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A REPORT GUIDE TO LITERATURE IN THE FIELD OF ELECTROMAGNETIC TESTING - VOLUME II

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MATERIALS TESTING TECHNOLOGY DIVISION

July 1977

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ARMY MATERIALS AND MECHANICS RESEARCH CENTER
Watertown, Massachusetts 02172

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This report guide covers a portion of the abstracts on magnetic particle and electromagnetic nondestructive testing included in the holdings of the Nondestructive Testing Information Analysis Center.

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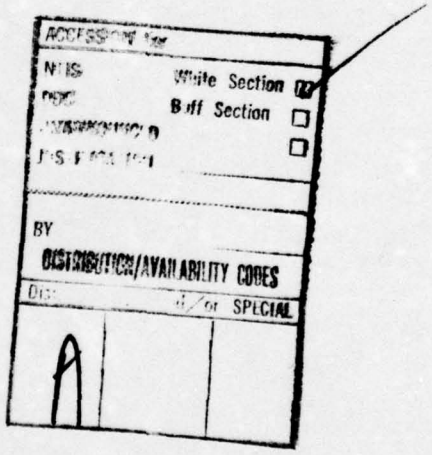

PREFACE

This bibliography and topic analysis is intended 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.

The information for this publication has been compiled and prepared by the U. S. Army Materials and Mechanics Research Center (AMMRC). All items included in this volume have been taken from the holdings of the Department of Defense Nondestructive Testing Information Analysis Center (NTIAC) housed, staffed, and maintained at AMMRC until October 1975, and since relocated under contract to the Southwest Research Institute, San Antonio, Texas 78284. All items held in this system have been obtained from numerous sources, both foreign and domestic, including Government reports, technical journals, periodicals, and any other source of information considered to be of value to those concerned with Nondestructive Testing.

All documents included cover some aspect of Nondestructive Testing involving electromagnetic and magnetic particle testing methods even though a large number of the documents may also be concerned with other phases of Nondestructive Testing. The term "electromagnetic testing" as it is used in this guide shall refer to those nondestructive test methods for engineering materials, including magnetic materials, which use electromagnetic energy having frequencies less than those of visible light to yield information regarding the quality of material tested. Each document is covered by as many word descriptors as are deemed necessary for complete coverage of that document.

ACKNOWLEDGMENT

Special thanks go to two abstracting services for their kind and generous permission to reproduce their abstracts. They are the Documentation Service of the American Society for Metals, Metals Park, Ohio, and Engineering Index, Inc., 345 East 47th Street, New York, New York. The following copyright holders are also to be thanked for their courtesy in granting reproduction rights:

Henry Brutcher Technical Translations, Altadena, California

Iron Age, Chilton Co., Inc., Philadelphia, Pennsylvania

Materials Evaluation (formerly Journal of Nondestructive Testing), Evanston, Illinois

Materials Research & Standards, American Society for Testing Materials, Philadelphia, Pennsylvania

INTRODUCTION

Where available, each item in this publication 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) abstract.

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 radiographic testing and also to provide sufficient information in the form of abstracts and word descriptors to make the listing useful.

SCOPE

This guide to Volume II of a series of planned report guides consisting of the complete coverage of items in the Department of Defense Nondestructive Testing Information Analysis Center covering the subject of electromagnetic and magnetic particle testing. Subsequent volumes will be published as the work load permits.

The following is a list of report guides previously published by the Department of Defense Nondestructive Testing Information Analysis Center. The guides may be obtained from the National Technical Information Service, Springfield, Virginia 22151.

AMRA MS 64-10 *A Report Guide to Autoradiographic and Microradiographic Literature,* August 1964, AD-612 047

AMRA MS 64-11 *A Report Guide to Gamma Radiographic Literature,* August 1964, AD-612 042

AMRA MS 64-12 *A Report Guide to Liquid Penetrant Literature,* August 1964, AD-612 044

AMRA MS 64-13 *A Report Guide to Literature in the Fields of Fluoroscopy and Remote Viewing,* August 1964, AD-612 045

AMRA MS 64-14 *A Report Guide to Thermal Testing Literature,* August 1964, AD-612 043

AMRA MS 65-03 *A Report Guide to Electromagnetic Literature,* April 1965, AD-615 346

AMRA MS 65-04 *A Report Guide to Magnetic Particle Testing Literature,* June 1965, AD-617 758

AMRA MS 65-09	*A Report Guide to Ultrasonic Attenuation Literature*, December 1965, AD-627 565
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

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 descriptor cross references.

The abstracts normally refer the reader to the source where the complete report may be obtained.

ABSTRACTS

AMMRC IDENTIFICATION NUMBER

3363 **NONDESTRUCTIVE TESTING METHODS AS APPLIED TO RESISTANCE SPOT WELDS**
H. Noreen, Jr.
WAL-TR-140/24, AMRA*, Watertown, Mass., November 1957
AD-697 133

At the present time, inspection of resistance welds can be successfully carried out by employing careful process control through qualification testing of welding machines, lot percentage destructive tests for strength consistency, and weld metal structure etching examinations. The best apparent method of nondestructive testing of resistance welds is by visual inspection of welded parts and structures in conjunction with radiographic examination. These are discussed in this report. Other methods are also reported with the advantages and disadvantages of each outlined.

*Now Army Materials & Mechanics Research Center

3373 **NONDESTRUCTIVE TESTING OF SOLID PROPELLANT MISSILE MOTORS**
F. C. Hund, U. S. Naval Weapons Station, Concord, California
Symposium on Recent Developments in Nondestructive Testing of Missiles, Los Angeles, 1962; ASTM Special Technical Publication No. 350, pp. 62-84
EI 64 21921

Requirements, techniques and procedures for nondestructive testing of large solid propelland motors for the Polaris, Minuteman, Skybolt, and other missiles are discussed. Among the applications covered are: radiography, magnetic particle, and ultrasonic examination of welded steel cases; radiography, penetrant, eddy current, and ultrasonic testing of refractory metal nozzle; ultrasonic testing of case-liner bond; and radiography of the completely assembled solid propellant motor for integrity of the grain, insulation and bonded surfaces.

3380 **NONDESTRUCTIVE TESTING IN THE QUALITY LABORATORIES**
The Martin Company, ER-11566, December 1960

This document outlines the capabilities and equipment pertinent to nondestructive testing maintained and utilized at the Quality Laboratories of the Martin Company. Coverage includes; eddy currents, Ultrasonics, X-ray, penetrants, thermographics, etc.

3383 **FOR LINE PIPE, TWO TESTS ARE BETTER THAN ONE**
W. A. Black
Welding Design & Fabrication, vol. 36, no. 8, August 1963, pp. 54-56

Why hydrotest, magnetic particles, and radiography did not meet requirements in testing resistance-welded line pipe at Republic Steel Corp. A description of electromagnetic and ultrasonic tests is given. The Farrowtest and Ultramat, which proved ideal for line pipe, are described.

3396 **LAMINATION DETECTOR FOR THE CONTINUOUS INSPECTION OF STEEL STRIP**
B. O. Smith, A. G. Grimshaw
Journal of the Iron and Steel Institute, vol. 189, 1958, pp. 66-71

An instrument which makes use of the distortion in the flow pattern of electric current in steel sheet due to the presence of laminations is described. The laboratory design which consists of a single scanning heat is capable of inspecting a 6-inch band along the length of the strip travelling at 300-500 ft/min with a fairly high probability of interception. It is believed that the use of multiple overlapping scanning heads in an industrial instrument would offer an effective method of intercepting the majority of laminations likely to cause trouble in subsequent processing.

3398 **ROLLING DEFECTS IN STEEL SHEET**
F. W. Boulger
Metals Progress Digest, vol. 73, no. 2, February 1958, pp. 174
(Digest of: A. M. Armour, Detection of Rolling Defects in Steel Sheet, Metallurgia, vol. 54, December 1956, pp. 301-304)

Internal splits or layers of inclusions occurring on planes parallel to the surface are troublesome defects characteristic of flat rolled products. In this article, the various nondestructive testing methods which have been developed and are used for detecting these laminations; mechanical, electrical, ultrasonic and magnetic methods, are discussed.

3413 **INVESTIGATION OF HALL-EFFECT DEVICES FOR FLAW DETECTION IN METALS**
H. Sipler
Frankford Arsenal, Philadelphia, Pa.
Report R-1710, March 1964
AD-433 895

The technique of using a Hall generator to plot the flux-leakage due to flaws was established in Frankford Arsenal Report No. E-1581 of February 1961, "Investigation of Hall-Effect Devices for Flaw Detection in Ferrous Materials". This effort was extended to study artificial flaws simulating the random slopes and depths encountered in real surface cracks. Improvements have been developed in the test instrumentation to allow photographic records to be made via cathode-ray oscilloscope presentations. Determination of vertical flaw depths greater than 30 mils was found to be feasible as in earlier studies.

3415 **OPERATING INSTRUCTIONS AND PROCEDURES FOR OPERATION OF THE GAP MEASURING SYSTEM**
Interim Report, U. S. Army Materials Research Agency, Watertown, Mass.*

This procedure establishes a semi-automatic "go-no-go" measurement of Titanium-Titanium gaps in the o-.001 "width range of base to rear body gap. The gap is circumferential in cylindrical objects between 6" and 6.5 inches in diameter.

*Now: U. S. Army Materials & Mechanics Rsch. Ctr., Watertown, Mass.

3419 **NONDESTRUCTIVE TEST METHODS FOR CORROSION DETECTION**

C. E. Lautzenheiser
Southwest Research Institute, San Antonio, Texas
Materials Protection, vol. 2, no. 8, August 1963, pp. 72-76

This article discusses the use of visual inspection, radiographic, ultrasonic dynamic pressure testing, hydrogen evolution, and corrosion probes as means of detecting extent and location of corrosion in operating equipment. Stress corrosion cracking, strain measuring devices, and eddy current measurements are included.

3483 **EDDY CURRENT, HARDNESS, STRENGTH RELATIONSHIP OF 2024 ALUMINUM ALLOY**

D. Hogemaier
Rocketdyne (Div. of North American Aviation, Inc.), Canoga Park, California
Paper presented at Spring SNT Meeting, Los Angeles, 17-18 March 1964.

Stress corrosion failures of standard aluminum AN-818 coupling nuts led to an evaluation of materials considered nonsusceptible to stress corrosion. Metallurgical data indicated that 3 alloys, 2024-T6, 6061-T6 and 7075-T73 fulfilled the necessary requirements for acceptable B-nut materials. This study was to determine if the -T6 temper of 2024 could be reliably identified by NDT methods. Differences in electrical conductivity, hardness, and strength do exist for 2024 alloy in various tempers. Strength can be determined by evaluating conductivity vs hardness values. Variations in and verification of aging can be determined by the conductivity and hardness relationship.

3487 **PIEZOELECTRIC CRYSTAL STUDIES AND MEASUREMENTS**

Karl S. VanDyke
Squier Signal Laboratory, Wesleyan University, Middletown, Connecticut
Contract DA36-039-SC-42587, rpt. 16 (final), 14 June 1956
AD-108 334

A continuation study of shear vibrations of quartz plates and an investigation of the amplitude distribution of these vibrations; preparation and investigations of representations of matrix data by crystal classes with a view to their more direct relation to the basic phenomena. A bibliography is included. This document also includes a thesis by P. E. Weston entitled "Electrical Measurement of Strain Distribution in Quartz Plates". Using a strain analyzer, point probes, and associated electronic circuitry he was able to produce 3-dimensional graphs over the entire face of a crystal.

3533 **METALS & CERAMICS DIV. ANNUAL PROGRESS REPORT, PERIOD ENDING 31 MAY 1963**

Oak Ridge National Laboratory, Oak Ridge, Tennessee
ORNL-3470, 1963

(Only the NDT portion of the report is considered here) NDT is under continuous development for testing nuclear components, esp. w/electromagnetics, ultrasonics, and penetrating radiation. A new phase-sensitive eddy current instrument has greater applicability to thickness measurements than more conventional instruments. A mathematical model for improved electromagnetic probe design is being programmed. A new device for ultrasonic inspection of brazed heat-exchanger joints has been developed. Low voltage radiography extended to contact radiography capable of 500 X magnification. Improved gamma-and X-ray transmission techniques are being developed for the determination of fuel-loading variations on fuel plates and rods.

3564 **THE INSPECTION OF THIN-WALLED STAINLESS STEEL REACTOR GRADE TUBING**
R. S. Sharpe and S. Aveyard
Journal of the Iron and Steel Institute, vol. 201, no. 10, 1963, pp. 856-862

A comprehensive study of a number of nondestructive testing techniques. It is based on detailed examination of some 2,000 specimens ranging in diameter between 0.25 in and 1.25 in and in wall thickness between 0.010 in and 0.35 in. Ultrasonic, radiographic, eddy current, fluorescent penetrant and optical methods are compared and as primary inspection for ultrasonic micrometer capable of measuring 2×10^{-5} in thickness variations in 0.015 in walled tube is described.

3606 **INVESTIGATION OF SECONDARY PHENOMENA FOR USE IN CHECKOUT**
G. Hwang
Systems Research Laboratories, Dayton, Ohio
Rpt. APL-TDR-64-4, Wright-Patterson, Ohio, January 1964
AD-431 821

This report discusses the experimental work, results and conclusions of the investigation of secondary phenomena for use in checkout of electrical components and circuitry. Detection techniques cover X-ray absorption, infrared using a thermistor, infrared using fluorescence, radio frequency emission, magnetic fields, and electrical fields. Most promising are X-ray absorption, infrared and radio frequency.

3607 **NONDESTRUCTIVE TESTING**
W. McGonnagle, F. Park
Southwest Research Institute, San Antonio, Texas
International Science and Technology, no. 31, July 1964, pp. 14-27; Materials Research, December 1964, pp. 561ff

This paper is of a general, yet wide, coverage of the field of nondestructive testing and covers such topics as radiography, neutrons, thermal testing, liquid penetrant, magnetic techniques, Ultrasonics, etc. Some ideas for further advancing the state of the art are also included.

3621 **MASS SPECTROMETER CHECKS WELDS**
Iron Age, vol. 193, no. 5, 30 January 1964, pp. 98-9

Foxboro Co., Foxboro, Mass., verifies difficult welding operations with mass spectrometer leak detector; product is differential pressure measuring instrument called "d/p Cell" transmitter; welded part is small diaphragm capsule which serves as sensing element; on test, capsule is positioned so that its opening coincides with evacuation port in table; vacuum is then drawn within capsule; outside of capsule is next exposed to puff of helium; deflected helium ions strike collector plate to generate small electrical current; after signal which is proportional to leak rate, is amplified, it is read on output meter.

3638 **THE DIFFUSION OF PULSED CURRENT FIELDS IN GOOD CONDUCTORS**

C. J. Renken
Argonne National Laboratory, Illinois
Rpt. ANL-6346 (Symposium on Physics and Nondestructive Testing, Argonne National Laboratory, Oct. 1960), pp. 127-128

The use of pulsed fields in electromagnetic testing is a fairly recent development. This technique offers a number of theoretical and practical advantages over methods which use steady-state sinusoidal fields. It is possible to use fields of small cross-sectional area to produce electromagnetic test systems of improved resolution. The relatively slow rate of diffusion of current fields in good conductors makes possible the time separation of reflections from the surface of the metal from internal discontinuities.

3639 **MAGNETIC PROPERTIES OF REACTOR METALS AND ALLOYS**

M. V. Nevitt
Argonne National Laboratory, Illinois
Rpt ANL-6346 (Symposium on Physics and Nondestructive Testing, Argonne National Laboratory, October 1960), pp. 139-153

A survey is made of some of the magnetic properties of metals and alloys of reactor significance, involving principally the thoride elements, thorium, uranium, and plutonium, the rare earth elements and the transition elements, titanium, zirconium and hafnium. The fundamental concepts of dramagnetism, ferromagnetism, and antiferromagnetism are given a short review and some of the important experimental techniques used in magnetic measurements are described briefly. Principal attention is given to paramagnetic susceptibility, saturation and spontaneous magnetizations of ferromagnets, Curie temperature, crystalline anisotrophy of magnetization, and the Hall effect.

3653 **APPLICATION OF A PHASE SENSITIVE EDDY CURRENT INSTRUMENT**

C. V. Dodd
Oak Ridge National Laboratory
Materials Evaluation, vol. 22, no. 6, June 1964, pp. 260-262, 272

A fresh approach to eddy current analysis indicates that by special techniques it is possible to decrease or eliminate undesirable liftoff effects and to extend the useful thickness range of eddy current inspections. Equipment designed and constructed at CRNL is discussed.

3672 **NUCLEAR REACTORS TESTING**

F. Foerster
Die zerstoerungsfreie Unterzuchung von Reaktorcomponenten mit electromagnetischen Verfahren
Metall, vol. 18, no. 5, May 1964, pp. 450-460
EI 64 20323

Nondestructive testing of reactor components by electromagnetic methods; discussion is limited to testing for defects; principles of electromagnetic testing are outlined and apparatus, particularly "Defektograph," described in detail; different methods and results are compared.

3682 **MAGNETIC TESTING OF THE HARDNESS OF STEEL TUBING**

P. I. Vit'ko et al.
Khimicheskoe Machinostroenie, July-August 1963
Henry Brutcher translation no. 6126

Heat treatment, more specifically hardness of steel tubing, cold or hot rolled, checked by a nondestructive method, based on the measurement of the coercive force. Overcoming the problem of testing magnetically soft steels. Development of a differential coercimeter and the mode of its operation. Plotting of a calibration curve and factors affecting scatter are covered. Verification data of the accuracy of the coercimeter readings is also included.

3708 **DEVELOPMENT OF EDDY-CURRENT TESTING TECHNIQUES FOR TUBE INSPECTION**

D. Terry
Radio and Electronic Engineer, vol. 26, no. 5, November 1963, pp. 373-382
EI 64 22009

Short history of subject, basic principles, and methods of measuring effects of variations in test specimen; block circuit diagrams and complex-impedance curves, evaluation of a-c and d-c saturation techniques; practical testing equipment, using phase and modulation analysis; how phase-sensitive devices and modulation-analysis techniques are applied, and their limitations; uses of internal probes and surface probes. 30 refs.

3716 **NONDESTRUCTIVE TESTING AND ITS APPLICATIONS ON THE SATURN S-1C BOOSTER**

F. J. Musil
Boeing Company, New Orleans, Louisiana (Launch Systems Branch)
Date - 1964

Practically all phases of nondestructive testing are being applied or developed for application to some inspection problem on the S-10. Almost no detail part is assembled without undergoing some form of nondestructive testing. This paper gives a complete description of the fabrication, tooling, testing, and automation of testing methods. Such methods include radiography, penetrant, Ultrasonics, microwave, eddy current, and infrared techniques. Elaborate automatic scanning methods are described in some detail.

3728 **TESTING SINTERED METALS BY EDDY CURRENT METHODS (GERMAN)**

A. Keil
Zeitschrift fur Metallkunde, vol. 52, April 1961, pp. 215-218

Use of eddy current methods in conductivity measurements on sintered Ag-Ag_2O (10% Ag_2O) specimens from 0-600° C. to detect decomposition temperature of Ag_2O and in detection of cracks in 2-8 mm. diam. tungsten rods.

3729 **INSPECTING FUEL-SLUG CLADDING AT HANFORD AUTOMATICALLY**
D. C. Worlton
Nucleonics, vol. 19, July 1961, pp. 92, 94, 96, 98

Lamb wave and eddy current tests are made on Al-clad fuel rods to detect bonding layer defects such as voids, nonwets and brittle bonds.

3732 **METHOD OF ASSESSING INTERNAL QUALITY OF STEEL TUBES AND WELDS**
J. S. Blair
West of Scotland Iron and Steel Institute Journal, vol. 68, 1960-1961, pp. 25-40

Review and comparison of nondestructive testing techniques for steel tubes and welds including radiography, ultrasonic, eddy current and diverted magnetic flux.

3771 **NONDESTRUCTIVE TESTING AS APPLIED TO AIRCRAFT**
T. H. Norris
Hawker-Siddely Aviation, Chester, England
British Journal of Nondestructive Testing, vol. 6, no. 2, June 1964, pp. 31-39

A general discussion of inspection and quality control methods used on raw materials, structural assemblies and aircraft.

3772 **NONDESTRUCTIVE TESTING FOR ROUTINE SERVICING IN THE ROYAL AIR FORCE**
J. C. Drury
C.S.D.E. Swanton Morley, Norfolk, Great Britain
British Journal of Nondestructive Testing, vol. 6, no. 2, June 1964, pp. 40-44

This article is devoted to nondestructive testing of aircraft by the aircraft operators in the Royal Air Force after predetermined periods of time or after minor accidents. Techniques discussed cover radiography, Ultrasonics, eddy currents, electromagnetics, and dye penetrants.

3783 **TUBE INSPECTION BY EDDY-CURRENT TECHNIQUES**
H. A. Libby
Metal Treatment and Drop Forging, vol. 31, no. 220, January 1964, pp. 31-33

New, highly accurate techniques developed by author at Hanford Labs., effectively isolate harmful defect signals from normal background signals; tubes which have been destructively examined, have, without exception, revealed defects in exact location indicated by eddy-current tests; methods described were developed to inspect tubing of new N-Reactor heat exchangers.

3794 **EDDY CURRENT TESTING, FAST AND VERSATILE**

R. A. Seidel
Westinghouse Electric Corp., Large, Pennsylvania
In: NDT Testing for Management, Metals Park: American Society for Metals, 1963

This testing method offers the producer a way to inspect bars, tubes, wire and similar products for surface defects, size variations, composition changes, and other variables. Instrumentation is sensitive and accurate, and can be integrated into a production line.

3804 **TOTAL TESTING FOR NAVAL AIR MAINTENANCE PROGRAM**

Magnafacts, vol. 11, no. 3, Summer 1963, pp. 8-9 (Publisher: Magnaflux Corp., 7300 West Lawrence Ave., Chicago, Ill.)

Describes the mission of the nondestructive test program at the Navy's Overhaul and Repair Department at the Naval Air Station. Its mission is to assure the reliability of part after use and to check out parts for inclusions, discontinuities and impurities after they have been manufactured in the processing shop. A brief description of some of the methods used.

3818 **PRINCIPLES AND APPLICATIONS OF MICROWAVES IN MATERIALS TESTING**

R. Hochschild
Microwave Instruments Co., Corona del Mar, California. Bulletin 1000, October 1964

This paper is aimed at the basic elements of microwaves, what they are, their application to nondestructive testing, and a look into future applications for microwaves.

3831 **DIRECT ENERGY CONVERSION IN THE NAVY**

J. A. Satkowski
Office of Naval Research
Symposium on Physics and NDT, San Antonio, 2-4 October 1962, Proceedings, pp. 345-371

Improved power source and energy conversion systems represent one of the most important long range scientific problems facing the Nation. Five energy conversion processes are receiving the majority of attention and are classified as follows: Photovoltaic cells, thermoelectricity, magnetohydrodynamics. This paper covers a discussion of thermoelectric, thermionic and magnetohydrodynamic systems.

3852 **EDDY-CURRENT IMPEDANCE CALCULATED BY A RELAXATION METHOD**

C. V. Dodd
Oak Ridge National Laboratory, Oak Ridge, Tennessee
Symposium on Physics and NDT, San Antonio, 1-3 October 1963, Proceedings, pp. 300-314

Eddy currents were first used as a means of nondestructive testing in 1879 by D. E. Hughes to sort metals. Since Hughes' experiments, the technology and use of eddy currents has grown tremendously. Recently, sophisticated eddy-current instruments have been designed to determine conductivity, permeability, hardness, thickness, integrity, and other properties of metals. While such empirical knowledge has been gathered, little progress has been made toward an analytical solution of the problem. Now, by using a relaxation technique, an engineering solution may be obtained for the coil impedance of a cylindrical eddy-current probe coil.

3858 **EDDY CURRENT TESTING ARTIFICIAL DISCONTINUITIES**

P. Garatoni
Anaconda American Brass Company, Waterbury, Conn.
Materials Evaluation, vol. 22, no. 10, October 1964, pp. 479-480

This article specifies the means of making artificial standards rapidly, accurately and on the spot for setting the sensitivity of eddy current equipment.

3862 **ELECTROMAGNETS (Second Edition)**

R. M. Whitner
Englewood Cliffs: Prentice Hall, 1962

A testbook giving wide coverage to the background and theory of electromagnetics.

3864 **ULTRA-STABLE EDDY CURRENT METHOD FOR DETECTING HYDRIDE IN ZIRCALOY-2**

D. R. Green
Hanford Labs, Richland, Wash.
Rpt. HW-SA-3496, October 1964

A new eddy current method using a unique comparator circuit was applied to detect concentrations of hydride as low as 250 ppm (parts per million by weight) in zircaloy-2. Absorption of 250 ppm hydrogen by the zircaloy results in a 0.4 per cent increase in resistivity which can be detected with the instrument. Lift-off compensation was attained by referencing the eddy current bridge to the center of curvature of the probe motion signal locus on the complex voltage plane. Drift usually in the center of curvature method of lift-off compensation was eliminated. A discussion of the new circuit is included, and correlation between the circuit output and metallographic analysis of the hydride content of test pieces is shown.

3868 **NDT TESTER PROBLEMS IN PRODUCTION APPLICATIONS: SENSITIVITY' MEASUREMENT ERROR AND ECONOMIC CONSIDERATIONS**

C. J. Denton
Hanford Atomic Products Operation, Richland, Wash.
Presented at the 24th Annual Meeting of the Society for NDT Testing, October 1964

The large tonnages of reactor elements fabricated for use in Hanford reactors must be nondestructively tested to rigid quality specifications to prevent costly failures in use. Testing this large volume of elements reliably and at a minimum of cost with electronically and mechanically complex testers is a major fuel production problem. Simple control charts are indispensable in maintaining control of the various units in the tester complex. A unique, statistically-designed measurement error program has been devised to monitor and identify measurement error problems with the various testers in the terter complex. The results of the work performed to decrease testing costs, and increase tester reliability are briefly discussed in this paper.

3872 **CORROSION PREVENTION & CONTROL**
The Detection of Porosity by Electrical Means
D. C. Kovkman and C. H. Potter
Corrosion Prevention and Control, vol. 7, September 1960, pp. 1-2, 8

Explanation of the principles of high-voltage testing (spark testing). Advantages and limitations. The wet-sponge test; the direct current high-voltage test.

3873 **EDDY-CURRENT CRACK DETECTION IN SHORT ZIRCALOY TUBING**
R. G. Holt
Knolls Atomic Power Lab., Schenectady, New York
Rpt. KAPL-2000-10, June 1960, pp. E29-E39

The use of short Zircaloy sleeves in fuel elements dictates rigorous inspection of each sleeve. To meet the inspection requirements, the Hectmeter, a very sensitive eddy-current test apparatus, was developed. It consists of standard electronic equipment and a simple parallel resonant circuit. The flexibility of the test allows selection of test frequency and coil design with a minimum of circuit changes.

3875 **A MAGNETIC TESTER FOR THE MEASUREMENT OF INTERLAYER AIR-GAPS BETWEEN STEEL REINFORCING BANDS OF PRESSURE VESSELS**
J. W. Walley,
Metallurgia, vol. 64, October 1961, pp. 165-175

New NDT testing device designed to give magnetically an approximate indication of the air-gap length between ¼ in. thick steel reinforcing bands used to strengthen a large steel vessel. The tester reads average gap directly from 0-0.060 in. to within about ±20% provided certain test conditions obtained. 4 ref.

3876 **POWER REACTOR PROGRAM. PROGRESS REPORT TO SAVANNAH RIVER OPERATIONS OFFICE, UNITED STATES ATOMIC ENERGY COMMISSION FOR THE PERIOD 1-31 JAN. 1961**
S. Isserow et al.
Nuclear Metals, Concord, Mass.
Rpt NMI-7236. Nucl. Sci. Abstr. 15-16012, 1961

An investigation of the cladding thickness of U-Al-Si, U-Cr-Mo, Mg-Si-Zr, and U-Al- alloy tubes by endoradiographic and eddy current analyses. Data are given for cracking, penetration rates, bendability and grain size.

3881 **MEANS FOR PRECISE CRACK DEPTH MEASUREMENT (GERMAN)**
A. Matting, V. Deutsch
Materialprufung, vol. 3, June 1961, pp. 218-224; ASM no. 3635 (available from American Society for Metals, Metals Park, Ohio)

Nondestructive measurement of crack depth by direct or alternating current methods. Investigation of factors controlling accuracy of measurements such as contact resistance, shape and composition of specimen and shape and location of crack. 5 ref.

3882 **THE SIGNIFICANCE OF DEFECTS IN RELATION TO THE USER—WITH PARTICULAR REFERENCE TO CASTINGS AND FORGINGS**
F. Buckley
West of Scotland Iron and Steel Institute Journal, vol. 68, 1960-61, pp. 61-70

Report on steel casting and forging defects, including voids and inclusions, as related to machine service and longevity, acceptance standards and inspection technique.

3906 **INVESTIGATION OF EDDY CURRENT TECHNIQUES IN ANALYZING AIRCRAFT STRUCTURES FOR FATIGUE DAMAGE**
E. M. Sims
Univ. of Oklahoma, Norman, Okla.
Oklahoma City Air Material Area, USAF, contract AF 34(601) 17360, April 1964

An investigation aimed at the development of a method for detecting material damaged from fatigue loading and a means of estimating the extent of damage as related to mechanical properties of the material. Flat plate and sheet aluminum alloys were used for the test program. Specimens were reverse stress cycled to varying degrees of damage and inspected with eddy current instrumentation, in the hands of an experienced operator, can be used as a reliable tool for detecting fatigue damage. More development work needed for refinement of equipment and techniques.

3918 **DEVELOPMENT OF NONDESTRUCTIVE TESTS FOR THE EGCR FUEL ASSEMBLY**
Robert W. McClung
Nondestructive Testing, vol. 19, September-October 1961, pp. 352-358

Test techniques for Experimental Gas-Cooled Reactor (EGCR) include penetrants, pulse-echo and resonance ultrasonics, radiography, eddy currents, helium-leak and others. Capabilities and limitations with reference to specific inspection problems. 10 ref.

3923 **EDDY CURRENTS TRIED FOR NEW ROLES**
Steel, vol. 149, July 17, 1961, pp. 118-1120

Applications of nondestructive eddy current testing to measurement of core and case hardness in ferrous automobile engine components and of tensile strength and conductivity of Al aircraft components.

3945 **COST CUTTING IDEAS**
Welding Design and Fabrication, vol. 34, March 1961, pp. 54-69

Applications, advantages and limitations of nondestructive metal testing by ultrasonic, radiographic, penetrant, magnetic particle, eddy current, thermographic, magnetographic, thermal and tensile techniques.

3946 **NDT TESTING IS KEY TO FUTURE OF WELDING QUALITY CONTROL**
Glenn G. Gibson
Welding Journal, vol. 40, March 1961, pp. 225-228

Review of NDT testing methods including leak, liquid penetrant, radiographic, ultrasonics, eddy current and magnetic particle tests, their use in welded joint inspection and general application to quality control. 6 ref.

3952 **NDT TEST DEVELOPMENT**
J. W. Allen, Jr., R. A. Nance
Oak Ridge National Laboratory, Tenn.
ORNL-2988, July 1960, pp. 406-420. (Metallurgy, Div. Annual Report, period ending 1 July, 1960)

A new transistorized eddy-current instrument, the Metal Identification Meter, for sorting metals and alloys according to electrical conductivity & magnetic permeability designed & built by the Instrumentation & Controls Division in conjunction with the NDT Test Development Group. New eddy-current instrument was designed & developed for use with probe-coil techniques. Investigation of the fabrication of realistic reproducible standards for tubing inspection. Equipment and techniques were developed for using the eddy-current "lift off" effect for measurement of fuel-element spacing. Studies of ultrasonic behavior in thin sections are being expanded to include quantitative measurements of reflection, transmission and Lamb-wave propagation as a function of variation in metal thickness & the ultrasonic frequency & incident angle. Studies of exposure requirements for helium & air atmospheres for low voltage radiography demonstrated the advantage of the helium atmosphere. Ultrasonic techniques used to measure the wall thickness of Zircaloy-2 core vessel. Use of ultrasonics for weld inspection in thick plates.

3954 **STUDIES ON THE INSPECTION METHODS OF SMALL-SIZED STAINLESS STEEL TUBES FOR FUEL CLADDING (Japanese)**
S. Mochizuki et al.
Atomic Energy Society of Japan Journal, vol. 3, July 1961, pp. 30-39

Methods of measuring efficiency, dimensions and integrity of AIS1304L stainless steel cladding tubes. Outside and inside diameters are measured by an airmicrometer, material integrity is checked by eddy current instruments for NDT testing, pressure resistance is measured for internal and external pressure by hydrostatic testing at high temperature.

3965 **STRETCH PRESS AGES SHEET, PROBE TELLS HOW MUCH**
Steel, vol. 148, April 3, 1961, p. 88

Use of an eddy current probe during stretch aging of 17-7PH stainless steel to determine elongation and ultimate tensile strength. Mechanical properties are read directly from the eddy current meter during the process, eliminating a majority of tensile tests.

4004 **VARIATION OF COERCIVITY OF MAGNETIC MATERIALS WITH DRIVING FIELD**

G. R. Hoffman, J. A. Turner, H. K. Lachowicz

Journal of Applied Physics, vol. 34, September 1964, pp. 2708-2715

The use of a low-frequency sinusoidal driving field to measure the B-H characteristics of magnetic materials is now a well known technique. An increase in amplitude of this field is generally accompanied by an increase in coercivity. Ferrite cores, tape cores, and thin magnetic films, have been investigated, all of which exhibit a similar characteristics. Both coercivity and saturation fields are shown to depend upon the rate of rise of the applied magnetic field, thus enabling a mathematical analysis to be made which is in good agreement with the experimental results. Pulse techniques are also used in the case of anisotropic, thin magnetic films to confirm the view that changes of magnetic states are by domain-wall motion.

4005 **ELECTROMAGNETIC TESTING BRIDGE NETWORK WITH DIGITAL PROGRAMMING CONTROL FOR OPERATION UNDER A PLURALITY OF INITIAL UNBALANCE CONDITIONS**

Richard Hochschild

U. S. Patent 3,132,299

Materials Evaluation, November 1964, p. 505

This patent describes an eddy current inspection apparatus utilizing flaw sensing induction coils in an initially unbalanced bridge circuit. The desired initial phase and amplitude unbalance can be determined for each material and punched into individual cards. Placing the card into the console then programs the initial unbalance settings of the machine so that a number of adjustments are not necessary with each change in tested connected to parallel high and low band pass filters. The outputs of the filters may be displayed by meters or recorders.

4016 **A STUDY OF THE FACTORS INFLUENCING THE EDDY CURRENT LOSSES IN 3% SILICON-IRON**

D. A. Leak, W. E. Duckworth

Iron and Steel Institute, Journal, vol. 201, July 1963, pp. 588-593; Materials Evaluation, October 1964, p. 462 (Abstract)

Definition of anomalous loss in soft magnetic material, and review of previous work in the area. Investigation of the application of a theoretical expression for evaluating the eddy current loss in a material with a domain structure to losses of 46 grade, grain oriented 3% Si-Fe. Results are presented showing the variation of eddy current loss with surface roughness.

4019 **ELECTROMAGNETIC TESTING APPARATUS USING AN ECCENTRICALLY MOUNTED ANNULAR TEST COIL WHOSE AXIS IS ROTATED ABOUT THE WORKPIECE AXIS**

J. W. Allen

U. S. Patent 3,110,860

Materials Evaluation, April 1964, p. 151

Describes an eddy current search coil translating apparatus for detection of seams and other longitudinal flaws in pipes. Annular eddy current test coil encircles the pipe with its axis parallel to, but not coincident with, the pipe axis. The coil axis is then caused to translate in a circle about the pipe axis so that a portion of the coil is in close proximity to the pipe surface at all times. The portion of the coil which is close to the pipe surface covers a helical path along the pipe wall as the pipe passes through the coil.

4044 **THICKNESS MEASUREMENTS IN AEROSPACE**
R. Nance
The Budd Co., Phoenixville, Pa., date: 1964

An excellent discussion of the use of eddy currents as an inspection technique particularly in thickness measurements application. Extremely accurate measurements are possible.

4046 **HALL EFFECT INVESTIGATIONS**
H. H. Wieder, A. R. Clawson
Naval Ordnance Laboratory, Corona, Calif.
NAVWEPS Rpt. 8167, 15 Sept. 1963 (Oy. prog. rpt., April-June 1963)
AD-421 033

Thin films of indium antimonide vapor-deposited on oxide-coated surfaces of aluminum or tantalum offer an advantage in the fabrication of thin film Hall generators because of the superior thermal conductance between the films and substrate. The deposition and recrystallization of InSb films on oxide-metal substrates have been investigated in detail. Additional studies on the magnetic circuit associated with Hall generators are described and the flux concentrator problem is treated empirically. This is the fourth report in the series. Preceding reports were NAVWEPS report 7242, NAVWEPS report 8148, and NAVWEPS report 8156.

4049 **UTILIZATION OF MICROWAVE FREQUENCIES FOR QUALITY CONTROL AND NONDESTRUCTIVE TESTING OF DIELECTRIC COMPONENTS**
J. Leonard and G. Stropki
Proceedings, 2nd Annual Symposium on Nondestructive Testing of Aircraft and Missile Components, San Antonio, Texas, 14-16 Feb. 1961, pp. 31-39

A discussion of the use of a microwave thickness guage at North American Aviation is given. Vastly improved manufacturing methods in radome production has resulted in radome testing procedures have been greatly simplified. Comparisons of results with ultrasonic thickness gages are given, as is a graph relating dielectric constant and resin content. Vidigage readings vs resin content are also given. Results on a fiberglass laminate test sample are also given.

4069 **THE NONDESTRUCTIVE TESTING OF FILIMENT WOUND CONTAINERS**
M. E. Liebman, S. Branman and A. D. Lucian
Aerojet General Corp.
Proceedings, 4th Annual Symposium on Nondestructive Testing of Aircraft and Missile Components, San Antonio, Texas, 27-28 Feb. 1963, pp. 139-151

A description of radiographic methods as an aid in design, fabrication, in-process inspection, failure and stress analysis, and structural testing. Tapping, Statiflux and ultrasonic inspection performed before and after hydratest. Contact ultrasonic inspection is used to determine aluminum separation from insulation or from overlying filament windings. Eddy current, infrared, microwave, corona, and lower frequency ultrasonics are being investigated.

4084 **INSPECTION OF WELDING**

Magnaflux Corp., Chicago, Ill., Bull. M-182. Reprint from Welding Handbook, American Welding Society, 5th edition, 1962

An excellent article on magnetic particle testing which is complete, concise and contains useful information. Liquid penetrant, ultrasonic and eddy current testing is also covered but to a much lesser degree.

4126 **INSPECTION OF MATERIAL UNIFORMITY AND THICKNESS USING DIELECTRIC MEASURING**

I. C. Lynnworth
Parametrics Inc., Waltham, Mass.
International Conference on Nondestructive Testing, 4th, London, 9-13 Sept. 1963, Proceedings, pp. 283-290. London: Butterworth, 1964

This report, based on the physical principles of materials science and electrostatics, shows by experimental results that uniformity of materials properties and thickness may be evaluated by nondestructive dielectric measurements, for many materials. It is shown that capacitive-type probe considerations are similar to those of the inductive-type eddy current probes. Frequency, depth and area of penetration, sensitivity, a similarity principle, commercial instruments, test piece geometry and inspection speed are discussed. Contains an extensive bibliography.

4128 **NONDESTRUCTIVE TESTING BY THE PULSED ELECTROMAGNETIC SYSTEM**

S. Uozumi
Electronic Research Lab., Teikoku Tsushin Industries, Tokyo, Japan
International Conference on Nondestructive Testing, 4th, London, 9-13 Sept. 1963, Proceedings, pp. 295-303. London: Butterworths, 1964

This paper describes methods for metal inspection which utilizes pulsed or gated electromagnetic systems, along with synchronous magnetization, and the probe vibration method. Theory, principles and general features of testing are discussed as well as typical examples of test data.

4129 **RECENT EDDY CURRENT DEVELOPMENT AT THE OAK RIDGE NATIONAL LABORATORY**

C. V. Dodd
Oak Ridge National Laboratory, Oak Ridge, Tenn.
International Conference on Nondestructive Testing, 4th, London, Sept. 1963, Proceedings, pp. 304-307 London: Butterworths, 1964

This report describes activity at O.R.N.L. which resulted in the development of equipment and techniques utilizing "light-off" insensitive eddy current inspection using phase measurements. Transistorized instrumentation was developed employing a driving coil to furnish the magnetic field and a pick up coil for measuring the transmitted field. Reactor components made of aluminum, stainless steel, and graphite have been inspected by these phase sensitive techniques. Probes, amplitude measurements, phase measurements and instrumentation, range and accuracy and applications are all covered.

4135 **PENETRATION OF TRANSIENT ELECTROMAGNETIC FIELDS INTO A CONDUCTOR**
Alex Grumet
Journal of Applied Physics, vol. 30, no. 5, May 1959, pp. 682-686

The case of a uniform electric field, infinite in extent, abruptly applied to the plane face of a semi-infinite conductor is considered. The amplitude of the field as a function of distance into the conductor and of time is then determined for different conductivities. Finally the time ans space nature of the applied electric field at distances far removed from the semi-infinite conductor is considered.

4140 **NONDESTRUCTIVE TESTING: A PROGRESS REPORT**
Andrew G. Forrest
Blast Furnace Steel Plant, vol. 53, no. 1, Jan. 1965, pp. 37-43

Developments in nondestructive testing techniques, both ultrasonic and magnetic as applied to resistance welded tubing and pipe, fusion welded pipe, continuous weld pipe, and seamless tubing and pipe, bar products; flat rolled products; billets, blooms and tube rounds. Testing equipment included an ultrasonic tester, electromagnetic tester, automatic bar classifier testing stations and sorting cradles, supersonic reflectoscope, portable ultrasonic pipe detector and a fluorescent magnetic particle surface quality inspection system.

4141 **METHOD AND APPARATUS FOR DETERMINING MOISTURE CONTENT OF DIELECTRIC MATERIALS BY MEASURING THE RATIO OF VOLTAGE CHANGES AT TWO FREQUENCIES**
G. W. Walls
Patent No. 3,155,902
Materials Evaluation, April 1965, p. 162

This patent describes a radio frequency capacitor technique for determining the moisture content of a dielectric material independent of the mass of the material. This is done by measuring the dielectric properties of the material at two different frequencies. The apparatus is comprised of a test capacitor having plates between which the material to be tested is passed. Two voltages of different frequencies are impressed across the plates by use of a capacitance bridge. The bridge output is connected to two bandpass wave filters (one for each frequency). The output of each filter is connected to a detector, which in turn is connected to a logarithmic amplifier. The outputs of the amplifiers are connected to a differential indicator which indicates a function of the ratio of the two dielectric constants. The ratio of the two simultaneously occurring voltages can be adjusted to be independent of the mass of the material and to be dependent only upon its moisture content.

4143 **NONDESTRUCTIVE METHODS OF EVALUATING COATING-METAL BONDS**

A. M. Baumanis, W. Lawrie
Armour Research Foundation, Chicago, Ill.
Rpt. ARF 1213-5, Sept. 1962
AD-296 977

The objective of the program was the development of ultrasonic methods is to examine the strength and continuity of ceramic-metal bonds. The investigations continued along two main paths. Further work was done on the measurement of Rayleigh wave attenuation and several limitations and effects not previously noted, were discovered. Further investigations were also made of the interferometric method of determining the properties of a coated specimen. A small proportion of the total effort was expended in investigating non-ultrasonic methods of inspecting ceramic metal bonds. In particular, thermal, electrical and nuclear methods were selected as possible appropriate techniques.

4149 **METALLURGICAL FACTORS INFLUENCING THE MAGNETIC ANALYSIS OF SURFACE HARDENED AND TEMPERED STEEL**

E. L. Bartholomew, Jr., R. Biederman
University of Connecticut, Storrs, Conn.
Final Progress Report, 1 Oct. 1963

Continued investigation has shown that residual stress, retained austenite, and percarbide formation in martensite plates influence the magnetic analysis of H-3620 steel. The effect of carbide appearance has been evaluated at constant levels of austenite and stress. Surface residual stress varied inversely with surface retained austenite. The austenite distributions varied exponentially with depth (case to core). Residual stress distributions for various heat treatments were similar, showing marked differences only near the surface.

4156 **PREPARATION AND EVALUATION OF HIGH PURITY BERYLLIUM**

G. E. Spangler, M. Herman and others
Laboratories for Research and Development, Franklin Institute, Philadelphia, Pa.
Qtrly. rpt., 2 April - 1 July 1962
AD-285 676

Contents: Zone refining; mechanical testing (tensile tests, compression tests); polycrystalline zone melted beryllium (hot rolling, texture studies); electron transmission microscopy (basal glide, prism glide, cross slip); eddy currents, (apparatus, experimental results); and self-diffusion in beryllium

4157 **DEVELOPMENT OF NONDESTRUCTIVE TESTING TECHNIQUES FOR THE HIGH FLUX ISOTOPE REACTOR FUEL ELEMENT**

R. W. McClung
Oak Ridge National Laboratory, Oak Ridge, Tenn.
Rpt. ORNL-3780. April 1965

A number of nondestructive testing techniques were evaluated or developed for the measurement of certain desired properties of HFIR fuel elements. These included through-transmission ultrasonics for nonbond evaluation with a demonstrated capability of finding nonbonds as small as 1/16 in diameter. A continuous scanning X-ray attenuation technique and related equipment were developed for the evaluation of fuel concentration variations. Scintillation detection of beam intensity variations and tapered calibration standards permitted both go-no-go inspections and complete recording of concentration variations. Orientation of the fuel gradient in the core of each plate was determined rapidly by the use of eddy-current instrumentation. Coolant channel spacing was gaged with an impedance technique using minute probe heads, which were custom developed and fabricated. Each of the cited techniques increased the assurance that the HFIR fuel element will perform within the stringent design levels that have been established.

4169 **A PULSED ELECTROMAGNETIC TEST SYSTEM APPLIED TO THE INSPECTION OF THIN-WALLED TUBING**

C. J. Renken
Argonne National Lab, Ill., March 1964
N64-21608

There is a considerable range of tube wall thicknesses over which both electromagnetic and ultrasonic methods are applicable. The inspection of tubes below 5.8 mm by ultrasonic methods is plagued by formidable alignment problems; on the other hand, it becomes difficult to maintain a defect sensitivity of 10% of the wall thickness by electromagnetic tests on tubes with over 0.64-mm wall thickness. In certain cases, noise in the tube caused by nondeleterious dimensional or metallurgical variables may produce a clear advantage of one method over another. This report explores the possible application of pulsed fields to electromagnetic testing and suggests test systems that would exploit some of the advantages of pulsed field operation.

4172 **EXPERIMENTAL ELECTROMAGNETIC TEST METHODS FOR THE NONDESTRUCTIVE EVALUATION OF CARBURIZED STEEL PARTS**

H. P. Hatch, K. A. Fowler
Springfield Armory, Mass., 29 April 1964, 72 pp.
AD-603 536

Several experimental electromagnetic test methods were investigated. The results indicate that accurate and rapid measure of the case depth of carburized parts can be made based on measurements of the phase of the third harmonic component of the secondary test coil voltage. This test parameter can be relatively insensitive to certain normal process variables. An a.c. inductance bridge was used to obtain measurements indicative of the tempering temperature and free ferrite content of the part. Results concerning the influence of retained austenite and residual stress on the magnetic comparator are also reported. Experimental procedures are outlined and results are discussed in terms of potential applications.

4181 **EVALUATION OF ANODIC COATINGS BY IMPEDANCE MEASUREMENTS**

E. T. Englehart and D. J. George
Material Protection, vol. 3, no. 11, Nov. 1964, pp. 24-30

Evaluation of anodic coating on aluminum by impedance measurements. Equipment requirements and operation directions for the procedure. Factors affecting impedance of anodic coating such as alloy variations, coating thickness, sealing, aging, and others. Commercial applications for the coating test.

4184 **EVALUATION OF EDDY CURRENT INSPECTION FOR HOT SODIUM BONDING IN STAINLESS STEEL CLAD URANIUM CARBIDE REACTOR FUEL ELEMENTS**

P. S. Vandervort, J. W. Morris, S. H. Fitch
Atomics International, Canoga Park, Calif.
Materials Evaluation, April 1965, pp. 196-199

Radac Model 440 eddy current equipment was evaluated for inspecting the sodium bonding of stainless steel clad uranium carbide nuclear reactor fuel rods. Using "Standard" fuel rods containing known simulated defects, experiments were run with numerous machine settings, recorder chart speeds, and rod travel speeds, to obtain optimum resolution of discontinuities. Excellent correlation between visual and eddy current inspection was obtained on over 80 fuel rods. Results of the evaluation indicated that the equipment is capable of reliably detecting and identifying voids, gas bubbles, and lack of bonding or welting as small as 1/8" diameter. Since this is less than the maximum amount of unbonding permissible, the eddy current technique was demonstrated to be suitable and adequate for the application under consideration.

4186 **METHODS AND APPARATUS FOR THE NONDESTRUCTIVE MEASUREMENT OF FILM THICKNESS**

P. Moller
Metall, vol. 18, no. 9, Sept. 1964, pp. 954-963 (In German)

Methods and devices for the nondestructive testing of thickness of metal coatings, such as Al on Cu, Cu on bronze, Cd on steel and plastic and lacquer coatings on metal surfaces. Use of X-ray back reflection, capacitor techniques and eddy current, magnetic and thermovoltage measurements.

4193 **AN IMPROVED EDDY CURRENT TUBING TEST**

H. L. Libby
Hanford Atomic Products Operation, Richland, Wash.
Materials Evaluation, April 1965, pp. 181-187

An eddy current tubing test has been developed which has new features to aid in the interpretation of the test coil output signals. Signal patterns for several different tubing test conditions are characteristically different and are readily identified. The major characteristics of the patterns are permanently recorded for future reference. Studies of the signal patterns obtained are being continued and means to provide automatic readout are being explored.

4206 **EVALUATING ALUMINUM ALLOYS BY NONDESTRUCTIVE TESTS**
D. Hagemaier, R. Kleint
Metal Progress, vol. 86, no. 5, Nov. 1964, pp. 115-118

Electrical conductivity tests on 2024, 2014, 6061, 7075 Al alloys to determine mechanical properties and verify heat treatment. Conductivity-hardness-heat treatment relationship for different tempers of the alloys. Factors affecting results, such as improper quenching or overranging.

4210 **WHAT ADDITIONAL STANDARDS ARE NEEDED IN NONDESTRUCTIVE TESTING? (AIRCRAFT)**
K. R. Wilson
Production Engineer, vol. 42, no. 2, Feb. 1963, pp. 88-90

Standardization of magnaflux, X-ray, ultrasonic and eddy current methods of nondestructive testing of ingots, billets, slabs, castings, bars, plates, and weldments for aircraft construction are discussed.

4219 **MAGNETOSTRICTION IN NICKEL ALLOY**
L. Berger
Carnegie Institute of Technology, Pittsburgh, Pa.
Physical Review, vol. 138, 1965, pp. A1083-A1085

This report discusses theoretical and experimental data showing that the magnetostriction should change sign in certain alloys.

4227 **QUALITY CONTROL AND NONDESTRUCTIVE TESTING OF DIELECTRIC COMPONENTS USING THE MICROWAVE THICKNESS GAUGE**
J. D. Leonard and G. T. Stropki
Ohio State University Research Foundation, Columbus, Ohio
OSU-RTD Symposium on Electromagnetic Windows, 2-4 June 1964, Proceedings, vol. 5
N65-11858

The factors that enter into the design of radomes (physical thickness, incidence angle, relative dielectric constant and wavelengths) are interrelated and can be considered together in terms of "electric thickness". It is this quantity that is observed in the various applications of interferometry to measurement and control problems. A highly successful device, a microwave thickness gage (MTG) was developed as a result of the need for greater precision in electrical thickness control. Radomes fabricated with the aid of the MTG have exhibited excellent properties and repeatability without the need for individual tailoring. The theory of operation and a discussion of the gage sensitivity are presented.

4230 **A MANAGER LOOKS AT NONDESTRUCTIVE TESTING**

Dr. Werner R. Kirchner
Solid Rocket Plant, Aerojet-General Corporation, Sacramento, Calif.
Materials Evaluation, June 1965, pp. 271-278

This discussion covers a nondestructive testing program designed for inspection of rocket motors. Covered are ultrasonics, dye penetrant, eddy current, gamma scintillation, and high energy radiography. Inspection commences at the billet stage and progresses through machining, bonding of the insulator, propellant inspection, hydrostatic tests etc.

4235 **ULTRA-STABLE EDDY CURRENT METHODS FOR DETECTING HYDRIDE IN ZIRCALOY-2**

Donald R. Green
Pacific Northwest Laboratory, Richland, Wash.
Materials Evaluation, June 1965, pp. 279-284

A new eddy current method using a unique comparator circuit was applied to detect concentrations of hydrides as low as 250 ppm in Zircaloy-2. Absorption of 250 ppm hydrogen by the zircaloy results in a 0.4% increase in the resistivity which can be detected with the instrument. Lift-off compensation was attained by referencing the eddy current bridge to the center of curvature of the probe motion signal locus on the complex voltage plane. Drift usually inherent in the center of curvature method of lift-off compensation was eliminated. A discussion of the new circuit is included, and correlations between the circuit output and metallographic analysis of the hydride content of the test pieces is shown.

4238 **ELECTRONIC INSPECTOR CHECKS BILLETS**

Iron Age, vol. 192, no. 21, Nov. 21, 1963, pp. 83

Description of an electronic tester for detecting flaws and seams in square and rectangular steel billets. The tester makes use of eddy current for detecting seams, and the position of the seam is automatically identified with a paint mark.

4247 **DEVELOPMENT OF NONDESTRUCTIVE TESTING METHODS FOR THE EVALUATION OF THIN AND ULTRATHIN SHEET MATERIALS**

G. Schmitz, A. Wireczorek, M. Levine
General American Transportation Corp., Niles, Ill.
Wright Patterson Air Force Base Contract No. AF 33 (657)-11228, ML TDR 64-278 DCC, Sept. 1964
AD-608 072

This report describes activity on the subject program for the first year including a survey of literature, equipment, research efforts, and nondestructive testing needs. As a result of this survey, the second portion of the first year's activity was directed toward the development of thin sheet nondestructive test instrumentation in the field of high frequency eddy current equipment, Lamb wave ultrasonic techniques, and electrostatic testing techniques. The eddy current instrument operates at 5 Mc. with future work being planned for frequencies to 50 Mc. The Lamb wave techniques are directed toward finding material parameter variations and laminations in thin sheet. The electrostatic tests utilized thin nonconductive samples with application to ceramic coated refractories is considered.

4253 **MEASUREMENT OF COATING THICKNESS BY MAGNETIC METHODS**
Friedrich Foerster
Industrial Finishing (London), vol. 15, no. 184, Oct. 1963, pp. 36-38, 40

Description of a standard coating-thickness gauge which is fitted with a large precision meter with a triplicate scale. Measurement of thickness of nickel-coatings on nonferro-magnetic base. The method is not affected by the permeability of the coating nor the conductivity of the base; whereas eddy current testing and the low-frequency alternating-current method are affected by the permeability and conductivity.

4265 **PRINCIPLES OF EDDY CURRENT TESTING**
Dr. Friedrich Foerster
Institut Dr. Foerster, Reutlingen, Germany
Bulletin MT-9, Magnaflux Corp., Chicago, Ill.; Metal Progress, vol. 75, no. 1, Jan. 1959, pp. 101-105

Describes a versatile method of nondestructive testing which is becoming more and more useful by the day. Defective specimens cause impedance of a test coil to vary, and these variations can be measured to determine several properties such as hardness, tensile strength, diameter, conductivity, and permeability.

4270 **TESTS FOR METALLIC COATINGS (In French)**
A. Kutzelnigg
Paris, France: Dunod, 1964, 223 pp.

Review of testing techniques to determine physical, mechanical, electrical, magnetic and optical properties of Al, Cd, Cu, Ni, Ag, An, Sn, Pb, brass, Au and Cr electrolytic coatings. Description of the methods used for the determination of thickness, uniformity, surface finish and porosity. Presentation of a detailed review of the different corrosion testing techniques.

4284 **STUDY OF HIGH-CURRENT RESISTANCE TESTING OF GROUNDED SHIELDED CHROMEL-ALUMEL THERMOCOUPLES**
H. F. Houke
Aerojet-General Corp., Sacramento, Calif., Aug. 1961
AD-459 284

Advantage of high-current resistance testing with respect to other methods is that is completely nondestructive, and is an accurate evaluation of the welded junction. A short time is required to conduct the test (approximately two minutes), and a relatively short time is required for data interpretation (approximately two minutes).

4286 **NONDESTRUCTIVE INSPECTION OF SPOT WELDS IN STEEL STRUCTURES BY MEANS OF A ZSK-2 MAGNETIC DEFECTOSCOPE (Polish)**
B. Calusinski, J. Gallar and A. Skorupa
Przeglad Spawalnictwa, vol. 15, no. 10, 1963, pp. 228-229

Describes a magnetic apparatus for inspecting spot welds. Tabular comparison of defectoscopic findings and tensile tests.

4288 **SCOPE RECONSTRUCTS FLAWS IN TUBES**
Iron Age, vol. 192, no. 24, Dec. 12, 1963, pp. 101

Application of eddy current techniques for the detection of defects and corroded areas in stainless steel generator heat exchanger tubes as small as 1/8 in. diam.

4304 ***DETERMINATION OF THE ADHESION BETWEEN ANTIFRICTION COATING AND SURFACE OF THE BEARINGS***
C. Bordoni
Fiat Technical Bulletin, vol. 1, no. 2, April-June 1963, pp. 43-47

Inspection of adherence between the antifriction coating and the surface of the bearings. Two nondestructive methods of inspection based on the variation of electric resistance and on ultrasonics are illustrated.

4309 **NONDESTRUCTIVE TESTING, QUALITY GUARANTEE OF STEEL CASTINGS**
R. Hubert and M. J. Thuillier
L'Usine Nouvelle, Jan. 1964 (Special Issue), pp. 89, 92-93, 96-97, 100-101, 104

Description of X-ray, gamma ray, radiography, ultrasonic testing transparency, reflection, sweating, pickling, magnetic detection and imperviousness tests to determine defects in various steel castings. Observation of metallic inclusion, blowhole, hot tear, shrinkage hold and crack defects.

4316 **QUALITY CLASSIFICATION FOR NICKEL COATINGS–BETTER CORROSION RESISTANCE BY NICKEL PLATING**
H. Heiner
Chemische Rundschau, vol. 15, no. 23, Dec. 1, 1962, p. 729 (In German)

Classification of Ni coatings on steel, brass, and Zn pressure die castings into quality groups and measurement of Ni film thickness by microscopic analysis and nondestructive techniques, including the "Magne-Gage" technique, which is based on magnetic measurements, and a thermo-electric method based on electrical resistance measurements using thermovoltages.

4317 **MEASUREMENT OF METALLIC DEPOSIT THICKNESS**
P. Morisset
L'Usine Nouvelle, Apr. 1963 (Special Issue), pp. 229, 231, 233, 235-236, 241, 243-244, 249, 251-252, 257 (In French)

Equipment and techniques for destructive and nondestructive chemical, optical, electrical, electron and magnetic determination of the thickness of Sn, Zn, Al, Au, Ni, Cr, Cd, Cu, Co, Ag, and Pb deposits on cast iron, steel, Al, Zn, Cu, brass, Fe, Mo, Zn alloy and Al alloy sheets, wires and components.

4324 **AN APPARATUS FOR CONTINUOUS MEASUREMENT OF WATER CONTENT OF FOUNDRY SANDS**

R. G. Godding and D. Bird
BCIRA Journal, vol. 11, no. 5, Sept. 1963, pp. 641-661

Measurement of the water content in clay bonded foundry sands by using the electrical resistance, capacitance, neutron and microwave absorption and nuclear magnetic resonance changes.

4326 **DEVELOPMENT OF NONDESTRUCTIVE TESTING INSTRUMENTATION FOR REACTOR PRESSURE VESSELS**

Warren J. McGonnagle
Southwest Research Institute, San Antonio, Texas
Rpt. SWRI-1296-6-2, 15 July 1963

An investigation is being conducted to develop a nondestructive testing technique for measuring the shift in the nil ductility transition temperature of A-212 Grade B steel. A correlation was found between the amount of cold working and magnetoabsorption, thermal conductivity, and ultrasonic attenuation. Magnetoabsorption measurements as a function of cold work in A-212 Grade B steel appear to be very promising. The measurement of the ultrasonic attenuation coefficient in cold work material by a through transmission technique showed a relationship between cold work and the attenuation coefficient. The thermal comparator shows applicability to measuring the level of cold work in A-212 Grade B steel. It appears that all three of the techniques evaluated have potential for determining the level of cold work in A-212 Grade B steel.

4337 **NONDESTRUCTIVE MEASUREMENT OF HARD Cr DEPOSITS BY *MAGNETIC AND ELECTRIC METHODS***

P. Morisset
Chrome Dur, 1961-1962, pp. 70-73 (In French)

Use of magnetic, electric or X-ray equipment to determine hard Cr deposit thickness on steel, cast iron, Al, Zn, Cu, Ni and Mo components.

4338 **PECULIARITIES OF DEFECT DETECTION IN HIGH PRESSURE WELDED VESSELS FOR CHEMICAL INDUSTRY**

V. I. Etingov, L. A. Guseva
Svarochnoe Proizvodstvo, no. 2, 1964, pp. 38-39 (In Russian)

Repairing of defective high pressure welded vessels of Cr-Ni-Mo steel, which operate in corrosive media at up to 300°C. by argon arc manual welding. A method is proposed for detection of cracks in welded seams which includes magnetic and ultrasonic flaw inspection of welds, hydraulic pressure testing and repeated magnetic and ultrasonic control.

4339 **NONDESTRUCTIVE TESTING EQUIPMENT AND TESTING INSTRUMENTS (In German)**
F. Wulf
Schweisstechnik, no. 6, 1962, pp. 259-261
FTD-TT 64-1332/1 and 2, 30 Apr. 1965 (Foreign Science and Technology Div., Wright-Patterson Air Force Base, Ohio)

A brief description of German nondestructive testing equipment which includes X-ray, ultrasonic, isotope and magnetic units.

4345 **THE NONDESTRUCTIVE TESTING OF TUBES IN ENGLAND**
E. S. Hughes
Industrie-Anzeiger, vol. 86, no. 16, 25 Feb. 1964, pp. 272-274 (In German)

Examples for nondestructive testing techniques employed in quality control in tube fabrication such as magnetic testing for cracks, eddy current technique and ultrasonic testing.

4353 **EFFECT OF SPECIMEN THICKNESS, CLADDING AND LIFT-OFF ADJUSTMENT ON THE CONDUCTIVITY OF 7075-T6 ALUMINUM ALLOY**
R. A. Chihoski et al.
National Symposium on Nondestructive Testing of Aircraft and Missile Components, 1st, San Antonio, 1960, Proceedings, pp. 18/1-18/13

Influence of cladding, paint or nonmetallic film thickness, and the resultant "lift-off" space between the metal surface and the measurement probe, is considered, with specimen thickness effects, in relation to the accuracy of readings by a conductivity meter.

4355 **MEASUREMENT OF SEMICONDUCTOR FILMS ON SUBSTRATES OF DIFFERENT CONDUCTIVITY ACCORDING TO THE FIVE POINTS TECHNIQUE.**
Heinrich Hora
Zeitschrift fur Angewandte Physik, vol. 15, no. 6, June 1963, pp. 491-496

Description of a technique for nondestructive measurement of the electrical resistance and thickness of semiconductor films on thicker substrates of different conductivity using a fivepoint measuring arrangement.

4359 **EXPERIENCE IN USING MAGNETIC METHOD FOR CONTROL OF TUBE HARDNESS (In Russian)**
P. I. Vit'ko, V. I. Roytman and A. V. Voznyy
Khimicheskoe Mashinostroenie, no. 4, 1963, pp. 35-36

Determination of hardness of ferromagnetic cold rolled and hot rolled ShKh15, 12KhN3A, 12Kh5MA and 20 steel pipes by using a device that measures the coercivity of the tested specimen which (coercivity) is compared with that of the standard specimen of known hardness.

4378 **THE CONTRIBUTION OF THE STEEL INDUSTRY TO A MEANINGFUL APPLICATION OF NONDESTRUCTIVE TESTING IN QUALITY CONTROL (In German)**
W. Rauterkus
Berg- und Huttenmannische Monatshefte, vol. 109, no. 1, Jan. 1964, pp. 26-31

Critical analysis of the development of nondestructive testing technique for steel products and their significance and limits in production control. The following techniques are included: X-ray transmission testing, magnetic techniques and ultrasonic methods.

4389 **PROBELESS METHOD OF MEASURING SPECIFIC RESISTANCE OF *HIGHLY ALLOYED SEMICONDUCTORS***
V. I. Fistul, O. B. Ormbeviskii
Zavodskaya Laboratoriya, no. 11, 1963, pp. 1327-1329

The method is based on the generation of eddy current in the tested specimen. Investigation includes depth of penetration of a high-frequency field in the semiconductor, measurement accuracy as related to specimen configuration and relation of sensitivity to specific resistance changes.

4400 **EFFECT OF ULTRASONIC VIBRATIONS ON CERTAIN MAGNETIC PROPERTIES OF THIN FILM**
N. G. Pak, S. G. Rusova
Physics of Metals and Metallography, vol. 17, no. 4, 1964

A study of magnetic properties of massive ferromagnetics and the effects of ultrasonics, coercive force, and distortion on these properties. It is shown that properties of ferromagnetic thin films have greater resistance than massive specimens to mechanical effects.

4412 **THE PRESENT STATUS OF NONDESTRUCTIVE TESTING IN STEEL FOUNDRIES**
C. M. Stoch and J. D. Lavender
Metallurgia, vol. 70, no. 417, July 1964, pp. 25-30

Nondestructive methods used in foundries for testing castings include ultrasonic testing, radiography, acid pickling and the use of pressure and magnetism. Data on the frequency of use of these techniques in foundries.

4413 **TAILORED TESTS UPGRADE COPPER**
P. Garatoni
Iron Age, vol. 193, no. 17, April 23, 1964, pp. 92-93

Increased nondestructive testing at lower cost is achieved by using eddy current devices to monitor phosphorus content in phosphorus-deoxidized Cu billets, check tolerances on Cu tubings and sort mixed lots of small diameter Cu tubings.

4422 **CONTACTLESS PROBES MEASURE BY CAPACITANCE**
Metalworking Production, vol. 108, no. 25, June 17, 1964, pp. 126-128

Nondestructive test method, called a contactless probe, which measures the geometrical relationships of a body by capacitance and impedance. Application to the measurement of bore diameter, bore ovality, bore eccentricity and dimensional changes.

4423 **METHODS FOR THE DETERMINATION OF THE THICKNESS OF ANODIZED FILMS**
Aluminum, vol. 40, no. 8, Aug. 1964, pp. 506-510 (In German)

Techniques for the thickness measurement of thin films such as anodized layers on Al surfaces by microscopic methods, by electrical techniques based on eddy current measurements and on measurements of the breakthrough voltage, and by X-ray techniques using radioactive isotopes as radiation source.

4427 **A WIRE MILL IN PARKLAND SETTING**
Wire Industry, vol. 31, no. 367, July 1964, pp. 679-682

Description of a mill and its materials handling and transport, cleaning, drawing and heat treating facilities producing 1000 tons of wire per month. Lime-coated carbon and alloy steel wire, 0.040 in. diam., and stainless steel wire to 0.056 in. diam. Production of semidrawn wire for later finishing, 0.001 in. diam. Eddy current on-line inspection is performed. Product applications include ball, roller and needle bearings, welding and metal spraying, sewing machine needles and watch pinions.

4438 **MAGNETIC QUALITY CONTROL OF NV STEEL DRILLS**
A. Stryk, A. Feill
Prace Instytutow Hutniczych, no. 2, 1964, pp. 87-100

Experiments on 5-mm diam. NV steel drills and on current production drills to determine feasibility of 100% nondestructive control of heat treatment by measurement of coercive force. Determination of coercive force in hardened drills by time and temperature of heating, and in tempered drills by hardening conditions and by time and temperature of tempering. Conclusion is that 100% control of NV steel drills by the magnetic method is possible.

4442 **INSPECTION OF BUTT WELDS BY A MAGNETIC METHOD (In Polish)**
B. Calusinski, J. Gallar, A. Skorupa
Przegl Spawalnictwa, vol. 16, no. 7-8, 1964, pp. 189-190

Use of transistorized magnetic defectoscope in the inspection of butt welded joints. Design and operation of the apparatus illustrated. Results obtained in testing compared with findings obtained by X-ray inspection.

4449 **THE NONDESTRUCTIVE TESTING OF REACTOR COMPONENTS BY EDDY-CURRENT METHODS (In German)**
F. Foerster
Metall, vol. 18, May 1964, pp. 450-460

Electromagnetic and magnetic methods of testing reactor components are discussed. Equipment, procedures, and examples of results are described.

4456 **THE DEVELOPMENT OF TECHNIQUES TO MEASURE THE DYNAMIC FILM THICKNESS AND FILM PRESSURE IN JOURNAL BEARINGS LUBRICATED WITH LIQUID POTASSIUM**
D. Grieser et al
Battelle Memorial Institute, Columbus, Ohio
Quarterly Progress Report 15, 15 May - 14 August 1964

The program to develop techniques for the static and dynamic measurement of liquid-potassium-lubricated journal-bearing film thickness, film pressure, and film extent has continued. The first phase, paper evaluations of a number of potential techniques to accomplish the program objectives, was completed. Of the techniques studied, the eddy-current and magnetic-inductance method were selected as being most favorable for the film-thickness and film-extent measurements. A device based on the Villari effect is being designed for measurement of the potassium-film pressure. The laboratory evaluations are approaching completion, and the designing of prototype transducers and supporting instrumentation has been started.

4457 **NEW QUALITY CONTROL TEST FOR ANODIZED ALUMINUM**
E. T. Englehart and G. Sowinski, Jr.
Modern Metals, vol. 20, no. 7, Aug. 1964, pp. 56-58, 60

Nondestructive method of evaluating the quality and performance of anodized Al. Drawbacks of the present accelerated tests are discussed. New methods is based on the measurement of impedance of the anodic coating. Method is rapid (1 to 2 min.) and is discriminating with regard to coating thickness and seal, regardless of the alloy employed.

4472 **INFLUENCE OF ANNEALING TEMPERATURE ON PHASE COMPOSITION OF QUENCHED FERRITE-AUSTENITIC Fe-Mn ALLOYS**
A. S. Nilonenko
Fizika Metallov i Metallovedenie, vol. 18, no. 1, 1964, pp. 139-141

Use of X-ray, magnetic, electrical and thermoelectrical testing methods for determination of hardness and concentration of epsilon, alpha and gamma phases in Fe-Mn alloys, containing from 6 to 12% Mn, after water quenching and isothermal annealing from 200 to 900 C. Curves given depicting the phase composition, hardness, coercivity, electrical resistance and thermo-emf on isothermal annealing temperature and Mn concentrations.

4481 **ELECTROINDUCTIVE INSTRUMENT FOR CHECKING DIMENSIONS AND DETECTING FLAWS IN METAL PRODUCTS**

A. T. Nikolaenko, N. L. Bondarenko
Russian Patent No. 155291, Translation FTD-TT 64-1282/1&2,
Wright-Patterson AFT, Ohio, 19 April 1965

The object of the invention is an electroinductive instrument for checking dimensions and detecting flaws in metal products, based on the method of excitation and recording in a controllable area of eddy currents, which contains an inductive pickup, a comparison pickup, a generator of electrical oscillations, an amplifier, an indicator, and electrical elements of regulation. To reduce the temperature error of the measuring pickup and to increase the precision of checking, the coil of the pickup is provided with an additional winding wound with double wire which is soldered at one end. The free ends of the wire are included in the circuit of the automatic compensator on the axis of the motor of which there are mounted slides of the elements of the temperature compensation of the measuring bridge.

4518 **ALL-UNION CONFERENCES ON ELECTRON MICROSCOPY AND NONDESTRUCTIVE METHODS OF TESTING**

Ye. Levin, W. Lukyanovich
Zarodskaya Laboratoriya, 1963, no. 10 (two papers)
Joint Publications Research Service, Washington, D.C., translations: JPRS-22443 and OTS-64-21112
N64-11923

Excerpts from reports on electron microscopy and nondestructive testing are presented. These excerpts include: (1) the use of the electron microscope in the study of the dislocation structure of metals, deformation processes, and the fine characteristics of the structural transformations during hot-working; and (2) X-ray and gamma-ray flaw detection, ultrasonic flaw detection, magnetic flaw detection, and luminescent flaw detection.

4529 **DEVICES FOR NONDESTRUCTIVE TESTING OF FINISHED AND SEMIFINISHED STEEL PRODUCTS**

H. Heptner
Maschinenbau, vol. 11, no. 10, Oct. 1962, pp. 426-428

Design, operation and applications of nondestructive magneto-inductive testing apparatus, including crack detector for rods and tubes up to 80-mm diam., hardness tester for needles, tester for sorting steels, tester for quality and hardness control, anisotropy and microstructure tester and wall-thickness meters.

4530 **NON-DESTRUCTIVE WELDING INVESTIGATION (EURAEC-244)**
Roentgen Technische Dienst N.V., Rotterdam
Rpt. EURAEC-244, 8 Feb. 1962

The rolled steel in thicknesses of 50, 100, 200 and 300 mm intended for test pieces to be welded was subjected to an extensive investigation. Ultrasonic research with both straight and angular probers, and a magnetic investigation was carried out on the sectional surfaces. It was noted that one of the plates (200-mm. thick) had rolling defects, the greatest of which had a length of at least 25 mm. in one direction. The disturbing influence of these discontinuities in the material on the noise transmission when using an angular prober was also investigated. The influence of absorption on the measuring sensitivity was checked by means of tests on 200- and 300-mm. thick material.

4538 **A NEW APPLICATION OF THE ARMASTEEL CASTING—THE AUTOMOTIVE CONNECTING ROD**
William B. Larson
General Motors Engineering Journal, vol. 9, no. 4, 1962, pp. 27-31

Casting procedures for producing Arma Steel connecting rods, normally a forged product, for use in the Buick Special (1962) automobile V-6 engine. Visual, magnetic, ultrasonic and X-ray inspection of cast connecting rods to determine the stress patterns with various rod loads, fatigue life and strains.

4551 **NONDESTRUCTIVE TESTING FOR MATERIAL CONTROL**
Giulio Cossio
Rivista di Meccanica, vol. 13, no. 295, 10 Dec. 1962, pp. 35-42

Design and operating details of the apparatus used for ultrasonic and magnetic testing of steel weldments, tubes, forgings, turbine rotors, springs and castings to determine their porosity, cracks, blowholes and discontinuities.

4556 **NEW DEVELOPMENTS IN THE FIELD OF THE MAGNETIC TESTING FOR CRACKS (German)**
Karl Deutsch and Volker Deutsch
Industrie-Anzeiger, vol. 85, no. 23, 19 March 1963, pp. 427-430

Review on new techniques and testing devices for the magnetic crack detection on steel surfaces with emphasis on the impulse magnetization technique, combined longitudinal and alternating magnetization for the detection of longitudinal and transverse cracks, and contact-less testing technique.

4574 **WAYS FOR THE AUTOMATION OF NONDESTRUCTIVE WELD-JOINT INSPECTION METHODS**
S. T. Nazarov
Foreign Translation FTD-TT 65-50, Wright-Patterson Air Force Base, Ohio, 14 May 1965

General discussions of various automated methods of inspection including fluoroscopy and ultrasonic inspection systems as well as a brief on electromagnetics.

4586 **MAGNETIC METHOD FOR MEASURING THE THICKNESS OF NICKEL DEPOSITS ON A COPPER SUPPORT (In French)**

B. Coutout, M. J. Barbier

Corrosion Anti-Corrosion, vol. 12, no. 8 Dec. 1964, pp. 383-386

Method and apparatus developed for spot checking thickness of Ni coatings, ranging from 1 to 50 microns, on a cathodic plate, can be used to measure such coatings on any flat copper support. Technique consists of evaluating the attraction, at any point on the specimen, between a permanent magnet and the ferromagnetic coating. 6 ref.

4587 **ON METHODS USED FOR FLAW DETECTION IN ARTICLES MADE OF PLASTICS**

S. T. Nazarov

Zavodskaya Laboratoriya, vol. 29, no. 1, Jan. 1963

Soft radiation, utilizing fine-focus tubes having beryllium windows provides good sensitivity when X-raying plastics. Exposure techniques are discussed. Also utilized for the detection of defects in plastics is the electro-spark method. It is claimed that minute defects, undetectable even by hydraulic pressure tests are easily revealed by the electrical discharge method.

4599 **DEVELOPMENT OF A NONDESTRUCTIVE INSPECTION METHOD FOR TITANIUM WELDMENTS**

H. H. Spieth, A. D. Warren

Douglas Aircraft Co., Santa Monica, Calif.

Rpt SM-44667, 7 Aug 1964

AD-608 069

Work accomplished during the program to develop a nondestructive inspection method for titanium weldments is presented. The most successful method developed was neutron activation analysis for oxygen and carbon detection. A vacuum hot extraction method using an electron beam welder successfully differentiated uniformly contaminated screening specimens but was unable to detect single contaminated passes in a two inch weldment. The electron beam spike apparently damaged the weld as well. Temperature coefficient of resistance and ultrasonics inspection methods were eliminated after the screening phase of the program.

4601 **NONDESTRUCTIVE TESTING OF LOW-COBALT STAINLESS STEEL FUEL CLADDING FOR CORE II, N. S. SAVANNAH. N. S. SAVANNAH FUEL DESIGN AND DEVELOPMENT PROGRAM**

G. L. Boshears, E. L. Dunn

General Electric Co. (Atomic Power Equipment Dept.), San Jose, Calif.

Contract AT(04-3)-189, 22 June 1960

Nondestructive (ultrasonic, eddy current, and fluorescent penetrant) and destructive tests were carried out on type 304 stainless steel tubing with low Co content (less than 50 ppm). The results show that the standards and techniques currently used will detect defects in excess of 10% of the wall thickness. Small laminar inclusions and voids were found in all the tubing; they did not appreciably affect the tube strength except under fatigue loading conditions. Eddy current techniques were found to be limited in their application to re-drawn tubing with small reductions.

4604 **WELD REPAIR AND INSPECTION PROCEDURES**

Martin-Marietta Corp., Denver, Colo.
DSR-S-11050, 6 Oct. 1964
AD-451 022

Contents: Section I – Review of weld defects causing leaks; Section II – Inspection and control techniques for aluminum fusion welds and weld repairs – state-of-the-art survey, comparative evaluation of inspection methods – (technique approach, radiographic inspection, ultrasonic inspection, penetrant inspection, eddy current inspection, destructive test evaluation of discontinuities); Section III – Repair welding study; Section IV – Weld defect repair by localized mechanical removal.

4628 **DETERMINATION OF INTERGRANULAR CORROSION WITH EDDY CURRENTS**

N. V. Khimchenko, V. H. Prikhod'ko
Khimicheskoye Mashinostroyeniye, vol. 3, May-June 1962, pp. 35-37
Tech. Memorandum 1147, Picatinny Arsenal, Dover, N. J., Sept. 1965 (U. S. Joint Publication Research Service Translation)

A method for determining the depth of penetration of transcrystallite corrosion is described and the results obtained by its use reported. The method is based on the excitation of eddy currents in the section to be tested and the establishment of their dependence on the electroconductivity of the material. The relative error does not exceed 4-5%, and therefore fully satisfies the industrial requirements.

4632 **INSPECTION OF THICK FILM LININGS**

D. H. Gelfer, B. Conrad
Amercoat Corporation, Brea, Calif.
Materials Protection vol. 4, no. 4, April 1965, pp. 26-30

This article covers the problems encountered in conducting continuity tests on plastic coatings in the 40 mil or thicker range. Plasticized polyvinyl chloride films are discussed to some extent. By utilizing the plastics dielectric properties, resistance measurements of the plastic cross section are performed by conduction equipment. Coatings of plastic over metal and concrete are covered as well as other types of coatings such as glass reinforced epoxy or polyesters.

4636 **DOUBLE FREQUENCY EDDY CURRENT INSTRUMENT FOR NUCLEAR FUEL CLAD TUBING INSPECTION (Japanese)**

K. Ono
Atomic Energy Society of Japan Journal, vol. 6, no. 8, 1964, pp. 13-20

Depth and location of defects in tube walls determined by nondestructive test instrument. Two pulse generators supply different frequencies to a driving coil; ratios of reflected amplitudes indicate position of defects.

4647 **ADVANCES IN NONDESTRUCTIVE TESTING**

B. Banks
Robert Jenkins and Co., Great Britain
Metal Industry, vol. 103, 19 Sept. 1963, pp. 390-393

This paper describes the developments in radiography, eddy current inspection, and ultrasonic testing. Various coverage includes gamma radiography, particle accelerators, xeroradiography, remote X-ray television systems, pulsed X-ray sources, automatic multi-probe ultrasonic inspection and eddy currents. General in nature.

4662 **A REVIEW OF NONDESTRUCTIVE TESTING FOR PLASTICS: METHODS AND APPLICATIONS**

N. T. Baldanza
Plastics Technical Evaluation Center (PLASTEC) Picatinny Arsenal, Dover, N. J.
Plastec Report 22, August 1965

A review of nondestructive test methods and applications for plastics is presented. Included are the activities of both industrial and governmental establishments within this area, with special reference to specifications, significant defects, and test methods. Recent techniques for certain missile and aircraft components are discussed. The information presented is particularly applicable to those readers desiring a general review of the science of nondestructive testing and a better understanding of its scope for plastics. Included are the tests which were felt to be applicable. These are defined, discussed, and frequently illustrated. Included are listings of 146 references used, and a bibliography of 254 items.

4663 **PHASE SENSITIVE EDDY CURRENT TEST EQUIPMENT**

T. A. Cox
Frankford Arsenal, Philadelphia, Pa.
Memorandum rpt. M66-2-1, August 1965

Nondestructive test equipment was developed to detect an eddy current signal voltage and to automatically resolve it into in-phase and quadrature components. The equipment was then used to perform various tests for the determination of its applicability to hardness measurements of ferrous materials and case depth measurements of ferrous parts. Test results using the automatic phase detection technique were promising, and it is believed that practical systems can be developed for the automatic hardness testing of ferrous materials. Deficiencies in the uniformity of metallurgical characteristics of the reference materials prevented linear correlations from being achieved. Special emphasis will be placed on the procurement of specimens with the desired metallurgical characteristics during the next phase of the program.

4664 **RADIOACTIVE MAGNETIC FLAW DETECTION COMPOSITION AND PROCESS FOR MAKING SAME**

Z. Kazenas, R. A. Ward (to John D. Steele)
U. S. Patent 3,155,622, Nov. 3, 1964, Filed Aug. 3, 1959

A radioactive paramagnetic powder for use in magnetic methods of nondestructive testing may be made by dispersing a powdered paramagnetic material and a carrier material for radioactive elements in a resin prior to final solidification of the resin, solidifying the resin, and grinding to a fine powder. The powder may be immediately or later dispersed in a fluid dispersion of radioactive material to bond the radioactive material and the carrier material together. A fluorescent dye may also be added to make the particles both radioactive and fluorescent. The carrier component may be either a chelating material or a resinous ion-exchange material. The radioactive material may be 137-Cs, 60-Co, 204-Tl, 147-Pm, 144-Ce, 152-Eu, 154-Eu, 46Sc, or 198-Au in either positive or negative ion form.

4670 **NEW USES FOR HALL-EFFECT**

Albert R. Hilbinger
Aircraft Armaments Inc. Cockeysville, Md.
Electronics, vol. 37, no. 3, 17 Jan. 1964, pp. 30-32

This article points out some of the important advantages of Hall multipliers despite their inherent low efficiency. Their simplicity and wide dynamic range offsets their low efficiency. A few applications are presented and described. Their rugged simplicity and low cost are factors to be considered.

4683 **DEVELOPMENT OF NONDESTRUCTIVE METHODS FOR THE EVALUATION OF THIN AND ULTRA THIN SHEET MATERIALS**

M. B. Levine, G. Schmitz, A. Wieczorek
General American Transportation Corp., Niles, Ill.
Wright-Patterson AFB Contract AF33(657)-11228; Prog. rpt. no. 2, Feb. 1964

Preliminary experiments utilizing electrostatic methods are described in addition to preliminary experiments to evaluate commercially available eddy current and ultrasonic test equipment. A need is indicated for high frequency eddy current equipment which is to be developed in the next quarter. The experimental procedure for using ultrasonic Lamb waves to measure the properties of specially prepared, controlled parameter, aluminum samples is also discussed. Appendices contain a description of the sample properties, a tabulation containing the results of a survey of 254 test equipment manufacturers and 450 abstracts of technical articles.

4685 **USE OF EDDY CURRENTS IN THE ANALYSIS AND INSPECTION OF THE STATE OF ALUMINUM ALLOYS (Russian)**

O. L. Bendryshev and N. V. Dorosheva
Zarodskaya Laboratoriya, no. 1, 1965, pp. 65-69

Application of a device which uses eddy currents for the inspection of Al alloys. Data, obtained from measurements of electroconductivity made on this device, are presented for 19 alloys. Effect of crystal structure, cladding layer, mechanical work hardening, grain size and temperature on degree of electroconductivity was studied.

4689 **METHODS AND EQUIPMENT FOR THE MEASUREMENT OF COATING THICKNESSES (German)**
H. Plog
Galvanotechnik, vol. 56, no. 5, 15 May 1965, pp. 261-301

Destructive methods are knife-edge penetration, grinding or filing, micrometer measurements, chemical removal and weighing, rate of penetration and peeling, dipping and spot analysis, calorimeter determination of heat of decomposition, electrolysis, breakdown voltage and spectographic analysis. Nondestructive methods are calibration of analytical balance, study of adhesive quality, magnetic inductance, eddy currents, capacitance and thermoelectric effect. Optical methods utilize interference, reflectivity and photoelectric effect. Measurements by emission and detection of radiation are given. Principles, application possibilities and limits of methods are described. 27 ref.

4693 **PHASE SENSITIVE EDDY-CURRENT CONCENTRATOR**
Engineering Materials, Oak Ridge National Lab., Tenn.
Rpt. CAPE-1139

This non-destructive testing instrument was originally designed to inspect graphite spheres; however, it is also useful in detecting flaws in any non-magnetic material. The device generates an electromagnetic wave, which induces eddy currents in the conductor being tested. The transmitted or reflected wave is measured by a pickup coil. The voltage differential between the driving and pickup coils permits accurate measurement of stainless steel thickness as great as 1.25 cm (0.5 in). (For details, see *TID-4100.)*

4698 **GUIDE TO NON-DESTRUCTIVE TESTING IN CORROSION PROTECTION**
L. Mossom
Corrosion Prevention and Control, vol. 12, no. 4, April 1965, pp. 19-22

Nondestructive test instruments for determining thickness of protective coatings on metals may be based on magnetic, eddy current or nucleonic back scatter measurements. Designs of typical instruments of each type are illustrated. A wet sponge pinhole detector is used to determine porosity in insulating coatings applied to metals. In measuring the extent of existing corrosion in such items as boiler and heat exchanger tubes and ship plating, eddy current and ultrasonic techniques are most suitable.

4703 **MULTI-METHOD NONDESTRUCTIVE TESTING SYSTEMS**
Tracy W. McFarlan
Paper No. 724, 1965; ASTME, 20501 Ford Rd., Dearborn, Mich. 48128

Ultrasonic and magnetic particle inspection techniques were combined into a single multimethod system for the inspection of rectangular and round steel billets from 12 to 40 ft. long with cross sections from 2¼ to 8 in. The multimethod system is used for inspecting glass-epoxy rocket motor chambers using corona, eddy current, beta-ray back scatter and microwave techniques for detecting resin-to-glass-ratios, insulation thickness, voids and delaminations. Electric resistance welded pipe requiring 100% inspection at mill speeds up to 120 ft/min is checked by the following methods: magnetic particle testing, pulse ultrasound, eddy current testing, and a through-coil technique to detect surface defects. Advantages of the nondestructive multisystem test package are: reduction in materials handling and testing time; improved reliability and reduced total inspection cost. By using this system, parts are tested by more than one method to assure thorough inspection, usually at a production line rate with automatic handling facilities. (ASM M19-31187)

4707 **ANALYSIS OF THE RESISTIVE LAYER TRANSDUCER**

John L. Scales
Harry Diamond Laboratories, Washington, D. C.
TM-65-5, 15 June 1965
AD-619 226

In a piezoelectric semiconductor, a surface layer of high resistivity material is driven by an alternating electric field, while the conducting substrate is mechanically coupled but not driven electrically. This analysis shows the response of the composite system, giving the behavior with frequency and effects due to loading. For reasonable (low) values of the attenuation constant, it is shown that the effect of the substrate is to lower the amplitude of vibration but leave the resonant frequency almost unchanged. An assumption, which limits the analysis, is that the proportionality constant between stress and rate of change of strain is independent of frequency.

4708 **NONCONTACT MAGNETIC-HARDNESS GAUGE FOR CONTINUOUS TESTING OF STEEL STRIP**

G. Quittner*, H. Hansen, Jr.**
*A.P.I. Instruments Co., Chesterland, Ohio; **United States Steel Corp., Gary, Ind.
ISA Transactions, vol. 4, 1965, pp. 275-280

This article describes a noncontacting device which operates by magnetics and developed for sensing of magnetic hardness of strip tin plate at high speeds. Magnetic hardness is correlated with physical hardness and other metallurgical factors.

4714 **THEORY OF THE LOOSE CONTACT PROBE USED IN TESTS BASED ON EDDY CURRENTS**

V. S. Sobolev
Institution of Automation and Electrometry, Siberian Div., Academy of Sciences, U.S.S.R.
Defectoscopy, 1965, no. 1, pp. 1-11

This article gives the theory of the subject matter and also an analysis of the results and recommendations on the design of equipment having loose contact probes. Discussions are presented on contactless measurement of electric conductivity, thickness measurement of conducting sheet material, nonconducting coating thickness measurements and problems encountered in defect detection in metallic parts.

4715 **ELECTROMAGNETIC PROCESSES IN A CONDUCTING PLATE GENERATED BY PULSED MAGNETIC FIELDS**

A. I. Kadochnikov
Institute of Physics of Metals, Academy of Sciences, U.S.S.R.
Defectoscopy, 1965, no. 1, pp. 12-17

This paper is devoted to the non-steady state electromagnetic processes occurring in magnetic materials. A uniform plane-parallel plate of constant permeability, infinite length and width, and finite thickness is subjected to a uniform magnetic field. A mathematical analysis of the resulting complex electromagnetic process in the plate is reduced to two simple problems. The paper proposes a simple approximate solution to facilitate practical calculations.

4716 **MAGNETOGRAPHIC TESTING OF WELDED STEEL JOINTS IN LONG-DISTANCE AND OTHER PIPELINES**

A. S. Fal'kevich
Institute for Construction of Main Pipelines, Moscow, U.S.S.R.
Defectoscopy, no. 1, 1965, pp. 18-25

This article describes the use of the magnetic-tape method for detection of cracks, porosity, lack of fusion and inclusions in welded joints. A cathode ray tube is also used which produces an after-glow and in turn, a visible picture of the magnetic field. The shape of this display corresponds approximately to the shape of the defects. Cost is said to be minimal when compared with radiography.

4717 **METHOD OF THE APPLIED FIELD IN FERROPROBE TESTING OF TUBE BLANKS FOR SURFACE DEFECTS**

N. N. Zatsepin, V. E. Shcherbinin
Institute of Physics of Metals, Academy of Sciences, U.S.S.R.
Defectoscopy, 1965, no. 1, pp. 27-31

This paper describes an investigation carried out to develop test apparatus capable of screening steel rounds into three categories: acceptable, blanks with surface defects which could be machined out, and scrap blanks. Micro probes were utilized and acted as gradient meters. The magnitude of the signals gave a certain correlation with the actual size and shape of the defect as well as the defect depth.

4718 **INVESTIGATION OF THE DEFECT FIELDS IN HIGH-SPEED ELECTROMAGNETIC TESTING OF RAILS**

B. P. Donvar, V. A. Shcherbinina
Defectoscopy, 1965, no. 1, pp. 32-40

This article discusses an experimental comparison of rails under dynamic and static states of magnetization in areas of natural defects. An increase in the magnetizing field of the detection carriage and placing the search coil nearer to the electromagnetic pole will increase the efficiency of detection.

4719 **SOME FEATURES OF THE ACOUSTIC-IMPEDANCE METHOD IN DEFECT DETECTION**

Yu V. Lange
Defectoscopy, 1965, no. 1, pp. 32-39

Electric resistance between the dry point contact probe and the test piece is discussed. This method is said to be suitable for detecting lack of bond between metallic and non-metallic joints, sandwich structures and brazed joints. Automatic recording equipment is now available. Contact tips should be constructed of material with high modulus of elasticity and they should have large radii of curvatures.

4720 **NONDESTRUCTIVE WELDING**

Roentgen Technische Dienst N. V. Rotterdam (US-Euratom R/D Program)
Rpt EURAEC 1342, 30 March 1965

Results of ultrasonic examination of 200 and 300 mm thick welds are compared with destructive tests. Test specimens were X-rayed, etched and subjected to macroscopic and magnetic examination. All discontinuities detected by ultrasonics were confirmed in the destructive tests. Position of defects showed accuracy of less than 5 mm. No correlation between echo-amplitude and defect size.

4729 **RECENT DEVELOPMENTS IN PIPE AND TUBE INSPECTION TECHNIQUES**

G. C. Page
Metallurgist, vol. 3, no. 10, Aug. 1965, pp. 218-223

On-stream corrosion inspection of pipe and tubing is limited to ultrasonic, radiographic and electrical resistivity techniques. Ultrasonic methods can be used on wall thicknesses of 1½ mm up to 10 m with high accuracy but require skilled operators and relatively expensive equipment and do not leave a permanent record. X-ray and gamma-ray inspections provide a permanent record with portable equipment, but present a potential health hazard. Although electrical resistivity methods permit a continuous instantaneous check of corrosion at the test point, they have not been applied commercially because of expensive equipment requirements. Off-load inspection techniques include: eddy current testing, caliper gaging, television inspection, cinematographic inspection and direct viewing; eddy current testing is the most widely used for nonferrous materials.

4736 **HARMONIC ANALYSIS METHOD FOR THE NONDESTRUCTIVE DETERMINATION OF CASE DEPTH OF CARBURIZED STEEL**

K. A. Fowler and H. P. Hatch
Springfield Armory, Springfield, Mass.
Rpt. SA-TR 19-1514, 30 Nov. 1965

An investigation concerned with the nondestructive determination of case depth by harmonic voltage analysis measurements is described. A prototype test instrument was designed and constructed which permits rapid, accurate measurement of the amplitude, phase, and in-phase and quadrature components of harmonic frequencies generated by the test piece under the influence of sinusoidal applied field. The design is such that a wide range of frequency and strength of applied field can be investigated. Results obtained by harmonic analysis are primarily produced by the additional surface carbon content achieved by the carburizing process rather than such secondary factors as residual stress or retained austerite. Effective separation of two simultaneous changing variables (i.e., case depth and tempering temperature is possible).

4740 **A PULSED EDDY CURRENT TEST SYSTEM USING REFLECTED FIELDS**

C. J. Renken
Argonne National Laboratory, Argonne, Ill.
Materials Evaluation, Dec. 1965, pp. 622-627

In the past, eddy current fields have almost always been sinusoidal, or near sinusoidal, functions of time. Pulse fields seem to be a fairly recent development. It appears that some of these test systems offer certain advantages over existing sinusoidal equipment. An understanding of how the pulsed eddy current equipment operates requires at least a quantitative knowledge of the behavior of pulsed current fields in a dispersive medium. This paper is an attempt to supply some of this information.

4753 **FUNDAMENTALS OF SOLID STATE WELDING AND THEIR APPLICATION TO BERYLLIUM, ALUMINUM, AND STAINLESS STEEL**

D. Hauser, P. A. Kammer and D. C. Martin
Battelle Memorial Institute, Columbus, Ohio
Rpt. RSIC-437, 15 July 1965

This report represents the results of a state-of-the-art survey of solid state diffusion welding and roll welding of aerospace metals. Particular emphasis is given to beryllium, high-strength aluminum alloys, and type 321 stainless steel. Includes a bibliography of 130 items. Also includes nondestructive testing techniques for solid state welded joints, and their applicability.

4755 **MICROSTRUCTURE DETERMINATION OF MOLYBDENUM – CHROMIUM – VANADIUM STEEL BY MAGNETIC ANALYSIS**

Rudolph V. Giangrande
U. S. Army Materials Research Agency, Watertown, Mass.
Rpt. AMRA-TR-64-36, Nov. 1964

The theory of complex coil impedance is presented and the effect of steels with varying microstructures on impedance behavior is indicated. A system design employing harmonic analysis is presented and correlations of electro-magnetic properties to microstructure are discussed.

4757 **THE MAGNETIC REACTION ANALYZER – A NEW EDDY CURRENT NONDESTRUCTIVE TEST**

R. C. McMaster
Technical Report No. D5-10.3, Oct. 1965. Metals Park, Ohio: American Society of Metals

Discussion of a new nondestructive test instrument for eddy current, magnetic field and displacement measurements. It permits noncontacting measurements of magnetic permeability, electrical conductivity, and thickness of materials (both ferromagnetic and nonmagnetic conductors) and coatings over a frequency range of 20 cps to 100 kc. It can also be used as a static or dynamic displacement gage (for vertical displacements above a conducting surface, or horizontal displacements from an edge or slit in a conductor.) Potential applications in nondestructive testing, process control, and dimensional measurements are described.

4759 **"AUTOMATIC" FLAW INSPECTION**

R. R. Webster, W. M. Smith and R. E. Kronk

Technical Report No. D5-10.1. Oct. 1965. Metals Park, Ohio: American Society for Metals

Development of inspection systems for steel products such as billets, pipe, rods, wire, plate and strip; each has a unique set of requirements. A few examples of mechanized techniques demonstrating the present status of the art are given. Early inspection is important since defects can often be removed or defective material set aside to avoid further finishing expense. Four basic techniques include: ultrasonics, eddy-current, magnetic leakage flux and X-ray fluoroscopy.

4767 **A MAGNETOGRAPHIC METHOD OF INSPECTING WELDED JOINTS (Russian)**

L. S. Denisov and V. S. Kozlov

Svarochnoe Proizvodstvo, 1965, no. 7, pp. 16-18

Detection of nonfusion, gas holes, slag inclusions and cracks in welded seams by a magnetographic method is described. Details of magnetization of inspected piece and deciphering of magnetic fields fixed on ferrotape are presented, as well as descriptions of applicable magnetizing and reproducing devices. Sensitivity and reliability of this method are discussed.

4768 **THE NONDESTRUCTIVE TESTING OF CAST STEEL (German)**

S. Silber

Radex Rundschau, Feb. 1965, no. 1, pp. 388-392

Increased requirements of cast steel materials necessitate the application of physical methods for nondestructive testing of the surface as well as of the internal zones of the material; description of the apparatus and methods for the magnetic detecting of cracks, radiography and ultrasonic testing of cast steel which proved to be successful in practice; cycle of the test.

4774 **MAGNETIC AND ELECTROMAGNETIC METHODS FOR NON-DESTRUCTIVE TESTING OF CASE DEPTH ON SURFACE HARDENED SEMI-FINISHED PRODUCTS AND FINISHED PARTS (German)**

Theobald Jakel

Materialpruefung, vol. 7, no. 7, July 1965, pp. 243-250

Properties of the hardening depth as a magnitude for testing are dealt with and are very important for the choice of suitable method. Three applicable methods; residual field method, yoke-flux method and alternating field method are described. The magnetic processes common to them are outlined and the physical laws determining the capacity of each method are explained. Properties of the basic shapes of measuring coils are discussed by means of the equivalent diagram of their magnetic circuits. This analysis facilitates the development of the transition form of coils which are adapted to special problems of practical testing.

4775 **NONDESTRUCTIVE TESTING OF IRRADIATED MATERIALS IN THE UNITED STATES**

R. W. McClung, D. Douglas, Jr.
Oak Ridge National Lab., Tenn.
Rpt. ORNL-P-1109, 1965
For presentation at International Symposium on Working Methods in High Activity Hot Labs., Grenoble, France

New demands for nondestructive evaluation of radioactive specimens of high-activity hot laboratories have required extensive development of new techniques. Several methods using external radiation sources have needed greater development beyond that necessary for cold laboratory operation. Radiation techniques which are discussed include neutron radiography, X-radiography, gamma attenuation, and the use of X-ray sensitive television. Many other methods such as ultrasonics, eddy currents, liquid penetrants, and leak testing have been possible by making mechanical modifications to allow the test to be performed remotely.

4797 **DEVICE FOR TESTING METAL SHEETS BY MEASURING THE TIME REQUIRED FOR ELECTROMAGNETIC PULSES TO PASS THERETHROUGH**

Claus J. Renken, Jr.
U. S. Atomic Energy Commission
U. S. Patent 3,189,817, 15 June 1965

A device for the nondestructive testing of conductive metal sheet is described. The device comprises a first coil mounted on one side of the metal sheet and spaced therefrom and a second coil mounted on the other side of the sheet and spaced therefrom. Means are provided for applying a pulsed signal to one of the coils and for detecting the time delay of the signal received by the other coil due to the presence of the metal sheet.

4799 **EDDY CURRENT METHOD FOR EVALUATION OF INTERGRANULAR CORROSION IN AUSTENITIC STAINLESS STEEL (Japanese)**

T. Ishihara, G. Ito, Y. Shimizu
Corrosion Engineer, vol. 14, no. 7, July 1965, pp. 9-15

An attempt was made to employ the eddy current principle for the development of nondestructive test equipment for the quantitative assessment of intergranular penetration suitable for stainless steel. An instrument was successfully made which was capable of indicating direct meter readings for quantitative assessment of intergranular penetration in type SUS 27 or 32 austenitic stainless steel. Standardization of the instrument was made under varied experimental conditions. Various factors, such as chemical composition, cold working and thickness of the specimen had great influence, while degree of surface roughness and nature of oxide film had a negligible influence.

4802 **QUALITY CONTROL OF ROD AND BAR PRODUCTS – PT. 2**

R. Stewartson, V. H. Bartlett and L. L. Davies
Wire Industry, vol. 32, no. 380, Aug. 1965, pp. 757-762

Control of finishing temperatures, determination of cooling rates, and use of escapement type cooling beds are discussed. Final testing of rolled products includes spark testing, testing for internal soundness by nick-fracturing, slug testing or upset testing, torsion testing, dimensional checks by micrometer, Magnaflux, optical analysis by shadowgraph and sampling by tensile hardness and Charpy or Izod tests.

4807 **OBSERVATION OF FERRITE AND MARTENSITE IN AUSTENITIC STEELS BY THE MAGNETIC METHOD (Symposium—Summary in Czech)**

A. Szombatfalvy

O Neresav Ocelich, 1961, pp. 207-210, 211-221

A magnetic apparatus has been devised for high-speed nondestructive observation of ferromagnetic phases and determination of their content in austenitic steel. A transformer with an open core is placed on the specimen closing the magnetic field of the transformer. In the secondary winding the transformer is induced by the emf, which is proportional to the quantity of the ferromagnetic phases. The induced voltage can be measured with a galvanometer. The apparatus can be used to control the quantity of martensite in the austenitic steel, the quality of its heat treatment and for other testing. (ASM M-13-34723, abstract only)

4831 **ANALYSIS OF THE HEAT-AFFECTED ZONE IN 2014-T6 WELDMENTS BY NONDESTRUCTIVE (EDDY CURRENT) METHODS**

Don Hagemaier and G. J. Basl

North American Aviation, Rocketdyne Div., Canoga Park, Calif.

U. S. Army Missile Command Contract DA-20-113-AMC-1052(Z), c. 1966-7.

Eddy current, conductivity, and hardness plots were taken across fusion welds in 2014-T6 material. Tensile strength data was correlated with conductivity and hardness. Variations in conductivity and hardness were noticed across the heat-affected zone of weldments fabricated with and without chill bars. Test results indicate that mechanical property degradation of 2014-T6 material due to over-aging or improper quench delay can be determined by the hardness-conductivity relationship using a "Magnatest*" FM-110.

*Trade name—Magnaflux Corporation, Chicago, Ill.

4863 **SYSTEM FOR MEASURING SEEBECK COEFFICIENT AND RESISTIVITY**

J. E. Ivory

U. S. Naval Research Laboratory, Washington, D. C.

NRL Report, 6044, 19 Feb. 1964

AD-433 673

A system has been devised which combines a rapid method for measuring Seebeck coefficient with the Dauphinee and Mooser circuit for measuring resistivity. This system can be used from liquid hellium temperature to 1000°C. A temperature range from room temperature to 1000°C and back can be covered in less than 3 hours giving about 20 data points per hour for each of the two quantities measured.

4866 **TESTING FOR CRACKS WITH PARAMAGNETIC FLUORESCENT MEDIA**

C. G. Nestler

Die Technik, vol. 22, no. 11, Nov. 1965, pp. 725-727

U. S. Dept. of Commerce, translation 66-30508 (JPRS transl. 34,066), 9 Feb. 1966

This report discusses the use of wet and dry fluorescent particles in conjunctin with magnetic testing. A new fluorescent paste is described that is said to increase the reliability of crack detection tests.

4868 **NONDESTRUCTIVE METHODS FOR THE DETERMINATION OF DELTA FERRITE IN AUSTENITIC STEELS**

Karl Spiegelberg and Heinz Haupt
Neue Hutte, vol. 10, no. 8, Aug. 1965, pp. 480-484

Two nondestructive magnetic measuring methods are tested with respect to their relative applicability to the determination of delta ferrite in austenitic stainless steels, including welds and weld base material. Both methods are based on permeability and permeability difference measurements. Both prove to be suitable–following the establishment, with conventional methods, of calibration curves–for the nondestructive determination of the average ferrite content in specimens of a minimum size or of identical dimensions. In larger workpieces, these methods also permit the determination of the quantitative distribution of the ferrite. The accuracy of measurement is a function of the method of calibration and was found to be ±2% of the ferrite phase with metallographic calibration. The instruments described are suitable for production and quality control, weld testing, etc.

4869 **THE TESTING OF HOT ROLLED PRODUCTS WITH GAMMA RAYS (German)**

A. Kohn
Neue Hutte, vol. 10, no. 9, Sept. 1965, pp. 561-564

Hot rolled slabs of 75-100 mm thickness and billets of up to 200 x 210 mm cross section of Thomas steel, free machining steel, openhearth and electric furnace are tested. These hot rolled steel products are tested for rolling defects by gamma transmission; the apparatus consists of a radioactive Co cource in conjunction with special scintallation counter. The resolution of this simple testing device is sufficient to detect slag inclusions. Small defects, however, cannot be detected. Further development of this simple testing device increases the sensitivity considerably so that the commercial production of this gamma tester can be initiated.

4870 **MAGNETIC COMPARATOR INSPECTIONS**

A. Lindgren, J. Kagay, J. Moody and G. McCasland
Modern Castings, vol. 48, no. 5, 1965, pp. 154-164

A report on applicability of magnetic sorting instruments in malleable iron work and the basic theory underlying their use. The magnetic sorting instrument used in the foundry consists of a scope and a pair of almost identical through-type coils. All instruments of this type read only the effective permeability of the casting placed within the sensing coil so that a successful sort can only be made when the variable being sorted for, such as hardness, is larger than all other variables combined. A running check on actual hardness by Brinell should be maintained on all castings being set aside and setup samples consisting of a casting which is borderline high and a casting which is borderline low are a must for exact work. Methods of sorting for variables other than hardness are described. A practical setup in which any one of four methods of sorting can be employed and typical oscilloscope presentations is described.

4879 **AUTOMATIC PRODUCTION TESTING OF ELECTRIC RESISTANCE WELDED-STEEL PIPE**

W. C. Harmon
Republic Steel Corporation, Cleveland, Ohio
Materials Evaluation, March 1966, pp. 136-144

An article describing ultrasonic and electromagnetic testing equipment and techniques for the automatic production testing of welds in electric resistance welded steel pipe. Pipe diameters range from 6-5/8 inches to 16 inches inclusive. The paper covers many of the problems encountered in developing the tests, and describes how the problems were solved by the proper application of ultrasonic and electromagnetic testing theory. Similarities and differences in the test results of the two test methods are discussed. The capabilities of both tests in registering major weld defects are demonstrated by charts and photographs.

4882 **THE AIR FORCE REQUIREMENT FOR NONDESTRUCTIVE TESTING**

Hq. Middletown Air Material Area, Olmsted Air Force Base, Pa.
Presented at the Third Annual Aerospace Conference on Nondestructive Testing,
Georgia Institute of Technology, Atlanta, Georgia, 2-3 May 1966

This paper traces the development of the Air Force NDT program. It lists the NDT equipment presently available to Air Force maintenance activities for use in the optical, magnetic particle, penetrant eddy current, ultrasonic, and X-ray methods of inspection. Several routine and developmental NDT applications to Air Force equipment are illustrated and discussed. The Air Force is embarked on a concerted program to save lives, time, and money through the maximum economical use of NDT methods, and at the same time, to provide the United States with a better deterrent through more reliable weapons.

4884 **NONDESTRUCTIVE TESTING OF LAUNCHER COMPONENTS**

S. G. Walker
ARO, Arnold Air Force Base, Tenn.
Proceedings, Fifth Annual Symposium on Nondestructive Evaluation of Aerospace and Weapons Systems, Components and Materials, San Antonio, 20-22 April 1965, pp. 19-42

The Von Karman Gas Dynamics Facility performs tests in wind tunnels to determine the effects of airflow on the shapes of aircraft, missiles, satellites and space vehicles at simulated flight conditions. Design, manufacture, quality control and maintenance of the components used in the launchers of the ranges—which provide another means of hypervelocity testing—are discussed in this paper.

4889 **APPLICATION OF NEW MAGNETIC METHOD FOR MINUTEMAN ROCKET CASE INSPECTION**

E. Oakey
Southwest Research Institute, San Antonio, Texas
Proceedings, Fifth Annual Symposium on Nondestructive Evaluation of Aerospace and Weapons Systems, Components, and Materials., San Antonio, 20-22 April 1965, pp. 123-149

A new magnetic perturbation method which has high sensitivity and excellent repeatability, was investigated as a means of detecting surface and subsurface defects in cylinders, preform cylinders, and forward domes of the Minuteman rocket engine case. Inspection heads, mounted inside and outside, scanned the total volume of metal in the cylinder as it was rotated in a fixture. Surface and subsurface defects were successfully located, both in parent metal and in weld areas. Defects not detectable by other NDT methods were located and metallurgical sectioning was employed for confirmation.

4890 **MAGNETIC PERTURBATION SCANNER APPLICATION TO MINUTEMAN CASES**

Darwin W. Rathman
Proceedings, Fifth Annual Symposium on Nondestructive Evaluation of Aerospace and Weapons Systems, Components, and Materials, April 20-22, 1965, San Antonio, Texas

Magnetic perturbation scanning, now in a prototype stage of development is a new method which uses a pickup coil probe to detect the perturbing influences of internal anistropy upon an induced magnetic field. It has proven, thus far, by experiment to be considerably more sensitive to ferromagnetic anomalies than present nondestructive testing methods.

4891 **MAGNETIC METHODS OF EARLY FATIGUE DETECTION**

W. Lyle Donaldson
Southwest Research Institute, San Antonio, Texas
Proceedings, Fifth Annual Symposium on Nondestructive Evaluation of Aerospace and Weapons Systems Components and Materials, San Antonio, 20-22 April 1965

This paper describes a new method of nondestructive testing that can be used with magnetic materials to detect fatigue in its early stages as well as locate extremely small subsurface inclusions and surface imperfections. Background information is provided detailed results obtained on a research program for detection of early fatigue by the magnetic method. This magnetic method depends upon the detection of perturbations in the magnetic field at the surface of a metal part under inspection.

4892 **LOW CYCLE FATIGUE DAMAGE DETECTION IN MODEL PRESSURE VESSEL**

Felix N. Kusenberger
Southwest Research Institute, San Antonio, Texas
Proceedings, Fifth Annual Symposium on Nondestructive Evaluation of Aerospace and Weapons Systems Components and Materials, San Antonio, 20-22 April 1965

The purpose of the work reported in this paper was to investigate the potential of the magnetic perturbation method for detecting fatigue damage in a small steel pressure vessel model which was stress cycled at a large plastic strain amplitude. Results indicate that magnetic perturbation techniques were capable of detecting the initiation of "low cycle" fatigue damage in the specimen examined within percent of the total specimen life.

4894 **EARLY FATIGUE DAMAGE DETECTION IN 4140 STEEL TUBES**

J. R. Barton
Southwest Research Institute, San Antonio, Texas
Proceedings, Fifth Annual Symposium on Nondestructive Evaluation of Aerospace and Weapons Systems, Components, and Materials, San Antonio, 20-22 April 1965, pp. 253-276

For the experimental work reported in this paper, a test specimen similar to an SAE 4140 steel spar used in a helicopter rotor was selected and a magnetic inspection method developed to examine the spar from the bore. Flux leakage, caused by internal flaws, is measured by generating a voltage in an electrical conductor which is rapidly vibrated back and forth as the part is scanned. The detection of tight cracks are said to be easily detected.

4895 **CORRELATION OF MECHANICAL Q PARAMETERS TO FRACTURE AND FATIGUE PROPERTIES OF METALS**

I. G. Hendrickson
The Boeing Company
Proceedings, Fifth Annual Symposium on Nondestructive Evaluation of Aerospace and Weapons Systems, Components, and Materials, San Antonio, 20-22 April 1965, pp. 277-294

An apparent correlation between fracture, fatigue properties, and the mechanical Q parameters of moderate to high strength steels has been observed. The Q or material damping parameters were measured for both the flexural and torsional modes of vibration employing a tuned mechanical-electrical oscillator system. These Q data were compared with fracture toughness data as generated by fracture toughness data as generated by fracture mechanics techniques. A possible means to evaluate and process control materials, as to their various stress mode fatigue properties, is promising.

4896 **MAGNETOABSORPTION MEASUREMENTS IN FATIGUE**

L. Rollwitz and J. P. Claassen
Southwest Research Institute, San Antonio, Texas
Proceedings, Fifth Annual Symposium on Nondestrutive Evaluation of Aerospace and Weapons Systems, Components, and Materials, San Antonio, 20-22 April 1965, pp. 295-354

This paper discusses both theoretical and experimental data devoted to magno-absorption signal derivation, measurement analysis, magnetoabsorption signals from nickel and iron wires, magneto-absorption signals as a function of temperatures near the curie point, magnetoabsorption measurements on HY-80 steel, and measurements from an explosively formed sheet of 1020 steel.

4897 **NONDESTRUCTIVE TESTING OF AXIAL-FLOW ROTOR BLADES; RESULTS IN RE-HEAT TREATMENT OF ALL SAE 4140 BLADES**

J. R. Crenshaw
Arnold Air Force Station, Tenn.
Proceedings, Fifth Annual Symposium on Nondestructive Evaluation of Aerospace and Weapons Systems Components and Materials, San Antonio, 20-22 April 1965

Magnetic particle and eddy current tests were utilized to inspect compressor blades in a preventative maintenance program. Cracks in many of the blades indicated a complete investigation was necessary. The microstructure revealed considerable acicular ferrite to be present. All blades were then re-heated treated to a tempered martensite condition.

4901 **NONDESTRUCTIVE DETECTION AND THICKNESS MEASUREMENT OF NICKEL PLATING ON URANIUM FUEL CORES**

P. E. Mix
Savannah River Plant, Aiken, South Carolina
Materials Evaluation, May 1966, pp. 253-256

The thickness of nickel plating on uranium fuel cores and the detection of residual nickel in aluminum-clad, nickel-plated fuel elements are being determined nondestructively by two newly developed instruments. These instruments use small permanent magnets to provide magnetic flux and "Hall-effect" devices that respond to changes in flux density.

4902 **REFRACTORY METAL TUBING INSPECTION USING ULTRASONIC AND PULSED EDDY CURRENT METHODS**

C. J. Renken, R. H. Selner
Argonne National Laboratory, Argonne, Ill.
Materials Evaluation, May 1966, pp. 257-262

The ultrasonic test system that has been used for refractory metal tubing inspection is capable of detecting both longitudinal and transverse flaws. The equipment is of the conventional commercial type, but the transducers are usually specially constructed with a particular application in mind. Pulsed eddy current test equipment induces a strong pulsed induction field which is generated in an enclosure constructed of copper or another high conductive material. This field impinges upon the tube and the pickup coil is used to detect the field reflected from the test specimen.

4903 **PULSE METHOD IN THE NONDESTRUCTIVE CONTROL OF METAL PRODUCTS**

A. T. Nikolayenko
Proceedings, 4th Conference, Novosibirsk, 1964
NASA Technical Translation, NASA TTF-384, December 1965

Describes the development of a pulse electroinductive method of controlling the quality of metal products. The device is said to be capable of analyzing automatically the nature of the transient process at any point. Schematics of the pulse electroinductive device is included as well as the theoretical parameters of the development.

4904 **DETERMINATION OF OPTIMUM FREQUENCY DURING NONDESTRUCTIVE CONTROL OF PIPE THICKNESS**

A. T. Nikolayenko
Proceedings, 4th Conference, Novosibirsk 1964
NASA Technical Translation, NASA TTF-384, December 1965

The author of this paper has proposed a method of determining optimum frequency when the thickness of pipes is controlled by means of a surface sensor. This method is based on determining the regions of frequencies where there is a maximum ratio between relative sensitivity of the measure-sensor with respect to variation in wall thickness of the pipe, and relative sensitivity to oscillations of electrical conductivity or magnetic permeability of the pipe metal.

4905 **AUTOMATIC CONTROL AND METHODS OF ELECTRICAL MEASUREMENTS (VOL. II)**
K. B. Karandeyev
Proceedings, 4th Conference, Novosibirsk 1964.
NASA Technical Translation, NASA TT F-384, December 1965

A compilation of 40 papers covering the theory of Data Processing systems, Automatic control systems, and electrical measurement of nonelectric quantities.

4914 **AUTOMATIC NONDESTRUCTIVE MILL EXAMINATION OF WELDED PIPE**
D. H. Davies
Stewarts & Lloyds, Corby, Great Britain
British Journal of Nondestructive Testing, vol. 8, no. 1, March 1966

This paper outlines some problems concerned with automatic or automated weld inspection. It points out that automated systems cannot think, or make decisions; they have no memory or experience; but can do only what they are programmed to do, and then cannot deviate from norm.

4920 **RECENT ADVANCEMENTS IN NONDESTRUCTIVE TESTING TECHNOLOGY AT HANFORD**
D. C. Worlton, C. L. Frederick, D. J. Denton
Battelle Memorial Institute, Pacific Northwest Lab., Richland, Wash.
Rpt BNWL-SA-404, October 1964

Thin wall tubing testers developed at Hanford can test tubing before and after installation. Advantages include increased defect information and display as well as improved reliability. Ultrasonic transducer evaluation tests have improved transducer uniformity and quality. Development activities include eddy current and ultrasonic techniques for measuring hydride in zircaloy-2 and electrostatic high temperature ultrasonic transducers capable of operating at 1000^{O}C. Inspection techniques developed at Hanford to test thin wall tubing before and after installation give improved reliability and greater defect information and display.

4923 **OPPORTUNITIES FOR AUTOMATION OF NONDESTRUCTIVE TESTING AT HOT-ROLLING MILLS (PART I)**
K. Fink
Stahl und Elsen, vol. 85, no. 6, 1965, pp. 353-364
Henry Brutcher Technical Translation No. H. B. 6404

Automatic nondestructive testing of steel during and after hot rolling for continuous quality control in the production flow line, and automatic evaluation of the results. Covers detection of pipe in hot blooms and slabs by X-ray, gamma-ray and neutron radiography; detection of laminations by ultrasonic through transmission, and examination of blooms, ingots and billets for interval defects by ultrasonic pulse-echo technique using both longitudinal and Lamb waves. Also covers the continuous surface examination of blooms and billets using flux leakage with magnetic tape.

4924 **OPPORTUNITIES FOR AUTOMATION OF NONDESTRUCTIVE TESTING AT HOT-ROLLING MILLS (PART II)**

K. Fink
Stahl und Eisen, vol. 85, no. 6, 1965, pp. 364-372
Henry Brutcher Technical Translation No. H. B. 6600

Covers eddy current testing of hot-rolled bar, wire rod, and seamless tube for surface defects. Cites the usefulness of eddy current probe for scanning flat and round test pieces for cracks. Discusses the aims of future research and development work at laboratory and plant, such as finding quantitative relationships between nature of defects and defect signals.

4926 **NONDESTRUCTIVE METHODS FOR THE DETECTION OF DELTA FERRITE IN AUSTENITIC STEELS**

K. Spiegelberg, E. Haupt
Neue Hutte, vol. 10, no. 8, Aug. 1965, pp. 480-484
Henry Brutcher Technical Translations No. H. B. 6756

This article gives the description and application of two instruments for the nondestructive testing of austenitic steels for the proportion of ferromagnetic phase. Both units are based on the search coil principle and suited for simple production control of semi and finished materials. Discusses the use of the Ferrotest for studying the transformations in austenitic steels, or checking welds for ferrite content.

4927 **STUDY OF THE PROCESS OF FATIGUE UNDER CONDITIONS OF ROLLING FRICTION *BY THE EDDY-CURRENT METHOD***

G. T. Nazarenko, A. D. Yaroshek
Dopovidi Akad. Nauk UkRSR, 1962, no. 3, pp. 370-373
Henry Brutcher Technical Translation No. H. B. 5687

This study is based on the use of eddy-current method of examining the surface zone of steel specimens in a roller system subjected to fatigue testing. Variation of resonance voltage and resonance capacitance at various frequencies and corresponding eddy-current penetration depths, under different maximum specific pressures. Discusses the suitability of eddy-current method for nondestructive detection of the changes in steel due to fatigue under rolling friction.

4928 **NONDESTRUCTIVE TESTING TECHNIQUES FOR MULTILAYER PRINTED WIRING BOARDS**

H. G. Hamre, R. B. Moler, R. A. Zalewski
IIT Research Institute, Chicago, Ill.
Rpt IITRI-E 6024-15, 30 Sept 1965
N66-11764

The technique of axial transverse laminography and the mutual coupling probe were selected for this study. Theoretical and experimental results have shown that laminography exhibits great promise as a practical inspection method capable of being used in 100 percent inspection since the technique affords adequate layer and defect resolution. The mutual coupling probe also showed promise, but in a more limited sense, since it would be used to inspect each through-hole individually. Application of the probe is envisioned only as an adjunct to laminography in inspecting multi layered boards.

4935 **NONDESTRUCTIVE EDDY CURRENT SUBSURFACE TESTING DEVICE PROVIDING COMPENSATION FOR VARIATION IN PROBE-TO-SPECIMEN SPACING AND SURFACE IRREGULARITIES**

H. L. Libby
U. S. Patent 3,197,693, July 27, 1965

A metal discontinuity measuring device is described. The device comprises a probe having an annular driver coil and a plurality of annular sensing coils mounted coaxially and coplanar with said driver coil and having their outputs connected to give a single resultant output. Means are provided for applying a variable amplitude a-c signal to the driver coil. Means are also provided for varying the amplitude and phase of the outputs of each of the sensing coils is a measure of discontinuities within the metal. Means are provided for measuring such phase of the single resultant output signal as an indication of such discontinuities. (AEC)

4936 **INSTRUMENTATION AND NONDESTRUCTIVE TESTING**

General Electric Co., Richland, Wash. (Hanford Atomic Products Operation)
Rpt. HW 84384, 1965, pp. 7.1-7.27

Research is reported on fuel rupture monitoring systems, gamma scanning fuel burnup measurements, regenerating neutron flux detectors, microwave neutron flux monitors, and boron-11 neutron detectors. Development of electromagnetic and thermal nondestructive test methods is described along with ultrasonic transducer research, ultrasonic imaging studies, and development of fatigue detection methods.

4954 **EDDY CURRENT TESTING OF TUBULAR STEEL PRODUCTS**

Henry N. Nerwin
Magnaflux Corporation, Chicago, Ill.
Materials Evaluation, April 1966, pp. 192-196

Eddy current testing techniques can be successfully used in conjunction with the nondestructive testing of tubular steel products. Permeability variations characteristic of steel products limit the signal-to-noise ratio very severely unless means are employed to eliminate noise signals resulting from these variations. One of the most successful methods of eliminating the effect of permeability variations is to apply a magnetic biasing field to the product sufficient to reduce the incremental permeability to a negligible level. The means of applying the magnetic biasing field is discussed, and its effect on the incremental permeability is described by reference to typical magnetization.

4959 **BROADBAND ELECTROMAGNETIC TESTING METHODS (PART III) PARAMETER EXTRACTION**

H. L. Libby, K. W. Atwood
General Electric Co., Richland, Wash. (Hanford Atomic Products Operation)
Rpt. HW 79553, Nov. 1963

A multiparameter electromagnetic or eddy current test method and prototype tester have been developed which permit the extraction and separation of multiple parameters or variables of a test specimen. A review of applicable signal analysis theory is presented, and principles of the multiparameter eddy current test are given.

4964 **HIGH-VOLUME NON-DESTRUCTIVE TEST APPLICATIONS AT THE HANFORD ATOMIC PRODUCTS OPERATION**

D. C. Worlton
Battelle Memorial Institute, Richland, Wash. (Pacific Northwest Lab.)
Rpt BNWL-SA-97
Reprint from: Nondestructive Testing in Nuclear Technology.
Vienna: International Atomic Agency, 1965, Vol. II, pp. 225-246
N66-25338

This paper describes inspection systems being used to ensure quality of Hanford's production nuclear-fuel manufacturing processes. Operated as regulars in-line manufacturing equipment, these systems employ ultrasonic attenuation measurements to monitor grain structure of bare uranium fuel cores, ultrasonic and eddy-current techniques to ensure adequate bonding and thickness of 0.040 in aluminum cladding on canned elements, and novel wide-band, high-resolution ultrasonic techniques to detect defects in the fuel end-weld closures. Combined eddy-current and ultrasonic tests are applied simultaneously to perform a complete fuel element inspection on a nine-second cycle; defective elements are automatically segregated from the process stream. Numerous other tests are discussed.

4968 **BROADBAND ELECTROMAGNETIC TESTING METHODS (PART 2) SIGNAL ANALYSIS**

H. L. Libby, C. W. Cox
Hanford Atomic Products Operation, Richland, Wash.
Rept. HN-67639, January 1961

The recent important work of Dr. W. H. Huggins in the field of signal analysis is reviewed as it applies to eddy-current nondestructive testing. Enough basic theory is provided for a working knowledge of this approach to signal analysis as it may apply to nondestructive testing. These methods show promise for a breakthrough in the problem of extracting information from the broadband, eddy-current, nondestructive test signals.

4969 **THE MEASUREMENT OF METAL TEMPERATURE BY AN ELECTROMAGNETIC INDUCTION METHOD**

H. L. Libby
Hanford Atomic Products Operation, Richland, Wash.
Rpt HW-79621, August 12, 1963

Inductive thermometry, the measurement of metal temperatures by an electromagnetic induction method, shows promise of fulfilling a need where fast response is required or where physical contact with a test metal is undesireable or impractical. In this method, metal temperature is measured by monitoring the electrical conductivity of the test metal by observing its effect on the impedance of an induction test coil placed adjacent to the specimen. Special effectiveness has been shown in the high speed scanning of a metal surface.

4973 **DETECTION OF ANISOTROPIC CONDITIONS USING EDDY CURRENTS**

R. L. Brown, Jr., H. L. Libby
Hanford Atomic Products Operation, Richland, Wash.
Presented at the 21st National Convention of the Society for Nondestructive Testing, Oct. 1961
Nondestructive Testing, Sept.-Oct. 1962

The method described in this paper provides a technique for nondestructively detecting metallurgical conditions which affect the electrical conductivity in an anistropic manner. The information obtained from an elongated probe coil is primarily affected by the impedance of the metal parallel to the major axis of the coil. However, it should be remembered that the information is also affected to a lesser degree by the metal impedance in other directions. Therefore, it can be stated that this technique is, at most, a method of obtaining information about the approximate conductivity in a given direction.

4976 **NONDESTRUCTIVE TESTING OF NUCLEAR STEAM GENERATORS AFTER INSTALLATIONS**

L. J. Shockie
Hanford Atomic Products Operation, Richland, Wash.
Rpt HW-SA-3245, 1963

This paper describes an eddy current tester developed to identify a condition of intergranular corrosion attack from other signals and to also accurately predict the depth. Extensive metallography was used to confirm the results from the eddy current test.

4977 **ELECTROMAGNETIC DETERMINATION OF NICKEL THICKNESS FOR REENTRY VEHICLE HEAT SINKS**

C. H. Hastings, S. A. Lopilato
AVCO (Research and Advanced Development Division), Wilmington, Mass.
Materials Research and Standards, vol. 1, no. 1, 1961, pp. 188-191

The increasing demand for high quality and precision in the missile field has created many unique and interesting problems in nondestructive testing. The problem of accurately measuring nickel coatings up to 12 mils thick electrodeposited on heat-sink copper is described. This required special consideration in eddy current instrumentation, measuring technique, and reference standards. The test which was developed was used to control metallurgical and electro-forming variables during fabrication. Processing variations which influenced the test results are also described.

4979 **FEASIBILITY STUDY OF NONDESTRUCTIVE METHODS FOR TESTING TORSION BARS**

J. Dudzinski
U. S. Army Tank Automotive Center, Warren, Mich.
Rpt No. 4965, 28 November 1960

It was concluded that several nondestructive methods are adaptable for the testing of torsion bar springs, and that their selection should be based on the type and location of flaws, or the material characteristic to be measured. Surface condition of the part was found to be critical in eddy current and ultrasonic surface-wave techniques of flaw detection. It appeared that the tests should be performed prior to shot peening during the manufacturing process.

4980 **THE MAGNETIC REACTION ANALYZER – A NEW EDDY CURRENT NONDESTRUCTIVE TEST**

R. C. McMaster
Ohio State University, Columbus, Ohio
Presented at the 1965 Metals/Materials Congress, 18-20 Oct. 1965, Detroit
ASM Technical Report No. D5-10.3

A nondestructive test instrument is described that is used for eddy current, magnetic field, and displacement measurements. It permits non-contacting measurements of magnetic permeability, electrical conductivity, and thickness of materials (both ferromagnetic and non magnetic conductors) and coatings over a frequency range of 20 cps. to 100 Kc. It can also be used as a static or dynamic displacement gage.

4985 **PREVENTING RAIL FAILURES IN TRACK**

G. M. Magee
Association of American Railroads, Chicago, Ill.
Materials Evaluation, vol. 23, no. 10, Oct 1966, pp. 508-511

Head and web defects in train rails are detected readily by AAR road-rail detector cars. One method consists of the inductance system whereby two sets of brushes for each rail are mounted to continuously contact the top of the rail as the car is moved along the track. A heavy voltage is passed between the brushes to the rail. A specially designed pick-up coil will detect any abrupt change of current flow at a defect. Another method utilizes the residual magnetic method, while the third method described is the well known Sperry ultrasonic rail flow detector.

4998 **CHARACTERIZATION AND EVALUATION OF 2014 ALUMINUM ALLOY BY EDDY CURRENT CONDUCTIVITY TECHNIQUES**

W. D. Rummel
The Martin Company, Denver, Colo.
Materials Evaluation, vol. 24, no. 6, June 1966, pp. 322-326

Practical, theoretical, and experimental data are discussed relating the various heat treat tempers of 2014 aluminum alloy to corresponding values in eddy current conductivity. Data are presented step-by-step with "normal" and 'abnormal" heat treatment operations and corresponding material properties. Practical use of the information is summarized for convenient reference.

5024 **HARDNESS GAGED AS STRIP FLIES BY**

H. J. Hansen, Jr.
U. S. Steel Company
Iron Age, vol. 192, no. 21, 21 Nov. 1963, pp. 73-75

A noncontact magnetic hardness-gage monitors strip for over-under annealing. It also logs the workability of fast moving steel. Unit is completely automated and tests up to 1500 feet per minute. Correlation between magnetic hardness readings and Rockwell values is evident.

5033 **ASSESSMENT AND DISTRIBUTION OF DELTA FERRITE IN TWO-PHASE AUSTENITIC STAINLESS STEELS**

P. Ravizza
Metallurgia Italiana, vol. 55, no. 12, 1963, pp. 635-640

Development of a method of measuring the percentage of ferrite in 18-8 type steels as a function of the magnetic permeability, as part of a program of experiments on the determination of hot workability of such steels. Magnetic and Metallographic methods, Schaeffer method. Investigational procedures and results. Correlation between ferrite content and permeability. Reasons for the higher ferrite contents along the ingot axis and in ingot top and middle; constancy of ferrite distribution during the pour. Confirmation of laboratory results by industrial-scale trials.

5034 **NONDESTRUCTIVE TESTING OF BOILER AND SUPERHEATER TUBING BY THE MANNESMANN AG**

Mannesmann Research Institute, Duisburg-Hurkingen, West Germany
Mitteilungen der VGB, Feb. 1964, no. 88, pp. 26-33
Henry Brutcher translation no. 6226

A survey of instruments, methods, and testing techniques currently available for the nondestructive testing of boiler and superheater tubing; their proper applications with elimination of the human element. Latest automatic magnetoinductive tube testing installations. Ultrasonic techniques suitable for production line testing of tubes; immersion and rotating probe technique and equipment. Specifications and standards discussed.

5035 **ELECTROMAGNETIC TEST CONTROL REQUIREMENTS**

P. G. McEleney, R. V. Giangrande
AMRA* Technical Report TR-64-26, Sept. 1964

Three areas which require control is electromagnetic nondestructive testing are identified. The magnetic field strength of the test, magnetic history of the part, and heating of the test standard can and have seriously affected results in magnetic testing in critical programs. Experiments conducted indicate how these factors influence test results, and techniques are recommended whereby adequate procedures can be established.

*Now U. S. Army Materials & Mechanics Research Center, Watertown, Mass.

5041 **ELECTRIC METHOD OF MEASURING CARBURIZED CASE DEPTH AND THICKNESS OF NONMAGNETIC ELECTRODEPOSITED COATINGS**

T. I. Pavlov
Kuibyshev Industrial Institute
Zavodskaya Laboratoriya, vol. 23, no. 1, 1957, pp. 67-69
Henry Brutcher Translation No. 4382

Describes the development of an electrical method for precise determination of depth of carburized cases on steel. A description of the equipment and principle of operation is included. Results obtained on plain carbon and low chromium steel prove that not only depth but quality of case as well is indicated.

5044 **ND TESTS: RUSSIAN WORK REPORTED**

M. Swiss

Iron and Steel, vol. 37, no. 1, Jan. 1964, pp. 33-44

This article is a report based on a Russian paper presented at a nondestructive testing conference. It covers the measurement of magnetic properties of metals for evaluating the heat treatment given to most constructional and tool steels. Subjects covered in the electromagnetic testing field pertain to coercive force and resestivity as applied to mechanical permeability properties.

5046 **DETERMINATION OF THE DEPTH OF THE ACTIVE QUENCHED LAYER AND THE AMOUNT OF RESIDUAL AUSTENITE IN THE SURFACE LAYER OF ROLLERS USED IN COLD ROLLING**

M. N. Mikheev et al.

Institute of the Physics of Metals, U.S.S.R.

Industrial Laboratory, vol. 29, no. 12, June 1964, pp. 1627-1628

This article discusses the use of magnetization to control the depth of the active quenched layer of rollers

5047 **APPLICATION OF THE DIFFERENTIAL MAGNETIC METHOD TO THE INVESTIGATION OF STEEL AT SUBCRITICAL TEMPERATURES**

K. K. Kozlov

Industrial Laboratory, vol. 29, no. 12, June 1964

By using a differential magnetometer, steels at subscritical temperatures may be studied more effectively.

5052 **DETERMINATION OF THE MAGNETIC PERMEABILITY AND THE LOSS OF FERROMAGNETIC MATERIALS BY MEANS OF Q-METER**

A. L. Grokhol'skii, A. F. Kugaevskii

Industrial Laboratory, vol. 29, no. 9, March 1964

Permeaters are used for measuring the magnetic permeability and loss of angle of ferromagnetic materials Calibration against standard specimens of known parameters is recommended.

5055 **MEASURING THE ELECTRICAL RESISTANCE OF CARBONACEOUS MATERIALS AT HIGH TEMPERATURES**

E. I. Parnov, R. B. Orshanskii

Industrial Laboratory, vol. 29, no. 9, March 1964, p. 1209

This article covers studies conducted to measure the electrical resistance of graphites, briquitted and shaped solid fuels, semicoke and coke covering temperature ranges from 232 to 1200^{o} C.

5056 **AN IMPROVED INSTRUMENT FOR CONTINUOUSLY RECORDING THE ELECTRICAL CONDUCTIVITY OF SPECIMENS DURING A THERMOGRAPHIC ANALYSIS**

I. A. Yakubovich, V. I. Ulanov, A. V. Machinskii
Industrial Laboratory, vol. 29, no. 9, March 1964, pp. 1245-1246

A means is now available for determining the variation in the electrical conductivity during a thermographic analysis of chemically pure substances. Instrumentation is described.

5066 **ULTRASONIC PROPAGATION IN NICKEL AND Mn-FERRITE AT HIGH MAGNETIC FIELDS**

J. Sakurai
Kyoto University, Kyoto, Japan
Journal of the Physical Society of Japan, vol. 19, no. 3, March 1964, pp. 311-317

Attenuation and velocity measurements at sufficiently high magnetic fields to produce sturat on in nickel and Mn-ferrite are discussed, as a function of orientation, magnetic field intensity and room temperature ultrasonic frequency. Experimental procedure, results and discussions are included.

5072 **ULTRASONIC CONTROL OF LASER PERFORMANCE**

A. J. DeMaria, G. E. Danielson, Jr.
United Aircraft Corp., East Hartford, Conn.
Rpt. C-920083-12, 25 Sept. 1964
AD-605 940

This report describes the work performed during the period from June 1963 to June 1964 on a research program directed toward determining the oscillation characteristics of a laser when the refractive index within the feedback cavity is perturbed by means of acoustic, electric, or magnetic fields. Experiments are reported which demonstrate that the periodic fluctuation of the refractive index resulting from the propagation of focused ultrasonic energy within a solid state laser medium can be utilized as a Q-spoiler to gate the output of high gain lasers without the introduction of lossy elements into the laser's feedback path.

5074 **PROGRESS IN NONDESTRUCTIVE TESTING (A SUMMARY OF HANFORD ACHIEVEMENTS IN THESE PROGRAMS UNDER GENERAL ELECTRIC), 1952-1964**

D. C. Worlton
Hanford Laboratories, Richland, Wash.
Rpt. HW-83608, August 1964, A.E.C.

Hanfords nondestructive testing programs from 1952 to 1964 are reviewed. Following the chronological development of these programs, this report first summarizes the fuel testing effort under which three separate, fully automatic inspection stations were developed and applied to the AISL fuel processes to insure core, cladding, and closure integrity of each fuel element. Following beneficial use of these test systems, similar inspection equipment was developed and successfully applied to the N-Reactor fuel process, results of this program are also summarized. Long range research and development programs oriented toward the development of advanced ultrasonic, eddy current, thermal and nuclear particle counting techniques were established as an outgrowth of the fuels effort, and progress under these programs is reviewed. Existing plant-wide problems guided the direction of the long range research and development activities, and provided incentive for immediate application of new test developments. Results contributed significantly to major plant programs; these are pointed out with a few illustrative examples.

5093 **ULTRASONIC DELAY LINES AND THEIR APPLICATIONS TO TELEVISION**

C. F. Brockelsby, J. S. Palfreeman
Mullard Research Laboratories, Salsfords (Surrey), England
Phillips Technical Review, vol. 25, 1963/64, pp. 234-252

Ultrasonic delay lines as applied to the field of television are described. Different varieties and types of dealy lines are discussed along with the characteristics that can be achieved.

5114 **NON-DESTRUCTIVE EDDY CURRENT TESTING OF GRAY IRON**

Kennedy D. Carter
Gray Iron News, Feb 1966, pp. 8-10

Nondestructive eddy current testing is used to measure the over-all hardness of gray iron castings at their skin. Electronic filtering systems are used to subdue the effects of discontinuities and dimensional changes so that changes in measured resistance mainly reflect the effects of alloy content and micro-structure. Brinell tests are used for hardness determinations on standards used in the test program.

5115 **PULSED NONDESTRUCTIVE EDDY CURRENT TESTING DEVICE USING SHIELDED SPECIMEN ENCIRCLING COILS**

C. J. Renken, et al.
U. S. Patent No. 3,361,960

An eddy current test system using encircling coils to detect subsurface flaws in small-diameter tubing. Two cylindrical magnetic shields containing detector coils are placed end-to-end, and a transmitting coil placed between them. All are axially aligned with the tubing. Circuitry is described which samples the detected signal for evidence of flaw-responsive characteristics.

5120 **DEFECTOSCOPY OF THIN-WALLED TUBES**

V. V. Gorskiy, V. M. Zakharov
International Atomic Energy Agency Symposium on Nondestructive Testing in Nuclear Technology, Budapest, 17-21 May 1965, pp. 1-30
Translation FTD-MT-65-562, 16 Feb. 1966 (Wright-Patterson AFB, Ohio)

In this report, certain questions on the theory of ultrasonic defectoscopy of thin-walled tubes are considered and a description of defectoscopy equipment in use is given. Both ultrasonics and eddy currents as a means of checking and testing tubes are covered.

5139 **METHODS AND EQUIPMENT FOR MEASURING THE THICKNESS OF COATINGS**

H. Plog
Metal Finishing Journal, vol. 12, no. 133, Jan. 1966, pp. 27-32, 34-41

Nondestructive test methods are described for determining coating thickness based on dial gaging, weighing, the attractive-force principle and magnetic-inductive, eddy-current, capacitance, thermoelectric, optical, light-section, interference, photoelectric and radiation methods. Types of equipment used with the various types of tests are tabulated.

5153 **DEVELOPMENTS IN THE HARMONIC ANALYSIS METHOD FOR THE NONDESTRUCTIVE DETERMINATION OF CASE DEPTH OF CARBURIZED STEEL**

H. P. Hatch, K. A. Fowler
Springfield Armory, Springfield, Mass.
Rpt. No. SA-TR 19-1520, 20 May 1966

The investigation concerned with the nondestructive determination of case depth of carburized steel by the harmonic analysis method is described. Results of the investigation demonstrated that the method was effective for measuring deep cases through .075 inch and shallow cases on samples having small cross-sectional areas. The ability to use a probe-type test coil for measuring case depth by this method was demonstrated by a prototype design.

5167 **THEORY OF THE USE OF EDDY CURRENT CONDUCTIVITY DEVICES TO MONITOR ALUMINUM ALLOYS**

Ward D. Rummel
The Martin Company, Denver, Colo.
Materials Evaluation, Sept. 1966, pp. 507-511

A theory of changes in electrical conductivity of aluminum alloys with changes in the amount of cold work and with changes in heat-treat condition is described. The theory relates changes in electrical conductivity to changes in the number of included electron-scattering-centers in the aluminum matrix. The various types and mechanisms for changing the electron-scattering-center density are described. Practical uses of the electron-scattering theory are proposed and illustrated by examples.

5180 **A SURVEY OF TELEMETRY TECHNIQUES APPLICABLE TO NONDESTRUCTIVE TESTING**

H. N. Nerwin
Magnaflux Corporation, Chicago, Ill.
Materials Evaluation, July 1966, pp. 373-377

Some nondestructive tests require the use of sensing elements (probes or transducers) where the sensing element must scan the surface of the object. In certain cases, notably the inspection of cylindrical objects, the probe must move rapidly over the surface with a continuous motion. This may necessitate the conveyance of the electrical signal across moving members. In this day of transistors and electronic miniturization, telemetry and modulated carrier techniques are likely means of transferring the electrical signal carrying defect information from a rapidly moving sensing element across moving members to final instrumentation. Various telemetry and modulated carrier techniques applicable to nondestructive testing are discussed to provide a foundation for further development.

5186 **THE INSPECTOR'S ROLE IN ONSTREAM INSPECTION**

E. F. Ehmke

Ameridan Petroleum Institute, Proceedings, Section III, Refining, vol. 45, no. 3, 1965, pp. 163-168

Inspection techniques for corrosion, onstream inspection methods and inspection tools used in the application of these techniques are described. Some equipment used in the detection of troubles and maintenance of assemblies is discussed. Ultrasonic translators are used to detect minor leaks and pinpoint the location in a flange where effective tightening could be applied. Vacuum leaks in valves of compressors and engines can be detected. Infrared pyrometers find use in checking hot spots and temperature gradients in internally insulated vessels. A systematic approach to the investigation of corrosion problems and expected failure in weldments is given. A preliminary investigation is followed by actual inspection. Radiographic and pulse-echo inspection are two commonly used methods. A case history of inspection of a weldment of 304 stainless steel piping using a variety of techniques, including ultrasonic shear wave testing, eddy current inspection and techniques mentioned above, is described, where the aim was to determine the extent and nature of the corrosion effects.

5205 **AUTOMATED EDDY CURRENT TESTING OF WIRE AND TUBE**

T. J. Baugh

Metals, vol. 1, no. 2, July 1966, pp. 46-47

Causes of poor spiralling of Ni-Cr alloy wire used in heating elements are shown to be cracks and uneven annealing. Eddy current method of inspection is used for crack detection. Special starch coil assembly, operating at a carrier frequency of about 4 megacycles/sec, is described for continuous testing of wire as small as 0.008 in. diam. Good correlation is found between recorded defect signals and spiralling quality. Also described is eddy current test equipment for tubes, using 2-50 kc/sec. Testing is used primarily as intermediate inspection procedure. Final inspection is by ultrasonic methods.

5207 **TEMPERATURE COEFFICIENT OF RF PERMEABILITY MEASUREMENT USING AN IMPEDANCE BRIDGE AS AN EQUALITY INDICATING DEVICE**

A. L. Rasmussen

Journal of Research of the National Bureau of Standards, Section C, Engineering and Instrumentation, vol. 70-C, no. 1, Jan-Mar 1966, pp. 19-24

Measurements are made on toroidal coils, without and with low-loss powdered Fe samples inside, from approximately 23 to 50C. and 300KHz to 1.5MHz. A high-precision Maxwell impedance bridge is used as an equality indicating device. Impedance changes of the toroidal coils are compensated by adjusting parallel capacitance and resistance standards which are external to the bridge. Data on several materials show that temperature coeficients of permeability of approximately 5 by 10^{-}/C. may be evaluated.

5208 **MATERIAL TESTING – METALS (Book In German)**
P. Riebensahm, Paul W. Schmidt
Berlin: Springer-Verlag, 1965, p. 68

A compilation of industrial testing methods and procedures based on pertinent German industrial (DIN) specifications is discussed. The following tests are included: mechanical testing, including static stress (tensile, creep, compression, bending, torsion, shear); impact (impact and impact compression, bending and notched impact); alternating fatigue; hardness (Brinell, Vickers, Knoop, Rockwell, dynamic hardness, conversions); spark testing, fracture testing; microstructure (Metallography, X-ray); nondestructive testing, including residual stresses (brittle coatings, mechanical and optical, pneumatic, electrical, X-ray); grade and state identification (electromagnetic, coercive); defects (penetrating, induction, eddy current, ultrasonic, X-ray and gamma radiation). Sampling, specimen and specifications for procedure are given for each method. Standard machinery is described in detail.

5217 **NON-DESTRUCTIVE TESTING OF MATERIALS**
D. Smart
U. S. Patent No. 3,258,957, July 5, 1966

A method of non-destructive testing of metallic materials to detect the presence and location of regions of altered internal energy, due for example to strains, voids or similar localized effects, comprising the steps of: (a) bringing into contact with spaced-apart regions of the material under test, respective contact pieces formed of different metals from said material under test, to form at least two junctions of dissimilar metals, (b) producing a temperature difference between said junctions, and (c) snesing the thermoelectric potential thereby produced between said junctions, while (d) moving at least one of said contact pieces to different regions of said material under test, to reveal, by the corresponding changes in said potential, the presence and location of regions of altered internal energy in the material under test.

5218 **N.D.T. APPLIED TO PIPELINE CONSTRUCTION AND OPERATION IN THE USA: PART I**
A. G. Barkow
British Journal of Non-Destructive Testing, vol. 8, no. 2, June 1966, pp. 22-38

Definition, purpose and history of nondestructive testing of pipelines are given. API standards on oil and gas pipeline field welding practices, including radiographic practices and standards of acceptability, are discussed. Nondestructive testing in pipe mills—visual inspection, radiographic, ultrasonic and fluoroscopic and their specific capabilities in detecting defects such as discontinuities, porosities, slag inclusions and cracks, is reviewed. Use of hydrostatic testing and X-radiation, electromagnetic or eddy-current tests to examine pipe welds in pipe mill are described. Nondestructive testing in pipeline construction includes radiographic inspection using film, visual inspection, hydrostatic yield testing and ultrasonic inspection. A detailed description of radiographic inspection, divided into internal and external methods, using either X-rays or gamma-rays, is given.

5246 **DEVELOPMENT OF NONDESTRUCTIVE METHODS FOR EVALUATING DIFFUSION-FORMED COATING ON METALLIC SUBSTRATES**

R. C. Stinebring, T. Sturiale
Avco Corp., Lowell, Mass.
Tech. Rpt. AFML-TR-66-221, Sept. 1966
AD-810 501

This program was originated to detect, define and characterize by NDT methods, those variables which significantly affect the service life of diffusion-formed coatings on refractory alloys. The following were studied: a) TZM alloy with W-3 coating, b) Cb 752 alloy with Cr-Ti-Si Coating, c) B-66 alloy with PFR 30 coating. All specimens were screened using such NDT methods as visual, microscope (40x), radiography, eddy currents, optical reflectometry, infrared, ultrasonic velocity, dye penetrant, wax replica, thermoelectric and electron beam. After screening, the specimens were heated at 2600°F and 2800°F and to plasma arc at 3000°F at reduced pressures (0.5mm Hg); removed periodically from the high temperature environments and evaluated to determine extent of degradation as a function of exposure time. NDT techniques applied on this program were adequate for detection of significant variables.

5263 **ULTRASOUND HUNTS FOR WEAK SPOTS**

Iron Age, vol. 198, no. 19, 10 Nov. 1966, pp. 90-91

Rapid nondestructive testing of cold formed transmission shafts is described. To detect internal bursts, known as chevron defects, a beam of ultrasonic energy is sent through a column of water which contacts the shaft. Inspection is made directly on the discharge of the cold forming press. An eddy current test is used after milling to test ends of shafts for splits. The same test system is applied to cold formed axle shafts.

5268 **NONDESTRUCTIVE TESTING OF WELDED PIPE**

R. N. Cressman
Iron & Steel Engineer, vol. 43, no. 9, Sept. 1966, pp. 147-150

Ultrasonic, eddy current and X-ray nondestructive test methods are compared for three groupings of pipe sizes, from 3/4 to 4-1/2 in., from 4-1/2 to 20 in. and above 20 in. The advantages and disadvantages of these methods and variations in relation to pipe diameter, class of defect, welding technique and production factors are noted.

5269 **EDDY CURRENT TESTING OF PEARLITIC MALLEABLE**

L. G. Wright
Foundry, vol. 94, no. 10, Oct. 1966, pp. 116-123

Eddy current testing is used to sort fully pearlitic (lamellar and spheroidized structure) malleable iron castings on the basis of hardness. Correlation between casting hardness estimated from eddy current traces and Brinell hardness is very satisfactory. Equipment and the theoretical circuit of a comparator-type eddy current tester are described and illustrated. To reduce the effects of surface variations, eddy current penetration to the greatest depth possible is required, necessitating the use of low frequencies (5 cps). Optimum conditions for sorting castings are summarized. Production operation for testing selector fork castings and valve rocker castings is described. Eddy current testing is shown to be reliable, saves testing time, eliminates the need for a tempering operation and grinding required for the Brinell test.

5280 **RECOMMENDED PROCEDURE FOR SURFACE FLAW DETECTION OF STEEL CASTINGS BY MAGNETIC PARTICLE EXAMINATION (Pamphlet)**
British Steel Castings Research Association, East Bank Rd., Sheffield, England, 1966

This procedure is applicable to the examination of ferritic castings of carbon and alloy steels. Surfaces to be examined must be accessible for efficient magnetization, for the application of magnetic particles and for subsequent visual inspection. A magnetic particle flaw detector, preferably portable, is required and a flux indicator may be used to assess the effectiveness of magnetization, to indicate the sensitivity of the ink or powder and to determine the direction of a magnetic field. The surface should be shot-blasted and/or chemically cleaned, then lightly ground before testing. Test procedures for current flow, magnetic flow and the application of magnetic particles are given. An appendix describes magnetization and demagnetization methods.

5282 **NONDESTRUCTIVE TESTING APPLICATIONS IN THE NUCLEAR INDUSTRY**
J. C. Spanner
Pattelle Memorial Institute, Richland, Wash. (Pacific Northwest Laboratory)
Rpt. BNWL-SA-1142, March 1967

The author discusses quality assurance, quality definition and quality reassurance, defining his terms and their interrelationship. Examples of NDT applications at the Hanford Atomic Energy plant are given. Examples include: Isotope Heat Capsules for which cladding core bond tests are made at numerous locations; Radioactive Waste Storage Tanks with an ultrasonic wall thickness readout map arrangement to monitor wall thickness changes; thin wall tubing with thicknesses down to .017" tested routinely with sharply focused transducers whose effective beam diameters are less than ½ the wall thickness; eddy current testing of steam generator tubing to determine intergranular corrosion.

5292 **MAGNESIUM ROUND DRY CELL BATTERIES**
T. G. Messing
Burgess Battery Co., Freeport, Ill. 61032
ECOM 02572-F, February 1968
AD-666 184

Discussion of the development of a magnesium dry cell with a mechanical seal is given. Data is shown describing this cell's delay time characteristics and capacities after extended periods of storage. The testing indicated that under controlled conditions cells with gross faults in construction can be identified, using a D.C. voltage measurement. Greater sensitivity is achieved with the measurement. Greater sensitivity is achieved with the measurement of A.C. resistance and capacitance. Measuring circuits to give a NDT test are described.

5295 **MAGNETIC METHODS FOR CRACK DETECTION IN CANNON BORES**

K. A. Fowler
U. S. Army Materials Research Agency, Watertown, Mass. 02172
Technical Rpt. AMRA TR-67-06, February 1967
AD-647 245

An investigation was made of some of the factors influencing crack detection in cannon bores by the magnetic techniques. A method of locally magnetizing a small portion of the tube, as it is being scanned, was developed and compared with residual magnetization of the complete tube. The detectors utilized in this work were of the tape-head type presently employed in the magnetic recording borescope (MRB). Measured crack indications are related to crack depth and width. It is concluded that, although the MRB approach may be satisfactorily applied to the smooth-bore powder-chamber area, it is inadequate for the rifled portion of the tube. An alternate scanning technique utilizing a high-resolution field-sensitive detector is proposed for crack detection in rifled bores.

5296 **DENSITY AND ITS DISTRIBUTION IN SINTERED METAL COMPACTS**

W. Cegielski and E. Maniewski
Prace Instytutow Hutniczych, vol. 14, 1962, pp. 309-315
Henry Brutcher translation no. 6037

The importance of density and density distribution for a number of properties of sintered metal-powder compacts is discussed. Equipment and measuring techniques of electrical conductivity in connection with powders and sintered compacts are studied. The merits of nondestructive electrical conductivity measurements are evaluated.

5297 **EDDY CURRENT AND ULTRASONIC TECHNIQUES FOR INSPECTION OF LARGE PARTS**

F. J. Musil
Journal of Materials, vol. 2, no. 1, March 1967, pp. 65-80

An automatic eddy current scanning and recording system utilizing commercially available scanning, recording and eddy current equipment is described. The system is capable of inspecting large parts (26 by 10 ft.) in about half the time it takes for conventional penetrant testing. There is a discontinuity size discrimination capability and a permanent record is provided. A technique for measuring the length and depth of discontinuities with a rotating eddy current probe is discussed. A brief discussion of automated surface inspection using ultrasonic surface waves is also included. Homemade vs commercially made probe coils are discussed.

5298 **NONDESTRUCTIVE TESTING OF MINE BATTERIES**

Naval Weapons Station, Concord, Calif.
Rpt QE/CO 67-13, Feb. 1967

Describes the investigative work that was performed and the test results that were obtained on the applicability of the nondestructive testing methods to Leclance type mine batteries for the purpose of indicating their capability and service life.

5301 **DEVELOPMENT OF NONDESTRUCTIVE TESTING METHODS FOR THE EVALUATION OF THIN AND ULTRA-THIN SHEET MATERIALS**

E. Kubiak, R. Hosek, W. Lichodziejewski
General American Trans. Corp., Niles, Ohio
AFML-TR-66-304, Feb. 1967
AD-813 860

Electronic modifications were made to the FM Lamb wave system which resulted in a signal-to-noise ratio improvement of better than one order of magnitude. Use of sound absorbing media significantly reduced "crosstalk" and stray reflections. Testing with FM Lamb wave system has proved the technique capable of detecting small "flaw", but relatively insensitive to material property variations. Application to on-line thin sheet inspection is planned. Analytical investigations of a forked-coil eddy current system shows that the technique can be used to measure material properties only if sheet thickness is monitored. Investigation of beta backscatter has shown relation to sheet hardness and surface finish by second order effects.

5310 **THE USE OF AC FOR STRUCTURAL ANALYSIS OF FERROMAGNETIC MATERIAL BY THE ELECTRIC RESISTANCE METHOD**

N. G. Shul'ga and M. F. Zamora
Defectoscopy, no. 1, Jan.-Feb. 1965, pp. 64-67

Both a.c. and d.c. electric resistance measurements were used as a method for the structural analysis of ferromagnetic materials. Resistance coefficient versus temperature curves clearly show the phase transformations which occur in the alloys investigated. The influence of the a.c. surface or "skin-effect" on the magnetic and electric properties of chromium steel during heating was also investigated.

5312 **PIEZORESISTIVE GAGE TESTS PIN-CONNECTOR SOCKETS**

NASA Tech Brief 65-10128
NTIS, Springfield, Va. 22151

This brief describes a gage for inspection testing the electrical contact characteristics of pin-connector sockets that employ retainer springs or snaps to exert contact force on the mating pins. The gage uses a test pin (the same size as a connector pin) on which a piezoresistive semiconductor is rigidly mounted and connected as one leg of a bridge circuit. It can be applied to a multiple-connector socket by using a connector with multiple test pins, the output of which would be fed into a programmed sequencing switch for automatic acceptance or rejection of a socket.

5314 **MAGNETIC PROPERTIES, ELECTRICAL CONDUCTIVITY, AND HARDENING OF RAIL STEEL M75 AFTER ISOTHERMAL HARDENING AND TEMPERING**

G. S. Tomilov, V. I. Matveev
Defectoscopy, no. 1, Jan.-Feb. 1965, pp. 55-63

A detailed investigation of the magnetic properties, electrical resistivity, and mechanical hardness of the microstructures produced by heat treating rail steel has shown a correlation between coercive force and hardness even when minor variations in chemical composition occur. However, evaluation of hardness by resistivity measurements is difficult. Nondestructive evaluation of subsequent tempering of hardened rails cannot be achieved at room temperature, but can be accomplished during manufacture if the magnetic properties are measured in the heated state during cooling.

5323 **ELECTROMAGNETIC INSPECTION OF HARDENED STEEL**

T. A. Cox

Memorandum Rpt. M67-24-1, Frankford Arsenal, Philadelphia, Pa.

The purpose of this program was to investigate the use of eddy current test techniques for (1) The measurement of case depth on steel parts processed by heat treat methods (no carbon added to the surface), and (2) The determination of through hardness or tempering temperature history of Stentor tool steel and 4340 steel parts. Eddy current tests showed that the relationship of case depth to eddy current output had insignificant correlation. However, tests utilizing third harmonics of the probe energizing frequency showed that tempering temperature history of 4340 and Stentor steel can be determined for all temperatures (265^{O}F to 820^{O}F) used for specimen preparation on this program. When the fundamental of the probe input frequency was utilized, tempering temperature determination was limited to the temperature range 300^{O}F to 570^{O}F. The tolerance on the detectable tempering temperature deviation range was 35^{O}F for Stentor steel and 70^{O}F for 4340 steel. Where tempering temperature can be directly related to hardness these tests give an indication of hardness within two Rock-"C" points.

5341 **MAGNETOABSORPTION TECHNIQUES FOR MEASURING MATERIAL PROPERTIES**

W. L. Rollwitz and J. P. Claassen

Southwest Research Institute, San Antonio, Texas

AFML-TR-66-76, Oct. 1966

It has been shown that magnetoabsorption signals are readily affected by changes in reversible permeability as caused by stress, heat treatment, composition, impurity, and temperature. Magnetoabsorption measuring equipment to detect low amplitude magnetoabsorption signals from specimens offering a small effective filling factor to a smaple coil or probe was refined. With improved sensitivity variations in harmonic content of magnetoabsorption signals arising from variations in the surface properties of a plate of maraging steel were related experimentally. Magnetoabsorption waveforms were also measured for a weldment in maraging steel, stressed and stress-relieved specimens of HY-80 steel, a bulge plate of 1020 steel, and magneto-absorption signal changes and its harmonic amplitude variations from nickel-plated aluminum rods and other ferromagnetic wires were related experimentally to applied compressive and tensile loads.

5344 **THE MEASUREMENT OF SPECIFIC RESISTANCE BY EDDY CURRENT SHIELDING**

W. D. Kouwenhoven and G. P. Daiger

Review of Scientific Instruments, vol. 5, Feb. 1934, pp. 94-101

A new method (Feb. 1934) of determining the specific resistance of materials is described. The method is based on the change of inductance of a solenoid that takes place when conducting material is brought into the field of the solenoid. The results given illustrate the practicability of using the phenomena of eddy current shielding as a measure of the specific resistance of large cylindrical non-magnetic conducting materials. The method offers a very simple and rapid means for checking the uniformity of raw material.

5349 **IS THERE ANY CORRELATION BETWEEN FLAWS AND SERVICE PERFORMANCE?**

R. Halmshaw
Royal Armament Research and Development Establishment, Fort Halstead, England
Symposium on Correlation of Material Characteristics with Systems Performance,
USAF Conference Facility, Orlando AFB, Florida, 10-12 May 1967

By non-destructive testing, most people understand the five techniques – radiography, ultrasonics, magnetic crack detection, penetrants and eddy current testing – and the commonest use of those is for flaw detection in welds, castings and forgings. Evidence is also building up from static and fatigue tests that the flaws found by these NDT techniques are not generally the most significant ones from the point of view of performance in service. Much more significance needs to be given to small surface notches and cracks, and crack-detection inspection methods may prove to be more useful tests. Studies of failures in service suggest that a large proportion of these is due to mistakes in design or to the use of wrong material, e.g., wrongly heat-treated steel, or steel used at temperatures below the brittle/ductile transition region.

5360 **CERMET BODY NONDESTRUCTIVE TEST DATA EVALUATED BY SPIN TESTS OF BLADES AND BEND TESTS OF BARS**

A. G. Holms, A. J. Repko
Journal of Nondestructive Testing, vol. 17, no. 3, May-June 1959, pp. 156-164

High quality cermet blades, previously screened by surface inspections for flaws were re-inspected at the root by means of several flaw detection and property measurements tests. Statistical techniques were used to compare the correlation of the blade root and modulus of rupture strengths with the several nondestructive test variables. A strong correlation was observed between electrical conductivity and bending strength. The latter also correlated strongly with hardness and some aspects of microstructure.

5362 **HIGH-TEMPERATURE EDDY-CURRENT CRACK DETECTION**

N. B. Edenborough
Los Alamos Scientific Laboratory, Los Alamos, New Mexico
Rpt. LA-DC-9382, June 1968

A technique was developed to detect the time of cracking of samples representing atomic reactor components under high thermal gradients. An eddy current coil of tungsten-rhenium wire (W-26% Re) was wound on a specially machined boron nitride coil form. This coil has been shown to operate at temperatures up to approximately 3200°F. This temperature was reached, from ambient, in 22 seconds. Special electronic circuitry was also developed to detect the small signal change caused by the cracking but ignoring the large changes caused by the quick heating.

5371 **MEASUREMENT OF ELECTRICAL RESISTIVITY OF BULK METALS**

J. E. Zimmerman
Review of Scientific Instruments, vol. 32, no. 4, April 1961, pp. 402-405

This paper describes a method of measuring the electrical resistivities of metals by ac induction methods, in which the specimen in bulk form, and no direct contact to it is required. Theoretical expressions are given for a sphere and for an infinite circular cylinder in a uniform applied ac field, and an experimental method is described which is applicable to any shape or applied field configuration.

5375 **PROGRESS IN TECHNOLOGY AND EQUIPMENT FOR EDDY CURRENT INSPECTION**
H. L. Garbarino and H. N. Nerwin
Journal of Nondestructive Testing, vol. 17, no. 4, July-Aug. 1959, pp. 229-234

In this paper, an attempt has been made to provide a qualitative understanding of how eddy-currents and magnetic fields penetrate into a material. The major problem in the design of suitable eddy-current testing equipment is to achieve good accuracy and flexibility at reasonable cost. The equipment should be suitable for different applications and should be able to accommodate different coil inspection systems.

5376 **BARKHAUSEN EFFECT IN IRON, NICKEL AND PERMALLOY. I. MEASUREMENT OF DISCONTINUOUS CHANGE IN MAGNETIZATION**
R. M. Bozorth
Physical Review, vol. 34, 1929, pp. 772-784

These experiments show that the changes in magnetization which take place suddenly in large groups of atoms account quantitatively for the whole change in magnetization which corresponds to the steeper part of the hysteresis loop. Since it is estimated that discontinuities corresponding to groups of 10^{10} atoms (10^{-13}cm^3) or less will not appreciably effect the measuring system, it is concluded that the magnetic moments of only a very small number of atoms are reversed in groups smaller than this. The maximum size of the discontinuities for all materials examined independent of crystal size, is found to be about the same, corresponding to the complete reversals of the elementary magnets contained in a volume of about 10^{-6}cm^3. The discordance of the results of previous measurements by others is explained as due to the different rates of decay or eddy-currents in the samples used.

5381 **THE MAGNETIC FIELD OF FLAWS FLOWN-AROUND BY DIRECT CURRENT**
G. A. Byuler
Defectoscopy, no. 3, May-June 1965, pp. 222-227

The problem of calculating the magnetic field above the surface of a conductor with flaws that emerge at the surface when direct current is passed thru it is presented. In particular, expressions for the components of the magnetic field are found in the form of multiple integrals for the cases when the flaw has the form of a hemisphere and semicylinder.

5382 **MAGNETIC METHODS AND INSTRUMENTS FOR MONITORING THE STRUCTURES OF CASTINGS OF SPHEROIDAL GRAPHITE IRON**
V. A. Ivlev and I. I. Kostetskii
Defectoscopy, no. 3, May-June 1965, pp. 232-240

Methods have been developed for monitoring castings of spheroidal graphite iron that insures 100% control of the structure of parts based on magnetic properties. The operation of the instruments developed for this purpose has been checked under industrial conditions. The results of studies of the magnetic properties of cast irons are discussed and magnetic methods of control of the structure of castings are described.

5389 **EDDY CURRENT METHOD FOR MEASURING CRACK VELOCITIES IN METAL**

H. L. Libby and L. T. Lamb
Battelle-Northwest Research Labs, Richland, Wash.
BNWL-CC-760, Dec. 1966

An eddy current device operating at 20MHz was developed for monitoring surface crack propagation in double cantilever beam specimens. Crack proportion profiles obtained using aluminum specimens during instrument tests are presented. These profiles show that the instrument responds to the crack propagation. A technique for calculating crack tip velocities from the instrument output data and calibration curves is given.

5398 **COMBINED LEAKAGE FIELD AND EDDY CURRENT DETECTION SYSTEM**

J. M. Mountz
Materials Evaluation, vol. 25, no. 1, January 1967, p. 8A

Described in this patent is a method for obtaining optimum bias field values for eddy current inspection of ferromagnetic material such as steel pipe. The purpose is to enhance the sensitivity to subsurface conditions relative to those on the surface. It is explained that the eddy current response is a function of derivatives of magnetic permeability and that optimum values of bias fields are significantly less than the saturation levels normally used.

5399 **ULTRASONIC TESTING APPARATUS HAVING IMPROVED RESOLUTION**

F. G. Weighart
Materials Evaluation, vol. 25, no. 1, January 1967, p. 10A

This invention concerns a method of reducing ringing in an ultrasonic receiver so that echo signals from defects near the front surface may be resolved from the front surface signal. The first negative half cycle of an echo signal, if over a threshold amplitude, is used to reduce the r.f. amplifier gain to reduce ringing due to saturation effects. This threshold value is selected to be larger than normal signals due to internal discontinuities so that no defect signal reduction is experienced.

5403 **APPARATUS FOR DETECTING A PARTICULAR EDDY CURRENT TYPE FLAW UTILIZING PULSE COINCIDENCE DETECTION**

W. H. Wells and T. J. Baugh
Materials Evaluation, vol. 25, no. 2, February 1967, p. 10A

This patent describes apparatus for eddy current testing of metallic components for inhomogeneities of preselected types. Pulse circuits are triggered from the sinusoidal data signals. Delay is provided, after which a coincidence gate responds to the presence of signals due to inhomogeneities. The delay may be adjusted to give effective response at the correct phase angle. The system claims as an advantage that multiple phase angles may be ignored and only the angle of interest accepted.

5420 **RECENT DEVELOPMENTS IN PIPE CORROSION INSPECTION TECHNIQUES**

G. G. Page

Corrosion Technology, vol. 12, no. 10, Oct 1965, pp. 40-44

Advantages and limitations are discussed of test methods for pipelines and tubing in petrochemical and power plants. On-stream inspection is limited to ultrasonic, radiographic and electrical resistivity techniques which may be supplemented with optical aids such as television and cine camera equipment during downtime inspection. Generally the eddy current method is limited to the testing of nonferrous tube materials such as brass and Ti. Caliper gaging is used to internally survey the cores of oil well pipes.

5422 **SELECTION/DEVELOPMENT OF NDT FOR QUANTITATIVE PREDICTION OF MATERIALS PERFORMANCE**

C. H. Hastings

AVCO, Lowell, Mass. (Space Systems Div.)

Symposium on Correlation of Material Characteristics with Systems Performance, Orlando AFB, Fla., 10-12 May 1967

An oversimplified relationship can express systems performance in terms of the quantitative definition of materials properties or behavior characteristics under environmental stresses. Materials properties are in turn controlled by chemical or structural variables in the materials which, if understood, can frequently be quantitatively defined by nondestructive tests. Ideally, therefore, carefully selected and applied NDT should permit quantitative prediction of at least some aspects of systems performance. This paper discusses three examples of NDT selection/development in which thermal conductivity of graphite for re-entry heat shields or rocket nozzles, mechanical properties of glass reinforced plastics, and oxidation resistance of diffusion-formed coatings on refractory metals are discussed.

5427 **NEW PHASE-SENSITIVE EDDY-CURRENT METHOD OF DETECTING SURFACE CRACKS IN METAL PRODUCTS: I. PHYSICAL PRINCIPLES; II. CONSTRUCTION OF FLAW DETECTOR**

V. Vlasov, Yu Subbotin

Defectoscopy, no. 3, May-June 1965, pp. 257-268

A new approach is considered in eliminating the effect of interference in the detection of relatively extended surface cracks in metal products. The method is based on eddy currents and employs a contact type search system. Results of experimental investigations are cited and the construction and operating features of the principally new flaw detector are described.

5429 **SPECTRAL DENSITY OF THE ELECTRIC SIGNALS INDUCED IN INDUCTION DATA TRANSMITTERS BY MAGNETIC FIELDS OF DEFECTS OF THE LINEAR-DIPOLE TYPE**

Yu. K. Fedesenko

Defectoscopy, no. 3, May-June 1965, pp. 241-246

The spectral composition of the electric signals induced in various types of induction data transmitters by magnetic fields of defects of the linear-dipole type is investigated by means of fourier transforms. Expressions for the spectral density of these signals are derived. The effect of different factors on the frequency spectrum of the signals under consideration is investigated.

5434 **BULK CONDUCTIVITY MEASUREMENT STANDARDS**

A. R. Jones
Boeing Company, Seattle, Wash.
Reprint, ASTM 70th Annual Meeting, Boston, 1967 (To be published in Materials Research and Standards)

Eddy current meters used for conductivity measurements require accurate traceable standards. Boeing has constructed a calibration facility for primary conductivity measurements. In addition, 12 sets of secondary standards have been prepared and distributed within the company. Most of the conductivity standards cover the aluminum alloy conductivity range. Procedures have been set up to monitor drift of primary and secondary conductivity standards.

5437 **PRINCIPLES OF THE MAGNETIC REACTION ANALYZER – A NEW EDDY CURRENT TEST SYSTEM**

R. C. McMaster and G. H. Smith
Materials Evaluation, vol. 25, July 1967, pp. 153-163

The Magnetic Reaction Analyzer is a sensitive new magnetic reaction and eddy current test instrument that permits noncontacting measurements of magnetic permeability, electrical conductivity, and geometric properties of metallic materials over a frequency range from 20Hz to 100KHz. In nondestructive testing, the analyzer provides all functions of eddy current test instrumentation, with unique sensitivity in many special inspection problem areas.

5449 **EDDY CURRENT INSPECTION OF TURBOJET ENGINE TURBINE DISKS FOR LOSS OF STRENGTH**

L. G. Marler
Oklahoma Air Materiel Area, Tinker Air Force Base, Okla.
Defense Conference on Nondestructive Testing, *15th, Army Materials and Mechanics Rsch. Ctr.*, Watertown, Mass., Oct. 1966, pp. 49-55

This paper concerns the use of eddy currents to detect a reduction in a materials strength after it has experienced repeated exposure to temperature and stress. The problem that necessitated this inspection technique, the experimental program that led to this method of inspection, and the present activity in this area is discussed.

5461 **NONDESTRUCTIVE TESTING TECHNIQUES FOR MULTILAYER PRINTED WIRING BOARDS**

J. F. Blanche
Nondestructive Testing: Trends and Techniques (Proceedings, 2nd Technology Status and Trends Symposium, Marshall Space Flight Ctr., 26-27 Oct. 1966); NASA-SP-5082, 1967

A number of methods for nondestructively examining multilayer printed circuit boards is considered. Among these are thermal, eddy current, intermodulation, E-field senors, and radiography. The two methods showing the greatest promise are radiography using an axial transverse laminographic technique and a mutual coupling eddy current method. Details of both methods are given and the laminographic technique appears to offer potential in several types of radiographic inspection problems.

5473 **HIGH VOLUME NONDESTRUCTIVE TEST APPLICATIONS AT THE HANFORD ATOMIC PRODUCTS OPERATION**

D. C. Worlton
Battelle-Northwest, Richland, Wash.
IAEA Symposium on Nondestructive Testing in Nuclear Technology, Bucharest, 11 Mar. 1965

The transition from laboratory to field use is discussed from eddy current and ultrasonic testing methods in two fields: inspection of thin-wall tubing, and automatic fuel testing.

5480 **EDDY CURRENT AND INFRARED INSPECTION OF GRAPHITE**

C. V. Dodd
Oak Ridge National Laboratory, Oak Ridge, Tenn.
Paper #61, ASTM 70th Annual Meeting, Boston, June 1967

Eddy Current and Infrared techniques are applied successfully to the inspection of graphite. A phase-sensitive eddy current instrument has been used in a through transmission mode to measure the thickness of thin graphite plates and to detect cracks in a variety of different graphite components such as spheres, tubes and cylinders. An infrared heat transfer technique was also applied to the spheres to detect near-surface laminations. Sample laminations with a diameter four times their depth beneath the surface were easily detected.

5485 **NONDESTRUCTIVE TEST METHOD FOR RAPID SEGREGATION OF MIXED M73 SOLENOID PLUNGERS**

H. P. Hatch, et al
SA-TN 19-1518, 17 March 1966

A nondestructive test for separating solenoid plunger of 1100 series steel from the specified ingot iron plunger is described. The procedure utilizes a commercial eddy current test instrument. Meter readings were also correlated with the hardness of the plungers which was higher for plungers of 1100 series steel. The plungers were also carburized to a depth of 0.010" to 0.020" but this did not invalidate the test.

5486 **EDDY CURRENT DEVICES FOR CRACK DETECTION**

H. Frankel
Watervliet Arsenal, Watervliet, N. Y.
WVT-6728, June 1967
AD-817 591

An eddy current device was built that can detect 0.0025 inch deep saw cuts in steel. Transducer heads are described for detecting cracks on both the OD and ID of tubes. The new instrument is compared with existing inspection methods and with a commercial eddy current test instrument. Problems associated with accurate crack depth measurements are mentioned.

5495 **NONDESTRUCTIVE TESTING FOR SPACE APPLICATION; FEASIBILITY AND PRELIMINARY DESIGN STUDY**

W. A. Zoran
Hamilton Standard Co. (Div. of United Aircraft)
NASA CR-84442, 15 Oct. 1966
N67-27429

The need for development of nondestructive testing technology for in-space use is clearly defined by a thorough examination of current and proposed future space programs. Its use, and selection of the best methods/methods of inspection considering ultrasonics, eddy current and radiography are also discussed. These are related to proposed in-space fabrication, repair and other functional requirements such as medical, preventative maintenance and scientific research aid. A preliminary design concept of an integrated ultrasonic-eddy current instrument with a detachable radiograph unit is presented. The space environments compatability and the required human engineering aspects are defined with a test plan for their evaluation.

5502 **A QUANTIZED EDDYFAX TECHNIQUE APPLIED TO THE INSPECTION OF REACTOR-GRADE GRAPHITE**

R. S. Sharpe et al.
The British Journal of Nondestructive Testing, vol. 9, no. 3, Sept. 1967, pp. 80-85

This report describes the Eddyfax eddy current technique which has provided a satisfactory production inspection procedure for graphite components for reactors. Limitations of radiographic, ultrasonic, and penetrant techniques for inspection of graphites are discussed. Results of quantizing the Eddyfax facsimile records are presented.

5512 **THICKNESS MEASUREMENT AND CONTROL IN THE MANUFACTURE OF POLYETHYLENE CABLE SHEATH**

W. T. Eppler
Western Electric Co., Kearny, N. J., 14 Dec. 1953

The problem relates to maintenance of proper thickness and concentricity of extruded polyethylene sheath. An A.C. impedance bridge setup was used to measure both thickness and concentricity. Using the procedure, concentricity can be controlled to within 10% and thickness to within ±0.003 inch.

5513 **THICKNESS MEASUREMENTS BY NONDESTRUCTIVE TESTING METHODS**

R. E. Cofield
Union Carbide Corp., Oak Ridge, Tenn. (Oak Ridge Y-12 Plant)
AEC R & D Rpt Y-1535, 21 June 1966

Dimensional parameters such as thickness can frequently be measured by nondestructive testing methods which are normally used for the evaluation of internal quality. These methods generally respond to the nature of the test object material rather than merely to the relative location of its surfaces. Thus, many of the techniques can measure thickness when only one surface is accessible or when the thicknesses of several layers of materials are involved. Tangential projection radiography, narrow-beam radiation absorption gaging, radiation backscatter, electromagnetic induction, microwave interaction and ultrasonic wave propagation are practical thickness-measurement techniques that are discussed in this report.

5514 **DEVELOPMENT OF AND USE OF AN EDDY CURRENT CONDUCTIVITY TECHNIQUE FOR MONITOR OF HEAT EFFECTS IN 2219 ALUMINUM ALLOY WELDMENTS**

W. D. Rummel

Martin Marietta Corp., Denver, Colo.

Rpt. QL-DEN 67-0227, 1967 (Given at 6th Symposium on the Nondestructive Evaluation of Aerospace and Weapons Systems Components and Materials, San Antonio, 17-19 April 1967)

The design, manufacture and quality assurance requirements for a dual thickness, maximum strength to weight ratio, 2219 aluminum alloy weldments are described. Emphasis is on a nondestructive technique for monitor of the heat effects in 2219 aluminum alloy weldments. Quantitative data and a description of experimental work are presented. The end product nondestructive quality assurance technique involves hand scanning of areas adjacent to a weldment and correlation of conductivity values to ultimate tensile strength. Assurance procedures described have been proven in production by manufacturing personnel over the past three years.

5517 **THE APPLICATION OF MICROWAVE TECHNIQUES TO NONDESTRUCTIVE TESTING OF FILAMENT-WOUND PLASTICS AND OTHER DIELECTRIC MEDIA**

D. K. Adams

[Symposium], Testing Techniques for Filament Reinforced Plastics, [Dayton, Ohio, 21-23 Sept. 1966] AFML-TR-66-274, Sept. 1966

Microwave radiation is particularly suitable for the nondestructive testing (NDT) of many modern, non-metallic materials. The topics considered in this paper concern the depths to which microwaves can penetrate materials of interest, and the experimental techniques available for employing microwaves in NDT. In particular, the microwave properties of fiberglass and three typical rocket motor materials are reported the design of a high-resolution, short-range, microwave scanning system is also described.

5521 **PULSE DEVICE FOR CIRCULAR MAGNETIZATION OF SPECIMENS**

G. I. Dmitriev, et al

Defectoscopy, no. 6, Nov.-Dec. 1965, pp. 510-511

This brief communication describes a magnetization technique found to be of value in flaw detection of industrial products. The magnetizing flux is provided by the current from a bank of capacitors; this produces a high residual field in the surface layer, which provides good sensitivity to hairline cracks when magnetic suspensions and magnetic probes are used.

5529 **ELECTROMAGNETIC TESTING OF TUBING: STANDARDIZATION OF SPECIFICATIONS AND TEST METHODS' PART 1**

R. Hochschild

Nondestructive Testing, vol. 16, no. 6, Nov.-Dec. 1958, pp. 495-499

One of the fundamental and recurring problems in nondestructive testing is to draw the line between an acceptable product and a rejectable one on the basis of what is often only vague knowledge of the causes of failure. Given a critical enough inspection, hardly a part manufactured proves entirely flaw-free. The impossibility of rejecting 100% of production means that certain types of flaws must be accepted. The knowledge of what type of information electromagnetic methods can supply about flaws, how they measure a flaw's severity, and the standardization of test methods are the subject of this present article.

5539 **MAGNETIC METHOD TESTING THE QUALITY OF THE QUENCHING AND TEMPERING OF RAILS**

G. S. Tomilov

Defectoscopy, no. 6, Nov.-Dec. 1966, pp. 476-481

The field topography associated with the residual magnetism in quenched and quenched-and-tempered rail samples after local magnetization with d.c. electromagnets was studied. A method was developed (together with the corresponding apparatus) for continually testing the microstructure and hardness of rails heated to 250 or 350°C by measuring the normal component of the field due to residual magnetization.

5545 **PREREQUISITES FOR QUANTITATIVE EDDY CURRENT TESTING**

L. C. Wilcox, Jr.

Materials Evaluation, vol. 25, no. 10, October 1967, pp. 237-244

It has been shown how four basic steps can be followed to perform quantitative eddy current tests based upon the concepts of electromagnetic field theory and measurement engineering. It is shown how the four steps of 1) establishing a basis for selection or rejection of eddy currents as a test method, 2) exercising control over the probing electromagnetic field, 3) obtaining valid data, and 4) interpretation of test data can be accomplished in a systematic manner. A test of aluminum foil illustrates these principles.

5551 **DYNAMICS OF THE MAGNETIC REVERSAL OF FERROMAGNETIC PLATES**

G. A. Burtsev

Defectoscopy, no. 2, March-April 1965, pp. 170-175

This work examines the calculation of the coercive force and maximal differential permeability of rectangular ferromagnetic plates of finite length magnetically reversed by an alternating (in time) spatially-homogeneous field. The theoretical calculations are confirmed by experimental results.

5552 **MAGNETIZATION CONDITIONS IN THE COMBINED INSPECTION OF PARTS BY THE MAGNETIC POWER METHOD**

A. V. Zhigadlo and V. V. Korsakov

Defectoscopy, no. 2, March-April 1965, pp. 165-169

The optimal magnetization conditions are established for two different methods of combined inspection of parts by the magnetic-powder method. The advantage of combined magnetization of parts by three-phase half-wave rectified currents over combined magnetization by direct full-wave and alternating current is shown. Experimental data are given.

5562 **THE MEASUREMENT OF WALL THICKNESS OF METAL FROM ONE SIDE ONLY, BY THE DIRECT CURRENT CONDUCTION METHOD**

J. Buchanan, et al.

Nondestructive Testing, vol. 16, no. 1, Jan.-Feb., 1958, pp. 31-35

A direct-current conduction method is described for the measurement of wall thickness of metal from one side only. Essentially the method involves the measurement of the resistance of an area, roughly circular, by means of a 4-electrode array. The theory of the method is developed, and equations derived for the relationship between the ratio V/I (potential difference/current) and the wall thickness for the general and the two-dimensional case. Full details of the apparatus, current circuit, potential circuit, and electrode head are given, together with a satisfactory testing procedure. Finally, examples of the practical application of the method and equipment for measuring corrosion thinning in steel plates, defects in plates, wall thinning of tubes, and lack of bonding are presented.

5565 **EDDY CURRENT AND MAGNETIC INSPECTION OF TURBINE BLADES**

R. R. Hooker & J. A. Bailey

Automatic Forster, Inc.

Sperry Nondestructive Testing Newsletter, vol. 10, no. 2, June 1967, p. 3

The application of eddy current test principles to defect detection on irregularly shaped objects, such as the leading and trailing edges on turbine blades, is described. New developments in areas of instrumentation and probe design which enable one to obtain the required accuracy and repeatability are discussed. Minimum defect size detectable as well as correlations between instrument indications and the parameters of the defect are discussed.

5568 **A NON-CONTACT MOISTURE METER FOR LUMBER**

W. Perry

Washington State University, Pullman, Wash. (College of Engineering)

Symposium on NDT of Wood, 2nd, Spokane, Wash., April 1965, Proceedings, pp. 297-305

This paper presents a new concept in moisture measurement involving a meter head that does not contact the lumber. Consequently, this meter is not affected by surface roughness, wood density, or production line speed as previous meters have been. The theory, capabilities and illustrations of the meter, which measures the internal impedance of the wood as it affects a balanced capacitance are presented.

5589 **SIMULATION OF THE PERFORMANCE OF EDDY CURRENT FLAW DETECTORS BY MEANS OF ELECTRICALLY CONDUCTING PAPER**

V. V. Sukhorukov

Moscow Power Institute

Defectoscopy, no. 4, July-August 1965, pp. 293-299

The use of a mathematical model of electrically conducting paper to solve problems in eddy current flaw detection in work on electrically conducting objects is demonstrated. Results of a simulation test run on the spar of a helicopter featuring lengthwise cracks of unequal depth are reported.

5596 **DEPENDENCE OF YOUNG'S MODULUS AND THE MECHANICAL QUALITY FACTOR OF MAGNETOSTRICTIVE FERRITES ON THE MAGNETIZATION**

I. P. Golyamina and V. K. Chulkova

Akusticheskii Zhurnal, vol. 12, no. 4, Oct.-Dec. 1966, pp. 428-434 (English lang. translation, cover-to-cover, as Soviet Physics-Acoustics)

The dependence of the dynamic Young's modulus and mechanical quality factor on the constant magnetic field is investigated experimentally for several types of magnetostrictive ferrites. The magnitude of the saturation OE effect is compared with the theoretical data. The behavior of Young's modulus and the quality along the steep portion of the magnetization curve is explained on the basis of the separation of two effects: mechanical vibrations under the conditions of a "magnetically clamped" sample and periodic magnetic reversals in pace with the vibrations. Data are given on the variation in Young's modulus and the quality in the important interval of field variations from the practical point of view.

5601 **ON THE DESIGN OF CONTACT PICKUPS WITH FERRITE CORES**

I. I. Kifer, V. S. Fastritskii

Defectoscopy, no. 6, Nov.-Dec. 1965, pp. 456-462

The possibility of designing contact pickups with ferrite cores is discussed on the basis of deriving the reflected impedance of a coil (without core) interacting with ferromagnetic material.

5602 **SIMULATION OF PROBLEMS OF METAL FLAW DETECTION ON THE EGDA INTEGRATOR BY THE POTENTIAL DROP METHOD**

E. I. Brainin, L. Ya. Vinnikov

Defectoscopy, no. 6, Nov.-Dec. 1965, pp. 450-455

Simulation on the EGDA (electrohydrodynamic analogy) integrator of problems of metal flaw detection by the potential drop method made it possible to give practical recommendations relative to the placement of the points of the conductor and removal of the potential difference in defectoscopy. The correctness of results obtained is confirmed by direct experiments.

5603 **FERROPROBE FLAW DETECTION ON STEEL TUBES IN AN EXTERNAL CIRCULAR MAGNETIC FIELD**

N. N. Zatsepin, et al.

Defectoscopy, no. 6, Nov.-Dec., 1965, pp. 445-449

Steel tubes may be tested for external and internal defects simultaneously by means of an external ferroprobe instrument. The ability to detect defects varies: surface defects of depths 0.1 to 0.2 mm are detectable, whereas defects on the inside wall (wall thickness 4 mm) must be 0.2 to 0.3 mm deep to be detected. It is found that the method can be used with the tube moving at production speeds.

5604 **ELECTROMAGNETIC INTROSCOPE FOR VISUALIZING THE MAGNETIC RELIEF OF METAL ARTICLES**

K. M. Klimov

Defectoscopy, no. 2, March-April 1965, pp. 182-183

This brief communication describes apparatus used for scanning ferromagnetic tubes to locate various types of defects. The scanning head detects leakage fields in the magnetized tube and signal amplitudes are indicated as density variations on electrosensitive facsimile type recording paper.

5605 **MAGNETIC PERMEABILITY OF A SECTION OF FERROMAGNETIC MATERIAL BEING MAGNETICALLY REVERSED BY AN ALTERNATING MAGNETIC FIELD**

I. I. Kifer, V. S. Fastritskii

Defectoscopy, no. 2, March-April 1965, pp. 176-181

Problems are examined which are associated with establishing a special type of magnetic permeability upon magnetic reversal of a portion of a ferromagnetic substance by a magnetic field whose direction is close to normal with respect to the surface of the ferromagnetic material. The characteristics of this type of permeability, certain possibilities of its use, and a method of determining its value are indicated.

5608 **NEW NDT METHODS PROBE: THE LOOK, SOUND, AND SMELL OF QUALITY**

Steel, 14 Feb. 1966, pp. S/1-S/8

A feature article on new trends in NDT, and written for the layman. Covered briefly are microwaves, infrared, microradiography, ultrasonics, eddy, and olfactronics, the latter being the art of detecting odors peculiar to corrosion, plastic impurities, surface microorganisms, etc.

5611 **PORTABLE MODULATION FLAW DETECTOR FOR INSPECTING THE INNER SURFACE OF FERROMAGNETIC TUBES**

V. A. Minchenko, et al.

Defectoscopy, no. 6, Nov.-Dec. 1966, pp. 466-470

A transmission-type flaw detector, intended for inspecting the inner surface of ferromagnetic steel tubes 80 to 200 mm in diameter is described. Results of testing the flaw detector performance are given. It has been found that with minimum lift-off, the instrument is capable of detecting cracks 0.2 mm deep.

5612 **MAGNETIC INSPECTION OF THE STRUCTURE OF THE METAL BASE AND FORM OF GRAPHITE IN CASTINGS OF CRANKSHAFTS OF HIGH-STRENGTH CAST IRON**

V. A. Ivlev

Defectoscopy, no. 6, Nov.-Dec. 1966, pp. 463-465

This article presents results of experiments on determining the possibility of inspecting the structure of the metal base and form of graphite inclusions in castings of high-strength cast iron crankshafts by the magnetic methods, without their preliminary machining or cleaning.

5615 **VTDN-1 SET FOR THE DETECTION OF SURFACE FLAWS IN FERROMAGNETIC TUBES**
P. K. Oshchepkov et al.
Defectoscopy, no. 6, Nov.-Dec. 1966, pp. 471-475

The construction and circuit diagram of an instrument for inspecting the quality of the outside surface of hot-rolled tubes are described. The results of industrial testing of the instrument are briefly mentioned.

5629 **BASIC PRINCIPLES AND TECHNIQUES OF EDDY CURRENT TESTING**
H. Libby
Nondestructive Testing, vol. 14, no. 6, Nov.-Dec. 1956, pp. 12ff

The basic principles and techniques of eddy current testing have been presented by the discussion of specific experimental testing results. An attempt has been made to explain the test results in terms of basic eddy current theory, but no detailed analytical treatment is given. It is realized that this presentation is not complete and may suggest to the reader many unanswered questions. In such event it is hoped that sufficient background information has been presented to encourage the reader to look further into this expanding field.

5647 **CURRENT AEROSPACE APPLICATIONS USING MRA EDDY CURRENT TEST SYSTEMS**
G. Smith and R. McMaster
Materials Evaluation, vol. 25, no. 12, Dec. 1967, pp. 283-288

The MRA (Magnetic Reaction Analyzer), representing a new concept in eddy current test systems, is finding use in a variety of applications throughout the aerospace industry. Current application areas to be discussed include the following: 1) Unusually deep penetration into high-conductivity materials, 2) Accurate determination of properties and thicknesses of thin magnetic coating and base materials, 3) Nearly linear measurements of thick nonconductive materials, 4) Definition of type, orientation and location of defects, 5) Location of hidden weld preparations and many smooth-finished welds. Preliminary work is revealed here on a practical eddy current "area-scan" method that facilitated detailed presentation of the continuity of properties of flat materials by means of C-scan plots.

5660 **OFFNER TYPE 542 RECORDERS USED IN TESTS REVEALING DEFECTS IN ATOMIC REACTOR TUBING**
Dynograph Data, vol. 3, no. 2, July 1964, pp. 3-7 (Publisher: Beckman Instruments [Offner Operations], Fullerton, Calif.)

New highly accurated eddy current techniques for inspecting tubing for atomic reactors are described. The test signal is broken in quadrature components. Special probe coils were developed. The equipment was particularly successful in locating regions containing intergranular corrosion and differentiating between corroded areas of varying depth in the tube wall.

5664 **CALCULATION OF THE CHARACTERISTICS OF FERROPROBES FOR MAGNETIC FLAW DETECTION**

I. I. Kifer, M. S. Tseplyaeva

Zavodskaya Laboratoriya, vol. 29, no. 6, June 1963, pp. 774-779

A method is described for calculating the characteristics of ferroprobes based on the volt-ampere characteristics of the core recalculated for the corresponding values of induction and intensity of the magnetic field. A way to derive the generalized characteristic is shown and a method is described to pass from the generalized characteristic to the characteristic of a real core.

5666 **NDT ASSURES QUALITY OF AUTO PARTS**

D. W. Pontius

Metal Progress, vol. 90, no. 4, Oct. 1966, pp. 183-184, 188, 190, 192

Cold extruded axle shafts, made of 1039 steel, are 100% ultrasonically tested by an installation in line with the extrusion press. Chevron defects are readily detected. An ultrasonic bath is used to clear steel and nonferrous parts. Front wheel spindles are 100% inspected by magnetic particle methods. The inspection machine has longitudinal charging heads which are interlocked to stop functioning if the current fails to pass through both branches of the Y-shaped spindles. Surface defects in spring wire are detected by eddy current tests. Devices with rotating probes are used to inspect wire continuously.

5667 **INSPECTION OF HEAT TREATMENT OF HIGH SPEED TOOLS WITH A UFAN COERCIMETER**

I. K. Kupaloya, V. A. Landa

Industrial Laboratory, vol. 28, no. 11, Nov. 1962, pp. 1431-1433

The results of a study of the effect of dimensions, state of surface, distortion, and the method of heat treatment of specimens and tools made of R18 steel by a UFAN Coercimeter are described. The limits of applicability of the instrument for the inspection of heat treatment of components made of high-speed steel in workshop conditions are determined.

5672 **OPERATING MANUAL FOR MAGNATEST* MAGNETIC FIELD METER TYPE FM-200**

Magnaflux Corp., Chicago, Ill.

This instrument is an electronic instrument for measuring weak magnetic fields. The operating principles description, operation instructions, calibration, service data schematic and circuit drawings are presented.

*TM, Magnaflux Corp., Chicago, Ill

5674 **EDDY CURRENT SLIDE RULE**

R. L. Brown
Batelle Memorial Institute, Richland, Wash. (Pacific Northwest Lab.)
Rpt BNWL-SA-1387, 1967

A slide rule type calculator has been developed for computation of the test parameters associated with eddy current testing of nonmagnetic metallic sheets or tubes. Operating frequency, material conductivity, or standard depth of penetration can be quickly obtained from the calculator when the other two parameters are chosen. A novel feature of this calculator is a scale giving an estimate of the angle, on the complex impedance plane between the locus of coil to metal spacing changes and the locus of material thickness changes.

5696 **DEVELOPMENT OF A PRACTICAL DEVICE FOR THE INSPECTION OF PRODUCTION PARTS BY ULTRASONIC ATTENUATION TECHNIQUES**

P. H. Todd
Martin Co., Denver, Colo.
Rpt. DEN 66-486, Nov. 1966

Ultrasonic attenuation measurements using the pulse method in the 30 MHz frequency range were made on 2014 aluminum alloy. Measurements show a significant increase in attenuation in overheated samples. Eutectic melting contributes to an increase in Rayleigh scattering. Ultrasonic measurements are compared with hardness and eddy current data.

5750 **NONDESTRUCTIVE INSPECTION OF THE ADHESION OF A SPRAYED ZINC COATING ON A STEEL BASE**

F. I. Brainin, V. V. Solov'yanova
Zavodskaya Laboratoriya, vol. 30, no. 4, April 1964, pp. 457-459 (English translation)

It is suggested that the adhesion of sprayed zinc coatings on steel be determined from the electrical resistance, measured by means of the four-probe method. The strength of the adhesion of electrically-applied coatings to the base metal can be characterized by the contact resistance between elementary sections of the coating and the base metal. A similar relationship can be expected in the case of a 0.1 mm thick sprayed zinc coating. The contact resistance was measured by the four-probe methods.

5751 **MAGNETIC FIELD OF NONCYLINDRICAL COILS**

W. J. C. Grant and M. W. P. Strandberg
Review of Scientific Instruments, vol. 36, no. 3, March 1965, pp. 343-346

An exact calculation is made for the magnetic field produced by a pair of rectangular coils. The calculation is not based on approximations tailored for the central region of the configuration. For current sheets of rectangular cross section, we obtain a closed analytical expression for the fields which is exactly valid for all points on the principal coordinate planes, and for all combinations possible of coil parameters. The calculation is extended to sources of arbitrary thickness by numerical integration. Detailed numerical application is made to the calculation of field homogeneity in the central region of the configuration.

5755 **ELECTROINDUCTIVE INSTRUMENT FOR CHECKING DIMENSIONS AND DETECTING FLAWS IN METAL PRODUCTS**

A. T. Mikolayenko, N. L. Bondarenko
Soviet Patent 155,291; application, 26 July 1962.
FTD-TT-64-1282 (Eng. lang. translation, Wright-Patterson AFB, Ohio

An instrument for checking dimensions and detecting flaws in metal products is described. This instrument is based on the method of excitation and recording in a controllable area of eddy currents. Temperature compensation is used.

5756 **OSCILLATIONS OF THE VELOCITY OF SOUND IN METALS IN A MAGNETIC FIELD**

S. Rodriguez
Physical Review, vol. 132, no. 2, 15 Oct. 1963, p. 535

A study is made of the effect of a constant magnetic field on the propagation of acoustic waves in metals. It is shown that the velocity of sound may experience two types of oscillations as a function of the intensity of the magnetic field. There exists geometric oscillations associated with the coincidence of the diameter of the cyclotron orbits of the electrons with a half-integral or with an integral multiple of the acoustic wavelength. There are also quantum oscillations which have the same origin as the de Haas-van Alphen effect.

5757 **COERCIVE-FORCE MEASUREMENTS ON COMPONENTS**

E. N. Chechurina et al.
Zavodskaya Laboratoriya, vol. 29, no. 6, June 1963, pp. 722-724 (English language translation as Industrial Laboratory)

A study has been made of the determination of coercive force on components of various shapes made from 10w-carbon transformer steel. It is found that inhomogeneous magnetication causes and apparent increase in the coercive force for curved components.

5758 **INSTRUMENT FOR DETECTING DEFECTS IN THE SUBSURFACE LAYER OF A NONMAGNETIC METAL**

A. N. Yermakov et al.
Machines and Instruments for Testing Metals. Kiev, U.S.S.R.: Ukrainian Academy of Sciences Press, 1961, pp. 116-127. FTD Engl. lang. translation, Wright-Patterson AFT, Ohio, 1 April 1966
AD-637 372

An instrument is described which enables detection of microinhomogeneities or disturbances of continuity in the surface or subsurface layer of a nonmagnetic metal, i.e., surface and subsurface cracks, cavities, nonmetallic inclusions, etc. With appropriate calibration the instrument can also be used for determining the intensity of work-hardening of the surface of a nonmagnetic metal. The measurement method is based on the determination of the anistropy of electrical resistance in two mutually perpendicular directions passing through a given point of the metal.

5763 **DEVELOPMENT OF A TEST DEVICE UTILIZING A PRACTICAL NONDESTRUCTIVE TEST TECHNIQUE TO DETECT FATIGUE DAMAGE IN METALS AND ALLOYS**

F. Kusenberger et al.
Southwest Research Inst., San Antonio, Texas. Final Report 15 June 1962
AD-633 873

Nondestructive magnetic field inspection techniques have been evaluated for the detection of fatigue damage in steel tubing. Methods of magnetizing the specimens as well as methods for measuring magnetic field perturbations were investigated. Design and evaluation of an ultrasonically driven search coil type probe for measuring field perturbations are described.

5773 **DEVELOPMENT OF NONDESTRUCTIVE TESTS FOR QUANTITATIVELY EVALUATING GLASS FABRIC REINFORCED LAMINATES**

J. Zurbrick
AVCO Corp., Lowell, Mass.
AFML-TR-67-170, Dec. 1967
AD-825 951

The 3rd year of this study (under the same contract) was devoted to four related but distinct areas: (1) Continued evaluation of thick laminates fabricated during the 2nd year (2) Evaluation of thinner laminates fabricated during the 3rd year (3) Significant defect evaluation (4) Development of low-frequency dielectric probes for nondestructive testing. The theoretical basis for the various probes and probe design are all discussed in detail. Micrographs of the laminates evaluated are displayed with typical destructive and nondestructive test values in the appendix.

5783 **TURBINE ENGINE COMPRESSOR BLADE CHECKOUT**

J. E. Bridges et al.
ITT Research Institute, Chicago, Ill.
AFAPL-TR-67-59, June 1967 (Air Force Air Propulsion Lab, Wright-Patterson AFB).
AD-818 274

The program objective was to demonstrate the feasibility of one or more techniques for a portable flight line checkout system that will determine foreign object damage to the compressor rotor blades of an installed jet engine. The blades are to be inspected without requiring personnel to gain access to the engine front end while the engine is in operation. Results pointed to the need for primary emphasis to be placed on electromagnetic techniques including millimeter wave, magnetic field, and eddy current techniques. Electrometer and optical techniques did not prove to have promising applications on a practical basis. The feasibility of promising techniques were verified by demonstrations.

5787 **CALIBRATING THE ELECTRIC POTENTIAL METHOD FOR STUDYING SLOW CRACK GROWTH**

H. H. Johnson
Materials Research and Standards, vol. 5, no. 9, Sept. 1965, p. 442

The author finds, contrary to earlier suggestion, calibration is insensitive to material chemistry, heat treatment, and thickness within substantial ranges of these variables. The calibration is sensitive, as expected, to the geometry of the crack-starting flaw. For simple specimen geometrics, theoretical calculations agree well with experimental calibrations and are a useful guide in experimental work.

5793 **ANALYSIS OF M114 VEHICLE REPLACEMENT SUSPENSION ARM**

John M. Ingraham

AMRA, Watertown, Mass.*, preliminary letter report, April 1966

Examination of one M114 vehicle replacement suspension arm indicated that with the exception of a heavy wall thickness this casting otherwise satisfied the existing procurement requirements. These requirements, however, permit tensile properties to be obtained from a test coupon block and the results do not agree with tensile properties obtained from the casting itself. Five tensile speciments, taken from the casting, failed to satisfy the ductility requirements of class 150-125 steel and it is recommended that future tests be taken from the casting in order to insure representative test results.

*Army Material Research Agency

5794 **NONDESTRUCTIVE INSPECTION METHODS APPLIED TO MULTI-FINNED SAP TUBING FOR NUCLEAR FUEL ELEMENTS**

S. Lunc*, P. Knudsen**

*Danish Central Welding Institution, Copenhagen; **Danish Atomic Energy Commission

Symposium on Nondestructive Testing in Nuclear Technology, Bucharest, Romania, 17-21 May 1965

Quality control of the canning tubes for heavy-water-moderated power reactors is discussed in this report. An account is presented of the nondestructive techniques developed for the measurement of wall thickness and diameters as well as flaw detection. Special recording beta gauge techniques based upon the attenuation of beta radiation from a Sr^{90} source is used for wall thickness measurements. Ultrasonic resonance method is used for continuous recording of wall thickness of more simple tube design. Inner and outer fin tip diameters are continuously recorded by rapid air-gauge systems. Flaw detection is carried out by the immersed ultrasonic pulse echo technique and by eddy current.

5833 **PROPERTIES DETERMINATION AND PROCESS CONTROL OF BORON FILAMENT COMPOSITES USING NDT METHODS**

R. C. Stinebring, J. R. Zurbrick

AVCO SSD, Lowell, Mass.

10th National Symposium of Aerospace Material and Process Engineers, San Diego, Calif., Nov. 1966

Material variability in boron filament composites which control strength is monitored by nondestructive testing methods. Among the NDT methods which have yielded valuable information for predicting performance of these materials are ultrasonic velocity, microradiography, dye penetrant and electric-field filament gauging.

5838 **NONDESTRUCTIVE TEST DEVELOPMENT FOR NUCLEAR REACTOR PROGRAMS AT THE OAK RIDGE NATIONAL LABORATORY**

R. W. McClung

Oak Ridge National Lab., Oak Ridge, Tenn. (Metals and Ceramics Div.)

Interamerican Conference on Materials Technology, May 1960, San Antonio, Texas

NDT development in the nuclear reactor development program at Oak Ridge is presented in general. Specific areas of interest include: eddy current development (theory, equipment, application); ultrasonic (optical imaging and viewing, standards, applications); penetrating radiation (absorption studies, radiography, X and gamma rays).

5841 **AUTOMATIC FERROPROBE EQUIPMENT FOR TUBE INSPECTION**

N. N. Zatsepin, et al.
Defectoscopy (Soviet Journal of NDT), no. 5, Sept.-Oct. 1967

The operating principle and the design of the FDU-1 automated ferroprobe defectoscopic equipment are described; this equipment is used for inspecting pearlite class tubing for surface and internal defects of the broken continuity type. Technical data for the equipment are given; results of its industrial tests are given.

5842 **MAGNETIC AND ELECTRICAL PROPERTIES OF HEAT-TREATED DUCTILE IRON**

P. I. Rusin, L. A. Gofman
Defectoscopy (Soviet Journal of NDT), no. 5, Sept.-Oct. 1967

The pattern of changes in heat-treated ferritic and pearlitic ductile iron, with the number of anneal carbon pockets differing with the final structure-phase state determined by isothermal annealing and austempering conditions, is detailed. The choice of magnetic and electrical parameters for nondestructive quality control of heat-treated ductile iron castings is discussed.

5847 **DEVELOPMENT OF NDT SYSTEM FOR ANALYSIS AND CONTROL OF RESIDUAL MACHINING STRESSES**

H. Schwartzbart
IIT Research Institute, Chicago, Ill.
AFML-TR-67-77, Sept. 1967
AD-830 856

The development of nondestructive testing system for identifying type, magnitude, direction and distribution of residual stresses is described. Relationship between grinding parameters and residual stresses, as well as effect of residual stresses on fatigue and stress-corrosion behavior are investigated for various materials.

5853 **INFRARED FOR ELECTRONICS EQUIPMENT DIAGNOSIS**

J. F. Stoddard
Raytheon Co., Wayland, Mass.
Tech. Rpt. AFAPL-TR-68-84, Aug. 1968
AD-840 020

A study was conducted employing infrared techniques for fault isolation on complex electronic printed circuit panels. The study consisted of evaluating panels containing both random defects and circuit anomalies. Approximately 70% of the defects and anomalies were identified by infrared analysis. Fundamental work was carried on in two other areas. The first was making radiant energy available from components buried in a thick opaque encapsulating material and the second involved evaluating component temperatures using thermo-sensitive phosphors. It was verified that both approaches are feasible. Proposed specifications for infrared testing of electronic circuit assemblies were developed. These specifications stressed the system approach to infrared test equipment and outlined the following test areas: acceptance testing, engineering design evaluation, stress analysis of component parts, reliability calculations, production testing and troubleshooting, and preventive maintenance.

5857 **VTDP-1 APPARATUS FOR TESTING DEFECTS IN THE INNER SURFACE OF HOT-ROLLED TUBES**

P. K. Oshchepkov et al.

Soviet Journal of Nondestructive Testing (Defectoscopy in English lang. translation), no. 1, Jan. Feb. 1967, pp. 38-41

Reasons are given for the necessity of testing the inner surfaces of hot-rolled tubes with wall thicknesses exceeding 3 mm by means of internal converters. Methods of eliminating interfering factors in the eddy-current defectoscope VTDP-1 are described. The construction of the mechanical system and the electronic measuring circuit of the apparatus are indicated. The results of tests on the checking of hot-rolled tubes in the First Ural New Tube Factory are presented.

5867 **MICROWAVE STUDIES OF BONDING**

A. E. Oaks

General Electric Co., Valley Forge Space Technology Center, King of Prussia, Pa.

Technical Information Series 68SD208, 17 April 1968

Studies were performed to demonstrate the feasibility and limitations of evaluating the bonding of dielectric materials on aluminum and titanium and of measuring the thickness of sprayed elastomers and paints on metal. An approach combining a vacuum cup with a miniature probe shows promise in detecting "unbonds" in elastomeric types of material. Data readout by static phase shift nulling and dynamic USWR recording techniques were evaluated.

5880 **POSSIBILITY OF OBSERVING INTERNAL STRESSES BY THE EDDY-CURRENT METHOD**

V. M. Tartarnikov, T. Ya. Gorazdovskii

Soviet Journal of Nondestructive Testing (Defectoscopy in Engl. lang. translation), no. 2, March-April 1967, pp. 131-133

It is shown that the effect of internal stresses on the electromagnetic parameters of automomotive steels differs from that of defects such as discontinuities on the same parameters. This makes it possible to sort bars of these steels into three groups (serviceable, crack-containing, and internally-stressed) from the form of the output curve by appropriate adjustment of an eddy-current defectoscope. The possibilities of sorting bars into several groups automatically are discussed.

5895 **A PORTABLE PHASE-SENSITIVE EDDY CURRENT INSTRUMENT**

C. V. Dodd

Materials Evaluation, March 1968, pp. 33-36

A new portable phase-sensitive eddy current instrument has been developed at the Oak Ridge National Laboratory. The instrument operates on either alternating current or its own rechargeable batteries. Its frequencies for operation are 50 and 500 kilohertz (kHz). The instrument can be used for a wide range of metal or clad thickness measurements and also for sorting and identifying metals according to their conductivity. It is insensitive to lift-off over a wide range of measurements. The instrument features ease of setup and operation along with good stability.

5897 **APPLICATION OF AC BIAS TO THE MAGNETIC TAPE METHOD OF INSPECTING BILLETS**
D. E. Lorenzi et al.
Materials Evaluation, Jan. 1968, pp. 13-16

This paper reviews some of the problems associated with the application of the magnetic tape method to the inspection of steel billets and then discusses the advantages through the use of AC bias. The effects of magnetizing current, seam depth and seam placement are illustrated as well as the use of various magnetic materials in the tape. The ability of the method to measure the depth of seams is demonstrated.

5903 **THE MYSTERY OF REINFORCED PLASTICS VARIABILITY: NONDESTRUCTIVE TESTING HOLDS THE KEY**
J. R. Zurbrick
Revision of preprint, 25th Annual Technical Conference of Society of Plastics Engineers, Detroit, 15-19 May 1967 (to be submitted for publication in Materials Research and Standards)

The detailed physical and mechanical properties typifying reinforced plastics and their separate reinforcements and matrices were studied. This was combined with knowledge of the well-characterized energy forms used in nondestructive testing. Material energy interactions, the key to predicting material properties from NDT response values, are defined. A workable "Variability Evaluation Plan" provided the framework for laboratory investigations and the basis for value engineering in production test situations.

5905 **MAGNETIC PARTICLE EXAMINATION OF FIN DOVETAIL BASE FILLET WELDING ON ASROC 11.65 INCH ROCKET MOTOR CHAMBER**
T. F. Jennings
Nondestructive Test Procedures, U. S. Naval Weapons Station, Concord, Calif. Part II, Section 11

This document provides a procedure for performing a magnetic particle examination of the villet welds joining the fin dovetail bases to the ASROC 11.65 Inch Rocket Motor Chambers.

5911 **A METHOD FOR PHOTOGRAPHING MICROWAVE WITH A POLAROID FILM**
K. Iizuka
Harvard University, Cambridge, Mass., (Div. of Engineering and Applied Physics)
Rpt TR-558, March 1968

A regular Polaroid film has proved to be applicable to a quick and easy direct mapping of an electromagnetic field. The method utilizes the selective development of the film in accordance with the thermal image produced by the electromagnetic field. The power required for the creation of a clear image is about 0.06 watts per square inch. The time of exposure to the microwave is about 15 to 60 seconds. The method would be useful for preparing microwave holograms. It can also be applied to the mapping of the temperature distribution in space.

5916 **HARMONIC TESTING PINPOINTS PASSIVE COMPONENT FLAWS**

V. Peterson and P. Harris
L. M. Ericsson Telephone Co., Stockholm, Sweden.
Electronics, 11 July 1966, 8 pp.

This method can measure a wide variety of non-linearities in all types of passive electronic components. Many defects successfully evaluated by harmonic analysis could not be detected by conventional NDT. Uneven film depositions, base material flaws, bad grindings and unreliable contacts in resistors can be detected Harmonic testing can also determine the hysteresis dissipation factor and the hysteresis loss coefficient in magnetic components and materials The basis of the non-linearity tester is the direct reading measurement of amplitude of the third harmonic voltage.

5927 **FIELD DETECTOR WORKS IN REAL TIME**

C. F. Augustine
Bendix Corp., Southfield, Mich.
Electronics, 24 June 1968, pp. 118-122

The real time technique discussed uses liquid crystals as sensing elements in a very broadband microwave detector that instantly produces color displays of field intensity. The device consists of a support structure made from a very thin Mylar membrane. A thin metallized film deposited on one side of the membrane is coated with the liquid crystals. A concentrated microwave beam sets up currents in the metallized film whereby segments of the film are heated up and displayed by the liquid crystals in proportion to the amount of energy absorbed. Radiation patterns of antennas and mode patterns in complex waveguides and resonators can be vividly described. Applications also exist in detecting internal flaws in materials translucent to microwaves. A method of mapping electric fields using photographic paper, just after the development action starts, in a microwave beam is described.

5928 **FINDING LEAKY IC'S ON P-C BOARDS**

F. L. Girard
Hughes Aircraft Co., Culver City, Calif.
Electronics, 24 June 1968

IC's or IC assemblies are exposed to a gas with a high dielectric constant and each module's capacitance is measured. If an IC leaks, its capacitance changes as the gas enters and leaves the package. The method requires several hours in its present stage but could be made quick enough if instrumentation were developed which could detect 10^{-5} picofarads instead of the present 10^{-3} picofarads. Present fine-leak detection methods are relatively slow, requiring at least four hours. Cross-leak detection methods are of insufficient reliability.

5931 **GETTING BENEATH THE SURFACE OF MULTILAYER INTEGRATED CIRCUITS**

F. J. Barone and C. F. Myers
Motorola Semiconductor Products Inc., Phoenix, Ariz.
Electronics, 22 July 1968, pp. 84-88

Involves a test pattern technique which can evaluate the processing parameters of high density integrated circuits at the time of fabrication. Method will provide design and reliability data for user and producer. Test patterns derive such information as diffusion sheet resistance, oxide stability and contact resistance which can predict resistor values and tolerance, transistor gain and frequency response, and component interconnection integrity. An example, using this technique on an 8-bit adder containing 11 sections is given. Each test pattern tests a specific connection or device characteristic.

5941 **EDDY CURRENT MAGNETIC FIELDS AROUND A FLAW**

V. A. Burtseva, V. V. Vlasov
Defectoscopy, Nov.-Dec. 1967, pp. 444-450

The mechanism of formation of eddy-current magnetic fields around a flaw is analyzed and the results are cited of an experimental investigation of the normal and tangential (with respect to the object surface) components of the flaw field in the case of an extended crack in magnetic and non-magnetic objects in which eddy currents were excited by a laid-on induction coil.

5943 **RAPID ELECTROMAGNETIC RAIL DEFECTOSCOPY**

B. P. Dovnar
Defectoscopy, Nov.-Dec 1967, pp. 436-443

A short survey of technical means is given for the defectoscopy of railway rails of domestic and foreign roads. The basic stages of development of a method of rapid electromagnetic rail defectoscopy are presented.

5947 **RADIOINTROSCOPY, BASIC PRINCIPLES AND CURRENT STATE**

P. K. Oshchepkov et al.
Defectoscopy, Nov.-Dec. 1967, pp. 479-485

Radioscopy is an aggregate of methods and means for investigating the structure and state of bodies by means of SHF radio waves. Article discusses the following directions that have been established in the use of the methods and means of radiointroscopy: 1) radio-wave flaw detection of industrial articles; 2) control of production technology; 3) radio-polarization method of investigating anisotropy; 4) radiointroscopy of bodies of unlimited size; 5) investigation of the structure of electromagnetic fields.

5964 **INSPECTION PROCESS, MAGNETIC PARTICLE, GENERAL SPECIFICATION FOR**
United Technology Center, P. O. Box 358, Sunnyvale, Calif.
Spec. No. 40GS-90403D, 23 Oct. 1964
AD-834 748

Covers magnetic particle inspection and the related acceptance standards for discontinuities discovered in magnetic materials. Requirements given for equipment, operators, and classification of characteristics. Military specifications are: MIL-I-6868, MIL-M-11473, MIL-STD-410

5973 **EDDY CURRENT INSPECTION OF HOT ROD**
A. Arnelo, A. Von Heijne
Essem Metotest AB, Skultuna, Sweden
Materials Evaluation, vol. 26, no. 11, Nov. 1968, pp. 230-235

Eddy current testing of hot-rolled steel, copper and aluminum rod detects such defects as cracks, laps, inclusions and rolled-in chips. A short account is given of the Metotest method of eddy current testing. Special water-cooled pickup units with differential coils have been designed to cope with the temperature of the rod, up to about 1100°C (2010°F). Information normally provided by the flaw detector can be processed in different ways. Defects are normally classified into three levels and defect position is recorded along the rod with a high speed printer.

5974 **EDDY CURRENT INSTRUMENT FOR MAINTENANCE-INSPECTIONS**
F. C. Parker
Branson Instruments, Inc., Stamford, Conn.
Materials Evaluation, vol. 26, no. 11, Nov. 1968, pp. 29A-36A

The applications of the Probolog, an eddy current instrument, to the inspection of nonmagnetic tubing installed in condensers and other heat-exchange equipment discussed. Success shown in detection of wall thinning, metallurgical changes in tube metal, corrosion pitting, and cracking. Paper tape recorder provides permanent record of each foot of tubing inspected, and the locations and extent of defective conditions. Percentage of wall thinning from corrosion and/or vibration also recorded. Scanning speed up to 48 ft. per minute indicated.

5980 **THE EFFECT OF CORE CURRENTS ON FERROPROBE CHARACTERISTICS**
G. A. Burtsev
Defectoscopy, May-June 1967, pp. 193-202

On the basis of a previously obtained approximate solution of the problem of the dynamics of magnetic reversal of ferromagnetic plates of finite length and made of material having a rectangular hysteresis loop in a sinusoidal three-dimensional homogeneous magnetic field, this article gives a calculation of the sensitivity of a two-element ferroprobe with a tight measuring coil taking into account the interaction between the half elements in the idling regime. Formulas are derived for calculation of the permeability of the ferroprobe cores with respect to the measured magnetic field taking eddy currents into account. Calculated results are compared with experimental data on the frequency dependence of the maximum sensitivity and the optimum ferroprobe magnetic field excitation.

5982 **EVALUATION OF THE SURFACE EFFECT AND THE APPEARANCE OF INTERNAL DEFECTS IN RAILHEADS WITH RAPID MAGNETIC DEFECTOSCOPY**

B. P. Dovnar et al.

Defectoscopy, May-June 1967, pp. 175-179

This article gives an approximate quantitative evaluation of the surface in the railheads magnetized by a moving constant magnetic field generator, with regard for the nonlinearity of the rail's magnetic characteristics; comparative experimental data are given. The appearance of contact-fatigue defects in the rails is determined for magnetizing fields of various strengths, translational speed, and the position of the pickup with respect to the electromagnetic poles. An evaluation is made of the resolution capability of rapid magnetic defectoscopy in the uncovering of internal defects at high translational speeds.

5983 **INCREASING THE ACCURACY OF MEASURING THE CROSS-SECTIONAL AREA OF ROLLED IRON BY THE EDDY CURRENT METHOD**

V. V. Volkov

Defectoscopy, May-June 1967, pp. 203-208

Consideration is given to the problems of the accuracy of measuring the cross-sectional area of rolled iron by the method of complex components for the case where the analytical coordinate system does not coincide with the coordinate system determined by the magnetic field of the transducer.

5990 **PREDICTION OF STRENGTH OF GRAPHITIC MATERIAL BY NONDESTRUCTIVE TEST TECHNIQUES**

L. H. Fanelli, R. D. McDown

ASTM Special Publication No. 439

A material consisting of zirconium diboride, zirconium carbide, and silicon carbide dispersed in a continuous graphite matrix was examined by nondestructive test techniques. To improve reliability of the material, a method of predicting strength was desired. Testing consisted of bulk density, penetrant, X-ray, eddy current, and ultrasonic measurements. These were correlated with compressive and flexural strength measurements. Penetrant, X-ray, and ultrasonic measurements, as performed, did not provide any useful information for the prediction of strength. Bulk density and eddy current measurements correlated with strength. Since density (and strength) were found to vary significantly over very short distances within the material, density alone did not provide sufficient information to predict strength. However, by the use of a combination of density to determine an average strength, and eddy current readings to measure local variations in strength, it was found that the strength of a graphite part could be predicted.

5999 **LOCATING DEFECTS IN STEEL PIPE AT 2,150 F**

M. M. Godshall et al.

Metal Producing Progress, Dec. 1967, pp. 119-122

Eddy current technique used to detect seams, pits and other defects in surfaces of hot pipe traveling over 200 feet per second. Inpsection equipment included a sensing coil, an eddy-current instrument, marking and alarm setups, and a recorder that provides permanent charts. Instrumentation and recorder were remotely located from the hot pipe, with the test coil assembly operating in an externally water-cooled conduit. Equipment features arrangements for quick changeover to allow switching to other pipe diameters, and spray metallizing with aluminum to mark defects.

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.

6018 **RESEARCH AND DEVELOPMENT OF NONDESTRUCTIVE TESTING TECHNIQUES FOR COMPOSITES**

G. Martin, J. F. Moore
North American Aviation, Inc., Los Angeles, Calif.
AFML-TR-68-202, Nov. 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 broac 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 densiometric 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 were also discussed.

6022 **FLAW-DETECTING APPARATUS HAVING A MEANS FOR SCANNING THE CORE OF A CYLINDRICAL MEMBER**

M. L. Hanson et al.
U. S. Patent no. 3,361,964

Apparatus for the detection of grain defects in propellant for large, solid-propellant rocket motors. A cylindrical conductor is positioned within the center of the core of the motor and a potential applied between the outer steel case and the inner conductor. The conductor and the steel case form a coaxial capacitor. If the cylindrical conductor is rotated, the entire grain area of the propellant may be scanned and current changes across the capacitor due to flaw-induced changes in the dieelectric constant of the grain material may be sensed.

6030 **NONDESTRUCTIVE TESTING DEVICE FOR TESTING WIRE ROPES AND SIMILARLY SHAPED OBJECTS**
J. P. Morgan
U. S. Patent no. 3,378,761

A solenoid search coil used for testing wire ropes or similar objects for breakages. The coil is made up of a number of insulated conductors wound helically on a flexible core of nonmagnetic material. This conductor combination is wound around the rope to be tested and means are provided to connect all conductors in series and the free ends to an indicating device or meter.

6032 **MAGNETIC CRACK DETECTOR FOR FERROMAGNETIC TUBING**
F. N. Kusenberger et al.
U. S. 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.

6033 **APPARATUS FOR INSPECTING CONTAINERS FOR WALL THICKNESS DISTRIBUTION**
B. B. Mathias et al.
U. S. Patent no. 3,379,306

Apparatus for inspecting glass containers by means of an electromagnetic field. A radio-frequency source is connected to a pair of antennas which direct an electromagnetic field so that a portion passes through the wall of the container. A voltage-sensing pickup is positioned so as to sense the field strength after passage through the wall. The container is rotated to give a scan of the total circumference of the wall at the level of the pickup.

6037 **A LOW COST PHASE-MEASUREMENT DEVICE FOR EDDY CURRENT SYSTEMS**
R. M. Ford, N. B. Edenborough
U. of Calif., Los Alamos Scientific Lab., Los Alamos, N. M.
LA-DC-9743, 1968; Materials Evaluation, January 1969, p. 23

A description of an easy-to-build, inespensive phase-measurement system for use in eddy current testing is presented. This system is capable of operating from 50 kHz to 1 MHz. The system is capable of measuring from 18^{o} to 162^{o} phase difference between two signals at 1 MHz with resolution of approximately $\pm 1^{o}$.

6047 **THE NONDESTRUCTIVE EVALUATION OF STRESS-CORROSION INDUCED PROPERTY CHANGES IN ALUMINUM**

W. N. Clotfelter, B. F. Bankston, E. E. Zachary
NASA, Marshall Space Flight Center, Huntsville, Ala.
Tech. Memorandum X-53772, 23 Aug. 1968
N68-35628

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.

6055 **HITACHI MODEL UMQ-20 CASE DEPTH METER (English)**

Hitachi, Ltd., Tokyo, Japan

This catalog describes an instrument which the company claims has been designed for the nondestructive measurement of case depth, carbon content, and heat-treat condition of steel. The change in coercive force is the basic principle utilized in this instrument. Examples of case depth, carbon content, and heat-treat conditions are given.

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.
Tech. Rpt. AFML-TR-68-128, Part II, Feb. 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.

6070 **EDDY CURRENT INSPECTION APPARATUS AND METHOD OF CALIBRATING**

R. N. Cressman et al.
U. S. Patent no. 3,394,303

Eddy current apparatus which may be used to inspect for example, the weld seam of a welded steel pipe. A low-frequency oscillator is provided which has been previously calibrated by means of artificial defects. This oscillator modulates the high-frequency current supplied to the testing coil with a continuous defect-simulating signal.

6071 **ULTRASTABLE EDDY CURRENT NONDESTRUCTIVE TESTING APPARATUS**
D. R. Green
U. S. Patent no. 3,394,304

An eddy current device including two bridge circuits fed by the same oscillator. One bridge output is used as a reference, and the other connects to the inspecting probe coils. A switching arrangement is described which connects alternately the reference and then the inspection bridge to two capacitors at the input of a recorder. The system is said to be capable of detecting a few hundred ppm of hydride in zirconium.

6074 **ULTRASONIC CABLE TESTING APPARATUS AND METHOD**
A. B. Widmer
U. S. Patent no. 3,370,226

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.
Air Force Rpt. 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., Philadelphia, Pa. (Vertol Div.)
Presented at Conference on NDT Plastic/Composite Structures, Dayton, Ohio, March 1969

This paper presents a 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 spars using a magnetic perturbation technique.

6082 **PHYSICAL PROPERTY EVALUATION OF COMPOSITE MATERIALS USING FRESNEL OPTICAL PRINCIPLES IN THE MICROWAVE REGION**

J. C. Plunkett
Martin Marietta Corporation, Orlando, Fla.
Presented at Conference on NDT of Plastic/Composite Structures, Dayton, Ohio, 18-20 March 1969

Definitive relationships between density/porosity variations and the shift of the Fresnel critical point using swept frequency microwave techniques have been established. These relationships are linear over an appreciable wide range. A functional relationship between thickness variation and Fresnel sheft has been established, which is sufficiently linear over the range of interest. Thickness variation can be compensated for by use of the Magnemike and a slide rule nomograph. (The Magnemike is a magnetic field thickness gage which will determine thickness from one side).

6083 **EVALUATION OF THIN SHEET MATERIALS BY FM LAMB WAVES**

E. Kubiak, I. Kraska
General American Transportation Corp., Niles, Ill.
AFML TR-68-285, Sept. 1968
AD-845 609

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

6087 **METAL FATIGUE IN AN AIRCRAFT STRUCTURE (Book)**

P. S. Shevel'ko
FTD-HT-23-491-68, 96B (Engl. lang. translation, Foreign Technology Div., Wright-Patterson AFB, Ohio)
AD-683 947

This book is intended for professional readers. It introduces the problem of metal fatigue in aircraft structures; describes some physical bases for fatigue processes which take place in airplane structures; and makes recommendations how to avoid formation of metal fatigue while the airplane is in service. Modern methods of detection of fatigue cracks are described. Research materials, both Soviet and foreign, were used in this study. Original text: 110 pages; published in 1967.

6094 **NEW ELECTROMAGNETIC METHODS FOR DESTRUCTION; FREE TESTING OF MATERIALS**

F. Forster
Translation No. 332, Fort Detrick, Frederick, Md., 1956
AD-846 824

This report is a general writeup on various electromagnetic test methods. The author was very active in the early development of these methods and as such the report is important from a historical point of view.

6102 **ASSURING SATURN QUALITY THROUGH NONDESTRUCTIVE TESTING**

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

6103 **AUTOMATED CRACKED NUT SORTING WITH EDDY CURRENT NDT**

J. H. Niskala and R. D. Carson
Materials Evaluation, July 1969, p. 153

An automated system has been developed for the inspection and sorting of nuts at the rate of 100 parts per minute or greater. The system has been designed to accommodate a variety of nut shapes and sizes with minor tooling changeover and set-up adjustment. The multistation system utilizes eddy current NDT instrumentation to detect forging cracks, seams, bursts, quench cracks, etc. on both the bearing surfaces and crown surfaces of notus. In addition, the system employs an automated plugging station to check the internal condition of tapped threads and, in the case of self-locking nuts, the presence of the locking element. A description of the machine design, eddy current instrumentation, system operating features including defect detection capability, operating speed and inspection reliability is presented.

6112 **BATCH INTERFACE DETECTOR**

University of Pittsburgh Research Staff, 1776 Massachusetts Ave., N.W., Washington, D C. 20036
Tech. Information Rpt. 33.8.6.10, Jan. 1968
AD-828 592

This technical information report describes briefly a vibratory-type batch interface detector. Comprising principally a detector head, a receiver-converter, a chart recorder, an indicating thermometer, and an alarm system, the device has a detection range of from 75 degrees to 25 degrees API gravity or a specific gravity of 0.680 to 0.880. It can detect interfaces, sound an alarm, and record the interface.

6116 **DEVELOPMENT OF NONDESTRUCTIVE TESTS FOR INTERMEDIATE FABRICATION OF SINTERED ALUMINUM PRODUCTS**

H. L. Whaley
Oak Ridge National Lab., Oak Ridge, Tenn.
ORNL 4352, Feb. 1969

Several techniques were developed for nondestructive evaluation of sintered aluminum powder materials. This included development of an entirely new air-settling technique for measuring flake thickness of powders. adaptation of eddy-current techniques and equipment for determining oxide content in both powders and extrusions, and application x-ray attenuation techniques to measuring the homogeneity of extruded billets. Equipment and results are described in detail for each test method.

6122 **EDDY CURRENT TESTING OF FAST REACTOR FUEL SUBASSEMBLY CLADS**

Jean-Pierre Dufayet
Centre d'Etudes Nucleaires de Cadarache, Cadarache, France
Materials Evaluation, June 1969, p. 129

This work was limited to nondestructive testing of small-diameter (around 7 mm), thin (0.3 to 0.5 mm.) 1 meter long austenitic stainless steel tubes. The goal is a systematic investigation not only of defects, but also of any heterogeneity within the material. Tests are carried out over relatively large samples of tubes of various origins obtained through different process techniques using two pieces of eddy current equipment. The obtained results using four frequencies in the 10-700 kHz range are compared with many impedance data of the exploring coils. A wide pattern of defects was identified, and later confirmed by micrographic examinations. As an application of these results, an automatic testing unit equipped with a fast data-processing system is described briefly.

6129 **CONDUCTIVITY TESTING AT THE McDONNELL COMPANY**

R. A. Mueller
Materials Evaluation, April 1969, p. 91

Electrical conductivity measurements (eddy current determined) combined with indentation hardness measurements are now being used throughout the aerospace industry for nondestructive evaluation of the metallurgical condition of commercial precipitation hardenable aluminum alloys. Magnesium alloys and one titanium alloy have also been evaluated by conductivity testing techniques. A brief literature review includes conductivity testing usage and includes discussion of some important metallurgical considerations. A new method for correcting conductivity data obtained at any temperature to room temperature data is described. It is based upon Hansen's equation $K=B\alpha+C$ where (K) is the conductivity, (α) is the temperature coefficient of resistance and B and C are easily determined material constants.

6145 **CLASSIFYING SEAM DEPTHS IN STEEL BILLETS BY THE MAGNETIC TAPE METHOD**

D. E. Lorenzi, G. E. Aguilu and G. O. McClurg
The Magnaflux Corporation, Chicago, Ill.
Materials Evaluation, November 1969

An evaluation is presented of the magnetic tape method used as a depth classifier for seams in steel billets. Classifying accuracies are given based on the results of measurements obtained for almost 700 natural seams. Photomicrographs of seam cross sections are shown to illustrate the wide variations in seam parameters which occur.

6151 **EDDY CURRENT TEST PATTERN RECOGNITION PROGRAM**

R. N. Ord, R. L. Richardson
Battelle Memorial Institute, Richland Wash. (Pacific Northwest Lab.)
BNWL-942, Nov. 1968

The size and shape of a test pattern generated by an "eddy current" probe passing a flaw defect in metal tubing presents an opportunity to classify flaw defect in metal tubing presents an opportunity to classify flaw patterns using automated techniques. The first step was the development of a mathematical model using the first two statistical moments to correlate an unknown pattern with a standard set of known patterns. Twelve of the 20 patterns selected at random were identified with the standard set of 23 patterns. The ultimate goal of this program will be the development of a test box for field use which will be used for "eddy current" incipient failure testing.

6152 **A CAPACITIVE MEASUREMENT SYSTEM FOR THE NONDESTRUCTIVE TESTING OF FIBER GLASS REINFORCED PLASTIC LAMINATES**

S. Smith
Stanford University, Stanford, Calif.
USAAVLABS Technical Rpt. 68-74, Jan. 1969
AD-857 310

The feasibility of utilizing capacitive measurements for the nondestructive testing of epoxy fiber glass composites is discussed. A simple theory is derived from parallel plate capacitor theory and the results are proven by experiment. It is shown that capacitive measurements can be used to accurately determine the thickness and resin glass ratio with an essentially one-sided test.

6153 **VIBRATION MONITORING**

J. M. Shea
Mechanical Engineering, October 1969, p. 40

Vibration monitors have become sophisticated, preventive maintenance tools. They serve as early warning devices and can shut down a machine when vibration becomes excessive. A survey of monitoring equipment is given which includes contact and noncontact pickups. To insure effectiveness of vibration monitors, a thorough analysis of machinery and environmental requirements must be made prior to installation. This article is a guide to aid the plant engineer in performing such an analysis.

6154 **MISCELLANEOUS EDDY CURRENT TECHNIQUES**

H. L. Libby
Battelle Memorial Institute, Richland, Wash. (Pacific Northwest Laboratory)
BNWL-996, January 1969

Several eddy current test techniques in different stages of development are described. These techniques may be of interest to those developing or using eddy current nondestructive tests. The following techniques are described: (1) controlling the curvature of test coil impedance lift off loci; (2) stabilizing the temperature of eddy current ultrasonic transducer; (4) notes on impedance relationship of a solenoid encircling a bar; (5) measuring the flow of eddy currents in liquid Wood's metal; (6) an operational test for phase detectors.

6155 **BROADBAND ELECTROMAGNETIC TESTING METHODS – PART V – PULSED EDDY CURRENT METHOD**

H. L. Libby
Battelle Memorial Institute, Richland, Wash. (Pacific Northwest Laboratory)
BNWL-976, January 1969

A pulsed eddy current nondestructive test method is described which has the capability of reading multiple parameters of a test specimen. Preliminary results show the separation of signals from irregularities in a short section of ½ in. diameter stainless steel tubing with a .050 in. wall. An inside circular coil 7/16 in. diameter was used. Signals from probe wabble and a small piece of ferrous material were discriminated against. Signals from fabricated notches on the inside and outside walls were separated and read on separate output channels. Much exploratory work remains to be done in evaluating variations of the spectrum analysis technique.

6165 **NDT SYSTEMS FOR ESTABLISHING WELD INTEGRITY OF SPACE VEHICLES**

C. W. Musser
The Boeing Co., Launch Systems Br., New Orleans, La.
Materials Evaluation, Feb. 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.

6166 **MAGNETIC PERTURBATION INSPECTION TO IMPROVE RELIABILITY OF HIGH STRENGTH STEEL COMPONENTS**

J. R. Barton, F. N. Kusenberger
Southwest Research Institute, San Antonio, Texas
ASME Publication 69-DE-58
AD-692 835

The significant role that microscopic inclusions, approximately 0.001 in. in diameter, play in the development of fatigue damage of high strength steels is established. Examples showing detection of such flaws by magnetic perturbation inspection, and also the detection of fatigue damage, minute cracks, initiated at these flaws are presented. Results substantiate that methanical removal of early fatigue cracks permits continued stress cycling far beyond the point of which failure would have occurred if the fatigue damage had not been removed. Statistical and individual comparisons of specimen lives are made relative to published data, and interesting aspects of these comparisons are discussed.

6168 **DEVELOPMENT OF THE AMLEC EDDY CURRENT CRACK DETECTOR**

D. Birchon, D. E. Bronley
Admiralty Materials Laboratory, Holton Heath, Poole, Dorset, England
A.M.L. Rept. No. B/177(S), Sept. 1967

An outline of the characteristics of eddy current techniques for non-destructive testing is followed by a brief description of an eddy current testing technique developed at A.M.L. Advantages of the new device are simplicity of circuitry, toleration of a wide range of surface conditions and irregularities, and adaptability for both elementary and sophisticated display.

6170 **THE NONDESTRUCTIVE EVALUATION OF LOW DENSITY FOAM-ALUMINUM COMPOSITE MATERIALS**

W. N. Clotfelter, B. F. Bankston, P. C. Duren
Marshall Space Flight Center, Alabama
NASA Tech. Memo. Rpt. No. 53940, Oct. 10, 1969

NOPCO BX-250, a polyurethane spray foam is now used as cryogenic insulation for S-II stages of the Saturn vehicle. This application has required considerable effort in the development of nondestructive methods to evaluate the mechanical integrity of foam to metal bonds. Certain inspection problems associated with low density foam-aluminum composites are evaluated in this report. The development of audio frequency methods required to overcome these difficulties are described. Additional effort was required to adapt one of these audio frequency methods and to develop radiographic techniques for the detection of voids in the foam. The complementary nature of these void detection methods is shown. All of the methods are thoroughly discussed.

6177 **DEFINITION OF FATIGUE CRACK GEOMETRY BY EDDY CURRENT TECHNIQUES**

V. E. Padilla, J. W. Parks
McDonnell Aircraft Company, St. Louis, Mo.
Proceedings, 7th Symposium on NDE of Components and Materials, San Antonio, April 1969, p. 79

Recent work has provided a method of utilizing eddy current inspection data to predict the geometry of fatigue cracks in fastener holes. This crack definition technique has been applied to structural fatigue programs for the F-4 and to element fatigue tests. The tests utilized a Magnatest ED-520 Eddy Current Instrument, a Mosely Model 680 Strip Chart Recorder, and probes manufactured by the Ideal Specialty Company of Tulsa. Analysis of recordings from fastener hole inspections revealed that fatigue cracks can be easily distinguished from scratches and other forms of surface roughness by the shape of the curves recorded from eddy current responses. Cracks as small as 0.004 in. deep were found routinely in fastener holes ranging from 0.250 to 0.500 in. in diameter, and crack profile growths were routinely plotted during fatigue tests.

6182 **PROTOTYPE NONDESTRUCTIVE INSPECTION EQUIPMENT FOR DETECTING FATIGUE DAMAGE IN DRIVEN GEAR OF SH-3A HELICOPTER TRANSMISSION**

F. Kusenberger, J. R. Barton
Southwest Research Institute, San Antonio, Texas
Final Engineering Rpt. SWRI Project No. 15-1945, 2 April 1968
AD-832 234

A prototype equipment was developed for the detection of fatigue damage in helicopter gears using the magnetic perturbation methods. A description of the magnetic perturbation technique is presented, along with a summary of experimental results obtained from prior work. Fundamental design considerations and laboratory design experiments are discussed. Photographs of the laboratory setup and the prototype equipment are shown, and features of the prototype are presented. Tests and evaluations conducted during development of the prototype are described, and typical data recorded during laboratory evaluation of the prototype are presented. (U)

6186 **ORBITEST FOR ROUND TUBES**

T. W. Judd
Electrochemical Research Center, Republic Steel Corp., Cleveland, Ohio
Materials Evaluation, January 1970, p. 8

The basic principles of eddy current testing are reviewed and inspection techniques for seamless tubular products are discussed. The Orbitest uses 4 independently operating probe coils each inducing eddy currents and detecting defects. The probes are mounted on a hollow cylinder encircling the tube. As the cylinder rotates the tube passes through so that the probes orbit the tube and generate a helical scan on the outside surface. Readout is by chart recorder and defects are located by a paint marking system. The Orbitest is calibrated on integral reference standards which are tubes containing artificial seam-type defect.

6195 **DETECTION OF ENTRAPPED MOISTURE IN HONEYCOMB SANDWICH STRUCTURES**
W. B. Hallmark
North American Aviation, Inc. (Space and Informaiton Systems Division)
Rpt. SID 66-15, January 1966

This report describes the work accomplished during a developmental research program to provide nondestructive testing techniques for detecting entrapped moisture within honeycomb structures. Many nondestructive moisture detecting methods and techniques have been investigated with varying degrees of success. This report describes the most promising methods in detail while the less successful are described in only general terms.

6214 **ANALYSIS OF MAGNETIC FIELDS IN A METAL**
D. L. Waidelich
Argonne National Lab., Ill., May 1969

In the nondestructive testing of metals, experimental measurements had shown that the attenuation of electromagnetic waves originating from a masked probe and passing through a thin sheet of metal was much less than that predicted by the use of a mathematical model employing plane waves with the pulsed magnetic vector parallel to the surface of the metal. An analysis was made by assuming that the pulsed magnetic vector was perpendicular to the surface of the metal. The results of both analyses indicated that the attenuation in the metal was the same and was very nearly equal to the attenuation observed experimentally.

6220 **NONDESTRUCTIVE TESTING OF SMALL DIAMETER, STAINLESS STEEL FUEL CLAD TUBING**
J. Ryden
Battelle Memorial Institute, Richland, Wash. (Pacific Northwest Lab.)

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.

6225 **ANALYSIS OF RESISTIVITY MEASUREMENTS BY THE EDDY CURRENT DECAY METHOD**
J. LePage, A. Bernatte, D. A. Lindholm
U. of California, Berkeley, Calif.
Review of Scientific Instruments, vol. 39, no. 7, July 1968
AD-683 889

A systematic analysis is presented of the conditions in which the measurements of resistivities of metallic samples by the eddy current decay method give meaningful and accurate results. Coil sample geometry and material parameters are examined by means of equivalent circuits, and ways of extracting the desired information from the signal are discussed. A carefully designed and tested apparatus for the accurate determination of resistivity at room and helium temperatures with an operational logarithmic amplifier has been constructed. Most of the important conclusions of this study are displayed in graphical form to assist workers in the field.

6228 **DEVELOPMENT OF A WELD QUALITY MONITOR**

J. G. Etzel, J. A. Munford
Goddard Space Flight Center, Greenbelt, Md.
NASA TN D-5304, August 1969
N69-33800

An investigation was performed to develop a nondestructive method of evaluating cross-wire resistance-welded joints used in electronic packaging. Mechanical strength and reproducibility of strength were determined for several alloy combinations. Data indicated that an optimum degree of embedment exists for each combination of materials. This report describes the development of an electromechanical device that automatically measures and displays the embedment of each welded joint and "locks out" the welding machine if the embedment value is not within preset upper and lower limits.

6235 **NONDESTRUCTIVE TESTING WITH STEADY-STATE MAGNETIC RESONANCE**

W. L. Rollwitz, J M. Victor, G. A. Persyn
Southwest Research Institute, San Antonio, Texas
Proceedings, 7th Symposium on NDE of Components and Materials, San Antonio, April 1969

In the last few years, we have been able to increase the signal/noise ratio (the sensitivity) of steady-state magnetic resonance measurements by 5 orders of magnitude. This increase means that nuclear magnetic resonance, electron paramagnetic resonance, and nuclear quadrupole resonance can now be made on nuclei whose concentration is 10^{-5} that measurable with presently available instrumentation. Thus, measurements of the quantities of all the elements, except iron, in blood can now be made within minutes. Also possible are the direct measurements on trace impurities of either natural or artivicial occurrence. The measurements made to date will be described, as well as other possibilities in N.D.E. field.

6236 **NONDESTRUCTIVE TESTING WITH TRANSIENT MAGNETIC RESONANCE**

G. A. Persyn and W. L. Rollwitz
Southwest Research Institute, San Antonio, Texas
Proceedings, 7th Symposium on NDE of Components and Materials, San Antonio, April 1969

The measurements made with transient magnetic resonance such as spin-echo nuclear magnetic resonance, can be used: (1) to give a quantitative measure of nuclei with a magnetic moment, and (2) to determine the relaxation times, both longitudinal and transverse, for the measured nuclei. With these data, the quantity and the environment of elements, containing measurable nuclei, can be determined. As an example, the amounts of the three distinct layers of moisture in paper have been separately measured. The data from this measurement, as well as those on cereal grains, propellants, metal powders, and plastics, will be presented.

6238 **NON-DESTRUCTIVE TESTING APPLIED TO NUCLEAR VESSEL FABRICATION**

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

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.

6245 **A COMPARISON OF EDDY-CURRENT AND POTENTIAL OR CONDUCTION TECHNIQUES IN NON-DESTRUCTIVE TESTING**

I. G. Scott
Australian Defence Scientific Service, Melbourne, Australia
Rpt. ARL/MET. 73, March 1969
N70-14210

The eddy current test technique is compared with other non-destructive test techniques based on the electrical properties of the specimen, with special attention being given to the theoretical bases of these techniques. The comparison is concerned with the measurement of conductivity and material thickness, together with the detection of cracks.

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 possiblities of inspecting radioactive objects and that of proton radiography.

6263 **NONDESTRUCTIVE TESTING OF SMALL-DIAMETER, STAINLESS STEEL FUEL CLAD TUBING**

J. Ryden, Jr.
Battelle Memorial Institute, Pacific Northwest Lab., Richland, Wash.

This paper discusses the techniques used by the Pacific Northwest Laboratory to inspect FFTF fuel cladding. 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.

6287 **THE ROLE OF THEORY IN EDDY CURRENT TESTING**

D. L. Waidelich
University of Missouri, Columbia, Mo.
Presented at 1970 Spring Conference ASNT, Los Angeles, Calif.

Nondestructive testing is greatly concerned with the assurance that tests do what they are supposed to and with determining the responsibility and the liability of engineers who interpret the results of the tests and make recommendations. In eddy current testing for the needs of these engineers, information in addition to the usual experimental tests may be provided by the bulk of theory that has been developed, particularly in the past decade or two. Unfortunately, much of this work is virtually unknown to most engineers, and the purpose of this paper is to review briefly what has been done and to suggest sources from which the more detailed theoretical information may be obtained. The principal problems discussed are the impedance of a coil surrounding a metal rod or tube and the impedance of a coil above a plane metal surface, but other problems are also considered.

6289 **THE USE OF STANDARD MICROWAVE COMMUNICATIONS TEST EQUIPMENT FOR NONDESTRUCTIVE TESTING**

M. J. Jacoby
Lockheed Missiles & Space Co., Sunnyvale, Calif.
Presented at the 1970 Spring Conference ASNT, Los Angeles, Calif.

Many NDT workers have not investigated microwave energy as an inspection medium because of the high cost and limited scope of the quipment offered specifically for NDT inspections. Recent advances in solid state technology have greatly increased the versatility and reduced the cost of standard microwave measuring instruments manufactured by communications companies. This paper discusses how the measurement of such basic parameters as gain and loss, group delay, return loss, and complex impedance and reflection coefficients can be made using this new, relatively inexpensive equipment and how these measurements can be used to determine physical properties and locate flaws in nonmetallic structures. Inspection set-ups are described in detail, and complete equipment and cost lists are provided.

6300 **AN ELECTRO-THERMAL NONDESTRUCTIVE TESTING METHOD**

D. R. Green, L. D. McCullough
Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, Wash.
BNWL-1273, December 1969

A nondestructive testing technique capable of detecting flaws in metals has been developed. This technique uses electrical heating in conjunction with infrared mapping of surface temperatures. It has been demonstrated on steel bars having 1/16 in. diameter holes drilled at a depth of approximately 0.146 in. under the surface.

6307 **MEASUREMENT OF PAINT FILM THICKNESS**

J. D. Keane, J. Chiavetta
Steel Structures Painting Council, 4400 Fifth Ave., Pittsburgh, Pa. 15213
Interim Rpt. 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 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.

6312 **MICROWAVE DIELECTRIC MATERIAL TESTING SYSTEM**

D. W. Prine
Patent No. 3,482,160 ,

Microwave system for testing dielectric materials, one application being the measurement of the thickness of the wall of a glass bottle. A coaxial line section is coupled through a directional coupler and a ferrite isolater to a reflex klystron having a repeller electrode which is coupled to an amplitude modulator in the form of a square wave generator Reflected energy is applied from the directional coupler to a detector which is coupled through an amplifier to an indicator.

6314 **THE NONDESTRUCTIVE INSPECTION OF TUBINGS FOR DISCONTINUITIES AND WALL THICKNESS USING ELECTROMAGNETIC TEST METHODS (PARTS I AND II)**

F. Forster
Institut Dr. Forster, Reutlingen, West Germany
Materials Evaluation, April 1970 (Part I), May 1970 (Part II)

Dr. Forster describes the testing of the inner surface of tubes with spinning eddy probes and lists experimental results of magnetic stray field on tubes, according to wall thickness, diameter, magnetization field and material. Also described is failure testing of tubes by measuring the magnetic flux with microprobes. Magnetic stray flux testing with inner probes for thick-walled tubes is also described. The paper also deals with the failure testing of tubes with extremely high failure resolution as applied on cannings. Finally, it discusses the combination of failure testing and measurement of wall thickness.

6327 **NONDESTRUCTIVE DETERMINATION OF NONELECTRONIC PART RELIABILITY**

H. G. Tobin, et al
ITT Research Institute, Chicago, Ill.
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 feasiblity 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.

6333 **NONDESTRUCTIVE EVALUATION OF METAL FATIGUE**

F. N. Kusenberger et al.
Southwest Research Institute, San Antonio, Texas
Final Rpt. 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 nondestructive 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 E ENGINE CYLINDERS**

I. R. Kraska, E. J. Kubiak
General American Transportation Corp., Niles, Ill.
Contract DAAE07-67-c-1990, May 1968
AD-686 344

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.

6337 **HIGH TEMPERATURE EDDY CURRENT CRACK DETECTION**

N. B. Edenborough
Los Alamos Scientific Laboratory, Los Alamos, N. M.
Materials Evaluation, December 1968

A technique was developed to detect the time of cracking of samples representing atomic reactor components under high thermal gradients. An eddy current coil of tungsten-rhenium wire (W-26%Re) was wound on a specially machined boron nitride coil form. This coil has been shown to operate at temperatures up to approximately 3200°F. This temperature was reached, from ambient, in 22 seconds. Special electronic circuitry was also developed to detect the small signal change caused by the cracking but ignoring the large changes caused by the quick heating.

6338 **TOROIDAL EDDY CURRENT NONDESTRUCTIVE TESTING PROBE**

R. L. Brown
U. S. Patent 3,395,339

A toroidal eddy current probe is provided for use with a conventional eddy current nondestructive testing device. The probe includes a number of encircling coils mounted to form a toroid whose annulus is sized to pass a sample. Each of the encircling coils is positioned so that its windings are substantially parallel to the direction of motion of the sample through the toroid annulus, and the coils are serially connected.

6340 **EDDY CURRENT CRACK DETECTOR SYSTEM USING CROSSED COILS**

D. Lorenzi, D. O'Connor
U. S. Patent 3,495, 166

A pair of identical coils are in a bridge network connected to an ac source and are arranged with their field perpendicular to each other and parallel to the surface of a part. Variations in conductivity, permeability, lift-off and surface conditions are said to produce substantially no output from the bridge network, whereas defects produce a large output A number of modifications and variations are also disclosed.

6342 **EDDY CURRENT AND RADIOGRAPHIC EVALUATION OF SODIUM-COOLED FAST BREEDER REACTOR FUEL ELEMENT**

J. C. Cwynar, R. K. McGeary
Westinghouse Electric Corp., Cheswick, Pa.
Materials Evaluation, May 1970, p. 111

Short uranium-plutonium carbide ceramic pellets are bonded inside stainless steel tubing with sodium to produce a fuel element after end sealing. The eddy current test requires use of a point probe to eliminate pickup of unwanted signals such as the numerous pellet interfaces and laterial pellet shifting. Voids as small as 0.03-in.-diameter are detected in the sodium bond of continuously varying thickness during rapid rotation of the fuel pin under the probe. A quantative correlation of size of the void and its signal is presented. Unique techniques are described for the correlation of pellet positioning, as revealed by radiography, with eddy current traces and other tests.

6348 **DEVELOPMENT OF LIQUID CRYSTAL MICROWAVE POWER DENSITY METER**
The Bendix Corp. Research Labs., Southfield, Mich.
PB 191,396, May 1970 (Avail. NTIS)

Bendix Research Laboratories, under contract to the Division of Electronic Products, developed a liquid crystal microwave power density meter. The meter has a Mylar membrane with resistive and liquid crystal coatings which serves as a large-area sensing element and uses direct current electrical power for bias and calibration of the membrane. The general operating principles of such an instrument and the design and operating principles of the particular meter constructed are described in the report.

6354 **IMPROVEMENT OF EDDY CURRENT INSPECTION**
H. Frankel
Benet Laboratories, Watervliet Arsenal, Watervliet, N. Y.
Rpt. No. WVT-6941, October 1969
AD-697 784

Inspection time can be reduced 75% with a quadruple coil transducer which was developed to work with existing eddy current equipment. Its lower sensitivity can be compensated by increasing the available gain of the detection system. The principal disadvantage of the new transducer is the greater difficulty in adjusting the equipment as compared with the single coil transducer. The O.D. of tubes can now be inspected during finish machining because of an eddy current system which was developed to automatically compensate for changes in surface scanning speed caused by different diameters at the muzzle and breech ends. All attempts have been unsuccessful in detecting cracks at the root of the groove in rifled tubes with eddy current equipment.

6411 **EXPERIMENTAL SUBSTANTIATION OF FATIGUE DETECTION CAPABILITY**
N. Kusenberger, J. R. Barton
Southwest Research Institute, San Antonio, Texas
Contract No. N600(19)-59307, final report, 1963
AD-844 804

An experimental device for detecting fatigue damage in steel tubing using magnetic field inspection techniques has been evaluated. Modification of the existing equipment for automatic operation is briefly discussed. Magnetic inspection records and surface photographs obtained at intervals during the stress cycling on one specimen are presented and discussed.

6418 **APPLICATION OF MICROWAVES TO NONDESTRUCTIVE TESTING**
C. N. Owston
College of Aeronautics, Cranfield, Bedford, U.K.
British Journal of Nondestructive Testing, vol. 11, no. 2, June 1969, pp. 26-30

The properties which make microwaves a suitable tool for certain NDT applications are outlined and some of the mystique of microwave engineering is explained in simple terms. Examples of the application of microwave techniques to the detection of flaws, study of composition, measurement of dimensions and high frequency eddy-current testing are discussed and possible future applications are outlined.

6422 **ELECTRONIC SIGNAL PROCESSING TECHNIQUES – PHASE II – NONDESTRUCTIVE TESTING**

C. Kennedy, W. E. Woodmansee
The Boeing Co., Seattle, Washington
Contract DAAA25-69-CO206, Phase II, Semi-Annual Rpt., May 1970 (Frankford Arsenal

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. Phaselock 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.

6432 **MAGNETIC RUBBER INSPECTION – DESCRIPTIVE REPORT**

General Dynamics, P.O.B. 748, Fort Worth, Texas
Rpt. FZM-12-10769, June 1970

A description of a new NDT technique developed in the engineering test laboratories for detecting cracks and other flaws in magnetic materials. MRI involves the use of room temperature vulcanizing rubber containing ferromagnetic powder to replicate the area to be inspected. A small magnetic field in the area causes the particles to migrate to magnetic field perturbations created by the presence of defects. Following cure, the solid rubber replica is removed for a visual examination. Application is, of course, limited to ferromagnetic materials.

6433 **MAGNETIC RUBBER INSPECTION INSTRUCTION MANUAL**

J. E. Halkias et al.
General Dynamics, Fort Worth, Texas.
Rpt. No. FZM-12-10957A, April 1970

Magnetic rubber inspection involves the use of room temperature vulcanizing rubber containing ferromagnetic powder to replicate the area causes the particles to migrate through the liquid rubber to secondary fields created by cracks or other flaws present in the metal. Following cure, the solid rubber replica is removed from the part where a visual examination shows the black indication of any flaw. This paper contains a complete instructions manual of the process.

6441 **UNDERWATER NDT SHOWS ITS PACES**

R.I.X. Ltd., Wimpey Base, South Denes Rd., Great Yarmouth, Norfolk, U.K.
Nondestructive Testing, vol. 3, no. 5, Oct. 1970, pp. 325, 327

R.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.

6458 **RAPID NONDESTRUCTIVE IDENTIFICATION AND COMPARISON OF METALS**

D. M. Schmid, J. E. Wolf
Techalloy Co., Rahns, Pa.

Materials Research and Standards, November 1970, pp. 14-15

The measurement equipment described herein was designed primarily for continuous comparison and identification of in-process wire. It has also proved useful for laboratory identification work and is adaptable for testing other forms such as heavy red, narrow width strip, tubing, and small parts.

6465 **REMOTE SENSING OF PARAMETERS FOR NONELECTRONIC SYSTEMS**

R. Hegner, A. H. Hehn
ITT Research Institute, Chicago, Ill.

AIAA Paper No. 67-774, 4th AIAA Annual Meeting, Anaheim, Calif., October 1967

This paper describes the relative merits, performance data, and limitations of various remote sensing techniques applied to monitor parameters which indicate the health status of nonelectronic systems. The three techniques are electronic, mechanical and chemical. The techniques, when applied to non-electronic systems, are shown to be able to isolate actual or potential failures in fully assembled systems.

6467 **CURRENT PROBLEMS IN PREVENTION OF FATIGUE**

H. J. Grover, A. A. Mittenbergs
Defense Metals Information Center, Battelle Memorial Institute, Columbus, Ohio

DMIC Rpt. 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.

6469 **NDT OF NUCLEAR REACTOR FUEL ELEMENTS**

W. Thompson
U.K.A.E.A., Salwick, Preston, Lance, U.K.

British Journal of Nondestructive Testing, vol. 11, no. 1, March 1969, pp. 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.

6486 **NONDESTRUCTIVE METHODS OF MATERIAL IDENTIFICATION**

R. E. Birley
Rolls Royce Ltd., P. O. Box 31, Derby DE2, 8BJ, U.K.
Nondestructive Testing, vol. 3, no. 3, June 1970, pp. 177-180

Current nondestructive methods of material identification and typical applications are briefly surveyed. The general approach and factors to be considered when establishing a suitable test method are discussed with particular reference to the compilation and evaluation of test data.

6492 **IMPROVEMENT OF EDDY CURRENT INSPECTION**

H. Frankel
Watervliet Arsenal, Watervliet, N. Y.
Tech. Rpt. No. WVT-6941, Oct. 1969
AD-697 784

Inspection time can be reduced 75% with a quadruple coil transducer which was developed to work with existing eddy current equipment. The O.D. of tubes can now be inspected during finish machining because of an eddy current system which was developed to automatically compensate for changes in surface scanning speed caused by different diameters at the muzzle and breech ends. All attempts have been unsuccessful in detecting cracks at the root of the groove in rifled tubes with eddy current equipment.

6521 **THE ROLE OF THEORY IN EDDY CURRENT TESTING**

D. L. Waidelich
University of Missouri, Columbia, Missouri
Materials Evaluation, vol. 28, no. 12, Dec. 1970, pp. 262-266

The purpose of this paper is to review briefly what has been published under the subject matter. An extensive bibliography is included from which, more detailed theoretical information may be obtained. The principal problems discussed are the impedance of a coil surrounding a metal rod or tube and the impedance of a coil above a plane metal surface, but other problems are also considered.

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, Nov. 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.

6534 **EDDY-CURRENT TESTING OF CONDENSER TUBES**

J. P. Butin

Nondestructive Testing, vol. 3, no. 1, February 1970, pp. 34-37

An account is given of equipment devised for the detection of corrosion, dents, holes, and other defects in condenser tubes used for large thermal power stations. Essentially an eddy current device, the equipment permits the insertion of the probe into a tube under test by compressed air and its withdrawal by means of a specially designed winch. Defect levels and the stages at which the equipment is used for testing tubes from manufacture to service are discussed.

6546 **NONDESTRUCTIVE TEST TECHNIQUE DEVELOPMENT BASED ON THE QUANTITATIVE PREDICTION OF BOND ADHESIVE STRENGTH**

J. R. Zurbrick

Avco Systems Div., Wilmington, Mass.

AVSD-0331-70-RR, 20 July 1970

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 mission, 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

Australian Defence Scientific Service, Melbourne, Australia (Aeronautical Rsch. Labs.)

Metallurgy Note 62, Feb. 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.

6554 **ELECTRONIC SIGNAL PROCESSING TECHNIQUES; NONDESTRUCTIVE TESTING**

J. C. Kennedy and W. E. Woodmansee

The Boeing Co., Seattle, Wash.

Boeing Company Rpt. D180-10589-1

ARPA Program. Annual Rpt., 30 Oct. 1969 to 29 Oct. 1970. November 1970, Phase II.

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.

6560 **HIGHLY LOCALIZED MAGNETOGRAPHIC TESTING OF THE GROUND SURFACES OF STEEL COMPONENTS**

G. A. Pankov

Zavodskaya Laboratoriya, vol. 12, no. 12, Dec. 1966, pp. 1483-1485 (Engl. lang. translation, cover-to-cover, as Industrial Laboratory)

A magnetographic method of testing ground ferromagnetic surfaces of steel components is proposed; this is based on highly localized magnetization, achieved by magnetically recording a periodic sinusoidal signal on the surface test. The intermediate magnetic carriers used for the contact introduction of magnetic relief are plastic magnetic tapes and elastic carriers with a rubber base.

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, no. 4, Nov. 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.

6594 **ELECTRONIC SIGNAL PROCESSING TECHNIQUES PHASE II – NONDESTRUCTIVE TESTING**

J. C. Kennedy, W. E. Woodmansee

Boeing Company, Seattle, Wash.

ARPA Program, Annual Rpt. for 30 Oct. 1969 - 29 Oct 1970

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 electronic 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.

See also No. 6422: Phase II – Semiannual report.

6621 **THE QUANTITATIVE SIGNIFICANCE OF NONDESTRUCTIVE EVALUATION OF GRAPHITE AND CERAMIC MATERIALS**

J. W. Orner
Avco Corporation, Lowell, MA
AFML TR-70-205, October 1970
AD-879 710

The objective of research 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. As a part of the program, nondestructive evaluation was carried out on a series of billets of hot pressed diboride compositions of zirconium and hafnium with various additions hot pressed. Two grades of graphite (ATJ and RVA) were investigated to determine the significance of typical defective conditions on the physical behavior of the material. Tensile specimens containing various types of flaws, and determined by nondestructive tests, were broken and the results correlated with the NDT findings.

6629 **THE GENERATED REACTION FIELD METHOD OF DETECTING DEFECTS IN STEEL BARS**

W. Lord and D. J. Oswald
Materials Evaluation, February 1971, pp. 21-27

This new inspection technique is explained by dc generator theory and consists of rotating the test specimen in a uniform dc magnetic field. Leakage fields resulting from surface and subsurface material discontinuities are detected with a Hall devide, and their topographies are recorded. The strong, unsymmetrical, internal magnetization generated in the test bar enables the detection of random-oriented seam defects of depths less than 0.005 in. and results in an approximate linear defect depth to defect signal relationship. The main disadvantage of this new method is the inherent lift-off characteristic of the Hall device.

6633 **OPTIMIZING DEFECT DETECTION IN EDDY CURRENT TESTING**

C. V. Dodd, et al.
Metals and Ceramics Div., Oak Ridge National Laboratory, Oak Ridge, Tenn.
Materials Evaluation, March 1971, pp. 59-63

A number of curves were prepared that show that the eddy current signal produced by a defect varies as a function of test parameters for various arrangements of the coil and conductor with special emphasis on differential encircling coils. From these curves the optimum parameters can be selected for a particular test.

6445 **A METHOD OF LEAK DETECTION IN SEALED CAVITIES**

V. G. Ames
Frankford Arsenal, Philadelphia, Pa.
Tech. Note TN-1139, July 1969
AD-859 742

This report describes a simple, inexpensive method of detecting gross or slow leaks in sealed cavities such as missile timers, propellant actuated devices, fuzes, and fir control instruments. The technique is quite versatile in that either a pressure or a vacuum can be used and the sensitivity of leak detection can be widely varied by changes of system parameters.

6456A **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 the thickness range of ¼ 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 wleds. This document represents Appendix A of the document listed below.

6456B **DEVELOPMENT OF AN ULTRASONIC GUIDE FOR THE INSPECTION OF BUTT WELDS IN COMMERCIAL SHIPS**
R. A. Youshaw
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. No. 6456-A is Appendix A of this report.

6459 **SIGNATURE COMPARISON TECHNIQUE FOR RAPID ALLOY SORTING WITH A RADIOISOTOPE EXCITED X-RAY ANALYZER**
B. Sellers, J. Brinkerhoff
Panametrics, Inc., Waltham, Mass.
Materials Research and Standards, November 1970, pp. 16-19

The recent introduction of radioisotope excited x-ray analyzers (REXA) has made the in-plant application of alloy sorting practical. The analyzer is relatively inexpensive, quite small, requires very little power, and is easily portable. Determination of an alloy type is made by measurement of the x-ray emission associated with one or more of its characteristic elements.

6645 **FEASIBILITY OF ROCKET MOTOR INSULATION INSPECTION USING INFRARED RADIATION**
D. R. Dreitzler, L. B. Thorn
U. S. Army Missile Command, Redstone Arsenal, Ala.
Rpt. 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.

6656 **MICROWAVE FLAW DETECTOR**
L. Feinstein, R. J. Hruby
U. S. Patent no. 3,532,973

A flaw-detecting system uses microwave energy radiated toward the surface to be tested and varying in a return-to-zero manner. The test surface modifies the reflected electromagnetic energy in accordance with the surface condition so that the reflected energy provides a measure of the surface condition as a function of the cyclic scan angle. This reflected energy is demodulated and then correlated, either with itself or with a reference pattern, to provide an indication of irregularities in the surface.

6659 **METHOD FOR MAGNETICALLY MEASURING WALL THICKNESS OF METAL PIPES AND PLATE STRUCTURES**
I. J. McCullough, et al.
U. S. Patent no. 3,532,969

A method for measuring metal thicknesses, such as the wall thickness of pipes, which are accessible from the inside, but not necessarily from the outside. A primary coil and secondary coil are positioned within the pipe, with means for attenuating the magnetic field from the energized primary coil. coil. Laminated rings positioned at the ends of the primary coil and secondary coil further act to concentrate the magnetic field so that it forms a coupling path outside of the pipe.

6662 **SENSOR FOR INSPECTING A TEST PIECE FOR INSIDE AND OUTSIDE FLAWS UTILIZING MEANS RESPONSIVE TO THE TYPE OF FLAW FOR ADJUSTING THE THRESHOLD OF THE SENSOR**
F. Forster
U. S. Patent no. 3,528,003

This invention relates to locating defects in a workpiece and indicating the characteristics and location of the defect. This is accomplished by providing a pickup probe to locate any stray magnetic fields produced by any inside or outside defects such as cracks, together with an eddy current probe, for simultaneously scanning the workpiece to locate only outside surface defects and modifying the response of the system to the stray fields according to whether the defect is on the inside surface or outside surface.

6663 **EDDY CURRENT METHOD AND APPARATUS FOR THE NONDESTRUCTIVE TESTING OF ELECTRICALLY CONDUCTIVE TUBES UTILIZING TWO MUTUALLY COUPLED HARTLEY OSCILLATORS**
J. Dufayet
U. S. Patent no. 3,543,145

A method for the testing of tubes in which the tube is disposed inside the windings of two Hartley oscillators with the windings spaced from each other by a distance small enough for allowing the two oscillators to generate sine waves at the same frequency whatever the characteristics of the tube may be. The difference between the potentials of the grids and the triodes of the two Hartley oscillators is measured as an indication of the impedance of the associated coils.

6664 **PULSED EDDY CURRENT APPARATUS FOR NONDESTRUCTIVE TESTING OF RESISTANCE TYPE WELDS**

G. A. Noble

U. S. Patent no. 3,526,829

A method of nondestructive testing of resistance spot welds in ferromagnetic materials by comparison of the depth of penetration of a pair of eddy current inducing, pulsed, high-intensity electromagnetic fields. The fields are locally applied to the test weld and to a reference weld, and dynamic impedance measurements of the effect of the induced eddy currents on their applied fields are made.

6665 **EDDY CURRENT CRACK DETECTOR SYSTEMS USING CROSSED COILS**

D. E. Lorenzi, D. T. O'Connor

U. S. Patent no. 3,495,166

A pair of identical coils are in a bridge network connected to an ac source and are arranged with their field perpendicular to each other and parallel to the surface of a part. Variations in conductivity, permeability, lift-off and surface conditions are said to produce substantially no output from the bridge network, whereas defects produce a large output. A number of modifications and variations are also disclosed.

6666 **MAGNETIC FLUX SENSORS HAVING CORE STRUCTURE OF GENERALLY CLOSED CONFIGURATION FOR USE IN NONDESTRUCTIVE TESTING**

N. B. Proctor

U. S. Patent no. 3,529,236

Magnetic flux detectors in the form of C-shaped or E-shaped magnetic core structures using flux responsive transducers such as Hall effect devices or flux gate magnetometers in the core structures. The detectors are said to be able to discriminate between signals from flaws and the disturbances generated by noise-producing factors such as magnetic surface domain perturbations and the like. These and other characteristics make these detectors particularly useful in the inspection of pipelines.

6668 **NONCONTACT EDDY CURRENT INSTRUMENT**

R. R. Petrini

U. S. Patent no. 3,491,289

An eddy current instrument for determining variations in the displacement of an electrically conductive target by means of a transducer. When the transducer is energized with a constant amplitude fixed frequency signal, displacement of the target causes the transducer to transmit an input signal to a phase control circuit. The phase control circuit compares the input signal to an out-of-phase reference signal. This comparison produces an output proportional to changes of the input. The output signal is thus a calibratable measure of the variations of target displacement.

6675 **IN-CORE EDDY-CURRENT MEASUREMENTS OF THE ATR FUEL ELEMENT CHANNEL SPACING**

F. L. Prestridge, M. L. Stanley
Idaho Nuclear Corp., Idaho Falls, Idaho
Presented at the Spring Conference of ASNT, March 1970

A nondestructive testing technique has been adopted and used successfully to make a difficult applied measurement under the restrictions of small space, thermal gradients, a radioactive environment, and underwater. During the Core I tests, or first power tests of the Advanced Test Reactor, it was necessary to measure the coolant channel thickness spacing in selected fuel elements. These measurements had to be made "in-core" with standby coolant water flowing while the elements were still giving off a considerable amount of decay heat. The transducer chosen was an eddy-current type using phase demodulation techniques to separate unwanted signals.

6679 **UNCALIBRATED CONTROL OF TUBE WALL THICKNESS BY MEANS OF POTENTIAL DROP**

M. I. Brainin et al.
The Soviet Journal of Nondestructive Testing, no. 3, May-June 1970, pp. 298-308

An approximate formula is obtained theoretically for calculating potential differences as pipe wall thickness is monitored by the four-sensor method of potential drops. Tests on copper and aluminum pipes of different diameters and with different wall thicknesses showed that the calculated values of potential difference agree well with experimental values. This permits the process to be controlled without prepared standards by using theoretically calculated graphs instead.

6680 **INSTRUMENT FOR MEASURING THE THICKNESS OF DECARBURIZED LAYERS**

F. N. Nuriev et al.
The Soviet Journal of Nondestructive Testing, no. 3, May-June 1970, pp. 316-319

During the production and heat treatment of steel articles a decarburized layer is formed on their surface which is much softer than the base material and is characterized by a greater magnetic permeability and smaller coercive force and resistivity. The main difficulty when checking the thickness of the decarburized layer by electromagnetic methods is the presence of many interfering factors. To tune out the interfering factors and to isolate the useful signal when developing our instrument, the eddy-current, multiple-parameter method was used.

6681 **MAGNETIC DEFECTOSCOPY OF RUBBER CONVEYER BELTS**

Yu. G. Evtukhov et al.
The Soviet Journal of Nondestructive Testing, no. 3, May-June 1970, pp. 309-316

Results of theoretical and experimental studies of magnetic field scattering on a damaged section in the cables of a reinforced conveyer belt are presented. A method of magnetic defectoscopy for conveyer belts in mines is described, and a defectoscopy, designed for this purpose, is presented.

6682 **THE ELECTRICAL POTENTIAL METHOD AND ITS APPLICATION TO NONDESTRUCTIVE TESTING**

G. Gille

Nondestructive Testing, vol. 4, no. 1, February 1971, pp. 36-44

This article gives a comprehensive review of the basic principles of the Electrical Potential Method in its application to non-destructive testing. Both direct current and alternating current are considered. Practical examples are given of useful results obtained and the performances of commercially available instruments are described. The article concludes with an indication of the possibility of using the Electrical Potential Method for measurement of inherent stresses.

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 Metod 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.

6687 **A NON-DESTRUCTIVE TEST FOR THE ADHESION OF BEARING LININGS**

Tin and Its Uses (Quarterly Journal of the Tin Research Institute), no. 80, 1968, pp. 13-14

This article discusses the Hoyt Bondmeter, an electrical potential measuring device which, it is *claimed, will give a measure of the bond of tin-based white metal anti-friction linings on steel or* bronze bearing shells.

6689 **THE USE OF THE CONDUCTING MASK IN PULSED ELECTROMAGNETIC TESTING**

C. W. Cox and C. J. Renken

Argonee National Laboratory, Argonne, Ill.

ANL-7172, April 1969

The application of conducting masks to the problem of nondestructive testing by means of pulsed electromagnetic fields is examined. The diffusion of a pulsed plane wave into a semi-infinite conductor is calculated, and formulas are derived for pulse attenuation and delay, as well as for field *strength inside and outside the conductor.* The plane-wave assumptions cause serious discrepancies between calculated and experimentally measured fields through conducting sheets. A qualitative analysis of the symmetrical mask offers a satisfactory explanation for most of the experimentally observed features of its operation, and provides an insight into the operation of other types of masks.

6699 **NONDESTRUCTIVE TESTING OF PLASTICS WITH MICROWAVES; PARTS I AND II**

R. J. Botsco
Microwave Instruments Co., Corona del Mar, Calif.
Reprints from Journal, Plastics Design and Processing, Nov. and Dec. 1968

The first part of this two-part article briefly summarizes the application of microwave nondestructive testing of plastic materials. The basic principles of microwaves are reviewed as well as some of the instrumentation currently in use. The concluding part of this two-part article presents various applications of microwave testing including thickness gaging, flaw detection, measurement of degree of cure, density (specific gravity), and measurement of moisture content.

6707 **MAGNETIC PARTICLE INSPECTION TECHNIQUES AND THEIR APPLICATION IN THE U.K.**

H. J. Bezer et al.
British Journal of NDT, vol. 13, no. 1, January 1971, pp. 2-12

Magnetic Particle Inspection is shown to be based on well established, simple principles, and a literature survey indicates that it is now well documented in books and papers. The vital importance which must be attached to correct magnetization and particle inspection media is emphasized. Information is provided on the types of particle inspection media available and ways of maintaining their qualtiy. In conclusion an estimate is made of the extent of the applications of these methods in the U.K. with some forecasts of future trends.

6722 **EVALUATION OF COMMERCIALLY AVAILABLE EDDY CURRENT EQUIPMENT**

I. R. Kraska and R. G. Prusinski
General American Transportation Corp., Niles, Ill.
AFML TR-69-221, May 1970, 60 pp.
AD-872 681

The relative merits of many commercially available eddy current inspection systems, particularly in applied to the inspection of aircraft structure, are presented. The capabilities of these eddy current instruments for nondestructive inspection applications are demonstrated by presenting the test results obtained from inspecting a selected range of test samples. In addition, the advantages and capabilities of each eddy current system are discussed. For ready reference the operating characteristics, apparent advantages and disadvantages, and approximate cost of each instrument are presented in tabular form.

6750 **DEFECTOSCOPE WITH SCINTILLATION COUNTERS FOR INSPECTING LARGE-SCALE CONCRETE STRUCTURES THROUGH USE OF BETATRON BREMSSTRAHLUNG**

V. A. Vorobev et al.
Soviet Journal of Nondestructive Testing, May-June 1968, pp. 181-183

The wide range of structural designs using assembled and monolithic concrete and reinforced concrete and reinforced concrete structures requires the development of reliable and highly productive methods for quality control of concrete and reinforced concrete. The use of radioactive isotopes makes it possible to inspect concrete up to 50-cm-thick. The use of betatrons makes it possible to use radioscopy for thicknesses up to 2-2.5m with detectability of defects of 1.5-2% of the thickness subjected to radioscopy. To increase inspection productivity it is desirable to use radiometric methods for recording the radiation (instead of radiographic methods).

6751 **EDDY-CURRENT INSTRUMENTS FOR DETERMINING CRACK DEPTH IN WELD JOINTS OF AUSTENITIC STEEL STEAM PIPES**

B. I. Volkov

Soviet Journal of Nondestructive Testing, May-June 1968, pp. 184-188

The electrical circuit of a phase-sensitivitive eddy-current instrument designed to detect surface cracks and estimate their depth in austenitic steam pipes and their weld joints is described. The method of tuning out an interfering factor, namely the deposited metal of the weld, is examined. The results of testing the instrument under laboratory and production conditions are presented.

6752 **HIGH-TEMPERATURE EDDY-CURRENT SENSORS**

V. E. Shaternikov, V. A. Denisov

Soviet Journal of Nondestructive Testing, May-June 1968, pp. 189-191

The article reports the results of research and development work on high-temperature eddy-current devices for work at variable temperatures up to 500°C. Design and fabrication technology of the devices are described, and hints on proper use are given.

6753 **USING EMID ELECTROMAGNETIC DEFECTOSCOPES FOR SORTING FERROMAGNETIC ALLOYS ACCORDING TO BRANDS**

A. Mushkin, et al.

Soviet Journal of Nondestructive Testing, May-June 1968, pp. 197-202

Problems associated with the use of an electromagnetic control method for sorting steel rods by brands at a machine-construction factory are examined: the difficulties of introducing them, the conditions under which they are used, the control method and also the results of five years of exploitation of the EMID-3 instrument.

6755 **NEW AND REFINED NONDESTRUCTIVE TECHNIQUES FOR GRAPHITE BILLETS AND SHAPES**

A. E. Oaks

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

AFML-TR-70-212 (1st Annual Rpt. May 1969 - May 1970)

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 Rpt. 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.

6770 **THE APPLICATION OF A RADIO INFLUENCE VOLTAGE TEST TO THE DETECTION OF VOIDS IN ELASTOMERS**

J. Martin
General Dynamics Corp., Groton, Conn. (Electric Boat Div.)
Materials Evaluation, May 1970, p. 116

The paper describes how a series of NDT methods were examined in order to obtain a reliable system of detecting voids in large elastomer structures which are bonded to metal. The technique chosen, called the Radio Influence Voltage (RIV) method, is an adaptation of a test used on high voltage power insulation. It measures certain electrical changes that occur when an electrical stress is applied to an elastomer if that elastomer has entrapped voids. The method is shown to be capable of detecting voids ranging from approximately 0.005-in. diameter to 1/16-in. diameter in a 1/8-in. thick layer of neoprene. Similar results were obtained on 1/4-in. and 3/8-in. layers of neoprene. The test is effective even when the bubbles are at a metal interface and is not sensitive to cure state of the polymer.

6771 **MICROWAVE MEASUREMENT OF MATERIAL THICKNESS**

R. V. Williams
U. S. Patent no. 3,490,037

A microwave system for measuring the thickness of materials, such as steel plate, from a rolling mill. A phase change in a microwave beam is converted into a phase change in a lower frequency by using an independent reference frequency source. A converted output signal is mixed with the reflected microwave beam to provide a phase displacement which is representative of the thickness of an object.

6774 **THE C.D.L. CRACK DETECTOR AND TUBE TESTER**

Central Dockyard Lab., Portsmouth, England
Rpt. CDL TM-HNJ 1970
AD-720 958

The C.D.L. Crack Detector was designed for the detection of cracks in tubes and bars of nonferrous metals. In operation, it comprises a search probe which is a sliding fit around the bar under test and a portable battery operated instrument. The probe is moved along the bar and flaws are indicated by a lamp set for a predetermined fault level. A meter also gives an indication of minor faults below the threshold set for lamp illumination. The CDL tube tester is a development of the CDL crack detector designed for the inspection of heat exchanger tubes in situe. The operating frequency has been increased to 1 MHZ to reduce the depth ot eddy current penetration in order to eliminate the effect of baffles and tube finning.

6780 **PULSED EDDY CURRENT APPARATUS FOR NONDESTRUCTIVE TESTING OF RESISTANCE TYPE WELDS**

G. A. Noble
U. S. Patent no. 3,526,829

A method of nondestructive testing of resistance spot welds in ferromagnetic materials by comparison of the depth of penetration of a pair or eddy current inducing, pulsed, high-intensity electromagnetic fields. The fields are locally applied to the test weld and to a reference weld, and dynamic impedance measurements of the effect of the induced eddy currents on their applied fields are made.

6785 **MAGNETIC RECORDING BORESCOPE INSPECTION RESULTS OF AUTOFRETTAGED 175MM CANNON TUBE**

H. P. Hatch
Army Materials & Mechanics Research Center, Watertown, Mass.
Letter Rpt., February 1969

A test firing program was implemented for the purpose of determining the service life of autofrettaged 175mm gun tubes. Magnetic Recording Borescope inspections were conducted periodically in an attempt to determine initiation and approximate rate of growth of fatigue damage during the firing schedule. Inspections are accomplished by scanning the critical portion of a circumferentially magnetized tube and electronically detecting the magnetic leakage associated with fatigue cracks. The output of the detector is recorded on a facsimile recorder to produce a map of the bore surface and by oscilloscope photographs which permit accurate signal amplitude measurements. Using this instrumentation, six unplated, autofrettaged 175mm tubes were inspected periodically throughout the duration of the firing program at Aberdeen Proving Ground.

6790 **PULSED EDDY CURRENT INSPECTION OF THIN-WALLED REACTOR FUEL TUBING**

T. H. Busse, N. S. Beyer
Argonne National Laboratory, Argonne, Ill.
Materials Evaluation, vol. 28, no. 10, Oct. 1970, pp. 228-236

This paper describes the successful eddy current inspection of approximately 137,000 feet of stainless steel fuel jacket tubing required for the Experimental Breeder Reactor II. Tubing containing discontinuities exceeding 10 per cent of the 0.009-in. wall thickness had to be reliably rejected. System response was statistically correlated to natural flaw characteristics, resulting in a dependable practical test. The procedure provided realistic and valuable insight as concerns testing equipment capability and tubing quality. The eddy current equipment is discussed; however, emphasis is placed on inspection technique. Specific items discussed include inspection results and statistical evaluation, inspection confidence and practical considerations.

6799 **BEWARE THE WILES OF EDDY-CURRENT TESTING FOR DIFFUSED METAL COATINGS**

C. N. Owston
Nondestructive Testing, vol. 4, no. 2, April 1971, pp. 106-109

Nickel alloy gas turbine blades are given an aluminum rich surface layer to provide protection against sulphur corrosion. This layer has an electrical resistivity which is different from that of the underlying alloy and which varies with composition. As the composition of the protective coating changes during its life, eddy-current nondestructive testing methods appear attractive for quality control and in-service examination. Unfortunately experimental investigation has revealed several major pitfalls.

6806 **AN EDDY CURRENT TUBE TESTING TECHNIQUE USING A HYBRID COIL CONFIGURATION WITH SEQUENTIAL SAMPLING**

J. Ryden, Jr.
Battelle Northwest, Richland, Wash. 99352
Rpt. BNWL-1355, May 1970

A new eddy current tube testing technique has been developed. This technique has increased resolution and sensitivity to defects and a reduction of nonpertinent tubing variations as compared to the encircling coil technique. This is accomplished with no loss of inspection rate. The new technique utilizes a hybrid coil configuration consisting of both encircling coils and probe coils. The encircling coils are used as the drivers. A plurality of probe coils, mounted between the encircling coils around the coil form circumference, serve as the pickups. These are sequentially sampled at a rapid rate; thus, a 100% inspection of the tube is performed by only translating the tube through the coil form.

6809 **NEW DEVELOPMENTS IN EDDY CURRENT TESTING OF HOT WIRE ROD AND TUBES**

W. Stumm
Nondestructive Testing, vol. 4, no. 2, April 1971, pp. 101-105

NDT of hot wire and hot tubes is described as a cybernetic process because of the high material speeds and high test-data-flow in on-line testing. The basic concept of a new eddy current test unit for the high speed testing of hot materials is described. Results of experience in many rolling mills with this unit when used for tests of ferrous, austenitic and non-ferrous hot wires and hot tubes (temperature 300-1200°C) in the diameter range from 5-60 mm are given. Artificial defects are used for initial tests. Correlations are derived between eddy current indications and depth of defects, which have been examined by eddy current as well as by visual and microscopical methods.

6811 **AUTOMATIC CRACK DETECTION SYSTEM FOR AUTOMOBILE STEERING TIE RODS**
T. P. Smith
Nondestructive Testing, vol. 4, no. 3, June 1971, pp. 192-197

A completely automatic machine designed for eddy current inspection of critical areas on automobile steering tie-rods is described. The machine allows a uniform standard of inspection and can test components at four times the rate of an operator using manual methods.

6814 **INPSECTION OF WORK HARDENING OF STEEL SHAFTS BY THE EDDY CURRENT METHOD, PART 3**
N. M. Rodigin et al.
Soviet Journal of Nondestructive Testing, no. 4, July-Aug. 1970, pp. 470-475

A procedure for handling quality control of the work hardening of steel shafts is proposed. A description of an experimental device is presented, and results of laboratory tests and plant tests in regular production work are reported.

6815 **INSPECTION OF COLD HARDENING OF STEEL SHAFTS BY THE EDDY CURRENT METHODS; PART 2**
N. M. Rodigin
Soviet Journal of Nondestructive Testing, no. 4, July-Aug. 1970, pp. 465-469

The electromagnetic characteristics of steel-45K shafts were investigated after heat treatment and after cold hardening by using different fields and frequencies.

6816 **INSPECTION OF WORKHARDENING OF STEEL SHAFTS BY THE EDDY CURRENT METHOD. I.**
N. M. Rodigin, et al.
Soviet Journal of Nondestructive Testing, no. 4, July-Aug. 1970, pp. 459-464

The results of investigating electromagnetic properties of steel in constant fields after heat treatment and after heat treatment and workhardening are presented.

6817 **ID-1M FLAW DETECTOR FOR INSPECTING THE CONTINUITY OF GLASS AND ENAMEL COATINGS ON THE INSIDE SURFACE OF TUBES**
A. A. Romanenko and N. G. Yanchenko
Soviet Journal of Nondestructive testing, July-Aug. 1970, pp. 455-458

The purpose and working principle of the ID-1M flaw detector are described. Its basic circuit is presented and the operating characteristics of its individual units are examined. On the basis of the results of the instruments operating under production conditions, the authors give some advice on its use. The main operating characteristics of the ID-1M instrument are reported.

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
Proceedings, 5th International Conference on Nondestructive Testing, Montreal, 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.

6834 **CONTROLLING THE ELECTRIC FIELD OF LOW-FREQUENCY DIELECTRIC NONDESTRUCTIVE TESTING DEVICES**

J. R. Zurbrick
Avco Corp., Lowell, Mass.
Proceedings, 5th International Conference on NDT, Montreal, Canada, 1967

Controlled-field capacitance probes have been developed which provide high sensitivity, stability, precision and accuracy. Theoretical and practical properties of electric fields projected from the various capacitance test devices are discussed, including concepts of electric-field projection pattern, field direction, effective depth of field, and stray field projection and interception. Basic principles of probe design used to control the projected field are discussed.

6845 **INSPECTION AND TRACKING OF WELDS USING THE NEW MAGNETIC REACTION ANALYZER**

G. H. Smith, R. C. McMasters
F. W. Bell Inc., Ohio State University
Proceedings, 5 International Conference on NDT, Montreal, Canada, 1967

A new eddy-current instrument, the Magnetic Reaction Analyzer has demonstrated strong potential as both a sensitive nondestructive test and a guidance control for welded products and automatic welding operations. The instrument uses a Hall element to sense the magnetic reaction fields. This facilitates high resolution and provides reduced sensitivity to lift-off variations. A description of the analyzer is included and applications are discussed.

6849 **THE MILL INSPECTION OF STEEL PIPE AT 2150°F**

M. M. Godshall et al.
The Budd Company, Phoenixville
Proceedings, 5th International Conference on Nondestructive Testing, Montreal, 1967

A greakthrough has been made in the eddy-current inspection of materials at elevated temperatures. A new inspection technique is described which permits an eddy-current encircling coil inspection technique to be used on steel pipe at temperatures up to 2150°F. Data is included indicating that the test obtained is approximately the same as would be attained at room temperature using magnetic saturation eddy-current inspection techniques. The development of this technique is discussed along with the many advantages it offers.

6858 **CORRELATION OF CONDUCTIVITY TO MECHANICAL PROPERTIES OF AGE-HARDENABLE ALUMINUM ALLOYS USING EDDY CURRENT METHODS**

D. D. Seltzer
Martin Marietta Corporation
Proceedings, 5th International Conference on Nondestructive Testing, Montreal, 1967

A correlative relationship exists between the electrical conductivity, hardness, ultimate tensile and yield strength of aluminum alloys 7075-T6, 2014-T6 and 2024-T4. Various characteristic curves for each of these alloys can be derived by using various times and temperatures to produce metallurgical changes; these changes directly affect the conductivity, hardness, ultimate tensile and yield strength. Conductivity and hardness can be used to verify proper process control in heat treatment and that material meets specified mechanical properties.

6860 **PROGRESS IN NONDESTRUCTIVE TESTING IN AERO ENGINE MANUFACTURE**

I. L. F. Glover
Bristol Siddeley Engines Ltd. U. K.
Proceedings, 5th International Conference on Nondestructive Testing, Montreal, 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.

6864 **EVALUATION OF SMALL DISCONTINUITIES IN NON-METALS WITH MICROWAVES**

D. W. Prine
Magnaflux Corp., Chicago, Ill.
Proceedings, 5th International Conference on Nondestructive Testing, Montreal, 1967

Microwaves provide an excellent tool for nondestructive testing of non-metals. We are capable of detecting very small discontinuities by any of several microwave techniques. However, when it becomes necessary to evaluate these discontinuities as to shape, size or depth within the sample, many problems are encountered. By using a microwave impedance plotter which automatically displays a polar plot of the phase and amplitude of the reflected microwave signal, we have found answers to some of the questions that arise when one attempts defect evaluation.

6876 **THE IMPORTANCE OF NDT FOR THE COATED METALLIC THERMAL PROTECTION SYSTEM**

R. A. Stinebring, A. E. Oaks
General Electric Co., Philadelphia, Pa.

Lewis Research Center Space Transportation System Technology Symposium, vol. 3, July 1970, pp. 261-272
N70-42997

The systematic approach to nondestructive testing (NDT) and the state-of-the-art of NDT for coated metallics are discussed. In-process NDT evaluation, systems checkout and prelaunch evaluation, and NDT assessment of reusability are outlined. Thermoelectric probing, backscatter X-ray or electron emission test, and eddy current techniques are described.

6879 **MAGNETIC PROPERTIES OF LIQUID CRYSTALS**

P. Pincus
University of California, Los Angeles

Journal of Applied Physics, vol. 41, no. 3, March 1970, pp. 974-979
AD-722 646

Liquid crystals are characterized by an orientational order of the rod-like (or possible disk-like) molecules of which they are composed. The anisotropic part of the molecular diamagnetic susceptibility gives rise to a coupling between external magnetic fields and the orientational structure. In terms of the frank elasticity theory we discuss several such effects of a static field, e.g. unwinding of a cholesteric helix, freedericksz transition. The second part of this review is devoted to a consideration of magnetic resonance as a tool to study both the order parameter and the orientational fluctuation modes in a liquid crystal.

6880 **THE C.D.L. CRACK DETECTOR AND TUBE TESTER**

Central Dockyard Lab., Portsmouth, England

Rpt. C.D.L. TM-HNJNSTIC-28182, 1970
AD-720 958

The C.D.L. Crack Detector was designed for the detection of cracks in tubes and bars of non-ferrous metals. In operation, it comprises a search probe which is a sliding fit around the bar under test and a portable battery operated instrument. The probe is moved along the bar and flaws are indicated by a lamp set for a predetermined fault level. A meter also gives an indication of minor faults below the threshold set for lamp illumination. The CDL Tube Tester is a development of the CDL Crack Detector designed for the inspection of heat exchanger tubes in situe. The operating frequency has been increased to 1 MHZ to reduce the depth of eddy current penetration in order to eliminate the effect of baffles and tube finning.

6884 **CRITICAL THOUGHTS ON STRUCTURAL MECHANICS AND NDE**

M. B. Zisfein, W. B. Tarpley
Franklin Institute Research Laboratories, Philadelphia, Pa.
Rpt. AFOSR-70-2870TR, 9 Sept. 1970
AD-720 899

A critical review NDE is given in general terms and specific examples of NDE techniques are given. The state-of-the-art is presently technique-oriented, rather than problem oriented ude, in part, to ineffective communication links between designer, NDE researcher and user. Problems areas are identified which include better data handling and interpretive techniques for the user as well as detectability and resolution criteria; and certain materials problems (e.g., limited ductility materials); and an especially urgent need is expressed for control indices for surface contamination by NDE. Methods are suggested for improving the communications link and the idea of 'analogue' acceptability or evaluation is stressed in favor of 'binary' go:no-go type decisions.

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 Rpt. NASA-CR-72840, 24 March 1971, 239 p.

An NDT system based on a through transmission ultrasonic technique of 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.

6911 **NEW RESULTS OF NDT BY THE MAGNETIC LEAKAGE FIELD METHOD**

F. Forster
Nondestructive Testing, Aug. 1971, p. 254

Defects of the same depth as the surface roughness of the specimen under test can be determined using the magnetic leakage field method. This paper discusses the underlying principles of this method and some of its applications.

6922 **APPLICATION OF MICROWAVES TO NONDESTRUCTIVE TESTING AND TO THE MEASUREMENT OF SOLID PROPELLENT BURNING RATES**

D. T. Green
British Journal of Nondestructive Testing, Sept. 1971, p. 134

A method is outlined which employs microwaves of frequency 35 GHz to monitor continuously the recession of a burning surface of a solid propellant. The use of microwaves as a non-destructive testing tool is discussed with particular reference to the detection of porosity in non-conducting materials by scattered radiation.

6923 **PHASE-SENSITIVE EDDY CURRENT TEST EQUIPMENT**

T. A. Cox
Frankford Arsenal, Philadelphia, Pa.
Memorandum Rpt. M66-2-1, August 1965

Test equipment was developed to detect an eddy current signal voltage and to automatically resolve it into in-phase and quadrature components. It was then used to test for determination of its applicability to hardness measurements of ferrous parts. Test results using the automatic phase detection technique were promising. It is believed that practical systems can be developed for the automatic hardness testing of ferrous materials. Deficiencies in the uniformity of metallurgical characteristics of of the reference materials prevented linear correlations from being achieved.

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.

6936 **CURRENT DENSITIES IN A METAL PRODUCED BY PULSED EDDY CURRENTS**

S. B. Chan, D. L. Waidelich
8th Symp. on NDE in Aerospace, Weapons Systems, and Nuclear Applications, Apr. 1971, pp. 231-239

In the nondestructive testing of metals by employing pulsed eddy currents, it is necessary to know the magnitude, direction and the variation with time of the currents below the surface of the metal. With this knowledge and the response of the pickup coil to a given defect excited by the currents, the evaluation of a given pulsed eddy current system may be determined. To find the currents experimentally is very difficult if not nearly impossible, so an analysis of the currents in a metal has been made assuming that a non-uniform pulsed field is excited in the air above the surface of the metal. The current densities in the metal are shown as various curves involving the time, the depth in the metal, the metal conductivity and the geometrical dimensions. An equivalent depth of penetration in the metal is also given.

6938 **A PERFORMANCE EVALUATION OF THE HONEYWELL R. F. PROBE**

G. K. McConnell
Naval Air Development Center, Warminster, Pa.
Rpt. no. NADC-MA-7108, June 1971
AD-726 179

The Honeywell R. F. (radio frequency) probe has been applied to malfunctioning equipment by electronics specialists, and laboratory tests have been performed on circuits containing simulated defects. The study indicated that the probe would be a valuable addition to the standard instrumentation of most electronic or electrical maintenance and repair activities.

6939 **AN ANALYSIS OF NONDESTRUCTIVE SENSING OF WATER CONTENT BY MICROWAVES**

P. Hoekstra, P. Cappillino
Cold Regions Research and Engineering Lab., Hanover, N. H.
Rpt. No. CRREL-PR-295, July 1971
AD-728 831

Microwave instrumentation is used for nondestructive measurement of the water content of materials. The basis of all microwave moisture sensors is that the dielectric constants of material that contains water are a strong function of water content. The microwave moisture sensors based on a reflection or transmission principle are shown to have the disadvantage of requiring that a calibration be made for each sample thickness. Several alternative routes for developing reliable microwave moisture sensors are discussed.

6943 **MONITORING THE DECARBONIZING OF BARS OF BALL-BEARING STEEL USING THE METHOD OF HIGHER HARMONICS**

A. V. Maksimenko et al.
Soviet Journal of Nondestructive Testing, Sept.-Oct. 1971, pp. 585-588

This article presents experimental data obtained during the determination of decarbonization in steel using the method of higher harmonics in eddy current monitoring. Descriptions are given for an industrially introduced method and a defectoscope for 100% nondestructive testing of the decarbonization in standardized bars of ball-bearing steel.

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 holography, visual, liquid penetrant, magnetic, thermal and radiography.

6948 **A HIGH FREQUENCY EDDY-CURRENT NONDESTRUCTIVE TESTING APPARATUS WITH AUTOMATIC PROBE POSITIONING SUITABLE FOR SCANNING APPLICATIONS**

C. N. Owston

British Journal of Nondestructive Testing, November 1971, p. 170

By considering the equivalent circuit of an inductive probe in the vicinity of a metal object it is shown that at high frequencies the reactance reflected into the probe circuit is independent of the resistivity of the metal object. This reflected reactance can be used to control the degree of coupling between the probe and the object with the result that the reflected resistance is determined solely by the resistivity of the metal. A prototype instrument is described which makes use of these principles. When placed near a metal object the test probe is automatically adjusted to be at the correct distance from the object. The instrument can be scanned over a surface with an irregular topography without making mechanical contact, and the resulting information will distinguish between changes in topography, variations in resistivity, and mechanical defects such as cracks.

6952 **GENERAL ANALYSIS OF PROBE COILS NEAR STRATIFIED CONDUCTORS**

C. C. Cheng, C. V. Dodd, W. E. Deeds

International Journal of Nondestructive Testing, 1971, vol. 3, pp. 109-130

A general theory is presented for the axially symmetric, time-harmonic eddy currents produced by a probe coil of rectangular cross section in linear, isotropic homogeneous, conducting media bounded by an arbitrary number of parallel plane boundaries. First, the Green's function in each medium is calculated by a material method, which greatly simplifies the procedure. Then the vector potential and other quantities of interest are calculated from the Green's functions. The general results are specialized to three cases: a probe coil above an arbitrary number of parallel-plane conductors, a probe coil between two three-layer conductors, and a probe coil above a three-layer conductor. Computer programs that numerically calculate electromagnetic properties if one specifies the location and physical properties of the coil and conductors have been written.

6956 **MEASUREMENT OF SMALL MAGNETIC PERMEABILITY CHANGES BY EDDY CURRENT TECHNIQUES**

C. V. Dodd and W. A. Simpson

Oak Ridge National Laboratory, Oak Ridge, Tenn.

Materials Evaluation, Oct. 1971, pp. 217-221

A low-frequency eddy current bridge to measure accurately small changes in the magnetic permeability of weakly ferromagnetic materials has been developed. This technique has been used to evaluate nondestructively the fabrication history of certain austenitic stainless steels, the ferrite (alpha martensite) content of which increases with the amount of cold work. By using a bridge unbalance technique, the effects of small variations in lift-off, conductivity and thickness of the sample can be minimized. Permeability changes in tubular specimens have been determined to an accuracy of 150 ppm. This value can probably be improved to approximately 50 ppm.

6961 **INSPECTION OF WORK HARDENING OF STEEL SHAFTS BY THE EDDY CURRENT METHOD; PARTS I, II, III**

N. M. Rodigin et al.

Soviet Journal of Nondestructive Testing, July-Aug. 1970, pp. 459-464, 465-469, 470-475

I. The results of investigating the electromagnetic properties of steel 45KhN-MFA in constant fields after heat treatment and after heat treatment and work-hardening are presented.
II. The electromagnetic characteristics of steel-45KhNMFA shafts were investigated after heat treatment and after cold hardening by using different fields and frequencies.
III. A procedure for handling quality control of the work hardening of steel shafts is proposed. A description of an experimental device is presented, and results of laboratory tests and plant tests in regular production work are reported.

6966 **BARKHAUSEN EFFECT – AN INDICATION OF STRESS**

R. L. Pasley

Southwest Research Institute San Antonio, Texas

Materials Evaluation, vol. 28, no. 7, July 1970, pp. 157-160

Residual or applied stresses in ferromagnetic materials are measured by a nondestructive, magnetic method that utilizes the Barkhausen phenomenon. Test data are presented that demonstrate this method can sense and, under appropriate conditions, quantitatively measure surface or near-surface stresses. Equipment that electronically detects Barkhausen noise has been developed and can be used to rapidly measure stress. The theory of the measurement process is described in terms of magnetic domain theory. Magnetic domain activity during magnetization is affected by applied or residual stresses, and certain properties of the sensed Barkhausen noise reflect the magnitude and direction of such stresses.

6978 **PRECISION MEASUREMENT OF INTERNAL DIAMETERS OF LONG, SMALL BORE METAL TUBING**

R. E. Edsinger, L. A. Guildner, R. L. Anderson

National Bureau of Standards, Washington, D. C.

Review of Scientific Instruments, vol. 42, no. 7, July 1971

Internal diameters of a long, small bore metal tube were calculated from the measured capacitances between it and a cylindrical coaxial probe of known characteristics. The tube and the probe were used as the electrodes of a three-lead capacitor, measurable with high accurace in a transformer ratio arm bridge. For tubes of 0.1 cm bore or less, average diameters as a function of position can be determined by this method with an over-all uncertainty of $\pm 6 \times 10^{-5}$ cm over lengths of 1 m. The method can readily be extended to larger bores and greater lengths.

6999 **NONDESTRUCTIVE EVALUATION OF METAL FATIGUE**

F. N. Kusenberger et al.
Southwest Rsch. Institute, San Antonio, Texas
AFOSR-TR-71-1965, April 1971
AD-728 637

The results of continued fatigue crack nucleation and propagation investigations in the vicinity of inclusions in 4340 steel are presented. NDE results using ultrasonic and 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.

7011 **COMPUTER-BASED DISPLAY OF NDE DATA**

B. Stiefeld
Sandia Labs, Albuquerque, N. M.
8th Symposium on NDE in Aerospace, Weapons Systems, and Nuclear Applications, April 1971, pp. 183-190

This paper discusses techniques employed to reduce data acquired from a variety of NDE systems. These techniques include:

1. Automatic generation of 3D plots of characteristics over large surface areas.
2. Contour plotting of significant gradients in data.
3. Use of color to supplement digital enhancement techniques.
4. Multisectioned plots of large bodies to show internal flaw areas.

These data reduction techniques are applicable to many NDE techniques and present a significant departure from data presentations now employed.

7012 **NONDESTRUCTIVE EVALUATION OF METAL FATIGUE**

F. N. Kusenberger et al.
Southwest Research Institute, San Antonio, Texas
AFOSR-TR-73-1070, April 1973
AD-762 608

A model is proposed which is consistent with the early phases of crack front propagation observed in steels by the dormant period in surface crack extension heretofore observed in steels by others. Precycle magnetic signatures from inclusions are analyzed and the results presented show a functional relationship between signal amplitude and life to crack initiation. Experiments in the local removal of fatigue cracks show that significant extensions in fatigue life are possible through such "rework" and that subsequent crack initiation occurs at a location different from that corresponding to prior crack removal. Magnetic signatures from a fatigue crack at several intervals during propagation are also presented. (See also nos. 6999 and 7191.)

7016 **THE TDA: AN EFFECTIVE NONDESTRUCTIVE TEST FOR FURNACE AND REFORMER TUBES**

L. W. Hollaway, G. B. Kellum
Industrial Technical Corp., Baton Rouge, La.
Materials Protection and Performance, Oct. 1971, pp. 39-40

The Tube Deviation Analyzer (TDA) is an eddy current device which externally tests tubing without requiring access to tube ID. Detection and evaluation of furnace and reformer tubes is possible with the TDA. (This paper is a condensation of the original work. For information on obtaining the complete paper, contact the Editor, Materials Protection and Performance, NACE, 2400 West Loop South, Houston, Texas 77027).

7023 **DEVELOPMENT OF IMPROVED MAGNETIC PARTICLE INSPECTION PROCEDURES**

E. F. Bauer
Picatinny Arsenal, Dover, N. J.
Technical Rpt. 4156, Sept. 1971
AD-733 910

This report is concerned with the development of a device to semi-automatically detect and make a decision regarding fluorescent indications. The surface is scanned using a simple XY table and fibre optics. The signals from the Fluorescent particles are detected by means of a photomultiplier tube. The problems with interfering visible light were controlled with selective optical filters.

7025 **INDUCTIVE SENSING TECHNIQUE ADVANCEMENT**

G. G. Moross
Mechanical Technology, Inc., Latham, N. Y.
USAAMRDL Tech. Rpt. 71-51, Sept. 1971
AD-734 342

This program is concerned with the advancement and development of the inductive sensing system. The system significantly enhanced in its ability to detect early fatigue damage in 6061 T-6 aluminum. Samples were fatigue-cycled up to 2,000,000 cycles, and crack signals have been observed as early as 9.7% of life. The system greatly enhanced in its sensitivity to cracks and its insensitivity to extraneous factors such as probe proximity and generalized surface damage. This increased sensitivity to flaws, coupled with the ability to selectively disregard extraneous surface conditions or probe proximity, significantly advanced the state of the art in NDT.

7026 **NON-DESTRUCTIVE TESTING: METHODS, TECHNIQUES, AND THEIR APPLICATIONS (DDC BIBLIOGRAPHY, MAY 1964 - MARCH 1971)**

Defense Documentation Center, Alexandria, Va.
Rpt. DDC-TAS-71-58-1, Dec. 1971, 156 p.
AD-733 850

The bibliography is a compilation of references which are grouped under eight major headings: 1. Lasers, 2. Eddy currents, 3. Electrical, 4. Magnetic, 5. Visual, 6. Thermal, 7. Stresses, pressure, and leak testing, and 8. Miscellaneous. Note: This bibliography updates AD-421 564.

7027 **CORRELATION OF MAGNETIC AND MECHANICAL PROPERTIES OF STEEL**

H. Frankel
Watervliet Arsenal, Watervliet, N. Y.
Rpt. WVT-7147, July 1971
AD-734 303

If a nondestructive test could be devised for measuring the mechanical properties of steel, the cost of making and breaking Charpy, tensile and fatigue bars could be saved. In addition, the mechanical properties could be determined for areas which are now practically impossible, such as along a gun tube where there is not enough surphus material to obtain these bars. This investigation shows a correlation between coercivity, a magnetic property of steel, and some of the mechanical properties. Unfortunately the departure from ideal, linear correlations prevents the immediate application of this process.

7028 **NONDESTRUCTIVE TESTING: RADIOGRAPHY (REPORT BIBLIOGRAPHY) (MAR. 1964 - DEC. 1970)**

Defense Documentation Center, Alexandria, Va.
Rpt. DDC-TAS-71-54-1, Nov. 1971, 83 p.
AD-733 860

This report includes: References pertaining to radiographic techniques for use in inspection and evaluation of electronic parts, fatigue of plates and weldments in steels, evaluation of metal fatigue, lack of penetration in aluminum fusion welds, small scale footing tests in clay, and evaluation of void content in epoxy-glass filament-would material. Citations were selected from entries processed into the Defense Documentation Center's Data Bank during the period from December 1963 through August 1971 and updates an earlier bibliography, AD-421 564.

7038 **THE MAGNETIC RECORDING BORESCOPE-INSTRUMENTATION FOR THE INSPECTION OF CANNON TUBES**

H. P. Hatch, N. Rosato
Army Materials and Mechanics Research Center, Watertown, Mass.
AMMRC PTR 71-4, Nov. 1971
AD-737 586

A two-phase project was implemented with the objective of extending the Magnetic Recording Borescope capability to various caliber cannon tubes. Phase I involved the design and fabrication of an integral, self-propelled scanning mechanism adaptable to calibers 152mm through 175mm and Phase II provided a second model for similar adaptation to 90mm and 105mm tubes. The principle of operation is based on the electronic sensing of magnetic leakage fields associated with cracks in a previously magnetized gun tube. A Hall-effect device was incorporated as the magnetic field detector. The resulting MRB readout includes a continuous three-dimensional recording of the interrogated bore surface as well as a two dimensional recording where quantitative defect signal amplitude data may be obtained for correlation with crack depth.

7044 **NONDESTRUCTIVE FLAW DEFINITION TECHNIQUES FOR CRITICAL DEFECT DETERMINATION**

F. J. Sattler
TRW Equipment Group, Cleveland, Ohio
Rpt. TWO-ER-7419, Jan. 1970
N70-19719

The accurace of radiographic, penetrant, ultrasonic shearwave and ultrasonic delta inspection methods were evaluated on defect specimens made from 2014 and 2219 aluminum, and 5A1-2.5Sn and 6A1-4V titanium alloys. The accuracies of these test methods are compared for these alloys at nominal section thicknesses of 0.020, 0.125, 0.500 and 1.000-inches. The penetrant test method provided the most accurate test to determine defect length in all but the 0.5 and 1.0-inch aluminum specimens. Radiographic inspections provided the best accuracy in the 0.5 and 1.0-inch aluminum specimens. None of the test methods had sufficient accuracy in determining critical crack depths as determined from fracture toughness calculations. The effects of stress conditions on the detectability of defect dimensions was evaluated. Fracture toughness calculations were made from the defect dimensions and tensile test data on the specimens.

7049 **EVALUATION OF AN EDDY-CURRENT TESTER FOR DETECTING SEAMS IN ROLLED URANIUM RODS**

C. E. Neu
National Lead Co., Ohio, Cincinnati, Ohio
Rpt. NLCO-1059, June 1970

A "Roto-Bar-Tester"* was evaluated and found capable of detecting and measuring Seams in rolled uranium rods. The instrument contains probes which rotate about the rod while the rod is moved longitudinally through the machine.

*Rotating-probe seam detector, Magnetic Analysis Corp., Mount Vernon, N. Y.

7052 **ELECTRON SIGNAL PROCESSING TECHNIQUES: NONDESTRUCTIVE TESTING – PHASE III**

J. C. Kennedy, W. E. Woodmansee
Boeing Co. (Aerospace Group), Seattle, Wash.
Boeing Co. Rpt. D180-10589-3, Jan. 1972, (Final rpt. for Dec. 1970 - Dec. 1971)

Correlation methods have been used to reduce surface roughness noise in eddy current and ultrasonic flaw detection systems. Titanium plates containing artificial flaws in the form of small drill holes and EDM slots have been ultrasonically inspected using multi-transducer techniques. It has been shown that cross correlations formed between the various signals available significantly reduce the limiting background noise. A steel plate containing EMD slots has been inspected with an eddy current probe which produces four separate flaw detection signals. It has been shown that a quadruple product formed from these four signals reduces the background noise level. Initial tests indicate that coherently optical processing techniques are not likely to significantly enhance the clarity of marginal flaw signals on X-ray radiographs. (See also: 6933, 6554, 6442, 6345).

7054 **METHOD OF MEASURING DYNAMIC CLEARANCES: MICROWAVE INTERFEROMETRY AS AN NDT TECHNIQUE**

D. J. H. Wort

Nondestructive Testing, Dec. 1971, pp. 380-381

Many industrial problems of clearance and vibration measurement can be solved by the application of microwave interferometry. This non-contacting method is accurate to 0.01 mm, has an extremely fast response, can be used to measure a variety of surfaces, and is unaffected by most of the hostile environment encountered in industry. The equipment is robust and presents no operational hazard, and is sufficiently versatile to meet a wide range of requirements by straightforward modifications to the basic configuration.

7069 **NONDESTRUCTIVE MONITORING FOR OPTIMIZATION OF IN-SERVICE PERFORMANCE TESTS**

Oak Ridge National Laboratory, Oak Ridge, Tenn.

Materials Research and Standards, June 1972, pp. 11-16

Nondestructive evaluation techniques can provide significant benefits to performance of service tests through monitoring of changes in the specimens during the test. Penetrating radiation methods detect changes in thickness, chemical composition, density, or the presence of discontinuities. Electromagnetic induction methods monitor changes in thickness, discontinuities, and the electrical or magnetic properties of a specimen. Ultrasonic methods can be used to detect changes in elastic properties, dimensions, or flaws. Other techniques such as acoustic emission, thermal monitoring, holography, and microwaves are also finding application for predictive testing.

7071 **NEW AND REFINED NONDESTRUCTIVE TECHNIQUES FOR GRAPHIC BILLETS AND SHAPES**

A. E. Oaks

General Electric Co., Philadelphia, Pa., (Reentry & Environmental Systems Div.)

AFML TR-70-212 (part 2), July 1971. (Final summary rpt.)

AD-736 774

The limits of utility of several advanced NDT approaches for detecting small flaws in graphite were evaluated. (1) Focal plane ultrasonic inspection was the most successful in delineating defects (in depths of from 0.060 to 4 in.) down to 0.020 to 0.030 in. diameter in ATJ-S, and 0.010-in. diameter in AXF-90 graphite. (2) For nearer surface inspection, 1 MHz differential eddy current techniques can be applied to detect voids down to approximately 0.010 x 0.010 in. (3) For billet and part inspection, slit radiographic techniques were found to reduce scatter and parallax distortion-induced image degradation and to achieve 10 to 15 percent improvements in the film contrast and defect resolution achieved with graphite.

7079 **THE NEW ECONOMICS OF ELECTROMAGNETIC METHODS OF NON-DESTRUCTIVE TESTING**

W. S. Gould

British Journal of Non-Destructive Testing, vol. 14, no. 1, Jan. 1972, pp. 1-5

The historical development of electromagnetic (eddy current) methods of testing is described. Reliable high-speed testing equipment can now be integrated with the production process and the economics of the use of such equipment is considered in detail. Comparison is made with visual inspection.

7080 **NONDESTRUCTIVE TESTING OF SCOUT ROCKET MOTORS**

A. E. Oaks
General Electric Co., Philadelphia, Pa.
Rpt. no. NASA CR-2013, April 1972

The nondestructive tests applied to Scout rocket motors were reviewed and appraised. Analytical techniques were developed to evaluate the radiographic and ultrasonic procedures used. Major problem areas found were the inadequace of high voltage radiography for detecting unbonds and propellant cracks having narrow widths, the inability to relate the ultrasonic signals reviewed from flat-bottomed holes in standards to those received from real defects and in the general area of the specification of acceptance criteria and how these were to be met. To counter the deficiencies notes, analyses were conducted of the potential utility of radiometric, acoustic, holograph and thermographic techniques for motor and nozzle bond inspection, a new approach to qualifying magnetic particle inspection and the application of acoustic emission analysis to the evaluation of proof and leak test data.

7086 **LOCATING TUBE BLOCKAGE THAT X-RAY CANNOT DETECT**

AEC-NASA Tech. Brief 71-10129, May 1971

This brief tells of a study made of alternate choices, other than the standard use of x-rays, available in detecting low density foreign materials present in thick-walled metal assemblies. The methods include negative radiography, neutron radiography, liquid crystal inspection, and ultrasonics. The study presents the features, advantages, and disadvantages of the methods along with photographic plates displaying the comparative detection capabilities in each case.

7087 **ELECTRONIC FLAW SIMULATOR FOR EDDY CURRENT PROBE CALIBRATION**

AEC-NASA Tech. Brief 70-10533, Oct. 1970

The reference flaws of known dimension that are used to calibrate eddy current probe coils may be altered gradually because of undetected dust collection, chipping, and handling wear. To overcome this disadvantage, an electronic flaw simulator is built into the eddy current system. This technique provides a system calibration time saving of 1/5 over prior methods. The electronic simulator has been in use since 1968 without measurable change in performance. Minor maintenance has not adversely affected calibration.

7094 **MAGNETIC PERTURBATION INSPECTION OF INNER RACE BEARINGS**

J. R. Barton, J. Lankford
Southwest Research Institute, San Antonio, Texas
NASA CR-2055, May 1972

Approximately one hundred inner race bearings were inspected nondestructively prior to endurance testing. Two of the bearings which failed during testing spalled at the sites of subsurface inclusions previously detected by using magnetic field perturbations. At other sites initially judged to be suspect, subsurface inclusion nucleated cracking was observed. Inspection records and metallurgical sectioning results are presented and discussed.

7106 **AN ELECTRICAL METHOD FOR EVALUATING BRIDGE DECK COATINGS**

D. L. Spellman, R. L. Stratfull
California Dept. of Public Works
Rsch. Rpt. M&R 635116-5, June 1971
PB-204 368

An electrical method for evaluating bridge deck coatings is being experimentally used on California highway bridges. Tests indicate that its electrical resistance can be related to the coating's voids and to its sealing ability. This may be an additional tool for evaluating membranes used to prevent ingress of de-icing salts. The method measures the resistance between bridge surface locations and reinforcing steel; it assumes that an excellent waterproof bridge coating produces values >500.000 ohms/ft^2, and a poor or perforated one–values never $>100,000$ ohms/ft^2.

7107 **REMOTE INSPECTION OF WELDED JOINTS**

R. W. McClung
Oak Ridge National Laboratory, Oak Ridge, Tenn.
ORNL-TM-3561, Sept. 1971

This literature survey considers present and then speculates concerning future technology. Maintenance and repair of reactor components by remote welding will require development of adequate NDE techniques. Recommended developments include: improved closed-circuit TV, new high-temperature penetrants, study of neutron radiography, improved transducers, and application of acoustic emission and eddy currents. Sophisticated mechanical positioning, manipulation, and scanning equipment will be required for most techniques.

7114 **TESTING PLATED-THROUGH HOLES ON PRINTED CIRCUIT BOARDS**

Circuits Manufacturing, June 1972, pp. 34-38

Two methods are outlined: beta-ray backscatter and the micro-resistance method. These methods are compared with the metallographic method and the advantages and disadvantages of the three methods are tabulated.

7122 **ELECTROMAGNETO-ACOUSTIC NONDESTRUCTIVE TESTING IN THE SOVIET UNION**

A. I. Butenko, I. N. Ermolov, Y. M. Shkarlet
Non-Destructive Testing, June 1972, pp. 154-159

The electromagnet-acoustic method of generating ultrasound for flaw detection has attracted more interest in the Soviet Union than in the west. The "ema" method works on the principle that eddy currents excited by a coil in a metallic article under test interacts with the magnetic field causing mechanical stresses in the surface layer of the article. These stresses cause excitation and propagation of a resilient wave at a frequency equal to that of the coil. The converse is also true. Advantages include: (a) The method is non-contacting; (b) it is possible, in principle, to test metals in an almost unlimited temperature range including molten metal.

7132 **TESTING METHODS AND TECHNIQUES: A COMPILATION**
Technology Utilization Office, NASA, Washington, D. C.
NASA SP-5931(01), 1970

This compilation covers a selected group of nondestructive tests for materials, welds, valves, tubing, wire insulation, bearings, and instrumentation fittings. Other tests include means for determining gas contamination, detecting hydrogen fires, detecting leakage in pressure transducers, and conducting shock tests of large items. Several computer programs that may be applicable to industrial testing are also presented. The information is primarily intended for those with practical experience in quality control, inspection, and industrial testing.

7157 **NEW DEVELOPMENTS IN THE EDDY CURRENT TESTING OF HOT WIRE AND HOT TUBES**
W. Stumm
Applications Lab of the Institut Dr. Forster, Reutlingen, West Germany
Materials Evaluation, July 1971, pp. 141-147

The basic concept of a new eddy current test unit for the high-speed testing of hot materials is discussed. Results of experience in many rolling mills with this unit when used for tests of ferrous austenitic and nonferrous hot wires and hot tubes (temperature 300 to 1200^{o}C) in the diameter range from 5mm to 60mm are given. Artificial defects are used for initial tests. Correlations are derived between eddy current indications and depth of defects, which have been examined by eddy current as well as by visual and microscopical methods. Typical statistical relations between defect depth and the percentage of defects detected by eddy current result from this investigation.

7179 **MICROWAVE MEASUREMENTS OF AEROSPACE MATERIALS**
M. H. Jacoby
Lockheed Missiles and Space Co.
Typescript, 47th Nondestructive Test Committee Meeting, Aerojet Solid Propulsion Co., Sacramento, Calif., 4-5 April 1972

Conventional microwave-measuring techniques have been adapted to determine the dielectric properties of nonmetallic materials in a nondestructive manner. The method measures the properties in free space. Of particular interest there was the development of a microwave method to determine the amount of moisture in a solid propellant.

7182 **EVALUATION OF NEW NDT TECHNIQUES FOR DETECTION OF WELD DEFECTS**
J. S. Schliessmann, R. R. Corle
Lockheed Propulsion Co., Redlands, Calif.
Typescript, 47th Nondestructive Test Committee Meeting, Aerojet Solid Propulsion Co., Sacramento, Calif., 4-5 April 1972

The objective of this investigation was to evaluate three modern NDT methods which might be used to detect flaws in solid rocket motor cases, via., laser holography, acoustic emission, and X-ray enhancement. The subsequent results were compared with standard radiographic and magnetic particle inspection test results. Preliminary tests conducted on uniaxial 4335V steel specimens indicated that acoustic emission would be optimum for detecting tight motor case defects, and could detect flaws as small as 0.02 inch deep and 0.3 inch long. Other tests involving a D6AC steel case show that acoustic emission can be used in conjunction with proof testing to detect flaws before catastrophic fracture occurs.

7185 **MEASUREMENT OF TURBINE BLADE WALL THICKNESS BY PHASE-SENSITIVE EDDY CURRENT**

C. F. Smith, Jr.*, A. J. Passeri**
*Laser Systems and Electronics, Inc., Tullahoma, Tenna.
**Pratt and Whitney Aircraft Corp., East Hartford, Conn.
Materials Evaluation, June 1972, pp. 113-116

A phase-sensitive, eddy current instrument has been shown to be capable of obtaining rapid-scan wall-thickness measurements on turbine blades. The effect of various parameters on measurement accuracy is described. Data obtained by destructive measurements are compared with those of X-ray, amplitude-sensitive eddy current, and ultrasonic techniques.

7192 **APPLICATION OF NON-DESTRUCTIVE INSPECTION METHODS TO AIRCRAFT STRUCTURES**

P. Gallinaro*, R. B. Oliver**
*Via Stampatori, Torino, Italy
**Cabot Corp., Kokomo, Ind., USA
AGARD-R-587-71, Oct. 1971

This is a report to the Structure and Materials Panel of AGARD on a survey which was made in the NATO countries during the months of May, June and July 1967. The objective was: "To review the application of non-destructive methods of inspection of operational aircraft structures in the NATO countries in regard to equipment and techniques used, structural components examined and the reliability of results obtained". Discussions have been held about some problems relevant to in situ inspection of bonded, welded, and riveted structures with particular reference to the use of X-rays, ultrasound and eddy-currents. The time available for the discussions was too short, however, to allow a complete and detailed comparison of the experience gained and of the different opinions expressed.

7197 **TESTING HOT WIRE AND HOT TUBES BY EDDY CURRENTS**

A. Kalish, W. Stumm
Soviet Journal of Nondestructive Testing, vol. 7, no. 5, Sept.-Oct. 1971

The construction and operation of a new device for the eddy-current testing of hot wires and tubes at high rates of production, and also for the execution of the necessary cybernetic processes, are described. Tests on hot ferritic, austenitic, aluminum, and copper wires, and steel and aluminum tubes 5-60mm in diameter at 300-1200^{O}C are reported. Some typical relationships between the depth of a defect and the probability of its detection are presented. The eddy-current method of testing may be used in order to optimize the trimming (cutting of the ends of a wire rod) to achieve operative monitoring of the state of the rolls (by reference to the appearance of uniformly distributed defects at a specific frequency), and to test the roughness of the rolled material (by reference to the noise level).

7206 **DEVELOPMENT OF AN UNDERSTANDING OF THE FATIGUE PHENOMENA OF BONDED AND BOLTED JOINTS IN ADVANCED FILAMENTARY COMPOSITE MATERIALS**

A. C. Fehrle, et al.
Lockheed-Georgia Co., Marietta, Ga.
AFFDL TR 71-44, June 1971 (Interim Rpt. for March 1970 - Feb. 1971)
AD-729 189

Initial program efforts were directed primarily to planning, joint design, joint analysis, and basic evaluation of the boron material. Specimen design, test parameters, and a number of specimens required for accomplishing the objectives of this program have been established. A closed form joint analysis has been developed for the elastic condition and expanded to include nonlinear adhesive properties. All baseline data have been generated and constant life diagrams developed for the basic bonded specimen configuration. Failure mode studies have been conducted for specimens subjected to various types of loading and definite failure modes have been established for specific loading conditions.

7245 **THE USE OF AN ELECTRICAL INDUCTION METHOD FOR DETERMINING THE PHYSICAL CONDITION OF A GROUND STEEL SURFACE**

V. D. Ostapenko, V. S. Gaidamakin, O. P. Chikhachev
Soviet Journal of Nondestructive Testing, vol. 7, no. 5, Sept.-Oct. 1971

A method of investigating the physical condition of the ground surface of hardened steel by means of measuring the vector of reflected impedance of an applied sensor is described. The effect of grinding on the structure and phase content of the surface layer of a particular is studied. Data from the electrical induction method is compared with the results of x-ray and metallographic testing, making it possible to obtain a definite correlation between readings from the equipment and the physical condition of the surface layer.

7248 **THE MAGNETIC FIELD OF EDDY CURRENTS ABOVE A SURFACE CRACK IN METAL WITH EXCITATION OF THEM BY AN APPLIED INDUCTOR**

V. V. Vlasov, V. A. Komarov
Soviet Journal of Nondestructive Testing, vol. 7, no. 6, Nov. - Dec. 1971, pp. 665-675

A method is proposed for a qualitative estimate of the magnetic field of eddy currents occurring along the walls of cracks spread on the surface in metal with a comparatively highly developed skin effect.

7251 **CHARACTERIZATION OF WIRE-WOUND TUNGSTEN COMPOSITE**

J. G. Hill, F. L. Banta
United Technology Center, Sunnyvale, Calif.
AFML-TR-71-245, Jan. 1972
AD-743 970

This program was conducted to determine and extend the potential of wire-wound tungsten composites for analysis, design and fabrication of rocket hardware through characterization of its properties. Specimens were fabricated by previously developed rocket nozzle techniques of plasma-spraying and filament reinforcement. Thermal and mechanical properties were determined for the temperature range of 70^{O} to $4{,}000^{O}$F. Suitable test methods for nondestructive examinations were determined, and a material specification was prepared, based on the program results.

7254 **EVALUATION OF THE RELIABILITY AND SENSITIVITY OF NDT METHODS FOR TITANIUM ALLOYS: INTERIM RPT. NO. 1**

R. J. Lord
McDonnell Aircraft Co., St. Louis, Mo.
MDC-A1920, 20 Oct. 1972 (Rpt. for period 1 May - 30 Sept. 1972; contract F33615-72-C-1203)
(Not at DDC)

This report represents the semi-annual status report on the Evaluation of the Reliability and Sensitivity of NDT Methods for Titanium Alloys Program (Contract F33615-72-C 1203) covering the period 1 May - 30 Sept. 1972. Discontinuities representative of those which might occur in titanium airframe and jet engine components will be utilized in this study. Improvements will be stressed for NDT methods used, viz., x-ray, eddy current—and with particular emphasis—ultrasonics and penetrant. This information to be developed will be included in a document that can be incorporated into specifications describing improved NDT procedures for the testing of titanium alloys.

7277 **DEVELOPMENT OF A NEW ACCEPTANCE CRITERION FOR M-1 HELMETS; PHASE II: PRELIMINARY DESIGN OF A THICKNESS INSPECTION SYSTEM**

J. M. Harris, J. S. Glasgow, A. Rudnick
Battelle Memorial Institute, 505 King Ave., Columbus, Ohio
Tech. Rpt. 72-60-GP, March 1972
AD-750 153

Previous studies* demonstrated that the currently used ballistic inspection of M-1 helmets could be replaced by an inspection based on thickness requirements. It was demonstrated that inspection based on thickness would provide greater confidence in the quality of helmets and to do so at appreciably lower cost. The objective of the current study was to identify the most effective way to perform the inspection in production situations, and to make a preliminary design of a thickness inspection system. A thickness-averaging ultrasonic system, containing a set of stationary transducers connected to averaging circuitry and digital readout, was selected as most appropriate. A design of such an inspection system was prepared.

(*Development of a New Acceptance Criterion for M-1 Helmets: Phase I. . .NLabs publication 72-20-GP, Nov. 1971; etc.)

7280 **AUTOMATIC EDDY CURRENT SYSTEM FOR DETECTION OF FASTENER HOLE CRACKS**

A. P. Rogel
McClellan Air Force Base, Sacramento, Calif.
Separate, 20th Defense Conference on NDT, Jacksonville, Nov. 1971

The automatic eddy current system was especially developed to reliably detect fatigue cracks present in fastener holes of structural members such as a wing. The automatic scanning system replaces not only the cumbersome hand eddy current scanning technique, but also the optical and penetrant methods which have limited value for detecting cracks developed in holes of service aircraft. The permanent recording of inspection results provides an accurate means of analyzing the condition of a hole and thereby insuring the safety-of-flight of the aircraft on its mission. See also, for revised version, AD-894 935, pp. 63-87.

7281 **DEVELOPMENT OF AN UNDERSTANDING OF THE FATIGUE PHENOMENA OF BONDED AND BOLTED JOINTS IN ADVANCED FILAMENTARY COMPOSITE MATLS. VOL. II: FABRICATION, INSPECTION AND TESTING**

A. C. Fehrle et al.
Lockheed-Georgia Co., Marietta, Ga.
AFFDL-TR-72-64, Vol II, June 1972
AD-750 133

Fabrication and inspection methods were established which resulted in specimens of uniform high quality fabricated to close tolerances. Both bonded and bolted joints of widths, from one to ten inches, were evaluated. Primary emphasis was on joints in boron-epoxy, and between boron-epoxy and titanium or aluminum; limited evaluations of graphite-epoxy/titanium and fiberglass-epoxy/titanium were included. Joint configurations evaluated were single and double splice butt joints; boron-epoxy to metal stepped single scarf joints; and surface to understructure attachments. All laminates and specimens were inspected non-destructively. Base material properties and process control measures were verified by destructive testing.

7285 **STUDY TO INVESTIGATE NDT TECHNIQUES SUITABLE FOR INSPECTING THE M55 DETONATOR CUP FOR FLAWS**

D. H. Fryklund
Accumetrics Corp., Cambridge, Mass.
AC-164, July 1972 (Picatinny Arsenal Contract)
AD-904 307

Detonator cups (e.g., ordnance M55, Part #8798332) experience various flaws, viz., cracks, scratches, slivers, burrs, and thus require inspection during the production process. In the interests of mechanizing the inspection operation, several feasible techniques were studied and tested. These included photoelectric and electrostatic scanning. The small size of the M55 cup presented difficulties in obtaining good resolution with all except the photoelectric technique. Preliminary designs were then evolved for an automatic inspection machine based on the photoelectric technique.

7287 **HIGH PERFORMANCE CASTINGS**

National Materials Advisory Board (Committee on High-Performance Castings), Washington, D. C.
NMAB-291, March 1972, 235 pp.
AD-748 462

This report delineates the factors influencing the characteristics, design, and properties of high-performance castings and the outstanding problems that must be resolved to enhance their reliability and use. It suggests a number of programs and methods to improve their integrity and acceptance. An integrated plan is proposed to make these castings competitive with forgings. Specific recommendations are proposed for individual metallic alloys systems. (Pages 45-57 deal with nondestructive evaluation of castings).

7289 **MICROWAVE COUPLED-STRIPLINE SURFACE-CRACK DETECTOR**

L. A. Robinson, U. H. Gysel
Stanford Research Institute, Menlo Park, Calif.
AMMRC CTR 72-15, Aug. 1972
AD-749 799

The detector was built using the capability of a pair of conductors over ground to support propagation in two orthogonal TEM modes. The two conductors are flat strips printed on a dielectric sheet. The other side of the dielectric sheet is clad with metal at RF ground potential. The printed stripline assembly is used to scan a surface which is also at RF ground potential. When the stripline approaches a surface crack, the crack couples energy from one mode into the other because the symmetry of the geometry is upset. This detector model operates at 10 GHz, and has been evaluated using simulated cracks milled in flat aluminum stock. The crack dimensions range 0.006 to 0.0312 inch in width, 0.125 to 0.5 inch in length, and 0.0312 to 0.25 inch in depth. All can be found by the detector. This form of surface-crack detector shows definite promise for practical applications.

7296 **THICKNESS MEASUREMENTS USING EDDY-CURRENT TECHNIQUES**

C. V. Dodd, W. A. Simpson, Jr.
Oak Ridge National Laboratory, Oak Ridge, Tenn.
Conf-720301-5, 1972 (Avail: NTIS)

Eddy currents have been used for many years to measure the thickness of a single conductor and the thickness of one conductor clad on another. By performing a computer analysis of the problem, we have been able to choose the optimum conditions for performing such measurements. Effects of varying thickness, frequency, coil size, conductivity, lift-off (or coil-to-conductor spacing), and coil resistance are discussed. The use of a phase-sensitivy eddy-current instrument in performing thickness and clad thickness measurements is emphasized.

7300 **EDDY CURRENT INSPECTION OF TURBINE BLADES**

I. R. Kraska, H. W. Kamm
General American Transportation Corp., Niles, Ill.
AFML-TR-70-266, June 1971
AD-743 105

This report is concerned with a nondestructive field inspection technique designed to detect cracks in the leading and trailing edges of Jet engine turbine blades. Of the various NDI methods considered, the eddy current method was the one found suitable for field testing. It can detect cracks down to 0.020" long, 0.0005" wide, 0.005" deep; and it can do so at a rate of one stage in 15 minutes on rotors having 108 cleaned blades per stage. The eddy current system is attractive for field maintenance inspection of turbine blades.

7317 **EVALUATION OF CARBON-CARBON REENTRY HEAT SHIELDS BY NONDESTRUCTIVE AND DESTRUCTIVE TESTS**

J. L. Irwin, O'N. J. Burchett
Sandia Laboratories, Albuquerque, N. M.
SC-R-71-3354, 1971

A two-phase program was undertaken to evaluate and select two reentry heatshields from among several candidates. Property tests were performed on samples of excess material cut from each end of cones; these were correlated with nondestructive test data obtained from the cones. The use of NDT for carbon-carbon materials requires techniques not common to the other types of materials. Considerable evaluation and destructive testing are needed to determine correlations between destructive and nondestructive test data. Two successful reentry flights with tested cones validate the laboratory's analyses.

7322 **DEVELOPMENT OF NONDESTRUCTIVE TESTING TECHNIQUES FOR PLATED-THROUGH HOLES IN MULTILAYER PRINTED CIRCUIT BOARDS**

P. L. Anthony, J. E. McMurtrey
North American Rockwell Corp., Anaheim, Calif.
NASA-CR-61378, Dec. 1971
N72 22501

The objective was to develop a NDT system capable of interrogating plated-through holes as small as 0.51 mm inside diameter, and of detecting defects (holes, voids, cracks, thin spots) which reduce current-carrying capability of plated-through interconnects by 20% or more. Two 1.52 mm and one 0.75 mm probes were designed and fabricated using the mutual coupling principle. The fabrication of a probe down to 0.51 mm in tip diameter appears to be practical. Despite inconclusive results, much original, practical information was obtained. The high output signals and the extreme sensitivity of the probes make it difficult to distinguish between different defect types.

7344 **THE USE OF CROSSING POINTS IN PULSED EDDY CURRENT TESTING**

D. L. Waidelich, S. C. Huang
University of Missouri-Columbia, Columbia, Mo.
Materials Evaluation, vol. 30, no. 1, Jan. 1972, pp. 20-24

Once primarily used to overcome the lift-off effect, the idea of crossing points is now found useful in overcoming the effects of other variables, e.g., the conductivity of a metal. An analysis of pulsed eddy currents has been developed primarily for the application to the problems of defects. This same analysis, however, may be applied to the idea of crossing points; this has been done. Computed results show that the lift-off distance may be varied without changing essentially the position of the crossing point. A greatly magnified picture of the crossing point indicates that there is a slight change of position. Similar results were obtained for the crossing point for conductivity.

7349 **THE ANALYSIS OF REFLECTION-TYPE COILS FOR EDDY CURRENT TESTING**

C. V. Dodd et al.
Oak Ridge National Laboratory, Oak Ridge, Tenn.
ORNL-TM-4107, April 1973

This report contains theoretical analysis and computer programs for reflection type coils above multiple layered conductors. Performance of the coils when connected to phase-sensitive eddy current instrumentation can be evaluated. Programs are written in both BASIC and FORTRAN for timesharing on the PDP-10 to calculate the effects of defects or variations in either conductivity or thickness for multiple conductors, all in the presence of lift-off variations. Program options are included that allow the study of the design of the coil, the effects of small variations or drifts of all the coil, conductor and instrument parameters, and the effects of the instrument output and input impedance on the problem. Application of these techniques allow optimum design of eddy current tests using probe coils without the necessity of expensive trial and error experiments and fabrications.

7385 **THE MAGNETOSTATIC DEFECTOSCOPE – A QUANTITATIVE CHARACTERIZATION OF CRACK DEPTH AND WIDTH**

H. A. Feldstein
Kelly Air Force Base, San Antonio, Texas
Preprint, 7th International Conference on Nondestructive Testing, Warsaw, Poland, 4-8 June 1973

The magnetostatic field intensity emanating from the two faces of a crack is quantitatively related to crack depth and width by a mathematical analysis which satisfies Laplace's and Maxwell's equations. One structure-insensitive material constant (the coefficient of surface pole density) is required, whose measurement is established by experimental means. Theory agrees with experiment for both surface and interior cracks. However, for the latter, the lift-off coordinate is unknown and requires an additional equation. This is expressed as a function of surface crack lift-off by a Taylor series expansion of the H_X vs X intercepts at the boundary.

7386 **DEVELOPMENT OF NONDESTRUCTIVE TEST TECHNIQUES FOR MULTIDIRECTIONAL FIBER-REINFORCED RESIN MATRIX COMPOSITES**

J. L. Cook
McDonnel Douglas Astronautics Co.- West, Santa Monica, Calif.
AFML-TR-70-239, February 1971
AD-883 978

The first year of effort on a two-year duration program was designed to NDE as-woven multidirectional quartz yarn reinforcement material processed thru 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. The cured composite was also evaluated using sound velocity thru the thickness, ultrasonic pulse echo techniques, and ultrasonic through-transmission attenuation C-scan mapping. (See also nos. 6754, 6792, 7262, 7324.)

7427 **ENGINEERING EVALUATION OF BARKHAUSEN EFFECT STRESS MEASUREMENT INSTRUMENTATION FOR APPLICATION OF AUTOFRETTAGED GUN TUBES**

C. G. Gardner
Southwest Research Institute, San Antonio, Texas
AMMRC CTR 72-22, Sept. 1972
AD-755 864

A limited preliminary evaluation was made of the potential of the ferromagnetic Barkhausen effect Stress-measuring instrumentation for monitoring residual stresses induced in gun tubes by autofrettaging. Experiments conducted on small scale tubes verified the proportional sensitivity to stress induced by autofrettaging. Measurements made on a full scale 175 mm gun tube before and after autofrettaging gave unexpected anomalous results. Measurements made on finished 175 mm and 8-inch gun tubes indicated that the instrumentation is capable of distinguishing between tubes which have been autofrettaged and comparable tubes which have not.

7431 **TEST PLAN FOR NONDESTRUCTIVE INSPECTION INVESTIGATION OF THE CATAPULT AND ARRESTED LANDING CARRY-THROUGH STRUCTURE OF THE E-2 AIRCRAFT**

L. Berman
Naval Air Development Center, Warminster, Pa.
NADC-72087-VT, 15 July 1972
AD-752 492

Nondestructive inspection techniques, for utilization by the NAVAIREWORKFAC (Naval Air Rework Facility), are required to inspect the catapult and arrested landing carry-through structure of the E-2 airplane. This program proposes an NDI investigation to be performed during the E-2 fatigue tests.

7432 **DEVELOPMENT OF TECHNIQUES AND INSTRUMENTATION FOR THE NONDESTRUCTIVE EVALUATION FOR MULTI-LAYER INSULATION**

B. Vetrano
Battelle Pacific Northwest Labs., Richland, Wash.
NASA Contract NAS8-27479, Nov. 1972

The main objective of the present program is to develop techniques and instrumentation suitable for NDE of purged multilayer insulation prior to and after a shuttle orbiter flight. Such techniques are desirable because of possibility that corrosion, compression, and tearing of the insulation will degrade insulation performance during subsequent flight. A second objective is the application of technology to the evaluation of other insulation types. Three NDE techniques were evaluated, viz, electromagnetic (the most promising and feasible), thermal, and acoustic during phase I of this program.

7433 **EVALUATION OF ELECTROEXPLOSIVE DEVICES BY NONDESTRUCTIVE TEST TECHNIQUES AND IMPULSIVE WAVEFORM FIRINGS**

V. J. Menichelli
California Inst. of Technology, Pasadena, Calif. (Jet Propulsion Lab.)
JPL Tech. Rpt. 32-1556
N72-27964

Special requirements of the space industry necessitate more detailed knowledge of the quality and reliability of each electroexplosive device (EED) selected for use aboard on a spacecraft. Statistical methods do not practically demonstrate the high reliability needed. To close this gap, NDT techniques and instrumentation for 1-W/1-A no-fire devices have been developed. Several lots of squibs have been evaluated using these techniques and instrumentation. They yield data as to the quality and normal behavior of each electroexplosive device without firing or degrading the unit. Performance data were obtained by initiating the EED's with an impulsive waveform and sensing the initiation characteristics, sensitivity, and output.

7446 **EDDY CURRENT EVALUATION OF NUCLEAR CONTROL RODS**

C. V. Dodd, J. H. Smith, W. A. Simpson
Oak Ridge National Laboratory, Oak Ridge, Tenn.
ORNL-TN-4321, Sept. 1973

An eddy-current technique was developed and tested to detect cracks and measure thickness of cladding and oxide thickness on new and used nuclear control rods for the High Flux Isotope Reactor at the Oak Ridge National Laboratory. A computer design was performed for coils to maximize sensitivity of surface cracks and cladding thickness variations and minimize effects due to liftoff and temperature variations. In spite of radiation levels measured to be 10^5 R/b at 1 ft from the surface and temperature variations of 5^{o}C on used control rods, flaws as small as 0.001 in. were detected and the cladding thickness was measured to within 0.001 in.

7464 **U.S. ARMY TEST AND EVALUATION COMMAND TEST OPERATIONS PROCEDURE; NONDESTRUCTIVE TESTING OF MATERIALS**

Army Test and Evaluation Command, Aberdeen Proving Ground, Md.
AMSTE-RP-702-102 (Test Operations Procedure 3-2-807), 11 Sept. 1972
AD-764 200

This Test Operations Procedure describes standard techniques and facilities for evaluation of surface and subsurface characteristics of metallic and nonmetallic materials. It provides procedures for magnetic particle, liquid penetrant, radiographic, and ultrasonic inspection methods. Appendixes identify current nondestructive test methods and additional ultrasonic test techniques. It is applicable to cannon tubes, cast armor plate, welded joints, projectile fuzes, vehicle track shoes, and other material in detection of cracks, voids, corrosion and thickness variations.

7471 **ADVANCED TECHNOLOGY FOR PRODUCTION OF AEROSPACE ENGINES; AGARD CONFERENCE PROCEEDINGS NO. 64**

North Atlantic Treaty Organization, Advisory Group for Aerospace Research and Development (AGARD) Neuilly-Sur-Seine, France
AGARD-CP-64-70, Sept. 1970

The papers presented at the 35th meeting, AGARD Propulsion and Energetics Panel, London, 6-10 April 1970, emphasize state-of-the art and future prospects in manufacturing techniques, materials, and testing methods, as applied to aerospace engines. Of particular interest are the papers given at Session III, viz., a. Comparison of radiographic techniques for large titanium billets, b. Neutron radiography, c. X-ray fluorescence analysis as aid to production and repair of aircraft engines, d. NDT techniques for advanced composites, and e. Recent advances in magnetic field methods of NDE for aerospace applications.

7474 **USE OF NONCONTACT MAGNETO-ACOUSTIC TRANSDUCERS IN ULTRASONIC FLAW DETECTION**

G. K. Ul'yanov
FTD-HT-23-697-73, 1965. Translated from Russian.
AD-765 989

As indicated here, the use of magneto-acoustic transducers in ultrasonic flaw detection can be completely justified. Use of these transducers makes it easily possible to detect flaws located near the surface, while the absence of acoustical contact makes it possible to monitor parts with both clean and relatively rough finished surfaces. Conversion losses are considerably greater than for the piezoelectric crystal sensors, and thus items of relatively small dimension made of materials which do not significantly damp ultrasonic sound should be used. If slight modifications are made in industrial flaw detectors, then magneto-acoustic transducers may be used in addition to the piezoelectric crystal.

7481 **FEASIBILITY STUDY OF ELECTROMAGNETIC SUBSURFACE PROFILING**

R. M. Morey, W. S. Harrington, Jr
U. S. Environment Protection Agency, Washington, D. C.
EPA-R2-72-082, Oct. 1972

A study was made of a unique radar system which produces a continuous profile of subsurface conditions showing depth and location of geological formations and buried utilities. The radar unit travels at 3mph, and can detect interfaces directly below it to depths of 10 feet in clay and 25 feet in sand. Depth of penetration is governed by conductivity and dielectric constant. An increase in water content decreases penetration. A break in the pipe can be detected by the saturated soil around the break. Limits of penetration have not been reached; work is being done to determine empirical standards of system performance on a wide variety of soils. Since better information yields better cost estimates for designing sewage collection systems, the advantages of the radar system are apparent.

7488 **EDDY CURRENT MEASUREMENT OF MAGNETIC FLUX DENSITY**

I. R. Kraska, R. G. Prusinski
General American Transportation Corp., Niles, Ill.
AFML-TR-72-115, Nov. 1972
AD-759 207

This report presents the results of an effort to improve the reliability of magnetic particle inspection of large or irregular-shaped parts by assuring optimum magnetic flux densities in the areas of interest during inspection. An assessment of flux density influence on the sensitivity of magnetic particle inspection is given. Data is provided showing eddy current response to changes in magnetic flux densities in the range of 2 to 13.5 kilogauss. This range is investigated to assure compatibility with the inspection density requirements of MIL-I-6868.

7492 **DEVELOPMENT OF A MICROWAVE GAUGE TO MEASURE THE THICKNESS OF HOT METAL PLATE (>8MM)**

B. L. Dalton
BISRA, 24 Buckingham Gate, London, England
Rpt. PH/54/71, August 1971 (Availability: NTIS, Springfield, Va.)
PB-212 210

This report describes the development of a microwave gauge capable of measuring the thickness of hot metal products in an on-line environment. The report covers the evolutionary stages of the design from laboratory prototype to on-line prototype; it discusses the difficulties and measurement problems which were solved and the accuracies obtained on-line.

7497 **A COMPARATIVE STUDY OF FOUR METHODS OF NONDESTRUCTIVE TESTING OF WELDS**

J. C. Manaranche
Commissariat a l'Energie atomique, Valduc, France
British Journal of Nondestructive Testing, vol. 15, no. 16, Nov. 1973, pp. 179-186

The detection of cracks in welding heads on axisymmetrical metal tanks is used as an example to describe and compare four methods of NDT which are very different in their principles; mechanical impedance, liquid crystals, Foucault (eddy) currents, and measurement of potentials. A philosophy for the use of multiple inspection techniques, as described for this specific application, is suggested.

7512 **ELECTROMAGNETIC DETECTION OF ACOUSTIC EMISSION FROM A MARTENSITIC TRANSFORMATION**

B. W. Maxfield, R. Cochran
Cornell Univ., Ithaca, N. Y. (Lab of Atomic & Solid State Physics)
COO-3150-1, March 1972 (Avail: NTIS)

The acoustic emission resulting from the martensitic phase transformation in a gold-47.5at.% cadmium alloy has been observed using a purely electromagnetic means to detect the acoustic signals. This detection method eliminates transducer-related resonances which usually make a determination of the frequency spectrum associated with acoustic emission very difficult. Both the temporal and frequency response of individual acoustic emission events have been determined. For the small specimen used in this investigation the frequency response is dominated by acoustic cavity resonance effects in the specimen. This work shows that electromagnetic detection of acoustic emission may be especially useful when attempting to determine the frequency spectrum of various sources of acoustic emission.

7520 **INVESTIGATION OF ELECTRONIC FIBERS FOR NONDESTRUCTIVE EVALUATION OF ADVANCED COMPOSITES**

D. R. Ulrich, E. C. Henry, H. W. Rauch
General Electric Co., Philadelphia, Pa. (Space Sciences Lab)
Final Rpt., Contract N00019-72-C-0285, 30 July 1973
AD-768 211

This report pursues the feasibility of developing and using crystal-bearing fibers as sensors in the NDE of fiber-reinforced plastic structural materials. The fibers or filaments contain electronic ceramics. Compositions considered include ferroelectric potassium sodium niobate, lithium niobate, lead germanate, lead germanium silicate, lead zirconate titanate, and a magnetic ferrite. These electronic ceramic materials were dissolved in molten glass, and then shaped and annealed; the test shapes were then treated to precipitate dissolved materials. Further, devitrified filaments were incorporated into an epoxy-novalac composite matrix and then tested electrically. Effects of glass content and microstructure are reported as they affect electrical properties.

7522 **NDT EVALUATION OF BALLISTICALLY IMPACTED LAMINAR COMPOSITE ARMOR STEEL**

R. Chait, S. DerBoghosian
AMMRC, Watertown, MA
AMMRC TR 73-37, Aug. 1973
AD-769 738

Laminar composite armor steel consists of a high carbon, high hardness frontal plate metallurgically bonded to a lower carbon, softer backup plate. Since this material is being evaluated for its load-carrying capability, ballistic response for both ball and armor-piercing projectiles was examined with various tensile loads that were applied during impact. Plates were inspected by a magnetic particle technique. Crack formation was observed and analyzed, and residual strength values determined. Extent of examination, another ballistically induced defect, is satisfactorily determined by ultrasonic C-scan pulse-echo technique—as is also the existence of subsurface cracks. Acoustical holography was also evaluated for ability to detect debonding and crack formation.

7536 **NON-DESTRUCTIVE TESTING: METHODS, TECHNIQUES, AND THEIR APPLICATIONS; BIBLIOGRAPHY, MAY 1964 - APRIL 1973**

Defense Documentation Center, Alexandria, VA
DDC-TAS-73-67, Nov. 1973
AD-769 450

This bibliography is a compilation of unclassified-unlimited references dealing with nondestructive testing: methods, techniques, and their applications. Some methods and techniques discussed are electromagnetic, eddy current, holography, magnetic, photoplasticity, optical correlation and light scattering. This report also presents information on flaw detection, fatigue damage, thickness measurements, techniques for inspection, crack detection, and evaluation and characterization of materials.

7548 **NONDESTRUCTIVE TESTING OF CONSTRUCTION MATERIALS AND OPERATIONS**

G. W. Sevall, Jr.
Construction Engineering Research Laborabory (U. S. Army), Champaign, Ill.
CERL-TR-M-67, Dec. 1973

This report reviews NDT methods applicable to the construction industry. Established methods--and methods still in development--are included. Recently-developed methods were evaluated from initial reports and prototype applications. A number of the new methods show promise in reducing inspection time or in presenting information previously unobtainable. Existing and developing methods are also classified according to the construction materials and operations they test. The report is designed to help not only those interested in the field of nondestructive testing, but also those concerned with specific applications.

7585 **NONDESTRUCTIVE TESTING: A SURVEY**

NASA (Technology Utilization Office), Washington, D. C.
NASA SP-5113, 1973 (Availability: Supt. of Documents, Washington, D.C.
Order by stock no. 3300-00471; price $3.35 postpaid. For qualified users,
distribution is made through NASA.) 282 pp.

Both standard and developmental methods for nondestructive evaluation (NDE) are reviewed in this survey. Major fields of NDE (the use of liquid penetrants, magnetic particles, X-ray radiography, ultrasonic vibrations, eddy currents) ..ave reached a high state of development. Less widely used techniques in industry include: strain sensing, neutron radiography, leak detection, heat (thermal or infra-red methods), the use of microwaves, acoustic emission, and holography. The information in this survey is based on an examination of pertinent literature from NASA and its contractors, and discussions with scientists in the field. A comprehensive reference and bibliography will aid the reader who seeks further details. Bibliography.

7587 **DEVELOPMENT OF CARGO SLINGS WITH NONDESTRUCTIVE CHECKOUT SYSTEMS**

H. T. Hone, W. E. Huebner, D. J. Baxter
United Aircraft Corp., Stratford, Conn. (Sikorsky Aircraft Div.)
USAAMRDL Tech. Rpt. 73-106, Feb. 1974

This report describes the design, fabrication and testing of the following equipment which was developed to extend the facilities for carrying external loads on U. S. Army helicopters, viz., 1. Four-legged nylon rope slings of 6,000 and 25,000 pounds nominal capacity; 3. Nylon rope pendants of 6,000 and 20,000 pounds nominal capacity for use in conjunction with the 6,000 and 25,000 pound slings; and 4. Nondestructive test apparatus for the stainless steel wire rope slings. (An electromagnetic device is recommended for detection of defects in the wire rope slings.)

7593 **INTEGRATED LOGISTICS SUPPORT (ILS) NONDESTRUCTIVE INSPECTION (NDI) MAINTAINABILITY GUIDE**

E. W. Monroe, P. L. Sterling
North American Rockwell, Los Angeles, Calif.
NA-72-476, 21 July 1972
AD-909 717

The ILS NDI guide has been prepared (1) to compile a layman's description of the various NDI processes envisaged for operational use on the B-1 program, and (2) to document standard ILS procedure for performing aircraft maintenance engineering analyses that relate to NDI. ILS has become involved in NDI early in the design of the B-1 (1) in order to identify operational resources needed, and (2) to insure that access required to facilitate NDI is available on the operational air vehicle.

7594 **ENGINEERING APPRAISAL OF SOUTHWEST RESEARCH INSTITUTE MAGNETIC CRACK DEFINER APPLIED TO CH47 ROTOR BLADES**

J. R. Birchak et al.
Southwest Research Institute, San Antonio, Texas
USAAVSCOM TR 73-20, Oct. 1973
AD-769 068

The Magnetic Crack Definer was evaluated to determine the applicability for detecting fatigue cracks in CH-47 helicopter rotor blade spars (AISI 1340) in the fully assembled blade. For test purposes, fatigue cracks were produced by cyclically stressing several sheet specimens cut from a spar from a scrap blade. Cracks as small as 0.3 inch long by 0.025 inch deep were reliably detected under the major adverse conditions associated with the blade, namely: varying lift-off up to 0.10 inch; and different types of overlaying materials, including stainless steel, fiberglass, mastic, and adhesive.

7599 **FLYING SPOT SCANNER**

Magnaflux Corporation
Typescript, 19 Dec. 1974

The concept of a fully automatic fluorescent particle test system was the subject of experimentation in the middle 1950's by the Magnaflux Corp. The introduction of the laser and the availability of digital integrated circuits would appear to make a fully automated system entirely feasible today. The concept of the flying spot scanner involves (1) a scanning head using a helium-cadmium laser and (2) signal processing circuits. It is applicable to both fluorescent magnetic particle inspection and fluorescent particle inspection. Using a scanning rate of typical 500-1000 Hz, it would be able to inspect a billet at a rate of 200 feet/min.

7613 **THE STATE OF THE ART OF NONDESTRUCTIVE TESTING OF TIRES**

P. E. J. Vogel
Army Materials and Mechanics Research Ctr., Watertown, MA
AMMRC PTR 73-9, Oct. 1973
AD-774 188

The work was performed to provide a source of information on all known methods of nondestructive testing of tires. The report reflects the results of a tire testing survey which has been conducted over the past year. It represents an extensive literature search, visits to Army, Navy, Air Force, Department of Transportation Installations, and to the National Bureau of Standards; to three major high performance tire rebuilders; ten tire test equipment manufacturers; three major test tracks; and 22 manufacturers of new tires. (Same subject matter covered in Rubber Age, Nov. and Dec. 1974 issues.)

7621 **INVESTIGATION OF INSPECTION AIDS**

R. L. Cahoon et al.
RCA/Government and Commercial Systems, Burlington, Mass.
USAAMRDL-TR-74-44, July 1944 (US Army Air Mobility Rsch. and Devt. Laboratory, Fort Eustis, VA)
AD-787 333

The investigation of inspection aids was performed to identify specific inspection requirements and recommend relatively small aids or indicators, current or conceptual, that will enhance the trouble-shooting inspection/preventive maintenance process for Army helicopters. The six helicopter types involved were the AH-1, UH-1, CH-47, CH-54, OH-6, and OH-58 models. Several available and conceptual inspection aids were found to rate highly for organizational and direct support use in terms of effectiveness, use, cost, device maintenance and application factors. They provide feasible solutions to 17 specific inspection problems and applications identified by the requirements analysis. Bibliography: 16 refs.

7646 **DEVELOPMENT TEST II (ET) – COMMON TEST OPERATIONS PROCEDURES; INSPECTIONS AND MEASUREMENTS OF CANNON**

Army Test and Evaluation Command, Aberdeen Proving Ground, MD
Test Operations Procedure 3-2-800, 20 Dec. 1973
AD-775 447

Herein is outlined inspection and measurement procedures for cannon and recoilless rifles. Cannon is taken to mean that portion of a gun, howitzer, or mortar which consists of the tube, breech mechanism, firing mechanism, and bore excavator. This document provides references for techniques including use of star gage, pullover gage, and borescope; impressions, and casts of bores; and magnetic particle, magnetic recording borescope, radiographic, ultrasonic, and liquid penetrant inspections.

7649 **ADVANCEMENT OF CLOSED CIRCUIT TV GUN TUBE INSPECTION**

V. G. Compisi et al.
Watervliet Arsenal, Watervliet, N. Y.
WVT-QA-7401, March 1974
AD-779 586

This report presents an account of the present optical system, the borescope, used for magnetic particle inspection of gun tube bore surfaces. It describes further the continuing effort to expand the capabilities of a closed circuit (CCTV) inspection system applicable to the same purpose. A monochrome CCTV system, previously devised, does reduce inspection time and provide higher magnification and resolution; it is more effective with a visible light-sensitive vidicon tube than with one sensitive to UV light. At present, however, magnetic particle inspection is more effectively accomplished with an optical borescope than with a CCTV system.

7693 **ENGINEERING APPRAISAL OF SwRI MAGNETIC CRACK DEFINER APPLIED TO CH-47 ROTOR BLADES: VERIFICATION ADDENDUM**

J. R. Birchak et al.
Southwest Research Institute, San Antonio, TX
USAAVSCOM TR 74-9, May, 1974
AD-779 497

An earlier report—under the same title (AD-769 068) and authors—demonstrated the effectiveness of a magnetic crack definer (MCD) system for inspection of CH-47 helicoptor rotor blade spars. It noted also that MCD was unsuccessful in detecting fatigue cracks contained in spar portions blocked by ferromagnetic steel doubler plates. The current report (or verification addendum) describes a supplementary ultrasonics procedure capable of inspecting portions of spars not accessible to successful MCD application. Remaining outboard regions not accessible to ultrasonics inspection (because of overlaying materials) were demonstrated, nevertheless, to be accessible to MCD inspection. It is concluded therefore, that the combination of MCD and ultrasonics is adequate for rotor blade spar inspection. (See also NDT 7594.)

7696 **THE DETECTION OF FATIGUE CRACKS BY NONDESTRUCTIVE TESTING METHODS**

W. D. Rummel et al.
Martin Marietta Aerospace, Denver, Colo.
NASA CR-2369, Feb. 1974
N74-17285

The program described herein was conducted to demonstrate that current NDT methods can reliable detect small tightly closed cracks in 2219-T87 Al alloy—used in thickness of 0.060"–0.250" as Space Shuttle primary skin material—and to evaluate the influence of various surface finishes and of proof test loading against crack detection. X-radiographic, penetrant, ultrasonic, eddy current, holographic, and acoustic emission techniques were optimized and used to evaluate specimens containing cracks characterized by a 0.007"–0.500" length and a 0.001"–0.178" depth. Inspection data were analyzed to provide a statistical basis for determining threshold crack detection sensitivity at 95% probability and 95% confidence level.

7702 **NONDESTRUCTIVE TESTING OF BERYLLIUM**

R. J. Runck, ed.
Metals & Ceramics Information Ctr. (Battelle Columbus Labs.), Columbus, Ohio
MCIC Rpt. 74-22, July 1974
AD-784 492

Beryllium has unique properties that make several of the conventional nondestructive tests especially difficult. Of note are its high modulus of elasticity, high velocity of sound transmission, and high transparency to x-rays. Special low voltage x-ray radiography remains the "workhorse" method. The tightness of surface cracks requires special liquid penetrants. In commercial practice, neither ultrasonics nor eddy-currents are used extensively. Acoustic emission has proven useful for testing beryllium under load and will be more extensively used in the future. Holography is not especially effective with beryllium because of the high stresses necessary to produce appreciable strain. There remains an urgent need for a method of evaluating the surface condition of the fabricated metal. Biblio. – 49 refs.

7703 **DESIGN AND FABRICATION OF STRIPLINE MICROWAVE SURFACE-CRACK DETECTOR FOR PROJECTILES**

U. H. Gysel, L. Feinstein
Stanford Research Institute, Menlo Park, Calif.
AMMRC CTR 74-58, Sept. 1974
AD-A001 624

A self-contained coupled detector crack detector was built, tested, and evaluaged. Extensive measurements were performed with a planar detector on panar plates and a curved detector on 175 mm artillery shell bodies. The system operates at 10GHz and has tuning adjustments to give better than 75 dB isolation between the two modes at the output of the stripline detector. Artificial cracks in a wide range of sizes were machined into the test objects. All were detected, the smallest one being 0.0015 inch deep, and 0.1 inch long. A disadvantage of the present system that affects its sensitivity is the difficulty of maintaining high isolation between the two modes at the output of the detector.

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 item numbers which apply to the particular descriptors of interest and turn to the abstract applicable to those referenced numbers.

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1. Authors of all books, articles or items are listed in alphabetical order with the pertinent AMMRC identification number/s itemized after each author.

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