NORTHROP CORPORATION
NORAIR DIVISION

NOR 69-64

EVALUATION OF NORPEENING

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ABSTRACT

An investigation was conducted to evaluate Norpeening as a method of cold working the surface of holes in high strength aluminum alloy parts. The surface of holes in a test specimen were cold worked, some by Norpeening, some by shot peening, and the remainder by glass bead peening. Residual stress measurements and stress corrosion tests were conducted.

Norpeening is accomplished with a tool that forces steel balls against the surface of a hole, producing a peening effect.

Results indicate that Norpeening produces compressive stresses and, hence, stress corrosion resistance that is equivalent to that produced by shot peening or glass bead peening.

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INTRODUCTION

Stress corrosion has been a problem for many years on parts made from high strength aluminum alloy forgings.

Cold working of the surface of the parts by shot peening or glass bead peening has proven effective in producing compressive stress, thus providing resistance to stress corrosion cracking. However, many parts that have been peened previously then require that holes be drilled and reamed during assembly. Therefore, some method of cold working the surfaces of these drilled holes is needed to reduce their susceptibility to stress corrosion cracking.

Shot peening was first considered, but was eliminated because of the problems created by metallic shot entrapped in the aircraft. Glass bead peening was finally selected over other methods, such as planishing or mandrelizing. However, glass bead peening has severe limitations in that (1) it requires a special fixture for each hole, (2) it requires lengthy set up, (3) a large amount of equipment is required, (4) glass beads are released into the aircraft, and (5) the process is expensive.

A Norpeening tool was developed and patented at Northrop Norair for cold working of holes. This tool is inexpensive and is easy to operate for production line peening. Floating steel balls retained in the races of the tool are forced into the hole surface by a revolving hammer to produce the required peening.

OBJECTIVE

The object of this invstigation was to compare the cold working effect produced by Norpeening with that of shot peening and glass bead peening and to determine the optimum parameters for Norpeening.

CONCLUSIONS

Processing of holes with a Norpeening tool imparts substantial cold working to the hole surface.

The stress corrosion life and the compressive stress produced by Norpeening are equivalent to those produced by shot peening and glass bead peening processes.

The optimum parameters for processing holes with Norpeening are as follows:

a. Shaft speed 700 to 900 RPM

b. Peening time 5 minutes minimum

c. Nominal tool diameter from 0.001 to 0.005 inch smaller than the minimum diameter of the hole

PROCEDURE

Test specimens were machined from the short transverse direction of a forged billet of 7079 aluminum alloy. Preliminary testing was performed to develop an optimum technique for processing and for loading. As a result, the following processing steps were used:

a. Machine specimen in accordance with Figure 1, except omit center hole,

b. Heat treat to the -T61 condition (hot water quench),

c. Peen specimen all over with 280 size metal shot at 0.010-0.012A,

d. Drill and ream 0.875 inch diameter hole in center of specimen,

e. Cold work hole surface by shot peening, glass bead peening, or Norpeening,

f. Clean specimen by immersion in a water solution of nitric acid (50 percent by volume), then in Smut-Go No. 4 solution,

g. Mask specimen, leaving center hole uncovered,

h. Conversion-coat center hole with Alodine 1200.

Hole diameters were measured prior to the peening operation and immediately following the immersion cleaning.

Four techniques for shot peening or glass bead peening the holes were evaluated. The specific combinations of intensity and shot or bead size are listed in Table 1.

Five combinations of variables were used for Norpeening. The specific combinations used are listed in Table 1. In all cases, however, the tool was rotated and translated in the hole, while chucked as shown in Figure 2.

Preliminary testing of specimens peened by all 3 methods was used to determine the stress most likely to produce failure by stress corrosion in 300 to 600 hours; all stress corrosion testing thereafter was conducted at 38,000 psi (65 percent of nominal yield strength). The notch factor of the hole in the test specimen is 2.0.

Twenty-four specimens were loaded to 38,000 psi in the fixture shown in Figure 3. The specimens were then subjected to alternate immersion in a 3.5 percent sodium chloride water solution, being immersed in the solution for 10 minutes, then air dried for 50 minutes; this test cycle was continued for 1000 hours or until failure of any individual specimen.

Residual stress measurements on the surfaces of selected holes were used to determine the compressive stress produced by each of the peening techniques. In addition, the compressive stresses at selected depths on a section through a Norpeened specimen were determined; the hole was 0.001 inch oversize, peened 5 minutes at 825 RPM. The stress measurements were taken with a portable X-ray diffraction unit by the single exposure back reflection film technique.[1]

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[1] R. J. Homicz, "Fundamentals and Basic Techniques of Residual Stress Measurements with a Portable X-ray Diffraction Unit," Proceedings of the Annual Meeting of the Society of Automotive Engineers, 9-13 January 1967

Several test samples that had been Norpeened were sectioned, polished, and etched to reveal the effect of cold work produced by Norpeening. Photomicrographs were taken to show the effect on grain structure in both the longitudinal and transverse directions. A test block in which a hole had been Norpeened was cut in half and the peened surface photographed.

RESULTS AND DISCUSSION

Stress corrosion test results are given in Table 1 and Figure 4. In general, Norpeened specimens exhibited resistance to stress corrosion comparable to that of the metal shot and glass bead peened specimens.

Compressive stresses exhibited by all specimens were fairly consistent, with some exceptions; see Figure 5. Since 3 readings were well above the nominal yield strength of the alloy (an obvious impossibility), these readings were considered to be a product of X-ray diffraction uncertainties. There appeared to be no correlation between high (or low) compressive stress and stress corrosion life.

Compressive stress at several depths below the surface of a Norpeened specimen is plotted on Figure 6. At a depth of 0.005 inch, the stress could not be measured.

The change in hole size produced by each technique is listed in Tables 2 and 3. This change was consistent at 0.0001 inch for Norpeening and varied from 0.0001 to 0.0011 inch for the other methods. The apparent decrease in hole diameter is caused by the roughening of the hole surface.

Surfaces of Norpeened specimens exhibit cold work, as noted in Figure 7. The transverse section shows deformation to a depth of approximately 0.003 inch, while strain lines can be seen on the longitudinal section. The surface of a Norpeened test block is shown in Figure 8. The degree of cold working imparted by Norpeening is quite significant.

The results of the tests were not completely satisfactory; the control specimens (unpeened) exhibited stress corrosion life and residual stress comparable to those of the peened specimens. These effects can be partially attributed to the drilling and reaming operations which will tend to impart working and smearing of the hole surface. However, since this working is superficial, is inconsistent from sample to sample, and varies with different machining practices, the effects of the peening processes are needed to impart a controlled worked surface.

TABLE 1. STRESS CORROSION LIFE OF SPECIMENS PRODUCED BY VARIOUS TECHNIQUES(1)

Peening Method	Peening Variables			Hours to Failure(2)
	Intensity		Shot or Bead Size	
Shot Peening	0.003 to 0.005A		110	139.8 180.7 192.8
	0.003 to 0.005A(3)		110	274.5 649.5 129.4
Glass Bead Peening	0.003 to 0.005A		0.013 Beads	195.1 223.2 224.3
	0.006 to 0.008N		0.002 to 0.004	197.8 245.2 275.3
Peening Method	Hole Oversize(4)	Shaft Speed, RPM	Peening Time, minutes	Hours to Failure(2)
Norpeening	0.001	465	5	300.9 378.3 231.8
	0.001	825	2	106.0 366.8 219.1
	0.001	825	5	232.2 244.1 263.9
	0.003	825	5	432.3 347.6 347.5
	0.005	825	5	(5)
None	as drilled and reamed			219.4 219.4

CONTINUED ON NEXT PAGE

NOTES:

1. Specimens were heat treated to the -T61 condition, then shot peened on all surfaces with 280 shot at an intensity of 0.010 to 0.012A. The holes were then drilled and reamed to the required diameter and peened as required. The entire specimen was then masked, except in the holes, and Alodine 1200 was applied in the holes.

2. Tested at 38 ksi.

3. Plus glass bead cleaning.

4. In relation to the Norpeening tool size (0.875 inch).

5. Not tested; for hole dimension check only.

TABLE 2. DIMENSIONS OF HOLES BEFORE AND AFTER SHOT PEENING AND GLASS BEAD PEENING (1)

Process	Shot Intensity	Shot Size	Hole Dimension Before Peening	Hole Dimension After Peening	Change in Hole Size
Shot Peen	0.003 to 0.005A	110	0.8748 0.8760 0.8747	0.8744 0.8756 0.8737	-0.0004 -0.0004 -0.0010
	0.003 to 0.005A	110	0.8747 0.8748 0.8748	0.8745 0.8745 0.8747	-0.0002 -0.0003 -0.0001
	0.003 to 0.005A	110	0.8749 0.8750 0.8749	0.8744 0.8741 0.8742	-0.0005 -0.0009 -0.0007
	0.003 to 0.005A	110	0.8748 0.8749 0.8749	0.8742 0.8743 0.8743	-0.0006 -0.0006 -0.0006
	0.003 to 0.005A	110(2)	0.8749 0.8749 0.8749	0.8743 0.8742 0.8745	-0.0006 -0.0007 -0.0004
Glass Bead Peen	0.003 to 0.005A	0.013	0.8749 0.8750 0.8748	0.8742 0.8743 0.8742	-0.0007 -0.0007 -0.0006
	0.003 to 0.005A	0.013	0.8750 0.8750 0.8750	0.8743 0.8744 0.8742	-0.0007 -0.0006 -0.0008
	0.006 to 0.008N	0.002 to 0.004	0.8749 0.8750 0.8749	0.8746 0.8744 0.8743	-0.0003 -0.0006 -0.0006
	0.006 to 0.008N	0.002 to 0.004	0.8749 0.8751 0.8749	0.8740 0.8748 0.8738	-0.0009 -0.0003 -0.0011

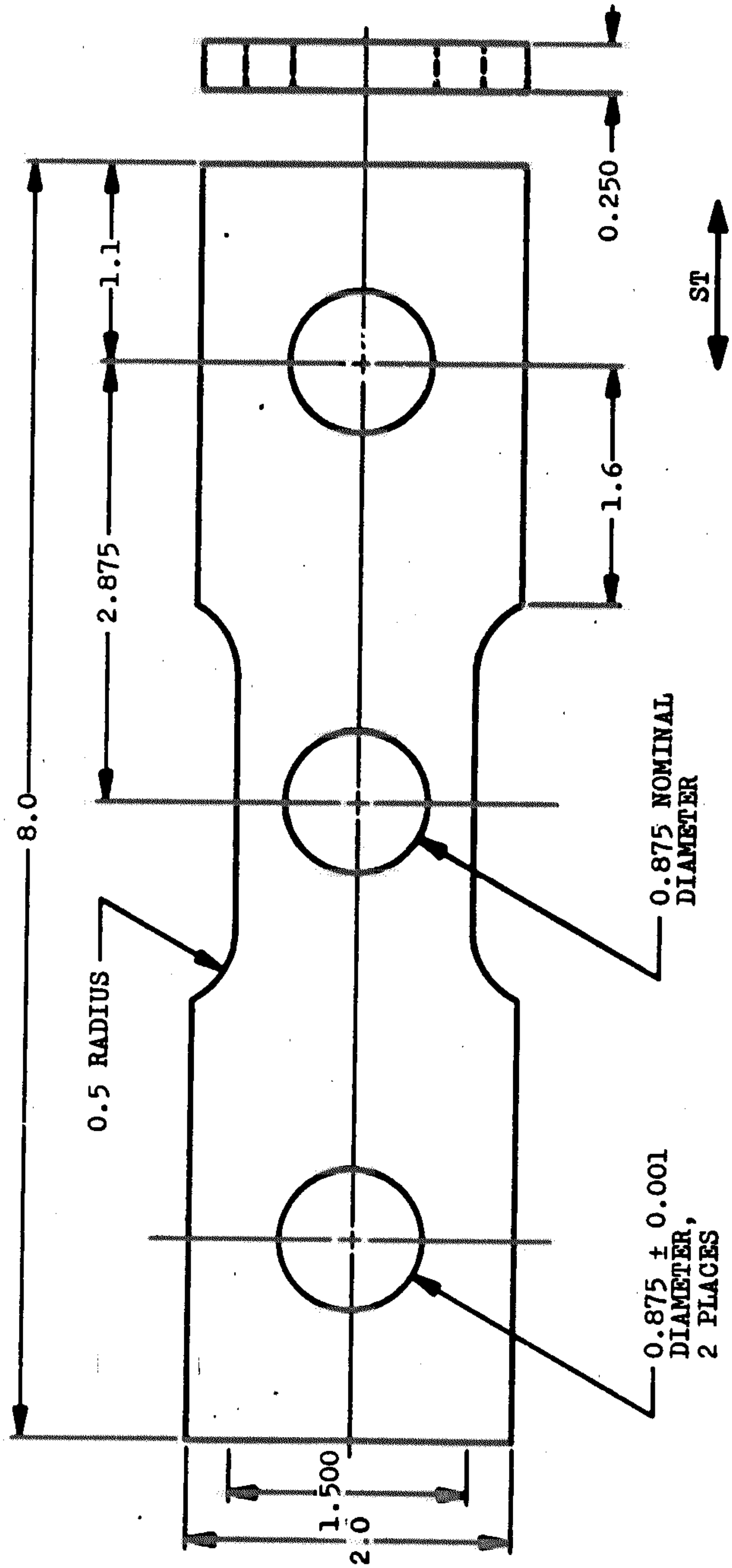
NOTE: 1. All dimensions in inches.

2. Glass bead cleaned after peening.

TABLE 3. DIMENSIONS OF HOLES BEFORE AND AFTER NORPEENING (1)

RPM of Hammer	Peening Time, minutes	Hole Oversize	Hole Dimension Before Peening	Hole Dimension After Peening	Change in Hole Size
465	5	0.001 0.001 0.001	0.8762 0.8762 0.8762	0.8761 0.8761 0.8761	-0.0001 -0.0001 -0.0001
825	2	0.001 0.001 0.001	0.8762 0.8762 0.8762	0.8761 0.8761 0.8761	-0.0001 -0.0001 -0.0001
825	5	0.001 0.001 0.001	0.8762 0.8762 0.8762	0.8761 0.8761 0.8761	-0.0001 -0.0001 -0.0001
825	5	0.003 0.003 0.003	0.8784 0.8784 0.8784	0.8783 0.8783 0.8783	-0.0001 -0.0001 -0.0001
825	5	0.005 0.005 0.005	0.8800 0.8800 0.8800	0.8799 0.8799 0.8799	-0.0001 -0.0001 -0.0001

NOTE: 1. All dimensions in inches.



MATERIAL: 7079 HAND FORGED BILLET

NOTCH FACTOR OF HOLE
$K_t = 2.0$

FIGURE 1. STRESS CORROSION TEST SPECIMEN

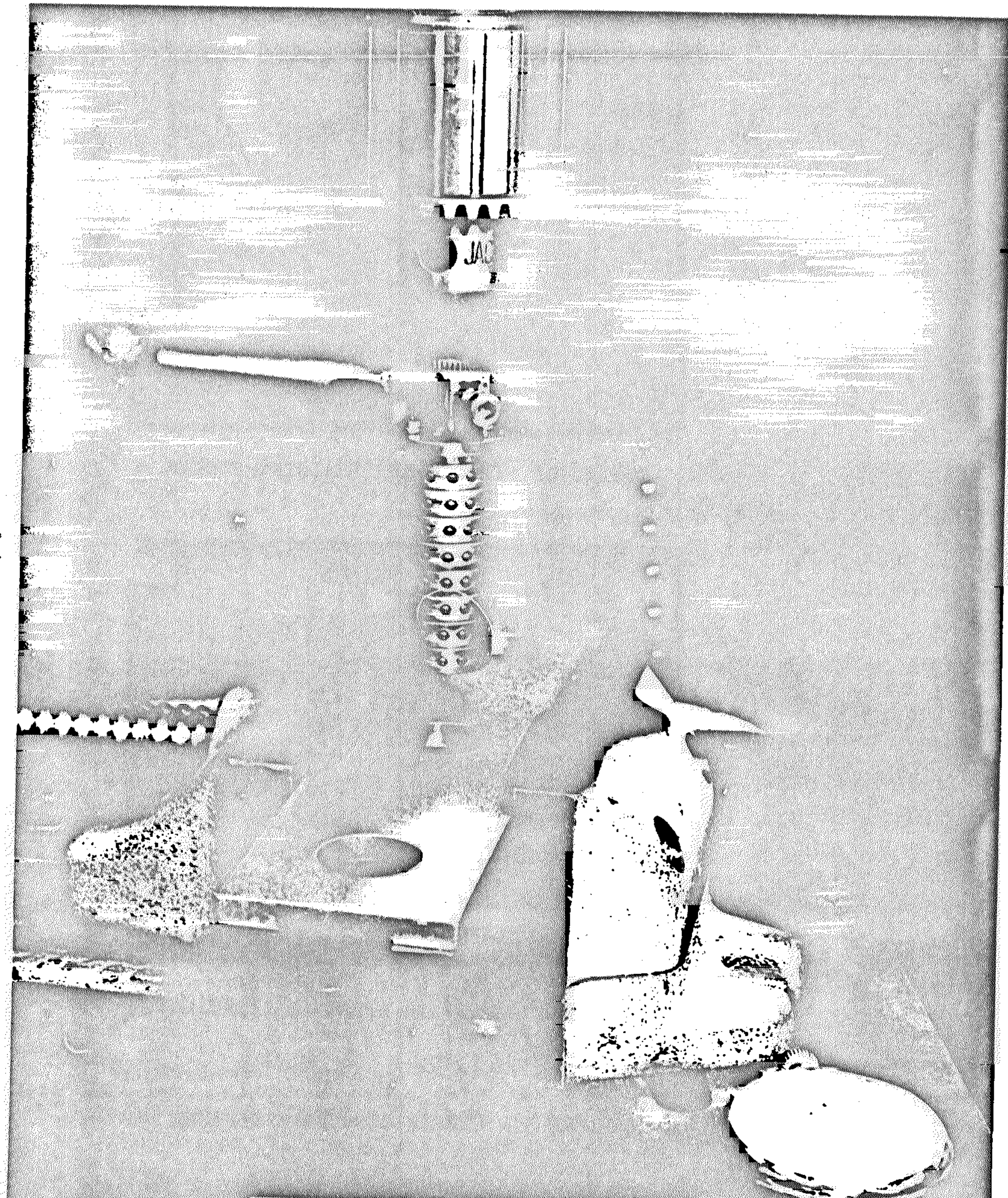
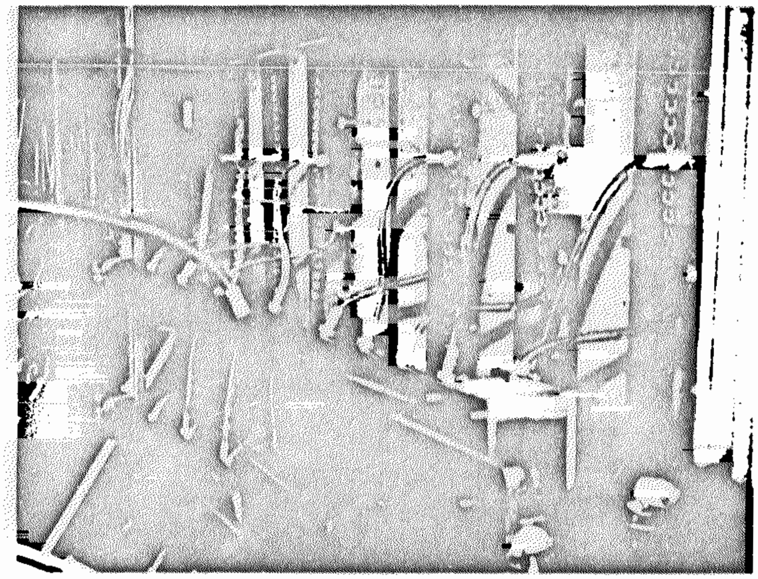
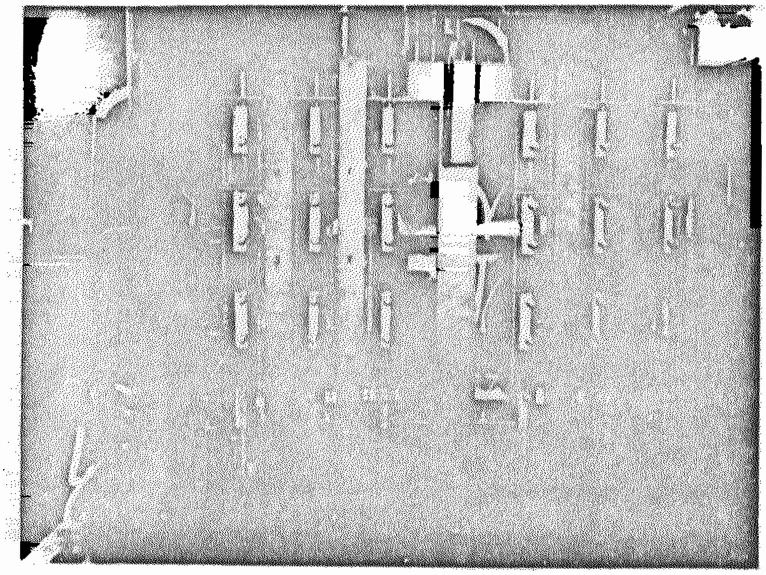


FIGURE 2. NORPEENING TOOL SETUP



DETAIL OF FILLING AND DRAINING SYSTEM



OVERALL VIEW OF 18 SPECIMEN LOCATIONS

FIGURE 3. STRESS CORROSION FIXTURE

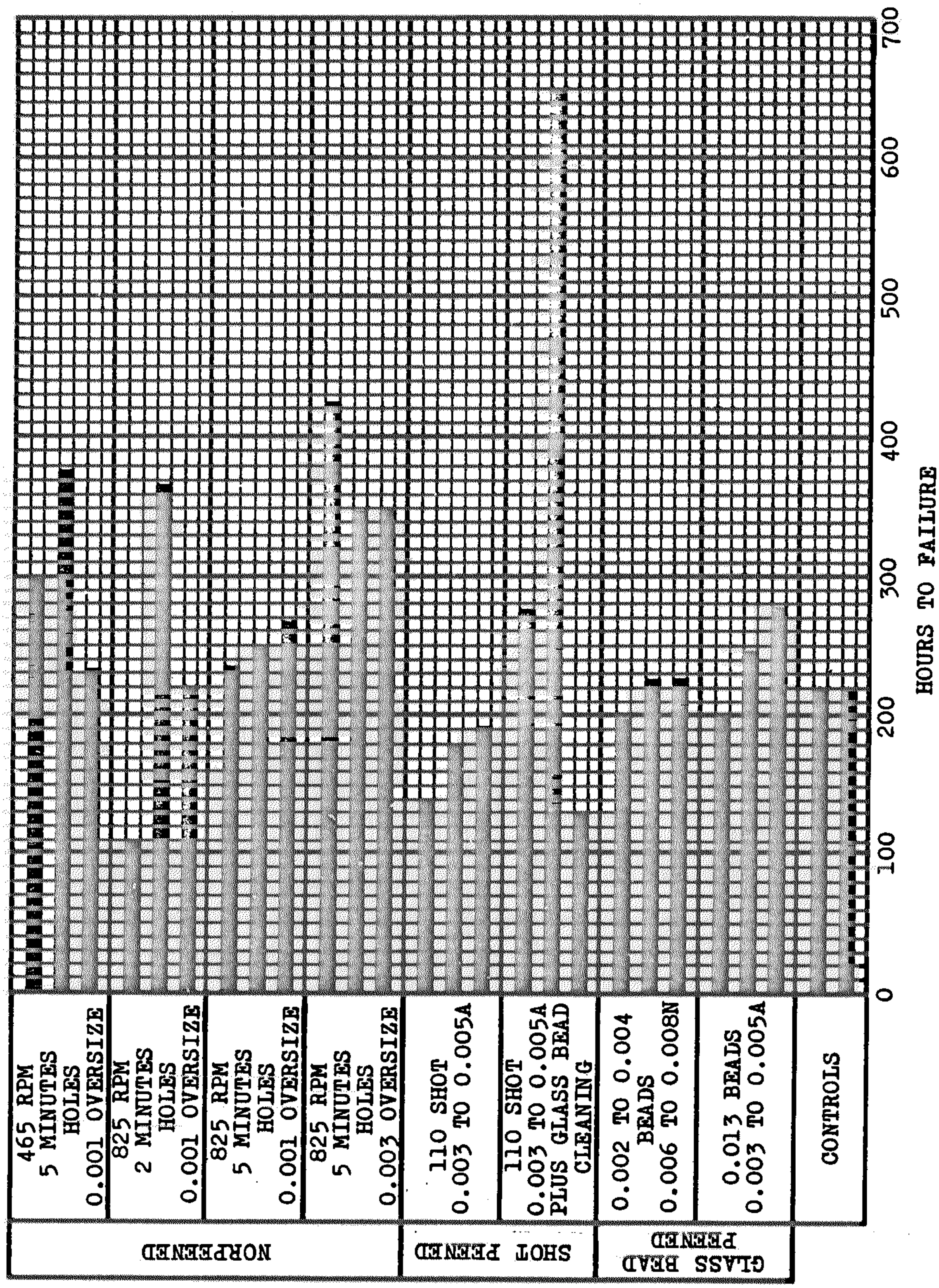
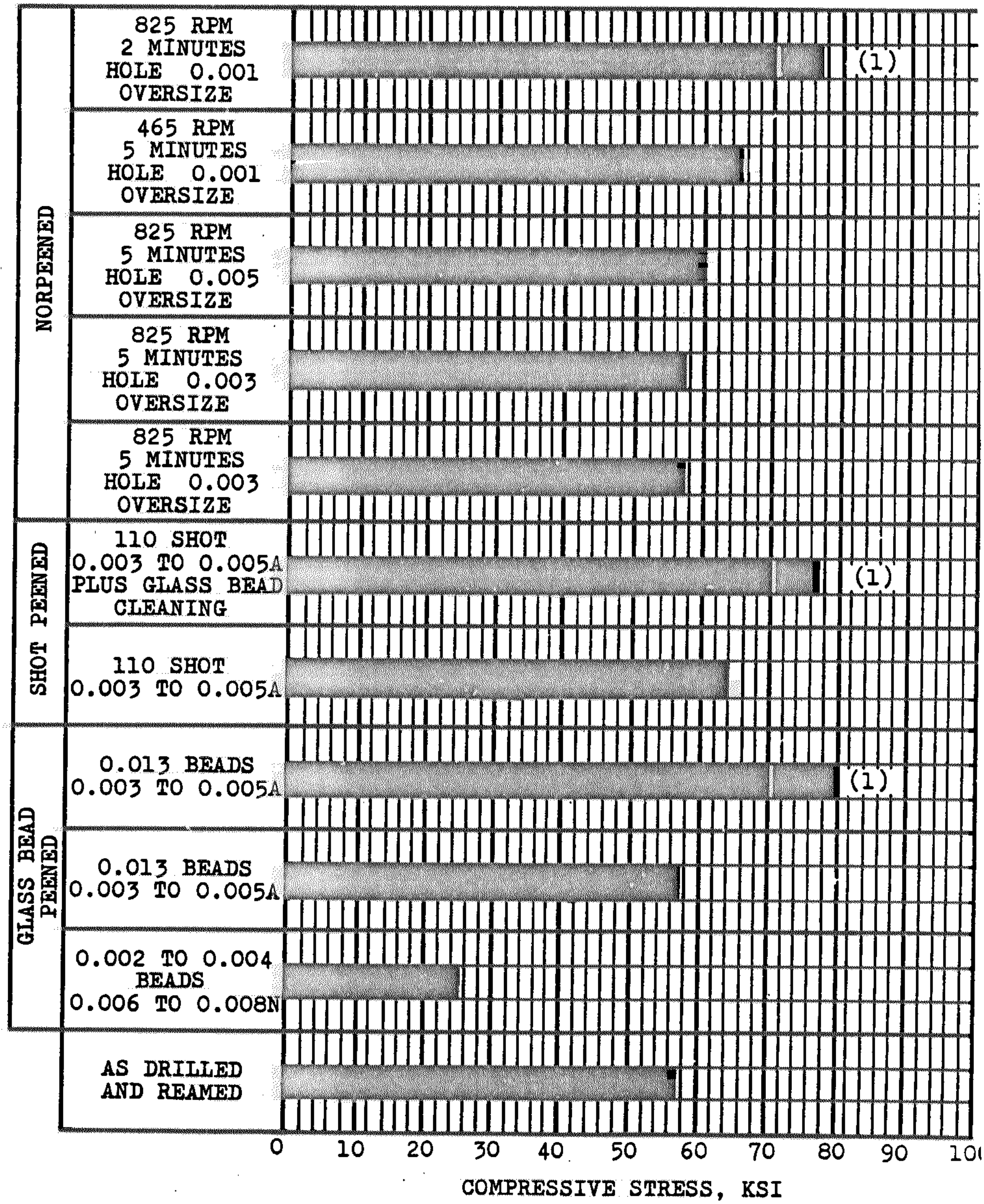


FIGURE 4. STRESS CORROSION LIFE OF PEENED AND UNPEENED SPECIMENS



NOTE: 1. VALUES WERE ABOVE THE YIELD STRENGTH

FIGURE 5. COMPRESSIVE STRESSES AT PEENED AND UNPEENED HOLE SURFACES

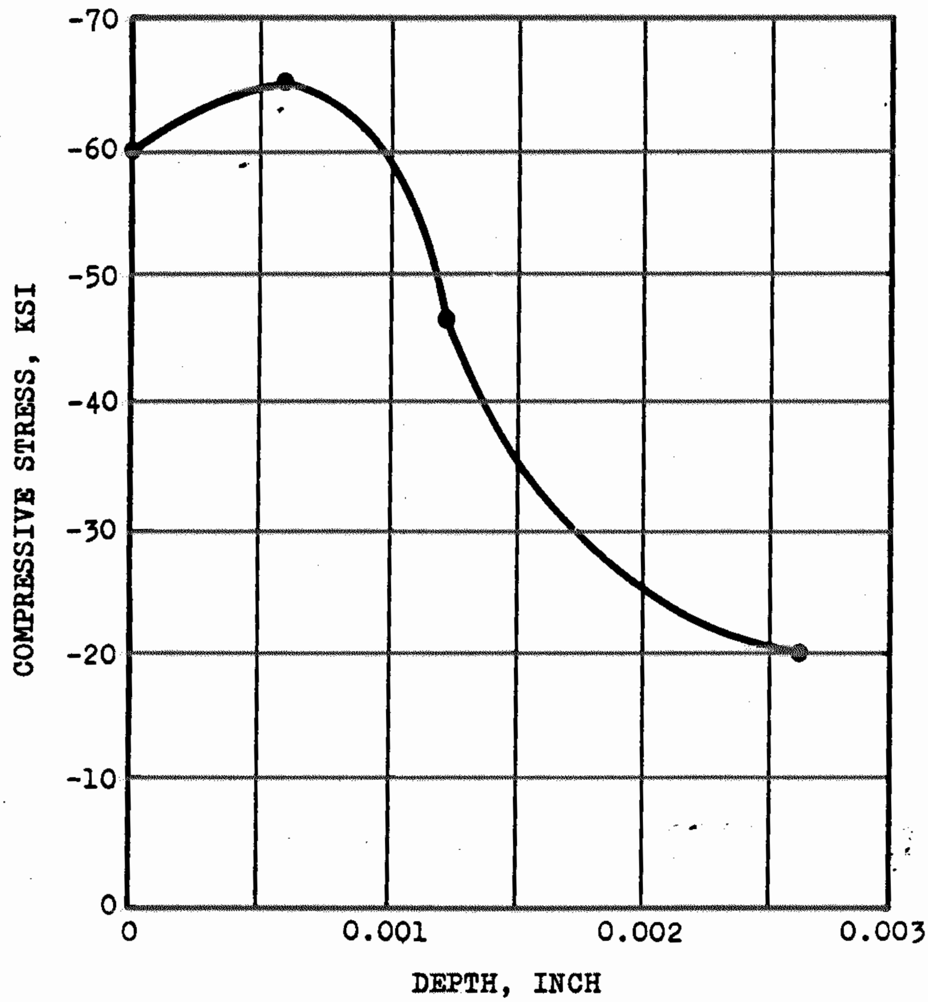
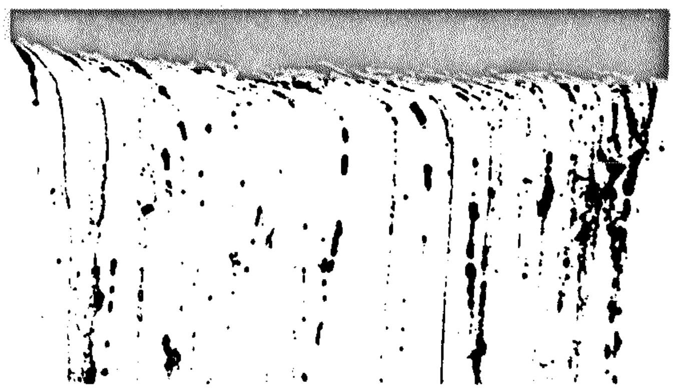


FIGURE 6. DEPTH OF COMPRESSIVE STRESSES PRODUCED BY NORPEENING

KELLER'S ETCH: 250X

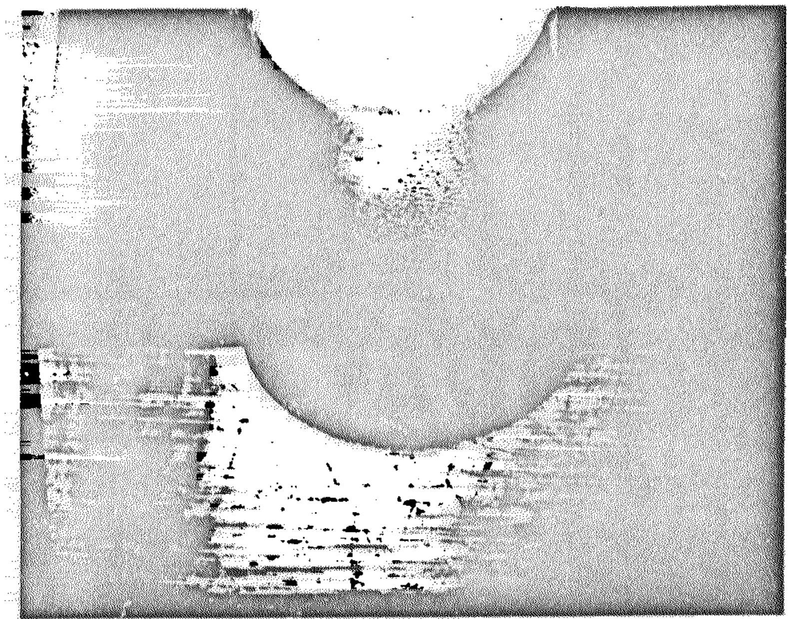
LONGITUDINAL



TRANSVERSE

NORPEENED 465 RPM FOR 5 MINUTES

FIGURE 7. SURFACE COLD WORKING AS PRODUCED BY NORPEENING



2X

FIGURE 8. SURFACE APPEARANCE OF TEST BLOCK COLD WORKED BY NORPEENING