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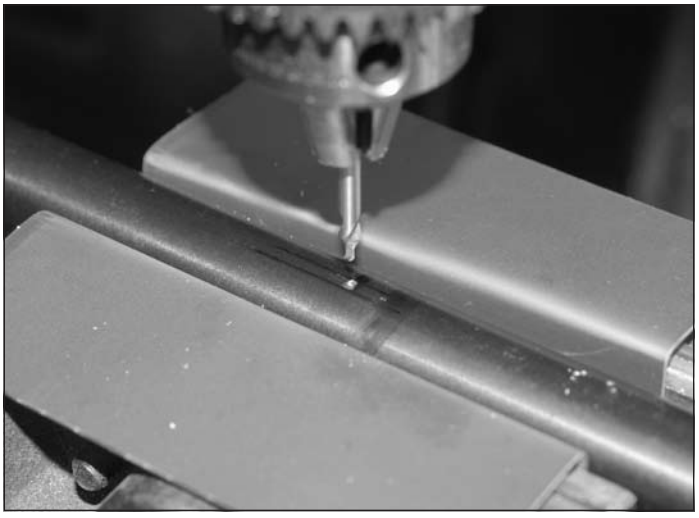


Ultrasonic Firearm Cleaning, Part One

How this time-saving tool works and its evolution to firearms cleaning.

by Richard MacLean

Even a novice gunsmith recognizes the damage that can be done to an expensive firearm with an ordinary screwdriver. They also know exactly why a correctly sized hollow-ground screwdriver is so effective at preventing damage when extracting hard-to-remove screws. Ultrasonic cleaners are another variety of tool that is gaining in popularity among gunsmiths, now that these devices have become more affordable. But just as the wrong screwdriver can ruin a firearm, so too can an ultrasonic cleaner if used improperly.

There is surprisingly little detailed, credible information on this subject and the classic gunsmithing books were written long before the invention of ultrasonic cleaning. These cleaning units can be a tremendous time saver for a gunsmith. They can perform certain operations that are all but impossible using solvents and manual brushing but they also come with potential issues. Many of the key warnings and relevant instructions are either absent from the manufacturer's literature or mentioned briefly. Just as significant, the reasons behind certain precautions are rarely explained and these warnings are soon forgotten. Compound this dearth of information with the ego factor ("I'm smart and only need to glance at the manual") and you have a recipe for disaster.

In this series, we'll explore all of the relevant dimensions of ultrasonic cleaning in the context of gunsmithing. There are hundreds of opinions about ultrasonic cleaning on various firearm forums. They cover the spectrum from favorable to very negative and from sensible precautions to absurd recommendations. Although they provide an initial framework to guide our investigation, we'll rely on the experts to get the facts straight; the manufacturers of the units, firearm finishers, product suppliers, and leading manufacturers of weapons and accessories, such as tritium night sights. We'll provide direct quotes from the early developers of ultrasonics for firearms and national experts on what ultrasonics can and cannot do and why. A draft of this article has been reviewed and scrutinized by numerous specialists—even Glock's United States legal department had a look.

Because this is a subject area that has not been adequately covered in the past and much of it may be unfamiliar to even expert gunsmiths, we chose to fully explore ultrasonics in a two-part series. This, the first, covers the background on ultrasonic cleaning, its evolution in firearm cleaning and the current state of the technology. The second part will explore proper cleaning techniques, what the experts say about ultrasonic cleaning, and essential tips that have, to the best of our knowledge, never been published before. It also contains an essential summary list of dos and don'ts and what to look for in a unit.

Ultrasonic Cleaning Origins

Bouncing sound waves off of underwater objects has been around since the early 1900s and was propelled to the forefront during World War I for submarine detection. The energy levels and frequencies are considerably different than those of ultrasonic parts cleaners but the principle is the same. Electricity is used to stimulate a disk made from a crystalline substance such as quartz and ceramic which, in turn, generates mechanical waves. Your stereo speakers or headphones perform a similar function, only in air and in the sonic hearing range between 20 Hz to 20 kHz. Ultrasonic is defined as frequencies that are above this threshold of hearing.

The first report of the "piezoelectric effect" generating ultrasonic waves was in the laboratories of Radio Corporation of America (RCA) in the 1930s. The scientists noticed that waves were generated around a radio crystal in a bath of liquid Freon but it was not until the 1950s that Bendix Corporation found practical application in cleaning. They discovered that if you pump in enough electric energy and at the right frequency, the waves generated are an effective surface scrubber.

The waves alternately compress and expand the molecules of the liquid in which the generating units or "transducers" are suspended or directly attached. There are currently two varieties of transducers. Magnetostrictive transducers generate waves when nickel or its alloys change dimensions in the presence of a varying magnetic field. Electrostrictive transducers generate waves in response to varying voltages via the aforementioned piezoelectric effect. These are currently made of ceramics (lead zirconate titanate) instead of quartz.

During the expansion phase, bubbles are formed that are invisible to the naked eye. The bubbles are subjected to enormous pressures during the compression phase and collapse with tremendous force, theoretically

estimated to be as high as 10,000 psi and 20,000 °F. Their microscopic size and the large volume of liquid in which they are formed absorb and buffer this energy release. Cumulatively there are millions of small expansions and implosions that both heat and mechanically agitate the liquid and produce the desired intense scrubbing action.

The optimum frequency for ultrasonic cleaning depends on the application. Heavy parts in large tanks clean best at 25 kHz. The optimum for firearms is around 40 kHz. Clocks and medical equipment do best at around 68 kHz. Disk drives and semiconductor parts require the upper limit of 170 kHz. While it may appear contradictory, lower frequencies exhibit a much more aggressive cleaning action. The bubbles formed are much larger, again at a microscopic level, and when they collapse, the implosions are powerful enough to knock the sand off of metal castings.

Higher frequencies penetrate better in the inner workings of delicate components. Higher frequencies have a more dense ultrasonic coverage on the cleaned surface, thus covering a higher percentage of the area to be cleaned. For example, in optics, silicon wafers, and surgical equipment, a higher frequency is required in order to provide a more thorough cleaning.

Another important concept is power. In air it is measured in decibels (dBA.) In ultrasonic cleaning the power is expressed as watts per gallon. The power (amplitude) of the waves generated must be sufficient to cause the pressure in the liquid at the point where a bubble forms to be less than the vapor pressure of the liquid. A few of the factors that influence the required power level to optimize cavitation are the type of liquid and its surface tension and temperature. In part two of this article we will discuss the importance of solution chemistry.

Most industrial cleaners have a watt density of between 50 to 100 watts per gallon. In general, smaller parts requiring more thorough cleaning need a higher watt density. There are exceptions for the cleaning of large parts in industrial tanks of over 50 gallons. Known as the "large tank phenomenon," only about 20 to 50 watts per gallon is required. Again, optimum power and frequency is not intuitively obvious and more is not necessarily better.

It is important to understand this distinction if you are in the market for a used industrial unit. A unit coming out of a dental office would probably work well on handguns and parts, but one used in the semiconductor or metal casting industry may not. Indeed, the aggressive action of low frequencies, in addition to the very harsh cleaning solutions and long immersion times in industrial applications, would ruin most gun finishes.

Ultrasonic Cleaning Evolution

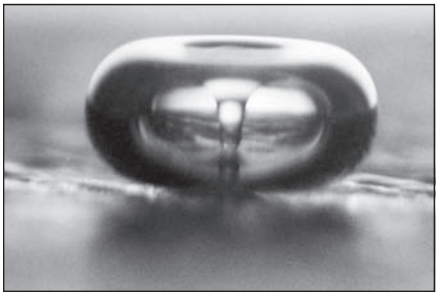
In the very early days, these key parameters were not well defined for most cleaning applications, let alone firearms. Bendix led the way and by the late 1950s, the public's eye was drawn to popular literature articles on ultrasonic applications. Other companies started to get into the commercial and industrial ultrasonic cleaning business. In 1980, Bendix sold off this division to a group of former employees who formed Swen Sonic Corporation, which later became Blue Wave Ultrasonics in 1990. Similarly, there have been scores of companies that have come and gone over the years. Most have specialized in industrial parts, biomedical, and dental device cleaning. In alphabetical order, Blackstone-NEY Ultrasonics, Blue Wave Ultrasonics, Bransonic, Crest Ultrasonics, GunCleaners Division of Police Products Corporation, L&R Manufacturing, SharperTek, Ultrasonic Power Corporation, and Zenith Manufacturing are among the most widely known and respected brands.

The ultrasonic cleaning industry in the early days was filled with optimism, going so far as to predict that the technology would replace conventional clothes washing machines. If you stuck anything in the tank it would be cleaned, or so the thinking went. By the 1970s some of these commercial units were being tried ad hoc for firearms cleaning. The results were disappointing because the overall processes specific to firearms cleaning had not yet been perfected. Specifically, the cleaning liquids were toxic (e.g., trichloroethylene), smelly (e.g., popular gun cleaning and ammoniated solvents), flammable (e.g., kerosene), and/or corrosive (e.g., strong caustics.)

The "if a little cleaning is good, a lot of cleaning is better" philosophy reigned. Not only that, the units were adaptations of industrial units and very expensive. That started to change in the 1990s. By then, L&R Manufacturing was producing a product line specific to firearms. Interest was growing, but it took two major developments to shift the firearms cleaning landscape to what is available today.

Greg Infante, President of Police Products Corporation and marketing his systems under the name GunCleaners, picks up the story from here. "Since 1978 I have been in the firearms business as an FFL and later as a law enforcement dealer for H&K, supplying firearms to police departments. In 1994, I was in a major police department as part of a weapons upgrade project. I noticed that the armorer had a Crest Ultrasonic unit containing what appeared to be a typical flammable gun solvent. Aside from the fire hazard, it smelled awful. I thought, 'There has to be a better way.'

"Soon thereafter I contacted Crest and worked out an agreement to be their exclusive distributor for firearm cleaning units in exchange for my development and marketing of their equipment and chemicals into improved firearm clean and lube



Left: *The typical benchtop ultrasonic setup includes two baskets, one for cleaning and one for lubrication (upper tank.) This Sonic Systems unit will clean gun parts up to 19" long or four pistols.* ***Below left****: Ultrasonic bubbles are only 8 microns (µ) or 0.0003 inches at 40 kHz but, collectively, millions pack a punch and scrub efficiently. Source, Dr. Lawrence Crum, University of Washington.*

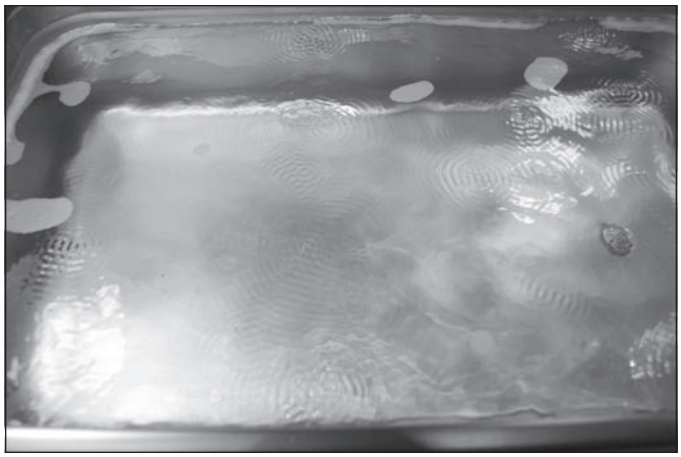
systems. One of the first challenges was to develop cleaning and lubricating solutions that were nontoxic, nearly odorless, and very efficient. In effect, we needed to hit the right balance between the power of the units and the aggressiveness of the cleaning solution.

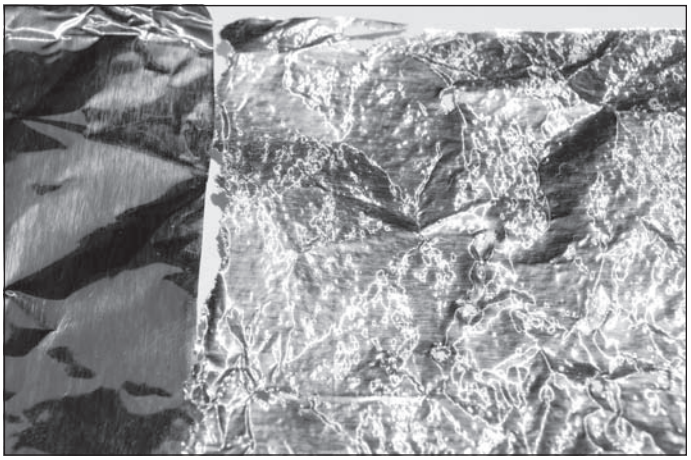
"For example, the surfactants used in the cleaning solution and the bath temperature significantly affect cavitation. It was not easy since one formulation might work well with a particular finish to remove some forms of crud but be useless on other finishes or hardened oils; some removed finishes. We got the best results with all finishes by using a cleaning solution safe enough to put on with your hands but with cautions on long durations in the tank. It took a lot of trial and error to come up with the current solution that has an extensive positive track record when used as directed.

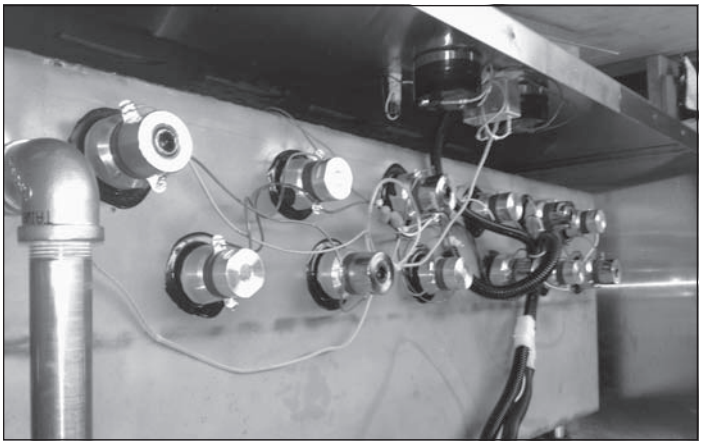
"The next challenge was to develop the overall process parameters such as time in tank, rinse, lubrication, and drying procedures. A special water-removing lubricant was also developed to be nonhazardous, odorless, and nonflammable that removes water through ultrasonic energy by emulsification rather than displacement with a solvent. Crest Ultrasonics had the technical resources to work with me to accomplish these goals and develop an extensive line of systems for any cleaning operation. I have also developed a new line of systems under my own GunCleaners brand with additional features. Brownells sells our systems, and cleaning and lubricating solutions, and the industry has pretty much adopted similar chemicals and processes."

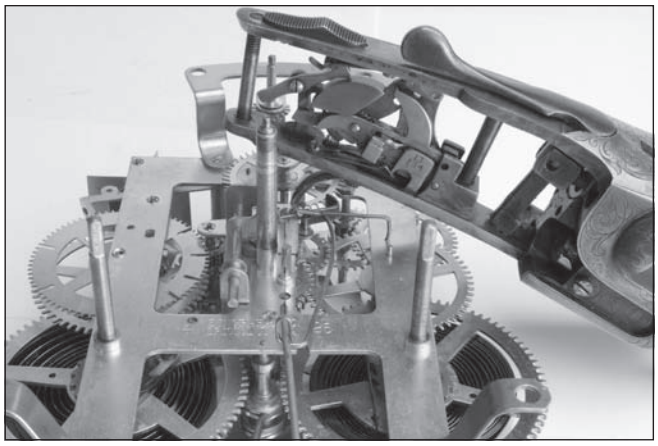
Simultaneous with the evolution of the chemistry and the process steps for firearms cleaning was the development of better, yet less expensive, hardware and tanks specifically designed to handle long guns. For example, the internals have become more reliable with the addition of new designs incorporating higher powered and longer lasting wave generators. Fabrication techniques have improved to minimize the erosion of the generating diaphragms. Heaters became standard on firearm cleaning tanks. There is no doubt that foreign imports also have had a major impact on putting these improved units within reach of any professional gunsmith. Indeed, small, inexpensive cleaners are currently available to clean brass for shooters. Both RCBS and Lyman now offer such units.

Below left: *Cavitation bubbles are invisible to the eye but the cleaning tank emits a buzz and the surface ripples from the waves.* ***Below right****: Soft, unsupported aluminum foil (left) is subject to both vibration and cavitation damage even after five minutes (right.) Photos such as this have been used to support claims that firearm finishes will be damaged by ultrasonic cleaning. It's true, if used improperly, ultrasonic cleaning can damage finishes on some firearms.*









Current High Tech State

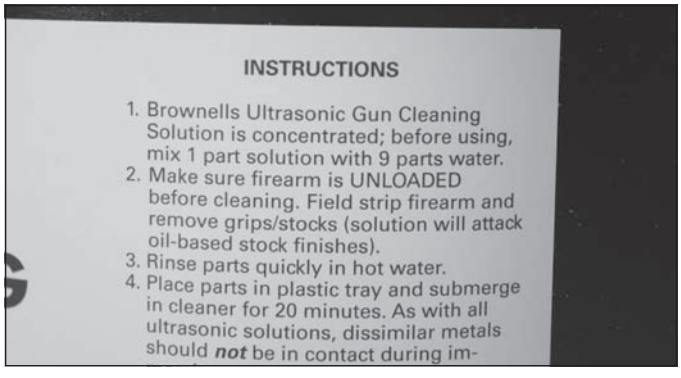
The original ultrasonic cleaning units could only generate a single frequency. Standing waves—the repeat bombardment of the same frequency wave to the surface location—can be an issue for parts that are very sensitive to cavitation attach, such as shiny, soft aluminum. Some units "sweep" the frequency over a few kHz range to help prevent standing waves and degas the solution from entrapped vapors that might reduce efficient cleaning. This technology allows a set frequency (e.g., 40 kHz) to be raised or lowered about 2%. In so doing, it continuously changes the conical ultrasonic wave form that is being emitted from the transducer. The sweeping frequency helps to reduce energy dead spots. High-end industrial cleaning systems were the first to incorporate this sophisticated feature, and now they are common on the larger firearm cleaning units used for rifles.

Another development was the invention of wave generators that send out two or more frequencies simultaneously, such as those offered by Zenith Manufacturing. Further innovation includes the use of arrays of two different transducers, each emitting a different frequency to cover a much broader range than a sweep frequency can deliver. As discussed previously, each frequency has a range of surface particles that it can best remove.

Yet another development was the invention of electronics to optimize the running frequency of a system, according to its natural resonance. The natural resonance depends on factors

Above left: *Advanced ultrasonic cleaning units use wave generating transducers that vary or "sweep" above and below the set frequency. The system above uses two different transducers operating at two separate frequencies of 40 kHz and approximately 65 kHz, each sweeping +/- 3 kHz. This improves cleaning and minimizes finish damage due to standing waves and hot spots. Source, Police Products Corporation.* ***Above right****: Disassembling an LC Smith inertia trigger group or an antique Ingraham clock mechanism is a time-consuming chore even to experienced clock repairers or gunsmiths. Both of these were inoperable due to hardened gunk. Five minutes of ultrasonic cleaning followed by oiling repaired both.*

Below left: *Key improvements have been made in cleaning and lubricating chemistry over the past 20 years. Use only cleaning and lubricating solutions designed specifically for firearms and supplied by reputable suppliers. Never use ammoniated or caustic cleaning solutions or low flash point lubricants. Dilution ratios vary; cheaper is not always better if the "concentrate" is weak.* ***Below right****: Two essential improvements to firearm ultrasonic cleaners are temperature control (left) and especially automatic timers (right.) Much of the damage reported from using ultrasonic cleaners has been due to firearms left in a unit for hours instead of just a few minutes.*



such as the transducer frequency, electronics, tank material thickness, transducer bonding agent, cleaning solution properties, cleaning solution temperature, atmospheric pressure, and other related system properties. Systems such as the SharperTek's Auto-Tune and Auto-Track system continuously search for the optimal running frequency. As the system properties change from day to day because of the particular jobs, the generator tunes itself to give the best operating frequency for optimal cleaning results.

In very specific industrial application, all these new bells and whistles are essential. Large high-end firearm cleaning units, especially those large enough to clean rifles, often contain these features, such as Crest True Sweep and L&R Manufacturing's SweepZone®.But even for economical benchtop cleaners suitable only for a single handgun, the cleaning solutions, process, and hardware have never been better and priced so reasonably.

Other Opportunities

Let's face it, many individuals love to shoot but hate to clean guns. Yes, there are excellent products, such as Cylinder & Slide's "Dunk Kit" (402/721-4277, cylinder-slide.com) that help loosen crud and leave a protective coating, but they all require field stripping and brushing and, more significantly, do not always reach and remove the crud in the nooks and hard-to-reach areas.

Some enterprising individuals have capitalized on this dislike for cleaning. A number of large ranges, such as the LAX Firing Range in Inglewood, California, and the Classic Pistol Range in Southampton, Pennsylvania, have ultrasonic cleaning facilities where, for a few dollars (typically $10 for pistols to $30 for rifles) shooters can have their guns cleaned in a few minutes before they leave the range. Thinking beyond the box, why don't gunsmiths offer a similar "cleaning on steroids" service?

An additional benefit of owning an ultrasonic unit is that it can be used for so many other cleaning purposes besides just firearms and brass. If it fits in, it will be cleaned, not withstanding all the cautions described in this article. It's perfect for gunsmiths and shooters who are mechanically inclined in general and have other hobbies such as tinkering with old cars, especially carburetors, and antique mechanical clocks. For clock repairers, ultrasonics works miracles and are the only way to go.

A table with further guidance is available on the website (americangunsmith.wordpress.com) but comes with a word of caution. The advanced features on some units, especially those involving impressive-sounding claims about sophisticated electronics and transducers, can be misleading. The buzzwords may represent little other than a more expensive unit with not much added value. Check to see what the terms really mean and if the manufacturer can back the words up with facts. Manufacturers may be willing to discuss the potential weaknesses in their competition's claims. Do your due diligence.

Conclusion

Which brings us to the key point of all this background information. Cleaning firearms using an ultrasonic cleaner requires the right frequency, power level, and cleaning solution in a system properly loaded and operated for the proper length of time. If you go significantly outside this set of parameters, you may at best get little cleaning action, or at worst, wreck the finish on a valuable gun. In the next installment we will cover how to get the best results from these units and reveal some key tips from the experts. AG

Above Left: *Two essential improvements to firearm ultrasonic cleaners are temperature control (left) and automatic timers (right.) Much of the damage reported from using ultrasonic cleaners has been due to firearms left in a unit for hours instead of just a few minutes.* ***Far left and left:*** *The price of ultrasonic cleaners has dropped dramatically with the introduction of imports. Both RCBS (left) and Lyman Products (far left) offer small units for brass cleaning. Source, RCBS and Lyman Products.*