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**NASA TECHNICAL  
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(NASA-TM-X-73452) APPLICATIONS OF THE  
ULTRASONIC SERIAL NUMBER RESTORATION  
TECHNIQUE TO GUNS AND TYPICAL STOLEN  
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**APPLICATIONS OF THE ULTRASONIC SERIAL NUMBER RESTORATION  
TECHNIQUE TO GUNS AND TYPICAL STOLEN ARTICLES**

by S. G. Young  
Lewis Research Center  
Cleveland, Ohio 44135  
July 1976



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16. Abstract <p>An ultrasonic cavitation method for restoring obliterated serial numbers has been further explored by application to articles involved in police cases. The method was applied successfully to gun parts. In one case portions of numbers were restored after prior failure by other laboratories using chemical etching techniques. The ultrasonic method was not successful on a heavily obliterated and restamped automobile engine block, but it was partially successful on a motorcycle gear-case housing. Additional studies were made on the effect of a larger diameter ultrasonic probe, and on the method's ability to restore numbers obliterated by peening.</p>			
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SUMMARY

Investigations of the advantages and disadvantages of the ultrasonic method for restoring obliterated serial numbers were continued. The restoration mechanism involves preferential metal removal by cavitation in water. The cavitation is induced by the ultrasonic vibration of a piezoelectric transducer.

Parts of two hand guns, a heavily obliterated and restamped automobile engine block, and a motorcycle gear-case housing have been subjected to serial number restoration attempts by the ultrasonic cavitation method. The method was most successful on the guns. Portions of numbers were restored even after numerous chemical etching attempts had failed to restore any portion of these numbers. The ultrasonic method was only partially successful on the motorcycle gear-case housing, and unsuccessful on the automobile engine block.

Some studies were also made on a number stamped on aluminum and obliterated by peening which showed partial restoration; and, in addition, the effect of a larger diameter probe (than that used on earlier studies) was examined on a steel specimen.

INTRODUCTION

Serial numbers on stolen property or guns are often removed or obliterated by various means such as filing, grinding, or peening. On recovered property, it is necessary to restore the numbers sufficiently so that they may be read or photographed before they can serve as

evidence. Many different types of restoration techniques are available (refs. 1 to 4). They include chemical, magnetic, heat treatment and other methods. Most of the above methods require a specific chemical and/or process for each of the great variety of metals involved. Recently, a new technique was introduced (ref. 5), which selectively removes metal by cavitation generated by ultrasonic vibration in water. This method was used to restore stamped and ground off serial numbers on laboratory samples of brass, steel, copper and aluminum with a high degree of success. An additional benefit of the method is that no prior surface preparation such as grinding and polishing is required before the restoration process can begin.

To better examine the merits of the ultrasonic method, two areas of continued work were needed: (a) A careful laboratory analysis of the method using controlled stamping techniques and controlled number removal methods as well as comparisons between the ultrasonic method and the best alternative method available for the particular metal being studied. (b) Actual application of the ultrasonic method to gun samples, engine blocks, and other articles typical of frequently recovered stolen goods with illegally removed serial numbers.

The first of the above areas of continued work and some efforts in the second area with the ultrasonic method are currently being performed by Dr. Richard Treptow of Chicago State University under NASA Grant NSG-3030. This work should be finished by early 1977. Additional effort in the second of the above work areas, examination of the ultrasonic method's applicability to obliterated serial numbers on specific guns and representative stolen articles, was performed at the NASA Lewis Research Center and is the subject of this report. The results of tests on two gun samples, a cast iron engine block, and an aluminum motorcycle gear-case housing are discussed. In addition a demonstration of this method applied to a sample in which a stamped number was obliterated by peening has been included. And, several additional laboratory studies are also included.

## MATERIALS, APPARATUS, AND PROCEDURE

### Materials

A steel frame of a Browning .38 cal. automatic pistol was furnished by the police department of a large city. The number had been filed from this frame before it was recovered so that a flat area clearly showed on the handle. This gun had then been subjected to numerous chemical treatments by two law enforcement agencies, but no traces of the serial numbers were restored. Other items tested included a portion of a steel gun barrel from an unidentified gun model with a number that had been carefully milled off to a depth 1.3 times the depth of the stamped number (furnished by Northeastern University), a cast-iron Chevrolet V-8 engine block (furnished by the Cleveland Police Department) which had numbers removed and new ones stamped over them, and an aluminum motorcycle gear-case housing (furnished by the National Auto Theft Bureau). In addition to the above items, the same aluminum and iron specimens as used in reference 5 were used for laboratory studies.

### Apparatus and Test Conditions

A schematic drawing of the apparatus used for the ultrasonic serial number restoration is shown in figure 1 and is described in references 5 and 6. It consists of a piezoelectric transducer assembly driven by a power supply at a frequency of 20 000 Hz. Cavitation bubbles are induced in water at the tip of the transducer and the force of the collapsing bubbles is directed to the specimen immersed in water directly below the vibrating head. The bubbles attack weaker portions of the specimen and restoration occurs by one of two methods: (1) smeared metal is removed from the grooves, or (2) when grinding is deep, cavitation attack differentiates between the worked metal under the number and the surrounding background metal so that under direct light a "ghost image" is produced. The major probe used was 1.6 cm diameter. A second probe was used (1.9 cm diameter) for a laboratory study to compare a broader area of

restoration with that of the smaller area. Tap water at 20° C ( $\pm 2^{\circ}$  C) was used with 30 grams of a potassium dichromate rust inhibitor per liter of water. A constant temperature water circulator was used to remove heat generated by the cavitation.

### Procedure

Test procedure varied with the article or specimen used and is so closely related to geometry that it will be covered more thoroughly under Results and Discussion for each case. The main emphasis was placed, however, on the ability to completely immerse the numbered portion of the article so that the cavitation could occur in the desired area. The probes were moved to different locations across the article if areas of interest were larger than the diameter of the probe. Whenever possible the probe was placed within 1 millimeter of the surface of the article before vibration. Low magnification photomacrographs were taken before and after testing.

## RESULTS AND DISCUSSION

### Steel Gun Frame

The .38 cal. automatic pistol frame and the location of the obliterated numbers are shown in figure 2. The flat area that had been filed to remove the number is indicated by an arrow in figure 2(a) and is shown in figure 2(b) at 2 $\times$  magnification. As previously mentioned, two different law enforcement agencies were unable to restore any trace of the numbers after having tried with numerous chemical etches. After 360 minutes of cavitation attack, traces of markings began to appear (see fig. 3(a) and (b)). Parts of three numbers, most likely an 8, 2, and an unidentified number can be seen. Both photomacrographs are of the same area; however, the photo of figure 3(b) has been marked with circles around the number traces, and arrows, to make the numbers easier to locate. In this effort (and the figure) the numbers are extremely difficult to see.

However in this series of tests, the operator had no idea of the size, orientation or exact location of the numbers. When these were observed and compared with the numbers on another gun from the same manufacturer, they were found to be in the same location and of the same size as standard stamped numbers for this gun model. Therefore, this is an indication that when other tests fail, or if only partial chemical restoration is successful, the ultrasonic method might help bring out the complete number or might be useful as a "last resort" method to restore a number in a critical case.

### Steel Gun Barrel

A portion of a gun barrel was furnished by Northeastern University, School of Forensic Sciences. The number had been carefully milled off to a depth of 1.3 times the depth of the stamped number. No prior knowledge was given to NASA of the original number. After 5 hours of cavitation attack, the correct number "15567" appeared as a ghost image as shown in figure 4(a) and (b) (see arrows on fig. 4(b)). After longer times of cavitation attack the numbers started to fade.

### Automobile Engine Block

Photographs of the automobile engine block are shown in figure 5. Figure 5(a) shows an overall view of the engine block. The original number on this cast-iron block had been ground to a depth at least 1/16 inch below the surface and then new numbers had been roughly stamped over the old number. The serial number portion of the engine block can be seen in figure 5(c). A plastic box was built up around the number (fig. 5(b)) to provide the water bath necessary for the ultrasonic treatment. Figure 6 shows photomicrographs of the number as-received, after 150 minutes, and after 240 minutes of cavitation attack. Unfortunately, very little information was obtained from this test. Observations of similar factory stamped serial numbers on other engine blocks show them to be quite shallow. Grinding on this block was obviously several times the

depth of the original numbers. The probe had to be moved around this number considerably to cover the entire area. To cover the entire surface with 4 hours of cavitation attack, nearly 30 hours of total attack time was used. This method, as presently applied, thus becomes impractical for actual use for engine block cases. Also considerable difficulty is obviously necessary to prepare the engine block for the restoration process. To be practical for this type of restoration, an adaptor could be made for coupling the ultrasonic tip with the engine block. Water circulation and proper sealing would allow the ultrasonic probe to be used at various angles, thus making it more portable and applicable to large items. Nevertheless, in-situ chemical and other standard methods appear better suited for large engine parts.

### Motorcycle Gear-Case Housing

An aluminum alloy gear-case housing with a known number is shown in figure 7(a). The number was removed by hand grinding in the NASA-Lewis laboratory to an estimated depth of the numbers. After 10 minutes of cavitation attack some of the letters are readable. After 25 minutes of cavitation attack the number was estimated to be nearly 40 percent restored. Further cavitation exposure of the aluminum caused extensive pitting. A lip next to the number caused uneven focusing of the cavitation cloud, thus attacking the metal unevenly. For this reason an overall flat working surface is highly desirable.

### Additional Laboratory Studies

Effect of peening. - The letters "W" and "N" were stamped on an aluminum sample and the letters were peened until they were no longer visible (see fig. 8(a)). The specimen was immersed in water and subjected to cavitation for varying periods of time (fig. 8(b)-(h)). Figures 8(e), (f), and (g) show the partial restoration of these letters by the cavitation at 30, 40, and 50 minutes, respectively. After 50 to 60 minutes (fig. 8(g) and (h)) the attack was so severe that the letters were being destroyed.

This indicates that, to a limited extent, the method may restore numbers if in the peening process, smeared metal and traces of the original grooves remained.

Effect of probe diameter. - All previous studies in reference 5 have been made with a probe diameter of 1.6 cm (see fig. 9(a)). The number 3 on the specimen from this early work was ground down (fig. 9(b)) and a 1.9 cm diameter probe was used to restore it. After 120 minutes of cavitation attack, the number could be clearly seen. Figure 10 is a high magnification photograph of the same specimen of figure 9. Portions of other originally stamped and ground off numbers were more completely restored than in the earlier work of reference 5. (See, for example, the number 6 in fig. 10(c).) Thus, the larger diameter probe has the distinct advantage of restoring numbers over a broader area, thus reducing the number of shutdown times and position changes required for working on actual stolen articles.

## SUMMARY OF RESULTS

The ultrasonic cavitation method for restoring obliterated serial numbers was further explored by applying the technique to typical items of interest to law enforcement agencies. The following results were obtained:

1. Traces of serial numbers on a steel gun frame were restored by the ultrasonic cavitation method after repeated chemical-etch method attempts by two different law enforcement agencies failed to produce any evidence of the numbers. Total restoration, however, was not achieved by the cavitation approach in this case.
2. A complete serial number on a steel gun barrel was restored after the number had been milled off to a depth 1.3 times the depth of the stamped number.
3. Attempts to restore numbers on a deeply ground and restamped cast iron automobile engine block were unsuccessful.
4. A partial restoration was achieved on a motorcycle gear case housing made of aluminum.

5. Preliminary laboratory studies showed that the ultrasonic cavitation method was partially successful in restoring numbers obliterated by peening and also that a larger diameter probe (up to at least 1.9 cm diam.) can be used successfully to restore numbers.

### CONCLUDING REMARKS

The reported studies have shown that the ultrasonic cavitation serial number restoration technique appears to be primarily suited to guns with an indication of superiority over some chemical methods. Variation in the results of restoration of obliterated gun serial numbers depends, of course, on extent of obliteration and amount of previous treatment. However, this approach offers an attractive potential last resort after chemical methods have failed to restore any or all of the numbers. Additional work is needed and currently is being done under controlled laboratory conditions to make comparisons of the ultrasonic method with chemical, electrolytic, magnetic, and other serial number restoration methods.

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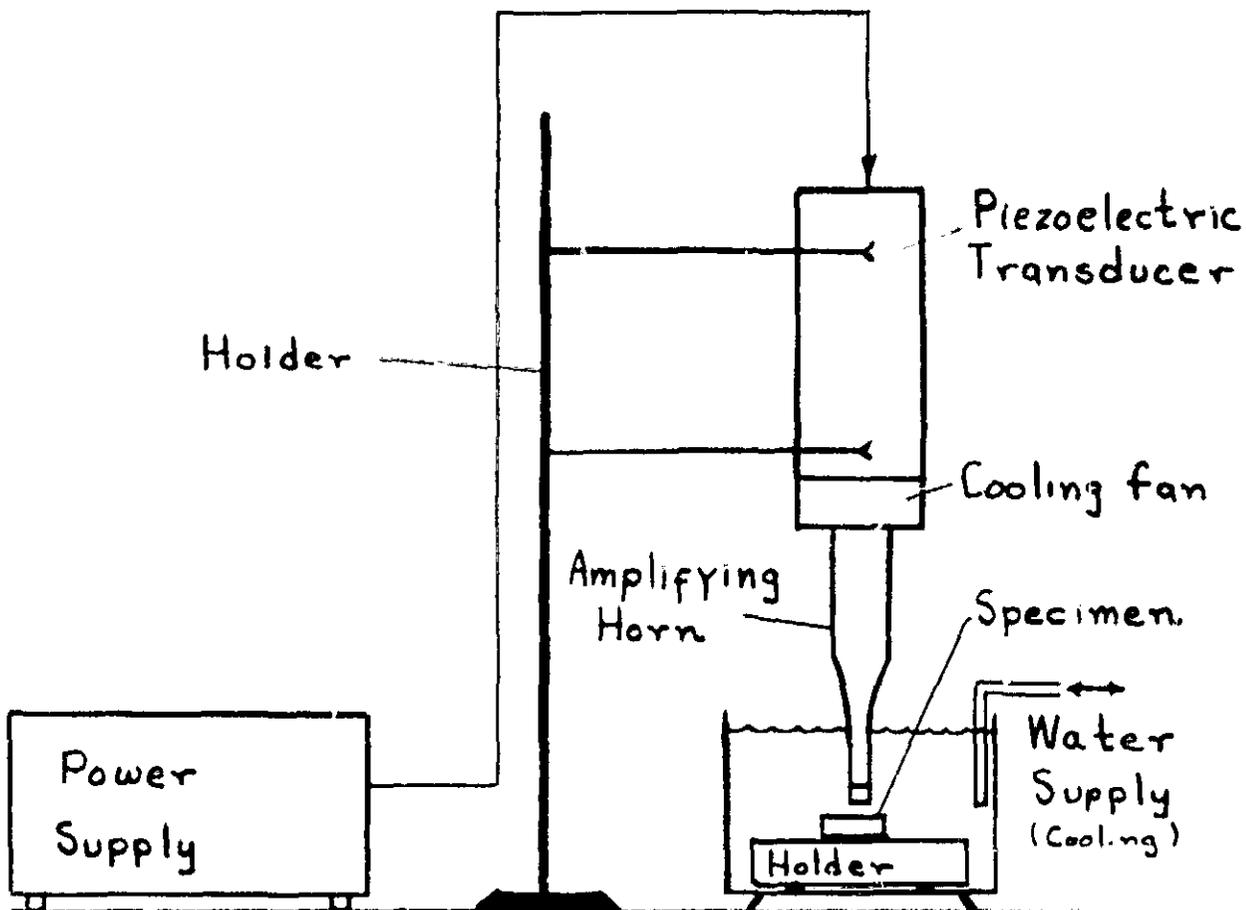
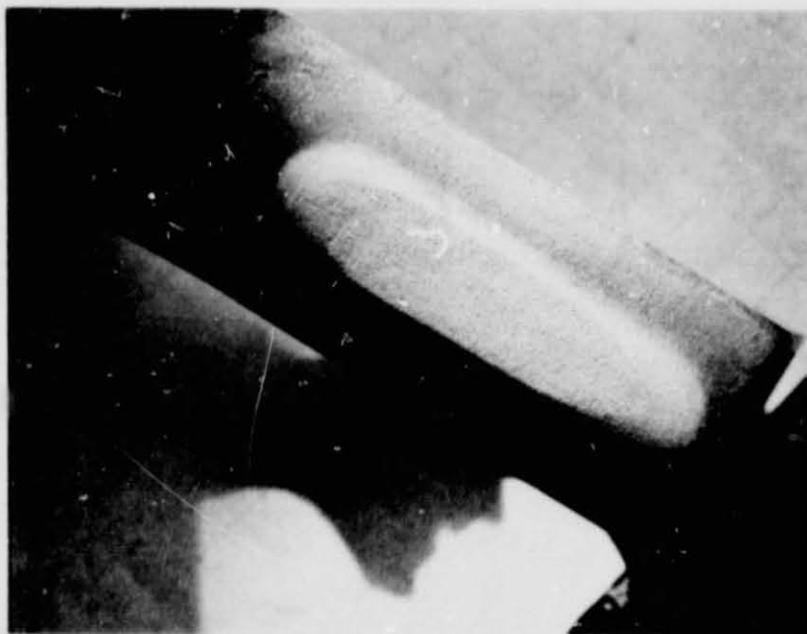


Figure 1. Schematic diagram of test apparatus used to restore serial numbers by ultrasonically induced cavitation.

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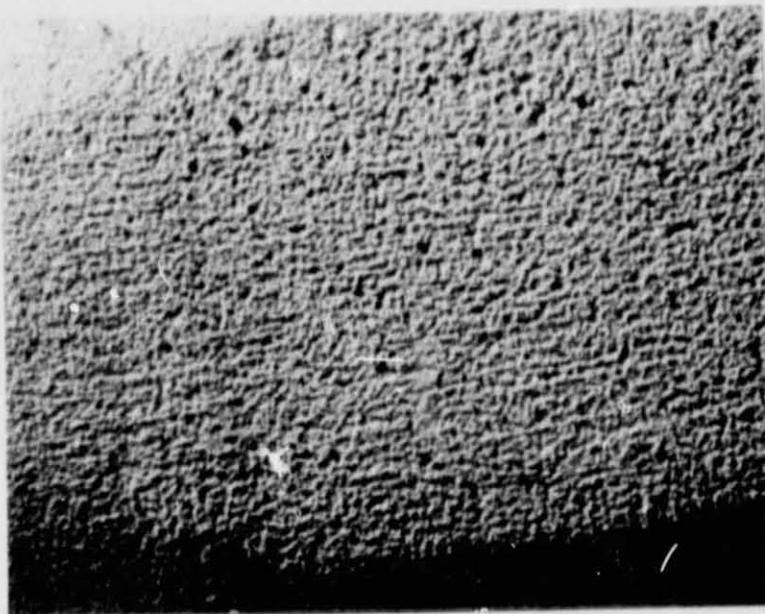


(a) Overview view of frame - arrow signifies location of obliterated serial number.

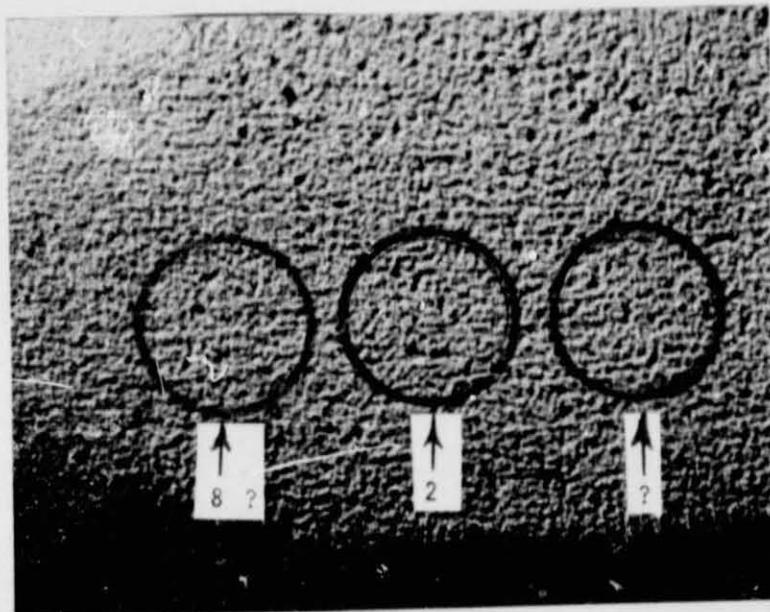


(b) 3X photomicrograph of flat area on handle showing serial number removed.

Figure 2. - Steel frame of Browning automatic pistol with serial number removed.



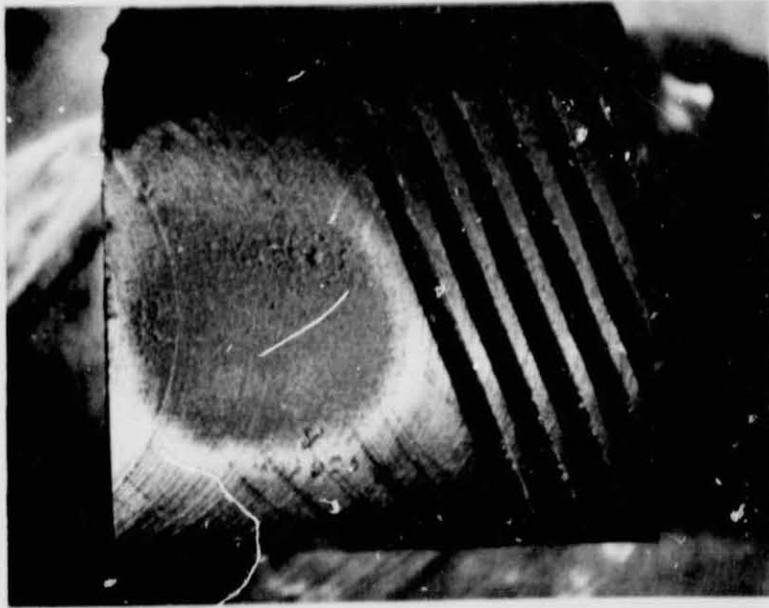
(a) Untouched photograph of number area.



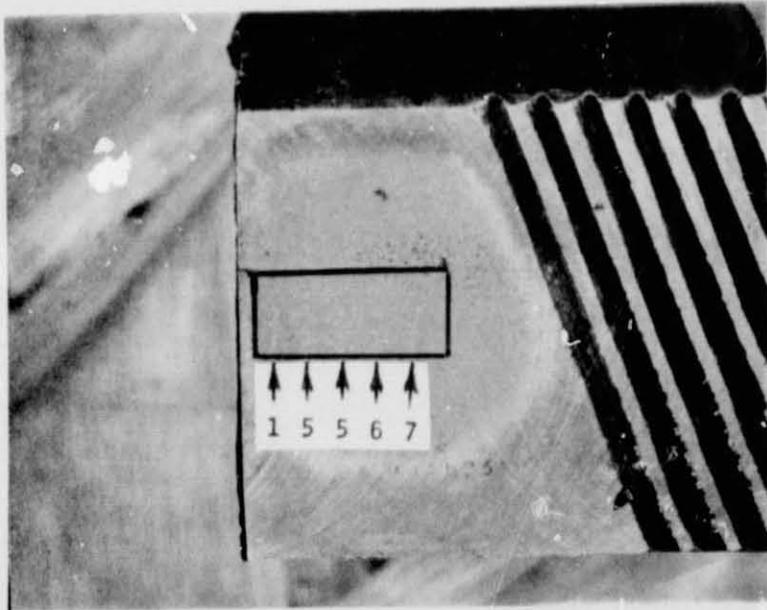
(b) Circles drawn on area around restored traces of the original stamped numbers.

Figure 3. Photomicrographs (at 12X) of handle of steel frame of gun shown in figure 1 after 360 minutes of cavitation attack.

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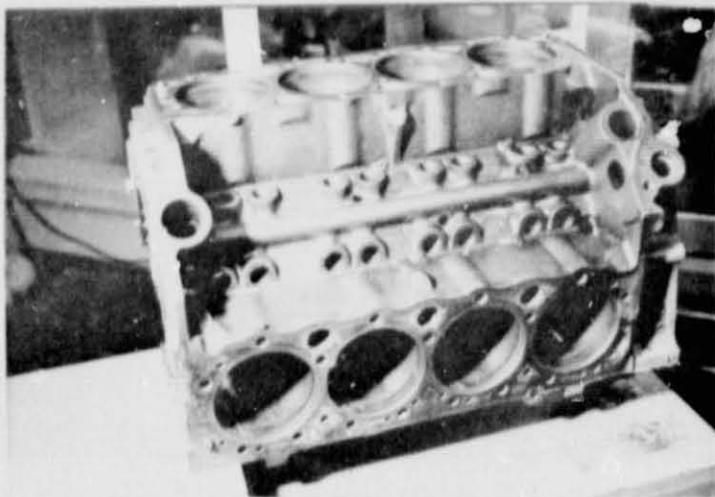


(a) Oblique light.

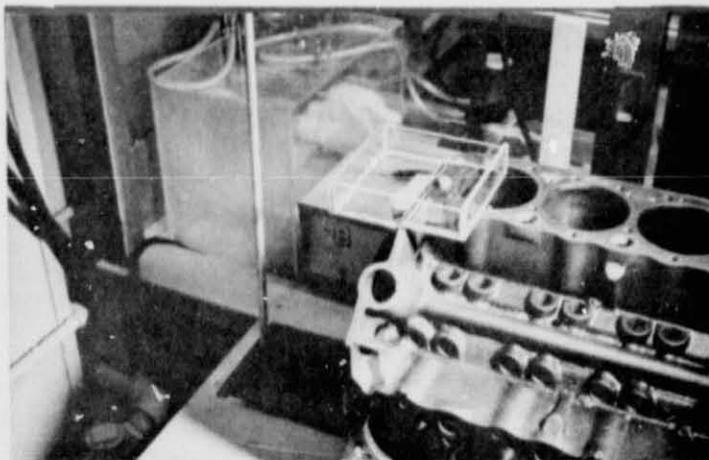


(b) Direct light.

Figure 4. - Photomicrographs of restored number "15567" on steel gun barrel after 2 hours of cavitation attack.



(a) Overall view of engine block.



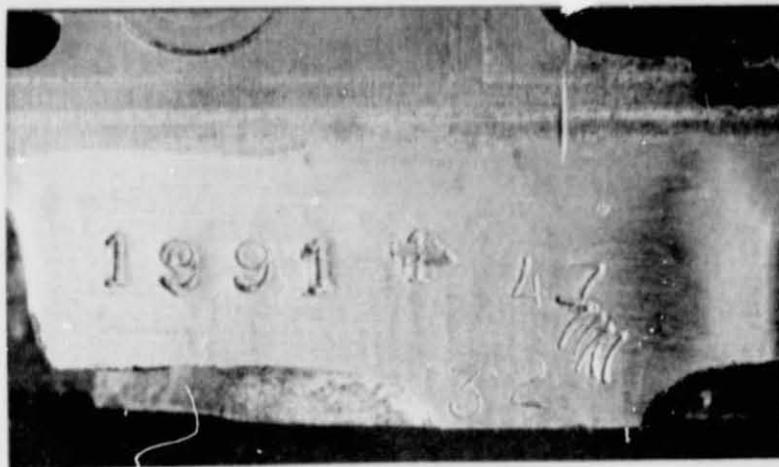
(b) Elastic water container attached over serial number.



(c) Obliterated and re-stamped number.

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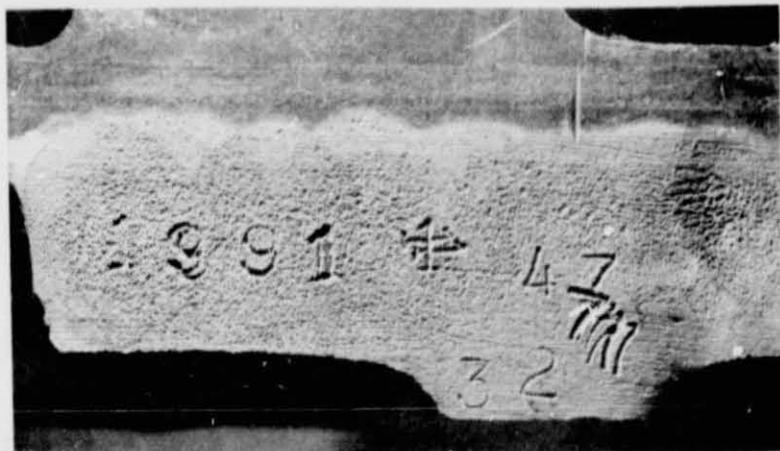
Figure 5. - Photographs of automobile V-8 cast-iron engine block, obliterated and re-stamped number and water bath for restoration attempt.



(a) received original number ground off with attempted new  
ers over-stamped on ground area.



(b) 150 minutes of cavitation attack over area.



(c) 240 minutes attack over area.

Figure 6. - Macro photograph showing serial number as-received  
after various time increments of cavitation attack.



(a) Original serial number.



Number obliterated and then treated with cavitation for 10 minutes.



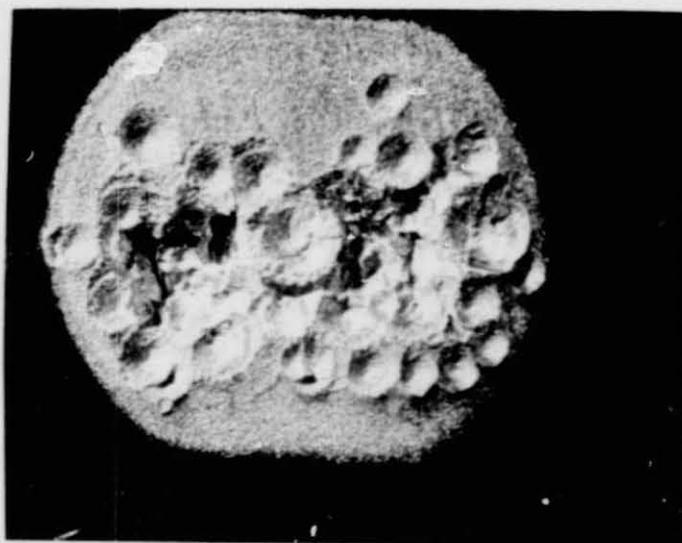
(c) 25 minutes of cavitation attack - number approximately 40% restored.

Figure 7. - Aluminum motorcycle gear-case housing before and after serial number obliteration and restoration by cavitation.

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(a) As obliterated (0 minutes cavitation)



(b) 5 minutes cavitation



(c) 10 minutes



(d) 20 minutes

Figure 8. - Restoration of stamped letters "W" and "N" on aluminum, that were obliterated by peening (as opposed to grinding). Magnification - 7X.

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(e) 30 minutes



(f) 40 minutes

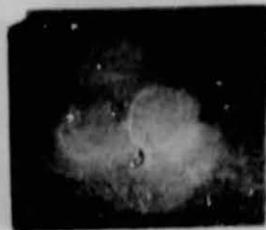


(g) 50 minutes

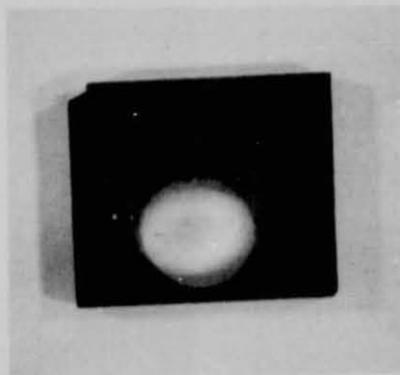


(h) 60 minutes

Figure 8. - Concluded

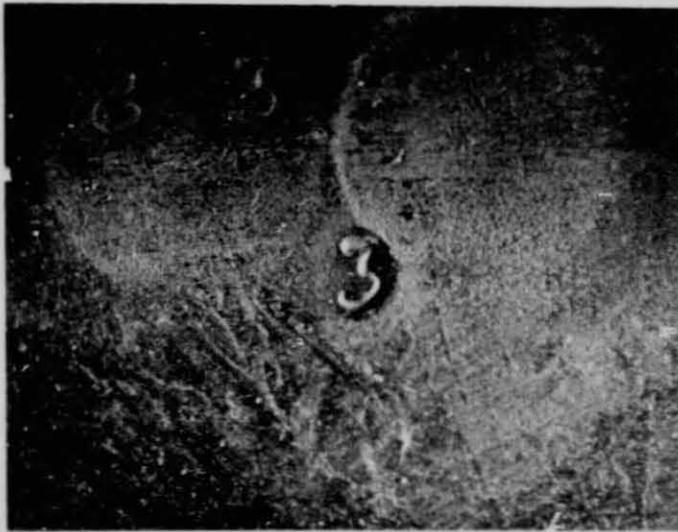


(a) Specimen from Ref. 5 showing number "3" before removal.

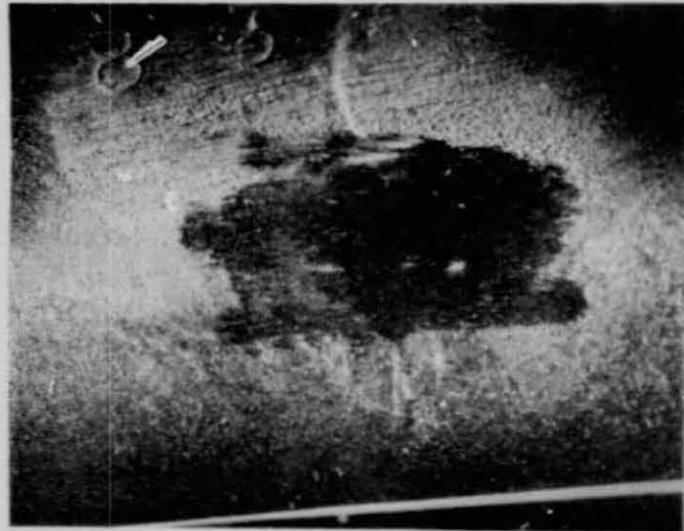


(c) Restoration after 120 minutes cavitation.

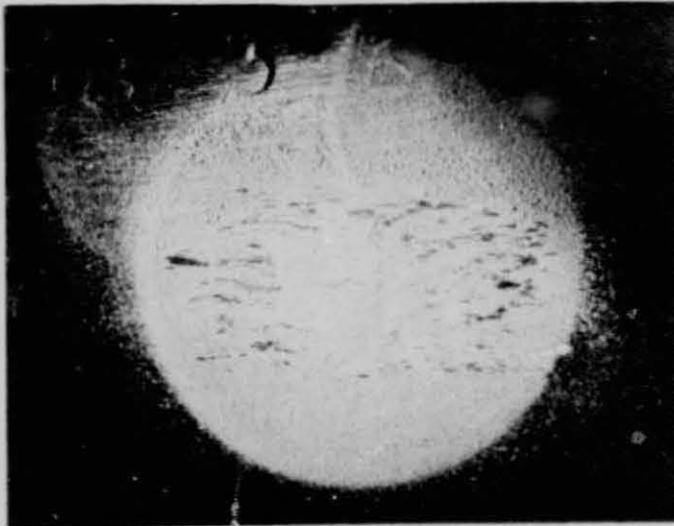
Figure 9. - Steel specimen subjected to cavitation showing restoration of the number "3" using a 1.9 cm. diameter probe (original magnification - 1X).



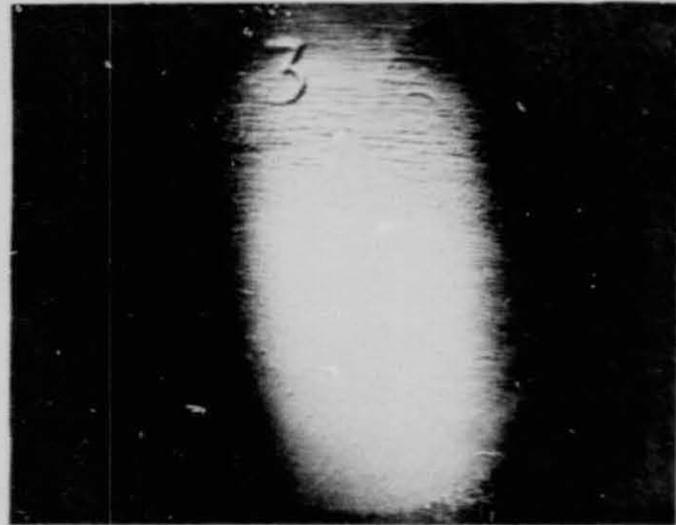
(a) Number "3" before removal.



(b) Obliterated number.



(c) 90 minutes cavitation.



(d) 120 minutes cavitation.

Figure 10. - Steel specimen of figure 9 subjected to cavitation showing restoration of the number "3" using a 1.9 cm. diameter ultrasonic probe (original magnification - 4X).