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A REPORT GUIDE TO ULTRASONIC TESTING LITERATURE - VOLUME VII.(U)  
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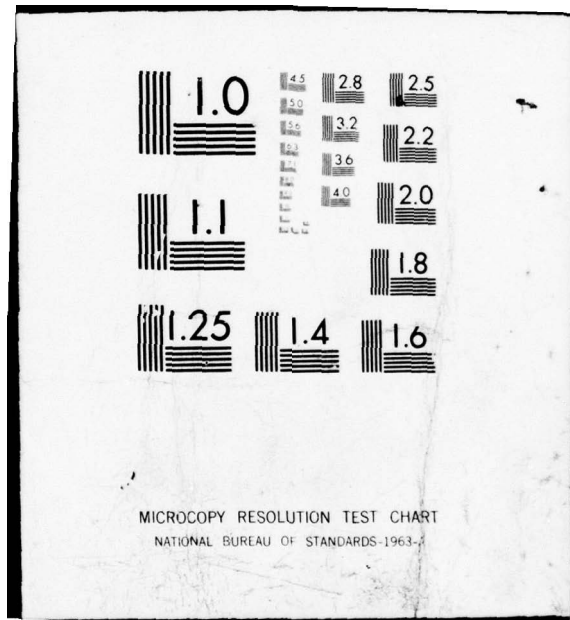
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# A REPORT GUIDE TO ULTRASONIC TESTING LITERATURE - VOLUME VII

WALTER R. KLAPPERT and CHARLES P. MERHIB  
MATERIALS TESTING TECHNOLOGY DIVISION

November 1976

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report guide covers a portion of the abstracts on ultrasonic testing included in the holdings of the Nondestructive Testing Information Analysis Center.		

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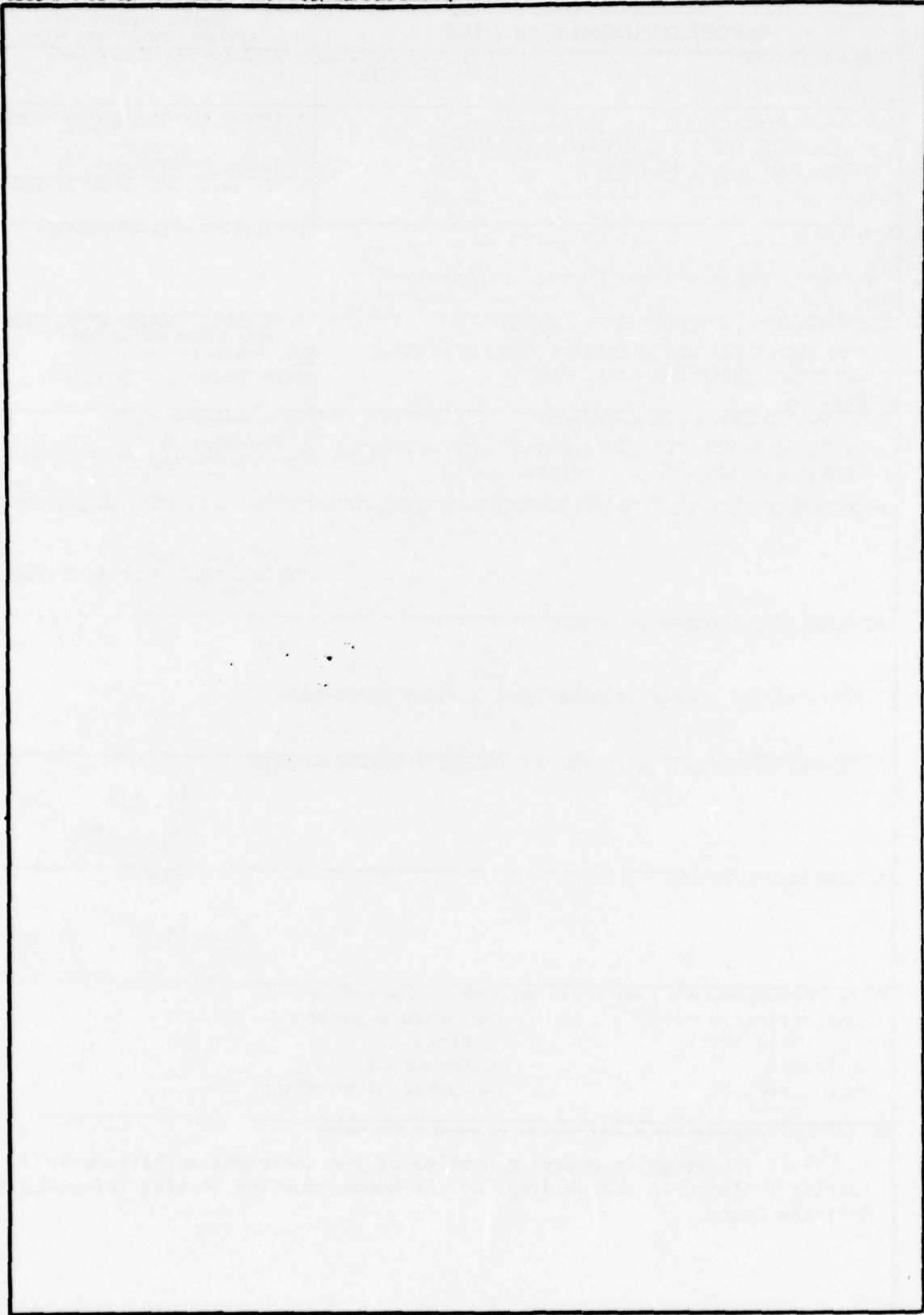
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## PREFACE

This is one of the series of volumes prepared by the U.S. Army Materials and Mechanics Research Center (AMMRC) covering the field of ultrasonic testing. This volume contains all the information on ultrasonic testing taken from the seventh 1000 references held by the Nondestructive Testing Industrial Applications Branch of AMMRC. Ultrasonic attenuation references are also included.

All items included in this report guide cover some aspect of ultrasonic testing even though the majority include numerous other descriptors. Each item is covered by as many descriptors as were deemed necessary for complete coverage of that item.

The intent of this journal is to assist research investigators and industrial inspection personnel by providing a ready reference and access to the extensive and widely scattered literature on the subject matter.

This project has been accomplished as part of the U.S. Army Materials Testing Technology Program, which has for its objective the timely establishment of testing techniques, procedures or prototype equipment (in mechanical, chemical, or nondestructive testing) to insure efficient inspection methods for materiel/material procured or maintained by DARCOM.

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## INTRODUCTION

Where available, each item in this Journal consists of the following information: (1) item, report, or article title (2) author or authors, (3) source or facility, (4) report number or identification, (5) date, and (6) abstracts.

Word descriptors pertinent to each item are listed in alphabetical order and are cross-referenced by the AMMRC identification number. Also provided is an author index or, if no author is available, then the issuing organization is listed.

## OBJECTIVE

The main objective of this compilation is to provide a simple and fast access to information on the subject of ultrasonic testing and also to provide sufficient information in the form of abstracts and word descriptors to make the listing useful.

## SCOPE

This guide is Volume VII of a series of planned report guides consisting of the complete coverage of items in the AMMRC Nondestructive Testing Industrial Applications Branch covering the subject of ultrasonic testing. Subsequent volumes will be published as the work load permits.

The following is a list of report guides previously published.

- |                      |   |
|----------------------|---|
| <b>AMRA MS 64-10</b> | <i>A Report Guide to Autoradiographic and Microradiographic Literature, August 1964, AD-612 047</i>                     |
| <b>AMRA MS 64-11</b> | <i>A Report Guide to Gamma Radiographic Literature, August 1964, AD-612 042</i>   |
| <b>AMRA MS 64-12</b> | <i>A Report Guide to Liquid Penetrant Literature, August 1964, AD-612 044</i>   |
| <b>AMRA MS 64-13</b> | <i>A Report Guide to Literature in the Fields of Fluoroscopy and Remote Viewing Techniques, August 1964, AD-612 045</i> |
| <b>AMRA MS 64-14</b> | <i>A Report Guide to Thermal Testing Literature, August 1964, AD-612 043</i>  |
| <b>AMRA MS 65-03</b> | <i>A Report Guide to Electromagnetic Literature, April 1965, AD-615 346</i>   |
| <b>AMRA MS 65-04</b> | <i>A Report Guide to Magnetic Particle Testing Literature, June 1965, AD-617 758</i>                                    |
| <b>AMRA MS 65-09</b> | <i>A Report Guide to Ultrasonic Attenuation Literature, December 1965, AD-627 565</i>                                   |

- AMRA MS 66-02**     *A Report Guide to Ultrasonic Testing Literature, Volume I, March 1966, AD-630 652*
- AMRA MS 66-05**     *A Report Guide to Ultrasonic Testing Literature, Volume II, June 1966, AD-638 749*
- AMRA MS 66-11**     *A Report Guide to Ultrasonic Testing Literature, Volume III, December 1966, AD-648 905*
- AMRA MS 67-03**     *A Report Guide to Ultrasonic Testing Literature, Volume IV, April 1967, AD-650 279*
- AMRA MS 67-06**     *A Report Guide to Ultrasonic Testing Literature, Volume V, June 1967, AD-660 790*
- AMMRC MS 67-03**     *A Report Guide to Radiographic Testing Literature, Volume I, December 1967, AD-664 780*
- AMMRC MS 67-05**     *A Report Guide to Fatigue Testing Literature, May 1967, AD-652 881*
- AMMRC MS 68-02**     *A Report Guide to Radiographic Testing Literature, Volume II, February 1968, AD-667 400*
- AMMRC MS 68-08**     *A Report Guide to Radiographic Testing Literature, Volume III, September 1968, AD-676 835*
- AMMRC MS 69-03**     *A Report Guide to Ultrasonic Testing Literature, Volume VI, April 1969, AD-689 455*
- AMMRC MS 72-4**     *A Report Guide to Radiographic Testing Literature, Volume IV, June 1972, AD-749 258*
- AMMRC MS 72-3**     *A Report Guide to Thermal Testing Literature, Volume II, April 1972, AD-740 654*
- AMMRC MS 73-5**     *A Report Guide to Radiographic Testing Literature, Volume V, December 1973, AD-772 929*
- AMMRC MS 75-3**     *A Report Guide to Radiographic Testing Literature, Volume VI, April 1975, AD-A023 900*
- AMMRC MS 75-4**     *A Report Guide to Radiographic Testing Literature, Volume VII, May 1975, AD-A023 901*

## SOURCES

The information contained herein and in the AMMRC Nondestructive Testing Industrial Applications Branch has been gathered from many sources such as: Defense Documentation Center; foreign translations; numerous books; technical journals; and reports from DOD installations.

## USAGE

All word descriptors included in this guide are listed in alphabetical order and are cross-referenced to the AMMRC report identification number. Also listed is an author index, or, if no author name is available, then the issuing organization is listed. Users have only to refer to those descriptors that they are concerned with at the time and read only those abstracts which the descriptors cross-reference.

The abstracts normally refer the reader to the source where the complete report may be obtained if the reviewer desires it.

## ABSTRACTS

AMMRC  
IDENTIFICATION  
NUMBER

- 6006      **CWEA-4 SONIC ANALYZER WITH UH-1 HELICOPTER CAPABILITY**  
W. B. Gray and R. G. Locklin  
Curtiss-Wright Corp., Curtiss Division, Caldwell, New Jersey, May 1968  
U. S. Army Aviation Material Labs., Ft. Eustis, Va. USAAVLABS Tech. Rpt 68-28  
AD-674 198

Report presents the results of work performed in the application of the CWEA-4 Sonic Engine Analyzer to the UH-1 complete dynamic component system, includes the results of the design and development of the UH-1 acoustic plug-in module, and describes the CWEA-4 analyzer, including the design concepts. Mechanical analysis of all rotating train components of UH-1 helicopters for calculation of expected acoustic frequencies, compilation of an acoustic handbook listing these acoustic frequencies, determination of optimum microphone location, laboratory analysis of all acoustic recordings for identification of engine components, and establishment of the best locking frequency accomplished. Will eliminate unnecessary troubleshooting now being practiced under conventional inspection methods.

- 6011      **NONDESTRUCTIVE INVESTIGATION OF HIGH MODULUS GRAPHITE FIBER COMPOSITES**  
J. R. Zurbrück  
AVCO Corp., Lowell, Mass. 01851. Presented at the Meeting on Fiber Composites,  
Cleveland, Ohio, 8 and 9 October 1968

High modulus graphite fiber composites, in the form of crossplied ( $0^{\circ}$ - $90^{\circ}$ ) laminates, have been evaluated for inherent variability using quantitative nondestructive testing techniques. As part of four years of research and development sponsored by the Air Force Materials Laboratory these materials have served in the development of a totally new NDT capability; the complete elastic characterization of reinforced plastic laminates. The joining of ultrasonic velocity measurements and gamma radiometric absorption measurements with micromechanics theory has provided this illuminating capability. One outcome is the ability to calculate the effective modulus of the high modulus graphite fiber as it exists in the finished laminates.

- 6012      **FEASIBILITY OF NONDESTRUCTIVE EVALUATION OF SIC PROPERTIES**  
E. A. Proudfoot  
AVCO Corp., Lowell, Mass. AVSSD-0144-66-RR, July 1966

Reports on the feasibility of using nondestructive measurement techniques to evaluate the effect of one variable (density) on the thermal conductivity and high-frequency dielectric properties of clay-bound silicon carbide materials. Techniques used include microwave frequencies (10-35 GHz) measurements of total absorption; relative dielectric constant and loss tangent; gamma-ray radiometric density determination; ultrasonic wave velocity measurement; low frequency (1 KHz) capacitance measurement; and cut-bar thermal conductivity measurement. Results show that material density has an important and predictable influence on microwave frequency dielectric constant, loss tangent, and total absorption, as well as on thermal conductivity.

6013

**THE DELTA TECHNIQUE – A RESEARCH TOOL – A QUALITY ASSURANCE TOOL**

B. T. Cross

Automation Industries, Inc., Boulder, Colo. TR-68-11, March 1968

This paper discusses the status of the Delta technique in the transition from a research tool to a quality assurance tool. Delta capabilities are discussed with respect to the confidence levels achieved with the latest developments of this technique. Extensive destructive testing was performed to establish these confidence levels. A statistical comparison was made between Delta weld inspection, radiographic weld inspection, and destructive analysis. For lack of penetration (LOP) Delta weld inspection detected 80% of the total LOP as opposed to 40% for radiography. The various ways of using the Delta technique as a production tool for quality assurance are presented with respect to these specific points: (1) type of flaw information desired—location, depth, and/or approximate flaw size, (2) type of test—immersion, bubbler, or contact, (3) type of scanning—automatic semi-automatic, or manual, and (4) type of test records—facsimile recordings, strip chart recordings, or manual recordings.

6016

**THE VIDEO TAPE RECORDING OF ULTRASONIC TEST INFORMATION**

R. A. Youshaw, C. H. Dyer, E. L. Criscuolo

Naval Ordnance Laboratory, White Oak, Md.

Final Report on Project 176, "Quality Assurance", to the Ship Structure Committee,

Rept. No. SSC-189, October 1968

AD-677 894

A video tape recorder was converted into a wide band instrumentation recorder. The 'A' scan from the ultrasonic tester is directly recorded, together with the operator's voice giving the location, transducer position and interpretation of test data. An oscilloscope is used for the playback. The circuitry necessary to couple the output of the ultrasonic tester to the tape recorder is described.

6018

**RESEARCH AND DEVELOPMENT OF NONDESTRUCTIVE TESTING TECHNIQUES FOR COMPOSITES**

G. Martin & J. F. Moore

North American Rockwell Corp., Los Angeles, Calif.

AFML-TR-68-202, June 1968

AD-844 984

A number of test specimens of various filament-matrix combinations containing deliberately introduced defects and substandard mechanical properties were fabricated and used together with other specimens for NDT evaluation. Metallographic and destructive tests showed a considerable local variation in properties including density, surface finish and bond strength. A comprehensive evaluation of broad and narrow beam radiographic techniques was utilized to develop optimized inspection technique capable of detecting single filament anomalies in almost all of the multilayer composites. Microradiographic and densitometric techniques were adapted to determine the depth of filament breaks to a specific filament layer. Acoustic inspection pulse-echo techniques show good capability for the detection of disbonds. Acoustic velocity relationships were established with filament volume percent and general bond strength properties. Numerous other NDT techniques are also discussed.

6020

**METHOD USING SUPERSONIC WAVES FOR MEASURING STRESS**

Soji Sasaki

Patent No. 3,364,732

Commissioner of Patents, Washington, D. C.

A method for measurement of stress, modulus of elasticity, or Poisson's ratio by measuring the velocity of ultrasonic surface waves on the workpiece. An ultrasonic energy is directed toward the workpiece, the incident angle is varied and the reflected signals detected and displayed on a meter. The incident angle corresponding to a peak meter reading is used in a formula to determine the surface wave velocity.

6024

**AN ULTRASONIC PULSE GENERATOR USING THE TRANSDUCER AS A FREQUENCY DETERMINING ELEMENT**

D. E. Watke

Master Thesis for The University of Missouri at Rolla, for Degree of Master of Science in Electrical Engineering, Rolla, Missouri (132919) 1968

This paper describes the development of a method of ultrasonic pulse generation in which the transducer determines the frequency of oscillation. A definite advantage of this method is the ability of the frequency of oscillation to change with changes in the transducer mechanical resonant frequency. This maintains peak efficiency at all times. The method is demonstrated in a small sonar transmitter but could be applied to any area involving driven ultrasonic transducers.

6031

**PIEZOELECTRIC ULTRASONIC TRANSDUCER**

J. R. Colbert

Commissioner of Patents, Washington, D. C. Patent No. 3,376,438

An ultrasonic transducer with a damping member as a backing. The damping is provided by a self-sustaining sintered skeleton of metal particles impregnated with a sound insulator such as silicone rubber. This backing is said to have more reproducible performance and to be cheaper to produce than the commonly used cardboard type.

6032

**MAGNETIC CRACK DETECTOR FOR FERROMAGNETIC TUBING**

F. N. Kusenberger et al

Commissioner of Patents, Washington, D. C. Patent No. 3,379,970

A magnetic device for inspection of metal tubing to detect defects such as fatigue cracks. The tubing is positioned inside a solenoid-type magnetizing coil. The leakage flux detector is a wire coil mounted on an ultrasonic transducer. The vibration of this ultrasonic transducer provides relative motion between the coil and the leakage flux so that an electrical signal is generated which may be displayed on an appropriate indicator.

6044

**A SOLID-STATE ULTRASONIC IMAGE CONVERTER**

R. J. Larkin

U. S. Naval Postgraduate School, Monterey, Calif. 93940, June 1968

AD-840 257

(Circuitry details are given for the converter). Acoustical techniques can be used to obtain underwater images at distances greater than those currently obtained by optical means. Electronic scanning of a mosaic transducer at the focal plane of an acoustic lens enables target image reproduction on a cathode ray tube using intensity modulation. Previous work in developing the required amplifier and gating circuitry has resulted in systems with excessive cabling and of excessive size. This report is a study of the design of a 16-channel printed circuit board immediately adjacent to a linear transducer array so as to eliminate cabling. Microelectronic devices are used to confine all electronics to a 0.26 x 0.26 inch cross-section for each channel. A 32 x 32 element mosaic at 250 kHz could be scanned by a package no larger than 9 x 9 x 6 inches. A discussion of performance, size, and costs is included.

6045

**DETERMINATION OF TENSILE STRENGTH OF GRAY CAST IRON BY MEANS OF ULTRASONICS**

S. Kipka, G. Pursian

Translated from *Giessereitechnik*, vol. 13, 1967, #12, pp. 373-376.

HB No. 7397 (available from H. Brucher, P. O. Box 157, Altadena, Calif 91001)

Critical review of available literature data on the nondestructive determination of the UTS of cast irons, particularly by ultrasonics; calculation of modulus  $E_0$  as affected by the velocity of ultrasonic longitudinal waves (Fig. 1); connection between tensile strength, modulus  $E_0$ , and Brinell hardness, according to Collaud. Author's testing procedure and results: compositions of gray irons used in study role of degree of saturation, density, section size, and furnace practice. Tensile strength as function of Brinell hardness times  $E_0$ , and velocity of longitudinal ultrasonic waves for different groups of alloyed and unalloyed cast irons from cupola, rotary drum, and electric arc furnace.

6046

**COMPUTER PROGRAM FOR ACOUSTIC PULSE-ECHO DATA REDUCTION**

K. A. Kemp, M. G. Kim, S. U. Letcher

Dept. of Physics, Univ. of Rhode Island, Kingston, R. I.

Technical Report No. 2, 15 Aug. 1968

AD-673 269

N68-35262

A FORTRAN computer program has been developed to compute ultrasonic velocity and absorption in liquids from variable distance pulse-echo measurements of sound path length, travel time, and amplitude. The calculations, data input, and computed output are described in this report. A program listing and sample output are presented for reference purposes.

6047

**THE NONDESTRUCTIVE EVALUATION OF STRESS-CORROSION INDUCED  
PROPERTY CHANGES IN ALUMINUM**

W. N. Clotfelter, B. F. Bankston, E. E. Zachary  
Tech. Memorandum X-53772, 23 Aug. 68. NASA, G. Marshall Space Flight Center,  
Huntsville, Ala.  
N68-35652

The problem of stress corrosion failures has plagued most current aerospace vehicles. In an attempt to establish a better understanding of this phenomenon and to develop methods by which it might be depicted in early states, experiments were designed to investigate methods by which potential stress corrosion failures could be evaluated during the period of incubation. These experiments involved very precise measurements of selected physical property changes in the material during the onset of stress corrosion. Both highly susceptible and highly resistant materials were included. The data show clearly that the period of stress corrosion incubation can be detected nondestructively in the highly susceptible alloys.

6048

**REFERENCE BLOCKS FOR ULTRASONIC TESTING OF ENGINEERING MATERIALS**

S. G. N. Swamy and P. C. Mahajan  
Central Mechanical Engineering Research Institute, Durgapur, India  
CMERI-A14, PB 178871, December 1967  
N69-12267

The report discusses the superiority of IIW block over the various other calibration blocks developed and used in different countries, and summarize the know-how developed on the precise use of IIW block for calibration of ultrasonic testing equipment.

6056

**SOME NON-NUCLEAR MATERIALS & TESTING STUDIES AT THE ATOMIC  
ENERGY RESEARCH ESTABLISHMENT, HARWELL, ENGLAND**

E. F. Carome  
Office of Naval Research, Branch Office, London, England. 3 February 1969  
AD-682 916

This Report covers a one-day meeting on "Materials & Testing at Harwell," held at the Atomic Energy Research Establishment, Harwell, Berks., on 3 Dec. 1968. It was sponsored by the Materials and Testing and the Acoustics Groups of the Inst. of Physics and the Physical Society and by the British Acoustical Society. Industrial applications (non-nuclear) of many techniques were discussed, e.g., flaw detection, macroscopic and microscopic properties of materials, laser light scattering techniques, measuring flow velocity in fluids, ultrasonic holography, etc. This Report attempts to present highlights of the papers presented.



6057

**INVESTIGATION OF NONDESTRUCTIVE METHODS FOR THE EVALUATION OF GRAPHITE MATERIALS**

R. C. Stinebring, A. W. Schultz, J. W. Orner  
AVCO Space Systems Division, Lowell, Mass. 01887  
Tech. Report AFML-TR-68-128, Part II, February 1969  
AD-851 233

The objective of the program was to utilize the nondestructive testing information, correlations, and techniques, developed during the previous year, for characterizing and evaluating zirconium and hafnium diboride systems and aerospace graphite materials.

6059

**DETECTION OF FATIGUE CRACKS BY MEANS OF ULTRASONICS**

P. Reti  
Materialprüfung, Vol. 10, No. 10, 1968; HB Translation No. 7653, H. Bratcher, Altadena, Calif.

Redesign of fatigue specimens used in study to avoid spurious echoes. Relationship between ultrasonic beam and resulting defect amplitude as a function of artificial and natural reductions in cross sections. Staining of fatigue cracks by immersion of specimens into hot hydrochloric acid at pre-selected echo amplitudes and at failure. Planimetry of stained surface area of fatigue cracks. Evaluation of results obtained on a 0.40% carbon steel. Correlation between amplitude of defect echo and area of crack as crack propagation progresses. Mathematical expression of  $A=f(N)$  and  $N=f(A)$ . Future work on subject.

6060

**APPARATUS FOR ULTRASONICALLY SCANNING A TUBULAR MEMBER**

J. C. Heselwood  
Patent No. 3,382,707  
Commissioner of Patents, Washington, D. C. 20231

An ultrasonic transducer mounted on a flexible disc attached to and rotated by a shaft. The axis of the shaft perpendicularly intersects the axis of the tubular member and is movable in a direction parallel to the tube. The disc edge is guided along a contour corresponding with that of the surface of the tube. The radiating axis of the transducer is normal to this surface at all times, and the distance between the transducer and the surface of the tube is kept constant.

6061

**ULTRASONIC TRANSDUCER**

J. S. Arnold  
Patent No. 3,384,767  
Commissioner of Patents, Washington, D. C. 20231

An ultrasonic transducer which may be used to evaluate the bond between layers of a laminated product such as plywood. The transducer is made in the form of a right circular cylinder which is made to vibrate in a predominantly radial mode. The electrodes are on the opposite flat surfaces and composed of concentric rings covering the whole surface except predetermined nodal regions. Two transducers may be rolled on the workpiece, with one driven by an oscillator and the other receiving the signal transmitted through the workpiece.

6065

**PULSE CIRCUIT FOR PULSE ECHO ULTRASONIC TESTING**

K. H. Brech

Patent No. 3,387,257

Commissioner of Patents, Washington, D. C. 20231

A pulse circuit for pulsing a piezoelectric transducer. A capacitor is alternately charged and discharged in response to an electronic switch. A rectifier in the circuit between the transducer and the capacitor blocks current flow to the transducer when the switch changes from the conductive to the nonconductive state and causes the capacitor to become charged.

6066

**METHOD OF FORMING A PIEZOELECTRIC ULTRASONIC TRANSDUCER**

N. F. Foster

Patent No. 3,388,022

Commissioner of Patents, Washington, D. C. 20231

A piezoelectric ultrasonic transducer is formed by evaporating a semiconductive material, such as cadmium sulfide, having latent piezoelectric properties onto a heated substrate, where it recrystallizes into piezoelectrically aligned crystals. The resistivity of the layer is raised so it can support a piezoelectric field. Choice of substrate and direction of evaporation controls the primary ultrasonic mode generated.

6072

**ULTRASONIC MEASURING APPARATUS**

C. N. Davey

Patent No. 3,394,585

Commissioner of Patents, Washington, D. C. 20231

A thickness measuring device for immersion testing of workpieces such as tubes. A frequency-modulated signal is transmitted to the workpiece, and reflections from the front and back surfaces are received by a receiving transducer. The mean frequency transmitted is varied until a response null is obtained. The mean frequency at this resonance point is recorded as an indication of thickness.

6073

**SONIC TRANSDUCER**

R. C. McMaster et al

Patent No. 3,368,085

Commissioner of Patents, Washington, D. C. 20231

An ultrasonic transducer combining a piezoelectric driving element and a displacement amplifying horn. This resonant horn structure is excited internally, near the vibrational node rather than at an antinode, as is commonly the case. An arrangement is described which allows the node to be used as the position of mounting of the transducer and for applying external static force.

6074

**ULTRASONIC CABLE INSULATION TESTING APPARATUS AND METHOD**

A. B. Widmer

Patent No. 3,370,226

Commissioner of Patents, Washington, D. C. 20231

A method of testing high voltage cable for insulation defects such as pinholes or voids. A high voltage is applied between the conductor and shield of the cable. This cable is then passed through an inspection zone in which an ultrasonic vibration detector is located. The corona present at an insulation defect produces vibrations which may be detected by the ultrasonic detector.

6078

**NONDESTRUCTIVE TEST METHODS FOR REINFORCED PLASTIC/COMPOSITE MATERIALS**

G. Epstein

Aerospace Corp., El Segundo, Calif.

Aerospace Rept. No. TR-0200 (4250-20)-4

Air Force Rept. No. SAMSO-TR-69-78, 3 February 1969

AD-686 466

A review is presented of various methods for nondestructive testing (NDT) of reinforced plastic/composite materials and structures. Visual inspections, ultrasonic methods, sonic methods, radiography, electrical properties, microwave techniques, thermal techniques, and other NDT methods are examined with regard to their characteristics, instrumentation, utility, and limitations. Recent developments are also discussed.

6079

**NONDESTRUCTIVE INSPECTION OF AN ADVANCED GEOMETRY COMPOSITE BLADE**

R. D. Whealy, A. Intrieri

Boeing Co., Vertol Div., P. O. Box 16858, Philadelphia, Pa. 19142

Presented at Conference on NDT Plastic/Composite Structures, March 1969 Dayton, Ohio

This paper presents Boeing's approach to provide an integrated QA plan for an Advanced Geometry Composite Rotor/Propeller Blade program which includes specific applications that will be used to control quality throughout the fabrication process. Included are: Inspection of Rotor Blade Honeycomb Box assemblies for voids using infrared; Inspection of rotor blades using a semiautomatic X-ray sensitive vidicon/image intensifier system; Inspection of rotor blades for bond quality using a semiautomatic ultrasonic system; and inspection of steel spares using a magnetic perturbation technique.

6081

**NONDESTRUCTIVE TESTING OF ADHESIVE-BONDED JOINTS**

H. M. Gonzalez, C. V. Cagle

Space Technology Laboratories, Redondo Beach, Calif.

ASTM Special Technical Publication No. 360, 1964

Test specimens bonded under the same process and at the same time, destructively tested, cannot provide complete quality assurance. The test specimens can exhibit and guarantee only that bonded assemblies are properly processed, that is, that proper surface preparation and cure treatment were used. The test coupons can, therefore, indicate the adhesive quality of a joint, but not the cohesive quality of the bondline. A nondestructive testing procedure that provides an indication of the cohesive quality of a joint has been studied, developed, and applied to the production-line testing of bonded structures at Hughes Aircraft Co. This paper briefly describes the background for this study, the procedure developed, and the technique used to generate the measurement criteria.

6083

**EVALUATION OF THIN SHEET MATERIALS BY FM LAMB WAVES**

E. Kubiak, I. Kraska  
General American Transportation Corp., Niles, Ill. 60648  
AFML-TR-68-295, September 1968  
AD-845 609

This report discusses the nondestructive evaluation of thin sheet materials using FM Lamb Waves.

6095

**NEW TECHNIQUES IN NONDESTRUCTIVE TESTING BY ACOUSTICAL AND EXO-ELECTRON EMISSION**

R. H. Chambers, S. A. Hoenig  
Engineering Experiment Station, U. of Arizona, Tucson, Arizona 85721  
Semi Annual Progress Report, ARPA Order No. 1244 - 1 July 1968 - 28 February 1969  
AD-691 230

The purpose of the acoustical emission studies was to determine 2 points: (1) the upper range of the frequency spectrum of acoustical emissions and whether it is limited by the rapidly rising attenuation usually associated with rising frequency, (2) the existence of any recognizable peaks or valleys in the acoustical power spectrum indentifiable with a particular mechanism of acoustical emission, for example, with initial microcrack size. The exo-electron emission effect is not clearly understood, therefore the first step was to determine the exact relation, if any, between exo-electron emission and dislocations in metal. The apparatus and experiments are described.

6096

**DEVELOPMENT OF NONDESTRUCTIVE TEST DEVICE FOR EVALUATION OF 3/4 -INCH THICK POLYURETHANE SPRAY-ON FOAM INSULATION (SOFI) ON THE SATURN S-II STAGE**

J. Haynes, H. S. Haralson  
Spaco Inc., 3022 University Dr. NW, Huntsville, Ala. 35805. Work done for  
Marshall Space Flight Center, Ala. Nasa Tech. Memo. Rept. No. 53852, May 1969  
N69-35245

This report describes the technical survey, research development, and applied engineering effort performed to develop a nondestructive test for evaluation of the cryogenic insulation used on the Saturn S-II stage. Several methods of testing were studied but the sonic impedance method was determined to be the most favorable. Since the sonic impedance method was capable of locating defects in the insulation smaller than specifications limitations, it is recommended for inspecting the insulation on the S-II stage liquid hydrogen tanks.

6098

**APPARATUS FOR DETERMINING DYNAMIC MODULUS OF ELASTICITY AND INTERNAL DAMPING CAPACITY**

D. W. James  
Westinghouse Research & Development Center, Pittsburgh, Pa.  
Materials Evaluation, May 1969, p. 102

Investigations of the damping mechanism of metals and alloys require that damping capacity measurements be made over wide stress, frequency and temperature ranges. The apparatus described herein fulfills these requirements in all respects except that it has a limited (low) stress range. This equipment also provides elastic modulus data over corresponding stress, frequency, and temperature ranges.

6099

**ULTRASONIC/RADIOGRAPHIC EXAMINATION OF HEAVY-WALL PRESSURE VESSEL WELDMENTS**

D. E. Center, R. J. Roehrs  
Materials Evaluation, May 1969, p. 107

This paper presents an analysis of ultrasonic and radiographic examinations of heavy wall pressure vessel weldments. Similarities and differences in the two methods are discussed. There has been some reluctance to utilize ultrasonics for the examination of welds; however, this inspection method has continually proven to be valuable for detecting planar type defects such as cracks, lack of fusion, and lack of penetration. Since ultrasonic inspection of welds is not mentioned in Section VIII of the ASME Code, controlled studies have been made to determine the feasibility of using this method as a supplement to present ASME acceptable radiographic procedures, and some results are discussed along with the findings of actual production weld testing.

6102

**ASSURING SATURN QUALITY THROUGH NONDESTRUCTIVE TESTING**

R. W. Neuschaefer  
George C. Marshall Space Flight Center, Huntsville, Ala.  
Materials Evaluation, July 1969, p. 145

The Saturn V space vehicle is briefly described. The organizational responsibilities of NDT groups are discussed as well as the approach to management of research and development activities. Applications of the various nondestructive testing methods employed to evaluate materials and processes used in the manufacture of the various stages and major components are described. Emphasis is placed on a discussion of the special NDT methods and equipment developed to satisfy the unique requirements of the Apollo program. Advancements in the state-of-the-art, including a solid-state, radiographic image amplifier and an RF device suitable for measuring the thickness of nonmetallics on metallic objects, are described.

6106

**USE OF THICK TRANSDUCERS FOR GENERATING SHORT-DURATION STRESS PULSES IN THIN SPECIMENS**

AEC-NASA Tech Brief 69-10045  
Available CFSTI, Springfield, Va.  
See also Journal of the Acoustical Society of America, Vol. 41, No. 2, pp. 336-345,  
February 1967

By using thick transducers to generate short stress pulses, the pulse-echo method for determining sound velocities and acoustic attenuation can be applied to thin specimens. The stress pulses are generated at the faces of a thick transducer and are allowed to enter a specimen where one pulse is reflected several times before a succeeding pulse enters the specimen. This method is described in conjunction with its use in the observation of phase transformations in which both transit-time data and attenuation measurements are used to determine the mechanism and kinetics of the transformation.

6111

**ULTRASONIC PULSE-ECHO METHOD APPLIED TO RADIATION DAMAGED METALS**

R. J. Kolouch

Electronic Material Sciences Laboratory

Electronics Research Directorate

Air Force Cambridge Research Labs., Bedford, Mass. January 1963

The purpose of this investigation is to determine the feasibility and sensitivity of the pulse-echo method of ultrasonics as applied to the detection and interpretation of damage in irradiated solids. This method would be of value in the study of irradiated metals in view of the relatively good correlation between the existing theory and experiments of ultrasonics. The results would prove valuable as another available source of data for theoreticians to consider in their search for satisfactory radiation damage models.

6113

**EXPLORATORY DEVELOPMENT OF NONDESTRUCTIVE TESTING TECHNIQUES FOR DIFFUSION BONDED INTERFACES**

G. Martin, J. F. Moore

North American Rockwell Corp., Los Angeles, Calif.

AFML-TR-68-253, September 1968

AD-843 914

A literature survey describes the current inspection practices employed on diffusion-bonded laminates and the nature of the interface and bond properties. Test specimens of titanium, columbium, and td-nickel were prepared for evaluating various test methods. The specimens provided a range of thicknesses and varying degree of bond quality as determined by mechanical property tests. In addition, a number of diffusion-bonded specimens were supplied by the air force. Conventional ultrasonic techniques and recently developed selective interface inspection techniques clearly indicate bond conditions where these vary from a no-bond condition to substandard bonds. A number of methods show potential correlation between a quantitative expression of bond quality such as shear or tensile strength. These methods include longitudinal and shear wave velocity, ultrasonic attenuation, and vibration analysis.

6114

**ULTRASONIC AND THERMAL STUDIES OF SELECTED PLASTICS, LAMINATED MATERIALS, AND METALS**

J. R. Asay, et al

Air Force Weapons Laboratory, Kirtland, AFB, N. Mex.

AFWL TR-67-91

AD-827 596

Ultrasonic and thermal investigations of several common plastics, nose cone materials, and alloys are presented. The ultrasonic data consist of measurements of the acoustic shear and longitudinal velocities in the frequency range of 1 to 10 MHz and as a function of temperature (to approximately 125C for most of the plastics and to approximately equals 250C for most of the alloys). Some information is presented regarding the dependence of acoustic velocities on uniaxial stress in two aluminum alloys. The temperature dependent ultrasonic data are used to calculate the temperature dependence of the elastic moduli for the materials studied. The thermal analyses describe a differential thermal technique used to study the phase transitions and chemical transformations of the reported materials.

6119

**AN ULTRASONIC CRACK GROWTH MONITOR**

W. G. Clark, L. J. Ceschini  
Westinghouse Research Laboratories, Pittsburgh, Pa.  
Materials Evaluation, August 1969, p. 180

An ultrasonic nondestructive test procedure has been developed to measure and record the extent of crack growth encountered in fatigue and stress corrosion tests involving the Wedge-Opening-Loading fracture toughness specimen. The essence of the technique is to relate the position of an ultrasonic transducer on the specimen surface to the tip of the propagating crack such that crack length can be interpreted in terms of transducer location. The required instrumentation includes commercially available ultrasonic flaw detection equipment and a test fixture designed to permit completely automatic measurement of crack growth. The technique yields a crack length measurement sensitivity of  $\pm 0.010$  in. and provides a continuous record of crack length versus elapsed time which, in turn, can readily be converted into crack growth rate data suitable for use in design.

6121

**STRESS-CORROSION CRACK DETECTION AND CHARACTERIZATION USING ULTRASOUND**

B. L. Weil  
Lockheed-Georgia Co., Marietta, Ga.  
Materials Evaluation, June 1969, p. 135

Described is the development of a nondestructive test technique following the occurrence of a stress-corrosion failure in a ring support structure of 7075-T6. Configuration of the part and concealment of the area of surface tensile stress under a glass-resin structure dictated that a shear wave technique be used to detect and characterize the stress-corrosion cracks. To stimulate discontinuities, machined standards with induced stress-corrosion cracks of various locations, sizes, depth and angles were evaluated. Characterization was finally optimized through development of standards with induced stress-corrosion cracks of various sizes, locations, depths and angles propagated by submitting sections of the part to acidified salt spray while under a residual tensile stress of 80 per cent of the yield stress. Information was correlated using data from both the ultrasonic and metallographic evaluation of these specimens.

6123

**THE DETECTION OF INCIPIENT FAILURE IN BEARINGS**

H. L. Balderston  
The Boeing Co., Seattle, Washington  
Materials Evaluation, June 1969, p. 121  
AD-858 093

Detection of incipient failure, in general, is related to detection of the basic causes of failure. In this paper, defects which lead to failure are created and/or simulated and are detected, utilizing resonant frequency techniques falling in the ultrasonic frequency range. Rotational frequencies of the bearing are calculated and identified as are resonant frequencies. Correlation is shown between RMS amplitude at these frequencies and severity of the defects incorporated. Frequency translation techniques are used to bring within the range of hearing, the ultrasonic resonant frequencies used to detect defects. A tape recording enables the listener to differentiate between various defects which cause failures.

6126

**ULTRASONIC INSPECTION OF THIN-WALL PIPING BY MANUAL METHODS**

J. W. Collier  
NDT Services Corporation, Houston, Texas  
Materials Evaluation, April 1969, p. 73

Utilizing ultrasonic inspection on thin-wall piping presents many problems when the transducer is manually operated. "Drop through" of weld material and excessive weld crown present the largest problems because of the different reflecting surfaces. The narrow contact surface between the search unit and the pipe poses another major problem as does the beam travel the ultrasonic technician has to cope with, due to the thickness of the pipe (.158 or .218 of an inch). These problems were solved through experimentation and applying a few ultrasonic principles that are often overlooked. The results were checked against extensive radiography and destructive analysis.

6128

**USE OF RAYLEIGH WAVES FOR THE DETECTION OF STRESS-CORROSION CRACKING (SCC) IN ALUMINUM ALLOYS**

A. D. Cordellos, R. O. Bell and S. B. Brummer  
Tyco Laboratories, Inc., Waltham, Mass.  
Materials Evaluation, April 1969, p. 85

The attenuation of 4 MHz Rayleigh waves on aluminum alloy 7075-T6 has been studied. The effects of various surface preparations resulting from buffing, artificial defects, galvanic corrosion and stress corrosion have been explored. In all cases, the wave attenuation is greater than on a smooth surface. Attenuation is much higher for a given amount of stress corrosion than for the same amount of pure galvanic corrosion. In addition, reflections from microcracks are found in the former case. These reflections are anisotropic which is useful for distinguishing stress-corrosion damage from other surface defects. These observations and the finding that damage can be detected, at least as early as 18 per cent of the normal stress-corrosion life, suggest that Rayleigh waves can be used to detect indipient stress-corrosion damage in fabricated aluminum alloy parts.

6130

**A CORRELATION OF NONDESTRUCTIVE TESTING WITH DESTRUCTIVE TESTING OF ZIRCALOY-STEEL WELDED JOINTS FOR REACTOR PRESSURE TUBES**

C. Albertini, et al  
Euratom, C.C.R., Ispra, Varese, Italy  
Materials Evaluation, September 1969, p. 185

Coextrusion, swaging and explosion-welded Zircaloy-steel tubes joints were tested with an ultrasonic through-transmission technique which gave a map of welded zones with varying degrees of bonded and unbonded areas. These results were checked with destructive testing (tensile testing and microscopic examination) in order to establish a correlation, if possible. Microscopic examination showed a good agreement with ultrasonic data. On the coextruded and swaged joints, the ultrasonically bonded zones gave values of mechanical strength varying in a wide range due to the presence of intermetallic bonds; on explosive welded joints, constant values of mechanical strength were obtained in good agreement with ultrasonic testing.



6133

**INVESTIGATION OF THE APPLICATION OF COHERENT ACOUSTIC IMAGING TO NDT**

Perkin-Elmer, Optical Group, Norwalk, Conn.

Second Annual Technical Report, Rept. No. 9668, November 1968 thru April 1969

The purpose of this research program is to analyze and perform experimental demonstrations of the application of acoustic holographic and acoustic light diffraction techniques to the detection, analysis, and examination of the internal structure of optically opaque materials. This report has 2 sections: Section I contains a short introduction to acoustic holography; Section II describes the technical goals of the program and the technical progress achieved during the reporting period.

6146

**ULTRASONIC EVALUATION OF ELECTRICAL RESISTANCE SPOT WELDS**

D. I. Crecraft, G. Warner

Non-Destructive Testing, Vol. 2, No. 1, February 1969, p. 40

A method is described for evaluating electrical resistance spot welds that promises many advantages over existing methods in speed, accuracy and in the possibility of automatic control of the welding process.

6159

**AN EXPERIMENTAL ULTRASONIC IMAGE SYSTEM FOR UNDERWATER VISION**

K. G. Robinson

U. S. Naval Postgraduate School, Monterey, Calif.

Thesis, June 1967

AD-821 761

An experimental investigation of acoustic imaging in water is made at an ultrasonic frequency of 455 KHz. Using optical principles, the theory of image formation and resolution are discussed. The range capability of such a system is predicted by the use of underwater acoustic theory. The apparatus consists of a basic imaging system that provides a set of d.c. voltages, proportional to sound intensity at points in the image plane, to be applied to a visual display system. Such a display will present a two dimensional image of an insonified underwater target. This study differs from previous work done in underwater acoustic imaging, in that the image conversion process will lend itself to the application of integrated circuits.

6161

**THE DETERMINATION OF RESIDUAL AUSTENITE IN HARDENED BALL-BEARING STEEL BY MEASUREMENT OF THE VELOCITY OF SOUND WAVES**

M. Fenkner

Physical Laboratory, FAG Kugelfischer, Schweinfurt, Germany

Materials Evaluation, January 1969, p. 11

The propagation velocities of longitudinal and transverse sound waves in hardened roller-bearing steel 100 Cr 6 are measured by the pulse-echo method using a new ultrasonic material tester with a calibrated transit time base. For steel a reproducible relationship between heat treatment and sound velocity is detected which makes it possible to perform a nondestructive test of heat treatment with relatively simple means concerning the internal zones of workpieces. From this results a method to determine the residual austenite in hardened steel by measuring the velocity of longitudinal sound waves.

6163

**THE MAGNETIC TAPE RECORDING OF ULTRASONIC TEST INFORMATION**

R. A. Youshaw, E. L. Criscuolo and C. H. Dyer  
U. S. Naval Ordnance Lab., Silver Spring, Md.  
Materials Evaluation, February 1969, p. 34

This paper describes a method of recording primary ultrasonic test information. A video tape recorder has been converted into a wide band instrumentation recorder. The "A" scan from the ultrasonic tester is directly recorded, together with the operator's voice giving the location, transducer position and interpretation of test data. An oscilloscope is used for the play-back. The circuitry necessary to couple the output of the ultrasonic tester to the tape recorder is described.

6165

**NDT SYSTEMS FOR ESTABLISHING WELD INTEGRITY OF SPACE VEHICLES**

C. W. Musser  
The Boeing Co., Launch Systems Br., New Orleans, La.  
Materials Evaluation, February 1969, p. 42

All welding processes require inspection evaluation to ensure that assembled components have the required design integrity. Large space vehicles such as the Saturn V have thousands of feet of welds which must be evaluated using the latest concepts in radiography and supplementary techniques such as ultrasonics, eddy current and infrared. This paper shows the necessity for custom-designed integrated NDT Systems to ensure reliability of welded assemblies required for space vehicles.

6167

**THE USE OF ACOUSTIC EMISSION AS A WELD QUALITY MONITOR**

W. D. Jolly  
Battelle Memorial Institute, Pacific Northwest Lab., Richland, Wash. 99352  
BNWL-SA-2727, September 1969  
(also "ACOUSTIC EMISSION EXPOSES CRACKS DURING WELDING", W. D. Jolly,  
*Welding Journal*, January 1969).

Acoustic emission monitoring is discussed to provide a general understanding of this technique used as a weld quality monitor. The most important feature of the acoustic emission technique as opposed to other nondestructive testing methods is that the data is real-time; thus, one can more effectively determine the causes of the weld defects. The wide-ranging applications of this technique are illustrated by examples of real-time data from submerged-arc, gas tungsten arc, and spot welding. Acoustic emission can be used to detect defective welds and roughly indicate the extent of the defects; moreover, crack growth can be related to other dynamic conditions of the weld.

6169

**INVESTIGATION OF HOLOGRAPHIC TESTING TECHNIQUES**

E. N. Leith

Willow Run Laboratories, U. of Michigan, Ann Arbor, Mich.

Semiannual Report, 27 November 1968 through 31 May 1969

Rept. 2420-5-P, August 1969

AD-857 061

The first semiannual report of the application of holography to NDT includes studies of interferometric crack detection and transparent-model study, pulsed-laser interferometry and contouring, ultrasonic holography, and modulated reference beam holography. An investigation into the application of hologram interferometry to flaw detection has been initiated, which includes an analysis of fringe location and its manipulation. Experimental work has shown the feasibility of using hologram interferometry to detect various types of flaws in cylindrical steel objects.

6172

**INVESTIGATION OF ULTRASONIC METHODS FOR DETECTING SERVICE-INDUCED CRACKS IN ALUMINUM COMPRESSOR DISCS**

B. E. Leonard

Southwest Research Institute, San Antonio, Texas

Proceedings of the 7th Symp. on NDE of Components and Materials, held 23-25

April 1969, San Antonio, Texas, p. 10

Cracks formed during engine service have been observed near the tenon base region of second-stage T53 aluminum compressor discs which can result in catastrophic engine failures. The limitations of visual and liquid penetrant techniques for detection of such cracks are such that ultrasonic techniques were investigated. Surface waves and longitudinal waves with conventional pulse-echo and pitch-catch techniques were used. A discussion of the ultrasonic approaches used and typical results from systematically inspecting tenons from second-stage T53 compressor discs are presented. A most significant result of this inspection was the detection of a minute crack not detectable by macroscopic or penetrant inspections.

6179

**LOCATING LUMBER DEFECTS BY ULTRASONICS**

K. A. McDonald, R. G. Cox, E. H. Bulgrin

Forest Products Laboratory, Madison, Wisc.

Research Paper FPL 120, October 1969

AD-696 629

An ultrasonic scanning technique showed definite promise in locating lumber defects so they can be recorded in a precise manner. Defect detection is vital in any plan for future automated processing control of lumber. Key to this ultrasonic technique is pulse velocity, recorded as the transit time of the pulse through the piece of lumber being inspected. In this study three methods of analyzing pulse velocity were evaluated to determine their effectiveness in locating defects. Each method showed various abilities to detect different types and degrees of defects. The technique as applied worked particularly well with knots and steep grain. Additional research is needed to check the reliability of this ultrasonic technique and various analyses to cover the wide variation that exists in defects of this type.

6181

**SPECTRUM ANALYZER; STUDY OF TRANSDUCERS**

Raymond M. Willmote, Inc., Washington, D. C.

Report No. 2, 20 January 1955

AD-873 44

This study includes the analysis of techniques for: (a) translating a band of radio waves into a band of ultrasonic waves of requisite intensity in a suitable medium; (b) controlling the path of the ultrasonic waves as a function of frequency, and with adequate frequency resolution and band width, as for example, by diffraction of the waves or by other techniques; (c) rendering visible the paths of the waves; (d) measuring directly the frequency of ultrasonic waves by a device which provides a direct visible indication of the length of the waves; and (e) providing specialized types of ultrasonic displays.

6184

**RESIDUAL STRESS MEASUREMENTS**

NASA Tech Brief 67-10428

Marshall Space Flight Center, Huntsville, Ala.

A newly developed ultrasonic stress analysis technique for detecting residual stresses within a metal. Two piezoelectric crystals are mounted with their axes of vibration at right angles. The crystals generate and receive signals, and a phase comparison reveals changes in velocity. The amount of phase shift between the two signals is then proportional to the average stress difference between the two directions of vibration.

6185

**DEVELOPMENT OF A MANUALLY OPERATED MULTIPLE-TRANSDUCER ULTRASONIC INSTRUMENT FOR INSPECTING PLATES**

E. M. Nusbickel, R. N. Cressman

Homer Res. Labs, Bethlehem Steel Corp., Bethlehem, Pa.

Materials Evaluation, January 1970, p. 1

This paper describes the development of a manually operated multiple-transducer ultrasonic plate-tester. This tester makes it possible to detect internal defects in plate steel in less time than previously possible. In addition, the ultrasonic signal variation caused by variations in the coupling of sound energy to a plate has been reduced by an improved transducer mounting and coupling arrangement, a feature which permits greater confidence in test results. The developmental work from initial concepts through laboratory and mill trials to the present form of the tester is outlined. Described in detail are the design and testing of 1) the electronic instrumentation, 2) the transducers and 3) the ultrasonic coupling. Other possible applications for this instrument are noted.

6189

**A CONTINUOUS WAVE TECHNIQUE FOR THE AUTOMATIC MEASUREMENT OF ULTRASONIC VELOCITY CHANGES**

R. G. Leisure, R. W. Moss

Boeing Scientific Research Labs, Seattle, Wash.

Report D1-82-0827, March 1969

AD-690 580

A technique is described for the automatic measurement of ultrasonic velocity changes in continuous wave experiments. An oscillator is locked to a mechanical resonance of the sample. Velocity changes appear as frequency changes of the oscillator and are easily recorded. Some typical results are given.

6193 **ULTRASONIC DETECTION AND MEASUREMENT OF FATIGUE CRACKS IN NOTCHED SPECIMENS**

S. J. Klima, J. C. Freche  
NASA Lewis Research Center, Cleveland, Ohio  
NASA TN D-4782, September 1968

An ultrasonic technique was developed and used to observe the formation and growth of fatigue cracks in notched cylindrical specimens subjected to reversed axial fatigue loading. Fatigue curves showing cycles to initially detectable cracks as well as cycles to fracture for an aluminum, a titanium, and a cobalt-base alloy and for a maraging steel. Depth of initially detectable cracks ranged between approximately 0.005 and 0.004 in. (0.013 and 0.10 mm). Also obtained were curves relating ultrasonic system output voltage to crack depths up to 0.030 in. (0.76 mm) for three materials. These curves were used to demonstrate the capability of the device for monitoring crack growth.

6194 **ULTRASONIC IMAGING OF INTERNAL STRUCTURE BY BRAGG DIFFRACTION**

J. Landry, J. Powers, G. Wade  
University of California, Santa Barbara, Calif.  
Applied Physics Letters, 15 September 1969, p. 186

Results of experiments are described in which the technique of ultrasonic imaging by Bragg diffraction was used to observe internal detail in an aluminum plate and in a tropical fish. In addition, the extension of the Bragg technique to reflection and dark-field imaging is described.

6196 **DEVELOPMENT OF NONDESTRUCTIVE TESTING TECHNIQUES FOR HONEYCOMB HEAT SHIELDS**

G. Martin, J. F. Moore  
North American Aviation, Inc., Los Angeles, Calif.  
Final Report Vol. I, NA-66-912 15 November 1966, p. 162

This final summary report describes a research program for the development of a portable non-destructive testing and scanning/recording system, using ultrasonic techniques, for the detection of disbonds in composite honeycomb structures by inspection methods operating from one side of the honeycomb.

6198 **FUNDAMENTALS OF HOLOGRAPHIC VELOCIMETRY**

F. M. Shofner, R. Menzel, T. G. Russell  
U. of Tennessee Space Institute, Tullahoma, Tenn.  
AFFDL-TR-68-140, November 1968  
AD-692 477

The purpose of this exploratory research was to establish guidelines for the recording and recovering of three-dimensional velocity information utilizing holographic techniques. The form and resolution of the recorded data have been established experimentally and theoretically for both plane and spherical wave illumination. A theory has been developed for analyzing the Fraunhofer hologram of a single particle in the spatial frequency domain of an optical data processor. General considerations for both electronic and optical data processing of the flow field data are given.

6200

**RESONANT SENSING DEVICE**

N. G. Branson

Patent No. 3,472,063. Available from: Commissioner of Patents, Washington, D. C. 20231

A resonant sensing device for measuring the hardness of a test piece. A piezoelectric transducer with a front and rear mass is caused to vibrate at resonance, driven by a variable frequency oscillator. The frequency of the oscillator is controlled by a sensing circuit which senses the phase angle between transducer current and voltage and acts to reduce this angle to zero. The shift in resonant frequency is an indication of test piece hardness.

6202

**ADJUSTABLE TRANSDUCER MOUNTING**

J. L. Maxwell

Patent No. 3,472,065. Available from Commissioner of Patents, Washington, D. C. 20231

An adjustable mount for an ultrasonic transducer is described in which the pressure waves from the transducer are collimated and used to measure the compressional sound velocity of a test specimen. The transducer is mounted in a water-filled housing having means for collimating the sonic beam. The housing also contains adjustments for parallelism.

6205

**ULTRASONIC GAGING METHOD AND APPARATUS**

H. A. Mitchell et al

Patent No. 3,474,664. Available from: Commissioner of Patents, Washington, D. C. 20231

An ultrasonic gaging system with means for measuring and indicating elapsed time. Important features relate to 1) the use of a tuned circuit to improve accuracy and to discriminate against interference signals, 2) the use of a digital counter to develop the time interval to be measured, and 3) gating circuitry for applying selected signals to the measuring circuit in a manner to improve accuracy.

6206

**SOLID STATE ACOUSTIC IMAGE CONVERTER**

P. S. Green et al

Patent No. 3,475,551. Available from: Commissioner of Patents, Washington, D. C. 20231

A solid state acoustic image converter comprising a thin piezoelectric plate adapted to receive acoustic waves and convert them into an electric potential. Various photoconductive and photoresistive devices are connected to the electric side of the plate. Scanning techniques are utilized to sequentially conduct the electric from elemental regions of the plate.

6210

**BRUSHED-ON PIEZOELECTRIC TRANSDUCERS**

J. G. Martner

Ultrasonics, Vol. 7, October 1969, p. 234-237

Design considerations and operation of vibration-sensitive transducers that are brushed into place are described. These transducers are made of a slurry of crushed piezoelectric ceramic and a liquid binding material that becomes rigid upon exposure to the air. The resulting hard coating is electroded and polarized in place prior to its use as a vibration-detecting transducer. The sensitivities obtained are compared to those of solid piezoelectric materials.

6212 **ULTRASONIC TESTING OF COLD-ROLLED STRIP WITH LAMB WAVES USING THE ECHO METHOD (In German)**

V. P. Holler and H. Smit

Materialprüfung, Vol. 11, October 1969, p. 329-335

The transverse echo method has been examined for different types of waves, probes and probe arrangements. The excitation of Lamb waves and the construction of probes are discussed. It is shown that the detection sensitivity is about 0.1-mm line width when using probes with separated transmitter and receiver. The narrow flaw lines reflect only less than 1 per cent of the incident energy. This slight reflection makes it possible to locate single flaw lines in a varying distance. Different line widths can be distinguished, too, under certain conditions. By means of some examples this method is compared with the transmission method.

6213 **TENSILE DUCTILITY OF STEEL STUDIED WITH ULTRASONICS**

W. F. Chiao

Transactions of the Metallurgical Society of AIME, Vol. 245, April 1969, p. 861-869

With the application of dislocation damping theory, an attempt was made to determine whether the generation and extension of dislocations is inherently more difficult in a brittle steel than in a ductile steel. A ductile steel was compared with a brittle steel by simultaneously measuring the ultrasonic attenuation and velocity during tensile test, and the density of free dislocations and their mean loop length were then calculated as a function of strain.

6216 **ULTRASONIC DETECTION OF INCLUSIONS IN STEEL**

W. W. Bayre, D. D. McCormack

General Motors Corp., New Departure-Hyatt Bearing Div. Sandusky, Ohio  
Materials Evaluation, February 1970, p. 25

Methods of detection of nonmetallic inclusions in steel are discussed, with emphasis on the: (1) shallow stress wave for bearing component inspection. Research applications include detection of potential fatigue nuclei, studying incipient subsurface failure crack growth, and prediction of bearing group life performance, (2) development of ASTM method for "Detection of Inclusions in Bearing Quality Steel by the Ultrasonic Method". Fatigue correlation studies and steel heat inclusion distribution patterns are also discussed. (3) Bi-focal lens, a special focused transducer design which permits optimum concentration of energy for detection of minute discontinuities in cylindrically shaped parts.

6220 **NONDESTRUCTIVE TESTING OF SMALL DIAMETER, STAINLESS STEEL FUEL CLAD TUBING**

J. Ryden

Battelle Memorial Institute, Pacific Northwest Lab. Richland, Wash.

Materials Evaluation March 1970, p. 67. BNWL-SA-2275

This paper discusses the techniques used by the Pacific Northwest Laboratory to inspect FFTF fuel cladding for defects. Descriptions are given of the three different testers used to inspect this tubing. They are a sinusoidal eddy current tester, an ultrasonic pulse-echo tester, and an ultrasonic tester that uses a send-receive system of transducers. Micrographs, strip charts, and statistical data obtained from the inspection of 20,000 feet of tubing are presented.

6221

**ACOUSTIC EMISSION SIGNAL ANALYSIS IN FLAT PLATES**

C. E. Fitch, Jr.

Battelle-Northwest, Richland, Washington 99352

BNWL-1008, April 1966, p. 34

N69-34451

An acoustic emission signal from a deformation or fracture mechanism is assumed to initiate as essentially a point source for detection frequencies in the range of a few megahertz or below. Approximate mathematical expressions for predicting the number of signal reflections and their time separations, and thus total expected signal durations, were derived and studied for flat specimen geometries a 1/2 in. thick A-212-B steel plate was used to determine whether experimental observations could be predicted from approximate relationships derived. Both artificial and real acoustic emission sources were tested under a variety of conditions. A preliminary study of pulse shapes and pulse durations was also conducted in experimental attempts to determine source depth as well as range.

6223

**PRECISE MEASUREMENTS OF ELASTIC CONSTANTS OF COPPER AND SILVER BASE ALLOYS**

L. M. T. Hopkin, H. Pursey and M. F. Markham

National Physical Lab., Teddington (England) Div. of Materials Applications

April 1968 (copyright)

N69-21595

Measurements were made by resonance and pulse ultrasonic methods on the alloys mostly in polycrystalline form but some as single crystals. Corrections were made for slightly preferred orientation which produces large errors. The overall accuracy was about 0.1%. All solutes decreased the moduli with the exception of nickel additions to copper which produced an increase. The changes were linearly related with concentration, with the possible exception of the  $C_{44}$  constant for Cu-Ga alloys, and were associated more with corresponding lattice parameter changes than with electron concentration or ion-ion interactions.

6229

**A LEAD ZIRCONATE TITANATE STRESS TRANSDUCER**

R. E. Hutchinson

Sandia Laboratories, Albuquerque, N. M.

Report SC-DR-69-356, July 1969

This report describes a ferroelectric ceramic unidimensional stress transducer. The output current is shown to be proportional to a time-dependent function of the stress on the front electrode for one wave transit through the ceramic element. Experimental data are presented which verify the transducer response to initiating stress as consistent with the mathematical description. The useful dynamic range extends to approximately 1 kbar in the ceramic. The response is shown to be adequate for detection of microsecond stress time profiles with a sensitivity of 46 volts/kbar across a 50-ohm cable termination. Details are given on the design of a compensating termination which effectively cancels the time-dependent response function to unity.



6230

**ULTRASONIC CHANNEL MEASURING SYSTEM**

A. E. Arave  
Phillips Petroleum Co., Idaho Falls, Idaho  
Rpt. IDO-17290, January 1969  
N69-27215

To measure the ETR and ATR fuel elements in a canal after being removed from a reactor an ultrasonic system was used. It has an accuracy of 0.5 mil, a resolution of 0.1 mil, and a range from 50 to 175 mils. The heart of the system is a probe holding two 8-MHz, 10-mil-thick lead zirconate titanate piezoelectric crystals. Distance between channel walls is obtained by measuring the time for an 8-MHz sound burst to travel between the crystals which are held next to the walls. The signal received by one crystal, transmitted from the other crystal, is used as a trigger for a time-to-analog converter that is connected to the "Y" axis of a recorder. Longitudinal distance in the channel is converted to an analog output to drive the "X" axis of the same recorder.

6237

**ACOUSTIC EMISSION—A NEW TOOL FOR EVALUATING STRUCTURAL SOUNDNESS**

P. H. Hutton  
Pacific Northwest Laboratories, Richland, Washington  
Proceedings of the 7th Symposium on NDE of Components and Materials, held 23-25  
April 1969, San Antonio, Texas

Flaw detection resolution using acoustic emission exceeds that of any of the conventional nondestructive techniques such as ultrasonics, radiography, etc. It is, however, limited to detection of an active strain or flaw area—it will not detect static flaws. This paper discusses development work conducted at Battelle-Northwest to apply acoustic emission to detect flaw growth in nuclear pressure systems. It also deals with applications of acoustic emission to detect formation of cracks in welds, metal fatigue, and use as a surveillance tool in studying pressure vessel fracture modes. Preliminary work on application to graphite is included.

6238

**NON-DESTRUCTIVE TESTING APPLIED TO NUCLEAR VESSEL FABRICATION**

E. S. Proctor, Jr.  
Combustion Engineering, Inc., Chattanooga, Tenn.  
Proceedings of the 7th Symposium on NDE of Components and Materials, held 23-25  
April 1969, San Antonio, Texas

During the fabrication of a nuclear pressure vessel, approximately 2000 nondestructive examinations are performed on materials and/or fabrication processes. These tests include radiography, ultrasonic examination, dye penetrant, magnetic particle, eddy current, and leak detection. The assurance of the component quality depends largely on the adequacy of nondestructive testing equipment and procedures, and the qualification of personnel conducting the examination. The use of timely testing and rigid construction standards has resulted in the reduction of rework costs and delays. This paper discusses the application of the tests, problems, and limitations encountered, and the assurance of the final quality through nondestructive examinations.

6239

**EVALUATION OF DISCONTINUITIES IN HSST TWELVE INCH THICK PLATE**

K. K. Klindt, D. A. Canonico

Oak Ridge National Laboratory, Oak Ridge, Tenn.

Proceedings of the 7th Symposium on NDE of Components and Materials, held 23-25

April 1969, San Antonio, Texas

The Heavy Section Steel Technology Program (HSST) has provided an opportunity to correlate non-destructive testing techniques with a destructive investigation. The HSST program has purchased a number of 12-in.-thick plates of ASTM A533 grade B steel and a major task in the program is the characterization of plate. This provided the opportunity of following the processing of the steel from melting through rolling and final heat treatment. Included in this responsibility was the non-destructive testing of the plates. In mapping out discontinuities, the testing procedure was varied to include the effect of ultrasonic transducer size, testing frequency, and amplifier gain. A map of the percent-back reflection loss was made for each combination of the testing parameters. It was found that the test frequency had the major effect on the size of the area defining the complete loss of back reflection.

6240

**REMOTE ULTRASONIC EXAMINATION OF CLOSURE WELDS ON ISOTOPE CAPSULES**

K. V. Cook

Nondestructive Test Development Group, Metals & Ceramics Div., Oak Ridge National Laboratory, Oak Ridge, Tenn. 37830

Proceedings of the 7th Symposium of NDE of Components and Materials, held 23-25

April, 1969, San Antonio, Texas

The nondestructive evaluation of closure welds on fueled isotope capsules is necessary to assure high integrity and thus prevent the release of toxic radioactive fuels. At the Oak Ridge National Laboratory, we are evaluating closure or seal welds with an ultrasonic pulse-echo technique. This test is performed remotely in a "hot" cell and has been utilized on seven strontium fueled capsules sealed by electron-beam welding. The equipment is discussed along with results of calibration and correlation studies performed before and after "hot" cell evaluation. Discontinuities as small as 0.015 in. in diameter were detected and recorded. Weld penetration can be determined to an accuracy of 0.010 in. from the x-y recordings.

6241

**THE NONDESTRUCTIVE TESTING OF WELDS IN HAYNES-25 IN SNAP-27 ISOTOPIC HEAT SOURCE CAPSULES**

A. G. Barnett, M. I. Gray, P. A. Tucker

Monsanto Research Corporation, Mound Laboratory, Miamisburg, Ohio

Proceedings of the 7th Symposium on NDE of Components and Materials, held 23-25

April, 1969, San Antonio, Texas

Radiography and ultrasonics were performed on the outside closure welds in Haynes-25 in the SNAP-27 isotopic heat sources.  $^{192}\text{Ir}$  was used exclusively in tangential radiography which required sixteen exposures for each capsule covering approximately  $22\frac{1}{2}$  degrees of the specimen per radiograph. The ultrasonics employed a short focused transducer operating at 21 degrees to the radius vector of the cylinder and in a plane perpendicular to the plane containing the weld line. Extensive metallography was performed in the weld development prior to actual capsule welding. One finished capsule was destructively examined during production to correlate suspicious nondestructive indications. The results of these nondestructive methods are discussed and evaluated in terms of the destructive metallography.

6242

**APPLICATION OF ULTRASONIC INSPECTION TO COMPOSITE MATERIALS**

W. E. Garland, P. O. Ritter, J. K. Fee

Missile & Space Division, General Electric Co., Phila, Pa.

Proceedings of the 7th Symposium on NDE of Components and Materials, held 23-25

April, 1969, San Antonio, Texas

An advancement in nondestructive testing was recently demonstrated by the General Electric Company, during test programs conducted at Automation Industries, for USAF/SAMSO. The normal inspection techniques were found to be inaccurate for more than gross condition assessment. This led to a specialized use of ultrasonics for inspection of certain re-entry vehicle heat shields and composite materials. The composite material of interest was carbon-phenolic, bonded with Epon 934 to aluminum 7075-T6 in the form of plates and conical structures. Permanent ultrasonic records were derived, and, from these, the nature of anomalies could be determined. Such anomalies, identified by ultrasonic inspection, have been verified by microscopic examination of suspected areas.

6243

**NDT BY ACOUSTO-OPTICAL IMAGING**

R. Aprahamian and P. G. Bhuta

Applied Mechanics Laboratory, TRW Systems Group, Redondo Beach, Calif.

Materials Evaluation, May 1971, pp 112-116

A new technique, termed acousto-optical imaging, which provides visible images of flaws in optically opaque objects is described. The technique incorporates a device which uses ultrasonic acoustic waves to look inside the optically opaque objects. The ultrasonic waves are made to enter the body to be inspected and upon emergence from the object, interact with light from a laser resulting in a real-time optical image of what the sound waves have "seen". The device has overcome many problems, such as eliminating the use of pick-up transducers, associated with acoustic imaging devices. This paper describes the device, the principle of operation of the technique and presents the results of laboratory experiments which demonstrate the application of the device to nondestructive testing.

6246

**USE OF ACOUSTICAL HOLOGRAPHY FOR THE IMAGING OF SOURCES OR RADIATED ACOUSTIC ENERGY**

D. C. Greene

Pacific Northwest Labs, Battelle Memorial Institute, Richland, Washington

Journal of the Acoustical Society of America, Vol. 46, No. 1 (Part 1), 1969

It is experimentally demonstrated that scanned-receiver acoustical holography is useful for mapping or imaging those parts of a complex vibrator responsible for the energy radiated to the far field.

6247

**ULTRASONIC ELECTRONIC TEST BLOCK\***

H. H. Chaskelis, S. D. Hart  
Naval Research Laboratory, Washington, D. C. 20390  
Technical Memo 283, 12 October 1967

An ultrasonic "electronic test block" has been devised for use in calibrating ultrasonic nondestructive test equipment. This device is akin to a transponder. A device sensitive to ultrasonic waves receives the signal emitted by any ultrasonic equipment. This received signal is then electronically processed and re-emitted in such manner as to appear to be an echo from a standard reference block.

\*See also --

A Materials and Defect Simulator for Calibrating Ultrasonic Equipment Used in Nondestructive Testing or Inspection  
H. Chaskelis  
NRL Report 6984, 5 December 1969  
AD 699149

6249

**NONDESTRUCTIVE TESTING OF ELONGATED PLATES AND CYLINDERS EMPLOYING GUIDED ULTRASONIC WAVES**

L. H. Fentnor\* and L. J. Demer+  
Proceedings of the 7th Symposium on NDE of Components and Materials, held 23-25 April 1969, San Antonio, Texas

The general characteristics of various types of ultrasonic waves, are briefly considered. Lamb waves are then examined in detail and a short review of applications of Lamb waves in materials evaluation is given. The feasibility of employing Lamb wave techniques using guided ultrasonic waves in the defect evaluation of objects of solid cylindrical form is then examined. Results of recent experiments are presented, demonstrating the practicability of employing such guided waves for the continuous testing of objects of extended cylindrical form such as rods, wires, and filaments of both metallic and nonmetallic materials. Attention is drawn to the possibility of perfecting inspection equipment with the ability to detect minute defects, both on the surface and internally, and at high speeds making production testing readily feasible.

\* Hughes Aircraft Company  
+ The University of Arizona, Tucson, Arizona

6256

**ONSTREAM HIGH TEMPERATURE WALL THICKNESS MEASURING STUD**

N. O. Cross  
Esso Research and Engineering Company, Florham Park, New Jersey  
Proceedings of the 7th Symposium on NDE of Components and Materials, held 23-25 April 1969, San Antonio, Texas

A major breakthrough has been realized in overcoming the high temperature limitations for onstream ultrasonic thickness measurement of process equipment. The technique involves the use of an esso patented stud which is welded to the part to be inspected. There appears to be no upper temperature limitations for the technique; however, above 200°F, a simple heat sink is required to reduce the studs to ferritic and austenitic steels. However, use on martensitic alloys will produce a hardened zone in the base metal unless suitable heat treatment is applied. Using the new stud, wall thickness measurements can be conveniently secured under essentially any temperature conditions on operating equipment in the petroleum, chemical, paper, power generation, or in the manufacturing operations.

6257

**REMOTE ULTRASONIC TESTS IN PRESSURE VESSELS OF OPERATING NUCLEAR POWER STATIONS**

R. Gasparini

Ente Nazionale per l'Energia Elettrica, Rome, Italy

Proceedings of the 7th Symposium on NDE of Components and Materials, held 23-25

April 1969, San Antonio, Texas

The inaccessibility of existing reactor pressure vessels from the outside made it necessary for ENEL to design special equipment for periodic remote inspections under water of important areas such as nozzles. The paper describes the equipment using the so-called "immersion method," optimized to detect the presence of cracks starting from the inner surfaces. Information is given on the experience acquired from the inspections performed during refueling shutdowns of two water reactor power stations (BWR and PWR) since 1967. A description is provided of the laboratory tests for calibration of the equipment used for the determination of possible defects and of the interference by crude deposits on the inner surfaces.

6258

**THE STATE-OF-THE-ART OF NONDESTRUCTIVE EVALUATION IN CONCRETE TECHNOLOGY**

S. T. Li

South Dakota School of Mines and Technology, Rapid City, South Dakota 57701

Proceedings of the 7th Symposium on NDE of Components and Materials, held 23-25

April 1969, San Antonio, Texas

Herein are given the state-of-the-art of tests in contemporary concrete technology: mechanical means including spring hammer "Schmidt" spring hammer, pendulum hammer, and indentation; electrical resistance meters; gamma-ray and neutron tests; radiography and covermeter; sonic measurements of the fundamental or resonant frequency of vibration; and pulse methods for measuring the propagation of sound vibrations of ultrasonic frequency. They are first presented as being applied to non-destructive evaluation of concrete and concreting materials. But, finally, applications of some of these nondestructive techniques are extended to other areas of materials technology and geotechnology.

6260

**SOME EXPERIMENTS IN FAST NEUTRON RADIOGRAPHY**

H. Berger

Argonne National Laboratory, Argonne, Ill.

Materials Evaluation, December 1969, p. 245

Accelerators that provide 3-mev and 14-mev neutrons have been investigated as sources for fast-neutron radiography. Detection methods employed include direct film methods with hydrogenous, metallic and scintillator converters; transfer methods, such as copper activation for 14 mev neutrons, and track-etch techniques with both polycarbonate and cellulose nitrate plastics. It was concluded that fast-neutron radiography with these high-energy neutrons may not be generally useful. Promising special radiographic applications of these high-energy neutron generators include the possibilities of inspecting radioactive objects and that of proton radiography.

6268

**AN INVESTIGATION OF ULTRASONIC DATA ANALYSIS USING A MULTICHANNEL ANALYZER OR EQUIVALENT CIRCUITRY**

J. D. Elkins, R. D. Sachs, L. A. Austin  
Union Carbide Corp. Oak Ridge, Y-12 Plant, Oak Ridge, Tenn.  
Document Y-1698, 10 December 1969

A study of simulated weldment flaws by a multichannel pulse height analyzer showed that the flaws assume separate characteristic locations among the 400 memory channels of the analyzer. A digital computer may be used in conjunction with the analyzer to completely process the ultrasonic information.

6271

**ACOUSTIC EMISSION MONITORING SYSTEM FOR DETECTION OF CRACKS IN A COMPLEX STRUCTURE**

General Dynamics Corp., Convair Aerospace Division, Fort Worth, Texas  
Materials Evaluation, January 1971, pp. 8-12

An acoustic emission monitoring system designed to detect, in real time, initiation and growth of cracks in a complex structure during static as well as fatigue testing has been developed. The system consists of arrays of acoustic sensors, logic circuits and output devices. An effective spatial- and frequency-filter combination permits the use of the system in the presence of the heavy background noise ordinarily encountered in the testing of a large, complex structure. The system is being used successfully in static and fatigue testing of full-scale, as well as small-scale specimens of aircraft components and structures.

6272

**ACOUSTIC EMISSION—A TECHNIQUE FOR DETECTION OF CRACKS IN CERAMICS**

D. M. Rombell  
Battelle Memorial Institute, Richland, Wash.  
Presented at the 1970 Spring Conference, ASNT, Los Angeles, Calif.

Acoustic emission is defined as the elastic waves produced in a solid material by energy released as the material is deformed or fractured. These waves can be detected at the material surface using high sensitivity sensors. This provides the basis for a new technique for monitoring flaw growth in solids as it occurs and thus identifying incipient failure. Development of methods for integrity surveillance by acoustic emission detection has been primarily related to metals. Acoustic emission generated by cracking produced in ceramic tubes by thermal shock was found to be readily detectable. Furthermore, it showed that cracking occurred during a different part of the heat cycle than that predicted. Very early crack growth and impending failure were both detected.

6273

**ULTRASONIC REFERENCE STANDARDS: KEY TO RELIABLE ULTRASONIC INSPECTION**

H. Ellerington  
Automation Industries, Inc., Boulder, Colo.  
Presented at the 1970 Spring Conference, ASNT, Los Angeles, Calif.

Ultrasonic inspection procedures are based on the use of reference standards manufactured from carefully selected materials in which calibrated reflectors have been machined. The proper use of reference standards provides uniform inspection criteria that have significant meaning when used to describe inspection results. This paper describes the numerous types of reference standards being used throughout industry today and discusses the importance of standards and some of the precautions relative to their use in ultrasonic inspection processes.

6274

**ASSURING QUALITY IN QUALITY CONTROL EQUIPMENT**

C. W. Wyler

Krautkramer Ultrasonics, Inc., Stratford, Conn.

Presented at the 1970 Spring Conference, ASNT, Los Angeles, Calif.

Whether an ultrasonic flaw detector is used in the field, laboratory or plant, it must function at its maximum efficiency under these conditions. To insure that all ultrasonic flaw detectors and associated accessories, new or used, will perform at maximum efficiency, they must undergo and pass various tests prior to shipment to a customer. This paper describes procedures and tests employed during manufacturing assembly and calibration, including electronic vibration heat and cold checks.

6297

**DIFFERENT ULTRASONIC VISUALIZATION OF IMPACT FRACTURES IN GLASS-REINFORCED PLASTICS**

P. S. Green et al.

Materials Research & Standards, Vol. 9, October 1969, p. 24-25

Ultrasonic transmission images are made of glass-reinforced plastic panels both before and after these panels are subjected to impact in a weight-drop testing device. Impact-produced internal fracture is observed by superimposing the photographic negative of the "after test" ultrasonic image with the positive print of the "before test" image.

6299

**SOME APPLICATIONS OF ULTRASONIC IMAGE STORAGE METHODS**

F. Michalski

Materialprüfung, Vol. 10, 1968, pp. 37-42. Henry Bratcher Translation #7450

Automation of ultrasonic inspection and recording of the results, additionally to the current manual scanning and visual observation of the screen indications. Two-dimensional image ("echo area") method as a special type of recording giving an overall impression of testing operations by photographic or electronic means and thus supplying a document of the findings that is more dependable and concrete in its evidence. A-scope presentation. Examples of interpretation of test results on forgings: Effect of defects and of heat treatment. Two-dimensional image presentation: apparatus and principle. Application to weld defects, artificial and natural. Electronic image storage: apparatus examples. Scope for testing practice. Design of multiple testing installation. Television image: 'X' and longitudinal section presentation.

6304

**ULTRASONIC MEASUREMENT OF WALL THICKNESS VARIATIONS IN ZIRCONIUM CYLINDER**

Automation Industries, Inc., Boulder, Colorado

TR 67-2

A highly accurate ultrasonic thickness measuring method was required for zirconium tubing. A 4½" diameter 0.051" thick wall section was analyzed with the immersion ultrasonic method utilizing a Broadband Pulsar/Receiver, thickness readout and recorder. Results indicate that this material can be measured to an accuracy of .002".

6305

**AN APPARATUS FOR AUTOMATIC ULTRASONIC CHECKING ON THE QUALITY OF WELD SEAMS**

V. C. Davidenko, P. T. Yushchak, V. A. Tsechal  
Technical Translation FSTC-HT-23-464-70, Soviet Patent No. 211857  
AD-700 161

This patent describes an apparatus for the automatic ultrasonic checking of the quality of weld seams; it contains a two-channel flaw detector with search heads, servo system and indicating system. The proposed apparatus differs from others in that the indicator of flaws is a cathode-ray tube with persistent screen afterglow; it is supplied with two magnetic coils for deflecting the electron beam. The coils are placed on a common rotating ferrite core. The ferrite core is connected by a selsyn system to the speed checking transducer and the speed checking transducer is mechanically coupled to a drive mechanism which is used for the longitudinal movement of the tube being checked. As a result, the process of checking the quality of weld seams is simplified.

6306

**IMPROVEMENTS IN PULSE ECHO SYSTEM INTERVAL MEASUREMENTS**

B. B. Chick, C. Elbaum, A. E. Lord  
Brown University, Providence, R. I.  
Final Technical Report, October 1968

Changes in ultrasonic velocity in iron, while the specimen was being charged cathodically with hydrogen were studied near room temperature. These changes are expected to result from stress-induced motion of hydrogen atoms (in solution) between the various interstitial sites in the b.c.c. lattice. A comparison of the results on velocity changes and on embrittlement of the specimens strongly suggests that embrittlement is caused by hydrogen not in solution in the iron. Some modifications in the velocity measurement system particularly in the basic digital timing section have been carried out.

6307

**MEASUREMENT OF PAINT FILM THICKNESS**

J. D. Keane, J. Chiavetta  
Steel Structures Painting Council, 4400 Fifth Ave., Pittsburgh, Pa. 15213  
Interim Report No. 1, 1 August 1969

This is a literature review (through mid-1969) of current methods for measuring paint film thickness on steel. The purpose of this review has been to avoid duplication of work that others have done in the past, and to take full advantage of all pertinent information that can be used to plan the current experimental study on this subject by the Steel Structures Painting Council. The principal subject matter of this review has been field and laboratory methods and instruments in current use for non-destructive measurement of paint thickness on steel, particularly those instruments based upon magnetic principles.



6310

**ELECTRONIC EQUIPMENT AND IMAGE CONVERTER WITH ENLARGED IMAGE FIELD FOR VISUALIZATION OF FAULTS IN MATERIALS**

R. Pohlman, E. Schatzer, H. Licht

Laboratorium Für Ultraschall

European Research Office, Final Technical Report, June 1969

This report has two parts. The first describes an electronic device which enables the application of the pulse-reflex method for the ultrasound image-converting technique. The second part describes the construction and the development of an image converter tube, which, in contrast to tubes formerly built, uses a shell transducer. The method for plating the tube front with a gold layer for vacuum tightness is described.

6315

**AGIS – AN ACCOUSTOGRAPHIC IMAGING SYSTEM**

W. H. Sproat and S. E. Cohen

Lockheed Georgia Company, Marietta, Georgia

Materials Evaluation, April 1970, p. 73

This paper describes the design and operation of an image converter which employs a liquid crystal detection screen to provide a color display of ultrasonic wave information. The technique is based on the utilization of incident acoustic energy resulting in a response which is detected by cholestric liquid crystals. A description of a prototype unit, called the Acoustographic Imaging System (AGIS), is presented with data on operating parameters and potential uses in nondestructive testing and underwater imaging.

6323

**ULTRASONIC HOLOGRAPHIC IMAGING IN SOLIDS**

J. L. Kreuzer

Perkin-Elmer Corp., Norwalk, Conn.

Technical Report AMMRC CR69-05(F), 30 September 1969

AD-695 674

This report describes a basic investigation of the ultrasonic holographic imaging of the interior of solids immersed in water. Ultrasonic holograms were recorded from coherently pulsed 5-megahertz ultrasonic radiation in a horizontal plane over the specimen by point-wise mapping in a TV-like raster with a modified X-Y recorder. The ultrasonic holograms are recorded as a photographic transparency. When suitably illuminated, the hologram produces a visible three dimensional image. Several holograms and satisfactory holographic images of 1-mm-diameter holes in aluminum specimens were made. A hole in cast iron could not be holographically imaged because of ultrasonic scatter by the cast iron. Basic properties of these holographic images and the techniques used to produce them are described.

6325

**ULTRASONIC MONITORING OF INITIAL FATIGUE CRACK PROPAGATION**

P. Reti

Translation from *Gep (Machinery)*, No. 9, 1967

FTD-HT-23-780-68, Translated 4 October 1968

AD-849 953

Defects of up-to-date machinery are most frequently due to material fatigue. Ultrasonic flaw detection seems to be most suitable for initial fatigue cracks. The paper contains the author's recent reference to standards, were successfully applied to assessing the degree of fatigue cracking caused by repeated loads. Mathematical relationships were determined between the surface crack referred to by the defect signal, the crack propagation rate, and the increase in the amplitude. Orig. art. has: 9 figures.

6327

**NONDESTRUCTIVE DETERMINATION OF NONELECTRONIC PART RELIABILITY**

H. G. Tobin, et al

IIT Research Institute, 10 W. 35th Street, Chicago, Ill.

Final Technical Report RADC-TR-69-209, October 1969

AD-861 821

An investigation of the state of the art of the application of nondestructive testing to the task of reliability screening and/or life estimation was carried out. Both the literature and industry were surveyed to allow an assessment of the feasibility of carrying out the screening or estimation tasks. Components studied included motors, bearings, relays, switches, solenoids, and gear trains. The study found that NDT methods are well advanced. However, insufficient information concerning the failure modes of the components studied limits the applicability of these methods to the screening or estimation process. The two components for which significant information is available are relays and bearings. Suggested methods by which reliability screening or life estimation can be accomplished are described.

6331

**AUTOMATED ULTRASONIC NONDESTRUCTIVE TESTING SYSTEM**

R. C. Maxson

Oak Ridge Y-12 Plant, Oak Ridge, Tenn.

Y-1693, 5 November 1969

A small, general-purpose computer was used to automate an ultrasonic inspection machine designed to evaluate the internal integrity of flat plates and right circular cylinders. Application of the computer extended the capabilities of the basic system to include inspection of free-form surfaces of revolution. The automated system controls the positioning of the ultrasonic probe to maintain the probe perpendicular to and at a constant distance from the part surface. Using the front surface echo as the feedback control parameter, the desired tracking was achieved. Development of the automatic control system has greatly increased the versatility of the inspection device.

6332

**AN ULTRASONIC METHOD FOR TESTING THE ADHESION OF PLASTIC COATINGS ON PROPELLENT CHARGES**

J. Dickson, D. Young  
Rocket Propulsion Establishment, Westcott  
Technical Memorandum 485, December 1968  
AD-705 395

An ultrasonic immersion technique has been developed to inspect the bond between the plastic coating and the propellant charge of a solid propellant rocket motor. Some correlation between acoustic measurements and the peel strength of the bond has been found. Although more work must be done to gain some understanding of the mechanisms involved. The technique is best applied to materials having similar acoustic impedances.

6333

**NONDESTRUCTIVE EVALUATION OF METAL FATIGUE**

F. N. Kusenberger, et al  
Southwest Research Institute, San Antonio, Texas  
Final Report AFOSR 70-1206TR, March 1970  
AD-705 653

Attention is called to the significance of localized defects in the development of fatigue damage in metals of engineering interest. Recent studies, conducted both in air and in vacuo using NDE have established the influence of surface and near-surface inclusions on crack initiation in AISI 4340 steel. Accompanying metallurgical investigations indicate that bonding at inclusion-metal matrix interface is crucial to crack initiation and is followed in order of importance by inclusion size and depth below the specimen surface. The relationship and significance of ultrasonic and magnetic perturbation non-destructive evaluation results in terms of fatigue crack development are discussed. An earlier analytical treatment of the growth of surface fatigue microcracks is extended to describe the configuration of the propagating crack, and an approximate analysis has been initiated to ascertain the extent of plastic yielding expected in the neighborhood of a hemispherical cavity.

6334

**INVESTIGATION OF NONDESTRUCTIVE TEST METHODS FOR METALLIZED TANK ENGINE CYLINDERS**

I. R. Kraska, E. J. Kubiak  
General American Transportation Corp., Niles, Ill.  
Work done for ATAC under Contract DAAE07-67-c-1990, May 1968

In reconditioning tank engines, worn cylinders are flame sprayed with .010 in. thick molybdenum to bring the cylinder back to its original dimensions to permit use of pistons and rings of the original size. This reconditioning method generally works quite well but occasionally reconditioned cylinders have failed in operation. This program was initiated to (1) study in detail the flame spraying process to determine the nature of the steel-to-molybdenum bond and the molybdenum itself, (2) determine, if possible, the actual flaw producing mechanism, (3) investigate various NDT methods with the purpose of developing a method of detecting flaws and determining the integrity of the flame-sprayed coating.

6343

**INCREASING THE APPLICATION EFFECTIVENESS OF NORMAL AND TRANSVERSE ULTRASONIC WAVES IN THE INSPECTION OF TUBE JOINTS**

B. V. Kostynkov

The Soviet Journal of Nondestructive Testing, No. 3, May-June 1969, p. 253-258

An experimental unit used in the development of a method of applying Lamb and transverse waves is described. The possibility of determining the type and number of the Lamb wave without constructing its dispersion curve is shown. A method of increasing the effectiveness of the application of transverse and Lamb waves is introduced for quality control of tube joints.

6344

**PRACTICAL APPLICATIONS OF THE OPTICAL-HETERODYNE ULTRASONIC IMAGE-CONVERTER**

G. A. Massey

Ultrasonics, Vol. 8, January 1970, p. 16-18

Recent developments in electro-optics enable the construction of a sensitive optical device to serve as a scannable ultrasonic transducer. With a suitable display, this technique can provide high resolution, real time conversion of acoustic amplitude patterns into visible images. In this article the operation of the device is described briefly, and a number of applications, such as medical diagnosis and flaw detection, are pointed out.

6347

**DETECTION OF INCLUSIONS IN BEARING QUALITY STEEL BY THE ULTRASONIC METHOD**

Prepared by ASTM Committee E-4, Subcommittee IX, Ultrasonic Task Group  
Materials Research & Standards, September 1969, pp. 21-23, 72

The procedure described is for the detection of nonmetallic inclusions in rectangular steel sections by immersed ultrasonics. Purpose is to provide information on the inclusion content of steel which may supplement other methods in determining the suitability of a steel lot for certain applications. This method in no manner defines or establishes limits of acceptability.

6352

**A MATERIALS AND DEFECT SIMULATOR FOR CALIBRATING ULTRASONIC EQUIPMENT USED IN NONDESTRUCTIVE TESTING OR INSPECTION**

H. H. Chaskelis

Oceans Technology Div., Naval Research Laboratory  
NRL Report 6984, December 5, 1969  
AD-699 149

An ultrasonic Electronic Test Block (ETB) has been devised for use in calibrating ultrasonic non-destructive tests and equipment. The ETB is similar to a transponder. A device sensitive to ultrasonic waves receives the acoustic signal emitted by any ultrasonic equipment. This received signal is then electronically processed and re-emitted in such a manner as to appear to be an echo, as from a standard reference block. Both vertical and horizontal linearity on the cathode-ray-tube screen as well as resolution can be determined at the testing site rather than in the laboratory as is presently necessary with standard reference blocks.

6360

**DETERMINATION OF MICROSCALE ROUGHNESS OF CYLINDRICAL SURFACES USING ULTRASONIC CREEPING WAVES**

H. S. Hayre and G. Vroulis

University of Houston, Houston, Texas 77004

TR-69-7, March 1969

AD-707 286

The circumferential waves or creeping waves propagate in both media separated by a rough interface in an alternating fashion, and are reviewed from a theoretical point of view; the associated velocity of propagation dependence on the interface surface roughness is shown to be reasonably valid for micro-scale roughness determination. Experimental results are also included to support theory, and certain empirical relationships are derived as an example of the application of this technique.

6361

**THE APPLICATION OF NDT TECHNIQUES TO THE PROBLEM OF STRESS CORROSION CRACKING**

R. S. Sharpe

NDT Centre, A.E.R.E., Harwell, U.K.

In: AGARD Conf., Proc. No. 53. Symposium on the Engineering Practice to Avoid Stress Corrosion Cracking, Istanbul, 30 September-1 October 1969. Paper 10, pp. 1-11

AD-701 789

This paper examines the areas where improved nondestructive testing methods could assist in determining the susceptibility of components to stress corrosion supporting laboratory investigations into the mechanism of stress corrosion and monitoring the progression of cracking during the service life of components to replace the present practice of extrapolating from laboratory simulation tests. Emphasis is directed towards methods of residual stress measurement which seem closest to a practical test to replace the destructive stress relaxation methods currently used.

6364

**THE DEVELOPMENT OF NONDESTRUCTIVE METHODS FOR THE QUANTITATIVE EVALUATION OF ADVANCED REINFORCED PLASTIC COMPOSITES**

A. W. Schultz

Avco Systems Division, Lowell, Mass. 01851

AFML-TR-70-20, August 1970

AD-875 229

Described first in this report are the materials, their composition and the techniques used to fabricate them, and their resultant characteristics. Discussed then is a summary of findings involving problems associated with the use of carbon/carbon composites in aerospace systems. Described next are the procedures used to nondestructively evaluate the composites and the results obtained. Destructive mechanical, chemical, and photomicrographic tests and their results are described. A particular NDT technique called the "Interval Velocity Technique has been studied in some detail and described herein.

6370

**SOLID STATE RADIOGRAPHIC IMAGE AMPLIFIERS**

Z. Szepesi

Westinghouse Electric Corp., Electronic Tube Div., Elmira, N. Y.

NASA CR-61328, Final Report November 1969

This report describes the second part (Part B) of the program for the development of solid state radiographic amplifiers. The developed solid state image amplifiers are intended as equivalent or improved replacements for fluoroscopic screens and x-ray films used in radiographic evaluations of space vehicle components and structures. Amplifiers developed show high contrast sensitivity closely approaching the 2% of thickness definition of MIL-STD-453 for 0.25" thick aluminum plate. 2 T radiography was not obtained. (ie. to detect 2 T holes on 2% penetrameters).

6372

**EFFECTS OF VARYING DEGREES OF POROSITY IN WELDS ON ULTRASONIC PULSE ECHO INDICATIONS**

S. G. N. Swamy, et al.

Central Mechanical Engineering Reserach Institute, Durgapur, India

No. A18 - October 1968

N69-24314

Experimental observations on the effect of varying degrees of porosity in steel butt welds on ultrasonic pulse echo indications are reported. An attempt has been made to analyze and interpret the results in terms of equivalent radiographic standards of the International Institute of Welding. Results are illustrated by actual echo patterns. Good correlation has been established with radiographic and macrostructure studies.

6373

**NONDESTRUCTIVE INSPECTION NUCLEAR POWER PRESSURE BOUNDARIES**

A. R. Whiting

Southwest Research Institute, San Antonio, Texas, April 1969

Seventh Symposium on NDE, San Antonio, Texas, April 1969

This paper discusses design changes of, and the application of nondestructive inspection methods and equipment to determine the initial and continued integrity of nuclear power pressure boundaries. Techniques used to obtain pre-service "fingerprint" data and the data acquisition instrumentation necessary to correlate this information with subsequent in-service inspection are reviewed.

6376

**CRITICAL ANGLE ULTRASONIC TECHNIQUE FOR DETECTING HYDRIDES IN ZIRCALOY**

H. J. Willard, Jr.

Bettis Atomic Power Laboratory, Pittsburgh, Pa.

WAPD-TM-833, October 1969. Avail: NTJS

A feasibility study of a critical angle ultrasonic technique for detecting hydrides in zircaloy. In this technique, a focused ultrasonic beam is incident on the surface of the specimen at the Rayleigh critical angle. The amplitude distribution of the reflected beam is very sensitive to the density and elastic properties of the specimens, both of which are altered by the presence of hydrides. For this work the sensitivity of the technique was 600 ppm and appeared to be limited by the surface preparation of the sample.

6377

**DEVELOPMENT OF DEVICES AND TECHNIQUES FOR THE NONDESTRUCTIVE DETERMINATION OF RESIDUAL MACHINING STRESS UTILIZING ULTRASONIC AND SUPPORTING X-RAY TECHNIQUES**

W. E. Lawrie  
Tracor, Inc., Rockville, Md.  
AFML-TR-69-323 - February 1970  
AD-866 641

Residual surface stresses induced in 4340 steel by grinding have been accurately measured on flat specimens using an ultrasonic technique and correlated by x-ray diffraction. The basis of the technique is that ultrasonic velocity is strain dependent. Rayleigh waves were selected as the principal mode of propagation since their penetration depth can be made comparable to the stressed layer thickness. Glass wedge transducers, with y-cut quartz, plates, were designed and fabricated. Both pulse and continuous wave techniques are used for velocity measurement giving accuracies equivalent to 4000 psi. A Laser Rayleigh wave Detector has been designed for frequencies up to 40 MHz.

6378

**ULTRASONIC NONDESTRUCTIVE MEASUREMENT OF IRRADIATION DAMAGE IN STEEL**

D. O. Hunter  
Battelle Memorial Inst., Pacific Northwest Lab., Richland, Washington (1968)  
BNWL-SA-2207

The primary objective of the work described herein were to investigate the feasibility of ultrasonic methods for measuring radiation damage as manifested by embrittlement in low alloy steels and loss of ductility in austenitic steels. A secondary objective was to demonstrate a supplementary tool by which irradiation damage and recovery kinetics can be studied in the laboratory. It appears apparent that ultrasonic methods are useful laboratory tools in the study of radiation damage and recovery for polycrystalline alloys.

6382

**ULTRASONIC REFLECTIVITY OF CORRODED SURFACES**

F. R. Rollins, Jr.  
Midwest Research Institute, Kansas City, Mo. 1969  
Technical Report No. 4 to ONR  
AD-701 930

Useful information about the physical properties of solid surfaces can often be obtained from a simple study of ultrasonics reflectivity versus angle of incidence. This paper briefly describes a reflection technique which facilitates rapid examination of metal surfaces and discusses application of the technique to the study of corrosion. Results from several types of oxidized and corroded surfaces are presented and interpreted in terms of the physical properties of substrate and corrosion products.

6388

**DEVELOPMENT OF THE ULTRASONIC DELTA TECHNIQUE FOR ALUMINUM WELDS AND MATERIALS**

K. J. Hannah, et al.  
Automation Industries, Boulder, Colorado  
NASA CR-61952, May 1968  
N-69 14207

The Delta Technique is a unique, multi-crystal inspection method that is relatively insensitive to defect orientation. Internal weld defects including lack of penetration and lack of fusion were readily detected when using this technique. The method is capable of rapid scanning while providing a simultaneous and permanent record of test results. Both Delta wheel and the manual Delta probe are described.

6392

**NONDESTRUCTIVE EXAMINATION OF WELDS**

RONTGEN Technische Dienst N.V. Project Euratom  
EURAE C 1859, April 1967

Aspects of nondestructive testing of welds in steel thicknesses up to 300mm were investigated. Radiography (with the use of x-rays produced by Megavolt apparatuses and radiation of Cobalt 60) and ultrasonic testing were used in the investigation for the ultrasonic test, the only techniques used were pulse techniques involving the application of echo-sounding methods with one or more scanners.

6393

**AUTOMATIC ROTARY PROBE SYSTEM FOR THE ULTRASONIC INSPECTION OF STEEL TUBE**

R. Lewis, A. R. Cornforth  
British Steel Corp, Corby, Northamptonshire, U.K.  
Nondestructive Testing, Vol. 3, No. 2, April 1970, pp. 128-131

Manual systems for tube inspection are unable to keep pace with high-speed manufacturing processes, and only provide an imprecise test. A range of high speed rotating ultrasonic probe systems and static probe assemblies has been developed for automatic quality control and acceptance testing of tubes. These systems afford automatic inspection of tubes in the diameter range 0.5-44 in. (12.7mm-1.118m), seamless or welded tubes, at inspection speeds up to 200 ft/min (60.96m/min). The systems incorporate several novel features in the ultrasonic and electronic design. One system is described in detail.

6394

**INSPECTION OF GREY IRON CASTINGS BY ULTRASONIC ATTENUATION**

H. J. Meyer  
Nondestructive Testing, Vol. 3, No. 2, April 1970, pp. 99-104

Ultrasonic pulses of definite frequency and wavelength undergo a varying degree of scatter depending upon the size and quantity of graphite flakes in grey cast iron. The amount of sound energy left after a sound beam has passed a given cross-section provides, therefore, a measure of the structure and content of the graphite and consequently, the physical strength of the cross-section.



6395

**SIGNIFICANCE OF A DETECTION OF DEFECTS IN RAILS**

P. C. Johnson, S. Wise  
Railway Technical Centre, London Road, Wilmorton, Derby, U. K.  
Nondestructive Testing, Vol. 3, No. 2, April 1970, pp. 111-116

The article describes the principal types of defects which may be found in rails, and indicates those which are inherent in the manufacturing processes and those which arise as a result of service loads. The principles of resonance and pulse-echo ultrasonic flaw detection as applied to rails are given, and the current ultrasonic testing practice at British Rail is described.

6398

**PROBLEMS ASSOCIATED WITH ULTRASONIC REFERENCE DEFECTS**

R. Frielinghaus, et al  
Dr. J. U. H. Krautkramer, Gesellschaft fur Elektrophysik, Cologne, Federal  
Republic of Germany  
Nondestructive Testing, Vol. 3, No. 2, April 1970, pp. 125-127

When inspecting tubes and bars by obliquely incident transverse waves, rectangular grooves are usually used as reference defects. The echo amplitude from rectangular grooves and natural cracks in relation to the defect depth has been measured. For depths below two sound wavelengths the echo height is no longer proportional to the depth. This effect is less pronounced with natural flaws. Reasons for this phenomenon are explained.

6401

**INVESTIGATION OF THE APPLICATION OF COHERENT ACOUSTIC IMAGING TO  
NONDESTRUCTIVE TESTING**

W. R. Arndt, J. L. Kreuzer  
The Perkin-Elmer Corp., Optical Group-Research, Norwalk, Conn. 06897  
Tech. Report AMMRC CR 70-14, April 1970

The purpose of this research program is to analyze and perform experimental demonstrations of the application of ultrasonic holographic and ultrasonic light diffraction techniques to the detection, analysis, and examination of the internal structure of optically opaque materials. During the period covered by this report, the electronic circuits for the ultrasonic camera were redesigned and the new hardware fabricated and tested. The revised system, described in detail in this report, has the inherent flexibility, improved stability and enhanced performance to permit the accurate generation of ultrasonic holograms. An elementary theory of the ultrasonic diffraction microscope is outlined in the report and some preliminary supporting experiments are described.

6402

**ACOUSTIC ANALYSIS TESTING OF BODY ARMOR, AIRCREWMAN**

J. L. Davidson  
Frankford Arsenal, Phila., Pa. 19137  
FCDEL-5-69, March 1970

An acoustic analysis study to determine the feasibility of segregating cracked ceramic armor from serviceable armor. This report describes the procedure employed, analysis of recorded data, results obtained, conclusions drawn and recommendations.

6406

**NONDESTRUCTIVE TESTING TECHNIQUES FOR TITANIUM BILLETS**

F. J. Sattler  
TRW Inc., Cleveland, Ohio  
AFML-TR-68-345, March 1969  
AD-852 176

Large diameter billets were fabricated as ultrasonic test standards for evaluation of several ultrasonic techniques. Standard radiographic penetrameters were used for evaluating betatron radiographic procedures. Billet sizes were 5, 10, and 17 inch diameter. Limitations of ultrasonic tests were traced to grain structure variations within the billets and beam spread in the water coupling media.

6421

**ULTRASONIC INSPECTION OF WELDS WITH MORE THAN 500 MM SIZE**

J. Prepechal  
Skoda Concern, Nuclear Power Plants Div, Information Cen. Plzen, Czechoslovakia  
Report ZJE 51 (CFSTI)

Welds of more than 500 mm in thickness are found in pressure vessels of nuclear reactors, in parts of large hydraulic presses and other equipment. The importance of optimum methods of ultrasonic inspection is stressed by the fact that ultrasonics is the only nondestructive test method available for weld inspection in this thickness range.

6422

**ELECTRONIC SIGNAL PROCESSING TECHNIQUES – PHASE II – NONDESTRUCTIVE TESTING**

J. C. Kennedy, W. E. Woodmansee  
The Boeing Co., Seattle, Washington  
Advanced Research Projects Agency – May 1970

Phaselock detection was used in the performance of through transmission eddy current thickness measurements. Applications to chemical milling and in-motion thickness measurements were demonstrated. Phase lock detection and signal averaging were used to measure resistance and induction changes in conventional eddy current coils during a scanning operation. An application to aluminum brazed titanium honeycomb was examined. Signal averaging was used to enhance flaw indications in the ultrasonic inspection of election beam welds.

6423

**ULTRASONIC TEST PROCEDURE FOR RATING INTERNAL CLEANLINESS OF SEMI-FINISHED MATERIAL**

C. J. Carter, et al  
International Harvester Co., Mfg. Research, Chicago, Ill.  
Report No. AMMRC CR 69-11, June 1969  
AD-670 939

An investigation was conducted to evaluate and standardize upon various ultrasonic instruments and operational parameters which may alter inspectional response in the detection of nonmetallic inclusions and cleanliness rating of semi-finished material. Recommendations are presented with regard to specimen preparation, instrumentation requirements, search unit specifications, system calibration, inspection procedure and data processing. Correlative studies carried out to ascertain the relationship between ultrasonic inspection findings and conventional inspection results indicated that magnetic particle inclusion severity rating was lineally related to ultrasonic severity rating.

6424

**EFFECT OF INCLUSIONS AS MEASURED BY ULTRASONIC METHOD ON THE MECHANICAL PROPERTIES OF AIRCRAFT QUALITY STEEL**

C. J. Carter, et al.

International Harvester Co., Chicago, Ill.

WPAFB Technical Rpt. AFML-TR-68-303, January 1969

AD-853 178

Representative five inch round cornered square billets of 4340 steel (280 ksi grade) produced by various steel manufacturing practices, were inspected ultrasonically for nonmetallic inclusion content and cleanliness. An inclusion severity index was derived from this inspection and correlated with mechanical properties of the billets. Ultimate tensile strength was not affected by variations in inclusion size; ductility was significantly decreased with inclusion severity.

6428

**AN ACOUSTICAL BENCH FOR AN ULTRASONIC PULSE SYSTEM**

\*R. E. Thill, \*J. R. McWilliams, \*T. R. Bur

\*Bureau of Mines, Minneapolis, Minn.

\*\*Bureau of Mines, Washington, D. C.

Bureau of Mines Rpt. of Investigations No. 7164

The ultrasonic pulse measurement system described measures velocities of longitudinal (compression) and shear waves in rock to give values that can be used with density values to determine the dynamic elastic constants of rock. Special features of the acoustical bench are its highly versatile transducer cartridges, a pneumatic ram coupling device, an orientation mechanism, and a vacuum chuck sample holder.

6434

**ULTRASONIC BUBBLER DELTA SYSTEM**

C. G. Cullers

General Dynamics, Fort Worth Division. Rpt. No. FMR 67-1425B, December 1967

This report describes the development of an automatic bubbler ultrasonic system using the delta technique. Photographs and drawings help explain the delta technique. A bubbler head assembly to house the delta is discussed, and data from transducer evaluation and recordings made from test specimens using the delta ultrasonic technique are included. Specifications for an automatic system to be used for inspecting welds in the F-111 wing pivot support fitting have been given to tool engineering, and design is in progress.

6435

**TUBE WELD INSPECTION**

K. W. Hammer

General Dynamics, Fort Worth Division. Final Rpt. FMR 67-1425A, December 1967

Tube weld inspection was initiated to develop a portable ultrasonic system to check tube welds efficiently and accurately. Several testing methods used during the investigation included visual, borescopic, radiographic, ultrasonic, and metallurgical. Synthetic flaws of known magnitude were produced in test specimens by drilling and electrical discharge machining. Problems relating to reference standards, transducer alignment, 60-cycle power, and rotating connectors are discussed. Test results showed the ultrasonic delta technique capable of detecting much smaller flaws than normal radiographic techniques.

6436

**ULTRASONIC INSPECTION TECHNIQUES OF WELDING**

D. G. Cosgrove, et al

General Dynamics, Fort Worth Division. Final Rpt. No. FMR 56-1029B, December 1965

Data is presented to demonstrate why the interpretation of an ultrasonic evaluation is so difficult. The importance of the transducer, heat-treat state, and operator training are evaluated. The type of flaws that can and cannot be detected are reviewed and compared to the findings of x-ray inspection. Consideration is given to the production and employment of ultrasonic standards.

6441

**UNDERWATER NDT SHOWS ITS PAGES**

B.I.X. Ltd., Wimpey Base, South Denes Rd, Great Yarmouth, Norfolk, U.K.

Nondestructive Testing, Vol. 3, No. 5 (October 1970), pp. 325, 327.

B.I.X. Ltd. maintains a policy of training qualified ndt personnel to dive and to operate underwater—rather than following the practice of using trained divers who have been put through a crash course on ndt. The article describes B.I.X. Ltd. underwater techniques of radiographic, ultrasonic, and fluorescent particle ndt testing—as utilized on North Sea projects.

6442

**PIEZOELECTRIC TRANSDUCER**

D. A. Berlincourt

Gould Inc., Cleveland, Ohio

Electro-Technology — January 1970, p. 33

Piezoelectric materials in common use as electromechanical transducers are presented in this article along with some specific applications. Materials discussed include ammonium dihydrogen phosphate (ADP), CdS, ZnO, LiNbO<sub>3</sub>, Ba<sub>0.4</sub>Na<sub>0.2</sub>NbO<sub>3</sub>, and lithium sulphate crystals, several variances of lead zirconate-lead titanite (PZT) ceramics and a few other ceramic compositions.

6444

**AN INVESTIGATION OF FATIGUE BEHAVIOR OF REINFORCED PLASTICS FOR PRIMARY AIRCRAFT STRUCTURES**

P. N. Rao, K. E. Hofer, Jr.

Illinois Institute of Tech., Research Institute (IITRI). Rpt. D6002.

Naval Air Systems Command Contract, Final Report July 1969

AD-861 490

Investigation of damage and fracture in different composites under tension fatigue stress cycling. The information is a vital link in the understanding of the relationship between fracture toughness and fatigue life. The studies were residual strength determination, ultrasonic inspection, and scanning electron microscope examination.

6447

**NEUTRON RADIOGRAPHY**

P. W. Hesse

U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md.

Rpt. NOLTR 70-6, 15 January 1970

AD-709 548

Thermal neutron output from a moderated 14 MeV D-T reaction is discussed as applicable to neutron radiography. Detectors for radiography are evaluated and the results using the thermal beam of the Neutron Diffraction Facility at the National Bureau of Standards for the detection of low atomic materials contained in high atomic number materials are presented.

6449

**INTEGRATION OF ULTRASONIC BOND SIGNALS**

N. B. Edenborough

University of California, Los Alamos Scientific Lab., Los Alamos, N. Mexico

Rpt. LA-DC-9383, October 1968

Presented at 28th National Conference of ASNT, Detroit, Mich., October 1968. AEC Contract.

A circuit is described which integrates the ultrasonic signal from a bonded joint. This circuit is capable of measuring the percent of bond over any size area. Used in the circuit is a voltage-to-frequency converter which converts the analog gate signal to a frequency and a pulse counter. The number of pulses received over a length of scan is a function of the percent of bond.

6450

**THE EFFECTS OF VOIDS ON THE MECHANICAL PROPERTIES OF HIGH MODULUS GRAPHITE FIBER/EPOXY-REINFORCED COMPOSITES**

A. W. Schultz

Avco Government Products Group, Allied Technology Div, Wilmington, Mass. 01887

Rpt. AVATD-0153-69-RR. August 1969. U.S. Naval Air Systems Command Contract

AD-860 190

Described first in this report are the materials, the techniques used to introduce void levels into them, and their resultant characteristics. Described next are the procedures used to nondestructively evaluate the composites and the results and use of this evaluation to guide in the selection of locations of destructive test specimens. Destructive/nondestructive correlations for mechanical properties and void contents are described in detail.

6451

**ACOUSTIC IMAGING IN A TURBID UNDERWATER ENVIRONMENT**

P. S. Green, et al.

Lockheed Palo Alto Research Lab. Palo Alto, Calif. 94304

Journal of the Acoustical Society of America, Vol. 44, No. 6, December 68, pp. 1719-1730.

AD-687 635

Theoretical and experimental studies are presented concerning underwater acoustic imaging in general with particular emphasis on acoustic visualization in highly turbid water. A method of underwater acoustic imaging conversion is described which involves a sampled matrix of piezoelectric elements.

6454

**ADVANCED NONDESTRUCTIVE TESTING TECHNIQUES FOR TITANIUM BILLETS AND INGOTS**

I. M. Matay, F. J. Sattler  
TRW, Inc., Cleveland, Ohio  
Tech. Report AFML-TR-70-118, August 1970  
AD-875 597

The object of this program was to provide an improved inspection capability for small defects in titanium alloy billets and ingots. Emphasis was placed on improvements in the ultrasonic testing techniques for billets, and radiographic techniques for both ingot and billets. Main effort was devoted to improving the signal-to-noise ratio over those presently obtainable. Linear accelerator radiographic techniques were evaluated for billets and ingots up to 20 inches in diameter.

6455

**THE DETERMINATION OF THE MECHANICAL PROPERTIES OF METAL MATRIX COMPOSITES BY NONDESTRUCTIVE METHODS**

G. Martin, J. F. Moore  
North American Rockwell Corp. International Airport, Los Angeles, Calif. 90009  
AFML-TR-69-296 (Final tech. rpt. for period 1 June 68-30 September 1969), July 1970  
AD-874 529

This report is a technical summary of a 15-month study into the application of nondestructive test (NDT) methods to determine the mechanical properties of metal matrix composites. On the basis of a thorough evaluation of six representative sheet panels of unidirectional B-A1 composites, it was concluded that routine test methods comprising x-ray radiography and ultrasonic c-scans and a specially developed vibration test method correlate defect indications with each other and generally with metallographic tests, but no correlation between these results and mechanical properties could be established.

6456-A

**A GUIDE FOR ULTRASONIC TESTING AND EVALUATION OF WELD FLAWS**

R. A. Youshaw  
U. S. Naval Ordnance Lab. White Oaks, Silver Spring, Md.  
Final Rpt. SSC-213, 1970, Ships Structure Committee  
AD-713 202

This document presents procedures and acceptance limits for contact ultrasonic inspection of steel butt welds in thickness range of 1/4 to 2 inches. The acceptance limits described in the report are compatible with those set forth in SSC-177, "Guide for Interpretation of Nondestructive Tests of Welds in Ship Hull Structures" for radiographic inspection, and should therefore result in satisfactory ship welds. (This document is Appendix A of document 6456-B.)

6456-B      **DEVELOPMENT OF AN ULTRASONIC GUIDE FOR THE INSPECTION OF BUTT WELDS IN COMMERCIAL SHIPS**  
R. A. Youshaw  
U. S. Naval Ordnance Lab. White Oaks, Silver Spring, Md.  
NOLTR-70-85, 1 May 1970.  
AD-709 918

This report documents the technical considerations involved in preparing a guide for ultrasonic inspection of butt welds in commercial ships. Appendix A of this document is the ultrasonic guide; it is published separately as AD-713 202 (6456-A).

6457      **INVESTIGATIONS OF ELASTIC PROPERTIES OF SOME PLASTICS AT HIGH PRESSURES BY THE ULTRASONIC PULSE METHOD**  
M. P. Volarovich, Ye. I. Bayuk  
State Scientific Research Institute, Moscow.  
Translation FTD-MT-24-72-70. Foreign Technology Div, A.F. Systems Command.  
7 August 1970  
AD-711 761

Measurements were made of longitudinal and lateral elastic waves in specimens of plexiglass, polyfluoroethylene resin, textolite and AG-4S and RN-1 glass reinforced plastics at pressures up to 4000 kg/cm<sup>2</sup> employing a pulse ultrasonic method developed for the study of the elastic properties of rock.

6460      **MECHANICAL BEHAVIOR OF CONCRETE EXAMINED BY ULTRASONIC MEASUREMENTS**  
S. P. Shah, S. Chandra  
University of Illinois, Chicago, Ill. 60680  
Journal of Materials, September 1970, pp. 550-563

The velocity and attenuation of ultrasonic pulses transmitted across concrete and paste specimens subjected to various mechanical loads were measured and compared with surface strains and internal microcracking. Increasing the resonant frequency of the piezoelectric crystals increased the pulse velocity and the sensitivity of the measurements to crack growth.

6461      **AUTOMATIC MEASUREMENT OF ULTRASONIC VELOCITY CHANGES**  
J. G. Parks  
Army Tank-Automotive Command, Warren, Mich. 48090  
Review of Scientific Instruments, Vol. 41, No. 11, (November 1970), pp. 1595-1598

A technique is described for the automatic measurement of velocity changes of one part in 10<sup>5</sup> in continuous wave experiments. An oscillator is frequency modulated by an analog circuit which terminates frequency change when a mechanical resonance is achieved in an ultrasonic interferometer. Velocity changes appear as changes in terminal frequencies of the oscillator and are easily recorded.

6463

**THE EARLY DETECTION OF FATIGUE DAMAGE**

G. Martin, S. Tsang  
North American Rockwell Corp. Los Angeles, Calif.  
Rpt. AFML-TR-70-124, May 1970  
AD-872 139

The fatigue process of 1100-0 aluminum was studied by means of exoelectron emission and ultrasonic surface wave measurements, and correlated with metallographic examination. Measurements of exoelectrons was accomplished by emission counts, amplified by a Channeltron electron multiplier and integrated over short time intervals. Preliminary ultrasonic surface wave measurements disclose a change in material response at about 50 percent of the fatigue life, which so far could not be correlated with metallographic observations.

6467

**CURRENT PROBLEMS IN PREVENTION OF FATIGUE**

H. J. Grover, A. A. Mittenbergs  
Defense Metals Information Center, Battelle Memorial Inst., Columbus, Ohio 43201  
DMIC Report S-25, June 1968  
AD-842 706

Current fatigue problems are discussed, including poor quality control of materials, effects of fatigue on behavior of residual stresses due to mechanical working, and of various heat treatments. A discussion of methods for predicting and preventing fatigue damage leads into an extensive discussion of nondestructive test methods for determining fatigue damage. The many gaps in information on fatigue and the needs for future research are pointed out. An extensive bibliography is included.

6468

**ELASTIC MODULI AND ULTRASOUND VELOCITIES OF TUNGSTEN AS A FUNCTION OF TEMPERATURE**

R. G. Peterson  
Argonne National Laboratory, Argonne, Ill. 60439  
Report No. ANL-7272, December 1967

The results of a preliminary study of the elastic moduli and the ultrasound velocities of tungsten are given. The data were obtained by an ultrasonic pulse-echo method.

6469

**NDT OF NUCLEAR REACTOR FUEL ELEMENTS**

W. Thompson  
U.K.A.E.A., Salwick, Preston, Lancs.  
British Journal of Nondestructive Testing, Vol. 11, No. 1, March 1969, p. 12-18

Most of the component parts of fuel elements are inspected by nondestructive techniques at one or more stages in their manufacture and the completed fuel elements are rigorously examined. This article describes the various nondestructive tests that are utilized at the U.K.A.E.A. facility for inspection of the fuel elements.



6488

**SCHLIEREN TECHNIQUES FOR NDT**

A. S. Greer, B. T. Cross  
Automation Industries Inc., Boulder, Colorado 80302  
Nondestructive Testing, Vol. 3, #3, June 1970. pp. 169-172

The purpose of this paper is to define the theory involved in Schlieren imaging techniques and to discuss the application of these techniques in the field of NDT. Emphasis is placed on the use of the Schlieren technique as: (1) an educational aid in ultrasonic training programs; (2) an inspection tool for material evaluation; and (3) an analytical and development tool for studies of complex wave patterns.

6499

**IMPROVEMENT IN ULTRASONIC VELOCITY MEASUREMENT TECHNIQUES**

B. B. Chick et al  
Brown University, Providence, R. I. 02912  
Final Technical Report, October 1967  
Naval Air Systems Command Contract  
AD-663 534

A pulsed echo ultrasonic velocity measurement system with the design objective of resolving changes of time of  $10^{-11}$  seconds has been developed and is described herein.

6503

**INCLUSIONS IN HIGH-STRENGTH STEELS – THEIR DEPENDANCE ON PROCESSING VARIABLES AND THEIR EFFECT ON ENGINEERING PROPERTIES**

J. J. Hauser, M. G. H. Wells  
Crucible Steel Corp. Pittsburgh, Pa.  
AFML-TR-68-222, August 1968  
AD-842 819

An ultrasonic inclusion detection system was improved and data obtained by this method and a quantitative television scanning system revealed a correlation between inclusion indications, and reduction of area, impact and fracture toughness in 4340 steel. Careful correlation of inclusion parameters with mechanical properties and ultrasonic indications is necessary for meaningful non-destructive testing of billets.

6505

**ULTRASONIC TESTING OF STRUCTURAL WELDS**

D. A. Olsson  
Bethlehem Steel Corp., Bethlehem, Pa.  
Presented at First Annual Symposium on the Nondestructive Testing of Welds, I.I.T.R.I.  
February 1966.

A brief article covering the subject matter. Included is a discussion of equipment, transducers, couplants and techniques utilized.

6507

**THE EARLY DETECTION OF FATIGUE DAMAGE**

J. F. Moore, et al

North American Rockwell, Los Angeles, Calif.

3rd Semiannual Report – 1 June 1970–30 November 1970. NA-70-640 (ARPA Program 1244)

A continuing effort to develop nondestructive test methods capable of determining the extent of fatigue damage and providing a means of predicting the future safe life of aerospace materials and structures. The fatigue process in 1100-0 aluminum was studied during this reporting period utilizing exoelectron emission and acoustic emission measurements.

6509

**SIGNATURE ANALYSIS – A MATERIALS RELIABILITY TESTING TECHNIQUE**

R. B. Socky

General Electric Co., New York, N. Y.

Signature analysis has been defined to be any nondestructive test that utilizes characteristic signals to determine levels of performance and/or degradation of performance. The determination is accomplished by comparing the signature of a test specimen to a standardized reference signature that is characteristic of "good" performance. This paper demonstrates how the signature analysis concept provides a new measure of materials reliability leading to new, higher levels of product reliability.

6510

**A REVIEW OF THE TECHNIQUES USING ULTRASONIC WAVES FOR THE MEASUREMENT OF STRESS WITHIN MATERIALS**

B. J. Ratcliffe

RARDE, Fort Halstead, Kent, U.K.

British Journal of Nondestructive Testing, Vol. II, No. 3, September 1969

The various processes used to date for measuring stresses within materials have their individual limitations with respect to the information they can provide. The determination of stress using ultrasonics is possible because of the phenomenon known as acoustoelasticity. This paper is a survey of the extent to which work has progressed using this effect during the last decade.

6513

**STUDY OF THE GENERAL MECHANISM OF STRESS CORROSION OF ALUMINUM ALLOYS AND DEVELOPMENT OF TECHNIQUES FOR ITS DETECTION**

S. B. Brummer, et al

Tyco Laboratories, Waltham, Mass.

Contract NAS 8-20297. Seventh Quarterly Report, May 1 to August 31, 1968.

N69-14261

This investigation examines the mechanism of the stress corrosion cracking of Al alloys and the feasibility of using instrumental methods to detect stress corrosion cracking on fabricated Al alloy parts. This project aims to determine the range of detectability of stress corrosion damage and to specify components and procedures for an on-field instrument. The experimental technique involved attenuation of surface ultrasonic Rayleigh waves.

6514

**ABSTRACTS OF NDT TECHNICAL REPORTS**

Automation Industries, Inc. Boulder, Colo.  
Information Sheet 57-302, May 1970

A compilation of approximately 30 abstracts pertaining to ultrasonic and thermal nondestructive testing.

6515

**SOUND BEAM DIRECTIVITY: A FREQUENCY DEPENDENT VARIABLE**

B. T. Cross  
Automation Industries, Boulder, Colo.  
TR 70-23, 8 April 1970

This report covers continuation in the study of high frequency sound beam propagation. The information in this text concerns the frequency dependence observed in ultrasonic test results. These findings are significant in the respect that an accurate prediction can be made for a given ultrasonic inspection by considering the frequency range of its operation. These findings give insight into the reasons why two different instruments can give noncorrelating test data at the same apparent frequency.

6520

**A HIGH FREQUENCY ULTRASONIC TESTER FOR BOND INSPECTION OF THIN-CLAD REACTOR FUELS**

T. J. Davis  
Battelle Memorial Institute, Pacific Northwest Lab., Richland, Washington  
Materials Evaluation, (December 1970) Vol. XXVIII, No. 12, pp. 257-261

This paper describes an ultrasonic testing system which has usable bandwidth of 0-60 MHz. Operation of the tester with 30 MHz ceramic transducers has greatly extended the capabilities of a clad-to-uranium bond test for nuclear reactor fuel elements. Results achieved with this tester are presented along with a description of the high frequency circuitry employed.

6523

**DEVELOPMENT OF AN ULTRASONIC METHOD FOR DETERMINATION OF GRAIN SIZE IN CAST STEEL**

G. DiGiacomo, et al  
Formerly with Naval Applied Science Lab., Brooklyn, N. Y.  
Materials Evaluation, (December 1970) Vol. XXVIII, No. 12, pp. 271-276

The work reported herein was undertaken to determine the relationship between ultrasonic scattering and ferrite grain size and use it to evaluate nondestructively important mechanical properties of the steel. Results show the scattered energy increases as the grain size decreases within the range tested. The technique is reported capable of distinguishing grain sizes one ASTM number apart in this steel (cast carbon steel plate).

6530

**ICE ENGINEERING RESEARCH – ICE THICKNESS MEASURING DEVICE  
FOR WATER-BORNE ICE**

W. M. Malsukado

U. S. Naval Civil Eng. Lab., Port Hueneme, Calif.

NCEL-TN-655, November 1964

AD-453 176

The need for a simple device to accurately measure the thickness of water-borne ice has grown in importance. The following methods were reviewed: (1) gravitational, (2) Seismic, (3) radioactivity, (4) electrical resistance, (5) electrical capacitance, (6) electrical inductance, (7) pulsed radar, and (8) ultrasonics. Ultrasonic resonance and the pulsed methods were considered the most promising. An accuracy of plus or minus 10 percent may be expected.

6532

**ULTRASONIC INSPECTION OF WELDS IN NUCLEAR REACTOR PRESSURE VESSELS**  
(Newly Developed Equipment for Automatic Scanning & Recording of Butt Welds)

A. deSterke

Roentgen Technische Dienst N.V., Rotterdam, Netherlands.

British Journal of NDT, December 1970, p. 114

In this article the author states the case for ultrasonic inspection over radiography for steel welds in reactor vessels. He states that since ultrasonic testing requires no radiation protection facilities and because ultrasonic tests can be conducted right in the boiler shop, that for a fraction of the cost invested in a high energy radiation facility, one could have a respectable ultrasonic test installation. He further states that it is possible to obtain possibly more information on the possible presence of two-dimensional type of defects in the weld such as lack-of-fusion and cracks.

6540

**ULTRASONIC DETECTION OF DEFECTS IN WOOD**

D. M. Makow

National Research Council, Ottawa, Ontario, Canada

Nondestructive Testing – Research & Practice, Vol. 2, #3, August 1969, pp. 197-199

Pulsed ultrasound with water coupling has been used to detect knots, rot, shakes and pitch in samples of wood. This paper discusses the characteristic echo patterns which are obtained. The technique may find use in the lumber and wood industries.

6542

**FLAW SIZE EVALUATION IN IMMERSSED ULTRASONIC TESTING**

J. D. Hislop

Rolls Royce Ltd, Aero Engine Div, Derby, England

Nondestructive Testing Vol. 2, #3, August 1969, pp. 183-192

The factors which affect the evaluation of flaw size by echo amplitude measurements are discussed and fundamental weaknesses in the flat-bottomed hole test block system are outlined. The need for knowledge of operating frequency is stressed and the consequent corrections required are explained. Finally scanning methods rather than amplitude measurements are proposed as offering a way of eliminating most of the uncertainties in flaw size evaluation.

6543

**STRESS-WAVE EMISSION IN NDT**

A. A. Pollock  
12 Cedar House, Marloes Road, London W8, England  
Nondestructive Testing – Vol. 2, #3, August 1969, pp. 178-182

A brief state-of-the-art paper on stress wave emission. The author believes that this technique is one of the most promising new techniques of nondestructive testing. It is currently in use in the aerospace and nuclear industries for monitoring the growth of cracks and flaws in pressure vessels. It is particularly useful for locating flaws which may be tens of feet from the detecting transducer. Failure strength prediction and metal condition diagnosis can be carried out by use of acoustic emission.

6546

**NONDESTRUCTIVE TEST TECHNIQUE DEVELOPMENT BASED ON THE QUANTITATIVE PREDICTION OF BOND ADHESIVE STRENGTH**

J. R. Zurbrick  
Avco Systems Div. Wilmington, Mass. 01887  
Naval Air Engineering Center Contract, ARPA Order No. 1247; July 69 to July 70.  
AVSD-0331-70-RR  
AD-717 663

A second annual report and continuation of the first years study aimed at the development of NDT techniques for characterizing metallic substrate surfaces. Exo-electron emission, ultrasonic gas-phase transmission, and electric field reflectometry techniques were also evaluated in continuing feasibility studies.

6548

**THE EARLY DETECTION OF FATIGUE CRACKING**

I. G. Scott  
Department of Supply, Aeronautical Research Labs. Melbourne, Australia  
Metallurgy Note 62, February 1969.  
N69-38944

Methods suitable for the detection of fatigue cracking are described and discussed. It is concluded that although the sensitivities of existing methods are probably adequate, more knowledge about the fatigue process is needed before positive identification of early fatigue cracking becomes possible.

6549

**ULTRASONIC COUPLING LOSSES**

W. L. Ghering  
Pennsylvania State Univ. Ordnance Research Lab., University Park, Pa.  
Naval Ordnance Systems Command Contract, November 1967  
AD-683 304

Coupling losses must be considered in ultrasonic measurements of small specimens of high Q materials. In these measurements, the energy loss in the bonding material is often of the same magnitude or larger than the loss in the specimen. This study is an investigation of the characteristics of coupling losses.

6550

**NONDESTRUCTIVE SURFACE STRESS MEASUREMENTS**

F. A. Hiersch

Consultant, Sherman Oaks, Calif.

Test Engineering and Management, August 1969 p. 15

Residual stress, or stress due to steady or to oscillating loads, may be measured with the aid of the basic ultrasonic technique described in this article. Ultrasonic velocity of surface wave propagation in the stressed (circumferential) direction is obtained and compared to a standard velocity measured in an unstressed sample of the same material.

6552

**THE CHOICE OF OPTIMUM SOURCE-TO-FILM DISTANCE IN RADIOGRAPHY**

R. Halmshaw

RARDE, Fort Halstead, Seven Oaks, Kent, U.K.

British Journal of Nondestructive Testing, Vol. II, No. 3, September 1969

Experiments to determine the optimum distance from the focus of an x-ray tube to the film, with special reference to the radiography of specimens containing narrow cracks, are described. It is proposed that the minimum source-film distance can be determined from the relationship: Geometric Unsharpness = film unsharpness. Appropriate values of film unsharpness are detailed.

6554

**ELECTRONIC SIGNAL PROCESSING TECHNIQUES; NONDESTRUCTIVE TESTING (Phase II)**

J. C. Kennedy and W. E. Woodmansee

The Boeing Co., Seattle, Washington. Boeing Company Rpt. D180-10589-1

ARPA Program. Annual Report, 30 October 1969 to 29 October 1970. November, 1970, Phase II. AD-716 803

Signal averaging was used to enhance flaw indications in the ultrasonic inspection of electron beam welds. An electronic gate synchronized to the transducer motion through the use of an electrically controllable delay was also used to enhance flaw indications. To aid in electrical signal processing a technique for recording ultrasonic video information on a low-frequency tape recorder was developed. Applications to chemical milling and in-motion thickness measurements were demonstrated.

6555

**ULTRASONIC TESTING OF HOT WELDS**

F. A. Silber and C. Ganglbauer

VOEST, Linz/Donau, Austria.

Nondestructive Testing, Vol. 3, No. 6, (Dec. 1970), pp. 429-432

This article explores the possibility of ultrasonic testing at high temperatures. The design of special probes, the choice of suitable coupling media and the effect of temperature on the response of the flaw detector are discussed. It has been established that, in practice, examination can be satisfactorily performed at temperatures up to 200°C.

6558

**SIGNIFICANT VARIABLES IN CHECKING THE PERFORMANCE OF ULTRASONIC INSPECTION SYSTEMS FOR STEEL**

J. B. Morgan and H. M. Johnson

Allegheny Ludlum Steel Corp., Research Center, Brackenridge, Pa.  
Materials Evaluation, September 1967, pp. 206-213

A procedure which can readily be performed by the operator has developed for checking the performance of an ultrasonic inspection system. Variables encountered include couplant, cable and reference blocks. The need for checking the performance of ultrasonic equipment is stressed. Of equal importance the work shows the urgent need for standardization.

6561

**NONDESTRUCTIVE TESTING OF HIGH-PRESSURE GAS PIPELINES**

R. F. Lumb

Gas Council Engineering Research Station, Killingworth, Newcastle upon Tyne, England  
Nondestructive Testing, Vol. 2, #4 (November 1969), pp. 259-268

A comprehensive and detailed assessment of the use of NDT in the manufacture of high-pressure gas pipelines is given. A similar report of the NDT techniques applicable to the inspection of high-pressure pipeline girth welds is also presented. These two major aspects of pipeline NDT are subdivided respectively into (1) the different types of manufactured pipe and the NDT techniques available for their examination and (2) the various NDT methods used in the inspection of pipeline girth welds.

6565

**EVALUATION OF A RESIN MATRIX COMPOSITE SUBJECTED TO IMPULSIVE LOADING**

J. E. Zimmer, J. S. Evangelides

McDonnell Douglas Corp., 3000 Ocean Park Blvd. Santa Monica, Calif.  
MDAC-WD 62990

To assess the extent of material change within resin matrix composites after impulsive loading, pre- and post-test nondestructive analysis and mechanical testing were performed on multidirectionally reinforced (DACLOCK120) quartzphenolic composite specimens. Analysis of the test data showed that the acoustic velocity decreased, the attenuation increased, and the compressive strength and modulus decreased due to plate-slap testing.

6569

**NONDESTRUCTIVE TEST EVALUATES DUCTILE IRON FATIGUE LIFE**

M. W. Devers and W. B. Larson

Central Foundry Div., General Motors Corp.  
Foundry, August 1969, pp. 135-136

An ultrasonic velocity test applied to a ductile iron casting is related to the characteristics of the graphite phase and can be correlated with the mechanical properties of the material in the casting. One of the properties that can be correlated with the ultrasonic velocity is fatigue life.

6570

**ULTRASONIC MEASUREMENT OF WALL THICKNESS VARIATIONS IN ZIRCONIUM CYLINDER**

G. J. Posakony

Automation Industries, Boulder, Colorado, TR 67-2

The objective of this test was to provide an accurate measurement of the variations in the wall thickness in a sample zirconium cylinder with a nominal wall thickness of 0.051" in which variations to the order of 0.0005" could be detected. The zirconium cylinder selected for the test measured 4.5" in diameter by 11" long by 0.051" wall thickness. The test results were not limited to this size or shape of part.

6572

**HOT-GAS MEASUREMENTS WITH ULTRASONICS**

L. C. Lynnworth, et al

Panametrics Inc. Waltham, Mass.

Reprint, Space/Aeronautics, September 1967

In ultrasonics measurement of hot-gas properties, either a foreign sensor is introduced into the gas or the gas itself is used as the sensor. For the former technique, the temperature ceiling is about 5000°F; with the latter, temperatures of 30,000°F and more can be handled. In either case, one measures sound velocity and/or sound attenuation and derives the desired gas properties from the measured data.

6574

**THE PROPAGATION OF HIGH AMPLITUDE SOUND WAVES**

E. A. Hiedemann

Michigan State University, East Lansing, Mich.

ONR Contract, Tech Report No. 15, October 1965

AD-626 017

This report consists of reprint of papers published between July 1964 and December 1965 by the staff and graduate students supported by the U. S. Naval Research Office Acoustics Program.

6577

**DEVELOPMENT OF NONDESTRUCTIVE TESTS FOR PREDICTING ELASTIC PROPERTIES AND COMPONENT VOLUME FRACTIONS IN REINFORCED PLASTIC COMPOSITE MATERIALS**

J. R. Zurbrugg

AVCO Gov't Products Group, Wilmington, Mass. 01887

WPAFB Contract AFML-TR-68-233, February 1969.

AD-851 939

The primary goal in developing nondestructive test methods and techniques for evaluating reinforced plastics is the establishment of a thorough knowledge of the important material-energy interactions which occur in the composite system of interest. From this work has come the firm ability to predict elastic properties and laminate volumetric composition. Closed-loop fabrication process control, and in-service inspection for damage and aging is a further advantage of nondestructive testing.



6582

**AN ULTRASONIC NONDESTRUCTIVE TESTER**

J. C. Roubik  
General Electric Co. St. Petersburg, Florida 33733  
U. S. AEC Contract. GEPP-80, March 1970

This report describes ultrasonic, nondestructive testing methods for the evaluation of raw stock and manufactured items. A semi-automatic test system is used to perform the evaluation. The system includes an X-Y-Z axis manipulator, X-Y data potentiometers, a combination 1000-Hz transducer pulser and 60 MHz bandwidth electronic pulse receiver-detector, a 5 gallon immersion tank, and a set of profiling balls. The system has the capability of detecting flaws of smaller size in thinner material and closer to the front surface than commercially available systems.

6584

**ACOUSTIC EMISSION TESTING AND MICROFRACTURE PROCESSES**

A. S. Tetelman  
University of California, School of Eng. & Applied Sc. Los Angeles, Calif.  
UCLA Paper, Eng.-0370, October 1970.  
Contract DAH-04-68-C-008 (US Army Rsch Office).

This report briefly describes areas where acoustic emission testing has assisted or could assist materials scientists who are investigating microfracture processes in solids. The report concentrates entirely on application.

6589

**ULTRASONIC MEASUREMENT OF CRACK DEPTH IN THICK-WALLED CYLINDERS**

J. J. Miller  
Watervliet Arsenal, Watervliet, N. Y.  
Report No. WVT-7017, February 1970.  
AD-707 760

A program to study the propagation of cracks required a nondestructive inspection technique to locate cracks and measure their depth at frequent intervals during testing. An evaluation of the sensitivity of detection and accuracy of measurement of cracks is presented. Scanning the outside diameter of the cylinder with an ultrasonic normal-probe produces a response that can be readily interpreted in terms of crack depth, location, length and orientation. The method has also been successfully applied in the inspection of cannon tubes.

6593

**THE QUANTITATIVE SIGNIFICANCE OF NONDESTRUCTIVE EVALUATION OF GRAPHITE AND CERAMIC MATERIALS**

J. W. Orner  
Avco Corp., Lowell, Mass.  
WPAFB Report AFML-TR-70-205, October 1970  
AD-879 710

The objective of this program was to utilize the nondestructive testing (NDT) information, correlations, and techniques developed during previous years for the formulation of an experimental approach for verifying the quantitative significance of nondestructive evaluation of graphite and high temperature ceramic materials intended for aerospace structures and systems. Nondestructive evaluation was carried out on a series of billets of hot pressed diboride compositions of zirconium and hafnium.

6597

**DEVELOPMENT OF A LOW FREQUENCY ULTRASONIC INSPECTION SYSTEM FOR THE M-149 WATER TANK**

E. J. Kubiak

General American Transportation Corp., Niles, Ill.

USATAC Contract, Report Date: December 1967. Contract DAAE07-67-C-3614.

The purpose of this program was to determine the feasibility of low frequency ultrasonic testing techniques for detecting voids and debonds in the M-149 water tank. Extensive testing with pulse-echo and pitch-catch showed both methods to be unfeasible for this application, due to high rate of attenuation of the structure and the long ringing time of the transducers.

6605

**INVESTIGATION OF THE PROPERTIES OF CARBON CARBON COMPOSITES AND THEIR RELATIONSHIP TO NONDESTRUCTIVE TEST MEASUREMENTS (Part 1)**

J. S. Evangelides, R. A. Meyer

McDonnell Douglas Astronautics Co.-West, Santa Monica, Calif. 90406

Technical Report AFML-TR-70-213, January 1971, 279 Pages

AD-881 239

Ultrasonic longitudinal velocity and through transmission attenuation have been found to provide a successful means of monitoring the material uniformity and variability (type of defect introduced in carbon-carbon composites). By modifying the ultrasonic attenuation method with the use of a collimated receiver, the limit of defect detectability of this technique was increased. X-ray radiography was applied and the information contained in the X-ray radiographs was related to the defects present in the composite. Neutron radiography results were not as good as those with X-ray radiography. It was concluded that monitoring material uniformities and detecting discrete discontinuities in unidirectional and multidirectional carbon-carbon composites on an in-process basis can be successfully accomplished.

6607

**IMPROVED TECHNIQUES FOR THE NON-DESTRUCTIVE TESTING OF DIESEL ENGINE PISTONS**

W. W. Watson

Naval Civil Engineering Laboratory, Port Hueneme, Calif.

Technical Note N-1130, October 1970

AD-715 619

Repeated and catastrophic piston failures in a group of large diesel engines revealed the urgent need for the development of a fast, reliable means for the detection of incipient failures in these engines. A technique was developed utilizing commercial ultrasonic instrumentation of the pulse-echo type. The procedure, as finalized, will unfailingly detect cracks in the major webs of the diesel engine pistons and requires only the removal of the cylinder head for access to the piston top. The only major constraints in the application of this technique are the requirements that: (1) the piston material be homogeneous, (2) detailed information relating to piston configuration be available, and (3) the diagnosis be made by technical personnel experienced in ultrasonic interpretation.

6613

**A CORRELATION BETWEEN PULSE-ECHO ULTRASONIC ATTENUATION AND HARDNESS**

K. Reifsnider, S. I. Sawyer

Virginia Polytechnic Inst. and State University, Blacksburg, Va.

Report VPI-E-70-23, December 1970; Work Sponsored by U.S. Army OCRD

AD-717 099

Nondestructive evaluation and characterization of materials, especially in terms of parameters critical to modern design and fabrication, is a problem of growing magnitude. One example is the inability of any present NDT technique to definitely establish the yield strength of a fabricated section of steel. This report describes some results of one NDT method which does offer some improvement in such capabilities and indicates a direction for continued development. In particular, a theoretical correlation is established between pulse-echo ultrasonic attenuation values and hardness for alloys with variable impurity content. Experimental tests which qualitatively suggest the correlation are also described.

6614

**DEVELOPMENT OF NONDESTRUCTIVE TESTING METHODS FOR INSPECTION AND EVALUATION OF CLOSURES IN CHEMICAL MUNITIONS**

R. L. Frailer, P. D. Dixon

Edgewood Arsenal, Md. Report EATR-4449, October 1970

AD-878 496

The project has been an evaluation of the various nondestructive testing techniques applicable to the inspection of the three primary closures used for sealing highly toxic chemical munitions. The three closures are the press-fit doubled-ball closure, the circumferential tig weld, and the projection resistance weld. For the press-fit doubled-ball closure, a definite ultrasonic procedure has been established. For the circumferential tungsten/inert-gas weldment and the deep-seated projection resistance weldment, the results of this study have provided the direction required for followup investigations. Ultrasonic techniques, krypton diffusion, and electromagnetic methods were evaluated.

6616

**A NEW TECHNIQUE FOR ULTRASONIC FLAW DETERMINATION BY SPECTRAL ANALYSIS**

H. L. Whaley, L. Adler

Oak Ridge National Laboratory, Oak Ridge, Tenn.

ORNL-TM-3056, September 1970

Ultrasonic spectral analysis can be used to determine nondestructively the nature of flaws detected in a material by means of ultrasonic examinations. It is feasible to characterize a flaw by this technique in spite of its composition (i.e., crack, void, or inclusion) or shape and without the need for a calibration standard. This technique is free of several limitations inherent in techniques based on amplitude. The results presented here are based on a series of reflection experiments in which the ends of solid rods immersed in water and machined discontinuities in metal samples were used as reflectors. Broadbanded ultrasonic pulses were analyzed after reflection from the interface of interest. The feasibility and practicality of using this technique to test various materials and in automated testing systems were considered.

6618

**INCIPIENT FAILURE DETECTION BY ACOUSTIC EMISSION – A DEVELOPMENT AND STATUS REPORT**

D. L. Parry, D. L. Robinson  
Idaho Nuclear Corporation, Idaho Falls, Idaho  
IN-1398, August 1970

A practical incipient failure detection system, based on the phenomenon of acoustic emissions from imperfections in structural materials under stress, has been developed and tested on pressure vessels of various sizes and degrees of complexity. The acoustic emission technique has proven capable of rapidly detecting and locating flaws during hydrostatic acceptance and requalification testing of nuclear reactor pressure vessels. The technique, coupled with other standard nondestructive testing techniques, can provide improved capability for the integrity analysis of a wide variety of complex industrial structures.

6634

**METHOD TO EVALUATE DIRECT-READING ULTRASONIC PULSE-ECHO THICKNESS METERS**

H. Bosselaar and J. C. J. Goossens  
Koninklijke Shell-Laboratorium, Amsterdam, The Netherlands  
Materials Evaluation, March 1971, p. 45-50

A description is given of various types of ultrasonic direct-reading wall-thickness meters. The implications of the type of instrument as regards the indication error are discussed. The behavior of different instrument-probe combinations can be compared with the aid of diagrams showing the depth characteristic and the useful operating area. The influence of temperature on probe and object is analyzed. Suggestions are made with respect to minimum requirements for meters to be used in the process industry.

6635

**THICKNESS MEASUREMENTS IN ALLOYS USED FOR ADVANCED GAS TURBINE ENGINE AIRFOILS**

C. R. Honeycutt and F. J. Sattler  
TRW Materials Technology, TRW, Inc., Cleveland, Ohio  
Materials Evaluation, March 1971, p. 51-58

This paper describes a program conducted at TRW to develop test methods for turbine blade and vane wall thickness measurements. Two test methods have been evaluated for these applications. A high resolution pulse-echo ultrasonic thickness gage capable of measuring thicknesses down to 0.010-in. has been used. A thermo-electric comparator has been evaluated for measuring thickness utilizing the thermal properties of blade materials. Results are presented for comparing the thickness range on which these methods are usable for three nickel base alloys, and the accuracy of the measurements for the two methods.

6638

**DEVELOPMENT, FABRICATION, TESTING, AND DELIVERY OF ADVANCED  
FILAMENTARY COMPOSITE NONDESTRUCTIVE TEST STANDARDS**

W. M. Pless, et al

Lockheed-Georgia Company, Marietta, Ga.

NASA Contractor Report CR-61340, November 1970

Detailed designs of the test standards, including configuration, placement of defects/variations, and fabrication methods are presented together with the NDT development and results. Destructive tests were conducted on additional test panels, where necessary to verify the defective condition of the standards. A single nondestructive test method did not reveal all possible defects in a composite structure. Two or more methods were used in a complementary fashion to characterize these materials adequately. Generally, radiography and ultrasonic C-scan techniques reveal most defects that may be present in a single structure.

6642

**TRANSDUCERLESS METHOD FOR ULTRASONIC FLAW TESTING IN METALS**

W. D. Wallace, et al

Cornell University, Ithaca, N. Y.

The Review of Scientific Instruments, Vol. 39, No. 12, December 1968, p. 1863

An ultrasonic method for detecting flaws in metals has been developed which does not require physical contact with the metal in order to excite or detect the ultrasonic signal. The method of direct electromagnetic generation of ultrasound in the presence of magnetic fields has been used to detect both artificial flaws and naturally occurring inhomogeneities in aluminum rods and bars. See also R.F.-Ultrasonic Wave Generation in Metals. A.G. Betzemann et al, Physics Letters, Vol. 25A, No. 10, 20 November 1967; and Direct Electromagnetic Generation of Acoustic Waves, J. R. Houck, Physical Review Letters, Vol. 19, No. 5, 31 July 1967

6645

**FEASIBILITY OF ROCKET MOTOR INSULATION INSPECTION USING INFRARED RADIATION**

D. R. Dreitzler, L. B. Thorn

U.S. Army Missile Command, Redstone Arsenal, Ala.

Report No. RK-TR-69-15, November 1969

AD-864 370

Insulated, thin-wall motor cases have as a potential failure mode the burn-through of the motor case wall resulting from a defective liner. The objective of this investigation was to determine the feasibility of the use of motor case in order to detect a potentially defective liner. A relatively inexpensive infrared inspection system was designed and assembled which demonstrated that it is possible to detect cracks and density variations in the insulation of rocket motor cases.

6651

**MEHAHERTZ AND GIGAHERTZ ULTRASONIC ATTENUATION STUDIES IN METALS**

R. L. Thomas et al

Wayne State University, Detroit, Mich.

Final Tech. Report AFOSR-70-2712TR, 30 September 1970

AD-716 474

The use of standard ultrasonic techniques at frequencies from 10MHz to 10GHz is reported together with the development and application of the new technique of direct electromagnetic sound generation to probe the electron transport properties of metals in both the normal and superconducting states. A state-dependent electron mean free path has been deduced for the superconductor mercury, and a limiting behavior at high ultrasonic frequencies is found for pure mercury which is found to be anomalous (non-BCS-like). Sophisticated data acquisition and processing methods have been applied for a detailed ultrasonic quantum oscillation study of the Spin Density Wave electronic ground state of chromium.

6654

**ACOUSTICAL IMAGING SYSTEM**

F. L. Thurstone

Patent No. 3,541,848

Available from Commissioner of Patents, Washington, D. C.

A system for electroacoustically producing images of objects placed in an ultrasound transmitting medium which is coupled to a piezoelectric transducer. The coupling includes a sonic waveguide for accepting acoustical energy through a large angle of incidence and directing the energy to the transducer at a normal angle of incidence.

6655

**ULTRASONIC TESTING OF DRILL PIPE AND THE LIKE**

F. M. Wood

Patent No. 3,540,267

Available from Commissioner of Patents, Washington, D. C.

A bending movement is applied to a rotating length of drill pipe at the portion under investigation for cracks and the like, with the result that the abutting faces of the crack are alternately spread apart and urged tightly together. Ultrasonic transducers are located at the two points of maximum tension and compression to provide a comparison measurement to distinguish actual flaws from non-injurious anomalies by means of the signal variation due to the variation in spacing of the flaw faces.

6660

**ULTRASONIC INSPECTION APPARATUS FOR ROTATABLE CYLINDRICAL OBJECTS AND BODIES OF ELASTIC MATERIALS**

W. J. Pryor et al.

Patent No. 3,529,466

Available from Commissioner of Patents, Washington, D. C.

An ultrasonic nondestructive testing and inspection system for such elements as artillery shells and the like is provided for ascertaining the presence or absence of metallurgical and mechanical discontinuities. Access is only to the outer shell surface, without direct contact, through the use of shear waves. A pulsed transducer is positioned at a critical acute angle in a vertical plane at right angles to the longitudinal axis of the shell.

6674

**ULTRASONICS AS A MEANS OF RATING STEEL CLEANLINESS**

J. B. Morgan

Allegheny Ludlum Steel Corporation, Brackenridge, Pa.

Materials Evaluation, June 1970, p. 121

The use of ultrasonics as a means of rating steel cleanliness has been investigated. It holds considerable promise in inclusion detection and possesses advantages over conventional rating methods such as metallographic and magnetic particle. Various types of readout of the ultrasonic information have been used and one appears to be superior to the others. Factors such as test frequency, search unit, surface condition and direction of scanning have been considered. Work has been done with several types of steels. Ultrasonic results have been compared with the fatigue life of specimens taken from the various billet sections and a good correlation exists.

6676

**MULTIELECTRODE ULTRASONIC TRANSDUCER TEST TECHNIQUES FOR RADIOISOTOPE ENCAPSULATION INSPECTION**

D. R. Newman, R. W. Steffens

Battelle Northwest Laboratories, Richland, Washington

BNWL-1491, February 1971

Receiving ultrasonic transducers with 32 individual electrodes in a linear array on single piezoelectric chips have been fabricated. Linear densities of 32 electrodes per 4, 2.5, and 1.5 cm have been obtained on 5 MHz PZT-5. Electronic circuits for sampling and reading out the individual electrodes at rates of up to 2000 samples per second have been developed, along with the mechanical systems necessary for scanning and manipulating the transducers. The transducers have been used for rapidly testing radioisotope capsules for clad-to-core unbonds and core voids or porosities.

6683

**GENERATION OF ULTRASONIC WAVES WITHOUT USING A TRANSDUCER**

E. R. Dobbs, J. D. Llewellyn

Nondestructive Testing, Vol. 4, No. 1, February 1971, pp. 49-56

The physical principles are outlined of a novel pulse-echo technique in which ultrasonic waves are generated directly from rf pulses in a coil placed near a metal sample in the presence of a magnetic field. Measurements of the efficiency of this system and its possible applications to non-destructive testing are discussed. See also "Transducerless Method for Ultrasonic Flaw Testing in Metals" by W. D. Wallace et al, The Review of Scientific Instruments, Vol. 39, No. 12, p. 1863, December 1968.

6686

**INVESTIGATION OF THE APPLICATION OF COHERENT ACOUSTIC IMAGING TO NDT**

W. R. Arndt, J. L. Kreuzer

The Perkin-Elmer Corp., Optical Group-Research, Norwalk, Conn. 06897

Technical Report AMMRC CR 70-14/2, December 1970

ARPA Order No. 1245, Third Semi-Annual Tech. Report November 1, 1969 to May 1, 1970

AD-750 184

During the period covered by this report, holograms of simulated defects in aluminum blocks were made and their reconstructed images analyzed. Two basic techniques for NDT were evaluated: the contact technique, in which the illuminating transducer is separated from the specimen. Ray diagrams are provided to verify the experimental results. Investigation of the Bragg diffraction microscope was completed, and transmission-type images were made of small objects using a TV display output. The study of ultrasonic imaging arrays was started and images of simple targets constructed by means of a computer using the Fast Fourier-Transform (FFT) algorithm.

6690

**METHODS OF ACOUSTIC VISUALIZATION**

P. S. Green

Stanford Research Institute, Menlo Park, Calif. 94025

In this paper a review is made of the various methods of acoustic visualization that have application in nondestructive testing. Attention is restricted to those methods that produce two- or three-dimensional "images" of the object-field. A brief discussion is included regarding older methods such as B-scan and direct-transmission imaging, which respectively are two-dimensional generalizations of the pulse-echo and continuous-wave methods of flaw detection. The principles of acoustic image formation by means of focusing lenses and reflectors are discussed and applied to the cases of transmission and back-scatter imaging, wherein the effects of acoustic-field coherence and of specular reflectivity are assessed.

6693

**ULTRASONIC MEASUREMENT OF CORE MATERIAL TEMPERATURE**

M. S. McDonough, L. C. Lynnworth and E. H. Carnevale

Panametrics, Inc., Waltham, Mass.

NASA CR-72476, August 1968

N69-12302

A program was conducted to develop a sheath for the pulse-echo ultrasonic temperature sensor. Several materials and geometries were investigated for use in a sheath to protect the Re sensor from graphite. A Ta sheath enabled a Re sensor to operate up to 5300° R in a graphite environment for a few minutes following exposures to graphite at 4800° R for two hours, and at 5100° R for over one hour. A wrought W-2% ThO<sub>2</sub> sheathed Re sensor measured a temperature of 4900° R for one hour in a graphite environment.



6697

**AN ULTRASONIC METHOD OF MEASURING PISTON RING BORE-CONTACT PATTERNS**

T. Rudy

Perfect Circle Corp., Sub., Dana Corp.

SAE-670027, January 1967

Automotive Engineering Congress, Detroit, 9-13 January 1967

AD-686 345

A new method for detecting the shape of a piston ring has been developed. The method uses the magnitude of a surface wave ultrasonic echo to plot the quality of the contact between a piston ring and a gage bore on a polar graph. The testing method and the results are discussed for single-piece and multi-piece rings, and for various surface treatments utilized in automotive piston rings.

6704

**NEW TECHNIQUES IN NONDESTRUCTIVE TESTING BY ACOUSTICAL EXO-ELECTRON EMISSION**

R. H. Chambers, S. A. Hoenig

Engineering Experiment Station, University of Arizona, Tucson, Ariz.

Semi-annual proj. rept., 1 September 69 - 30 April 1970. ARPA Order No. 1244

The purpose of this report is to describe recent investigations of the frequency distribution of acoustical emission from growing fatigue cracks in 24-ST aluminum sheet. The fatigue cracks were introduced by a high-amplitude, low-cycle bending mode of deformation. Figure 1 shows a schematic representation of the mode of bending and the placement of the PZT-5, 9.7-MHz transducers. A Hewlett-Packard spectrum analyzer was used in the zero sweep mode to record the emission events. Work on exo-electron emission was also reported.

6712

**IMMERSED ULTRASONIC INSPECTION OF HIGH ACOUSTICAL ATTENUATIVE STRUCTURES**

NASA Tech. Brief 70-10055, May 1970

Technology Utilization Division, Code UT, Washington, D. C. 20546

This Technique allows ultrasonic inspection of acoustically high absorbing structures such as cork or honeycomb core panels. In this case the structure was 1/4-inch cork on 1-1/2-inch foam on 1/8-inch aluminum, and the object was to detect unbonded areas between cork and foam. By building a floating isolator box of cork around the test object and using a low frequency transducer to penetrate the structure, automated conventional "C" scan equipment was adapted to inspect the object ultrasonically. Vibrations were isolated and reflected noise from the immersion tank walls was reduced by employing this technique.

6729

**THE EFFECT OF STRESS FIELDS ON THE ULTRASONIC ENERGY REFLECTED FROM DISCONTINUITIES IN SOLIDS**

J. G. Sessler, et al

Syracuse Univ. Research Corp., Materials Science Lab., Syracuse, N. Y.

Contract N00600-71-0581, Qtry Prog. Rpt. No. 1, January 1971

AD-719-434

The challenge to the field of nondestructive testing (NDT) is to develop procedures capable of resolving defects of critical size and to accurately define defect geometry. The NDT research program now in progress under the contract is a modification of the ultrasonic pulse-echo method of flaw detection. The approach is based on the principal that when a stress field is applied to a discontinuity (defect or flaw) in a solid, a change in the geometry of the discontinuity is effected. The change in geometry can result in corresponding changes in amplitude and/or pattern of ultrasonic energy reflected from the discontinuity. It is reasonable to expect that the reflected energy response should be relatable to specific distinguishing features of a given type of discontinuity.

6732

**LOW CYCLE FATIGUE OF BUTT WELDMENTS OF HY-100(T) AND HY-130(T) STEEL**

J. B. Radziminski, et al

Univ. of Ill., Urbana, Ill., Dept. of Civil Engrg.

Rpt. No. Structural Rsch. Ser. 361

AD-872-664L

An evaluation of the axial fatigue behavior of plain plates and full penetration butt-welded joints in Hy-130(T) steel is presented. Fatigue tests were conducted with sound weldments and weldments containing internal defects including slag, porosity, and lack of fusion. Radiographic and ultrasonic inspection techniques were used to study the initiation and propagation of fatigue cracks originating at internal weld flaws. Acoustic emission measurements were taken for smooth and notched Hy-130(T) specimens tested in static tension and in fatigue. The results of preliminary tests of plain plates and butt weldments of Hy-100(T) (Hy-110) steel are presented.

6733

**INVESTIGATION OF ELECTRONIC CERAMICS AS SENSORS IN FIBER AND FILAMENT FORM**

E. C. Henry

General Electric Co., Space Div., Philadelphia, Pa.

Contract N00019-70-C-0416, February 1971, 39 p.

AD-881 326L

The objective was to investigate the feasibility of developing and using crystal bearing filaments as sensors in the nondestructive evaluation of fiber reinforced plastic structural materials. The fibers or filaments contain crystalline oxidic materials commonly referred to as electronic ceramics: these comprise compositions broadly classed as ferrimagnetics, ferroelectrics and dielectrics and include various soft and hard magnetic ferrites, ferroelectric potassium sodium niobate and lithium niobate, and dielectric materials such as barium strontium titanate. The electronic ceramic compositions were dissolved in various molten glasses, shaped, annealed, and cooled to room temperature. The test shapes (filaments and disks) were then heat-treated to precipitate (exsolve the material that had been put in solution).

6735

**NDT APPLICATIONS OF A PULSED LASTER SCHLIEREN SYSTEM**

D. R. Newman  
Battelle Northwest, Richland, Wash.  
BNWL-SA-3458, March 1971

A pulsed gas laser emitting an extremely short duration and high power pulse at fast repetition rates has been used in an ultrasonic schlieren system. The system allows visualization of individual wavefronts within tone bursts of ultrasound at frequencies up to 20 MHz. Highly damped, high resolution pulses can also be imaged. It is shown that the ability to image these wavefronts and pulses is helpful for understanding and designing ultrasonic test systems. Examples of applications in several ultrasonic areas including flaw detection, thickness measurements, and holography are given. The experimental optical and ultrasonic systems are described. In an appendix the system is briefly analytically described using the phase grating model and also more generally as an optical processing system.

6743

**WIDE BAND TRANSDUCER FOR SURFACE ELASTIC WAVES**

M. E. Motamedi, M. Epstein  
Northwestern Univ., Evanston, Ill. (Dept. of Electrical Engrg.)  
I.E.E.E. Proceedings, vol. 58, no. 11, November 1970, pp. 1870-1871  
AD-720 508

A log-periodic interdigital transducer for surface elastic waves was fabricated and shown to have good agreement with an approximate analytical model. Experiments were performed on a mechanically variable delay line.

6744

**AN INVESTIGATION OF ACOUSTIC EMISSION FROM DEFECT FORMATION IN STAINLESS STEEL WELD COUPONS**

C. K. Day  
Battelle Northwest, Richland, Wash.  
BNWL-902, January 1969

Results of an exploratory investigation to determine capabilities and limitations of acoustic emission techniques for detecting weld defects are presented in this report. Acoustic emissions reveal cracks while they form during the welding operation; data indicate that gross porosity can also be detected with this technique. Interference signals, similar to acoustic emissions from bonafide weld defects, can be produced by scale flaking away from the weld surface, by electromagnetic interference, and by impact on the weld material by tools, welding rods, and other metal objects. Suggestions for reducing the effects of interference signals are included in the report.

6745

**INSPECTION OF THE STRUCTURE OF THIN-WALLED PARTS BY THE ULTRASONIC SPECTROMETRY METHOD**

V. A. Tokarev, I. I. Averbukh  
Soviet J. of NDT, May/June 1968, pp. 218-224

The paper considers the effect of the damping of ultrasonic waves in a plate material on the form of the reflected and transmitted pulses and examines the spectral characteristics of these signals. Experimental investigations confirm the theoretical assumptions on the dependence of the form and amplitude spectra of the signals transmitted through and reflected from the plate, on the variation of the damping factor of the plate material.

6754

**DEVELOPMENT OF NONDESTRUCTIVE TEST TECHNIQUES FOR MULTIDIRECTIONAL FIBER-REINFORCED RESIN MATRIX COMPOSITES**

J. L. Cook

McDonnell Douglas Astronautics Co.-West., Santa Monica, Calif. 90406

AFML-TR-70-239, December 1970

AD-883 978

The first year of effort on a two year duration program was designed to nondestructively evaluate as-woven multidirectional quartz yarn reinforcement material processed through impregnation and cure cycles, and make preliminary nondestructive assessment of the cured composite materials. Both film and television imaging x-ray techniques were employed on both the as-woven reinforcement and the impregnated and cured composite. Neutron radiography with doped and undoped cured composite specimens was conducted and evaluated as compared to conventional x-ray radiography.

6755

**NEW AND REFINED NONDESTRUCTIVE TECHNIQUES FOR GRAPHITE BILLETS AND SHAPES**

A. E. Oaks

General Electric Co., Phila., Pa. (Re-entry & Environmental Systems Division)

AFML-TR-70-212 (1st Annual Rpt. May 69 - May 70)

AD-881 707

This report summarizes the first year's effort to develop more sensitive techniques for detecting and evaluating flaws in graphite. On the basis of preliminary studies, it was concluded that the potential areas of improvement in the state-of-the-art lay both in the interrogative and interpretative aspects of NDT - that is in the techniques of introducing the test energy and generating the test signal on one hand, and extracting it from other non-information bearing or noise signals on the other.

6762

**THE NONDESTRUCTIVE TESTING METHODS FOR REACTOR FUEL ELEMENT TUBING**

J. Rooney

The Reactor Group, Hq., Risley, Warrington, Lancs.

TRG Report 1427(S), 1967

Three methods have been developed for examining reactor fuel element tubing. The eddy-current method and the associated equipment which have been developed are described: the method presents a high-speed inspection technique. The ultrasonic method has been developed to provide uniform high sensitivity across the tube wall, on small-diameter tubing. Radiography is used to identify certain types of defect located by the other methods.

6763

**NONDESTRUCTIVE TESTING USING TRW ACOUSTO-OPTICAL IMAGING SYSTEM**

R. Aprahamian, J. L. Jacoby, P. G. Bhuta

TRW Systems Group, Redondo Beach, Calif. (Appl. Mechanics Lab)

Tech. Rpt. AMMRC CR-71-4/1, January 1971. (Annual Rpt. 30 June - 30 December 1970)

AD-723 434

The technique of Acousto-Optical Imaging (AOI) enables one to "see", on a real-time basis, within optically opaque materials and to detect internal or surface flaws and/or other irregularities which might be present. The process uses an ultrasonic beam to probe the object under study. As it interacts with the object, the ultrasonic beam acquires an acoustical "picture" of the object. The acoustic waves then interact with a monochromatic light beam (as from a laser). Optical sidebands are produced by the Bragg diffraction of light. The cumulative result this process is that these sidebands produce a visual image of the interior of the object. This paper discusses the results of an experimental study to evaluate the applicability of acousto-optical imaging to nondestructive testing. In addition to the determination of the system resolution, the effects of specimen thickness, geometry, composition and surface roughness are under investigation.

6766

**EVALUATION OF ELASTIC CONSTANTS FROM ULTRASONIC REFLECTION MEASUREMENTS**

F. R. Rollins, Jr.

Midwest Research Institute, Kansas City, Kan.

International Journal of Nondestructive Testing, 1970, Vol. 2, pp. 261-265

Ultrasonic reflection techniques have not been widely used to evaluate elastic constants despite the fact that reasonably good accuracies can be achieved with a minimum of test time and specimen preparation. This paper discusses the application of reflection measurements to the evaluation of elastic constants of both isotropic and slightly anisotropic solids.

6767

**DETERMINATION OF FLAWS IN AN 81 MILLIMETER PROJECTILE BODY USING THE TRW ACOUSTO-OPTICAL IMAGING DEVICE**

R. Aprahamian

TRW Systems Group, Redondo Beach, Calif. AMMRC CR-70-20. August 1970, 32 p.

AD-718 046

This report contains the results of a six month study designed to establish the applicability of the TRW acousto-optical system in depicting internal defects and surface flaws existing in an 81mm projectile body. An 81mm projectile body was furnished to TRW systems which contained three known flaws. The known flaws consisted of two surface flaws on the outer surface of the shell and one crack in the inner wall. Acousto-optical images of these three flaws were obtained in the frequency range from 8 to 20 megacycles.

6773

**THE ACCURACY AND PRECISION OF ULTRASONIC SHEAR WAVE FLAW MEASUREMENTS AS A FUNCTION OF STRESS ON THE FLAW**

D. M. Corbly, P. F. Packman and H. S. Pearson  
Materials Evaluation, May 1970, p. 123

Quantitative estimates of crack length and crack depth obtained from ultrasonic shear wave reflected peak intensities were correlated with the actual values of crack length and depth as measured on the fracture surface. Part through-surface fatigue cracks were initiated in 1/4-in. sheet 7075-T6511 aluminum and grown by fatigue cycling to various sizes ranging from 0.1 in. to 0.45 in. in length and 0.02 in. to 0.125 in. in depth. The precision of the flaw indications (scatter in estimate of flaw size) was determined for specimens in the stress-free condition and under several applied loads.

6783

**A PROPOSED RESOLUTION TEST FOR ULTRASONIC ANGLE BEAM PROBES**

H. Chapman  
Canadian General Elec. Co. (Engineering Laboratory), Peterborough, Ontario  
Materials Evaluation, January 1971, pp. 1-7

Results are presented of a study on and experimental verification of a resolution test for ultrasonic angle beam probes. A target is proposed consisting of a group of three small, in-line holes with finished bore. The interaction between the pitch of the holes and the attitude of the largest group to the sound beam is shown. Test blocks are proposed that maintain a common probe-to-target distance and take into account the frequency of the sound as well as the attitude of the target to the sound beam. Other models of test blocks from the literature are compared with the proposed blocks.

6787

**METHOD OF COUPLING ULTRASOUND INTO HOT METAL**

A. Thallman  
Patent No. 3,512,401  
Available from Commissioner of Patents, Washington, D. C.

An ultrasonic transducer is coupled to a hot body such as a continuous casting by introducing turbulent water flow as the coupling medium. The turbulent flow penetrates the steam barrier, and the fluid couples the ultrasonic vibrations. This method of precooling is said to permit hot metal at temperatures even exceeding 1000 C (1273K) to be so cooled in the region near the surface that no thermal stresses leading to the formation of cracks are generated.

6788

**SOME CHARACTERISTICS OF RAYLEIGH WAVE INTERACTION WITH SURFACE FLAWS**

H. W. Reinhardt, J. W. Dally  
Illinois Institute of Technology, Chicago, Ill.  
Materials Evaluation, Vol. 28, No. 10, October 1970, pp. 213-220

Dynamic photoelasticity is employed to provide a full field visual display of the complex interaction process which occurs when a Rayleigh-type stress wave encounters a slit. This problem is of practical importance in ultrasonic detection of flaws using surface-mounted receivers. The slit in the half plane photoelastic model represents a surface crack which extends in the body to some depth. Six photoelastic models were examined with slit depths ranging from 0 to 1 in. The Rayleigh stress wave was generated with a small explosive charge and exhibited a predominate wavelength of 2 in.

6789

**DETECTION OF FATIGUE CRACK GROWTH BY ACOUSTIC EMISSION TECHNIQUES**

H. L. Dunegan, D. O. Harris, A. S. Tetelman  
Lawrence Radiation Lab., Univ. of California, Livermore, Calif.  
Materials Evaluation, Vol. 28, No. 10, October 1970, pp. 221-227

It has been well established in tensile tests that acoustic emission is an irreversible process that is associated with plastic deformation. It is also widely recognized that plastic deformation is present at the root of a sharp crack in a structure that is stressed. Acoustic emission tests performed on cracked fracture toughness specimens have confirmed that acoustic emission associated with the plastic-zone at the crack tip is also very nearly irreversible for stress intensities at the crack tip of less than one-half the critical stress intensity value required to cause unstable fracture. It is shown in this report how this irreversible feature can be utilized in a practical NDT test on a structure undergoing crack growth due to cyclic loading or other environmental effects. This technique is based on periodic acoustic emission monitoring of a structure as it is loaded back to its proof stress.

6792

**CORRELATION OF NONDESTRUCTIVE AND MECHANICAL TESTING OF GRAPHITE**

J. L. Cook, L. L. Sampson  
McDonnell Douglas Corp., Huntington Beach, Calif.  
Report DAC-62118, February 1969

A program was undertaken to correlate discontinuities detected in graphite by nondestructive means with actual failure location and the appearance of the discontinuity on the fracture surface of tensile specimens. A series of 83 tensile specimen blanks of Poco AXF-5Q graphite were ultrasonic pulse-echo C-scan mapped and these data compared with post fracture analysis of specimen failure location and discontinuity size. Correlation was made between the C-scan maps and failure location, but the specific size of actual discontinuities was not accurately predicted. Discontinuities larger than 0.020 inch maximum dimension as measured on the fracture surface significantly lowered the ultimate tensile strength of the graphite used in this study.

6793

**DETERMINATION OF THE ELASTIC CONSTANTS OF A FIBER COMPOSITE USING ULTRASONIC VELOCITY MEASUREMENTS**

J. E. Zimmer\*, J. R. Cost\*\*  
\*McDonnell Douglas Astronautics Company, Huntington Beach, Calif.  
\*\*Purdue University

Douglas Paper 10181, June 1969. (Presented at Monsanto ARPA/Wash. Univ. 4th Annual Symposium on High Performance Composites, St. Louis, Mo. 8-9 April 1969)

An ultrasonic pulsed through-transmission technique was used to measure various sound velocities in the fiber composite. Five-MHz quartz transducers were bonded on opposite parallel faces of selected specimens and the time delay of the pulse measured. The velocities used to measure the elastic stiffness constants were the longitudinal and transverse wave velocities in the direction of the fibers, perpendicular to the fibers and at a 45° angle to the fiber direction. Since more velocities were measured than were necessary to obtain the five elastic constants required by the symmetry of this composite, the extra measurements served as checks on the experimental method.

6794

**AN INVESTIGATION OF THE ELASTIC CHARACTERISTICS OF FIBERGLAS-REINFORCED PLASTICS BY THE PULSE ACOUSTIC METHOD**

A. I. Potapov

A translation from the Russian by the Foreign Technology Div., Wright-Patterson AFB, Ohio. FTD-MT-24-47-68

AD-681 578

A method of determining the dynamic elastic properties of fiberlasses using pulsed ultrasound is described. The method is based on measuring the propagation time of an elastic ultrasonic pulse through the material. Conventional ultrasonic equipment is used. The theoretical basis for determining the elastic characteristics of orthotropic fiberlasses by this method is formulated. Experimental tests were carried out using sheet fiberglass fabricated by the Leningrad plant for laminated plastics. The dynamic and static elastic properties are tabulated and plotted. It is concluded that the ultrasonic pulse method is reliable in determining the elastic properties and in controlling the quality of polymer materials.

6795

**NONDESTRUCTIVE TESTS AS AN AID TO FRACTURE PREVENTION MECHANICS**

C. H. Hastings

AVCO Corporation, Lowell, Mass.

Journal of the Franklin Institute, Vol. 290, No. 6, December 1970. (Special Issue "Horizons in the Structural Use of Advanced Materials -Thraustics")

Meaningful analysis of product strain data or defect allowables requires knowledge of material macrodefects and property gradients. This knowledge can be supplied by nondestructive tests during design studies involving brittle materials. An NDT technology, capable of supporting this extension is rapidly developing, parallel with improvements in stress analysis techniques. The nondestructive, quantitative evaluation of material properties in discrete local volumes of materials and products makes knowledge of properties variability gradients available for more precise, nonstatistical analysis of thermomechanical stress behavior. Even in "defect free" material, failures may be initiated at sites of property-stress gradients. Recent advances in NDT determination of mechanical properties are reviewed.

6796

**ULTRASONIC MEASUREMENT OF THIN LAYERS**

S. Lees

IEEE Transactions on Sonics and Ultrasonics, Vol. SU-18, No. 2, April 1971, pp. 81-86

The pulse echo shape from a thin layer embedded between two thicker media is changed because successive echoes from the two close interfaces overlap. A computer algorithm is developed for real time computation of this change as a function of the film thickness when the specific acoustic impedances of the three media are known. In one experiment castor oil was embedded between glass and steel. The calculated echoes closely resembled the experimental results for films between 1- and 38 $\mu$  thick. A curve was devised for estimating the film thickness from peak ratios in the echo. A second experimental situation appeared in testing acoustical transmission across an amalgam-tooth dentin boundary with water as the film medium. Numerical calculations produced the same echo patterns as were observed indicating that there is a gap in the interface between 1 and 10 $\mu$  in the samples.



6798

**SOUND BEAM DIRECTIVITY: A FREQUENCY-DEPENDENT VARIABLE**

B. T. Cross

Nondestructive Testing, Vol. 4, No. 2, April 1971, pp. 119-125

This report is part of a study of high frequency sound beam propagation and the information concerns the frequency-dependence observed in ultrasonic test results. The author has mathematically predicted and empirically verified that ultrasonic response curves from area-amplitude references are influenced by frequency. The frequency influence is identified as the beam directivity associated with the  $d/\lambda$  ratio. Schlieren photography provides supporting data by showing the reflected sound beam patterns for various reflector sizes. These findings are significant accurate prediction may be made for a given ultrasonic inspection by considering the frequency range of its operation. Also insight is given into the reasons why two different instruments can yield non-correlating test data at the same apparent frequency.

6797

**ACOUSTIC HOLOGRAPHY WITHOUT DEMAGNIFICATION**

J. Stone

IEEE Transactions on Sonics and Ultrasonics, Vol. SU-18, No. 2, April 1971, pp. 86-89

A new method of holographic reconstruction has been analyzed for the case, such as in acoustic holography, where the wavelength of the recording radiation is greater than that of the reconstructing radiation. The new method involves reconstruction with two monochromatic waves whose spatial interference length is equal to the wavelength of the recording radiation, and the introduction of a suitably constructed phase plate in the reconstruction process. The technique does not require scaling down the hologram or microscopic viewing, nor does it destroy the inherent three-dimensionality of the holographic technique. For the particular case of acoustic frequency of about  $3 \times 10^3$  Hz in water, two longitudinal modes of a visible light laser could be used. An analogous technique could be used when the recording radiation is shorter than the reconstructing radiation.

6801

**ULTRASONIC TESTING REQUIREMENTS OF THE AWS 1969 BUILDING CODE AND BRIDGE SPECIFICATIONS**

G. A. Shenefelt

Welding Journal, Vol. 50, No. 5, May 1971, pp. 342-349

In 1969 the American Welding Society issued new editions of the Code for Welding in Building Construction (AWS D1.0-69) and Specifications for Welded Highway and Railway Bridges (AWS D2.0-69). Appendix C - Ultrasonic Testing of Groove Welds was a part of these documents. This is the first ultrasonic testing of groove welds between the thickness of 5/16 and 8 in., inclusive. The welds may be either butt, tee, or corner welds and may be either full or partial penetration welds. Electroslag and electrogas welds are also included.

6803

**ULTRASONIC INSPECTION OF THE CONTINUITY BETWEEN A BABBITT-TO-STEEL BOND**

Ya. G. Feigin

Industrial Laboratoriya, Vol. 36, No. 7, July 1970, pp. 1023-1024.

Our continuity inspection of the bond between the babbitt and the basic material of diesel engine parts is made by means of ultrasonics. The method was worked out on standard specimens consisting of diesel engine parts with artificial flaws. A type UDM-1M flaw detector was employed.

6804

**DEFINITION OF DEFECT SIZE FROM ULTRASONIC INSPECTION**

S. B. Bennett, R. G. Peterson

General Elec. Co., (Re-entry & Environmental Systems Div.) Phila., Pa., Tech. Info. Series 71SD233.  
(Presented at 8th Symposium on NDE in Aerospace, Weapons Systems, and Nuclear Applications,  
San Antonio, 21-23 April 1971 )

Acceptance criteria in Scout Rocket Motor forging inspections are based upon comparison of the return signal from an unknown flaw with one from a "standard" flat hole defect (Hitt block). Real defects have curved surfaces which spread the reflected signal. Thus, the return signal from a real defect of characteristic dimension "d" is usually considerably smaller than the return signal from a flat hole defect of diameter "d". In order to correlate the signal (in a typical water immersion test set-up) from flat hole defects to the return signal from more realistic flaw shapes, the return signal for flat hole and spherical defects ("least detectable" by standard scanning procedures have been mathematically modelled. Extensive analytical studies of received echo amplitude as functions of test and defect parameters have been performed.

6805

**THE NONDESTRUCTIVE EXAMINATION OF G AND H LOTS FFTF FUEL CLADDING**

J. Ryden, Jr., E. F. Perrizo

Battelle Northwest, Richland, Wash. 99352  
Rpt. BNWL-1359, May 1970

An inspection for defects, using ultrasonic techniques, has been performed on 2744 ft of small diameter stainless steel tubing. The intended use for this tubing was as reactor fuel cladding in fuel performance studies for the Fast Flux Test Facility. The ultrasonic pulse-echo inspection mode was used to detect and reject defects equal to or greater than 8% of the wall thickness in depth. Statistical control techniques were used to maintain the precision of the tester to a known value. This provided a test of high reliability and a greater assurance that defects of rejectable size were actually rejected.

6810

**FOCUSED ULTRASONIC BEAMS**

J. T. McElroy

Automation Industries Inc., Boulder, Colo.

*International Journal of Nondestructive Testing*, June 1971, Vol. 3, pp. 27-58

This paper is a guide for selecting focused ultrasonic search units. It is based on a research program which is designed to analyze, measure and categorize the focal characteristics of commonly used search units. The data compiled has been reduced to charts and graphs which describe focal distance, beam diameter, and the optimum ratio of lens radius: crystal diameter (R/D).

6812

**BONDED JOINTS AND NON-DESTRUCTIVE TESTING – NDT OF RESISTANCE SPOTS, ROLL-SPOT, STITCH AND SEAM WELDS**

E. T. Hall and D. I. Crecraft

Nondestructive Testing, Vol. 4, No. 3, June 1971, pp. 181-191.

Several ultrasonic techniques have been developed for measurement of weld quality, these are largely applicable to the spot welding process. Some of these techniques have been devised for application after completion of welding as a separate process away from the welding machine. Others have been developed for use on the welding machine. Of these latter some have potential application to in process quality control. This article describes the welding process and reviews current techniques for quality assessment including ultrasonic techniques either in use or under developments to be viewed against the background of current resistance welding practice the definitions and terminology of the welding processes are explained and the present position of alternative quality assurance techniques is reviewed.

6813

**ULTRASONIC TESTING OF BALL BEARINGS**

J. Vaerman, H. Forsans

Nondestructive Testing, Vol. 4, No. 3, June 1971, pp. 201-202

The most frequently encountered faults of ball bearings of the main shafts of jet engines are for new bearings: overheatings, cracks or unequal distribution of carbon; on used bearings with cracks, peeling, marks from oxidization, corrosion, pitting, lines and impact marks. Visual inspection was unsatisfactory. Ultrasonic inspection proved useful for detecting most of the defects in balls over 14mm in diameter.

6818

**ULTRASONIC FLAW DETECTION IN COLD-ROLLED STEEL SHEET ON A CROSS-CUTTING UNIT**

D. F. Kravchenko, et al

Soviet Journal of NDT, July-August 1970, No. 4, pp. 413-415

The authors describe an ultrasonic flaw detector for high-speed inspection of steel strip and give this the results of a semi-industrial testing of this device.

6819

**PORTABLE LAMINATION DETECTOR FOR METAL STRUCTURES**

V. S. Grebennik and V. I. Ryk

Soviet Journal of NDT, July-August 1970, No. 4, pp. 416-418

The authors describe the application, the principle of operation, and the design and operational characteristics of an ultrasonic thickness gauge for detecting laminations in structural metal components with a thickness of up to 60 mm. Light and acoustic signals indicate the presence of a lamination, the depth of which is indicated on a dial.

6820

**TWO-FREQUENCY ULTRASONIC FLAW DETECTOR**

V. T. Pronyakin, et al

Soviet Journal of NDT, July-August 1970, No. 4, pp. 409-412

Transmission of ultrasonic pulses through thin air layers was studied with the aim of determining the response of ultrasonic flaw detectors to the width of the defect opening. The paper describes the circuit diagram of the two-frequency flaw detector which makes it possible to evaluate the width of defect opening.

6823

**MAPPING ULTRASONIC FIELDS WITH CHOLESTERIC LIQUID CRYSTALS**

B. D. Cook and R. E. Werchan

Ultrasonics, April 1971, pp. 101-102

The temperature-sensitive light-scattering properties of cholesteric liquid crystals have been applied to the mapping of the intensity distribution in the near-field of ultrasonic transducers.

6824

**APPARATUS USED IN PULSE-TYPE ULTRASONIC FLAW DETECTION**

Eiji Yamamoto

Tokyo Keiki Company, Limited, Tokyo, Japan

Journal of the Acoustical Society of America, Vol. 49, No. 6, June 1971, pp. 1709-1716

In pulse-type ultrasonic testing, the size of a flaw is estimated by the size of the return echo. In today's ultrasonic flaw detecting, the reflection coefficient of flaws, the characteristics of the acoustic field, the echoes from flaws in specimens, etc., are handled as those of continuous waves. However, in order to improve the resolving power, which is one of the flaw-detecting capabilities of the ultrasonic flaw-detecting method, it is necessary to minimize the number of waves contained in the pulses, and because of this the frequency distribution becomes wide and it is not possible to determine the quantitiveness of the echo from a flaw. The author conducted a study especially on the probe, transmitter, receiver amplifier, etc., of the apparatus used in pulse-type ultrasonic testing, mainly in order to obtain the quantitiveness of the echoes reflected by flaws.

6830

**ADVANCES IN THE APPLICATION OF NONDESTRUCTIVE TESTING TO CAST IRON**

A. G. Fuller

British Cast Iron Research Association, United Kingdom

5th International Conference on Nondestructive Testing, Montreal, Canada 1967

The properties of cast irons used for most engineering purposes depend upon the form and amount of graphite in the casting and its matrix structure. For the routine inspection of castings, reliable, easy to operate nondestructive testing procedures are required. The British Cast Iron Research Association has been instrumental in developing resonant frequency methods of testing and demonstrating the application of eddy-current procedures for these purposes. Examples of typical foundry applications are illustrated.

6831

**THE EVALUATION OF SMALL SURFACE LAPS IN ALUMINUM ALLOY DIE FORGINGS**

J. G. Harris

James Booth Aluminum Ltd., United Kingdom

5th International Conference on Nondestructive Testing, Montreal, Canada, 1967

To determine the effectiveness of evaluation by red dye penetrant, forgings which exhibited small laps were examined by an eddy-current crack depth instrument and ultrasonic surface waves followed by destructive testing. Red dye penetrant showed up deep laps but not shallow laps. Eddy current tests detected laps of about .020 inch depth. Ultrasonic surface-wave testing detected the lap length on the surface. Utilizing ultrasonic surface waves and eddy current testing it is possible with limitations, to evaluate laps.

6833

**NONDESTRUCTIVE TESTING OF THE ELASTICITY AND STRENGTH OF WOOD**

N. D. Popescu

The Mining Institute of Petrosani, Romania

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

A method is described in this paper which encompasses the principle of coupled oscillations. Both bending and torsional oscillations generated in the test piece by pendulums determine the mechanical characteristics. Oscillation beats are compared with theoretical relationship to determine elastic characteristics which are correlated by ultrasonics. Elastic longitudinal wave velocity, beat period and mechanical strength are then derived experimentally.

6835

**THE RELATIONSHIP BETWEEN ULTRASONIC INSPECTION RESULTS, SLAG INCLUSIONS, AND FATIGUE STRENGTH**

S. Malmquist

Saab Aktiebolag, Sweden

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

A small pressure vessel, fatigue stressed in service, was inspected by ultrasonics for inclusions that were thought to impair its fatigue strength. Bar material was inspected by ultrasonics to select test samples with a high inclusion rate. Fatigue test specimens were prepared and tested ultrasonically. When correlating the results of fatigue tests with those of ultrasonic inspection it was evident that the best relationship existed between the fatigue strength and the sum of the ultrasonic flaw echoes.

6836

**ULTRASONIC AND METALLURGICAL EVALUATION OF FLAWS IN LARGE ROTOR FORGINGS**

R. W. Renner, et al

Westinghouse Research Laboratories, U.S.A.

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

Flaw size in large alloy steel rotor forgings is currently evaluated by either a back reflection or a reference block. This paper describes the development and application of the reference block technique for the inspection of rotor forgings. A relatively simple technique is presented by means of which inspectors can report flaw size directly in terms of equivalent reflecting area. Correlations between ultrasonic data and metallographic appearances of flaws are given.

6837

**THE ULTRASONIC INSPECTION OF STEEL SHEETS WITH LAMB WAVES**

E. Isono, T. Veno

Fuji Iron & Steel Co., Ltd., Japan

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

The attenuation and reflection of Lamb waves in the frequency range of 1 MHz to 5 MHz were studied. Results indicate that the attenuation proposed by Lehfeldt and Holler. Effects of curvature and pickling of steel sheets on the attenuation are negligible, but grain size influences attenuation. Appreciable damping was observed at some temperatures. The reflection of Lamb Waves at defects shows constant reflection ratio. The frequency spectra of Lamb Waves influences the attenuation.

6838

**UNDERWATER WALL-THICKNESS MEASUREMENTS AND WELD TESTING BY ULTRASONICS**

H. Junke

Kammer der Technik, Magdeburg, Germany

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

The application of underwater ultrasonic testing by using a submerged pulse system is dealt with. Laboratory tests on wall-thickness measurements, weld testing and crack detection are described with respect to application under water. Tests showed that pressure and water do not influence sound transmission of the recording equipment. Practical application of measuring wall thicknesses of sheet piling is described.

6843

**ULTRASONIC INSPECTION OF WELDMENTS USING THE DELTA TECHNIQUE**

B. T. Cross, G. J. Posakony

Automation Industries

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

The delta technique is an ultrasonic weld inspection method which employs several ultrasonic search units positioned in a configuration characteristic of the method. Its primary advantage is its ability to detect randomly oriented weld defects with nearly equal reliability. The delta technique has been tested with contact, manual water bubbler, ultrasonic wheels, manual immersion, and automatic C-scan ultrasonic immersion systems. This paper discusses the principles and potential application for the delta technique in the inspection of welded structures.

6844

**PRACTICAL QUALITY EVALUATION OF WELDS BY ULTRASONICS**

T. Fuji, N. Sato

Japan Steel & Tube Corp., Japan

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

A study was made of the ultrasonic inspection method applied to weldments in ship's hulls under construction and to underground pipelines. Ultrasonic indications were classified in 6 grades by taking into consideration both the echo-signal amplitude and the extent of lateral movement possible while still receiving a continuous echo signal. An automatic scanning system involving movement of the probe and the use of standard reflection pieces was developed.

6846

**TELEVISION SYSTEMS FOR NONDESTRUCTIVE TESTING**

H. Berger

Argonne National Laboratory

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

The methods of operation of a number of unusual television techniques are discussed, as are the capabilities of each system in regard to sensitivity, resolution, contrast, and speed of response. Emphasis is placed on those television techniques which respond to x-radiation, infrared, ultrasound, and neutrons. The general areas of application of television systems for nondestructive testing are outlined. Several methods for recording and using test data from such systems are given.

6847

**OPTICAL METHODS FOR STUDYING ULTRASONIC PROPAGATION IN TRANSPARENT MEDIA**

H. L. Whaley et al.

Oak Ridge National Laboratory

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

The schlieren and photoelastic methods for viewing continuous and pulsed ultrasonic waves propagating in transparent media were investigated. Limitations, possible applications, and results of the investigations of each system are discussed. Emphasis is placed on equipment improvements for the development of optimum systems for nondestructive testing applications.

6852

**ULTRASONIC TESTING OF SOLIDS AT ELEVATED TEMPERATURES**

L. C. Lynnworth, E. H. Carnevale

Panametrics, Inc.

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

High-temperature ultrasonic tests are required to measure and control materials early in processing. It is shown that shear waves offer some unique advantages over longitudinal waves, and that sometimes both waves are required to characterize a material ultrasonically. High-temperature ultrasonics provide information on basic physical properties of solids. Using the Pana-Therm, thin refractory wires have been ultrasonically tested beyond 3000°K.

6853

**THE ULTRASONIC TESTING OF HOT STEEL PRODUCTS**

S. Sekino, Y. Sasaki

Yawata Iron & Steel Co., Japan

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

- An apparatus for ultrasonic testing at high temperature was constructed in the blooming mill so as to detect mechanical "pipe" in a bloom or slab. The transducers were protected from heat by using stainless steel rods between the hot material and the transducers. The couplant used was mixed salt. Mechanical and shrinkage "pipe" can be detected above 1000°C, and the former can be cropped off exactly by the cropping shear.

6854

**A CONTINUOUS ULTRASONIC TEST INSTALLATION FOR STEEL STRIP WITH  
AUTOMATIC RECORDING OF DATA**

L. Brand

Theodor Wupperman, Leverkusen, Germany

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

Ultrasonic test equipment with automatic recording for testing hot rolled strips is described. Experiments showed that recording papers make screen observations superfluous. The abundance and length of the indications is of more importance than individual screens. Circumstances which influence the procedure are described and the possibility of achieving optimum test conditions is discussed. New developments may make further improvements of this testing method possible.

6855

**ULTRASONIC EVALUATION OF THE TENSILE STRENGTH OF BRITTLE MATERIALS**

Z. Pawlowski

Polish Academy of Science, Poland

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

A new approach to quantitative tensile strength measurements by ultrasonic is presented. It is shown that there exists a very simple relationship between the tensile strength of electroceramics and the reduced modulus of elasticity, the latter being approximately proportional to the quotient of longitudinal and transverse wave velocity. The same kind of relationship is valid for cast iron with lamellar and spheroidal graphite. The only difference being the two material constants. To evaluate the tensile strength of cast iron of an unknown origin, one has only to know the material constants and measure the velocity of longitudinal and transverse waves.

6856

**ULTRASONIC NONDESTRUCTIVE INSPECTION OF ROUND TUBES AND BARS BY THE  
ROTATING PROBE METHOD**

C. E. Hohl

Krautkramer Ultrasonics, Inc.

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

This paper describes ultrasonic inspection equipment, for round tubes and bars, in which several ultrasonic test probes are mounted in a fixture which rotates around the material at speeds of up to 3000 rmp, and in which the probes are so fixed as to scan the material simultaneously in a clockwise, counterclockwise, and longitudinal direction. All probes are pre-aimed for optimum test results which provides practically equal sensitivity on I.D. and O.D. of tubes.

6859

**PROJECT APOLLO - AUTOMATED ULTRASONIC BOND-QUALITY INSPECTION**

C. C. Kammerer

North American Aviation, Inc.

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

This paper describes the conception, design, development, construction, and operation of two large ultrasonic inspection systems. These systems are used to determine and record bond quality on all adhesive bonded assemblies of the Saturn S-11 booster and the Apollo Command and Service Modules. Both systems use turntables to rotate the test parts, and use tape-programmed drives to position ultrasonic water-squitter assemblies on opposite sides of the parts for the ultrasonic inspection. These systems are the largest ultrasonic inspection machines ever built and several advances in "state-of-the-art" were made during their development.



6860

**PROGRESS IN NONDESTRUCTIVE TESTING IN AERO ENGINE MANUFACTURE**

I. L. F. Glover

Bristol Siddeley Engines Ltd., U. K.

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

A large number of different types of nondestructive testing techniques are used during the manufacture of an aero engine. The methods described include the application of ultrasonics to the inspection of rotor discs, welds and plastics and other systems for material sorting and the determination of coating thicknesses. Many of the techniques described are used on a production basis, but other methods still under development are also discussed.

6861

**APPLICATION OF THE ULTRASONIC TESTING TECHNIQUE TO THE QUALITY EVALUATION OF CAST IRON ROLLS**

Soji Sasaki and \*Kunio Ono

Yawata Iron & steel Company, Japan; \*Hitachi Ltd., Japan

Proceedings of the 5th International Conference on NDT, Montreal, Canada, 1967

Ultrasonic testing techniques described here involve two procedures for evaluating the quality of cast iron rolls; the estimation of the thickness of the hardened layer is performed by the pulse-echo method. In detecting inner flaws, comparatively low frequency is preferable and combined type probes with resonant coupling were developed. The equipment described has a display system by which the thickness of the hardened layer or the existence of inner flaws can be interpreted by B-scan representation.

6868

**THE USE OF ULTRASONIC SURFACE WAVES TO EVALUATE MAGNETIC INDICATIONS OF SUBSURFACE DEFECTS**

S. D. Hart

Naval Research Laboratory, Washington, D. C.

NRS-MR-2236. April 1971. 18 p.

AD-723 526

An ultrasonic technique for detecting flaws near the surface in plate material has been developed. The technique makes use of pulsed surface waves in a two transducer 'pitch-catch' arrangement. This provides greater sensitivity than a single transducer pulse-echo system. The system is used to evaluate magnetic particle indications of near-surface flaws.

6877

**DEVELOPMENT OF ULTRASONIC SCANNING SYSTEM FOR IN-PLACE INSPECTION OF BRAZED TUBE JOINTS**

J. L. Haynes et al.

Marshall Space Flight Center, Huntsville, Ala. NASA-TM-X-64558. 14 September 1970, 34 p. N70-42932

The developed scan system is capable of scanning brazed tube joints, with limited clearance access, in 1/4 through 5/8 inch union, tee, elbow, and cross configurations. The average test time for a particular tube size and configuration, after a 30 minute setup sequence, is 3 to 4 minutes. The system is capable of detecting brazing defects as small as 0.008 by 0.010 inch which exceeds the 0.015 inch diameter defect resolution required by specification. The ultrasonic brazed tube scanner is recommended for any required evaluation of brazed tube joints which are within the scanner's dimensional capabilities. This recommendation is based upon the rapid inspection time and the capability of the basic ultrasonic method to detect defective conditions not associated with material density changes in addition to those which are dependent upon density variations.

6885

**DEVELOPMENT OF NONDESTRUCTIVE TEST TECHNIQUES FOR LARGE SOLID PROPELLANT GRAINS**

J. M. Amaral, B. L. Lamb

Aerojet Solid Propulsion Co., Sacramento, Calif. (Advanced Tech. Operations).

Final Report, NASA-CR-72840, 24 March 1971, 239 p. (Avail NTIS)

N71-20477

An NDT system based on a through transmission ultrasonic technique and a combination of film and scintillation radiography is defined for large solid propellant grains. A microwave scanning technique is described for inspection of propellant during casting of the grain. Investigation was preceded by a failure mode analysis (FMA) and a survey of available NDT techniques. The most promising techniques were comparatively evaluated by application to a specimen representative of the finned section of a full-length 260-in. dia motor containing critical flaws as determined by the FMA.

6892

**DEVELOPMENT AND FIELD EVALUATION OF A THIN SHEET INSPECTION SYSTEM**

I. R. Kraska, R. Prusinski

General American Transportation Corp., Niles, Ill.

AFML TR-70-315. April 1971. 59 p.

AD-883 606

A multichannel recording system was designed and fabricated to simultaneously monitor, discriminate, and record four inspection frequencies. With this system, lamb wave models which are most sensitive to particular types of discontinuities can be selected. Laboratory tests demonstrated that the improved system can: (1) inspect a variety of materials such as cold, rolled steels, stainless steels, ZR-CU-MO alloys, and aluminum alloys in the thickness range of 0.060 in. to 0.110 in. and (2) detect small inclusions, slivers, and scale. Two field tests were performed.

6895

**NONDESTRUCTIVE TESTING IN CANADIAN NAVAL BOILERS**

B. F. Peters

Defence Research Establishment Pacific, Victoria, B. C.

Journal of the Royal Naval Scientific Service, Vol. 25 (1970), pp. 36-106

AD-714 477

Nondestructive testing has been applied to the marine boilers of Canadian destroyer escorts. Ultrasonic techniques are applied to the superheater tubes, radiography to the outside-row generator tubes, radiography and borescope examinations to the economizer tubes and ultrasonics to the water wall tubes. The nondestructive techniques are discussed in terms of the wastage mechanisms experienced by the Y100 Babcock and Wilcox controlled superheat marine boilers.

6901

**RECORDING RAPID ULTRASONIC INSPECTION DATA ON A RELATIVELY SLOW-SPEED RECORDER**

J. M. Mesina

Jones & Laughlin Steel Corp., Pittsburgh, Pa. (Research Div.)

Materials Evaluation, Vol. 29, No. 4, April 1971, pp. 81-87

Recording systems have been adapted to two pulsed ultrasonic tests for electric-weld pipe. Functions of the system are 1) to record pipe weld quality as measured by ultrasound and 2) to monitor proper equipment operation. The four-channel ultrasonic inspection systems have been modified to permit accurate recording of high-speed defect information on a relatively slow recorder.

6905

**NONDESTRUCTIVE TESTING TECHNIQUES FOR FIBERGLASS, GRAPHITE, FIBER, AND BORON FIBER COMPOSITE AIRCRAFT STRUCTURES**

D. J. Hagemeyer, et al

Douglas Aircraft Co., Long Beach, Calif.

Materials Evaluation, Vol. 28, No. 9, September 1970, pp. 194-204

Various nondestructive test (NDT) methods were evaluated for inspection and evaluation of boron, graphite and glass-fiber composites for aircraft structures. Typical specimens were evaluated using microscopic fluorescent penetrant, radiographic, ultrasonic and thermochromic test methods. Optical microscopic examination is useful for determination of fiber pattern from the edge of a panel. It was concluded that fluorescent penetrant combined with microscopic examination is a useful tool to determine surface defects; radiography combined with magnified photography is an excellent method to determine fiber pattern, fiber gaps, broken fibers, crushed core, and resin-rich areas; and ultrasonic and thermal methods appear to have merit for determining unbonded areas.

6906

**AN ULTRASONIC METHOD FOR MEASURING CRACK DEPTH IN STRUCTURAL WELDMENTS**

G. DiGiacomo\*, J. R. Crispi\*\*, and S. Goldspiel\*\*\*

\*IBM Corp., Fishkill, N. Y., \*\*Naval Ship Rsch. & Devel. Lab., Annapolis, Md.,

\*\*\*Board of Water Supply, N. Y. Materials Eval., September 1970, pp. 189-193

Nondestructive methods capable of ascertaining the integrity of structural materials during fabrication and in service are very much in need. This paper deals with an ultrasonic technique developed for the purpose of determining the depth of cracks in structural materials. The technique has been applied on high strength steel plate weldments to study fatigue crack propagation while the plates were subjected to low cycle fatigue. The accuracy of the method was evaluated by comparing the depth of cracks obtained ultrasonically with the measurements after breaking the plate. Results show that depth increments of 0.1 in. are detected.

6908

**FLAW CHARACTERIZATION BY ULTRASONIC FREQUENCY ANALYSIS**

H. L. Whaley and L. Adler

Oak Ridge National Labs., Metals & Ceramics Div., Oak Ridge, Tenn.

Materials Evaluation, Vol. 29, No. 8, August 1971, pp. 182-188, 192

A new method was developed for the characterization (determination of the size and orientation) of a reflector by ultrasonic spectral analysis. This technique can be used to determine nondestructively the nature of flaws detected in a material by means of ultrasonic examination. It is shown that it is feasible to characterize a flaw by this technique in spite of its composition (i.e., crack, void, or inclusion) or shape and without the need for a calibration standard. This technique is free of several limitations inherent in techniques based on amplitude. The results presented here are based on a series of reflection experiments in which the ends of solid rods immersed in water and machined discontinuities in metal samples were used as reflectors.

6909

**ASPECTS OF IN-SERVICE INSPECTIONS ON REACTOR PRESSURE VESSELS IN GERMANY**

H. J. Meyer

Maschinenfabrik Augsburg-Nurnberg AG, Nurnberg, West Germany

Materials Evaluation, Vol. 29, No. 8, August 1971, pp. 171-181

In view of the safety requirements for nuclear reactor pressure vessels, nondestructive inspections are to be carried out not only during manufacture but also during the whole operational life of a reactor. Ultrasonic inspection systems and manipulation equipment are described which permit economical inspection of reactor components, at the same time avoiding subjective evaluation and manual probe guidance. The inspection system and manipulation are arranged so that when modern electronic components are employed two-dimensional flaws in particular (e.g., cracks) can be traced with a high degree of dependability.

6914

**A HIGH SENSITIVITY ULTRASONIC TEST SYSTEM FOR WELDS**

P. A. Fessler, W. E. Michaud  
General Electric Co., St. Petersburg, Fla.  
GE pp-83, 11 November 1970  
N71-26984

The scanning and recording equipment are described of a semi-automatic ultrasonic test system used for the inspection of electron beam welds. The equipment inspects an electron beam weld in stainless steel parts and is capable of indicating defects not detectable with conventional X-ray radiographic equipment. Nearly a year's production testing has proven that flaws which are as small as 0.015 inch in diameter and located as deep as one quarter of an inch below the surface of the part can be detected repeatedly. Misaligned welds, short welds and cracks are readily shown. The inspection takes about one minute. The ultrasonic information is electronically displayed and stored on the cathode ray tube of a storage display unit. Polaroid photographs of the display provide permanent records of each weld inspected.

6915

**THE EARLY DETECTION OF FATIGUE DAMAGE**

J. F. Moore, S. Tsang, G. Martin  
Los Angeles Div. of North American Rockwell  
AFML-TR-71-185, September 1971  
AD-730 348

*This is the final report for a program to develop NDT methods for the detection of early fatigue and fracture damage in metals and alloys. NDT methods were evaluated in terms of their potential detection and measurement capability of the observed fatigue-related effects and damage as determined by the study and fatigue evaluation tests. The following methods were selected for detailed evaluation; exo electron emission, acoustic emission, and ultrasonic surface wave attenuation and velocity. The change of exo electron emission current was found to have a relation to the spent fatigue life. A marked change in acoustic emission intensity could also be related to the percentage of fatigue life. A correlation was also found between the attenuation of ultrasonic surface waves and length of fatigue life.*

6920

**ACOUSTIC EMISSION FROM COMPOSITE MATERIALS**

G. Liptai  
California Univ., Livermore. Lawrence Radiation Lab. UCRL 72657, 3 February 1971.  
Presented at 2d ASTM Conf. on Composite Mater., Anaheim, Calif. 20-22 April 1971.  
Sponsored by AEC  
N71-29268

A review of the application of acoustic emission analysis to the evaluation of material properties and defect structure is presented, including a brief discussion of experimental techniques. Sources of acoustic emission in composite materials under strain are discussed. Particular attention is directed toward fiber reinforced composites, and experimental results on filament wound NOL rings and vessels (glass-epoxy) are reported. It is concluded that acoustic emission data are helpful in establishing the mechanisms governing operative fracture modes and assessing structural integrity.

6921

**A NEW TRIANGULAR ACOUSTIC PULSE: ITS GENERATION AND UNIQUE PROPERTIES FOR NDT APPLICATIONS**

N. E. Dixon and T. J. Davis

Battelle-Northwest, Richland, Wash. Pacific Northwest Lab. BNWL-1526, February 1971

35 p. Avail NTIS.

N71-29512

A unique ultrasonic pulse technique for transmitting individual triangular-shaped (either compressional or rarefactional) acoustic pulses is described from which the received unipolar pulse signal exhibits no transducer resonance. The associated transducer model and theory, pulse spectral characteristics, and transducer performance requirements are detailed. Included are experimental data and a partial listing of many inherent advantages of the unipolar pulse such as extremely high range resolution, the complete absence of field effects, extremely broad continuous spectral frequency content, and penetration characteristics. Also presented are some specific nondestructive testing applications.

6926

**NONDESTRUCTIVE TESTING USING TRW ACOUSTO-OPTICAL IMAGING SYSTEM**

R. Aprahamian, J. L. Jacoby, P. G. Bhuta

Advanced Technology Staff Group, TRW Systems Group, One Space Park, Redondo Beach, Calif.

For Army Materials and Mechanics Research Center, Watertown, Mass.

Technical Report AMMRC CR-71-4/2, August 1971, 49pp.

The technique of Acousto-Optical Imaging enables one to "see", on a real-time basis, within optically opaque materials and to detect internal or surface flaws and/or other irregularities which might be present. An ultrasonic beam interacts with the object, and acquires an acoustical "picture" of the object. The acoustic waves then interact with a monochromatic light beam (as from a laser). The cumulative result of this process is that optical sidebands produce a visual image of the object. This paper discusses the results of an analytical and experimental study to evaluate the applicability of acousto-optical imaging to nondestructive testing.

6927

**QUALITY ASSURANCE. GUIDANCE TO NONDESTRUCTIVE TESTING TECHNIQUES**

Army Materiel Command, Washington, D. C.

AMCP-702-10, April 1970

AD-728 162

Reference material is provided on the following topics: visual inspection: liquid penetrant inspection: magnetic particle inspection: X- and gamma-ray film radiography: fluoroscopic and electronic x-ray and gamma ray imaging systems: sonic and ultrasonic NDT: microwave NDT: infrared NDT: liquid crystal NDT: kryptonation NDT: corona discharge NDT: leak testing: effectiveness of NDT: comparative NDT.

6929

**FIELD EVALUATION OF HEAVY-WALLED PRESSURE VESSELS USING ACOUSTIC EMISSION ANALYSIS**

E. V. Waite, D. L. Parry

Idaho Nuclear Corp., Idaho Falls, Idaho

Materials Evaluation, Vol. 29, No. 6, June 1971, pp. 117-124

A portable acoustic analysis system has been developed by Idaho Nuclear Corp., which detects, locates and analyzes microacoustic energy emissions originating from flaws or cracks within a stressed structure. The system was developed for the U.S. Atomic Energy Commission for potential use as a nondestructive test technique for the safety assessment of pressure retention envelopes of nuclear power reactors. To aid in the development and evaluation of the acoustic system, acoustic emission data were obtained and on-site analyses made of the integrity of several large industrial chemical reactor pressure vessels in conjunction with the hydrostatic acceptance testing of the vessels. The system was shown to be capable of detecting and locating acoustic emission sites (flaws) as small as 0.1 in. (2.54 mm) in size with acoustic signal transmission distance of up to 60 ft. (18.28 m) from the emission site to the detector.

6930

**NONDESTRUCTIVE TESTING OF GRAPHITE FIBER COMPOSITE STRUCTURES**

D. J. Hagemaiier, et al

Douglas Aircraft Company, Long Beach, Calif.

Materials Evaluation, Vol. 29, No. 6, June 1971, pp. 133-140

This paper discusses NDT methods and techniques for detection of material and manufacturing anomalies in state-of-the-art graphite composites. Visual, liquid penetrant, radiographic, ultrasonic, sonic, thermal and acoustic-emission NDT methods are used to evaluate graphite fiber composite aircraft specimens and structures. Reference standards are fabricated with built-in discontinuities, commensurate with each structural article fabricated. The test specimens and parts were tested by various methods in order to determine optimum discontinuity detection. Tests were conducted in research and development graphite composite aircraft structures consisting of 1) graphite composite horizontal stabilizer assembly, 2) graphite composite flap assembly and 3) molded graphite flap ribs.

6933

**ELECTRONIC SIGNAL PROCESSING TECHNIQUES: NONDESTRUCTIVE TESTING**

J. C. Kennedy, W. E. Woodmansee

Boeing Co., Seattle, Washington (Aerospace Group). Report D180-10589-z, June 1971

(Semiannual Report 30 December 1970 - 30 May 1971). Phase III.

AD-717 156

Correlation techniques were used to improve the signal to noise ratio in the ultrasonic inspection of a simulated weld seam. A quarter inch titanium plate, containing Edm slots and drill holes, was inspected ultrasonically. The limiting background noise was due to surface roughness and grain boundary scattering. The weld line was inspected three times, a different transducer configuration being used for each inspection. The signal to noise ratio for the ultrasonic reflection from a ten (10) mil drill hole was improved from a value of one to one to a value of five to one.

6934

**ACOUSTIC EMISSION ANALYSIS OF PRESSURE VESSELS & PIPING**

D. L. Parry

Jersey Nuclear Co., Richland, Wash.

In: Eighth Symp. on NDE in Aerospace, Weapons Systems, and Nuclear Applications, San Antonio, April 1971, pp. 17-32.

Acoustic analysis technology is now being applied as a commercially available nondestructive test tool. A recent acoustic analysis test of a nuclear pressure vessel resulted in the detection and accurate location of thirteen weld slag and porosity regions. The defects were acoustically identified as being insignificant to the integrity of the vessel, but represented potential problem sites requiring close surveillance during planned future periodic in-service inspections. The defect sites were cross-checked and confirmed using standard nondestructive test techniques. Tests conducted on pressure piping have enabled the detection and location of fatigue originated microcracking and stress corrosion cracking.

6937

**NUCLEAR REACTOR BACKGROUND NOISE VS. FLAW DETECTION BY ACOUSTIC EMISSION**

P. H. Hutton

Battelle Memorial Inst., Pacific NW Labs, Richland, Wash.

Rpt. BNWL-SA-3820.

In: Eighth Symp. on NDE in Aerospace, Weapons Systems, & Nuclear Applications, San Antonio, April 1971, pp. 1-5.

This paper discusses results obtained from current investigation of the character of reactor background noise at various stages of operation of the San Onofre PWR at San Clemente, California, and its relation to acoustic emission detection. The results are encouraging to "clean" detection of acoustic emission in the 1 to 2 MHz region and recorded data samples are being used to investigate means of identifying acoustic emission signals within the general noise.

6945

**DIFFERENTIAL METHOD OF ULTRASONIC INSPECTION**

S. E. Baryshev and V. G. Davydov

Soviet JI. of NDT, September-October 1970, pp. 541-546.

The article describes differential method of ultrasonic inspection and binary-comparative search heads developed for its implementation, presents their technical specifications, and gives recommendation for their use.

6946

**A REVIEW OF NONDESTRUCTIVE METHODS FOR THE DETECTION OF CONCEALED CRACKS**

H. W. Kamm, I. R. Kraska

General American Transportation Corp., Niles, Ill.

Tech. Rpt. AFML-TR-71-120, July 1971.

AD-746 268

This report is a discussion of NDI methods for detecting concealed cracks with emphasis on crack detection under fasteners and painted and plated surfaces. They are classified as: recommended, potentially applicable, and inapplicable. The recommended methods are ultrasonic and eddy current. They are now field applicable. The potentially applicable methods are listed as acoustic impact, acoustic emission, and non-film x-ray imaging. Inapplicable methods are given as biography, visual, liquid penetrant, magnetic, thermal and radiography.



6949

**PLATE WAVE RESONANCE – A CONTACTLESS TEST METHOD**

M. Luukkala, P. Heikkila and J. Surakka  
Ultrasonics, October 1971, pp. 201-208.

A method is described whereby plate waves can be excited in thin sheets (such as paper or cardboard) directly from air without touching the sample. Using this contactless method, non-destructive testing of the elastic properties of various papers can be performed. The method may prove to be useful in "on-line" testing of various other, non-woven materials like plastic sheets.

6950

**NDT INSPECTION OF THE R1820 MASTER ROD BEARING**

J. Cipriani, Naval Air Development Center, Code STH-27, Warminster, Pa.  
Presented at 20th Defense Conference on NDT, Jacksonville, Fla. 10-12 November 1971.  
Also: NDT Newsletter NTN 71-2, pp. 17-18.

An inspection technique was urgently needed which could evaluate the bond condition of silver plating in new bearings before engine installation and in used bearings for possible extended service life. Using an immersion ultrasonic technique with a focused transducer the sound beam was focused on the bondline interface and suitable indications of unbond conditions were obtained. Of 75 bearings initially inspected, 12 were found to have discontinuities of varying severity.

6955

**FIELD INSPECTION OF HEAVY-WALLED REFINERY PRESSURE VESSELS**

R. P. Rathburn  
Standard Oil Company of Calif., Western Operation, Inc., Richmond, Calif.  
Materials Evaluation, October 1971, pp. 222-226.

The inspection of heavy-walled vessels in the field can pose many problems not faced by in-shop inspection. This paper attempts to point out such problems as insulation removal, staging and internal accessibility as well as instrument portability. Types of ultrasonic and magnetic particle instruments needed and techniques for their use are discussed. Experiences of the Standard Oil Co. of California inspection teams in performing complete inspections of heavy-walled vessels during the past four years are presented, with emphasis on the ultrasonic inspection of welds. The use of drawings in laying out sound paths, and systems of record keeping and reporting are also reviewed.

6957

**PROPERTIES OF CYLINDRICAL BOREHOLES AS REFERENCE DEFECTS IN ULTRASONIC INSPECTION**

H. Wustenberg, E. Mundry  
Nondestructive Testing, vol. 4, August 1971, pp. 260-265.

The properties of cylindrical boreholes, used as reference defects, lying perpendicular to an ultrasonic beam were examined. The influence of geometrical parameters on the echo amplitude are discussed and the echo amplitude of cylindrical boreholes are compared with the DGS-diagram for circular reflectors.

6967

**IN-SERVICE INSPECTION OF NUCLEAR REACTOR VESSELS USING AN AUTOMATED ULTRASONIC METHOD**

L. B. Gross, C. R. Johnson

Babcock and Wilcox, Lynchburg, Va.

Materials Evaluation, vol. 28, no. 7, July 1970, pp. 162-167.

A dual-probe, send-and-receive ultrasonic method for remote, on-site nondestructive inspection of the cylindrical region of nuclear reactor vessels was devised and demonstrated. The probes were moved about the vessel on a rigid, pre-programmed transporter. The resultant inspection records for initial and subsequent examinations could be compared by a computer to indicate the initiation or propagation of defects and to characterize the location, orientation and size of the defect.

6968

**ULTRASONIC THICKNESS INSPECTION OF AUTOMOTIVE COMPONENTS**

J. K. Schmitt

Chrysler Corp. Engineering Office, Detroit, Mich.

Materials Evaluation, vol. 28, no. 7, July 1970, pp. 145-152

This paper describes ultrasonic testing procedures employed to obtain thickness readings on six commonly used automotive materials. Grey iron, pearlitic and ferrite malleable, die cast and permanent mold aluminum and nodular cast iron were successfully investigated. Effective utilization of this application of pulsed ultrasound yields many advantages, such as speed, accuracy, reliability and capability where only one side access is possible or practical. With the basic knowledge developed, it is then possible to design a fully automated, computer controlled system for handling large quantities of test data. Such a system, in concept, is described.

6974

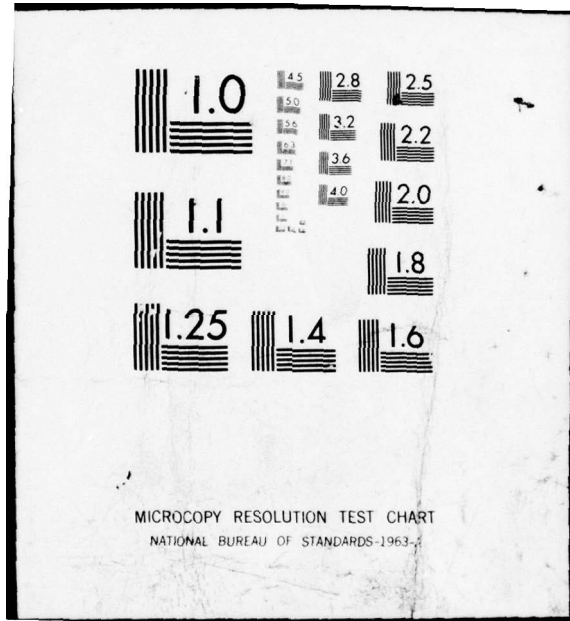
**A TRANSDUCER WITH UNIFORM INTENSITY DISTRIBUTION**

G. Kossoff

Ultrasonics, October 1971, pp. 196-200.

A transducer which generates a uniform axial and lateral intensity is described. The transducer consists of two concentric high electrodes, an inner disc and an outer ring, the dimensions of which are chosen so that the position of the last axial intensity maximum of the inner disc coincides with the position of the last axial intensity minimum of the large disc obtained when the two high electrodes are shorted. To obtain a uniform field, a higher voltage is applied to the disc electrode. The main feature of the transducer is that the degree of uniformity may be controlled by adjusting the voltage drive ratio. The same transducer may be used to produce a focused field, by applying voltages which are  $180^{\circ}$  out of phase.





6976

**ACOUSTIC EMISSION TECHNIQUES IN MATERIALS RESEARCH**

R. G. Liptai, D. O. Harris, R. B. Engle, C. A. Tatro  
Lawrence Radiation Lab., Univ. of Calif., Livermore, Calif.  
International Journal of Nondestructive Testing, December 1971, vol. 3, pp. 215-275.

A review of the application of emission analysis to evaluate materials properties and defect structure is presented. Topics discussed include fracture toughness and crack propagation, fatigue, plastic deformation, and creep processes in metals, composites, and rock materials. The status of emission techniques as applied to the evaluation of structural integrity is reported. A complete discussion of experimental techniques and data acquisition and processing systems is given. The authors conclude that acoustic emission techniques have wide applicability to experimental studies in materials research and to evaluation analysis of structural integrity. Directions of future developments and applications are discussed.

6979

**STRUCTURAL ADHESIVE BONDING REPORT**

T. A. Hollingsworth et al.  
Directorate of Quality Assurance, AF Contract Management Div.  
AF Unit Post Office, Los Angeles, Calif.  
AFCMD/QA-155 (also AFCMD-TR-71-02) June 1971  
AD-730 628

An evaluation was made of the structural adhesive bonding technology currently used by the aerospace industry and associated failure modes and causes of failure. Also included were the inspection and testing techniques used in the acceptance function and detection of bonding anomalies, primarily in honeycomb panels. Some of the methods used were ultrasonics, both C. Scan and through transmission; infrared, fluorscopy, and holography. No single nondestructive inspection technique has been established that can accurately detect all types of bonding anomalies.

6984

**EFFECTS OF VOIDS ON MECHANICAL PROPERTIES OF GRAPHITE FIBER COMPOSITES**

E. M. Lenoë  
AVCO Systems Div., Wilmington, Mass.  
Rept. No. AVSD-0166-71-RR  
AD-727 236

The results of an investigation of the effect of voids on the mechanical properties of ThorneI 50/epoxy and Modmor 11/5206 epoxy are discussed and presented. Undirectional, as well as quasi-isotropic, laminates with symmetrical and non-symmetrical ply-stacking sequences were fabricated with high and low porosity and subsequently subjected to detailed nondestructive and destructive testing. Longitudinal and transverse flexure and tension, short beam shear, and torsion rod experiments were completed on the two composite systems at 75 and 250 F. Ultrasonic compression and shear wave velocities were measured at discrete locations on a specimen-by-specimen basis, and the observations correlated with observed mechanical properties.

6995

**DETECTION OF VIBRATION IN NUCLEAR REACTOR INTERNALS BY  
ULTRASONIC TECHNIQUE**

S. P. Ying and J. A. Meyer

Southwest Research Institute, San Antonio, Tex. 78228

In: 8th Symp on NDE in Aerospace, Weapons Systems & Nuclear Applications,  
April 1971, pp. 42-47

The concept of ultrasonic vibration detection is based on utilizing a pulse-echo system to obtain information of vibration from the reflection signals. The feasibility test of this concept for the detection of vibration in a vessel has been accomplished with an actual segment of cladded nuclear reactor vessel wall 10 in. thick. The results of the test in the laboratory indicated that the transmission of ultrasonic waves between the transducer and water through the cladded vessel wall is sufficiently good. The parallel and the perpendicular displacements of a vibration with respect to the direction of the ultrasonic beam can be observed from the time shifts of echoes and the directivity of ultrasonic radiations, respectively.

6999

**NONDESTRUCTIVE EVALUATION OF METAL FATIGUE**

F. N. Kusenberger et al.

Southwest Rsch. Institute (Dept. of Instrumentation Rsch.) San Antonio, Tex.

AFOSR-TR-71-1965, April 1971, 114 p.

AD-728-637

The results of continued fatigue crack nucleation and propagation investigations in the vicinity of inclusions in 4340 steel and presented. NDE results using ultrasonic magnetic perturbation methods are illustrated and discussed. Certain characteristics of magnetic signals from a fatigue crack are examined with regard to the plastic zone in the vicinity of the crack. Other features of magnetic signal response from an inclusion as a function of stress cycling indicate that significant improvements in the magnetic detection of fatigue cracks appear possible. Using analytic approaches, estimates of the shape and extent of plastic yielding in the vicinity of a surface inclusion have been made and have shown qualitative agreement with metallurgical results. Important metallurgical findings related to crack initiation and propagation are also presented.

## DESCRIPTOR INDEX

All descriptors listed in alphabetical order pertain to the information contained in the report or item that is identified by the AMMRC number following the descriptor. This journal is for ultrasonic testing literature and every item in the journal contains some aspect of ultrasonic testing. A complete breakdown of each subject item by descriptors was deemed necessary in order to make the journal useful.

Reviewers need only to look up *the the item numbers which apply to the particular descriptors of interest* and turn to the abstract applicable to those referenced numbers.

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