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NAVAL UNDERWATER SYSTEMS CENTER NEWPORT R I  
A DEVICE FOR PRODUCTION TESTING THE TENSILE STRENGTH OF CERAMIC--ETC(U)  
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Project No.  
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A DEVICE FOR PRODUCTION TESTING  
THE TENSILE STRENGTH OF CERAMIC RINGS.

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⑩ by  
Gerald M. Mayer and Hector J. Cini  
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⑭ NUSC-TM-  
10 May 1971

⑪ 10 May 71  
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INTRODUCTION

The device described below was developed for better quality control of ceramic rings used in transducer construction. Previous tests conducted by Stanford Research Institute indicate that about 6% of the rings used in constructing TR-208 transducer elements have abnormally low tensile strength. This means that there is approximately 25% probability that a finished transducer element with a 4 ring stack will have at least one abnormally weak ring.

This production test device is used to stress each ring to a safe working level, approximately 60% of tensile yield strength and thereby eliminate any faulty rings before they are used in a transducer assembly.

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### DISCUSSION

The device is shown in Figure 1. A hydraulic pump supplies pressure to a small hydraulic jack, #1. Base plate #2, rubber washer #3, top plate #4 are held together by a bolt as an assembly and the bolt is threaded into the hydraulic jack #1. As the pressure is applied to the jack, the force causes the rubber washer #3 to compress against the base plate #4. This causes the rubber washer to expand radially and apply a uniform load on the ceramic ring. Releasing the pressure causes the rubber washer to return to its original position.

To test a ceramic ring, the ring is slipped over the top plate, down over the rubber washer, and brought to rest against the base plate. This positions the ring in line with the rubber washer. The assembly is then adjusted by the bolt so that the clearance between the ceramic ring and the rubber washer is approximately .002 to .005 inches.

Shroud #5 has a dual function. This is slipped over the assembly. The large hole fits over the ceramic ring under test and the shoulder of the small hole rests on the top surface of the ring. The small hole of the shroud fits over the top plate #4 and positions the shroud concentrically on the assembly. The shoulder on the shroud shorts out the electrical charge as the ring is stressed and protects the operator as he removed the ring which has passed the test. The large hole in the shroud fits over the ceramic ring and protects the operator from being injured by broken ceramic fragments from a ring that fractures.

Figure 2 shows an exploded view of the stress generating assembly and its component parts. Pressure gage #6 indicates the applied load in psi. No. 7 is a ceramic ring.

The stress impressed on the ceramic ring generated by the expanding rubber washer is determined by the load vs. stress calibration curve, Figure 3. This curve was generated by taking the average strain from two (2) strain gages on the outside diameter of a ceramic ring 90° apart and using a correction factor of 1.13 to obtain the maximum stress at the inner surface of the ring.

$$\text{Maximum stress} = 1.13 \times E \times e$$

The elastic modulus E was taken as  $14 \times 10^6$  psi.

Figure 4 gives tabulated results on tensile tests on thirty-nine (39) TR-208A ceramic rings using the described device. Taking 10,000 psi as

the nominal tensile strength of the ceramic material and 60% of this as a safe working stress, it can be seen that three (3) rings are below the 6000 psi stress requirement. This indicates a 7.6% failure rate on the 39 rings. In a transducer of four (4) stacked rings using the above 39 rings, it is conceivable that one defective ring could have been used in three of the eight (8) transducer assemblies.

Ceramic rings of various diameters and heights can also be tested by merely changing the stress generating assembly parts #2, #3, and #4 to appropriate dimensions. The feature of the device is that it permits simulated hydrostatic loading without the use of a fluid medium.

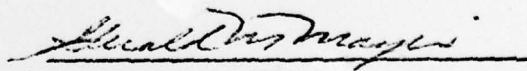
Figure 5 is tabulated data on forty (40) ceramic rings tested to fracture. The data is self explanatory.

Figure 6 is tabulated in serial number order and stress at failure order. It is interesting to note in the stress at failure order that ring serial #'s 196, 194, 193, and 195 have the lowest stress at failure. The consecutive serial numbers suggest that this is not a randomly distributed weakness, but can probably be attributed to some event in the production process common to that group of rings.

#### RECOMMENDATIONS

It is recommended that a tensile strength test using a device similar to the one described above be made a specification requirement in the procurement of all ceramic rings intended for use in active sonar transducers.

  
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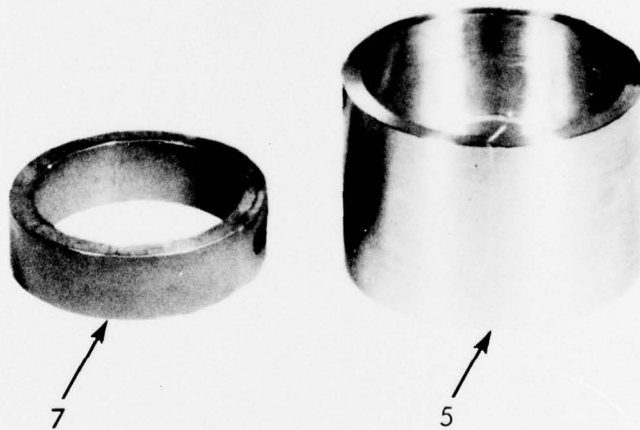
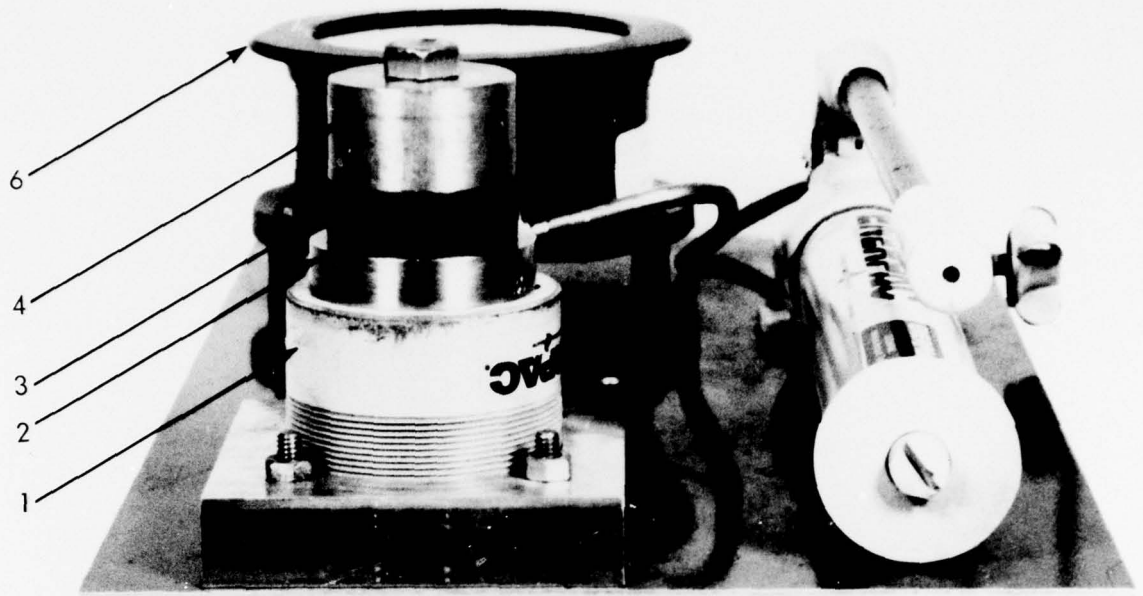


Fig. 1

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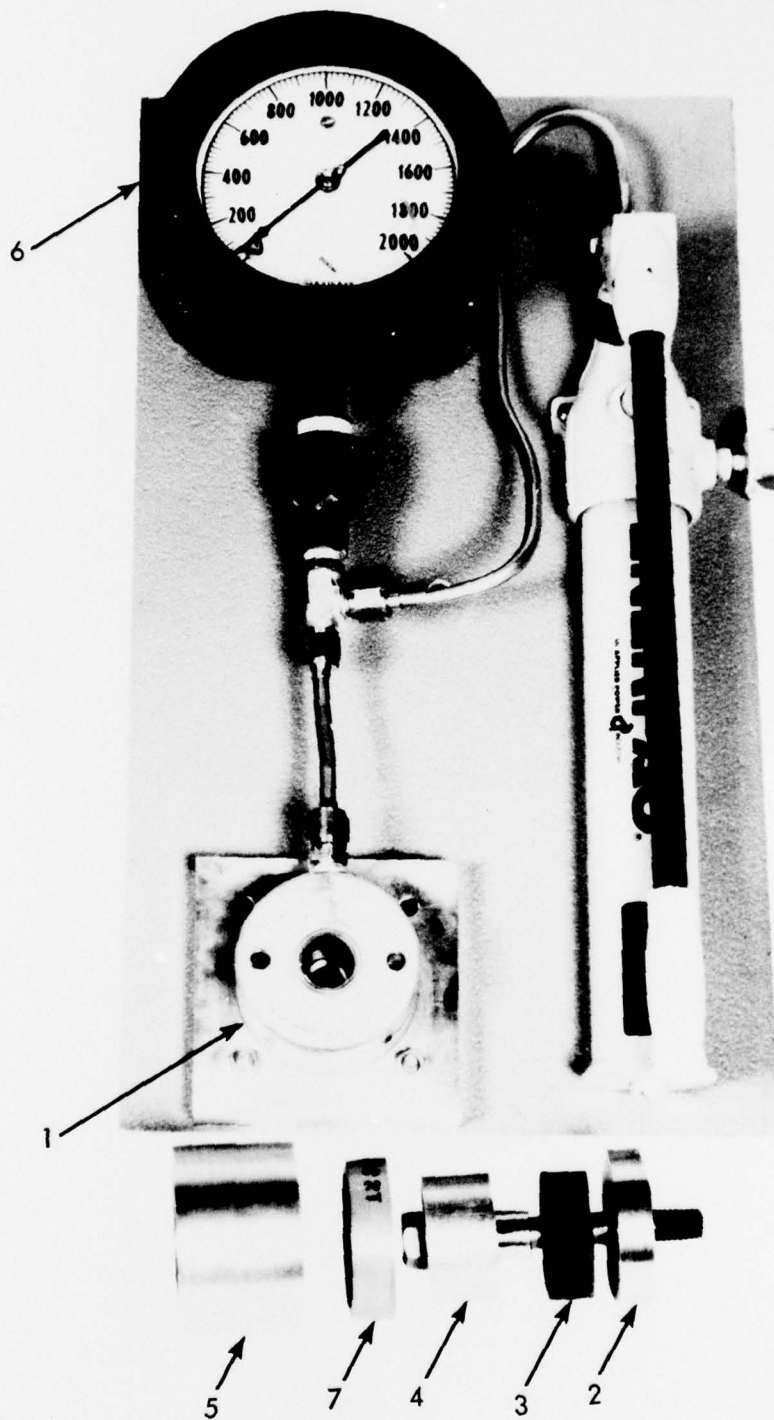
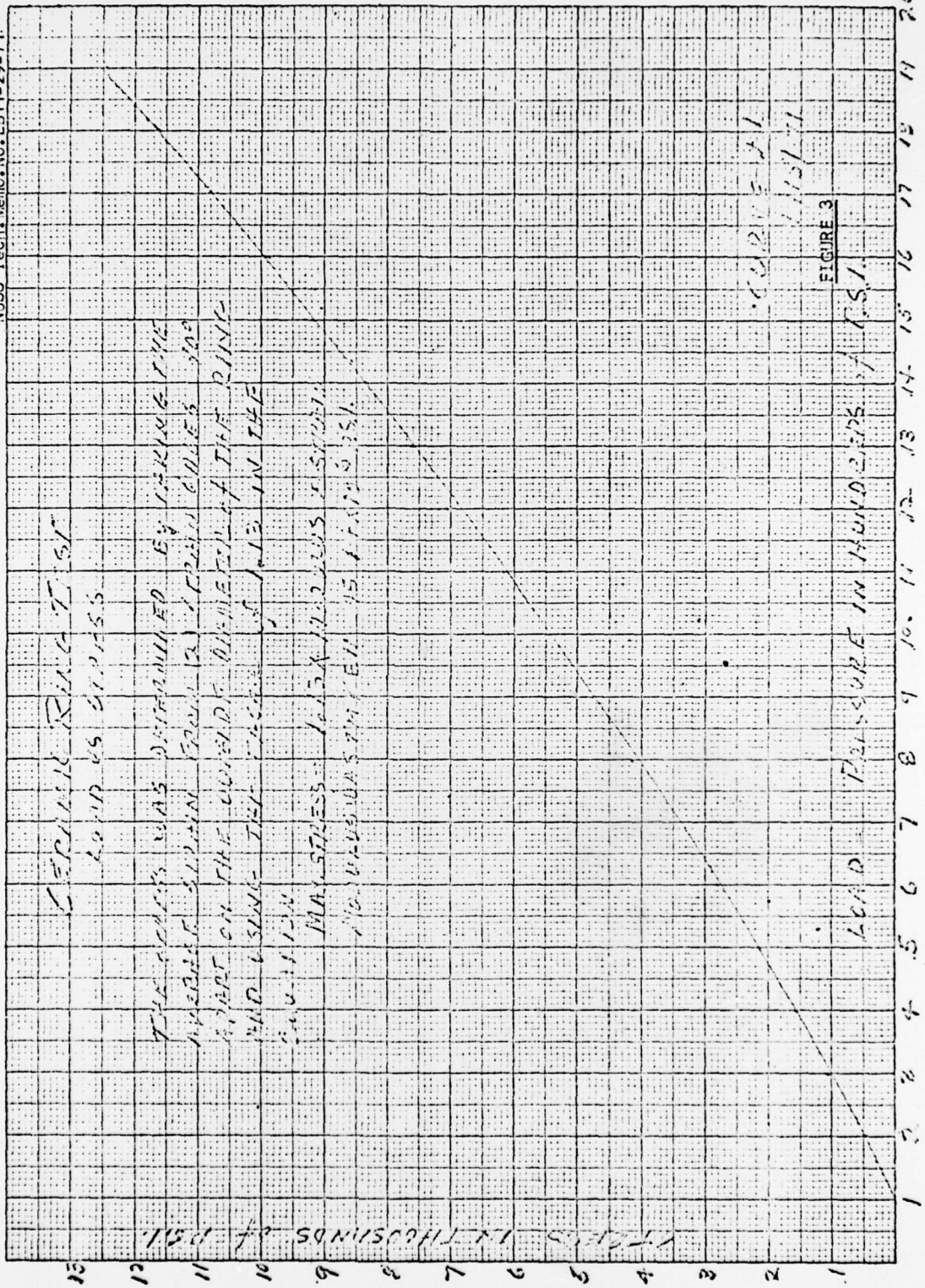


Fig. 2

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CERAMIC RING TEST

FIGURE 4

A total of thirty-nine (39) ceramic rings were tested using the described device. Each ring was taken to its ultimate tensile strength. The load at fracture was recorded and the stress determined from the calibration curve of Figure 1.

<u>Ring Serial Number</u>	<u>Load PSI To Fracture</u>	<u>Stress PSI</u>	<u>Ring Serial Number</u>	<u>Load PSI To Fracture</u>	<u>Stress PSI</u>
197	1740	11150	119	1740	11150
194	980	5300	105	1740	11150
193	1040	5700	98	1550	9600
200	1580	9800	113	1420	8500
195	1180	6700	86	1480	9000
199	1520	9300	87	1540	9500
196	500	2200	97	1740	11150
198	1280	7400	100	1720	11000
106	1440	8700	108	1640	10300
104	1680	10600	107	1780	11500
103	1440	8700	120	1400	8400
101	1760	11300	110	1240	7100
88	1850	12100	116	1660	10500
90	1480	9000	102	1680	10600
85	1800	11600	99	1640	10300
89	1800	11600	92	1800	11600
112	1380	8200	114	1420	8500
95	1700	10800	111	1580	9800
117	1620	10100	109	1760	11300
115	1640	10300	118	Accidentally Broken	

CERAMIC RING TEST DATA  
 EDO WESTERN TR-208 RINGS

FIGURE 5

Tech. Memo. No. EB11-29-71

SERIAL #	LOAD AT FRACTURE	STRESS AT FRACTURE	
197	1740	11,100	TESTED TO DESTRUCTION AT RECEIVED
194	980	5,250	
193	1040	5,700	
200	1580	9,800	
195	1180	6,660	
199	1520	9,300	
196	500	2,150	
198	1280	7,420	
106	1440	8,670	
104	1680	10,610	
103	1440	8,670	
101	1760	11,300	
88	1850	12,080	
90	1480	9,000	
85	1800	11,640	
87	1800	11,640	
112	1380	8,200	
95	1700	10,760	
117	1620	10,110	
115	1640	10,290	
119	1740	11,100	TESTED TO DESTRUCTION AFTER HIGH FIELD MEASUREMENTS
105	1740	11,100	
98	1550	9,550	
113	1420	8,500	
86	1480	9,000	
87	1540	9,480	
97	1740	11,100	
100	1720	10,950	
108	1640	10,290	
107	1780	11,450	
120	1400	8,350	
110	1240	7,110	
116	1660	10,460	
102	1680	10,610	
99	1640	10,290	
92	1808	11,640	
114	1420	8,500	
111	1580	9,800	
109	1760	11,300	
118	NO DATA - BROKEN BY ACCIDENT		
OVERALL FIGURES			
Mean fracture stress - $\sigma_{fract}$	9511 psi	} on raw data	
$\sigma_{fract}$	2038 psi		
Mean fracture stress - $\sigma_{fract}$	10201 psi	} After comparing alternative process eliminating outside of mean $\pm 2\sigma$	
$\sigma_{fract}$	1116 psi		

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CERAMIC RING TEST DATA

FIGURE 6

LISTED IN SER# ORDER				LISTED IN FAILURE SERIAL ORDER			
SER #	Stress at fracture			SER #	Stress at fracture		
85	11640			196	2150		
86	9000			194	5250		
87	9480			193	5700		
88	12080			195	6660		
89	11640			110	7110		
90	9000			198	7420		
92	11640			112	8200		
95	10760			120	8350		
97	11100			114	8500		
98	9550			113	8500		
99	10290			103	8670		
100	10750			106	8670		
101	11300			86	9000		
102	10610			90	9000		
103	8670			199	9300		
104	10610			87	9480		
105	11100			98	9550		
106	8610			111	9800		
107	11450			200	9800		
108	10290			117	10110		← MISSING
109	11300			99	10290		
110	7110			108	10290		
111	9000			115	10290		
112	8200			116	10460		
113	8500			102	10610		
114	8500			104	10610		
115	10290			95	10760		
116	10460			100	10950		
117	10110			97	11100		
118	NO DATA			105	11100		
119	11100			119	11100		
120	8350			197	11100		
193	5700			101	11300		
194	5250			109	11300		
195	6660			107	11450		
196	2150			85	11640		
197	11100			89	11640		
198	7420			92	11640		
199	9300			88	12080		
200	9800			118	NO DATA		

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