in place. Avoid overflowing. Fill the tray or beaker with the desired cleaning solution and allow to degas as noted above for the tank itself.

e. Watches, clocks, and other timepieces may be cleaned in the ultrasonic cleaner, BUT they will then be completely without corrosion resistance or lubrication. Do not clean timepieces unless you are able to relubricate and protect the delicate surfaces.

5. CLOISONNÉ - Special instructions for ultrasonic cleaning methods unique to cloisonné, enamelling can be found in the book **CLOISONNÉ - The Art of Cloisonn, Enamelling and Jewelry Making**, by Felicia Liban and Louise Mitchell, Chilton Book Co., 1980, Library of Congress Catalog Card No. 80-957, ISBN 0-8019-6900-x.

Ms. Felicia Liban
251-37 43rd Avenue
Little Neck, New York 11363

Mrs. Louise Mitchell
{formerly of
Glen Haed, New York}

- - - * - - -

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

MUCH MORE TO FOLLOW

You may wish to visit the main Ultrasonics page, et seq., as well as the Ultrasonics Glossary page {also in process}.

THUMBS UP!

THUMBS UP! - Support your local police, fire, and emergency personnel!

S. Berliner, III

To contact S. Berliner, III, please click here.

PREV.PAGE FIRST PAGE NEXT PAGE

To tour the Ultrasonics pages in sequence, the arrows take you from the main Ultrasonics Page (Ultrasonics index, Applications List, Keywords/Applications Index, and Brainstorming) to Page A ("Condensed Guide to Ultrasonic Processing" and "A Popularized Guide to Ultrasonic Processing"), Page 1 (with "A Popularized Guide to Ultrasonic Cavitation" and Tubular Horns), Page 1A ("Amplitude Measurement", Free Bubbling, Bubble Entrapment, Foaming and Aerosoling, and Extenders), Page 2 (More on Cavitation and "Ultrasonics and Fine Particles"), Page 3 ("Ultrasonic Sterilization and Disinfection","Ultrasonics, Hearing, and Health", Ultrasonics and Living Organisms, and What's New?), Glossary Page, Cleaning Page (Immersible Transducers and What's New?), Bibliography Page 1 (Reference Books on Acoustics, Vibration, and Sound), Bibliography Page 2 (Sonochemistry), and Bibliography Page 3 (Selected Articles).

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Updated: 23 Feb 2004, 19:50 ET
[Ref: This is us-gloss.html (URL http://home.att.net/~Berliner-Ultrasonics/us-gloss.html)]

S. Berliner, III's

Ultrasonics Glossary

Consultant in Ultrasonic Processing
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SONOCHEMISTRY * REACTION ACCELERATION * DISRUPTION
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INDEX

PLEASE NOTE: If some of the internal links on this page refuse to work, please click on Back and scroll down.

Ultrasonics and Nuclear Fusion.

On Ultrasonics Page 5:

Ultrasonic Whistles (Nozzles, Atomizers, Nebulizers). NEW! (23 Feb 04)

On the Ultrasonic Cleaning page:

ULTRASONIC CLEANING {in process}.

Immersible Transducers.

What's New?.

On this ULTRASONICS GLOSSARY page:

ULTRASONICS GLOSSARY {in process}, (now with alphabetical index).

ULTRASONICS BIBLIOGRAPHY

Ultrasonic Bibliography Page 1 - Reference Books on Acoustics, Vibration, and Sound.
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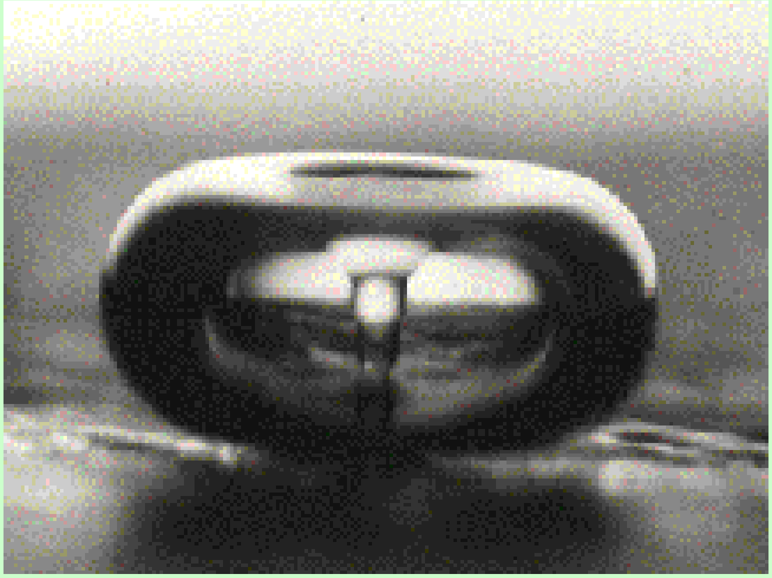
THE CAVITATION BUBBLE



[image from University of Washington, Applied Physics Laboratory (Lawrence Crum, Ph.D.)
- bubble diameter approximately 1mm]

You may wish to visit the main Ultrasonics page, the succeeding page and the next succeeding page, with more on **ultrasonics**, as well as the Ultrasonics Cleaning page {also in process}.

ULTRASONIC GLOSSARY

[Terms and definitions may overlap and even be redundant;
such is the nature of terminology in this complex little field.]

Alphabetical Index to Ultrasonics Glossary

[A]

Acoustic - having to do with the energy of sound waves.

Acoustics - the science and application of acoustic energy.

Active Tank - an **ultrasonic tank** which has been activated to produce **cavitation** (cf. **Still Tank**, terms coined by Berliner).

Amplification - the increase (which can be negative) of mechanical amplitude from one end of an acoustic element to another.

Amplifying Element - a part of a **stack** or **convertor** which boosts (or decreases) the amplitude of vibration of the output end.

[B]

Back - syn. **Rear**, q.v.

Bath - syn. **Tank**, q.v., or the contents of the liquid tank or container.

Blanketing - that limiting phenomenon in the **cavitation field** in which the density of the **bubble cloud** is such that no further **cavitation** takes place when additional energy is introduced (analgous to the phenomenon at the temperature of thermal boiling, above which no further change of state occurs (term coined by Berliner - see text).

Blanketing Threshold - that intensity of **cavitation** at which the **blanketing** phenomenon occurs; for practical purposes, the blanketing threshold may be considered a relative term based on the efficiency of conversion from increased radiated energy to increased **cavitation** (term coined by Berliner - see text).

Bubble - a spherical volume of gas or vapor in a liquid but also commonly used to refer to a spherical void in a liquid.

Bubble Cloud - a cloud of **cavitation** bubbles which hovers in front of an activated **radiating surface**.

[C]

Cavitation - the sequential formation and collapse of vapor bubbles and voids in a liquid subjected to acoustic energy at high frequency and intensity (analgous to thermal boiling but without the associated rise in temperature of the mass of liquid, although localized temperatures on the molecular level can be extremely high).

Cavitation Field - that volume, within a processing container or flow system, in which active **cavitation** is generated by the **radiating surface**.

Crystal - the **piezoelectric** element(s) in a **stack** which expands and contracts in an alternating (charged) electrical field, thus inducing vibration.nbsp; In low-powered ultrasonic cleaning tanks, crystals are sometimes bonded directly to the **diaphragm** (tank bottom or side wall).

Convertor (also **Converter**) - the combination of **transducer** elements, **front driver**, and (where so fitted) **rear driver** in a **stack**, together with a housing and electrical connections or cabling, which together with a horn forms a **probe**.

Cup Horn - a form of **ultrasonic bath** in which energy is imparted by an inverted horn sealed into the bottom of a water jacket or cup (see text).

[D]

Diaphragm - the side wall or bottom of an ultrasonic cleaning **tank** or the active surface of an **immersible transducer** or other radiating acoustic device that transmits ultrasonic energy from the **stack** or **transducer** into a liquid bath (analagous to the diaphragm in an early telephone), in effect thus forming the **radiating surface** - use of term in this fashion coined by Berliner - see text).

[E]

Electrode - in **piezoelectric** and similar systems, the means, usually thin metal plates, by which electrical energy is introduced to the faces of the **transducer crystals**.

Electrostrictive - syn. **Piezoelectric**, q.v.

[F]

Forward - arbitrary convention (by Berliner et al.) for direction in a **transducer**, **stack** or **convertor** away from the longitudinal center or **crystals** toward the **radiating surface** or **tip**.

Front - syn. **Forward**, q.v.

Front Driver - that set of elements forward of the transducing elements in a **stack** which (usually) amplifies the vibrational energy and transmits it to the **horn** or output end.

[G]

Gain Factor - the factor by which the gain (amplification) of a final **radiating surface** measured against the amplitude of the initiating device, such as the output surface of the **front driver** of a welding or processing **stack**, is given.

Generator (syn. **Power Supply**) - that device which powers and controls the **convertor** (**transducer**) of an electronically-driven ultrasonic device or system. Mechanical generators also have been made.

[H]

Hertz (Hz) - a unit of frequency equivalent to the now-denigrated "cycle-per-second" (cps). One Hertz (1 Hz) equals 1 cps.

Horn (syn. **Tool**) - usually an **amplifying element**, that includes, or is fitted with, a **tip** in an ultrasonic **probe**.

[I]

Immersible Transducer - a radiating device sealed in a housing (usually stainless steel), the forward or front surface of which is the **radiating surface**, and which can be submerged under the surface of a liquid **bath** to energize the liquid to produce **cavitation**. An immersible transducer placed in a **still tank** turns that tank into an ultrasonic **cleaner**. The immersible transducer is, in effect, a standard tank everted (turned inside out) with the radiating surface on the outside and the transducers on the inside.

Input - in terms of direction in an ultrasonic system, that direction toward the power source and away from the process.

Intensity - in terms of acoustic output, the term "**High Intensity**" is favored herein in lieu of "**High Power**" because high intensity is required for **cavitation**. A 1/16" (1.6mm) diameter **tip** on a **probe** does not require much power at all to radiate at high intensity whereas a large **sonar** array may soak up enormous power while radiating at very low intensity.

[J]

Jet - syn. **Liquid Jet**, q.v.

[K]

Kilohertz (**KHz**) - a unit of frequency equivalent to one thousand "cycles-per-second" (cps). One Kilohertz (1 KHz) equals 1,000 cps.

[L]

Liquid Jet - a jet of liquid, moving at extreme velocity against a surface, which results from the assymetrical implosion of a **cavitation bubble** in close proximity to that surface.

[M]

Magnetostrictive - having to do with systems driven by the effect of certain metals, especially nickel, and certain other materials such as ytterbium compounds, which expand and contract in an alternating magnetic field.

Megahertz (**MHz**) - a unit of frequency equivalent to one million "cycles-per-second" (cps). One Megahertz (1 MHz) equals 1,000,000 cps.

[N] - {no "N" definitions, yet.}

[O]

Output - in terms of direction in an ultrasonic system, that direction away from the power source and toward the process.

Output Surface - syn. **Radiating Surface**, q.v.

[P]

Permeability - while not a term of ultrasonics, per se, permeability of membranes (including skin) can be altered by application of ultrasonic energy (see What's New?).

Piezoelectric - having to do with systems driven by the effect of certain crystals, such as lead-zirconate-titanate, and other materials, which expand and contract in an alternating (charged) electrical field.

Power - see **Intensity**.

Power Supply - syn. **Generator**, q.v.

Probe - in ultrasonics, term commonly used to describe the **convertor-horn-tip** system which accepts power from a **generator** and does work. Not to be confused with sensing elements used in non-destructive testing and measuring.

Propulsive Force the force generated in a medium when acoustic energy leaves a radiating face. NEW!

[Q] - {no "Q" definitions, yet.}

[R]

Radar (Radio Detecting and Ranging) - an electronic means of determining distance (not an acoustic means).

Radiating Face - syn. **Radiating Surface**, q.v.

Radiating Surface (syn. **Radiating Face**) - that surface in a **stack** or **convertor** or on a **diaphragm** farthest away from the **transducer** which radiates acoustic energy (often the tank **bottom** or the horn **tip**).

Radiation - the propagation of energy; for the purposes of this text primarily restricted to the propagation of acoustic energy through a medium [as opposed to electronic radiation (such as light, electricity, radio waves, etc.), which does not require a medium]. Although primarily propagated by the vibration of a solid surface, acoustic radiation can also be generated by other means (see text).

Radiator - syn. **Radiating Surface**, q.v.

Rear (syn. Back) - arbitrary convention (by Berliner et al.) for direction in a **transducer**, **stack** or **convertor** from the longitudinal center or **crystals** and away from the **radiating face** or **tip**.

Rear Driver - that set of elements (when so fitted) behind the transducing elements in a stack which dynamically counter-balances the **front driver**.

Resonant Body - any physical object which can resonate when struck (ring like a bell).

ROSETT™ Cooling Cell - a specially-shaped processing vessel, usually glass, with semi-circular tubulations to facilitate turbulent, recirculating flow (originally developed by Dr. Theodore Rosett).

[S]

Sealed Atmosphere Treatment Chamber - a high-pressure processing vessel with inlet and outlet tubes.

Sonar (So und Navigation and Ranging) - an underwater acoustic means of determining distance.

Sonic - having to do with the velocity (speed) of sound (specifically as opposed to **ultrasonic**, q.v.). Some cleaning devices are labelled as "**SONIC**" to possibly imply that they operate ultrasonically, whereas in fact they merely vibrate parts without generating **caviation**.

Sonicate - to process materials with ultrasonics, specifically to change materials chemically and physically. Not generally used for cleaning or joining (term coined by Berliner).

Sonify - syn. **Sonicate**, q.v.

Sonochemistry - driving and accelerating chemical reactions through application of ultrasonic energy.

Sonolysis - disruption of biological cells through application of ultrasonic energy.

Stack - the most basic combination of **transducer** and amplifying elements together forming a **resonant body** to be attached to (or including) a **radiating surface** or **horn**. In some **magnetostrictive transducers**, the **stack** is a set of nickel laminations (shims) brazed at the ends and somemes at the midpoint and fastened to the **front driver** or **horn**.

Still Tank - an **ultrasonic tank** which has not (yet) been activated to produce **cavitation** (cf. **Active Tank**, terms coined by Berliner) or a tank which is not fitted with ultrasonic **transducer**s.

Subsonic - having to do with velocities below the speed of sound (specifically as opposed to ultrasonic, q. v.).

Supersonic - having to do with velocities above the speed of sound (specifically as opposed to ultrasonic, q.v.).

[T]

Tank - syn. **Bath**, q.v., or any container holding a body of liquid, especially an ultrasonically-activated container or tank.

Tip - the **radiating surface** of a **horn** or other final element of a **stack** or **convertor** which radiates acoustic energy outwards to do work (such as processing or joining). Tips may be integral with the final output element or may be removable.

Tool - syn. **Horn**, q.v. **Tool** is more commonly applied in welding and joining and like operations whereas **Horn** is more commonly applied in processing.

Transsonic - having to do with velocities around the speed of sound (specifically as opposed to ultrasonic, q.v.).

[U]

Ultrasonic - having to do with frequencies of sound above normal human hearing, generally accepted to be at 20KHz to 2MHZ and above, but also extended down to the 5KHz to 20KHz range in certain processing applications (cf subsonic, **supersonic**, or **transsonic**, which have to do with the speed of sound).

Ultrasonics - the application of ultrasonic energy to do work (specifically as opposed to subsonic, supersonic, or transsonic, q.v.).

Ultrasonic Cleaning - changing the surface of materials by the application of ultrasonics, thereby removing contaminants; for the purposes of this text, included in **Ultrasonics Processing**.

Ultrasonic Joining - a term of art covering ultrasonic welding, bonding, fusing, soldering, staking, and like applications.

Ultrasonic Liquid Processing - subset of **Ultrasonic Processing** in which work is done in a liquid medium; some processing, such as drying and levitation, can be accomplished in air or other gaseous media.

Ultrasonic Processing - changing materials (including the surface of materials) by the application of ultrasonics; term coined (by Berliner) to include various forms of application of ultrasonics such as cell disruption and homogenization and the like, and to differentiate them from joining, and other applications. However, for the purposes of this text, includes **Ultrasonics Cleaning**.

Ultrasonic Processor - a complete device, normally consisting of a **Generator** and a **Convertor**, plus a

Horn and accessories, which accepts a form of energy, usually electrical, and transforms it into ultrasonic energy to change materials.

["V", "W", "X", "Y", and "Z"] - {no "V", "W", "X", "Y", or "Z" definitions, yet.}

{Please advise of terms for consideration.}

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

You may wish to visit the main Ultrasonics page, et seq., as well as the Ultrasonics Cleaning page {also in process}.

THUMBS UP!

THUMBS UP! - Support your local police, fire, and emergency personnel!

S. Berliner, III

To contact S. Berliner, III, please click here.

To tour the Ultrasonics pages in sequence, the arrows take you from the main Ultrasonics Page (with full index) to Pages A, 1, 1A, 2, 3, 4, and 5, this Glossary Page, Cleaning Page, and Bibliography Pages 1, 2, 3, and 4 (see Index, above).

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S. Berliner, III's

Ultrasonics Bibliography - BIB-1

REFERENCE BOOKS ON ACOUSTICS, VIBRATION, AND SOUND

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This information is **NOT** current and is presented only as a guide to the older literature.

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.

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S. Berliner, III

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Suslick, K. S., and Flint, E. B., A Versatile Sonochemical Reaction Vessel,in Experimental Organometallic Chemistry, Darensbourg, M. Y. and Wayda, A. L. (Eds.), ACS Symposium Series #357, Washington, D.C., p. 195, 1987.

Suslick, K. S., Schubert, P. F., and Goodale, J. W., Chemical Dosimetry of Ultrasonic Cavitation, 1981 Ultrasonics Symposium, IEEE, pp. 612-616, 1981.

SONOCHEMISTRY - SONOLUMINESCENCE

Verrall, R. E., and Sehgal, C. M., Sonoluminescence, in Ultrasound: Its Chemical, Physical and Biological Effects, Suslick, K. S. (Ed.), VCH Publishers, New York, 1988.

SONOCHEMISTRY - NOT OTHERWISE CLASSIFIED

Boudjouk, P., Activation of Metals by Ultrasonic Waves, in Advances in Sonochemistry, Mason, T. J. (Ed.), JAI Press, New York, 1989. Suslick, K. S., Shape Selective Hydrocarbon Oxidation, in Activation and Functionalization of Alkanes, Hill, C. L. (Ed.), Wiley Publishers, New York, 1989 pp. 219-241.

Collman, J. P., Halbert, T. R., and Suslick, K. S., O^2 Binding by Metalloporphyrins, in Metal Ion Activation of Dioxygen, Spiro, T. G. (Ed.), Prentice-Hall, 1980.

- - - * - - -

[Heterogenous Sonochemistry - Liquid-Liquid Emulsions and many other aspects of Sonochemistry are covered in part in the books listed herein and in numerous journal references outside the scope of this listing; see Sonochemistry - Ultrasonic Cavitation and Chemical Reactions for more extensive references to the literature.]

- - - * - - -

The assistance of Professor Kenneth S. Suslick of the University of Illinois at Urbana-Champaign and of Professor Philip Boudjouk of North Dakota State University in the original preparation and current revision of the sonochemistry section of this bibliography is hereby gratefully acknowleged.

- - - * - - -

Those persons interested in **SONOCHEMISTRY** might wish to look at Prof. Kenneth S. Suslick's and Shiga University's Sonochemistry pages.

This information is **NOT** current and is presented only as a guide to the older literature.

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.

You may wish to visit the ULTRASONICS page, et. seq. with more on **ultrasonics**, as well as the Ultrasonics Cleaning page {in process} and the Ultrasonics Glossary page {also in process}.

THUMBS UP!

THUMBS UP! - Support your local police, fire, and emergency personnel!

S. Berliner, III

To contact S. Berliner, III, please click here.

To tour the Ultrasonics pages in sequence, the arrows take you from the main Ultrasonics Page (Ultrasonics index, Applications List, Keywords/Applications Index, and brainstorming) to Page A ("Condensed Guide to Ultrasonic Processing" and "A Popularized Guide to Ultrasonic Processing"), Page 1 (with "A Popularized Guide to Ultrasonic Cavitation" and Tubular Horns), Page 1A ("Amplitude Measurement", Free Bubbling, Bubble Entrapment, Foaming and Aerosoling, and Extenders), Page 2 (More on Cavitation and "Ultrasonics and Fine Particles"), Page 3 ("Ultrasonic Sterilization and Disinfection","Ultrasonics, Hearing, and Health", Ultrasonics and Living Organisms, and What's New?), Glossary Page, Cleaning Page (Immersible Transducers and What's New?), Bibliography Page 1 (Reference Books on Acoustics, Vibration, *and Sound), Bibliography Page 2 (Sonochemistry), and Bibliography Page 3 (Selected Articles).*

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Updated: 14 Aug 2002, 05:10 ET
[Ref: This is us-bib-3.html (URL http://home.att.net/~Berliner-Ultrasonics/us-bib-3.html)]

S. Berliner, III's

Ultrasonics Bibliography - BIB-3

Consultant in Ultrasonic Processing
"changing materials with high-intensity sound"

Technical and Historical Writer, Oral Historian
Popularizer of Science and Technology

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

[See "Keywords (Applications) Index" on Page 3.]

Specializing in brainstorming and devil's disciplery for new products and
reverse engineering and product improvement for existing products.

{"Imagineering"}

[consultation is on a fee basis]

MEMBER
Board of Directors

[New 2000 Logo -
all rights reserved to UIA.]

INDEX

PLEASE NOTE: If some of the internal links on this page refuse to work, please click on Back and scroll down.

On Ultrasonics Bibliography - BIB-1 page:

On Ultrasonics Bibliography - BIB-2 page:

On Ultrasonics Bibliography - BIB-3 (this) page:

AL-4 - AMPLITUDE MEASUREMENT.

Call for Contributions for Book.

On Ultrasonics Page 2:

More on Cavitation.

AL-2 - "ULTRASONICS AND FINE PARTICLES -
BENEFICIATION OF SLURRIES AND FINE-PARTICLE SUSPENSIONS
[CERAMICS, COAL & ORES, COATINGS, COLUMN PACKINGS, SINTERING, SLIPS].

On Ultrasonics Page 3:

AM-1 - "ULTRASONIC STERILIZATION and DISINFECTION".

UM-1 - "ULTRASONICS, HEARING, and HEALTH"

Keywords (Applications) Index.

On Ultrasonics Page 4: NEW!

Foaming and Aerosoling - moved 28 May 02 from Page 1A. REV'D

Ultrasonic Propulsion (Propulsive Force) - Moving Material. NEW!

Ultrasonic Fountains - Atomization, Nebulization, Humidification,
Misting, Particle Creation and Sizing. NEW!

Ultrasonics and Nuclear Fusion. NEW!

On the Ultrasonic Cleaning Page: ULTRASONIC CLEANING {in process}.

Immersible Transducers.

What's New?

On the ULTRASONICS GLOSSARY page:

ULTRASONICS GLOSSARY {in process}.

BIBLIOGRAPHY ON ULTRASONICS - BIB-3

SELECTED ARTICLES ON ULTRASONICS

[see also the author's BIB-1 re REFERENCE BOOKS ON ACOUSTICS, VIBRATION, AND SOUND and BIB-2 re SONOCHEMISTRY]

Some of the cited works may be out of print or are known to be [noted @];
consult your corporate, school, or public reference librarian for copies.

SELECTED ARTICLES ON ULTRASONICS

(citations are presented in top-down date sequence)

GENERAL

The following articles are readily accessible and are recommended
for practical knowledge of ultrasonic cavitation and the function and
application of probe-type devices in ultrasonic liquid processing:

Willard, G. W. (Bell Telephone Laboratories), "Ultrasonically Induced Cavitation in water : A Step-by-Step Process", JASA, 25, 4, 669-671, Jul 1953
Suslick, K. S., Sonochemistry, Science, 247, 1439-1445, 23 March 1990.
Suslick, K. S., The Chemical Effects of Ultrasound, Scientific American, February 1989, 80-86.
Berliner, S., III, Application of Ultrasonic Processors (Power vs. Intensity in Sonication), Amer. Biotech. Lab., 46-52, March 1984, and Int'l. Biotech. Lab., March/April 1984.]

ENVIRONMENTAL

Reddi, L. N., Berliner, S., III, and Lee K. Y., Feasibility of Ultrasonic Enhancement of Flow in Clayey Sands, Technical Note No. 3291, J. of Environmental Engineering, Environmental Engineering Div., American Society of Civil Engineers, 119, 4, 746-752 (Jul/Aug 1993).

This information is **NOT** current and is presented only as a guide to the older literature.

For the latest work in ultrasonics, refer to the extensive chapter references and bibliographies in:

Ensminger, D., Ultrasonics: Fundamentals, Technology, Applications, Marcel Dekker, Inc., New York, 1988

Suslick, K. S. (Ed.), Ultrasound: Its Chemical, Physical and Biological Effects, VCH Publishers, New York, 1988

Mason, Timothy J., and Lorimer, J. Phillip, Sonochemistry: Theory, Applications and Uses of Ultrasound in Chemistry, Ellis Horwood, Chichester, 1988

Shah, Y. T. , Pandit, A. B., and Moholkar, V. S.: Cavitation Reaction Engineering, The Plenum Chemical Engineering Series, Kluwer Academic / Plenum Publishers, 2000, LoC 99-37362, ISBN 0-306-46141-2 NEW!

and to Internet searches and the public and institutional libraries.

This information is **NOT** current and is presented only as a guide to the older literature.

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.

You may wish to visit the ULTRASONICS page, et. seq. with more on **ultrasonics**, as well as the Ultrasonics Cleaning page {in process} and the Ultrasonics Glossary page {also in process}.

THUMBS UP!

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PREV.PAGE FIRST PAGE

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S. Berliner, III's

THUMBS UP! Page

Updated: 21 Sep 2003, 19:55 ET
[Ref: This is thumbsup.html (URL http://home.att.net/~Berliner-Ultrasonics/thumbsup.html)]

We still think of all who worked and died at the
World Trade Center and Pentagon
in Manhattan and Arlington, and at Shanksville.
Our hearts go out to all who lost (or can't find) a friend or loved one.
No more need be said (but please see below*).

We were asked to wear RED, WHITE, and BLUE; I dug out my 1942 lapel pin:

Let me sadly add the valiant seven of the **Columbia** to this tribute (01 Feb 2003).

[Ref: This is thumbsup.html (URL http://home.att.net/~Berliner-Ultrasonics/thumbsup.html)]

S. Berliner, III's

THUMBS UP! Page

Consultant in Ultrasonic Processing
"changing materials with high-intensity sound"
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

---

"***The price of liberty is eternal vigilance***" (after John Philpot Curran* - 1790)
NOT eternal vigilantism! (SB,III - 1999)

{* - and NOT Thomas Jefferson, to whom it is widely attributed!}

PAGE INDEX:

AMERICAN ENGLISH FIRST FLAG.

THE THUMBS UP! PROGRAM

Thank Your Local Police Force or Law Enforcement Agency

and your local fire and EMS personnel, too!

**(not to mention Marshals, Inspectors,
the military/armed forces, etc.)**

I'm sick and tired of a few rogue cops blackening the name of those honest, decent officers who protect and assist me! I remember well the bumper sticker of the '60s;

IF YOU NEED HELP, TRY CALLING A HIPPIE!

Not that I was down on hippies, but the sentiment still applies. When you need them, the police and other law enforcement, fire, and EMS men and women are there to lend a hand. They have the training and equipment needed and they use both to do the job.

So, let's let them know they are appreciated!

Through the windshield or through an open window, give them a **THUMBS UP!**

Just make darn sure it's your thumb that's up!

It wouldn't hurt to be obeying the speed limit while you're at it, either!

A big smile wouldn't hurt, either!

DARKENED WINDOWS

Speaking of signaling through the window, let's get fully-tinted windows outlawed;

I can't bear the thought of an officer approaching a vehicle and being unable to see inside.

A note of appreciation:

** - Let me interrupt the intended flow of this page, impersonal as it is, to take note of a specific, real person, a neighbor, taken in the World Trade Center disaster on 11 Sep 2001; up to his confirmed loss, I'd been more or less "outside", looking in and on. I saw posters of the missing even out here on Long Island but, suddenly, it became too close; the widow of one of those heros was my dentist's assistant! Excerpting from the NEWSDAY obituary*

(I trust they won't object):

(photos from 03 Sep 2001 and 04 Feb 2002 NEWSDAYand © 2001 and 2002 NEWSDAY - all rights reserved)

JOHN {M.} PAOLILLO, of Glen Head, N.Y., on September 11, 2001. Battalion Chief of Special Operations Command Battalion FDNY; teacher for International Association of Fire Fighters and Task Force Leader for the Federal Emergency Management Agency. Beloved husband of Donna. Devoted father of Jake and Ella. Loving son of Martin and Elizabeth Paolillo. Dear brother of Joe and Sheila. A Memorial Service was held on 03 Oct at Our Savior's Lutheran Church, Glen Head {L.I.}, N.Y. In lieu of flowers, contributions may be made to the John Paolillo Memorial Fund, c/o North Shore School District, 112 Franklin Avenue, Sea Cliff, N.Y. 11579.

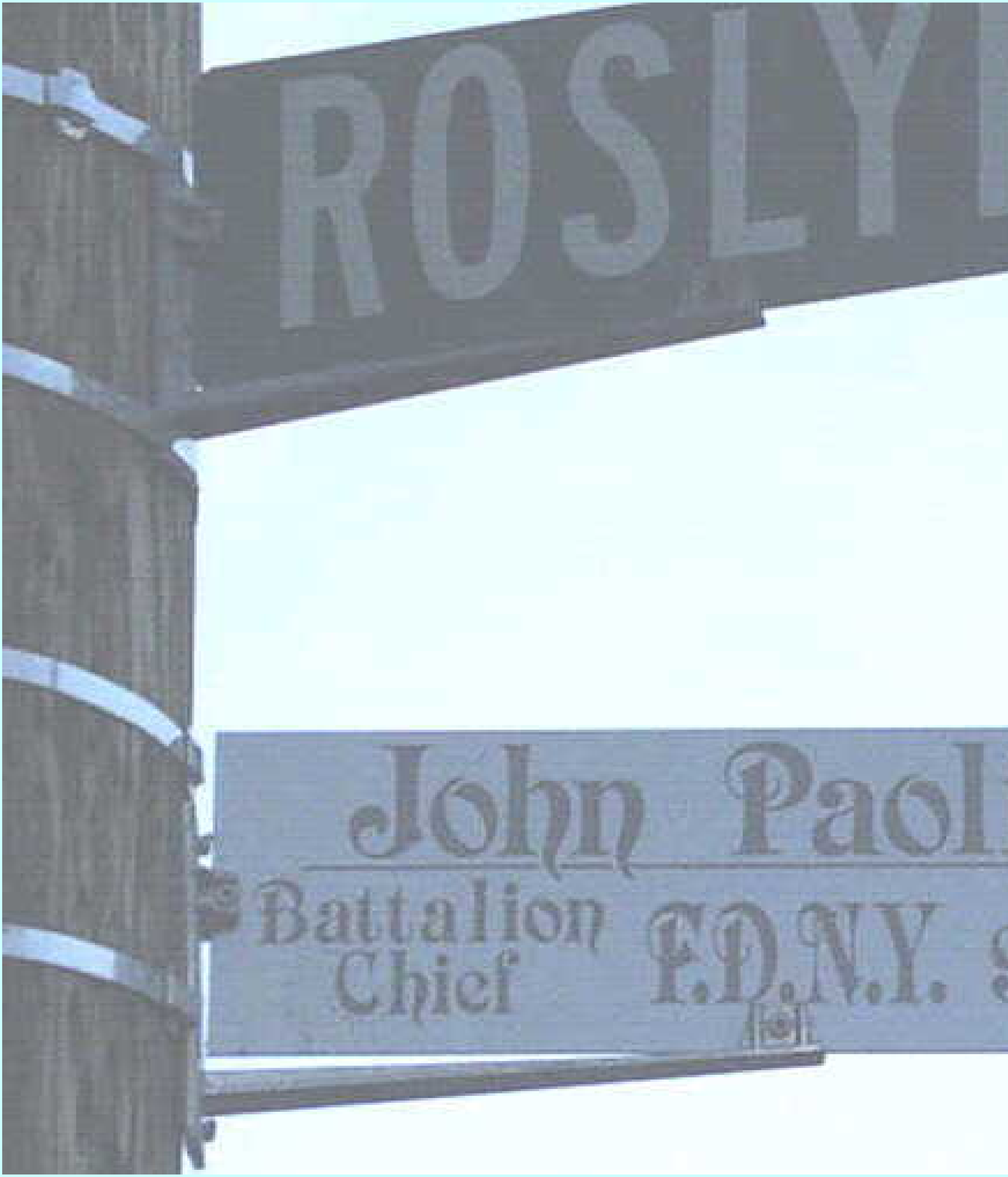
Rest in peace, John; you and your fellow bravest won't be soon forgotten. I picked John, a neighbor, as an examplar; there were far too many others like him. Too close, indeed!

I took the liberty of going in to Ground Zero (or as close as a "civilian" could get, even then) on 20 Dec 01; I figured 100 days was enough and I wanted to pay my respects up close; there is only one word and that is "some". It was **some**thing else! The cause was trouble**some**, the result fear**some**, the carnage tear**some**, the emptiness awe**some**, and the feeling lone**some** (I do NOT recommend your going down there alone, as I did). There were crowds of tourists, but all reverent and hushed.

[NEWSDAY devoted almost a half page (A21) to John M. Paolillo in its Monday, 04 Feb 2002 issue.]

11 Sep 2002 - I got kind messages from all over the world, whil(e)(st) they were out celebrating wildly in the streets of Baghdad. I can still remember quite vividly how wildly we celebrated incinerating Hiroshima and Nagasaki.

11 Sep 2003 - the Glen Head locals or the Town of Oyster Bay honored John by "renaming" Roslyn Drive, where he had lived, "**John Paolillo Way**":



(11 Sep 02 photo by and © 2003 S. Berliner, III -all rights reserved)

Thanks and **THUMBS UP!** to:

the **Nassau County** Police Department's **Sixth Precinct** in Manhasset
and especially their Booths E (Sea Cliff, my primary protection) and G (Roslyn),

the **Old Brookville** Police Department, which was my primary protection for several years,

the rest of the **Nassau County** Police Department, especially
the **Second and Third** Precincts, which often serve me now, especially the guys and gals at Second Precinct's Booths A (Bayville), B (Lattingtown), C (Oyster Bay village), D (Locust Valley@), and, now, H (Laurel Hollow)

[wonder which others I've missed?], and
the **Fourth Precinct**, which served me when I used to live down their way,

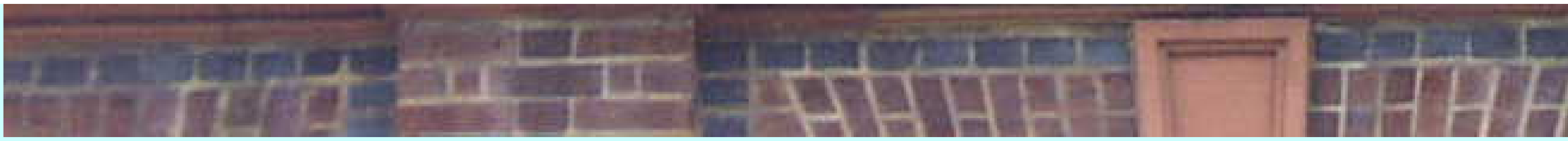
the **Glen Cove** Police Department which used to serve me for many years and again serves me (and well!),

{old 26 Apr 02 images lost - I took new ones 06 Feb 03}

[Former Glen Cove Police Station (left) - marked "**Justices Court**" / "**1907"**;
intended to become the **North Shore Historical Museum**
and the new Glen Cove Police Station (right) - the former City Hall
(06 Feb 03 photos by and © 2003 S. Berliner, III -all rights reserved)

{the grass is growing rather well on the entry overhang!}

Here's a detail of that plaque:



(06 Feb 03 photo by and © 2003 S. Berliner, III -all rights reserved)

and the **Centre Island, Oyster Bay Cove**, Cove Neck,** and **Old Westbury** Police Departments, which help me passing through.

I never seemd to get around to photos of the Nassau County station houses; that's now remedied. These are "my own"; 2nd at Crossways and Jericho in Woodbury, 3rd[3] on Hillside Avenue in Williston Park, and 6th on Community Drive (how apt) in Manhasset:

(06 Feb 03 photo by and © 2003 S. Berliner, III -all rights reserved)

[3] - Taking the photo of the 3rd involved quite a brannigan; I raised my camera in the parking lot and instantly was asked what I was doing by a gentlemen not in uniform, to which I bristled, and things went downhill from there. Once we calmed down and sorted it all out, all was well, but it got a wee bit dicey there; he was an officer, of course (a supervisor - gold badge), and well within his rights, given the terror threat, but we both could have been a lot more easy on each other. It's kinda funny, in retrospect, and, although I feel I did nothing wrong, I did apologize for my part in getting him so riled.

Here's the NCPD Second Precinct's Oyster Bay Booth C (looking west across South Street):

I also had photos of a bunch of other booths and stations in my locality; wonder where those photos went? Perhaps they were on film, not digital. On 06 Feb 2003, I wandered around my area to get the rest (natuirally, the sun vanished after I left); here they are (most of them, anyway), starting with NCPD Second Precinct's Booth A in Bayville and Booth B in Lattingtown:

(06 Feb 03 photo by and © 2003 S. Berliner, III -)

Next, we 'll go to 6th Precinct's Booth E in Sea Cliff and Booth G@ in Roslyn:

(06 Feb 03 photos by and © 2003 S. Berliner, III -all rights reserved)

The old Nike missile base in East Hills has been taken over by the municipality and one of the buildings by the main gate on Harbor Hill Road is now the 6th Precinct's Booth J: NEW! (30 Aug 03)


POLICE

(30 Aug 03 photos by and © 2003 S. Berliner, III -all rights reserved)

Lastly (for the NCPD), here is the old Laurel Hollow station, quite literally in a hollow, now 2nd Precinct's Booth H:

(06 Feb 03 photo by and © 2003 S. Berliner, III -all rights reserved)

Now for Old Brookville, itself, and the old Cove Neck station, now labelled as part of the Old Brookville force:

(06 Feb 03 photos by and © 2003 S. Berliner, III -all rights reserved)

Here's Centre Island and Oyster Bay Cove stations (still independent):

Hey, dispatchers relax; I'm not nuts. I know the area; I didn't drive around in the order I'm showing the pictures! Oyster Bay Cove's photo almost caused a problem; I'd turned south off eastbound Route 25A onto southbound Berry Hill Road and pulled off the roadway entirely to take the picture through my driver's window, but a big school bus turned south from westbound 25A and couldn't make the swing until I pulled away and I was so intent on the photo I didn't notice it until a horn blasted me out of my skin!

I have a lot of yarns to spin about Bill ("Willie-the-Whip") Whittendale, third man on the old Mill Neck force; here's one of his own shoulder patches:

(13 May 02 photo by and © 2002 S. Berliner, III -all rights reserved)

The first of my two articles about Bill appeared in the Spring 2002 issue (pp. 6-7) of the Oyster Bay Historical Society's superb publication, the *FREEHOLDER*, "The History Magazine of the Town of Oyster Bay"; the second installment, Part II, appeared in the Summer 2002 issue (pp. 6-7 and 18-19).

[For other patches, see Bosco link below.]

Ditto the **New York State Police** (especially Troop L in Farmingdale), the **New York State Park Police** (out of Bethpage), and the **Glenwood** and **Glen Cove** Fire Departments and EMS units.

While I'm at it, I mustn't forget the **Suffolk County** mounties who protect my grandchildren and their folks and the **CH**(i)**P**s who are there for my other daughter out on the Coast.

Kudos also to my neighbors, **NYPD Blue** and to "Big Daddy", the FBI, and to the DEA and the Bay Constables and the Game Wardens, and so on and on through so many people who put their lives on the line to maintain law and order.

And let's not forget the "bulls", the Long Island Rail Road **Police**; I don't ride that often and I trust I'm not an obnoxious railfan, but they are always polite and helpful!

The savage killing of NYC City Marshal Erskine Bryce on 21 Aug 01 prompted me to add Marshals and Fire Marshals and Inspectors and Case Workers and all those other civil servants, in and out of uniform, peace officers or no, and men of the cloth and so many more who put themselves in harm's way to do the work of and for the public.

Another fine, independent force bit the dust: the Laurel Hollow department went out on 31 May 98; it protected me in transit across Moore's Hill all these years and became a part of the Nassau force on 01 Jun 98; thanks, guys!

** - The Oyster Bay Cove Department also went Nassau (ca. Dec 00).

Hey, I inadvertently left out the **Port Washington** Police Department, which has been there for me for some 40 years of active involvement in the area, especially on Sunday mornings and weekday evenings on my way to and from church (until it moved to East Hills a few years ago).

NEWSDAY has a useful listing of all Nassau and Suffolk forces at their Police Departments page.

Those of you out there interested in present and vanished Nassau County forces should look at retired Garden City Police Detective James V. Bosco's fabulous Police Departments of Nassau County, Long Island, NY site; there are 30 police department shoulder patches shown (and 15 departments listed for which he shows no patches), with territories and histories!

{Oops! 13 May 2002 - the link doesn't work on either my or Jim's sites -
use this higher level link for his "Policeworks" Suffolk and NYPD patches;
I've asked Jim about Nassau.}

Jim Fordyce also has a neat site, Nassau County Police Information.

Meryl and Dick Olpe have a great page on law enforcement at CopCorner.

SOME RELATED N.Y. SUPPORTIVE ORGANIZATIONS:

(these listings are for information only and do not necessarily constitute any recommendation or endorsement)

NEW YORK STATE FRATERNAL ORDER OF POLICE Empire State Lodge, Inc.

NEW YORK POLICE BENEVOLENT ASSOCIATION - more links, including:
GARDEN CITY PBA,
LONG ISLAND ASSOCIATION OF CRIME PREVENTION OFFICERS,
LONG ISLAND SHIELDS,
NASSAU COUNTY MUNICIPAL POLICE CHIEFS ASSOCIATION,
STATE OF NEW YORK POLICE JUVENILE OFFICERS ASSOCIATION.

GARDEN CITY POLICE DEPARTMENT.

and the
NEW YORK STATE ASSOCIATION OF CHIEFS OF POLICE,
which my father supported all his adult life.

There are also the national **Fraternal Order of Police** and the New York City **New York Shields**, for neither of which have I found true home page URLS.

> Can anyone give me a direct URL for the F.O.P.? The Shields don't have one.

Nassau County residents may find these of interest -

NASSAU COUNTY P.D. PRECINCTS:

First Precinct - Baldwin
Second Precinct - Woodbury
Third Precinct - Williston Park
Fourth Precinct - Hewlett
Fifth Precinct - Elmont
Sixth Precinct - Manhasset
Seventh Precinct - Seaford
Eighth Precinct - Levittown

Nassau County has a complete listing of all its 8 precincts, their commander, phones, etc.

NASSAU COUNTY POLICE CAR NUMBERING

(probably not current):

(I forgot to whom I am indebted for the car numbering)

250 - Cove Neck P.D.
255-56 - Centre Island P.D.
260-61 - Laurel Hollow P.D.
262-64 - Mill Neck P.D.
266-67 - Oyster Bay Cove P.D.
270-79 - Glen Cove P.D. cars
282-83 - Glen Cove P.D. detectives
291-99 - Old Brookville P.D.

@ - Didja know? - The **Nassau County Police Department's Second Precinct Booth D** at the Locust Valley station, in an old two-story frame structure for the past few years, is actually the Long Island Rail Road's old **Locust** (Interlocking) **Tower**.

Here she is on 16 Feb 99, looking southeast and east and northwest:



It's featured on my LIRR continuation page 6; larger and newer images
(with details and and dimensions for modeling) are also there.

Names applied (more-or-less politely) to Police Officers:
[We will dispense with the "not-so-polite" appellations here; this is a family-rated site, you know!]

Well, it all started with Sir **Robert Peel**, who founded the first metropolitan police force back in 1829 in London. From "**Robert**" we get the British "**Bobbie**" and from "**Peel**" we get "**Peeler**"!

Now, Sir Robert, in order to distinguish his men (sorry, ladies, no women back then), gave them each a badge of office, made out of shiny (no fair; you guessed!) "**COPPER**", so now we have the classical British "**Copper**" and it's Yankee diminutive, "**Cop**"***!

*** - I've been taken to task, or at least quizzed, by a number of officers or retirees who all "know" that "COP" is an acronym for "**C**onstable **O**n **P**atrol" - well and good, but Merriam-Webster seems to agree with my take, dating "cop" from 1859 as short for "copper", in turn from 1846, both meaning "Police Officer".

I assume (probably incorrectly and certanly not politically correctly) that the archetypal overweight (read beer-guzzling) New York Irish cop pounding (literally) his beat gave rise to the term "**Flatfoot**"; happily, that archetype is gone (or all but so).

So, from whence cometh the terms "**Fuzz**" and "**Gumshoe**" ?

Bet the latter, "Gumshoe", is British, from the "gum" (rubber) soles on their shoes so they could move silently.

Military Police

MP (**Military Police**) - I'm sorry, gals and guys, for neglecting you! Although 4F, I used to live on base at Aberdeen Proving Ground, Maryland, when I worked there as an Ordnance Proof Director during the Korean fiasco (of course, there weren't any gals, then!) and my adventures there may amuse you; see my Ordnance pages. Since then, I have had many occasions to visit posts here and in Canada and have always been treated with the utmost of courtesy and helpfulness!

Speaking of Canada, let's hear it for the **RCMP** (and the **Provincials**), eh?

And, speaking of Mounties, I have always loved the appelation "**County Mounty**"; it rolls off the tongue so neatly.

You don't even have to be an officer or fire fighter or medic to be a hero; when I first visited Ground Zero, I saw for myself the truly-heroic labors of the utility people, especially the absolutely-fantastic work Verizon installers and cablers did rerouting tens of thousands of cable pairs in trenches and in surface conduit and as of 21 Nov 02 Verizon wanted to thank them for their herculaean efforts by laying them off while fat-cat execs get millions!

AMERICAN ENGLISH FIRST FLAG

Now, at the bottom of each of my Web pages, I have a little bit devoted to law enforcement and emergency personnel with which I display two current American flags, thusly:

These are the flag of a multilingual nation, torn apart by ethnic differences exascerbated by language, as is Canada; I could, instead, fly the Continental (or Grand Union) Flag of 1775, a flag of English-speaking people:

The current American flag came from the 18th Century British Union Jack and Royal Ensign and the Continental/Grand Union Flag through the so-called Betsy Ross 13-star flag, adding stars now and then for more states; we could always fly the 13-star or 48-star flags:

That would be grossly unfair to other states. I had written "Watch here for an even better {?} suggestion to come". How about a new American flag for the 21st Century?

Here's my "English First" variation on the Continental/Grand Union flag that adds the cross of St. Patrick of the current British Union Jack to celebrate the Irish that joined with the English and Scots in founding the United States:

I never realized before but there is good precedent for using the modern (20th Century) Union Jack in the field, witness the flag of the State of Hawaii:

If you enjoy this flag business, you must visit my Old Glory segment on my History page and two fabulous flag sites I ran across:

Rob Raeside's Flags of the World,
which illustrates almost every flag you can imagine, and

Ed Mooney, Jr.'s Flag Detective,
which helps you find flags by visual categories.

Should a police officer pursuing a cold-blooded killer in a face-mask have to call out,

"Stop, halt, arrêtez-vous, halto!"?

See my LANGUAGE page for a reasoned(?) discussion of English First

and my History page for more on the history of "Old Glory".

THUMBS UP!

S. Berliner, III

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(Created 04 Feb 2001)
[Ref: This is contact.html (URL http://home.att.net/~Berliner-Ultrasonics/contact.html)]
{Please note that it may ALSO be accessed as URL
http://berliner-ultrasonics.home.att.net/contact.html,
a *"vanity"* URL that does not require the tilde (~).}

S. Berliner, III's

CONTACT Page

Consultant in Ultrasonic Processing
"changing materials with high-intensity sound"
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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CONTACT

How to contact S. Berliner, III
by snail-mail, telephone, or e-mail:

PLEASE READ!

NOTE! **WAIT!** - before you start telling me about all the broken links to images from *home.light.att.net*, I know, I know (oh, do I EVER know)! AT&T WorldNet scrapped some 2,000 files (~126Mb) ca. 30 Jul - 08 Aug 2002, without a by-your-leave, just as my hard drive failed and overwrote many of my backups! A few image-intensive pages were especially hard hit. I am struggling to recover as best I can; please bear with me. If you find regular text links broken, please tell me specifically where and what.

NOTE! - **GREAT NEWS!** - I have succesfully recovered SOME "irretrievably-lost" files from **Internet Archive!** I highly recommend this invaluable service and, further, ask that you help fund this incredible effort.

In addition, **Google** has an Image Search capability (I use their Advanced Image Search function).

NOTE! 23 Jul 2002 - I regret to advise that I am being bombarded with spam and even malicious virus-laden messages and have finally been caught by a pernicious virus and will no longer even open any incoming messages that do not bear a full sender's name and a subject (and the subject better not be "Hi!").

With over 300 pages up on this site (as of 07 Jul 2003), many other storage sites, and a private domain (sbiii.com) in the works, the volume of incoming e-mail is getting more than I can handle, and I'm not even talking about spam (of which there is an ever-increasing flood!).

For example, I get requests to explain cavitation, to tell everything I know about ultrasonics or about the Long Island Rail Road or Motor Parkway or about boxcab oil-electric locomotives (early diesels); such inquiries come from people who haven't even taken the trouble to look at all the many pages I have put up (and indexed and even cross-indexed) with all that information and far more.

On the light side, I attended a college that ceased to exist in **1953** (!!!) and so state on that page, calling the school "**DEFUNCT**", and yet I keep getting serious applications to attend!

I may or may not be a gentleman (however crusty and cantankerous, especially now that I have to wait for a virus-checker to do its thing), but I **am** of the old school; to me, the Web/Net is like the telephone. My sites (and e-mail) are a service, a utility, even a luxury, for which **I** pay, for **my own** benefit, and for which **I** set the rules of use.

I have taken the trouble to put up a master Table of Contents on my home page and another on personal and hobby interests in more detail on a separate index page, Home Page 2, and even put up a **Semi-Alphabetical Index - A-K** and **L-Z**, with cross-referencing, and still the silly inquiries come in.

So, be advised; I will either ignore, or make short shrift of, ill-formulated inquiries or those that show a basic lack of courtesy.

Please exercise the courtesy of telling me to what page (by URL, preferably) you refer when making a specific comment; sometimes I have a really bad time figuring out to which of the 300+ pages people refer.

In spite of these caveats, I really DO appreciate corrections, however. NEW! (01 Apr 04)

I also do not do genealogical research! Please do NOT ask about your great-great- grandfather who worked on some unspecified railroad somewhere in the east sometime between the Civil War and the Great War; I do NOT know (or care) what the engraving in the lid of his Ingersoll might have read!

Under **NO** circumstances will I answer UNSIGNED e-mail! You know who I am; tell me who you are! It is a basic courtesy. You have my name; please sign yours!

Do NOT send me jokes or other puerile babble or off-color material, thank you.

Above all, I beg you, please, PLEASE, PLEASE do **NOT** send me back my own message when responding to my outgoing messages! I know what I wrote! Few e-mail discourtesies irk me more *(i.e. - if you want a friendly response, don't push your luck!)*. REV'D (24 Dec 03)

Also, please exercise the most basic courtesy of NOT sending images or other large files without first arranging with me to do so.

FORWARDING - please do NOT ever, EVER, **EVER**, **EVER** forward anything to me, especially not **virus warnings**! That's the best way to spread a virus or worm ever invented! If it's so important, and you KNOW what you're talking about, copy the text and send that, only, please.

You might also exercise the basic courtesy of editing out all the many levels of forwarding, and of duplications, before you send other people's texts.

(I know, I'm dreaming, but it can't hurt to ask!)

I have been taken severely to task for all these caveats; all I'm asking is basic courtesy. Normally, I answer all reasonably formulated incoming requests. The only major exception is that I am so inundated witrh e-messages that I miss a few now and then; please feel free to nag me if I miss yours (but be sure to give the subject and date of the original message!). REV'D (24 Dec 03)

Having ranted on so, I will continue to give out my normal snail-mail address and telephone number and my e-mail address (nothing anonymous for me!), all noted below, and beg that you not abuse this openness.

THUMBS UP!

THUMBS UP! - Support your local police, fire, and emergency personnel!

S. Berliner, III

{I moved in August 1998; my current mailing address and telephone number are:}

P. O. Box 183
Glen Head, New York 11545

tel.: 516-759-7360

[Incoming FAX is temporarily out of service.]

(Junk and unsigned e-mail and blind telephone messages will **NOT** be answered)

(Neither will messages without a sender's name or subject
because they will automatically be deleted)

e-mail*: **Berliner-Ultrasonics@att.net**

{* - The former e-mail address, "Berliner-Ultrasonics@worldnet.att.net" is perfectly valid
but unnecessary; leaving out the "worldnet**.**" simplifies the address and is equally effective.
The e-mail address is also NOT case sensitive; you can use lower case.}

*[How embarassing (mortifying, even)! Back around Nov 99,
I had left the "**.**" in after removing "worldnet" from some 150 pages
(then) so the address read "@**.**att.net" and somehow it crept back in
on this new page. My apologies to anyone inconvenienced by my oversight.]*

I would also point out that if you have been in contact with me about a shared interest and change your e-address without notifying me, I can not very well continue the interchange, can I? You might well be surprised at the number of good folks who have (in effect) simply dropped off the face of "my" earth.

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