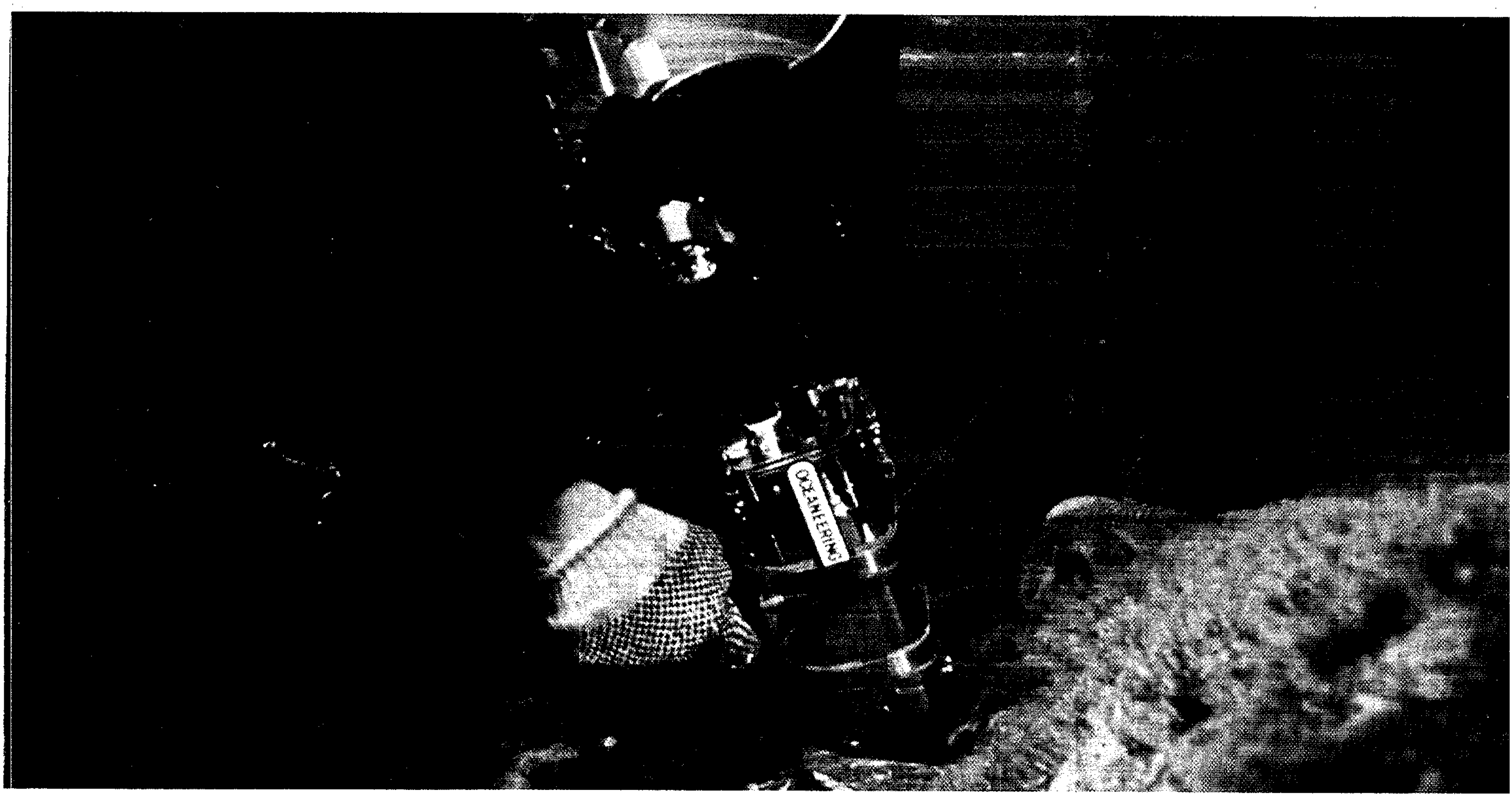
Materials Evaluation

An Official Journal of the American Society for Nondestructive Testing

April 1983/Volume 41/Number 5



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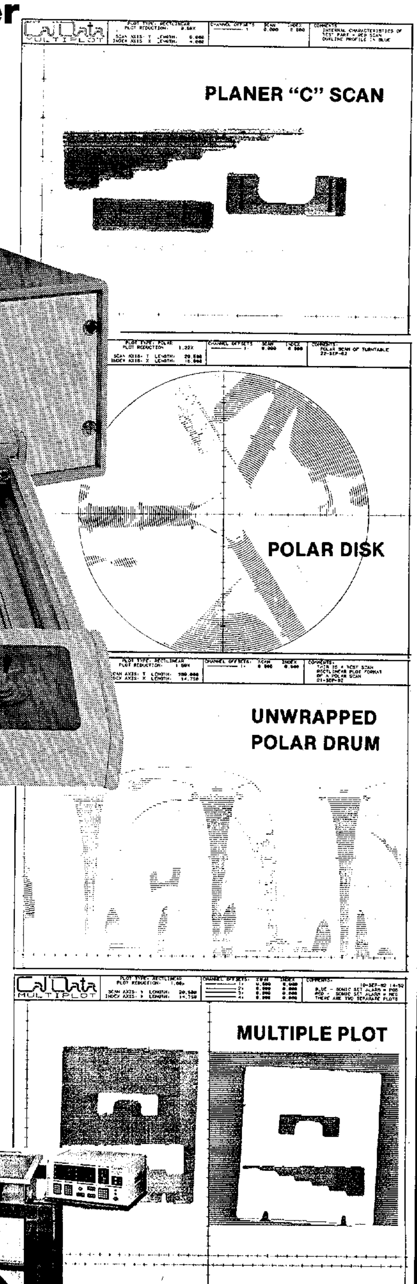

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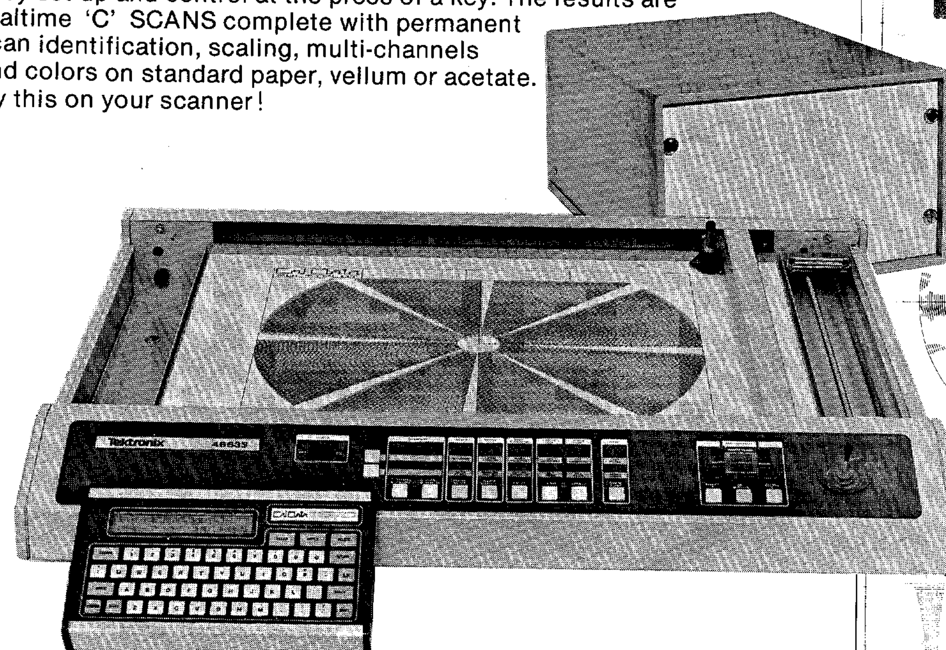

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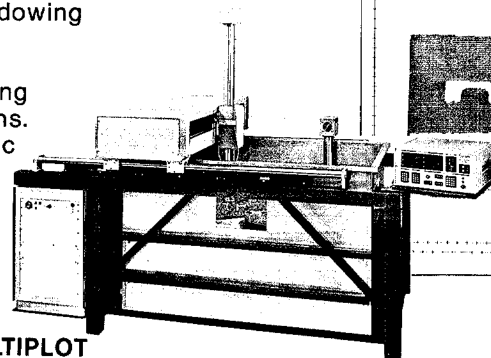

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Automation Industries, Inc.: Sperry Schools for NDT, 4000 Lockbourne Rd., Columbus, OH 43207. (614) 491-3000.

Balteau Electric Corp.: Joseph Silva, 63 Jefferson St., Stamford, CT 06902. (203) 324-6118.

Canadian Society For Nondestructive Testing Foundation (CSNDT Foundation): c/o Mohawk College of Applied Arts and Technology, 135 Fennell Avenue West, Hamilton, Ontario L8N 3T2 Canada. (416) 387-1655.

The Center for Professional Advancement: Rosanne Razanno X269, Dept. NR, P.O. Box H, East Brunswick, NJ 08816-0257. (201) 249-1400.

E. I. du Pont de Nemours & Co., Inc.: George L. Becker, Photo Products Dept., Laboratory, Chestnut Run, Wilmington, DE 19898. (302) 999-3065.

Eastman Kodak Co.: 343 State St., Rochester, NY 14650.

Gamma Industries: Harry D. Richardson, Box 2543, Baton Rouge, LA 70821.

Hartford Steam Boiler Inspection and Insurance Company: Ronald S. Wappel, Program Mgr., Educational Services, One State Street, Hartford, CT 06102. (800) 243-0090.

Intercontrole, Inc.: 5219 W. Clearwater Ave., Suite 9, Kennewick, WA 99336. (509) 735-4596.

J. D. Lavender: 19 Windermere Road, Penistone S30 6HL England. Barnsley (0226) 765769.

Krautkramer-Branson, Inc.: Louis Coppola, 250 Long Beach Blvd., Stratford, CT 06497. (203) 377-3900.

Magnaflux Corp.: Bruce D. Tyler, Director of Training, 7338 W. Lawrence Ave., Chicago, IL 60656.

NDT Associates, Inc.: Don McBride, 999 N. Sepulveda Blvd., Suite 602, El Segundo, CA 90245. (213) 615-1175.

Reinhart & Associates, Inc.: John P. Porter, Manager of Engineering and Training, P.O. Box 9802, Suite 173, Austin, TX 78766. (512) 346-3911.

Rockwell International: Energy Systems Group Training Center, 8900 De Soto Ave., Canoga Park, CA 91304. (213) 700-4329.

SGS Control Services Inc.: Industrial Division, P.O. Box 550, Deer Park, TX 77536. (713) 479-7170.

Sonic Instruments, Inc.: Technical Services Manager, 1014 Whitehead Rd. Ext., Trenton, NJ 08638. (609) 883-5030.

Southwest Research Institute: Daniel J. Tuschak, Training Coordinator, Quality Assurance Systems and Engineering Division, 6220 Culebra Rd., San Antonio, TX 78284. (512) 684-5111, Ext. 3146.

Tech/Ops: Radiation Products Division, 40 South Ave., Burlington, MA 01803. Toll free (800) 225-1383.

Westinghouse Electric Corp.: B. R. (Johnny) Johnson, P.E., Director, NDE Technical Institute, WRD Senior NDE Level III. 5 Parkway Center, 4th Floor, Pittsburgh, PA 15220. (412) 928-2791.

Whitson Sullivan Company: 12600 Northborough, Suite 180, Houston, TX 77067. (713) 893-5247.

Zetec, Inc.: A. L. Lucero, P.O. Box 140, Issaquah, WA 98027. (206) 392-5316.

MAY 2—Basic Ultrasonics, sponsored by Magnaflux Corp., in Los Angeles.

MAY 2—Ultrasonic Weld, sponsored by Magnaflux Corp., in Chicago.

MAY 2—Radiographic Interpretation, sponsored by Magnaflux Corp., in Chicago.

MAY 2—Level III, sponsored by Magnaflux Corp., in Chicago and Dallas.

MAY 2-4—General Basics for Level III, sponsored by Automation Industries, in Columbus, OH.

MAY 2-5—Gas Turbine Technology, sponsored by The Center for Professional Advancement, in Houston.

***MAY 2-6**—Ultrasonics, sponsored by Rockwell International, in Los Angeles.

***MAY 2-6**—Radiographic Film Interpretation, sponsored by Westinghouse NDE Technical Institute, in Pittsburgh, PA.

MAY 2-6—Principles of Heat Treating, sponsored by the American Society for Metals, in Toronto, Canada.

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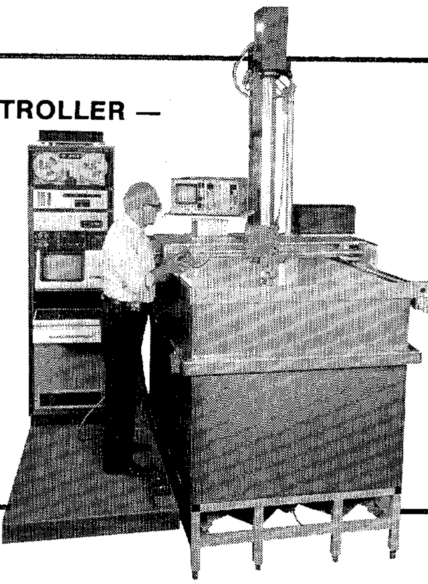

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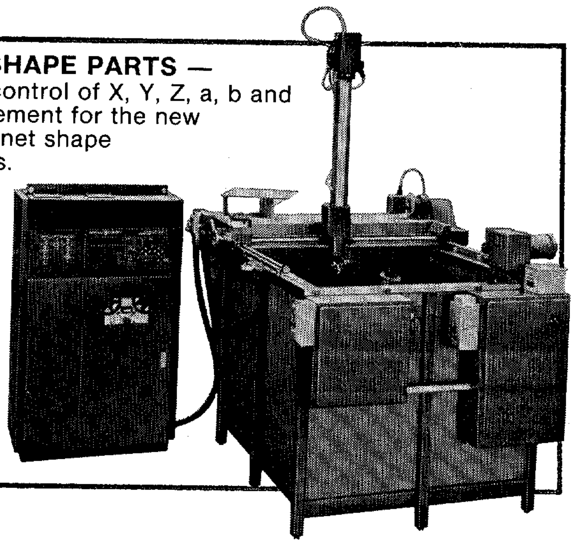

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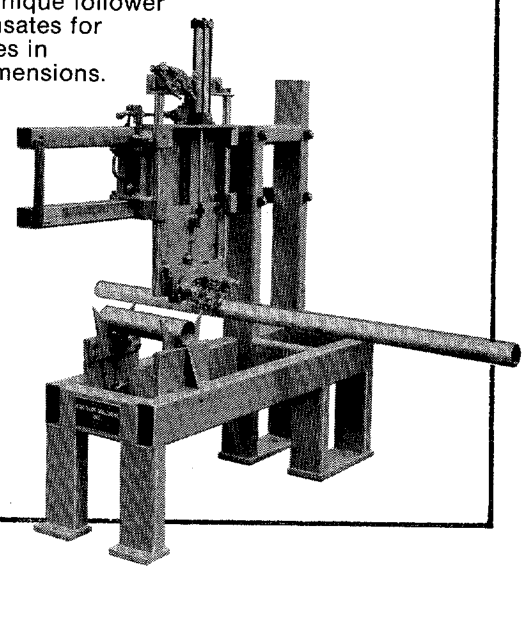

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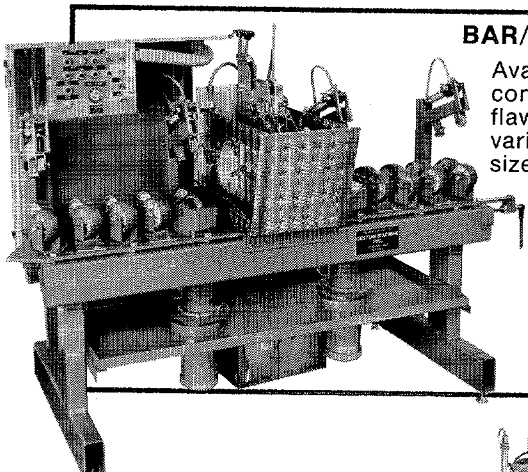

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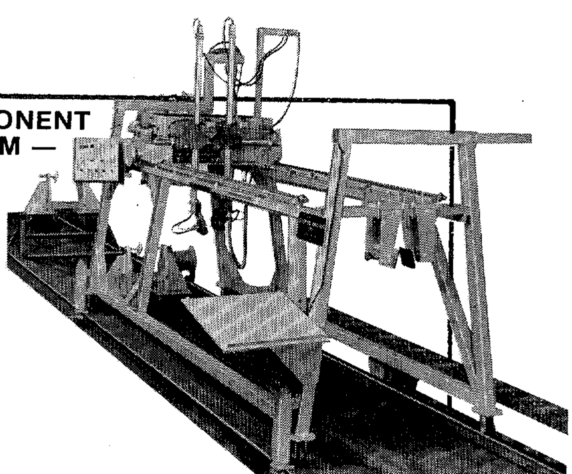

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MAY 2-6—Level III Refresher, sponsored by Nondestructive Test Engineering, in Essex, CT.

MAY 2-6—Eddy Current Levels I and II, sponsored by the CSNDT Foundation, in Hamilton, Ontario.

MAY 2-6—Level II Ultrasonics, sponsored by Krautkramer-Branson, in Stratford, CT.

MAY 2-6—Level I Ultrasonics, sponsored by Krutkramer-Branson, in Pittsburgh.

MAY 2-13—Radiography II, sponsored by Automation Industries, in Columbus, OH.

***MAY 3-5**—QA Mechanical/Electrical Surveillance, sponsored by Westinghouse NDE Technical Institute, in Pittsburgh.

MAY 6-7—Short Course on Compliance Requirements for ANSI/ASME Safety and Pollution Prevention Equipment Surface and Subsurface Safety Valves Used in Offshore Oil and Gas Operations, sponsored by the American Society of Mechanical Engineers, at the Marriott Astrodome Hotel, in Houston. Contact: Don Belanger, ASME, 345 E. 47th St., New York, NY 10017. (212) 705-7740.

MAY 8-13—Training and Certification Program—Session 2, sponsored by the National Association of Corrosion Engineers (NACE), in Houston, TX. Contact: Education and Training Department, NACE Headquarters, P.O. Box 218340, Houston, TX 77218. (713) 492-0535.

MAY 8-14—Training and Certification Program—Session 1, sponsored by the National Association of Corrosion Engineers (NACE), in Houston, TX. Contact: Education and Training Department, NACE Headquarters, P.O. Box 218340, Houston, TX 77218. (713) 492-0535.

***MAY 9**—Liquid Penetrant, sponsored by Rockwell International, in Los Angeles.

MAY 9—Radiation Safety-Aspects of Isotope Radiography, sponsored by Tech/Ops, Inc., in Burlington, MA.

MAY 9—Magnetic Particle/Liquid Penetrant, sponsored by Magnaflux Corp., in Chicago and Dallas.

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MAY 9—Liquid Penetrant Workshop, sponsored by the CSNDT Foundation, in Hamilton, Ontario.

MAY 9-11—Magnetic Particle/Liquid Penetrant, sponsored by Automation Industries, in Columbus, OH.

MAY 9-12—Magnetic Particle/Eddy Current, sponsored by SGS Control Services, in San Diego.

MAY 9-12—Welding per ASME Section IX, sponsored by The Center for Professional Advancement, in Chicago.

***MAY 9-13**—Liquid Penetrant Testing, sponsored by Westinghouse NDE Technical Institute, in Pittsburgh, PA

MAY 9-13—Industrial Radiography Level II, sponsored by Industrial Training Center, Inc., in Houston. Contact: Industrial Training Center, Inc., P.O. Box 75148, Houston, TX 77234. (713) 943-9613.

MAY 9-13—Level I-Basic Ultrasonics, sponsored by Nondestructive Test Engineering, in Essex, CT.

MAY 9-13—Certified Welding Inspector Examination Review, sponsored by Nondestructive Test Engineering, in Essex, CT.

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MAY 9-13—Level II Ultrasonics, sponsored by Krautkramer-Branson, in Pittsburgh.

MAY 9-13—Magnetic Particle Inspection, sponsored by J.D. Lavender, at South Yorkshire Steel Training Association facility, Sheffield.

MAY 9-14—Ultrasonics Level I, sponsored by the CSNDT Foundation, in Hamilton, Ontario.

MAY 9-18—Data Analysis of Non-Ferromagnetic Tubing Eddy Current Inspection Results Level IIA, sponsored by Zetec, Inc., in Issaquah, WA.

MAY 9-20—Fundamentals of Welding Engineering, sponsored by the Office of Continuing Education, The Ohio State University. Contact: Louise Larew, Office of Continuing Education, The Ohio State University, 2400 Olentangy River Rd., Columbus, OH 43210. (614) 422-8571.

***MAY 10**—Magnetic Particle, sponsored by Rockwell International, in Los Angeles.

MAY 10—Magnetic Particle Workshop, sponsored by the CSNDT Foundation, in Hamilton, Ontario.

MAY 10-12—Advanced Heat Treating Seminar, sponsored by the American Society for Metals, in Chicago.

***MAY 11-13**—Eddy Current, sponsored by Rockwell International, in Los Angeles.

MAY 16—Magnetic Particle/Liquid Penetrant, sponsored by Magnaflux Corp., in Chicago.

MAY 16—Radiographic Technician, sponsored by Magnaflux Corp., in Chicago.

MAY 16—Eddy Current, sponsored by Magnaflux Corp., in Chicago.

MAY 16—Level III, sponsored by Magnaflux Corp., in Los Angeles.

MAY 16-18—Radiographic Film Interpretation, sponsored by Industrial Training Center, Inc., in Houston. Contact: Industrial Training Center, Inc., P.O. Box 75148, Houston, TX 77234. (713) 943-9613.

***MAY 16-18**—Industrial Digital Radiography, sponsored by Science Applications, Inc., in San Diego, CA. Contact: John Reed, SAI Advanced Products Section, 10401 Roselle St., San Diego, CA 92121. (619) 452-1720.

***MAY 16-20**—Radiographic, sponsored by Rockwell International, in Los Angeles.

***MAY 16-20**—Magnetic Particle Testing, sponsored by Westinghouse NDE Technical Institute, in Pittsburgh, PA.

MAY 16-20—Isotope Radiography, sponsored by Gamma Industries, in Baton Rouge, LA.

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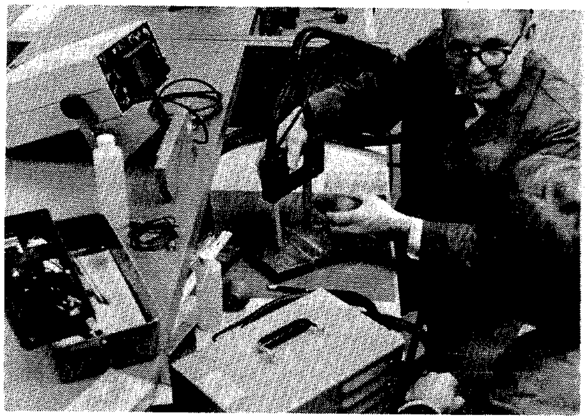

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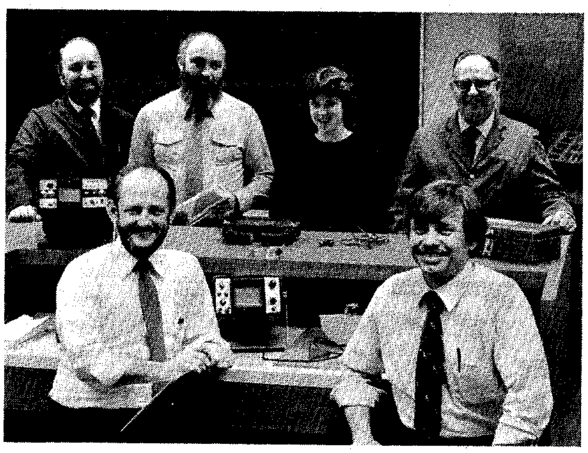

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MAY 16-20—Radioisotope Techniques, sponsored by the Nuclear Engineering Department, the Industrial Extension Service, and the Division of Continuing Education, North Carolina State University. Contact: Jerome Kohl, Nuclear Engineering Extension Specialist, North Carolina State University. Raleigh, NC 27650. (919) 737-2303.

MAY 16-20—Tool Materials: Metallurgy and Application, sponsored by the American Society for Metals, in Metals Park, OH.

MAY 16-20—Electroplating, sponsored by the American Society for Metals, in Metals Park, OH.

MAY 16-20—Radiography Level I, sponsored by the CSNDT Foundation, in Hamilton, Ontario.

MAY 16-20—Level II Ultrasonics, sponsored by Nondestructive Test Engineering, in Essex, CT.

MAY 16-20—Level I Ultrasonics, sponsored by Krautkramer-Branson, in St. Louis.

MAY 16-20—Ultrasonics, sponsored by Automation Industries, in Columbus, OH.

MAY 16-20—Level II Radiography, sponsored by the Du Pont Company, in Atlantic City, NJ.

MAY 16-20—Level II Radiography, sponsored by Nondestructive Test Engineering, in Essex, CT.

MAY 16-27—Comprehensive Seminar on Industrial Radiography, sponsored by Eastman Kodak, in Rochester, NY.

MAY 23—Magnetic Particle/Liquid Penetrant, sponsored by Magnaflux Corp., in Los Angeles.

MAY 23—Basic Ultrasonics, sponsored by Magnaflux Corp., in Chicago.

MAY 23—Radiographic Interpretation, sponsored by Magnaflux Corp., in Chicago and Dallas.

MAY 23—Penetrants Only, sponsored by Magnaflux Corp., in Chicago.

***MAY 23-25**—Film Interpretation, sponsored by Rockwell International, in Los Angeles.

MAY 23-25—Ultrasonic Weld, sponsored by Automation Industries, Columbus, OH.

MAY 23-25—AWS/Ultrasonic Testing of Groove Welds, sponsored by Nondestructive Test Engineering, in Essex, CT.

MAY 23-26—Welding Per ASME Section IX, sponsored by The Center for Professional Advancement, in Houston.

MAY 23-26—Metallurgy for the Non-Metallurgist, sponsored by the American Society for Metals, in Metals Park, OH.

***MAY 23-27**—Level I—Ultrasonics, sponsored by Westinghouse NDE Technical Institute, in Pittsburgh.

MAY 23-27—Level I Ultrasonics, sponsored by SGS Control Services, in Houston.

MAY 23-27—Radiographic Film Interpretation, sponsored by Nondestructive Test Engineering, in Essex, CT.

MAY 23-37—Level I Ultrasonics, sponsored by Krautkramer-Branson, in Toronto.

MAY 23-27—NDE III and Examination, sponsored by Automation Industries, in Columbus, OH.

MAY 23-27—Ultrasonic Welds, sponsored by J.D. Lavender, at South Yorkshire Steel Training Association facility, Sheffield.

MAY 24-26—Welding Seminar on Processes, Design, Metallurgy, and Quality Assurance, sponsored by McWane and Associates. Contact: McWane and Associates, P.O. Box 5175, San Jose, CA 95150. (408) 293-2325.

MAY 24-26—Level III Prep Course, sponsored by Krautkramer-Branson, in Stratford, CT.

MAY 26-27—Examination for Certification, sponsored by Automation Industries, in Columbus, OH.

MAY 30—Oil Tool Inspection, sponsored by Magnaflux Corp., in Dallas.

MAY 30-JUNE 3—Ultrasonics Level II, sponsored by the CSNDT Foundation, in Hamilton, Ontario.

MAY 30-JUNE 3—Level II Ultrasonics, sponsored by Krautkramer-Branson, in Toronto.

MAY 30-JUNE 4—Radiography Level II, sponsored by the CSNDT Foundation, in Hamilton, Ontario.

JUNE 1-3—Piping Design, Analysis, and Fabrication, sponsored by The Center for Professional Advancement, in Houston.

JUNE 1-3—Eddy Current, sponsored by Automation Industries, in Columbus, OH.

JUNE 5-10—Training and Certification Program—Session 3, sponsored by the National Association of Corrosion Engineers (NACE), in Houston, TX. Contact: Education and Training Department, NACE Headquarters, P.O. Box 218340, Houston, TX 77218. (713) 492-0535.

JUNE 5-11—Training and Certification Program—Session 1, sponsored by the National Association of Corrosion Engineers (NACE), in Houston, TX. Contact: Education and Training Department, NACE Headquarters, P.O. Box 218340, Houston, TX 77218. (713) 492-0535.

JUNE 6—Radiation Safety-Aspects of Isotope Radiography, sponsored by Tech/Ops, Inc., in Burlington, MA.

JUNE 6—Magnetic Particle/Liquid Penetrant, sponsored by Magnaflux Corp., in Chicago and Dallas.

JUNE 6—Ultrasonic Weld, sponsored by Magnaflux Corp., in Chicago.

JUNE 6—Level III, sponsored by Magnaflux Corp., in Chicago.

JUNE 6—Radiographic Interpretation, sponsored by Magnaflux Corp., in Los Angeles.

JUNE 6-8—Film Interpretation, sponsored by SGS Control Services, in Houston.

JUNE 6-8—QA Nuclear Auditing, sponsored by Automation Industries, in Columbus, OH.

JUNE 6-9—AWS Visual Weld, sponsored by Automation Industries, in Columbus, OH.

JUNE 6-9—Welding Per ASME Section IX, sponsored by The Center for Professional Advancement, in Calgary, Alberta.

JUNE 6-10—Classification of Discontinuities/Liquid Penetrant/Magnetic Particle, sponsored by Industrial Training Center, Inc., in Houston. Contact: Industrial Training Center, Inc., P.O. Box 75148, Houston, TX 77234. (713) 943-9613.

JUNE 6-10—Elements of Metallurgy, sponsored by the American Society for Metals, in Metals Park, OH.

JUNE 6-10—Metallographic Techniques, sponsored by the American Society for Metals, in Metals Park, OH.

JUNE 6-10—Level I Ultrasonics, sponsored by Sonic Instruments, Inc., in Princeton, NJ.

JUNE 6-10—Overview in NDT (All Methods), sponsored by SGS Control Services, in Houston.

JUNE 6-10—Magnetic Particle Inspection, sponsored by J. D. Lavender, at South Yorkshire Steel Training Association facility, Sheffield.

JUNE 6-10—Level I Ultrasonics, sponsored by Krautkramer-Branson, in San Francisco.

***JUNE 6-10**—An Introduction to Vibration and Shock Testing, Measurement, Analysis, and Calibration/Emphasis on Random Vibration, sponsored by Tustin Institute of Technology, at the Institute in Santa Barbara, CA. Contact: Wayne Tustin, Tustin Institute of Technology, 20-22 E. Los Olivos, Santa Barbara, CA 93105. (805) 682-7171.

***JUNE 6-10**—Level I PT/MT, sponsored by Westinghouse NDE Technical Institute, in Pittsburgh.

***JUNE 6-17**—Radiographic Testing, sponsored by Westinghouse NDT Technical Institute, in Pittsburgh.

JUNE 6-17—Comprehensive Seminar on Industrial Radiography, sponsored by Eastman Kodak, in Rochester.

***JUNE 7-10**—Quality Control for Managers and Supervisors, sponsored by Technical Seminars, at the Cherry Hill Inn, Cherry Hill, NJ. Contact: Thomas Shahnazarian, Technical Seminars, Box 22, New Canaan, CT 06840. (203) 966-5331.

JUNE 7-10—Eddy Current Inspection of Aircraft Structures Using Zetec Inspection Equipment, sponsored by Zetec, Inc., in Issaquah, WA.

JUNE 13—Industrial Radiography, sponsored by Tech/Ops, Inc., in Burlington, MA.

JUNE 13—Magnetic Particle/Liquid Penetrant, sponsored by Magnaflux Corp., in Chicago.

JUNE 13—Basic UT, sponsored by Magnaflux Corp., in Dallas and Los Angeles.

JUNE 13—Radiographic Technician, sponsred by Magnaflux Corp., in Chicago.

JUNE 13—NDT Sampler, sponsored by Magnaflux Corp., in Chicago.

JUNE 13-17—Ultrasonics, sponsored by Automation Industries, in Atlanta.

JUNE 13-17—Radiography, sponsored by Automation Industries, in Columbus, OH.

JUNE 13-17—Visual/Liquid Penetrant/Magnetic Particle—Level II, sponsored by Nondestructive Test Engineering, in Essex, CT.

JUNE 13-17—Metallographic Interpretation, sponsored by the American Society for Metals, in Metals Park, OH.

JUNE 13-17—Level II Ultrasonics, sponsored by Krautkramer-Branson, in San Francisco.

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JUNE 13-17—Magnetic Particle/Eddy Current, sponsored by SGS Control Services, in Houston.

JUNE 13-17—Introduction to NDT, sponsored by Nondestructive Test Engineering, in Kansas City.

JUNE 13-17—Isotope Radiography, sponsored by Gamma Industries, in Baton Rouge, LA.

***JUNE 14-17**—Statistical Methods for Quality Control, sponsored by Technical Seminars, at the Cherry Hill Inn, Cherry Hill, NJ. Contact: Thomas Shahnazarian, Technical Seminars, Box 22, New Canaan, CT 06840. (203) 966-5331.

JUNE 14-17—Theory Workshops for Nondestructive Testing-Examination Preparation, sponsored by the CSNDT Foundation, in Hamilton, Ontario.

JUNE 20—Radiographic Technician, sponsored by Magnaflux Corp., in Chicago.

JUNE 20—Eddy Current, sponsored by Magnaflux Corp., in Chicago.

JUNE 20—Liquid Penetrant Only, sponsored by Magnaflux Corp., in Chicago.

JUNE 20—Magnetic Particle/Liquid Penetrant, sponsored by Magnaflux Corp., in Los Angeles.

JUNE 20—Ultrasonic Weld, sponsored by Magnaflux Corp., in Dallas.

JUNE 20-22—Film Interpretation, sponsored by Automation Industries, in Columbus, OH.

JUNE 20-24—Level II Ultrasonics, sponsored by Krautkramer-Branson, in Houston.

JUNE 20-24—Level II Ultrasonics, sponsored by Krautkramer-Branson, in Calgary, Alberta.

JUNE 20-24—Repair, Calibration, and Certification of Eddy Current Test Equipment, sponsored by Zetec, Inc., in Issaquah, WA.

JUNE 20-24—UT Castings, sponsored by J. D. Lavender, at South Yorkshire Steel Training Association facility, Sheffield.

JUNE 20-24—Radiography Testing, sponsored by SGS Control Services, in Houston.

JUNE 20-24—Level II Ultrasonics, sponsored by SGS Control Services, in Houston.

JUNE 20-24—Radiographic Film Interpretation, sponsored by Nondestructive Test Engineering, in Kansas City.

JUNE 20-24—Introduction to NDT, sponsored by Nondestructive Test Engineering, in Essex, CT.

JUNE 20-24—Fundamentals of NDT, sponsored by the American Society for Metals, in Metals Park, OH.

***JUNE 21-23**—QA Auditing Training,

sponsored by Westinghouse NDE Technical Institute, in Pittsburgh.

JUNE 21-23—Welding Seminar on Processes, Design, Metallurgy, and Quality Assurance, sponsored by McWane and Associates. Contact: McWane and Associates, P.O. Box 5175, San Jose, CA 95150. (408) 293-2325.

JUNE 21-24—Metallurgy for the Non-Metallurgist, sponsored by the American Society for Metals, in Metals Park, OH.

JUNE 27—Magnetic Particle Workshop, sponsored by the CSNDT Foundation, in Hamilton, Ontario.

JUNE 27—Magnetic Particle/Liquid Penetrant, sponsored by Magnaflux Corp., in Chicago and Dallas.

JUNE 27—Basic Ultrasonics, sponsored by Magnaflux Corp., in Chicago.

JUNE 27—Radiographic Technician, sponsored by Magnaflux Corp., in Chicago.

JUNE 27—Eddy Current, sponsored by Magnaflux Corp., in Los Angeles.

***JUNE 27-30**—Visual Testing, sponsored by Westinghouse NDE Technical Institute, in Pittsburgh.

JUNE 27-30—Eddy Current Inspection—Level I, sponsored by Nondestructive Test Engineering, in Essex, CT.

JUNE 27-JULY 1—Level I Ultrasonics, sponsored by Krautkramer-Branson, in Niagara Falls.

JUNE 27-JULY 1—Nuclear Weld Inspection, sponsored by Automation Industries, in Columbus, OH.

JUNE 27-JULY 1—NDE III & Examinations, sponsored by Automation Industries, in Columbus, OH.

JUNE 27-JULY 1—Magnetic Particle/Liquid Penetrant/Visual Inspection, sponsored by SGS Control Services, in Houston.

JUNE 27-JULY 1—Powder Metallurgy, sponsored by the American Society for Metals, in Metals Park, OH.

JUNE 27-JULY 1—Heat Treatment of Steel, sponsored by the American Society for Metals, in Metals Park, OH.

JUNE 30-JULY 1—Examination for Certification, sponsored by Automation Industries, in Columbus, OH.

JUNE 27-JULY 1—Level II Radiography Testing, sponsored by SGS Control Services, in Houston.

***JULY 4-8**—Magnetic Particle and Liquid Penetrant Inspection, sponsored by J. D. Lavender, at South Yorkshire Steel Training Association facility, Sheffield.

***JULY 6-8**—Fundamental Theory & Modern Design Approaches for Gas Turbine Engines, sponsored by Union College, in Schenectady, NY. Contact: Office of Graduate and Continuing Studies, Union College, One Union Ave., Schenectady, NY 12308. (518) 370-6288.

***JULY 10-15**—Training and Certification Program—Session 2, sponsored by the National Association of Corrosion Engineers (NACE), in Houston, TX. Contact: Education and Training Dept., NACE Headquarters, P.O. Box 218340, Houston, TX 77218. (713) 492-0535.

***JULY 10-16**—Training and Certification Program—Session 1, sponsored by the National Association of Corrosion Engineers (NACE), in Houston, TX. Contact: Education and Training Dept., NACE Headquarters, P.O. Box 218340, Houston, TX 77218. (713) 492-0535.

***JULY 11**—Radiation Safety-Aspects of Isotope Radiography, sponsored by Tech/Ops, in Burlington, MA.

***JULY 11-15**—Eddy Current Testing, sponsored by Westinghouse NDE Technical Institute, in Pittsburgh.

***JULY 11-15**—Ultrasonics, sponsored by Rockwell International, in Los Angeles.

***JULY 11-15**—Principles of Failure Analysis, sponsored by ASM, in Metals Park, OH.

***JULY 11-15**—Eddy Current Inspection of Non-Ferromagnetic Tubing Level I, sponsored by Zetec, Inc., in Issaquah, WA.

***JULY 11-15**—Level I Ultrasonics, sponsored by Krautkramer-Branson, in Charlotte, NC.

***JULY 11-15**—Level I Ultrasonics, sponsored by Krautkramer-Branson, in Seattle, WA.

***JULY 11-15**—Applied Instrumentation and Measurements Engineering, sponsored by Union College, in Schenectady, NY. Contact: Office of Graduate and Continuing Studies, Union College, One Union Ave., Schenectady, NY 12308. (518) 370-6288.

***JULY 11-15**—Computer Software for the Processing of Experimental Data, sponsored by Union College, in Schenectady, NY. Contact: Office of Graduate and Continuing Studies at Union College, One Union Ave., Schenectady, NY 12308. (518) 370-6288.

***JULY 11-15**—Laser Nondestructive Testing, sponsored by Lake Forest College, Dept. of Physics, in Lake Forest, IL. Contact: Tung Hon Jeong, Dept. of Physics, Lake Forest College, Lake Forest, IL 60045. (312) 234-3100.

***JULY 11-15**—Basic Ultrasonics, sponsored by Whitson Sullivan Co., in Houston.

***JULY 18**—Liquid Penetrant, sponsored by Rockwell International, in Los Angeles.

***JULY 18-22**—Instructor Training, sponsored by Westinghouse NDE Technical Institute, in Pittsburgh.

***JULY 18-22**—NDE Engineering, sponsored by Westinghouse NDE Technical Institute, in Pittsburgh.

***JULY 18-22**—Weld Inspection, sponsored by Whitson Sullivan Co., in Houston.

***JULY 18-22**—Planning a Digital Data Acquisition and Control Computer System, sponsored by Union College, in Schenectady, NY. Contact: Office of Graduate and Continuing Studies, Union College, One Union Ave., Schenectady, NY 12308. (518) 370-6288.

***JULY 18-22**—Fracture Mechanics and Crack Growth for Fracture Control of Structures, sponsored by Union College, in Schenectady, NY. Contact: Office of Graduate and Continuing Studies, Union College, One Union Ave., Schenectady, NY 12308. (518) 370-6288.

***JULY 18-22**—Level II Ultrasonics, sponsored by Krautkramer-Branson, in Charlotte, NC.

***JULY 18-22**—Level II Ultrasonics, sponsored by Krautkramer-Branson, in Seattle, WA.

***JULY 18-22**—UT Forgings, sponsored by J. D. Lavender, at South Yorkshire Steel Training Association facility, Sheffield.

***JULY 19**—Magnetic Particle, sponsored by Rockwell International, in Los Angeles.

***JULY 19-21**—Welding Seminar on Processes, Design, Metallurgy, and Quality Assurance, sponsored by McWane and Assoc., in Philadelphia, PA. Contact: McWane and Assoc., P.O. Box 5175, San Jose, CA 95150 (408) 293-2325.

***JULY 20-22**—Eddy Current, sponsored by Rockwell International, in Los Angeles.

***JULY 24-29**—Training and Certification Program—Session 3, sponsored by the National Association of Corrosion Engineers (NACE), in Houston, TX. Contact: Education and Training Dept., NACE Headquarters, P.O. Box 281340, Houston, TX 77218. (713) 492-0535.

***JULY 25-29**—Level III Candidate, sponsored by Westinghouse NDE Technical Institute, in Pittsburgh.

***JULY 25-29**—Radiographic, sponsored by Rockwell International, in Los Angeles.

***JULY 25-29**—Eddy Current Inspection of Non-Ferromagnetic Tubine Level II, sponsored by Zetec, Inc., in Issaquah, WA.

***JULY 25-29**—Level I Ultrasonics, sponsored by Krautkramer-Branson, in Stratford, CT.

***JULY 25-29**—The Modern View of Fatigue and Its Relation to Engineering Problems, sponsored by Union College, in Schenectady, NY. Contact: Office of Graduate and Continuing Studies, Union College, One Union Ave., Schenectady, NY 12308. (518) 370-6288.

***JULY 25-AUG. 5**—Comprehensive Seminar on Industrial Radiography, sponsored by Eastman Kodak, in Rochester, NY.

***JULY 26-28**—Design & Fabrication in ASME Code Vessels, sponsored by ASM, in Metals Park, OH.

Characterizing Hydraulic Fractures in Gas Wells with Magnetic Particles

A fracture diagnostic technique based on magnetometry—the measurement of the magnitude and direction of magnetic fields—has just entered field development and testing with support from the Gas Research Institute (GRI), Amoco Production Company, and Dowell, a division of Dow Chemical U.S.A. Although natural gas producers have used hydraulic fracturing to stimulate gas flow from low-permeability reservoirs for over 30 years, producers have lacked geophysical techniques that can fully characterize a fracture, giving its length, width, height, and—most important in relation to the work reported here—the distribution of the proppants throughout the fracture. Composed of particles with carefully selected properties, proppants prevent the fracture from closing after the hydraulic pressure is relaxed.

Amoco Production's Research Department is participating in the field development of the new technology. Amoco's support for the project stems from the promising theoretical and laboratory results previously obtained for GRI by Hunter Geophysics under the leadership of its president, M. Darroll Wood, an expert in the field of fracture detection by surface mapping. The supporters of this field project to develop a unique fracture characterization device have committed a total of $8 million. GRI's share will be over $1.7 million over the 24-month life of the current contract.

Wood completed the initial theoretical and laboratory work with the support of GRI. The method involves coinjecting magnetic particles with the conventional fracturing fluid and proppant. The particles are then detected by an array of specially adapted, ultrahigh-resolution sensors. If successfully developed, the technology has the potential to help improve fracture treatment design and thus increase economically justifiable production from proven gas fields.

The first two shallow field tests at Catoosa, OK, operated properly, and the anticipated magnetic signals were received at the surface recorders. Magnetometers successfully mapped the fracture, which was further substantiated by tiltmeters and an analysis of the pressure record. Based on further analysis of these tests, Amoco, Dowell, Hunter, and GRI are preparing for additional field tests this spring. With continued refinement of the technique at increasing depth, the target is to attain effective operation at depths of 5000 feet or more.

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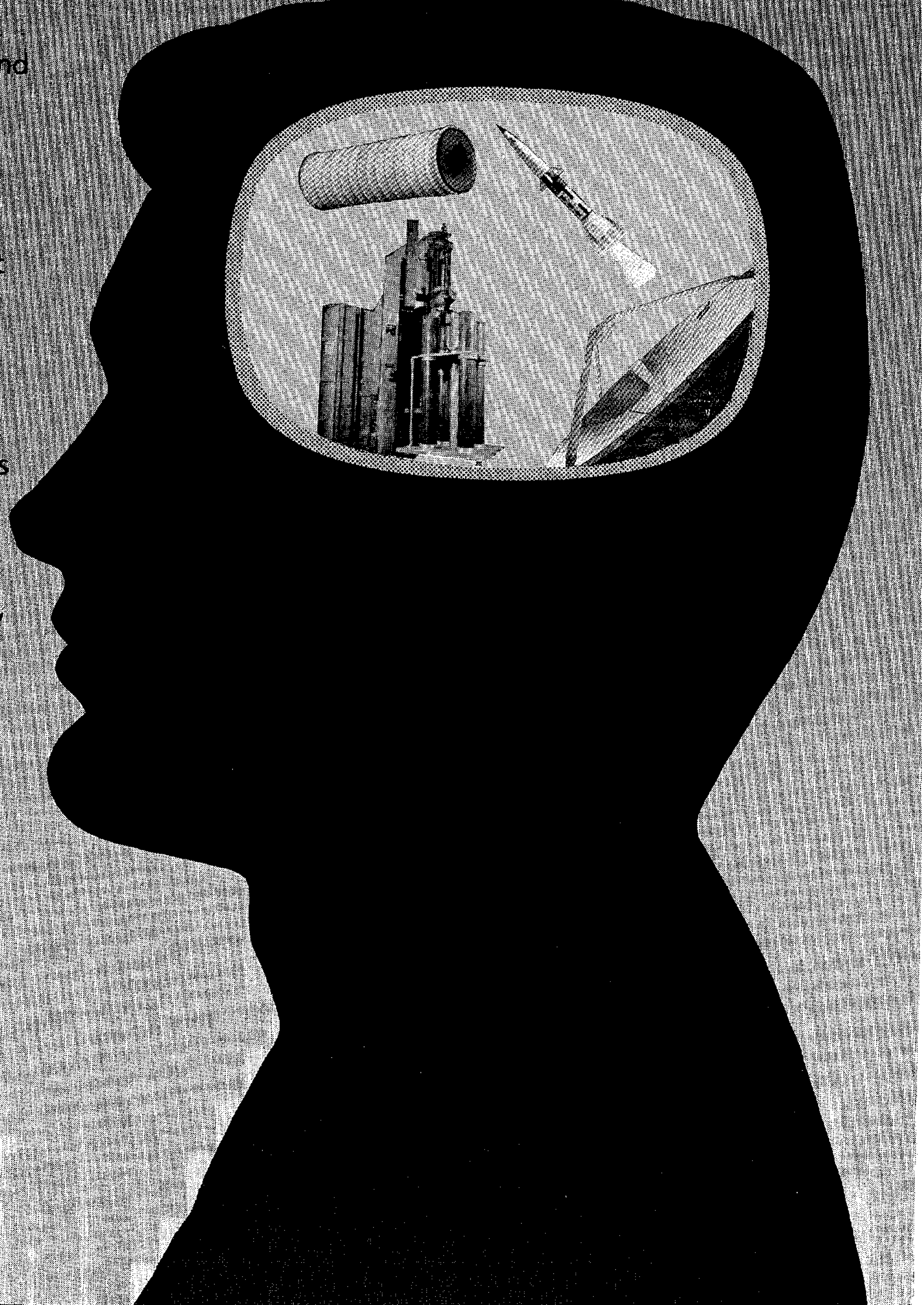
Write or call for more information about the SAI product line and the name of a distributor in your area. OEM inquiries invited.



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Telephone: (619) 452-1720
Telex: 910-337-1251.

Circle 115 on reader service card

Speaking of People

R. Bern Crowl has joined Reynolds Metals Co., Richmond, VA, an ASNT Corporate Member. He has been elected an executive vice-president succeeding Jesse T. Hudson, Jr., who is retiring as financial vice-president.

In his new position, Crowl will have responsibility for the company's various finance and accounting functions.

Formerly executive vice-president and chief financial officer of Amax, Inc., Greenwich, CT, Crowl has more than 26 years' experience as a metal industry executive. He joined Amax after receiving his B.S. in business administration from Rutgers in 1955 and progressed through a number of financial and operating positions. Crowl is a graduate of the Advanced Management Program at Harvard Business School. He is knowledgeable of coal and petroleum businesses and of international iron ore, ocean transport, and other overseas mining investments.

• • •

Christopher Horvath has been promoted to eastern regional product manager for the Magnaflux line of nondestructive coating-thickness testers. In his new position, he will provide technical and sales support to eight field engineers covering the eastern seaboard. He will work out of the company's Long Island City, NY, office.

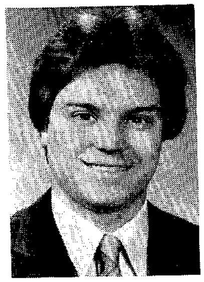
In his seven years with the firm, he has been involved in every facet of this type of instrumentation from original concept to final product. Prior to his new position, he had been assisting in the marketing and sales engineering of this product line. He has a background in business management from St. John's University, New York, NY.

• • •

Wordie Parr, former chief of Physical Agents Effects at the National Institute of Occupational Safety and Health (NIOSH), has joined the Dosimeter Corporation of America (DCA), Cincinnati, OH, as the product manager for toxic detectors. He has been responsible for obtaining the NIOSH data required for the development of noise, vibration, ionizing, and nonionizing radiation standards.

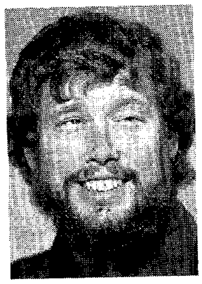
Parr's addition to the staff is part of the ASNT Corporate Member's planned expansion into the development and sale of toxic survey meters, dosimeters, and other hazard detection equipment.

He will continue to be active in the technical community and will operate from the DCA corporate headquarters in Cincinnati.



HORVATH

YUHAS



DAY

POLAYES

Donald E. Yuhas has been appointed to head Magnaflux Corporation's new Advanced Research Laboratory, Elk Grove Village, IL.

A physicist and researcher with an international reputation, Yuhas was previously vice-president and laboratory director at Sonoscan, Inc., Bensenville, IL, where he was involved in the development of the scanning laser acoustic microscope.

Yuhas' professional activities include membership in ASNT, IEEE, APS, ACS, ASM, and AMA. He is current Chairman of ASNT's Metallography Committee. He has written over 60 publications, lectured at national and local conferences, and is listed in *American Men and Women of Science.*

The Magnaflux Advanced Research Laboratory will seek contract projects to develop new NDE technologies, extend or alter existing technology, and solve specific NDT application problems.

• • •

Maurice B. Polayes, an ASNT Fellow and Past Chairman of the Boston Section, has been listed in the 1982/1983 *Who's Who in the World* (6th edition).

Polayes is the president of Addelco Corporation, Needham, MA, which is an ASNT Corporate Member. He is a registered Professional Engineer and is a member of the Harvard Business School of Administration. He is married to Toby Polayes and has two sons, Andrew and Gregory.

• • •

Robert A. Day has been appointed senior development engineer for the General Electric Company's Advanced Reactor Systems Department (GE-ARSD), San Jose, CA. He is responsible for the development of NDE methods.

After receiving his B.S. degree in engineering physics from Oregon State University in 1969, Day was an NDT engineer with Lawrence Livermore National Laboratory, Livermore, CA, where he worked on ultrasonic, optical, radiographic, and computer-assisted inspection methods. He then joined the Naval Air Rework Facility in Alameda, CA, where he worked on eddy current, ultrasonic, and metallurgical testing for aircraft maintenance applications.

He joined GE-ARSD in 1974 and has been involved in the application of ultrasonic, radiographic, and eddy current techniques for liquid metal fast breeder reactors and solar receiving plants. Currently, he is in charge of several programs related to in-service inspection of steam generators, development of elevated temperature (650°C) ultrasonic transducers, and application of phased array technology to the inspection of nuclear reactors.

He is a member of the Golden Gate Section of ASNT, a certified Level III in radiography and ultrasonics, and a registered Professional Engineer in California.

• • •

Mark H. Tennant has been selected to serve as a Congressional Fellow of the American Society of Mechanical Engineers for one year starting in January 1983. He will serve on the staff of a congressman or congressional committee of his choice in Washington, DC. He will learn more about the federal legislative process and help provide engineering expertise in public policy formation.

Tennant is a research supervisor at E.I. du Pont de Nemours and Co., Inc., Aiken, OH. He earned his B.S. and M.S. at Clemson University and his Ph.D. at Virginia Polytechnic Institute. He taught mechanical engineering at the institute and worked for Westinghouse Electric Corporation prior to joining DuPont.

• • •

J. Richard Schorr has been named a Fellow of the American Ceramic Society. He was honored for his contributions in developing and applying ceramic and glass technology.

Schorr is manager of the Energy and Chemical Processes Department at Battelle Laboratories, Columbus, OH. In this position, he heads research in thermochemical and inorganic processing, chemical processes, hazardous materials and biotechnology, energy and thermal technology, and fuels and combustion technology. Prior to this position, he managed materials applications research programs.

Handbook: /'hand-bůk/*n*, a concise reference book covering a specialized subject

Progress: /'prög-rəs/*n*, forward movement, advancement to a goal or objective

Report: see below

by Paul McIntire, Handbook Editor

Work proceeds on "Real-Time Radiography," the seventh chapter from NDT Handbook Volume 3, *Radiography and Radiation Testing*. This marks the completion of a third of Volume 3 since bringing the editorship in-house and producing the first chapter in September 1982.

The chapters are available individually in softback, and the titles now on sale include:

Section 1, "Radiation and Particle Physics," by C. R. Emigh

Section 5, "Film and Paper Radiography," by R. Quinn and J. C. Domanus

Section 7, "Radiographic Latent Image Processing," by W. E. J. McKinney

Section 15, "Image Data Analysis," by M. H. Jacoby

Section 17, "X-ray Diffraction and Fluorescence," by R. Jenkins

Section 18, "Radiation Protection," by W. D. Burnett

The good progress on this volume is due in part to the centralized production effort, but more important is the cooperation ASNT has received from its Handbook contributors. Their expertise and timely participation are essential to the success of the project.

One such contributor is William D. Burnett, manager of the Environomental Health Department of Sandia National Laboratories. His chapter, "Radiation Protection," was one of the first available from this volume, and its readers should benefit from the experience Burnett brings to his writing.

Past-president of his Health Physics Society chapter, Burnett is certified in health physics, has two post-graduate degrees (physics and radiation biology) and twenty years' experience in the industrial and environmental health physics fields. His past and present professional activities include memberships in the American Nuclear Society, the American Industrial Hygiene Association, and the panel of examiners for the American Board of Health Physics. Burnett was also a Fellow for the Atomic Energy Commission at Brookhaven National Laboratory and served as consultant to England's Ministry of Technology.

William D. Burnett

His work in Section 18 is available for $8 to ASNT members, $10 to nonmembers.

Spring Conference Handbook Action

Volume 3: *Radiography and Radiation Testing*

Handbook Coordinator, Larry Bryant, presented the Penetrating Radiation Committee with a report of its Volume's progress. The committee provided several names of new contributors to help complete final author assignments for Volume 3.

Volume 4: *Eddy Current Tests*

The Electrical and Magnetic Committee took some important steps in the production of their Handbook.

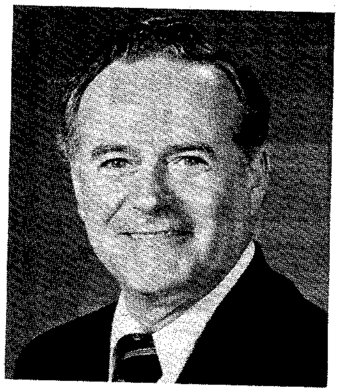
Mike Mester of U.S. Steel Corporation was appointed Coordinator for Volume 4. His first tasks will be to produce the needed chapter outlines and to assist in the assignment of authors.

The committee also chose their Handbook reviewers, who should begin receiving manuscript later this year.

Volume 5: *Acoustic Emission Testing*

Handbook Coordinator Ron Miller, United Technologies Research Center, presented written objectives and his Volume's outline for approval by the committee. Committee members are scheduled to return their review outlines to Miller by May of this year, with plans for author selection to begin at the Acoustic Emission Working Group meeting in June 1983.

Comments from the Coordinating Technical Editor for This Issue



This special issue of *Materials Evaluation* is the fourth in a series on specific nondestructive testing (NDT) topics. Underwater NDT follows special issues on Acoustic Emission, Ultrasonic Imaging, and Tomography. Unlike the preceding topics, most of the articles in this issue are not the highly technical, frontiers-of-science kind. Rather, most of the articles are how-to-do-it NDT with the novelty being how do you do NDT underwater. Other articles tell about the how and the what that will take the NDT inspector to his job in Davy Jones' Locker. Innovative technical advances are found in the technical articles and technical notes as well as in some of the feature articles and in Product Showcase. Something for everyone!

Underwater NDT today is being transformed from an essentially supportive, surface-oriented role to a discipline that is playing an important part in offshore oil production. Changes include the movement from shallow water to deeper and more hazardous areas, decreased use of divers, increased costs, and escalation of financial risk. More techniques are being developed for underwater use. Special modifications are becoming available to meet the deep-water challenge. Such new developments are very proprietary and provide a competitive edge to the companies that have them. These developments are almost impossible to get into print. Little-by-little, as can be seen in this issue, the important advances that permit increased safety and productivity along with decreased risk and cost in underwater NDT will be better shared and applied.

Frank A. Iddings
Nuclear Science Center
Louisiana State University
Tutorial Projects Editor, *Materials Evaluation*

NDT Reply Line

It is coincidental that two answers to a question about underwater examination arrived in time for this one-topic issue of *Materials Evaluation* on underwater NDT.

FRANK A. IDDINGS

21. Has anyone determined the maximum water current in which magnetic particles could be adequately applied during underwater examination of offshore structures?

The allowable water current will be very different depending on: (a) geometrical conditions of portion to be tested (jet effects); (b) field strength of applied magnetism; (c) orientation of member to be tested (horizontal verticle); and (d) type of MP solution applied (high-low magnetic susceptibility). For some of the above reasons (and others), we have developed the Magfoil-documentation method.*

K. G. Walther
Bocholt, West Germany

**Editor's note: An article on this method appears in this issue.*

It has been determined in numerous applications by utilizing a current flow meter that magnetic particle inspection does not generally work well when water currents exceed a speed greater than one knot.

Robert Maclellan
Coastal Inspection Services, Inc.
Chelsea, MA

Questions Awaiting Your Response

Starred items denote publication for the first time. To answer any of these questions or to submit a question, please use the form provided.

18. *I am concerned over the tendency of radiographers to interpret Paragraph T.243 ASME, Section V, as license for convenience. Where are details available, in depth, regarding effects of high-energy radiation on thin materials?*
22. *Is there any eddy current equipment on the market that can reliably detect 0.020 to 0.030 in. full-length seams or laps on hot-rolled 43xx or 41xx series ¾ in. rounds over 25 ft in length?*
23. *We have been looking for another Brinell hardness tester with the scope built into the machine. We have been unable to locate replacements for the two broken machines.*
26. *Is there a reliable way to test the structural integrity of a rope made of synthetic nonmagnetic material with a load attached to it? The full length of rope, hundreds or thousands of feet long, must be monitored for broken or deteriorated fibers throughout its cross section.*

*27. *Who makes a film storage envelope that meets ANSI Standard PHI. 53 for archival long-term storage? Many nuclear contracts seem to specify these envelopes, but we cannot find them.*

IF YOU CAN ANSWER ANY OF THESE QUESTIONS FOR OTHER READERS, OR IF YOU WISH TO SUBMIT YOUR OWN QUESTION, PLEASE USE THE FORM BELOW.

☐ **I am answering a question from NDT Reply Line.**

Question number ____________
(please specify)

☐ I give permission to have my name and city published.
☐ You may also publish my company's name.
☐ Please withhold my name, company, and city from publication.

☐ **I am submitting a question for NDT Reply Line.** I understand that my name will not be published or released without my permission.

Please clearly state your reply or your question. Attach an additional sheet if necessary.

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NAME ____________________ TELEPHONE NUMBER ____________________
(area code) (number)

ADDRESS ____
(company, if applicable)

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(no. and street, or box number) (city) (state) (zip)

Mail this form to NDT Reply Line, *Materials Evaluation*, 4153 Arlingate Plaza, Caller #28518, Columbus, OH 43228-0518.

Battelle-Columbus Establishes Electronics Department

A new Electronics Department has been established at Battelle's Columbus Laboratories to provide a focus for the research organization's growing number of electronics-related programs for industry and government. The department consolidates the research and development capabilities in electronics, optics, lasers, digital systems, and related technologies.

Bruce W. Davis, previously head of defense and space systems research at Battelle-Columbus, is manager of the new Electronics Department. Davis said his 170-member staff will continue to expand Battelle's R&D work in both traditional and emerging technologies in electronics. Studies are under way, for example, in technologies concerned with artificial intelligence, image processing, time-domain electronics, inspection techniques, millimeter wave systems, electromagnetic materials characterization, laser materials processing and machining, sensors and signal processing, systems reliability, and quality assurance.

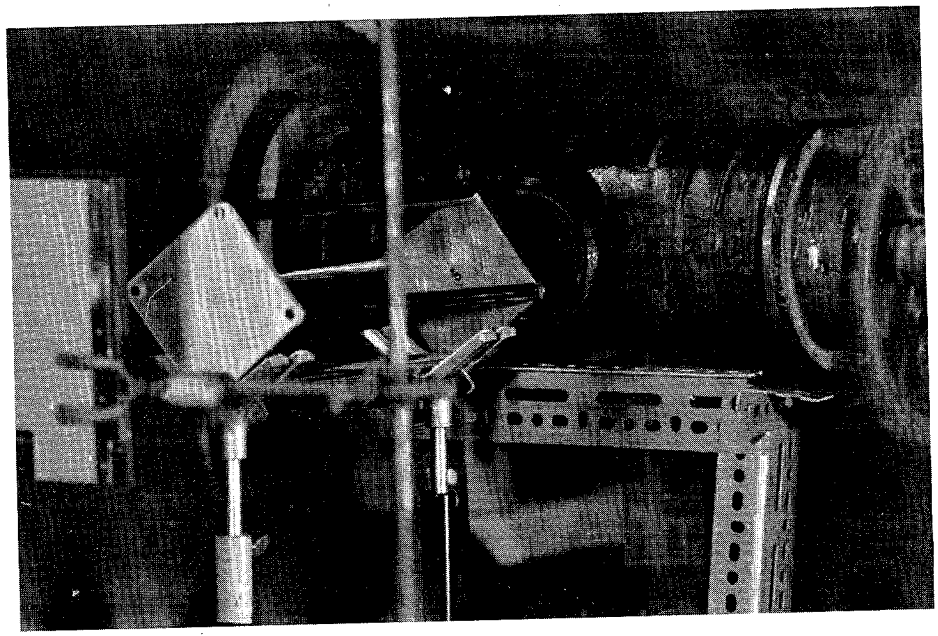
The new department also will further enhance Battelle's capabilities in transferring appropriate technology from the government to the private sector, and vice versa.

Specialized facilities of the new Electronics Department include a high-energy neodymium glass laser for material interaction studies; optics laboratories; a videodisc laboratory; and facilities for microprocessor-based systems, wideband signal acquisition and analysis, digital systems design and development, and radiofrequency and millimeter wave network analyzers.

Education Close-up

Technion—Israel Institute of Technology Haifa, Israel

The NDE curriculum at the Technion—Israel Institute of Technology is conducted in the Department of Nuclear Engineering. At the department, extensive efforts are directed at the safety and reliability (SR) aspects of nuclear reactors and nuclear handling facilities. The assurance of an SR level adequate to the stringent requirements in the nuclear industry is considered to be a prime objective. It is Technion's belief that SR is achievable if it is embedded in the system design, construction, and testing from the initial stages. To accomplish this task, highly qualified manpower turns out to be the critical element. At the department, the curriculum program is aimed at training top engineers required for the design of the nondestructive inspection net at the various stages of production and the NDT procedures. The studies should provide the engineer with the ability to cope with rapid changes in policy, engineering processes, materials and systems complexity, and the explosive



Measurement of source dimensions in 300 kV x-ray unit with a pinhole camera.

A Technion student examines a radiograph with an edge enhancement unit.

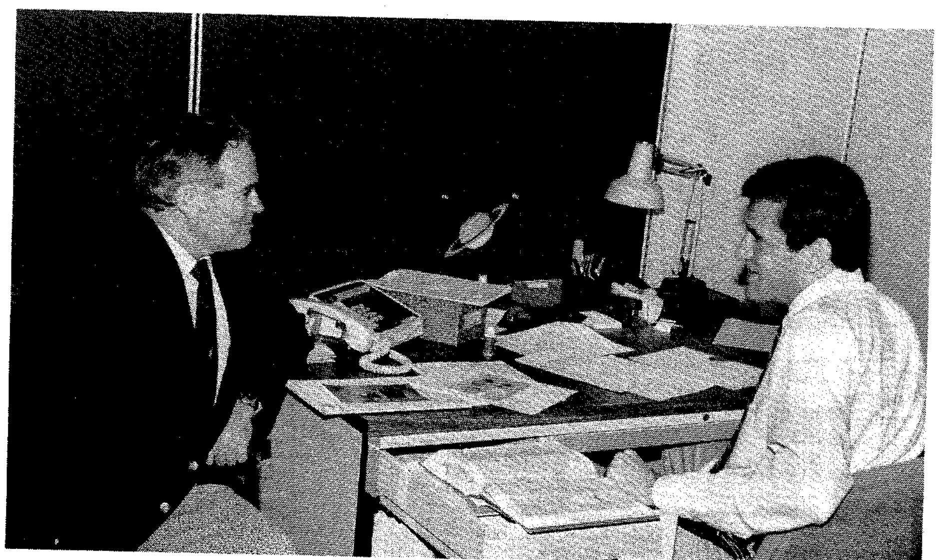
growth in SR requirements. The engineers receive an overview of the complete system so that they are familiar with trade-offs on its performances, SR, schedule, and cost.

The program is offered to graduate students studying toward M.Sc. and D.Sc. degrees. The students enrolled in the department have a first degree (B.Sc. or B.A.) in either engineering (mechanical, electrical, chemical, materials) or science (physics, applied mathematics, chemistry). Students with a B.A. who are graduates of a three-year program have to complete one year of engineering prior to entering the graduate program in the department. Students interested in the NDE area take a curriculum that covers a wide area: introduction to nuclear engineering (including radiation sources, interaction, detection, and radiobiological safety measures); instrumentation; radiography and gaging; digital image processing of industrial radiographs; acoustic methods; design of measuring systems and results interpretation; ma-

Passing Through

Frank Iddings confers with ASNT Production Manager Carolyn Wiseman on placement of a figure in a feature article for the "Underwater NDT" issue of *Materials Evaluation.*

Materials Evaluation Tutorial Projects Editor Frank Iddings, center, with ASNT Handbook Editor Paul McIntire, left, and ASNT Managing Director Scott Matheson. Iddings, an ASNT Fellow and professor of Nuclear Science at Louisiana State University, visited ASNT Headquarters February 21-22 to discuss details of the April issue of *Materials Evaluation* and his contribution to a volume of the *Nondestructive Testing Handbook.*



Frank Iddings, left, who is Coordinating Editor for *Materials Evaluation's* one-topic issue on "Underwater NDT" (this issue), discusses a technical article with Richard Straw, ASNT Editorial Assistant for Technical Papers.

terials; safety analysis techniques; principles of system reliability; reliability assessment of multicomponent systems; physical aspects of reliability in nuclear engineering; and real-time simulations of systems. The studies are accompanied with laboratory work where the student becomes familiar with the techniques of radiography, ultrasonics, liquid penetrants (visible and fluorescent), eddy current, magnetic particle, elemental analysis with x-ray fluorescence, and density-thickness control by through-penetration and backscattering of beta and gamma radiations.

The design of the NDE net depends to a large extent on the prediction of the measuring system response for the item under examination. This prediction enables the choice of appropriate techniques and the preparation of the inspection procedure. Therefore, the definition of a measuring system by its characteristic functions is stressed in most of the thesis research works. During the last few years, emphasis in the research and development projects has been directed toward quantitative information extraction from radiographs and ultrasonic scanning methods. Usually M.Sc. studies take from two to three years, and the D.Sc. takes an additional three to four years. With the increased awareness for NDE in various branches of industry, the subjects Technion tackles have extended to problems concerning composite materials, aluminum, plastics, glass, insulation materials, adhesives, etc., and to on-line process control.

In the new laboratory-building, a shielded hall for an industrial high-energy linear accelerator was designed. The accelerator is a Linatron 3000A from Varian, with acceleration voltage up to 11 MV and radiation dose of up to 3000 R per minute, at a distance of one meter. This unit is employed for research in thick-section radiography and computerized tomography of large bodies.

For the academic year 1983-84, an undergraduate curriculum program is under consideration. Additional information is available from Amos Notea, Department Head, Department of Nuclear Engineering, Technion—Israel Institute of Technology, Haifa 32000, Israel.

Underwater NDT

by Frank A. Iddings, Tutorial Projects Editor

If you haven't noticed, this issue of *Materials Evaluation* is devoted to underwater NDT. That is particularly significant to readers of "Back to Basics." Most of the articles in this issue are not examples from the ivory-towered frontiers of technical advance that are often found in the research section and that require an equivalent knowledge of a specific area of NDT. Rather, most of these articles are concerned with applying NDT to structures that are underwater (deep in the ocean, usually) or deal with the ways and means of getting the NDT inspector to the specimen so that the work can be done. Although new techniques are being developed for underwater NDT, they are usually considered proprietary and are not available for publication. What is being reported at meetings and then published is more like the "how-to-do" kind of article or more like articles describing changes in the familiar NDT techniques that allow them to work underwater. It is hoped that you will not only be able to read most of this month's articles comfortably but also with interest and even enthusiasm.

Two of the articles in this special issue feature the vehicles that are being used to bring NDT to the hostile environment of the ocean depths. Also included this month are articles on magnetic particle inspection, ultrasonic testing, and automated-remote probe handling. Those familiar with the inspection techniques should be comfortable with the extension of techniques to underwater.

This issue is a result of the growing interest in underwater NDT. That interest is shown by the number of meetings being held on underwater NDT and the increasing literature on the subject. For example, there was the Marine Session at the ASNT Fall Conference in 1982. Papers presented there, with summaries available in the *1982 Paper Summaries* for ASNT National Conferences (ASNT, Columbus, OH, 1982, pp 243–268), were:

> "Deep Water: The New Frontier for NDT," by A. Galerne and D. Walker (included in this issue of *Materials Evaluation*);
> "Underwater MT Practiced Today," by L. Goldberg;
> "The Diving Navy's Approach to NDT," by J. Mittleman; and
> "Acoustic Emission Monitoring of SMA and GMA Welds," by K. Nishida.

Another example of a meeting involving underwater NDT was the IRM82 Conference on Offshore Inspection, Repair, and Maintenance in Edinburgh, Scotland, November 2 to 4, 1982. One entire day was devoted to papers in a session called "Modes of Inspection Offshore—Tried and Tested Techniques and the Future."

If you would like to get a taste of what the practitioner of underwater NDT is trying to do, just get your gear together, head on down to your deepest swimming hole, jump in, and give it a try! Should that not appeal to you, give the articles in this issue a try. That should be a lot easier and safer for you and, I hope, a lot more enjoyable.

Back to Basics

Underwater NDE Techniques

By K. Sæbjørnsen and O. Førli*

Underwater nondestructive evaluation (NDE) has for several years been regularly applied to offshore installations. In the North Sea, for example, NDE of selected areas is one requirement to be fulfilled during the periodical survey of offshore steel jackets. NDE techniques currently available for underwater use are in most cases direct applications or modifications of techniques used above water. The only modifications usually made are to waterproof the equipment, build an instrument into a pressure housing, or in another way adapt an instrument to the underwater environment. A few types of equipment have become commercially available on the market, but there still exist many companies developing and adapting equipment and techniques for use by their own personnel. There is also a continuous process with research and development of new methods and solutions within this field.

With good reason, the reliability of NDE underwater has often been questioned. In the past, too much of the testing took place under unsatisfactory conditions and control, and neither the equipment nor the personnel were up to satisfactory standards.

Today, these conditions have improved, but it is still difficult to predict exactly the reliability of any one underwater NDE. Compared with above water testing, there are many uncertain factors influencing the result, such as the capacity and performance of equipment, environmental and working conditions, qualification of personnel, and the inspection procedure. If all of these factors are taken care of, it is possible to achieve a meaningful and reliable testing. However, it should be stressed that each method and technique has its limitations, and it is important that the correct method or technique is chosen depending on the object to be tested.

Most of the NDE is still carried out manually, and the final interpretation is left to the diver. Underwater testing often requires many operators because of the limited diving time; as a matter of fact, it is a problem to find divers properly qualified. The solution to this problem may be achieved by the automation of equipment, surface readout in addition to the diver's readout, permanent documentation of the testing, professional surveillance on the surface, and a reexamination or spot check by independent personnel. These measures are in use to a certain extent, but only on a small scale. In the future, it is desirable to develop the different equipment to eliminate as much as possible the judgment of the diver. In the following paragraphs are listed the most useful underwater NDE methods and techniques.

Visual Examination

A very important NDE method is visual examination. In connection with offshore installations, visual examination is used for detecting mechanical damages and obvious cracks; corrosion and coating damages; anode conditions and consumptions; marine growth; and scouring. Unfortunately, sufficient attention has not been paid to visual examination, and

*Det norske Veritas, P.O. Box 300, N-1322 Høvik, Oslo, Norway.

Diver performing wall thickness measurements using a digital ultrasonic meter.

Watertight housing for an ultrasonic flaw detector.

the examination very often takes place with unqualified divers who hardly know or understand what they are really looking for.

Divers should have a certain theoretical background and practical experience to be allowed to perform visual examination, but there does not exist any formal qualification scheme with sufficiently high standards for visual examination. In an attempt to compensate for this lack of qualification, the following steps are sometimes undertaken: detailed briefing of the diver prior to doing the job; detailed planning of the job including inspection route; construction of a detailed inspection program; clarification of exactly what to look for; strict observance of reporting routines; and additional video coverage.

Even with these precautions, it is difficult for an inexperienced diver to report only relevant findings. He may be completely dependent on the inspection program and not obtain findings outside the scope of the program. He may report many irrelevant findings, causing a lot of wasted time and money. And he may miss relevant findings, which may lead to a hazardous condition. To minimize these problems, it is considered important to have a professional inspection leader at the site in order to obtain the most relevant information possible.

Magnetic Particle Testing (MT)

Apart from visual examination, magnetic particle testing has so far been the dominant underwater NDE method. It is suitable for underwater use in the detection of surface-breaking cracks, and, if correctly used with qualified personnel, the same quality of examination will be obtained as above water.

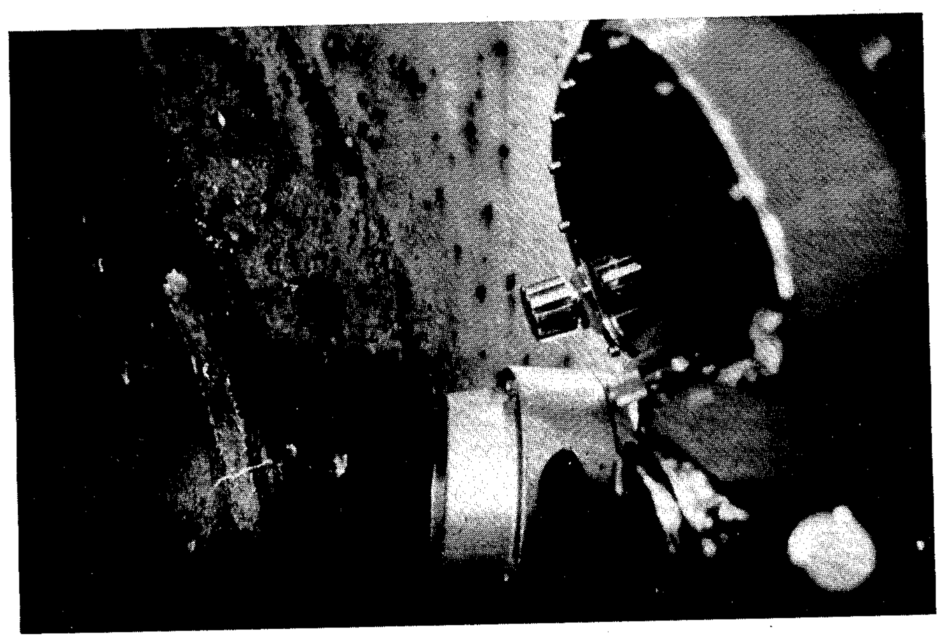
The method requires the testing areas to be cleaned free of marine growth, a process that is more time-consuming than the actual testing. In most cases, fluorescent magnetic particles are used and viewed in ultraviolet light. This testing requires reduced ambient light. Colored magnetic particles viewed in white light may also be used, but this requires an even more perfectly cleaned test surface and is not as sensitive as fluorescent particles used with ultraviolet light.

Different techniques for magnetization are available, but the choice of which technique to use depends on the test object mostly. The most commonly used techniques up to now have been the current flow with prods method and the coil method. Other techniques use parallel conductors, electromagnetic yokes, magnetography, or permanent magnets.

Permanent magnets are not recommended, however, for detection of surface cracks. This is due to uncertainties regarding the obtained magnetic field, especially with complex geometries. They are also time-consuming to use and may lose their power with time.

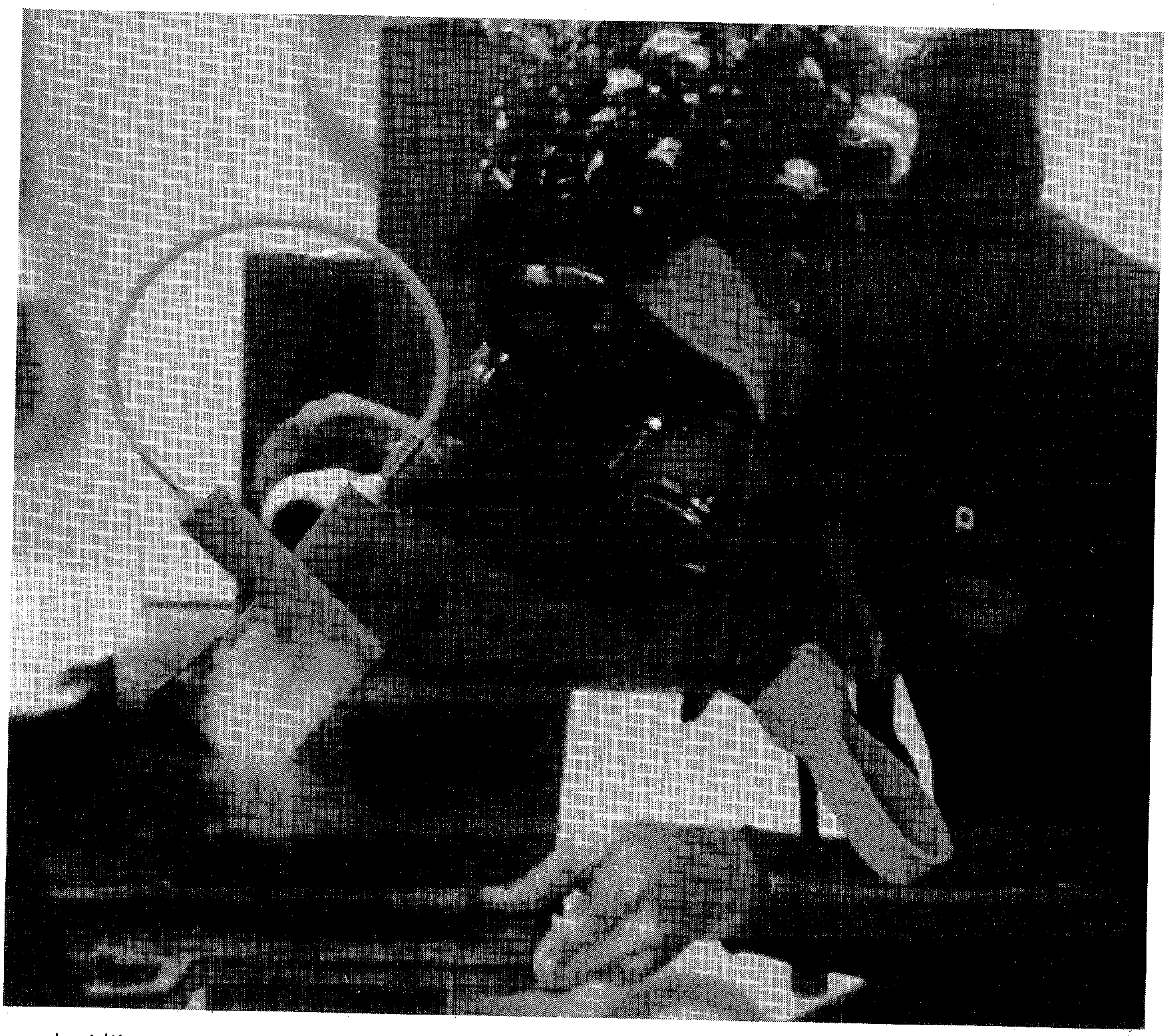
Magnetography gives a permanent record as a paper printout, but this technique has not been extensively used underwater. Due to some uncertainty with the interpretation and lack of experience with the method, magnetography has been acceptable to use only on the condition that findings could be confirmed by conventional MT.

A strip containing magnetic particles



Fluorescent magnetic particle indication on a node weld.

YOU MAY NOT HAVE TO DO YOUR MAGNETIC PARTICLE TESTING UNDERWATER...



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Diver with a helmet-mounted television camera.

Diver performing magnetic particle testing on a tubular joint.

and a solidifying medium to be wrapped around the weld is also on the market. When magnetized, this strip will keep all indications permanently recorded on the strip itself.

Both ac and dc power supplies are in use; however, because most underwater testing is aimed at detecting surface cracks, an ac supply is recommended and most often used.

Ultrasonic Testing (UT)

Ultrasonic thickness measurements are often performed underwater. Two types of equipment are in use: an ultrasonic A-scan (with a cathode-ray tube display) and an ultrasonic digital meter.

The digital meters are most commonly in use because of their small size and easy operation, but care should be taken during their use. Because mistakes are easily made, the meters should not be used by personnel unfamiliar with the principles of ultrasonics. Their use is recommended only on smooth and uncorroded surfaces.

The UT A-scan will give a more reliable reading under all conditions. However, the equipment requires exact calibration and qualified operators. If a surface readout is available, this problem may be eliminated. Internal corrosion may be detected by use of A-scan, while the digital meters often give erroneous readings or no signal at all.

Ultrasonic weld examination is considered too complicated to perform underwater on a large scale and is only used for diagnostic purposes and in connection with repairs.

Det norske Veritas has developed an automatic ultrasonic tool (Corroscan) for the detection and mapping of internal corrosion in offshore risers and pipelines. Applied from the outside of the pipe, the instrument is connected to a surface computer and can give different printout results. The automatic corrosion detector has proved to be very valuable in connection with specific problem areas.

Other Techniques

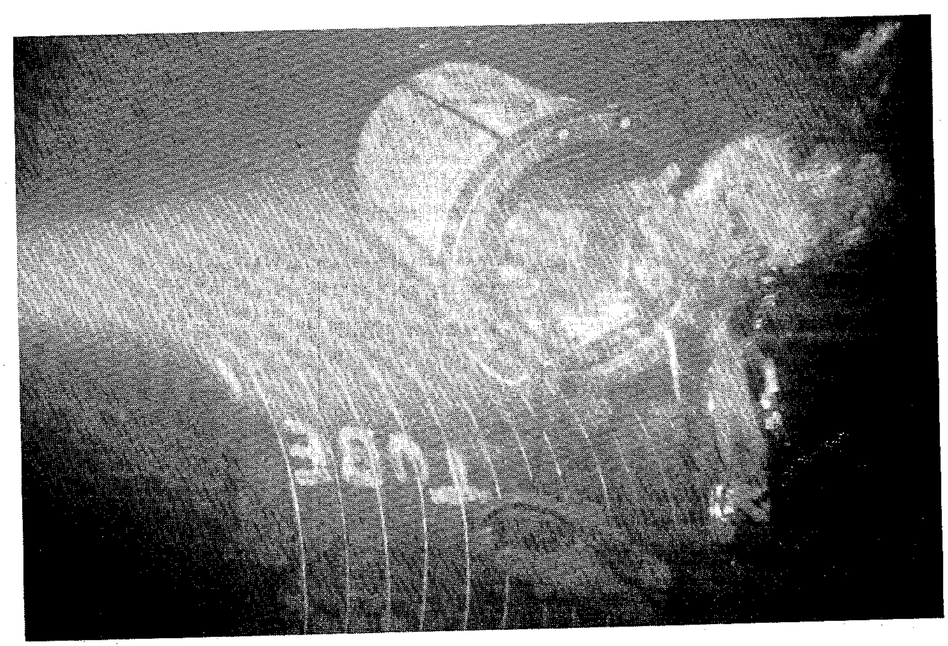
Crack depth measurements can be made with a tool developed by Det norske Veritas. It is based on potential drop measurements and is used in connection with magnetic particle testing. The measurements are useful for the evaluation of cracks and as input for fracture mechanics evaluation.

Underwater radiography testing is not in common use; however, gamma-ray radiography is used for the testing of hyperbaric welds.

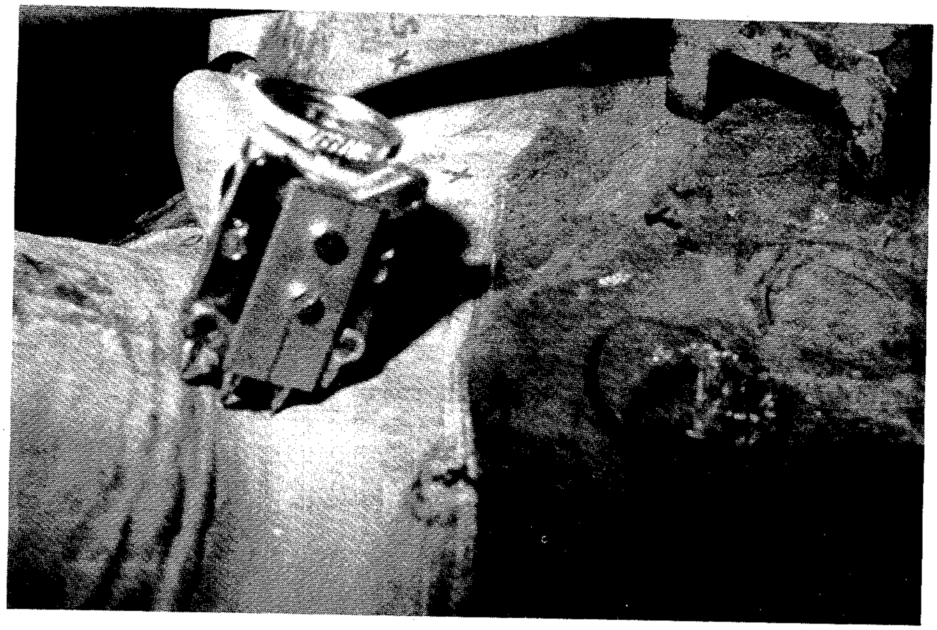
Eddy current equipment is now available. The equipment is claimed to be able to replace magnetic particle testing for surface crack detection in welds. However, the potential and efficiency of this type of equipment has not yet been fully established.

Future Trends

The development of new NDE techniques for underwater use is determined by the cost effectiveness of inspection and maintenance, the quality of inspection, and installations in deeper waters. Offshore inspection and maintenance costs in waters like the North Sea are tremendous, and savings related to re-



Diver performing manual ultrasonic wall thickness measurements.



Probe with four spring-loaded electrodes of Det norske Veritas' ac potential drop meter for crack-depth measurements underwater.

duced operation and diving time will have a great impact on these costs. The quality of underwater NDE is today very dependent on having qualified diving inspectors. Improvements are seen when critical examination result evaluations are no longer the responsibility of a diver who is inexperienced in NDT.

To cope with the above needs, development of underwater NDE is seen for automation and remote control of equipment, continuous monitoring, sophisticated ultrasonic testing, optical and acoustic imaging systems, and procedures for optimizing NDE efforts. Extensive research on the above is in progress and may someday change the underwater NDE scene.

Additional research includes automated ultrasonic equipment for weld examination, the use of acoustical holography and ultrasonic time of flight. Furthermore, acoustic emission and vibration analysis are being addressed as continuous structural integrity monitoring tools. To improve the quality of visual examination, especially in waters such as those off the coast of northern Alaska, imaging systems are being developed, based on sophisticated acoustic or optical principles.

Practical Articles

Materials Evaluation readers call Back to Basics the most useful single item in the journal! You can help expand this column and maintain its popularity by sharing your experience in writing with our readers.

All articles submitted for possible publication in the column are reviewed by our Tutorial Projects Editor, Frank Iddings, of Louisiana State University. Articles are seldom rejected due to a lack of originality or novelty but are selected on the basis of usefulness to others.

We hope you will take the time to share your insights and experience with other Back to Basics readers. Send your practical applications article to: Editor, *Materials Evaluation*, 4153 Arlingate Plaza, Caller #28518, Columbus, OH 43228. Let us hear from you!

Cooperative Study of NDE Reliability Set

As reported in the National Bureau of Standards' biweekly *NBS Update* in mid-December 1982, the NBS Office of Nondestructive Evaluation has received a two-year grant from the Pressure Vessel Research Committee of the Welding Research Council to work on a cooperative study of the reliability of ultrasonic and x-ray radiographic NDE tests.

The NBS Center for Applied Mathematics will use a new mathematical analysis procedure with extensive computer graphics, developed for the NDE program, to analyze five sets of flaw data for a low-alloy, high-strength, thick-section steel weldment. The data were gathered in an industry round robin of tests and include both nondestructive and destructive sectioning data, offering a unique chance to study the precision and accuracy of these important NDE techniques.

Leak Testing Topical Seminar
May 11–13, 1983
Marriott Hotel/Houston Airport
Houston, Texas
Registration Form

Sponsored by the ASNT Technical Council
Seminar Chairman: Gerald L. Anderson
American Gas & Chemical
Northvale, NJ

Seminar Co-Chairman: Charles N. Sherlock
Chicago Bridge & Iron
Houston, TX

Sessions	**ASNT Member**	**Nonmember**	**Total**
All Sessions/Events (includes: 2 luncheons, wine & cheese party, & coffee breaks)	$125.00	$150.00	______
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Leak Testing Topical Seminar
May 11–13, 1983
Marriott Hotel/Houston Airport
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Sponsored by the ASNT Technical Council
Seminar Chairman: Gerald L. Anderson
American Gas & Chemical
Northvale, NJ

Seminar Co-Chairman: Charles N. Sherlock
Chicago Bridge & Iron
Houston, TX

Objective: The topical is intended to broaden the user's understanding of the number of leak testing techniques available as well as their advantages and disadvantages.

Wednesday, May 11
SESSION I
1:00 p.m.
Introduction, Seminar Chairman Gerald L. Anderson

ELECTRONICS/VACUUM
Chairman: Paul R. Forant, Varian Lexington Vacuum Div., Lexington, MA

1:30 p.m.
History of Leak Testing; Al Nirkin, Veeco Instruments, Inc., Plainview, NY

2:00 p.m.
Gross Leak Testing Microelectronic Parts; Aron Der Mardesosian, Raytheon, Sudbury, MA

2:30 p.m.
Automatic Helium Leak Testing of Sealed Microelectronic Parts; Jim Rates, Triotech International, Burbank, CA

3:00 p.m.
Break

3:30 p.m.
Radioactive Tracers; Don Guthrie, Motorola Semiconductor Products, Phoenix, AZ

4:00 p.m.
Leak Testing Vacuum Systems for Production of Electronic Devices; Paul Forant, Varian Lexington Vacuum Div., Lexington, MA

Thursday, May 12
SESSION II
HELIUM LEAK TESTING WORKSHOP
Chairman: Charles N. Sherlock, Chicago Bridge & Iron, Houston, TX
9:00 a.m. to Noon
Participating companies: Leybold-Heraeus, Export, PA; Varian/Lexington Vacuum Div., Lexington, MA; Veeco Instruments Inc., Plainview, NY

SESSION III
PRESSURE VESSELS/CRYOGENICS
Chairman: George Clark, VALTEK, Inc., Springville, UT

1:00 p.m.
Ultrasonic Leak Detection; Ronald Marzoli, American Gas & Chemical, Northvale, NJ

1:30 p.m.
Helium Mass Spectrometer Testing of Large Double-Walled Vacuum Insulated Cryogenic Pressure Vessels; Charles N. Sherlock, Chicago Bridge & Iron, Houston, TX

2:30 p.m.
Integrated Lined LNG Containment; George Nassopolous, American Technigaz, Hingham, MA

3:00 p.m.
Break

3:30 p.m.
Care, Maintenance, and Calibration of Helium Leak Detectors; Bill Worthington, Leybold-Heraeus, Export, PA

4:00 p.m.
Short Duration Integrated Testing for Nuclear Power Plants; Hal Wilkerson, Bechtel, San Francisco, CA

Friday, May 13
SESSION IV
AIRCRAFT/AEROSPACE
Chairman: Dean Patterson, Boeing Commercial Airplane Co., Seattle, WA

9:00 a.m.
Aircraft Production Leak Testing Methods and Techniques; Ellsworth Phillips, The Boeing Co., Seattle, WA

9:30 a.m.
Automation of Leak Detection; Stuart Giles, Helium Leak Testing, Inc., Northridge, CA

10:00 a.m.
Break

10:30 a.m.
Leak Standards; Stan Ruthberg, National Bureau of Standards, Washington, DC

Product Showcase

As a supplement to our "New Products and Services" column, "Product Showcase" turns a spotlight on a different NDT area each month.

Materials Evaluation *encourages manufacturers and suppliers to submit information concerning their products in upcoming months and asks them to do so in the following manner.*

So that each company is given an opportunity to display a product of which it is particularly proud, each company should send one news release only, and it should be clearly marked "for Product Showcase." A company may combine two or three products in one story, but the story should be no more than four to five paragraphs long and a maximum of one-and-one-half pages, typewritten, double-spaced.

Upcoming "Showcases" will feature automated NDT in May; radiographic testing in June; magnetic particle testing in July; ultrasonic testing in August; acoustic emission testing in September; visual testing in October; transducers in November; and real-time imaging in December.

A "Product Showcase" news release that is clearly marked for the specific column and month should be mailed to the Editor, Materials Evaluation, *4153 Arlingate Plaza, Caller #28518, Columbus, Ohio 43228-0518. The deadline is a month-and-a-half prior to the month of issue; for example, a news release is due by April 15, 1983, for publication in the June issue.*

Underwater NDT

Underwater Magnetic Particle Testing

Circle Chemical Company, Inc., Hinkley, IL

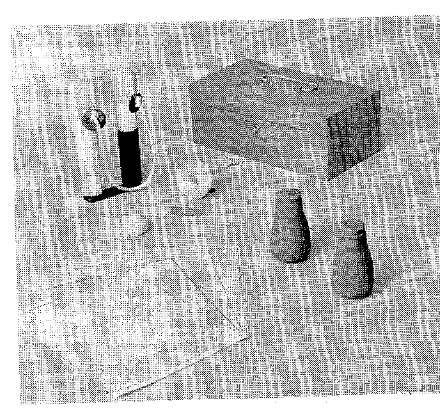
Circle Chemical Company offers two styles of permanent magnetic probes and two lines of particles designed for underwater magnetic particle testing (MT). These products are in addition to a complete line of particles for all MT applications.

MI-GLOW Magnetic Probe #50 and Magnetic Probe #25 are designed for underwater MT and are also suitable for nonmarine applications. The probes are pairs of cylindrical permanent magnets with a sturdy flexible connection designed to surpass the requirements for permanent yokes set forth in the ASME boiler and pressure code manual. Inspection with these probes means no wires to get in the way, no buttons to push, and no danger from electrical current. Small size and light weight (probes are 1 in. diameter by 7 in. long, 3.5 lb for the pair) simplify testing of irregular, contoured, or angular surfaces. The solid magnetic contact leaves both hands free for other work. Probe #50 is encased in stainless steel with a coil connection, while Probe #25 has a durable polyvinyl chloride (PVC) case and is connected with a strong nylon cord. With normal care, the probes will give years of service. If the probe is damaged or loses power, the set may be returned to Circle Chemical for repair and/or remagnetization.

MI-GLOW UW#1 particles were developed for nondestructive testing of platforms, pipelines, risers, and ship hulls beneath the surface of the water. These particles are easily visible in both white light and ultraviolet light. MI-GLOW UW#2 was designed to provide excellent visibility underwater and good contrast with the fluorescent chartreuse color of much marine growth. This material is more sensitive and will show up finer discontinuities than MI-GLOW UW#1, but it may be used only with an ultraviolet light source.

Circle Chemical also provides particles for wet and dry applications, using white and/or ultraviolet light, which meet relevant military and industrial standards. (Note: underwater MT is featured in the article appearing on page 527 of this issue.)

The Dry Powder Inspection Kit #125 includes the Magnetic Probe #25, two reusable dry powder applicator bulbs containing one pound each of Sir Chem Series 60 dusting powders, a magnetic flux indicator, transparent adhesive tape, and cleaning putty, all in a locking metal storage box. This kit is suitable for maintenance-type applications, for surface flaw inspection on items with contoured surfaces, and for locations remote from electrical outlets. The Probe #25 permanent magnetic probes attach to the inspection surface and create a flux field without the danger of arcing. The Magnetic Flux Indicator Strip is used to ensure the presence of a flux field in the part being tested sufficient to reveal surface indications similar to those found in the indicator strip. The tape may be used to make a permanent record of the indication by being applied to the particle buildup and then attaching the tape to an inspection report. Cleaning putty may be used on the ends of the Probe #25 to remove stray particles and can be reused many times.



Circle Chemical's Dry Powder Inspection Kit #125.

Circle 202

Handheld Underwater UT Thickness Gage

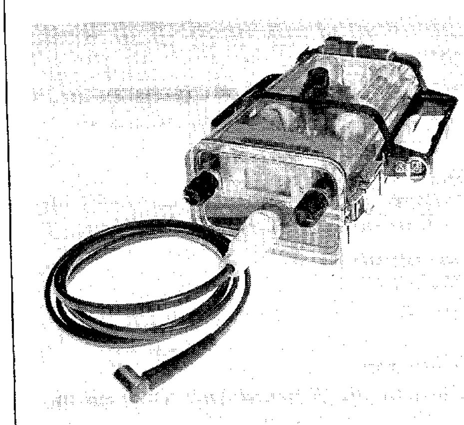
Nortec Corporation, Kennewick, WA

A handheld ultrasonic thickness gage that is designed specifically for underwater use has been made available from Nortec. The NDT-123U instrument, a modification of the company's NDT-123, is designed primarily for the offshore oil drilling industry or any other industry where accurate thickness measurements are required.

Some of its features include a measurement range of 0.050: to over 10 in.; a range selection switch on the front panel also activates instruments. The gage's resolution is 0.001 in. on the 2-in. range and 0.010 in. on the 10-in. range. Equipped with a backlighted liquid crystal display with 0.5-in. digits, the instrument also has adjustment knobs located on the control panel for easy accessibility. Measuring 4.75 by 3 by 9 in., it weighs 4.5 lb and is protected by a G.E Lexan Polycarbonate case that is good for depths in excess of 350 ft.

Accessories included with the gage are a standard 5 MHz dual element, a stainless steel calibration block, a carrying strap, and a wall plug charger.

Circle 201



Nortec's NDT-123U.

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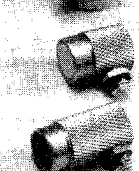

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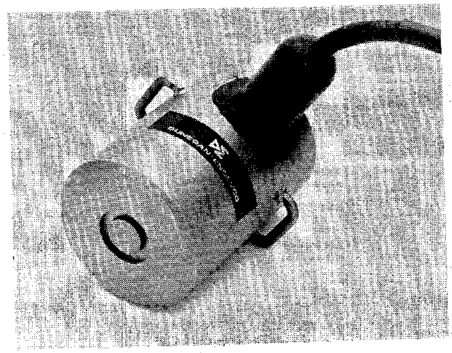
Underwater AE Sensor

Dunegan/Endevco, San Juan Capistrano, CA

Weighing a kilogram, the Dunegan/Endevco underwater acoustic emission (AE) sensor is built to withstand the forces that endanger the offshore structures it helps protect. The sensor has to be more rugged for its task than the structure it monitors because it must keep on working even if the structure starts to fail. Yet the rugged design must enhance, not hamper, the sensitivity of the piezoelectric element, which weighs less than 10 g. The sensor's job is to recognize and receive stress waves from growing cracks or other defects and to transmit corresponding signals to help locate and evaluate the sources of those acoustic emissions.

Case construction and integral electronics in this S9206 series work together to optimize the sensor's ability to pick up significant signals while ignoring extraneous mechanical and waterborne noise. The cable is double-jacketed polyurethane-neoprene, and the cable penetration is injection-molded with neoprene. To simplify mounting the sensor, it has protruding "ears" for strapping to the structural member being monitored, and the sensor's mounting face can be machined for closer fit to a curved surface.



Dunegan/Endevco's Underwater AE Sensor (S9206 Series).

The electrical characteristics of the sensor let it tune out frequencies below the range where acoustic emissions of concern occur. The integral high-pass filter can be ordered with a cut-off frequency of 50, 100, or 200 kHz, effective for the purpose because submerged parts of offshore structures are normally quiet above 60 kHz or so. The integral preamplifier provides a voltage gain of 40 dB, bandwidth of 20 to 600 kHz minimum (at the 3 dB point), and line-drive capability for use at depths of 300 m or more. The sensor design also results in excellent immunity to electromagnetic interference.

The S9206 sensor is the link between the inspection problems of offshore structures and the solution offered by AE testing, which can supplement other methods efficiently and economically. Prolonged testing on offshore structures has confirmed both the durability and the sensitivity of the Dunegan/Endevco unit. Installed on existing structures or inside new ones, the underwater sensor can follow up on the traditional visual/photographic inspection by divers, or it can supply information about suspect areas that should be checked visually. It can provide continuous monitoring or periodic testing under extra loading—in bad weather or during towing, for example. A strong advantage is the fact that the sensor can "listen" under the typical encrustation of marine organisms (often 6 cm thick, or more) that must be chipped and blasted off before other inspection methods can be used.

As offshore structures increase in number, size, and complexity, the conventional inspection methods cannot keep pace. With more than 3000 installations in the Gulf of Mexico alone, with 30 000-ton structures now in place, and with as much as 60 miles of welding on one installation, the time is ripe for AE testing and the D/E underwater sensor.

Circle 203

Automated Ultrasonic Corrosion Inspection Instrument

Det norske Veritas, Oslo, Norway

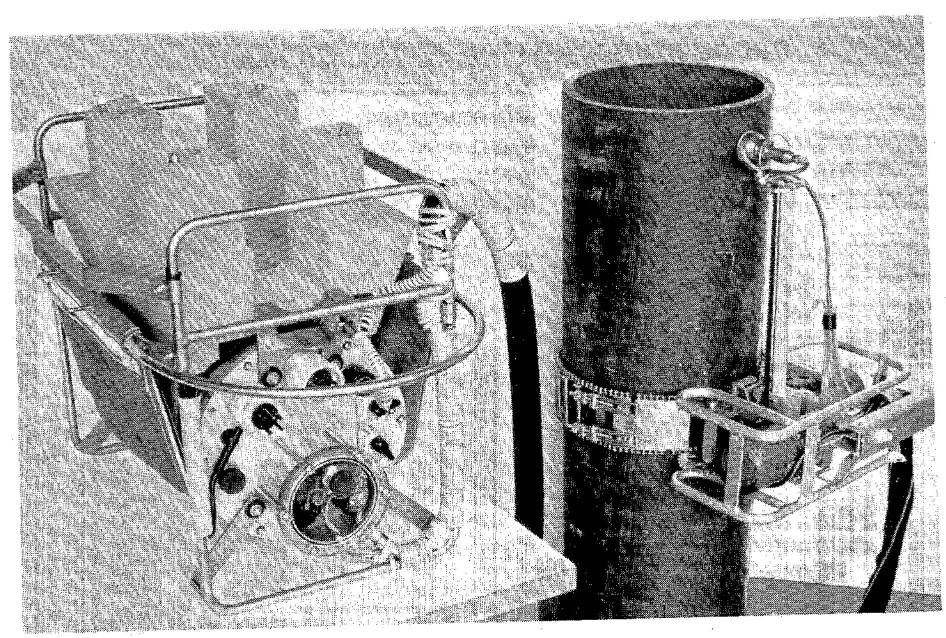
Developed for the detection and description of internal corrosion attacks in underwater pipelines and risers, the Corroscan system consists of an automatic scanner with an ultrasonic probe and a control unit operated by a diver. The scanner moves around the pipe on a chain, and ultrasonic signals as well as transducer position signals are transmitted through cables to a registration and processing system on deck. Corrosion attacks are presented as topographical maps giving full coverage of the inspection area for wall thickness and pits. The system has been operating in the North Sea since June 1981, and a large number of risers and pipelines have been successfully inspected in selected areas.

The central part of the system is an automatic scanner with an ultrasonic probe. The task of the diver is to locate and clean the inspection area, mount the scanner, and operate the control unit. The above-water parts, which are normally placed in a 10-ft container, consist of data registration and processing equipment, a power supply unit, and supporting equipment. Operation of the system and interpretation of inspection results are done by an operator inside the instrument container.

The standard probe is a 5 MHz model, slightly focused (focal distance of 60 to 100 mm in water) to improve the lateral resolution and the ability to detect small pits. A logarithmic receiver amplifier with a dynamic range greater than 100 dB is used, and the measurements are performed by triggering either on the edge or on the peak values of the echoes.

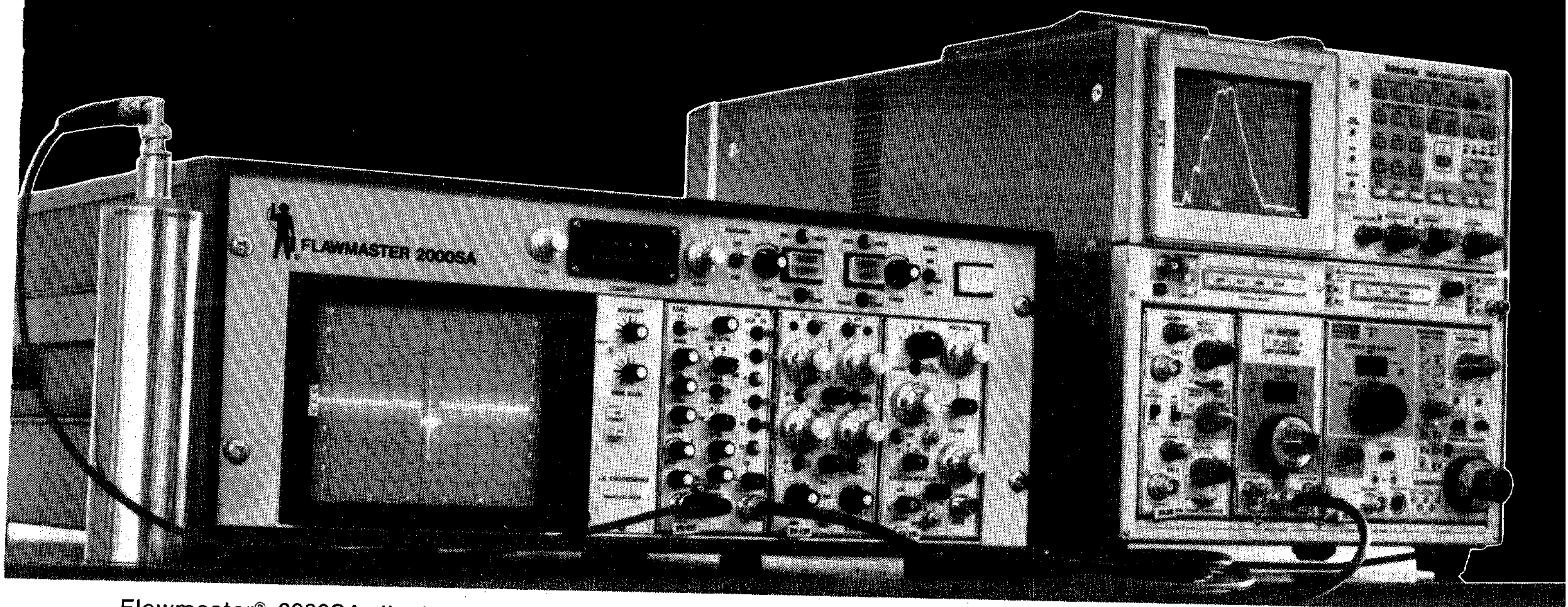
The inspection data, wall thicknesses with corresponding probe positions, are recorded and processed by the "P-scan" system, developed by the Danish Welding Institute. This system, which was originally developed for weld inspection, has been modified to include corrosion mapping. The results of the inspection are available in real-time; furthermore, the results and all the inspection system parameters are stored on magnetic tape, enabling later analysis.

Circle 204



Det norske Veritas' Corroscan.

Today's state-of-the-art ultrasonic flaw detector is equipped with a new standard feature.



Flawmaster® 2000SA displays isolated echo from test block. Tektronix® oscilloscope displays real-time spectrum.

If you're considering the purchase of a universal ultrasonic flaw detector that doesn't include spectrum analysis as a standard feature, you're looking at yesterday's outdated model.

The high-performance Flawmaster 2000SA from JB Engineering now comes with a spectrum analysis capability at no additional cost.

This unique capability, available only from JB Engineering, opens the door to the third dimension in ultrasonic testing. Now, in addition to looking at conventional time/amplitude information, you can simultaneously view the frequency domain. This spectrum analysis adds an important new dimension to the ultrasonic testing of bonds and welded joints, as well as composite, porous and fiber reinforced materials. Even if you don't need spectrum analysis for current needs, why compromise on a lesser unit when the Flawmaster 2000SA is competitively priced?

And spectrum analysis isn't the only competitive advantage of the Flawmaster 2000SA.

- The recorder amplifier is also standard.
- Edge writing capability allows you to outline parts without extra fixtures.
- Every output connector is clearly marked for easy, accurate usage.
- This high-resolution instrument readily marries to our full line or rugged immersion systems.

Before you buy, make sure you're getting the state-of-the-art ultrasonic flaw detector with all these features as standard. For information on spectrum analysis and detailed product specifications, call or write JB Engineering, 207 Greenwich Ave., Stamford, CT 06902. (203) 348-6753; telex 642634.

JB Engineering

The ultrasonic specialist

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Circle 133 on reader service card

AC-Powered, Flexible Magnetizing Unit

Henrichs & Walther GmbH, Bocholt, Federal Republic of Germany

Henrichs & Walther GmbH has introduced a product for use in the nondestructive inspection of complex-shaped structures with magnetic particle test methods. It is also applicable for subsea inspections on platforms and other marine structures by divers. Called the Flexiyoke, it is available in the United States through Mooney Sales & Engineering, Inc., Shelton, CT.

The unit's almost total flexibility allows for adaptation to nearly all geometrical conditions. Instead of the heavy losses in flux density when working with pole extensions, the full field strength is available at any location along the testing area. Fifty oersteds (4 kA/m) at 170 mm (7 ft) pole spacing are available. Clear defect indications can be obtained due to an extremely wide leakage-field-free-zone (LFZ), thus giving strong polarities at crack edges.

Different units, ranging from 50 (4 kA/m) to 145 oersteds (11.6 kA/m) for 110/220/42 and 60 V (secondary), with or without separation transformers, are available. Holding current supplies eliminate the weight of yokes because they hold onto material like permanent magnets. Timing circuits, safety breakers, and current controls are optional.

Henrichs & Walther's Flexiyoke.

Circle 205

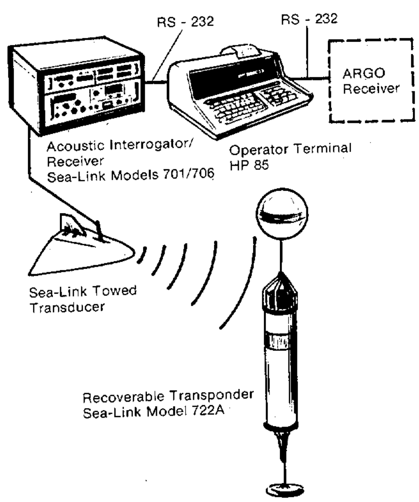
Coming to Product Showcase in May: Automated NDT

Marine Acoustic Equipment

EG&G Sea-Link Systems, Herndon, VA

Part of the Edgerton Germeshausen & Grier (EG&G) Corporation's Environmental Equipment Division since 1978, EG&G Sea-Link Systems has been a manufacturer of oceanographic equipment since 1964. It specializes in the manufacture of acoustic equipment and systems that link ships, submersibles, and platforms with the ocean floor. Its products are used commercially for offshore oil exploration and production and for deep sea mining; they are also applied to governmental studies and antisubmarine warfare. The equipment line includes release systems designed for the recovery of expensive mooring arrays, telemetry equipment, acoustic transponder navigation systems, range bearing systems, and current measuring systems and accessories.

The company's products have been used to precisely position surface vessels or objects for oil and mineral production, pipelaying, geophysical surveys, and oil spill cleanup. They measure physical oceanographic parameters for environmental impact statements and can relocate subsea oil wellheads, pipeline valves, fishing traps, and other salvageable equipment.



Sea-Link Systems' Acoustic ARGO Lane Recovery System.

One of the company's recent systems is the Acoustic ARGO Lane Recovery System. It is designed to quickly recover lost lane counts and minimize downtime. Requiring only a single transponder, the system can be quickly and easily deployed and recovered, thus permitting its use with ARGO for geographical surveys, rig positioning, hazard surveys, hydrographic surveys, and other ARGO applications. It is a portable and "weatherproof" recovery system that eliminates the need for returning to a shore station, recovering and redeploying streamers, or endless searches for surface buoys.

The user-friendly system requires only a single transponder for lane count recovery. The transponder is deployed in the area of operations using ARGO to determine its lane count position. Only a single pass around the area of the transponder is required. If at any time a lane count is lost, the operator simply returns to within acoustic range of the transponder. Once within acoustic range, a single pass in the area of the transponder provides the operator with information to correct the ARGO lane count. The system also provides a lane confirmation mode, which verifies that the lane recovery, including the resetting of the ARGO, is correct.

Simple to operate, the system has conversational instructions on the HP 85 that lead the operator through transponder survey, recovery, and confirmation modes. Displays include both alphanumeric and graphic; a hard-copy printout provides a permanent record. An operational simulation program is available on the HP 85 to train operators thoroughly in the laboratory, thus minimizing costly field training.

Circle 206

Underwater Magnetic Particle Inspection Unit

Lanshaw & Co., Sebastopol, CA

Lanshaw & Co., consultants in export marketing, have made available an underwater magnetic particle inspection (MT) unit manufactured by Oilfield Inspection Services (OIS), which have offices in Aberdeen, Scotland, and Great Yarmouth, England, and bases in Inverness, Scotland; Abu Dhabi, United Arab Emirates; and Perth, Western Australia.

Designed to meet stringent specifications for "safe" MT, OIS have produced a flexible and compact unit to provide an alternative to other systems. Emphasis has been placed on retaining size and weight to a minimum while achieving a high performance and reliability. Safety was the prime factor, and its specifications are in excess of recommendations (Det norske Veritas approved). The system provides the diver with all the necessary facilities to undertake the most critical MT.

Magnetization can be achieved by prod, coil conductor, or electromagnetic yoke techniques. A constantly agitated premix is contained in an external reservoir and delivered to the handheld ultraviolet (UV) lamp by means of a small diameter hose at 25 psi above ambient water pressure. The capacity of the reservoir is equivalent to approximately 10 L of ready-to-use MT fluid and can be easily

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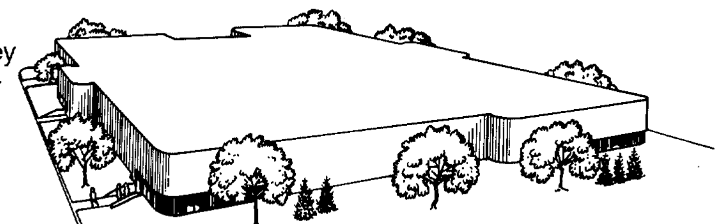

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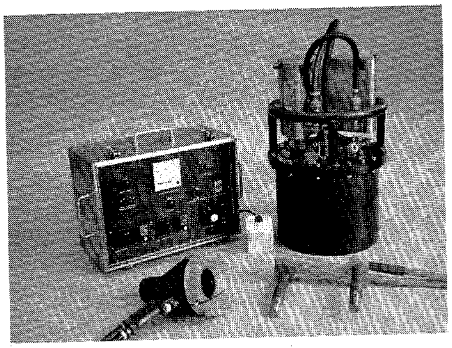


Lanshaw Offers OIS' Underwater MT Unit.

replaced underwater if desired.

The surface control unit is housed in a robust stainless steel case and contains safety and control equipment. Facilities include input/output current meter, remote control for magnetizing unit, magnetizing unit operating indicator, demagnetizing facility, earth leakage reset, mains isolation with earthed center tap, and earth leakage detectors. An input isolation transformer unit is provided to enable the system to be used for single- or three-phase supplies.

The submersible unit is housed in an aluminum, pressure-compensating container. A diaphragm is mounted in the base of the unit to compensate for variations of pressure. The housing is completely filled with a high-grade dewatering LPS fluid. Both the umbilical and UV lamp connectors can be mated and disconnected underwater.

The umbilical is a four-core conductor, steel-wire-armored, electromechanical cable. The braid acts as the earth line, and stainless steel conductor plugs are used at both ends.

Circle 207

Underwater Wall Thickness Gage

Krautkramer-Branson, Inc., Stratford, CT

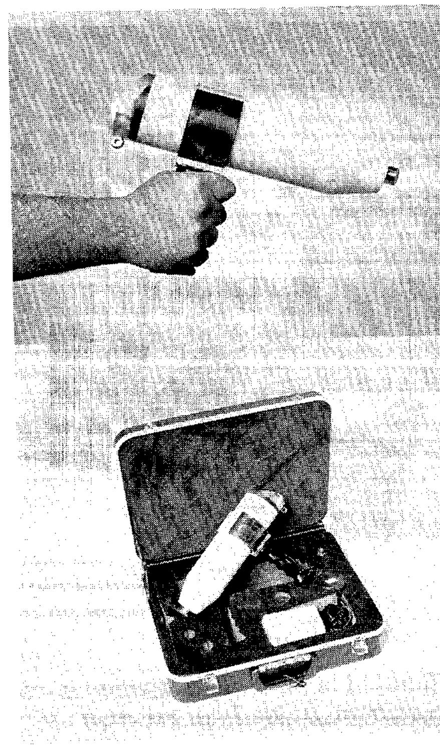
The DMU is a digital ultrasonic wall thickness gage designed by Wells-Krautkramer Ltd., Letchworth, Hertfordshire, England, and sold in the United States by Krautkramer-Branson, Inc. Its applications are for underwater and splash zone use.

Based on Krautkramer's DM2 wall thickness meter, which has rugged reliability for land-based measurement, the DMU combines the virtues of the DM2 with a number of special features. For ease of service and ensured reliability, the DMU incorporates the actual circuit boards of the DM2.

The 80 mm diameter instrument measures wall thickness from 2 to 300 mm (normally factory set for 4 to 100 mm) and operates down to 600 ft (Lloyds certificate of pressure test is supplied). It has an ergonomic design for diver convenience and provides single-handed operation with automatic switch-on and switch-off, a large and bright red digital light-emitting diode display for readability in undersea low-light conditions, and an 8-hour battery life between charges.

Standard accessories provided with the DMU include the pistol grip, which is detachable and can be moved to any convenient position along the body of the instrument; the wrist lanyard that is also detachable; a battery charger; and a custom carrying case for the outfit.

Battery charging is effected through a sealed socket situated under a cover plug beneath the display. Batteries (five 1.5 V cells) are fully charged within a 16-hour period and will provide sufficient power for a full 8-hour operation.



Wells-Krautkramer's DMU.

The DMU is precalibrated for steel (5940 m/s or as specified), and a zero facility is provided for adjustment out of the water in a service department by access through a sealed socket. The instrument may be laboratory recalibrated internally to any material and sound velocity and any range in the standard DM2 specification.

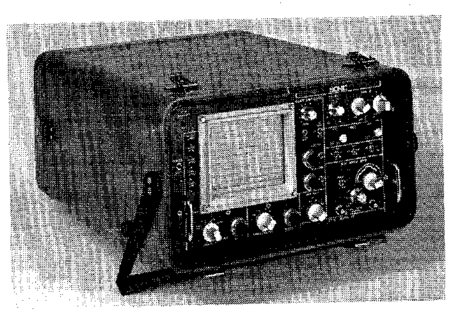
Circle 208

Underwater Sonic Alarm and UT Thickness Tester System

Sonic Instruments, Trenton, NJ

The task of conducting underwater ultrasonic thickness and flaw inspection is both difficult and time-consuming. This is due primarily to the fact that the test instrument is topside and the transducer and transducer operator (diver) is remotely located beneath the surface of the water. Formerly, the coordination of the ultrasonic testing (UT) could only be carried out by using normal voice communication between the instrument operator and the diver; however, this procedure is both inaccurate and inefficient. It requires a great deal of time and coordination for the instrument operator to inform the diver of the test location in order to obtain and peak flaw indications. By the time the diver is advised, he has already passed his transducer beyond the test point.

In response to the special NDE needs of the growing offshore drilling industry, Sonic Instruments' engineers developed a system that provides immediate feedback to the diver during the test. This system consists of a Mark IV portable ultrasonic thickness tester and an underwater sonic alarm. The latter is connected to the diver's communications system and the UT thickness and flaw tester. The frequency of the tone heard by the diver is directly proportional to amplitude of the echo appearing topside in the gate area of the CRT. By listening to the sound in the headset, the diver can actually locate and easily pick out the flaw indications or determine if proper thickness measurements are being achieved. This is especially helpful in zero visibility conditions that are common underwater. In addition to improving the accuracy and the speed of underwater testing, the new system reduces the overall test time, which allows a crew to conduct more tests, maximize diver "bottom time," and free the diver to perform other functions in addition to manipulating the transducer.



Sonic Instruments' Mark IV.

The company's underwater sonic alarm is compatible with any conventional commercial diving gear with standard communications hookup. It is available as an option (Part Number OPT-MF4012) to the Mark IV flaw thickness tester (Model MFDG4B). Originally designed for MIL-SPEC field applications, the Mark IV is built to survive hostile test environments. It is sealed tight for

maximum resistance to moisture and corrosion and has modular internal construction.

The Mark IV's bright 5.5 in. (14 cm) CRT allows excellent readability even in the presence of the reflected glare encountered in marine environments. Readable resolution is ±0.005 in. (±0.012 cm) over a 1.0 in. (2.54 cm) range. It also features high sensitivity. It can clearly resolve a #1 flaw as shallow as 0.075 in. (0.19 cm) below the surface in steel, making it very useful for all types of underwater ultrasonic inspection.

Circle 209

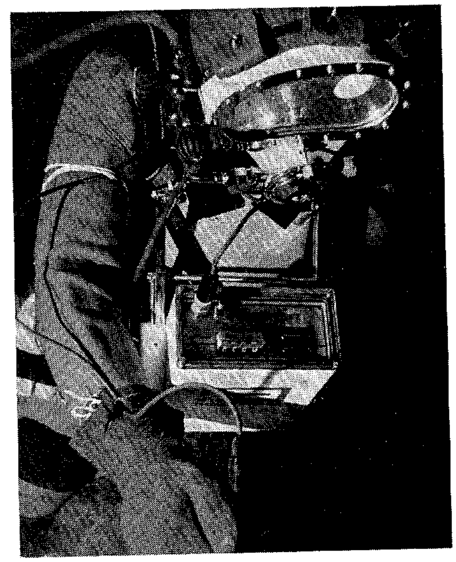
Underwater UT Gaging System

Panametrics, Inc., Waltham, MA

Panametrics, Inc., has introduced an ultrasonic thickness gage for underwater applications. The 5222UG underwater gaging system is a diver-operated unit that is entirely self-contained. Designed for independent underwater operation, the system does not require surface support, eliminates the long and cumbersome connecting cable, and considerably increases diver measurement output and productivity. An 8-hour battery allows the diver ample time to perform his work.

The complete underwater package consists of the Model 5222HP ultrasonic thickness gage, an instrument housing, a breastplate mount, a cable, and a transducer. These components have been engineered to meet the rugged demands of offshore work at depths to 1000 ft.

Operation is easy. After a simple calibration procedure, the Model 5222HP is slid into the instrument housing. A Lexan* faceplate caps the front of the unit. The gage's LED digital display is viewed through the faceplate clearly and conveniently by the diver.



Panametrics' Model 5222UG Underwater Gaging System.

The breastplate mount permits the housing to be retracted against the diver's chest for transport or work surface preparation and then folded out for convenient viewing of the display while making thickness measurements. The breastplate mount is designed to be used with most commercially available masks and helmets without interfering with diver mobility and safety.

Ultrasonic thickness measurements can be made accurately over a range of 0.125 to 10 in., depending on the material type and condition and the probe selected. Access is required to only one side of the structure, and measurements can be made rapidly with minimal surface preparation. Ultrasonic thickness measurements can be used to detect excessive thinning that could seriously weaken the material.

Circle 210

Underwater Inspection Photo Breakthrough

A practical technique for taking photographs of underwater magnetic particle inspection (MT) defect indications has been developed by Oceaneering International Services Limited, Aberdeen, Scotland, a contractor providing underwater services to the offshore and gas industry worldwide.

"The difficulties of long exposure times normally associated with photography of fluorescent indications through the use of ultraviolet light have been completely overcome," said R. Graham Mills, Oceaneering's Inspection Manager.

The technique uses an ultraviolet electronic flash of proprietary design, allowing the photography to be carried out underwater almost as fast as can be done using normal "white light" flash photography.

Authorities, including governments and certification bodies, are recommending that permanent recording of inspection results, such as photography, be included in underwater inspection survey requirements for offshore structures. This new method will produce higher resolution photographs more consistently, while allowing more cost effective fulfillment of recording requirements.

Further information on the photography breakthrough can be received from Rob Robertson, Corporate Marketing Manager, Oceaneering International, Inc., 10575 Katy Freeway, Suite 400, Houston, TX 77024. The company has 37 offices in 18 countries and is headquartered in Houston.

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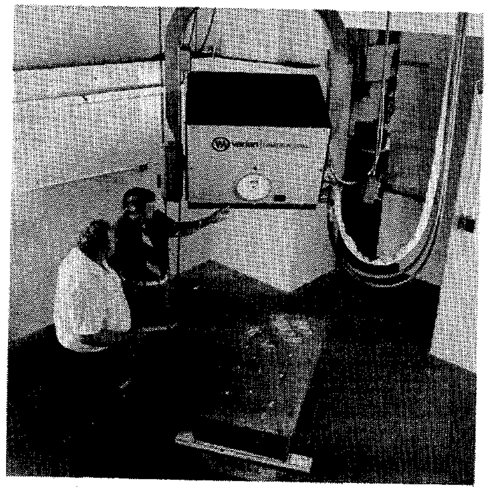

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Bring in a Linatron® Before Your Resotron Says Goodbye.

Circle 157 on reader service card

Qualifying Underwater Inspectors in Norway*

A structured program for underwater inspectors is under development at Det norske Veritas, Høvik, Oslo, Norway, to ensure that such personnel possess specialist skills in this field as well as the required background in general surveyor work.

Training for subsea inspection work can make extensive use of the facilities built up by Veritas in the fjord waters outside Bergen on Norway's west coast, which include a steel jacket section, a surface barge, and a 150-m pipeline length.

Divided into four course packages and three levels of competence, the proposed training scheme aims at contributing to the systematic acquisition of expertise through on-the-job learning and courses given in planned sequence.

In this way, the quality of the company's underwater survey services will be raised, and inspectors can acquire background in in-service inspection on fixed installations.

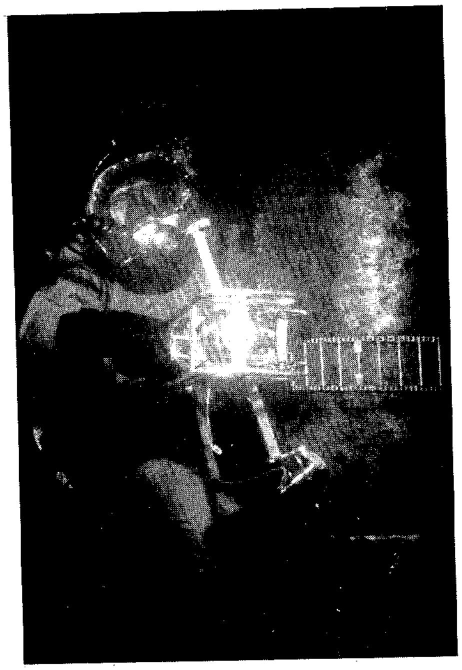
Taking a slightly longer view, underwater surveyors will also gain know-how likely to prove useful when they transfer to other work after they cease diving.

Given the anticipated expansion in subsea inspection and maintenance work as the number of completed field developments continue to expand and the average age of installations increases with time, the company anticipates a continuing need to train survey personnel for such work.

Involved in underwater inspection of offshore facilities since 1975, Veritas today has roughly 40 staff members directly engaged with these activities, including 35 full-time subsea inspectors.

About 85 percent of the work in this area relates to quality control and surveillance of underwater inspections, while nondestructive testing (NDT) accounts for a further 10 percent, and the remainder goes on various advisory services.

Viewed as a necessary part of the firm's main activities, like certification and third-party services, underwater inspection is looked on as an integrated part of its total engagement offshore. Again, this means that quality control requirements below water need to be at least as good as for installations above it.



Diver mounting the underwater scanner of the company's Corroscan instrument onto a riser in the North Sea.

The very different environment and procedures involved in subsea work underline the need for specialist training. In order to carry out efficient inspection, continuous first-hand evaluation of the collected data has to be made on site by a qualified surveyor/engineer with the necessary know-how. He should be able to dive in order to carry out spot checks and inspect important items.

To qualify as an all-round underwater inspector, certain minimum basic requirements for education and experience are set. These include an engineering qualification, air-diver training down to 50 m, good general know-how about inspection methods in and out of water (including NDT operation), a good knowledge of the company's inspection philosophy and routines, two years of engineering experience, and good know-how on materials and welding technology, damage types, and so forth.

At the same time, the firm wants its overall team of underwater inspectors to incorporate various specialist skills. About 80 percent of the group should accordingly hold a bell diving certificate, for instance, while just over a third should be qualified for operating the company's Corroscan system for measuring internal pipeline corrosion by ultrasonics.

Further, some 30 percent should hold an ultrasonic certificate, and an equivalent percentage needs to be able to evaluate equipment to be used in diving systems. Special skills in underwater photography and instruction/practice training would be welcome from roughly 15 percent of the inspection staff in each case.

Engineering qualifications and experiences are regarded as more important than diving qualifications because the main emphasis in the company's services is inspection in line with the conduct of other survey work.

The first course package in the proposed training schedule aims at qualifying trainees to participate effectively in project work within their departments.

Course package two covers NDT and inspections methods, including magnetic particle inspection, radiography, ultrasonics, and safety.

This in turn is followed by a three to four month diving course and practical work with NDT on the firm's test jacket, positioned in fjord waters near Bergen. Measuring 20 by 20 by 15 m, the full-scale section of a typical North Sea production platform jacket is equipped with a removable corner containing built-in defects, and similar defects are also incorporated into the main structure.

Most of the company's surveyors went through the one-week practical course last year, but the program may be extended to two weeks for fledgling personnel with no previous experience.

The course embraces exercises in such areas as inspection, detection, measurement and photography of damage, measuring scour buildup, inspection and photography of marine fouling, survey and measurement of anodes, potential

*From *Veritas*, No–106–OSLO–1982–II, Volume 28, and published originally by Det norske Veritas, Høvik, Norway.

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The introduction in 1960 of Structurix® X-ray film in daylight packaging with incorporated lead screens and in 1961 of the Structurix film in roll form, the so-called Rollpac®-proved an immediate success. In 1966 the Rollpac with incorporated lead screens was also introduced. To date, several thousand kilometers of pipelines have been inspected efficiently and thoroughly with Rollpac.
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Further efficiencies were achieved when Rollpac Pb in precut lengths was introduced in 1976. The Structurix RCF film/screen-system which reduces the time of exposure by a factor of 7 to 12, was developed in 1978 by special request of the offshore inspection companies. Agfa-Gevaert has also pioneered in the use of Holotest® materials in the field of holographic NDT.

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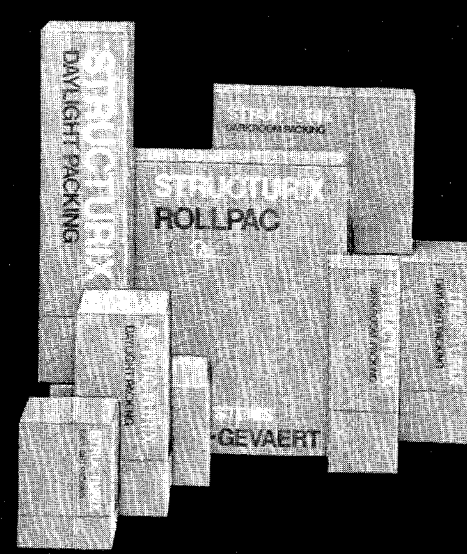

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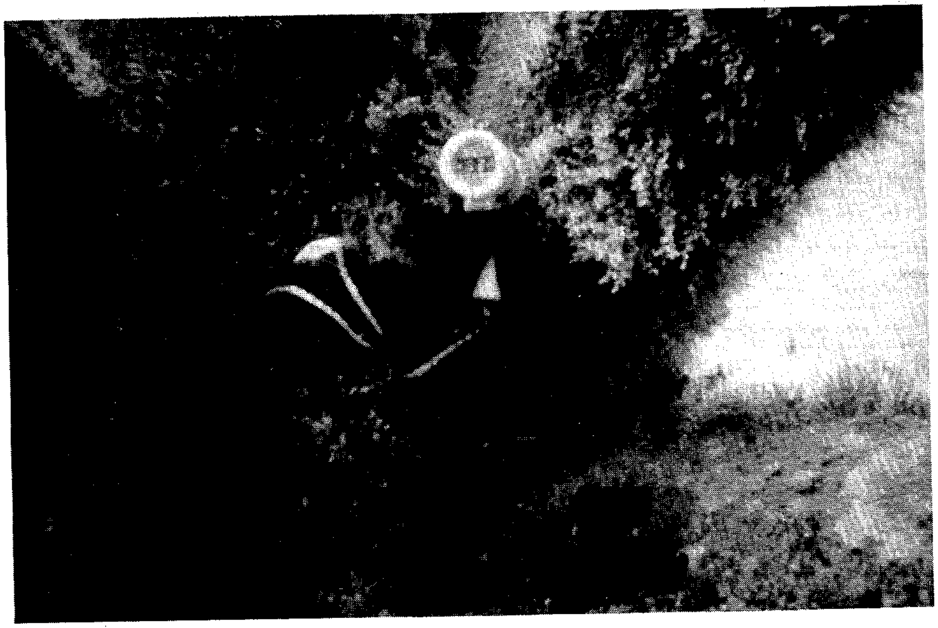

Diver making potential measurements on an underwater structure.

readings, various phases of magnetic particle inspection work, and thickness measurements.

By this time, the surveyor has reached Level I in the training scheme and is ready to go offshore as a junior trainee in association with an experienced underwater inspector.

Course package three is the next step taken, involving material technology and field inspection, quality assurance, corrosion, potential measurement and cathodic protection, systematics of inspection during the in-service phase, Veritas' systematics and know-how, and subsea inspection methods.

Combined with at least six to eight months' practical experience plus participation in preparing a minimum of one platform/riser inspection program and one or more summary reports for such installations, the surveyor is qualified to Level II in the planned training program. At this stage, he will be able to travel alone in traditional offshore work both locally and abroad in connection with underwater surveying.

A fourth course package, the top level, covers various aspects of principal steel structures, pipelines and risers and concrete installations—including design, strength and loading, materials, fabrication and protection, and damage. Advanced quality assurance, project management, ultrasonics, and radiography are also included in this package, which qualifies the trainee for the final Level III along with participation in other departments relevant for the surveyor's technical development.

With these qualifications, a surveyor can carry out demanding offshore work on his own account, such as evaluating damage; approving inspection gear, procedures, or personnel; preparing/evaluating inspection programs; and acting as a project manager.

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New NDT Patents

by Alfred E. Crouch
Manager, Inspection Research Department,
AMF Tuboscope, Inc., Houston, Texas

Tomographic Apparatus for the Production of Transverse Layer Images—4 345 158 (Manfred Pfeiler and Karlheinz Pauli)

A radiation measuring arrangement has two radiation sources of different radiation energy, which generate radiation beams penetrating the radiography subject. A radiation receiver behind the subject is composed of a number of detector elements. Only the sources are rotated about the subject for scanning, and the sources are at such a distance from one another that no detector element is simultaneously impinged upon by both radiation beams.

Contactless Resistivity Measurement Method and Apparatus—4 353 027 (Arthur Ballato and Gerald J. Iafrate)

A nondestructive method of measuring the resistivity of a semiconducting crystalline material. A disc of the material is supported in an air gap so that the disc is free to vibrate. An alternating electric field is established in the gap causing the disc to vibrate piezoelectrically, and then the frequency of the alternating field is adjusted to drive the disc into and beyond resonance. The current drawn by the disc is then compared with previously prepared characteristic graphs to determine the resistivity of the sample.

Eddy Current Surface Flaw Detection Employing Signal Correlation—4 355 281 (James M. Toth and Tyler W. Judd)

A pair of substantially coplanar detector coils are spaced along a workpiece for producing flaw indicative output signals, and a coincidence circuit rejects a signal from one coil unless it is coincident with a signal from the other coil. The eddy current circuits driving the coils are characterized by different but similar resonant energization frequencies differing from one another by less than about 50 percent to reduce inductive crosstalk between the coils.

Exo-Electron Nondestructive Test Device and Method—4 355 538 (Edward N. Hall)

A nondestructive test device that has the following components: a test enclosure with a vibrating holder for the test piece; a means for irradiating the test piece with radiant energy; a means for measuring electrons given off by the test piece; and a means for introducing controllably a gas into the enclosure.

Method for Determining Shape of Crack—4 353 255 (Yoshio Fukuda, et al.)

Several acoustic emission detectors are mounted on the test object, and the acoustic emissions produced by the crack are monitored by each detector. Positions of crack source points are determined based on differences in time points of signals produced by the detectors. A crack source plane is determined based on the positions of the crack source points, and the shape of the crack in that plane is determined based on a distribution of the crack source points.

Copies of patents may be obtained by sending the patent number and 50 cents to the Commissioner of Patents, P.O. Box 9, Washington DC 20231.

PATENTS IN BRIEF

Apparatus for Surface Stress Measurement of Glass Coating and Transparent Plastic Product—4 353 649 (Toru Kishii)

Laser Heterodyne Surface Profiler—4 353 650 (Gary E. Sommargren)

Methods and Apparatus for Testing Roundness and Straightness of Pipes and Tubings—4 354 379 (Robert M. Miner)

Apparatus for Measuring Automatically the Properties of Air-Permeable Rod-Like Articles—4 355 535 (Roger Vaughan)

Sludge-Measuring Apparatus and Ultrasonic Probe Assembly Therefor—4 355 536 (James L. McShane, et al.)

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Magnetic Particle Testing in the Marine Environment*

Magnetic particle testing (MT) has become recognized as a viable, cost effective nondestructive examination procedure in the marine environment, even underwater. Offshore structures, platforms, and ship hulls have all been successfully tested using underwater MT.

There are three important reasons for regular inspection of steel offshore structures and platforms. The first is that some of these platforms have now had over 20 years exposure to wind, seas, and corrosive conditions that have taken their toll. The second is the rapid expansion of new structures being placed in this severe evironment and the desire to minimize failure risks over their long-term operational life. Finally, much pressure is now being applied by financial and regulatory agencies to ensure greater operational safety, both for the men working on these structures and to protect the environment from potential hazards. While many companies had long recognized the need for preventive maintenance, until recently the methodology for simple but accurate inspection techniques just was not available. Perhaps the greatest factors standing in the way of underwater maintenance programs have been cost and diver safety.

With the advent of new materials, equipment, and effective nondestructive testing (NDT) techniques, there has been rapid expansion of underwater testing and maintenance programs. The three most common techniques are magnetic particle testing (MT), ultrasonic testing (UT), and stereophotography. All three systems complement each other, but to better understand the most common of these procedures, MT, one should look at a case study in the Gulf of Mexico.

Fifty miles off the coast of New Orleans, an unmanned oil platform was struck by a service vessel in dense fog. The structure was part of a complex at South Timbalier. The collision force with the vessel destroyed the platform's boat bumper and moved the surrounding structure about five feet out of alignment. Seacon Services, a division of Chicago Bridge and Iron, was contracted to perform NDT and reconstruction work for this structure.

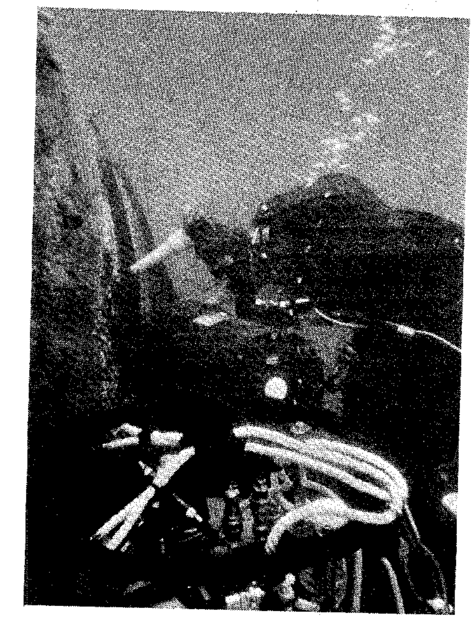
NDT procedures on the job were a combination of MT and UT. An overall inspection was accomplished with magnetic particles, which allowed the diver to cover large areas and visually locate surface discontinuities. UT was performed to identify voids and stress areas lying beneath the metal's surface. For the magnetic particle test, MI-GLOW UW#1 particles, a product of Circle Chemical Company, were used. They are specially designed for maximum visibility in the underwater environment using white light, ultraviolet (UV) light, or a combination of the two.

The first step, as with all underwater NDT procedures, was a thorough cleaning of the surface to be inspected. This was accomplished by hydroblasting and, in some locations, grinding or wire brushing the test area. A premixed solution of magnetic particles was then released onto the metal's surface between the opposite poles of two permanent magnets. Seacon used permanent magnets that allowed the diver to be more mobile and also eliminated the potential electrical safety hazards of electromagnets. An electromagnet requires topside personnel to alternately energize and deenergize the prod as the diver tests.

Following a pattern, the inspector/diver tested areas critical to the structure, including the areas adjacent to welds, where stress cracks show up most frequently. The magnetic field is established in a similar manner as in conventional above-water MT. The probes are placed both longitudinally and transversely to the weld, and the resulting magnetic field gathers the fluorescent particles into surface cracks that then become visible. Any indications are permanently recorded by the diver before moving to the next area. Permanent recording may be handled in several ways, including videotape, photographs, putty strips, and tape. The latter two are used to make a casting of the defect, which can be brought to the surface and studied.

Closed-circuit television, both black and white and color, is often utilized for remote monitoring. It allows both a visual study of the surface and audio contact with the diver. Similar to the videotape, transmissions can be preserved for future reference.

Another case study demonstrates the usefulness of magnetic particle testing of a ship hull. A navy tanker had experienced a slight but consistent loss of fuel from one of its tanks. This situation created difficulty not only in lost fuel, but also as a source of pollution, which drew criticism from the news media. Conditions that complicated the situation were that visibility in the water was less than one foot, and the area of the ship that required inspection was approximately 1320 square feet.



A diver performs an inspection using electromagnetic probes.

An underwater UV light unit was utilized to trace oil streaks in the water to where they originated. Magnetic particles were then applied to define fully the flaw, which was a 15-in vertical hairline crack. This crack would have been impossible to delineate fully with any other method while the ship was waterborne. Normal inspection procedures would have required drydocking and total costs approximating \$180 000. This job, however, was performed and completed in three days, which promptly returned the vessel to service and avoided the drydocking expense.

In another instance, a routine visual inspection of the rudder on a naval vessel revealed a crack beneath the water surface. The problem was to determine where to drill arresting holes. These holes are drilled at each end of a stress crack to prevent further elongation of the crack. Underwater MT was successfully utilized.

While MT has now been proven as a reliable means for underwater inspection, there remains a demand for further improvement in equipment and materials.

*Adapted from *Ocean Industry*, May 1979.

An Introduction to Atmospheric Diving Suits

by Steve Carnevale*

Introduction

Oceaneering International first introduced the atmospheric diving suit (ADS) to the offshore petroleum industry as an alternative deep-water diving system for exploration, construction, and production. Today, it exclusively owns and operates 27 "JIM" and "Wasp" ADSs. Since the first working dive in 1974, these atmospheric diving suits have established excellent track records while performing vital support tasks in fields all around the world. From Australia and the Gulf of Mexico to the North Sea and even the Arctic Circle, the 27 ADSs have collectively logged several thousand hours of working dives. Continuing development of this technology by the company has resulted in the establishment of one of the best diver alternate intervention systems available today. JIM and Wasp offer a safe, convenient, and cost-effective option to saturation and remote vehicle diving.

With the company's newly developed Wasp deployment system, a useful platform inspection tool, the Wasp ADS is deployed in a cage or garage until it reaches the required working depth. The Wasp then releases itself and maneuvers freely with only a light umbilical between it and the cage, thus removing the restraints of a heavy cable. Every Wasp has a fully integrated real-time television system that allows the client to supervise the work directly and maintain a permanent video record.

Inspector

Recently, Oceaneering completed its development of the Wasp Inspector. Borne out of Wasp, this inspection-oriented ADS is a totally redesigned vehicle. It has a tether management cage with 450 ft of neutrally buoyant umbilical that allows the Inspector to enter a platform structure safely and perform vital cleaning and inspection tasks. To improve access and stability while working, it has uprated thrusters, variable trim, and a third arm for attaching to undersea structures. It also has an electronic multiplexing system for collecting and gathering inspection data, along with a full range of tools.

Its capabilities include water blasting with grit entrainment, detailed visual observation, still and video photography, cathodic protection measurement, thickness reading (ultrasonic), pit corrosion evaluation, nondestructive testing, and wet welding (emergency).

The Wasp Inspector recently completed trials in the Gulf of Mexico on an offshore platform; it successfully carried out anode replacement on the platform. It is quickly gaining acceptance as one of the most capable and cost-effective vehicles for this type of work.

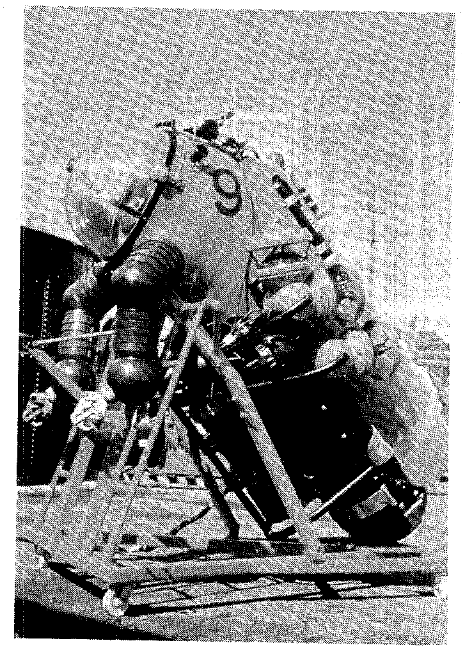
Utilization of Wasp Inspector for Platform Cleaning and Inspection

The following paragraphs itemize the work systems that are needed to complete several required platform cleaning and inspection tasks.

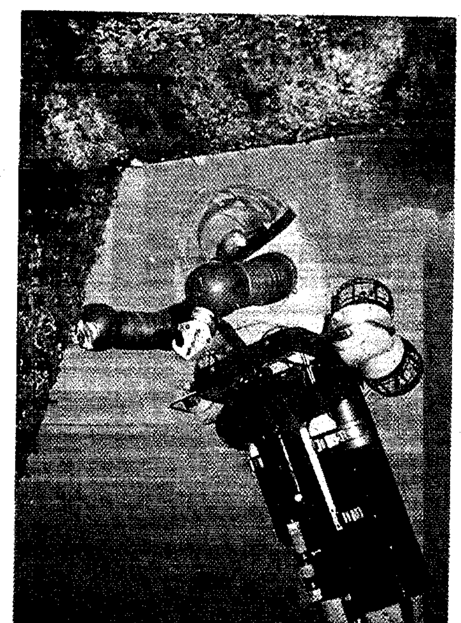
Several options exist for the ADS to clean structures. High pressure water blasters can be used with either pure water or grit entrainment. These systems run at a maximum of 10 000 psi from the surface or a subsea power pump and are the most common systems used for cleaning structures around the world.

A second option is the use of a low pressure cavitation jetting gun that runs at only 3000 psi and can also be powered with the subsea pump. This system takes advantage of cavitation theory to clean metal without subjecting it to higher and potentially damaging pressures. Such a system has had limited on-the-job-experience by divers in the field and is still considered experimental. Both water blasting and cavitation jetting are used to clean weld areas.

The ADS cleans general structural members with a "rotorbraide," which is an attachment fitted to a small hydraulic grinder that has a series of rows of spiked wheels to "flog" the surface. The rotorbraide works extremely well and is easy to handle because the tool is drawn to

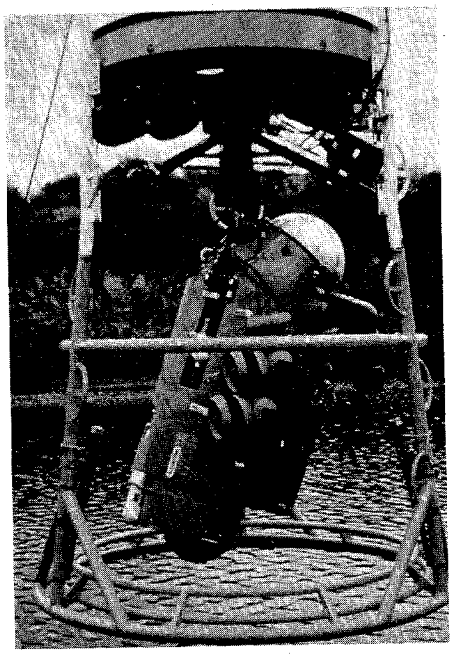


Topside view of Wasp ADS.



Wasp ADS maneuvering inside a platform.

*Oceaneering International, Santa Barbara, CA.



Wasp Inspector topside housed in the tether management cage.

the work surface by the suction effect of the rotation. It should be recognized, however, that the rotorbraide will not go into tight corners, and it tends to "peen" over very small cracks.

An option to the rotorbraide is a wire brush. This is another attachment that fits onto the hydraulic grinder and operates similarly to the rotorbraide. Although the cleaning action is not as thorough, it is sufficient for ultrasonic testing. Also, it will reach farther into tight corners.

Ninety percent of any inspection program is composed of visual observations of specific features. The ADS has a full range of systems to document, as required, structural integrity. Areas normally involved include weld areas, high stress members, anodes, condition of protective clothing, and assessment of debris and corrosion.

The Wasp Inspector is fitted with a standard monochrome CM8 camera with color or a stereo pair as options. The system is mounted on the vehicle with a pan and tilt operation to give real-time observation of ongoing work. It can also be held by the articulated arms for any required close-up video documentation.

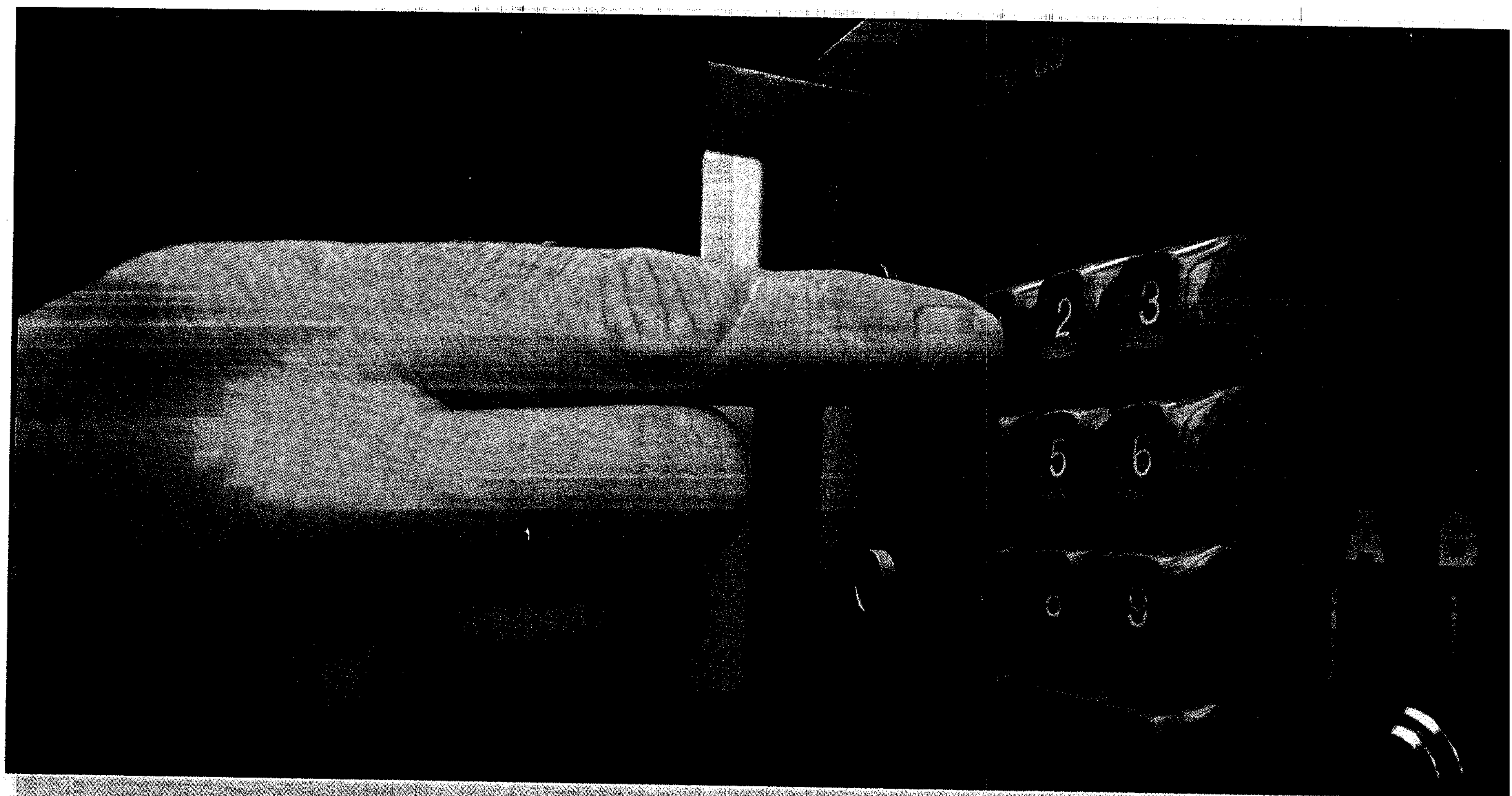
Standard documentation for the final inspection report is normally provided with still photos. The Wasp Inspector carries an Olympus OM2N 35 mm camera either in an encapsulation (rated to 2000 ft) for close-up photography or carried by the suit operator inside the pressure hull. The latter is good for wider angle shots, such as for anodes and debris.

The ADS has an on-site film processing facility that allows immediate processing to review the areas of immediate interest.

The Wasp Inspector uses a multihead probe that gives simultaneous reading of cathodic protection and thickness measurements. This enables the operator to ascertain both readings quickly and eliminates the need for two bulky instruments. Both systems are modifications of standard diver measurement equipment.

For physical measurements of corrosion, ADS uses a pit corrosion measuring device that reads the depth of pitting on general structural members.

The ADS has limited nondestructive testing capability, which is part of a current development project. Under examination is the feasibility of various methods, including magnetic particle testing, ultrasonic testing, eddy current testing, and the Harwell torch. Access to nodal areas becomes the most limiting factor. We have gained possession of eight anode fatigue fracture test pieces that allow us to conduct actual trials. This project will be completed by the spring of 1983 as part of Oceaneering's continuing ADS research and development.



Deep Water: The New Frontier for NDT

by Andre Galerne and Dan Walker*

This feature outlines the various types of vehicles now in use and in development for inspection and repair of deepwater structures. It does not deal with the technical aspects of NDT but describes the diving industry's present and future requirements for inspection tooling and techniques. The capabilities and limitations of various vehicles, manipulators, and their operators are described both for manned and unmanned intervention. The prospects are discussed for inspection at dramatically deeper depths in the near future. Figures illustrating manned submersibles, atmospheric diving vehicles, and remotely operated vessels (ROVs) are presented.

• • •

You probably know all there is to know about NDT. We can add not so much as a sou's worth of information to your store of expertise on that subject. With this article, however, some useful information can be brought to you regarding the present and future status of an industry with which you are intimately involved on a daily basis. That is, of course, the diving industry, which includes a wide variety of techniques and equipment that is constantly growing in depth and expertise—not unlike yourselves.

Now, the authors have been in what may be called industrial diving since shortly after World War II. How Andre Galerne became involved may serve as an interesting example of how one enters industrial diving. One month he was diving with Cousteau off the Calypso in the (then) pristine waters of the Mediterranean. The next month he had seized a bull by the horns or a tiger by the tail—or some such—and was deep in a sewer in Paris. Cousteau had his calling; Galerne had his. Perhaps the initial nudge had something to do with money.

Whatever the case, we have found adventure and rewards—and a great big challenge: an industry that needed to be developed from the ground down. It is an industry that would quickly spread over Europe in all manner of dirty and difficult industrial tasks. It is an industry that has simply kept on growing and going deeper and deeper to this very day. And, as you well know, your industry has gone every step of the way with ours, or vice versa.

At any rate, here we are, a thousand feet deep and going deeper. The diving industry continues developing equipment and techniques to put man at the leading edge of underwater technology. And you continue creating devices and methods to test those curious monuments to man's tenacity, ingenuity, and needs: the Hondas and the Cognacs and the tension leg platforms; the bottom completions and blow out preventors (BOPs); and the wet and dry subsea production systems and deep-water pipelines. This is an incredible offshore world, much of which did not exist even in the imagination as little as ten years ago.

We do not know how many of you have actually been down in that world that is so important to all of us. The world we are talking about is not the silent world of coral reefs and sandy bottoms and green-and-blue water with sunlight filtering down around angel fish. Not at all. Ours is a different world altogether:

monster steel legs slimy with algae that disappear below in the murky brown-and-black depths;

marine risers that plunge a thousand feet to an encrusted BOP stack in the blackness;

concrete behemoths that have no beginning and no end and are eerily out of scale to anything man has seen;

shrimp and plankton that cloud the bone-chilling waters;

visibility at an arm's length;

the constant sweep and tug of the implacable current;

communications that are far from superb;

a loss of orientation;

and time (there is no leisure here; time is your enemy).

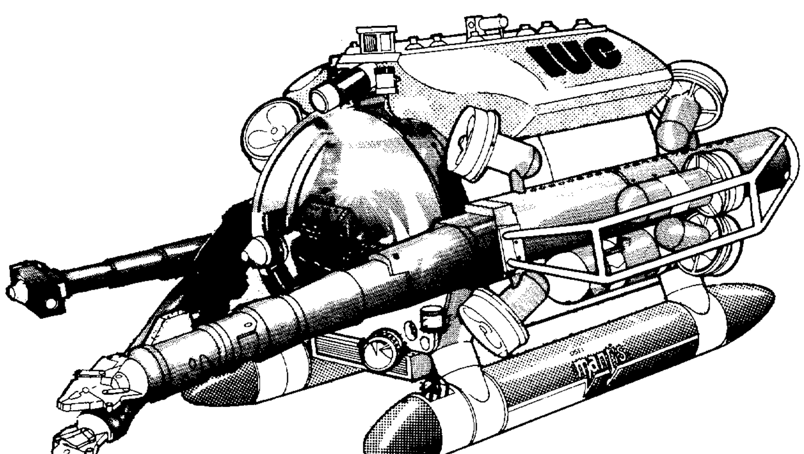
It is another world, and in a sense it is a nether world. We have some interesting news for you, too. Some of you may well be experiencing this world firsthand before long. Don't worry; it is statistically as safe as driving to the airport. You just have to follow a different set of traffic rules and regulations. But before we look closely at two submersibles that brave that world, we want to present a brief overview of the diving industry's ways of getting to work.

Basic Underwater Devices

Speaking for the underwater diving services community, there are four different kinds of underwater devices that we can use to work in conjunction with your NDT equipment. These are the human diver, working directly from a vessel or diving ball; the ROV; the one-man atmospheric tethered vehicle; and the multipassenger untethered submersible or minisubmarine.

There are many examples of each method, but these are the basic configurations of diving. Each has its advantages and limitations, but if one were to be singled out as the "best," it would be the multipassenger submersible.

Don't get us wrong. There will always be a use for divers. A superbly functioning brain, depth perception, stereoscopic vision and subtle color differentiation, hand-eye coordination, ability to make fast decisions—all of these qualities make the human presence underwater highly desirable. But divers are frequently too fragile for the hostile environments and



The new Mantis Duplus, a one-man, one-atmosphere tethered submersible capable of diving to 2300 ft, can be operated either with or without a human on board. This hybrid falls between a remotely operated vehicle (ROV) and a manned submersible.

*International Underwater Contractors, City Island, NY.

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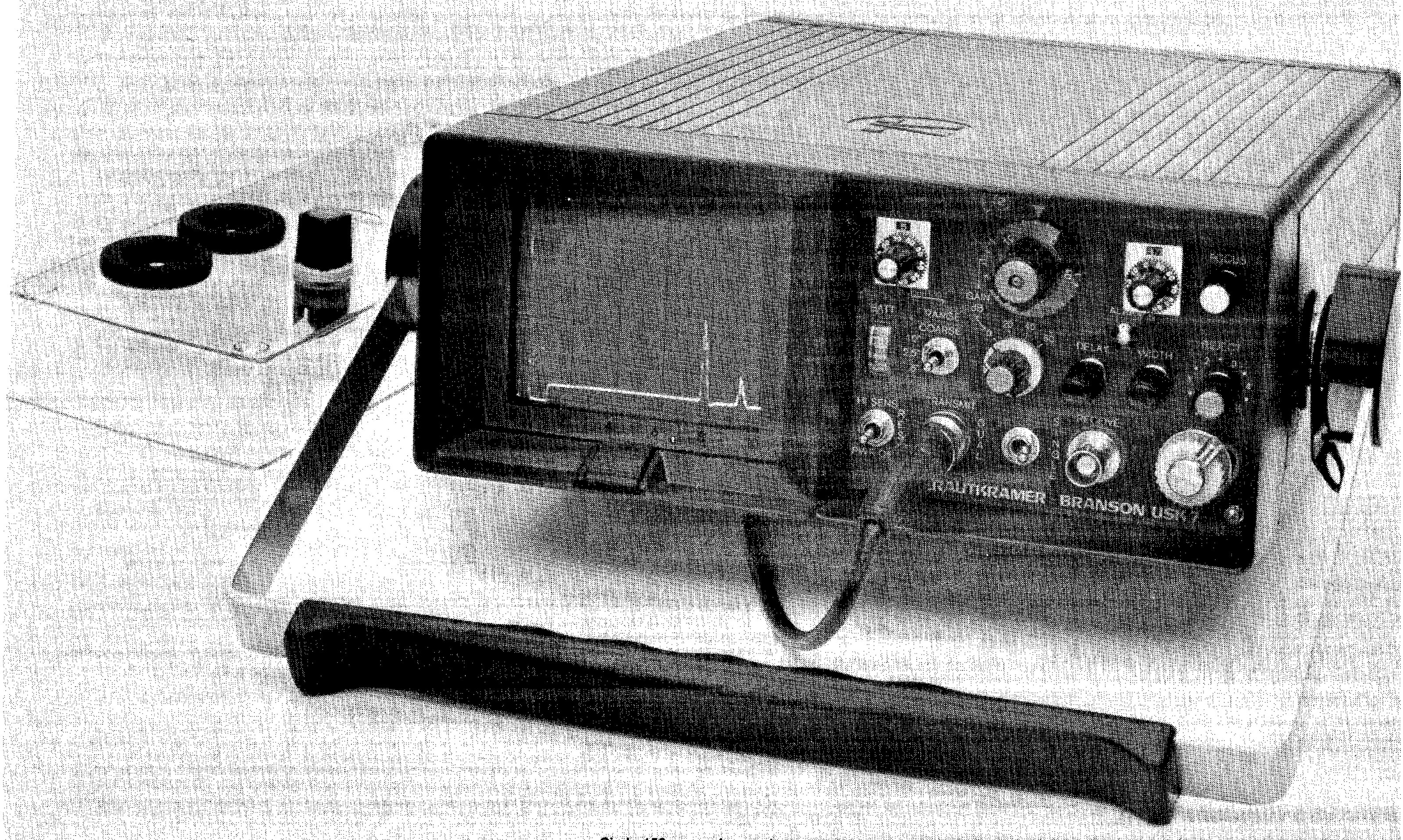

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great depths where our work now takes us.

An increasingly frequent replacement for divers on simple observation jobs is the tethered ROV, the so-called "flying eyeball." ROVs have one major attraction: unlimited bottom time, as power is supplied through the umbilical. And their small size often permits maneuvering into tight spots. But for general work, there are serious limitations. These include: weak, single, or no manipulators; light weight and a resulting instability; the umbilical itself, which is liable to get caught in the mother ship's props or entangled elsewhere; a remoteness from the surface operation that results in confused orientation; and, from an NDT point of view, a great distance between the article probe and the recording/interpretation point.

The one-man, one-atmosphere vehicle, which has become quite popular with pilot/divers, is the next best way to take man and his NDT equipment to the spot of testing. The Mantis is the prime example and has several things going for it. It can dive rapidly to 2300 ft and perform a number of tasks with its two strong manipulators. The pilot inside brings his or her abilities to the workplace and can augment live television sent to the surface. But it is relatively light in weight, and its umbilical or tether is always a problem.

We feel that the submersible with two or more people on board is the answer, both now and in the long-term future. There are a number of reasons for this, some of which are directly related to NDT activities. First, the basic ones. The crafts are piloted by men who are highly skilled as divers and topside life-support technicians and who know the operations both above and below the surface. Submersibles are considerably heavier, stronger, and more powerful than both ROVs and one-atmosphere vehicles. This means they provide a stabler platform from which to work. They can dive far deeper than either man or ROVs. They can stay down longer than a diver alone. They maintain orientation in water far better than a diver. They carry from two to half a dozen people. There is no need for lengthy decompression after a dive. They can fight most currents and withstand cold and great pressure. Most are equipped with dual manipulators, one of which can anchor the vehicle while the other operates an NDT probe. And, when needed, these minisubmarines can change buoyancy from negative to positive—an important control in certain instances. For example, the vehicle can take on water, thereby creating inertia that would enable its manipulators to turn a bolt that would not budge.

There are also advantages that are even more relevant to an industry such as NDT. Certain NDT techniques prohibit the use of a long line between the probing device at the article source and the data-gathering mechanism. ROVs, divers, and one-atmosphere vehicles necessarily need long lines. A submersible can bring the entire NDT operation right to the spot, including probe, computer, videotape machines, and the interpretive technician—you. The main advantage here is that the expert can see the result immediately and firsthand, in living color and three dimensions.

International Underwater Contractors has been steadily building a versatile fleet of manned submersibles since the late 1960s. In 1968, we acquired the first, the Perry PC3B, a one-man sub that had taken part in the search for the H-bomb lost off the coast of Spain in 1966. Since then we have added about one submersible every two years. Today, we own the Mermaid, capable of taking two men to 1000 ft; the Beaver, which can accommodate five people to 2000-ft depths; the two-person Pisces, which is rated to 8300 ft (we have done jobs with the Pisces in over 4800 ft, the current world's record); three Mantis one-atmosphere vehicles (one, the Mantis Duplus, can also be operated remotely); and several ROVs, including the totally autonomous Epaulard, which can do photographic and bathymetric surveys of the ocean floor down to 20 000 ft.

The Beaver and the Pisces

Now, let us take a brief look at two of these submersibles, the Beaver Mark IV and the Pisces VI. This will give you an idea of how well-adapted to underwater NDT work these vehicles really are.

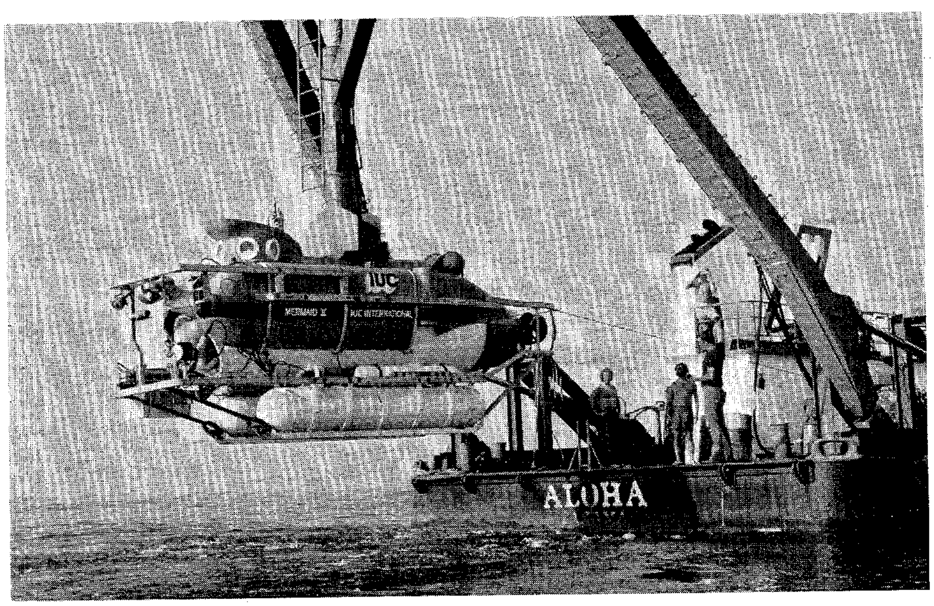
The Beaver Mark IV has been the most advanced workboat available for commercial use for about the last ten years. It was built by North American Rockwell for the Mobil Oil Company to use in the Gulf of Mexico, primarily to transfer personnel to a planned subsea production system. The lockout chamber can place divers in water at depths approaching 1100 ft, and the vessel itself is rated to 2000 ft.

The interior spaciousness compared to that of other submersibles is cavernous, allowing on-board use of any NDT equipment needed, as well as up to three NDT observers/technicians. Recently, we have designed, fabricated, and purchased several new features that make it even more versatile, including more powerful thrusters, stronger manipulators, and a full range of state-of-the-art electronics and imaging systems. Besides videotape and closed-circuit television, the craft carries a still color stereo camera, a device that we find extremely useful and will continue to champion until real-time color holography comes along.

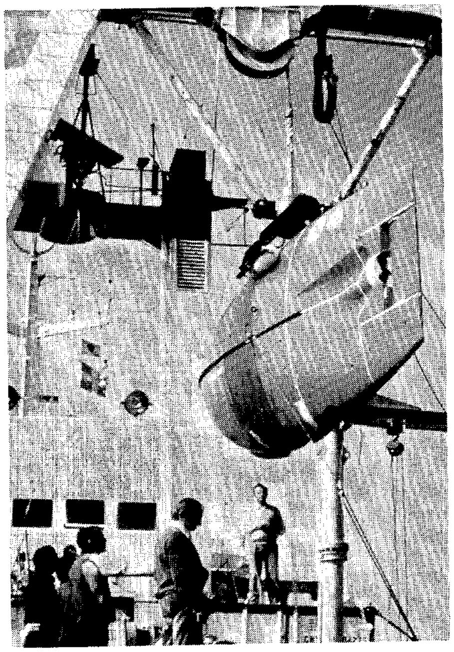
There are several other features that make a submersible such as the Beaver ideally suited to NDT. Its unusual size—17 tons—gives it the stability needed for much underwater work. It can handle currents to 2.5 knots and has a burst speed of over 5 knots. Moreover, it can hover and/or cruise for some 10 hours.

A final, singular feature is the "lazy Susan" tool basket mounted on the bow, just below the 30-in. viewport. Present manipulator tools include cable cutter, wire brush, impact wrench, stud gun, and power hammer and saw. The 10-function manipulators each have a 6-ft reach and a lift capacity of 50 lb at the "wrist" and 250 lb at the "shoulder," with a wrist rotation that has 83 ft/lb of torque. Perhaps more important for you, the manipulators can change their own tools underwater by using the tool basket.

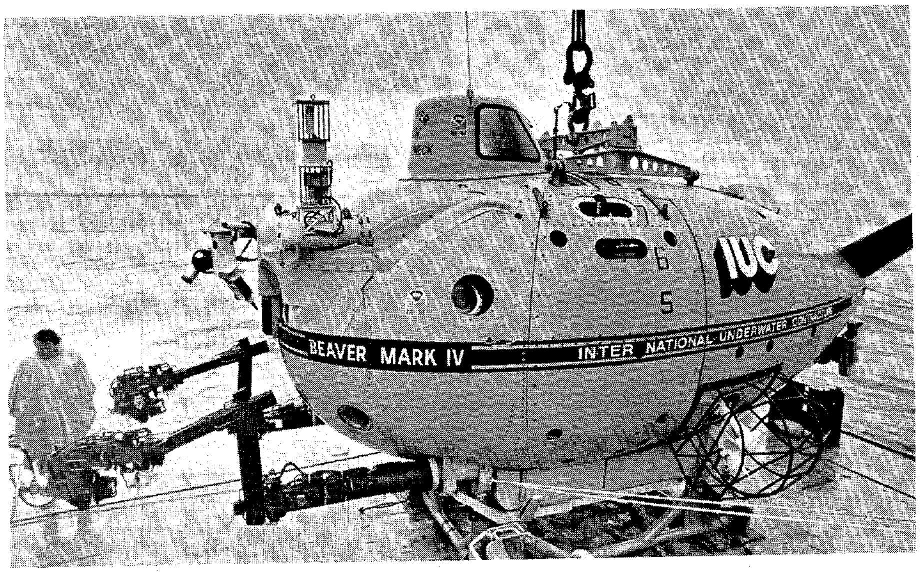
The Pisces VI is the second submersible that may prove of interest. There are several Pisces in that line, and we have the Pisces VI. We feel that this craft,



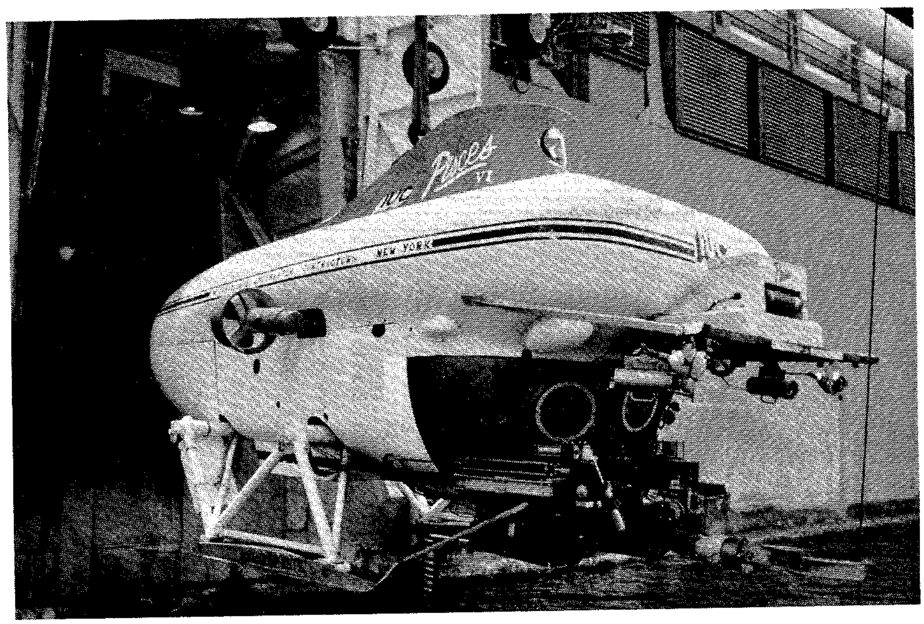
The Mermaid is a middle-range workboat, capable of tasks to 1000 ft.



The Epaulard is a highly advanced unmanned and untethered autonomous vehicle that can dive to 20 000 ft, take up to 5000 photographs of the bottom, and return.



The Beaver Mark IV is among the most versatile of submersibles, featuring heavy-duty manipulators, five-man capacity to 2000 ft, diver lockout, and dry personnel transfer connections.



The Pisces VI, rated to 8300 ft, is the deepest diving of today's working submersibles and may be the link with the future of manned submersible intervention.

which we have used successfully for the past three years, may be *the* link, the intermediate step in the evolution of deep-diving manned submersibles. In a 1979 magazine article, Galerne ventured the following estimate:

> Between the surface and its 8,300-foot depth limit, the Pisces can certainly do a wide variety of work not yet performed, some of which, perhaps, even the most advanced technology has not yet envisioned.[a]

This statement still holds. Recent research and testing would seem to place man's capacity to perform useful and efficient work in open water at ambient pressure at about 2500 ft. One-atmosphere vehicles now work at 2300 ft and will undoubtedly go deeper—once the tether and communications and power problems have been solved. But we are already out there working day-to-day with the Pisces at the leading limit of drilling technology. The 1979 record of 4876 ft off Newfoundland remains an industry record for observation and documentation of a spudding-in operation. Of particular interest was the ability and delicacy the operator displayed in bringing to the surface a live and kicking Healithodes grimaldi, a rare crab, grasped primly by a manipulator.

The Pisces has two manipulators. One is a general-purpose arm with seven functions that features a 7-in. grip and a 150-lb lift capacity; the other manipulator is a heavy-duty claw with a 28-in. grip and a 2000-lb lift. Among the tasks that the Pisces uses these and other capabilities for are placement of beacon caps; retrieval of small and large objects; guide base and stack inspection and cleaning; checking the BOP stack level indicator; entry and reentry guidance; and BOP connector seal ring replacement.

The two-person Pisces is smaller at 12 tons than the Beaver. But its astonishing depth capacity places it in the forefront of the progress toward reaching deeper waters. If and when either wet or dry ultradeep subsea production systems become a reality, the Pisces VI and a handful of other deep-diving submersibles are ready for duty.

We believe fully in the usefulness of man in the underwater work world. A Pisces-class submersible that can take men to 14 000 ft to do a day's work is currently planned. And another—perhaps the ultimate as far as the oil and gas business is concerned—is not far behind. This is a two- to three-person submersible that would place working human beings and their wisdom at the 20-000-ft level.

Owning and operating deep-diving manned submersibles is a special world. So is that of NDT in an often hostile and chilling environment. It is our hope that these respective talents can meet and work together—preferably in the comfort of a large and versatile submersible.

[a]"Pisces 6—Deep Eyes and Arms for Discoverer Seven Seas," *Ocean Industry*, Nov. 1979, p 146.

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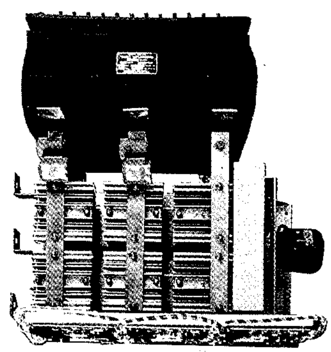

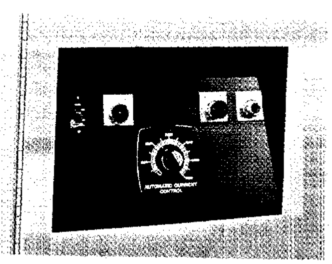

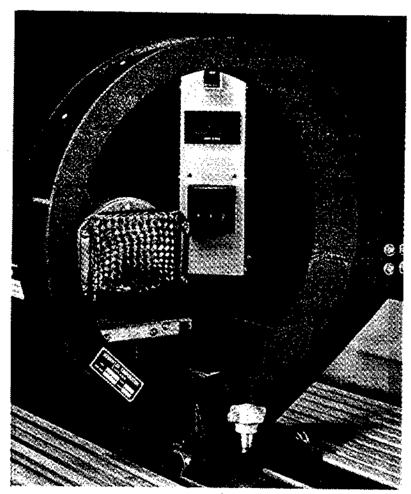

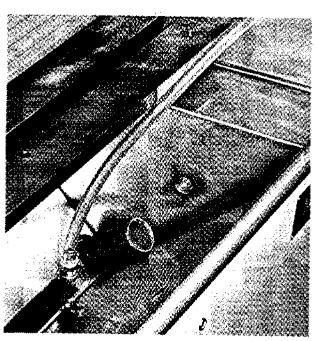

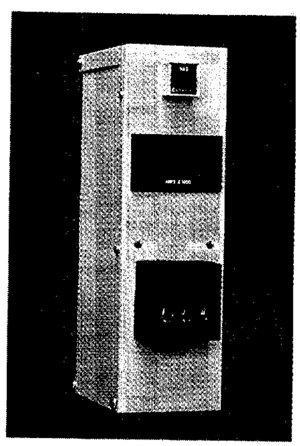

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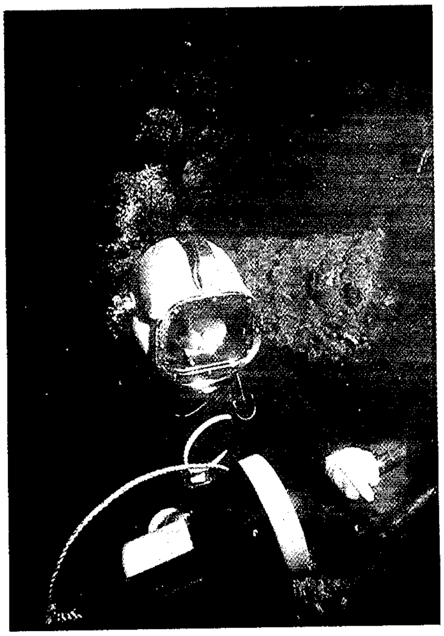
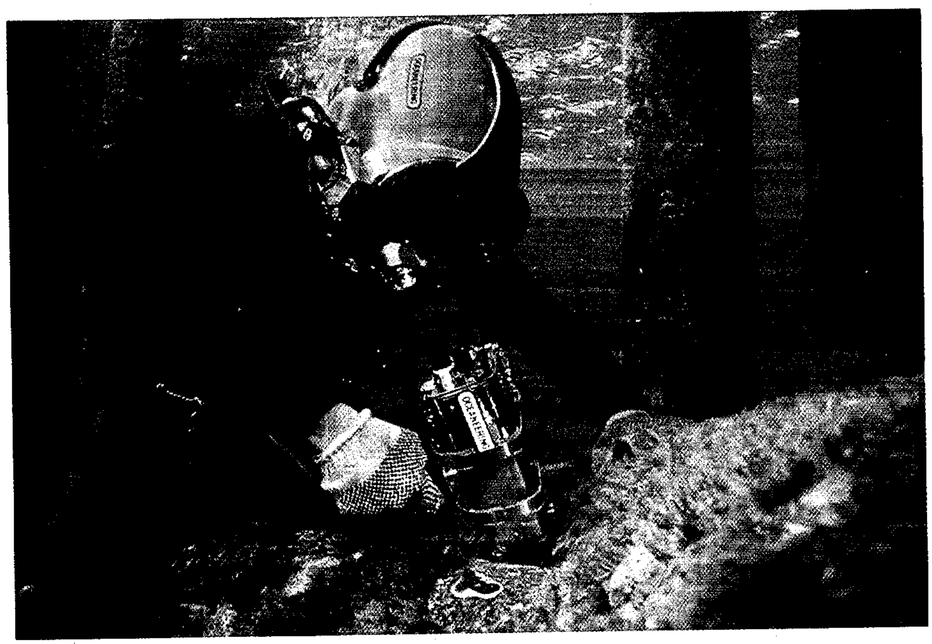
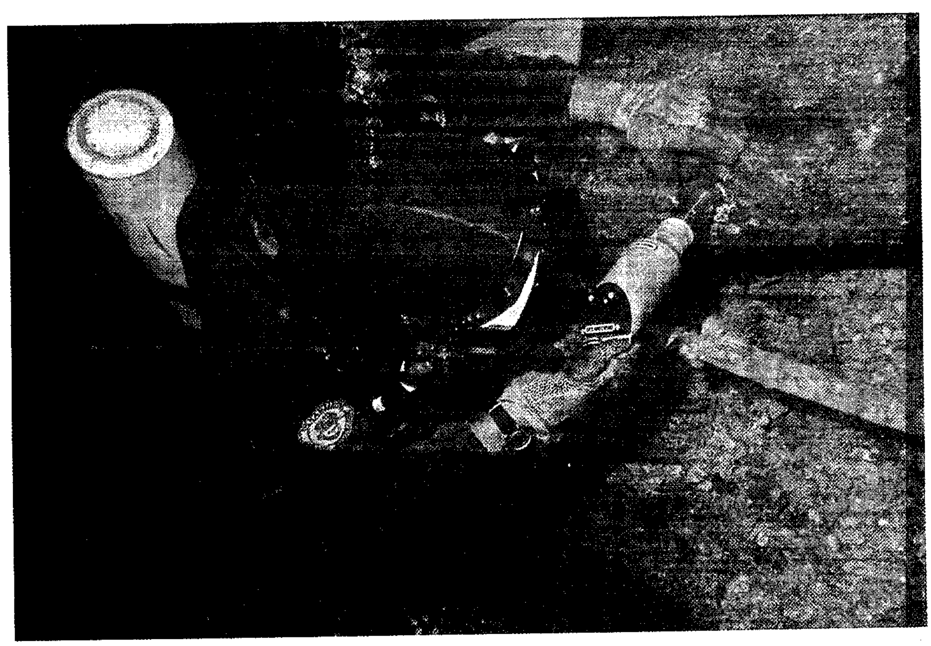


For a complete detailed underwater inspection in Southeast Asia, a diver uses articulating permanent magnets for a selected node survey.



A diver performs wall thickness measurements of a structure using a Nortec 123 digital display ultrasonic testing instrument. The "123" is a surface application instrument and can be used underwater by placing it in an underwater housing.

To determine if a structure is protected from corrosion of salt water, this Oceaneering International diver uses a Bathycorrometer Mk. V to take cathodic potential measurements during a complete detailed underwater inspection. The "Bathy" was specifically designed for underwater inspection and uses a silver/silver chloride reference cell. A protected structure would normally have a reading of greater than 800 mV.



The diver uses the Seaprobe to measure the wall thickness of a structure. The Seaprobe is the first digital display ultrasonic testing instrument developed specifically for underwater applications.

Omitted Pages!
Printed below and on following pages is the complete group of panel responses that should have appeared in the Materials Evaluation Redi Reference Guide/83, Vol. 41, No. 4, tab 5. Readers should note in the Redi Reference that six pages were inadvertently omitted and that the complete group of responses appears in this issue.

SNT-TC-1A Interpretation Panel Responds to Inquiries

The SNT-TC-1A Interpretation Panel, headed by Edward Briggs, Chairman of the SNT-TC-1A Interpretation Panel of the Education and Qualification Council, was established to respond to written inquiries about *ASNT Recommended Practice No. SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing.*

Following are recent responses by the panel. The responses clarify the intent of the Technical Council and the recommendations of SNT-TC-1A.

Users of SNT-TC-1A are reminded that the document is intended as a guideline for employers to establish their own written practices for the qualification and certification of their NDT personnel. It is not intended for use as a strict specification.

5

The responses of the SNT-TC-1A Interpretation Panel should be considered as clarifications of intent and are subject to the statement in the "Scope" of the June 1975 Edition of SNT-TC-1A, Paragraph 1.4, "It is recognized that these guidelines may not be appropriate for certain applications. In developing his written practice as required by Paragraph 5, the employer shall review the detailed recommendations presented herein, and shall modify them as necessary to meet his particular needs"; and in the June 1980 Edition of SNT-TC-1A, Paragraph 1.4, "It is recognized that these guidelines may not be appropriate for certain employers' circumstances and/or applications. In developing a written practice as required in Para. 5, the employer shall review the detailed recommendations presented herein, and shall modify them as necessary to meet particular needs."

Inquiries published herein are in reference to the June 1975 and 1980 Editions of SNT-TC-1A. The first two numerals of each inquiry number show the year in which the inquiry was made. Some of the questions relating to the 1975 Edition have been more fully clarified in the June 1980 Edition. In addition, some areas of the document have been changed to further clarify the intent of SNT-TC-1A.

Inquiry 76-1:

Table 6.2.1A contains the statement "Credit for experience may be gained simultaneously in two or more disciplines. The candidate must spend at least 25 percent of his work time on each discipline for which experience is being claimed." Our question is this: Over what time period does the term "simultaneously" apply?

Response:

The employer's written practice should specify the time period over which simultaneous experience shall be credited.

Inquiry 76-2:

1. *For requalification of Levels I & II NDT personnel, does Paragraph 6.2.1 imply that you must keep continuous records by the hour showing that the individual has continuously spent at least 25 percent of his work time working in each method to which qualified?*
2. *Because of the 25 percent used in the note to Table 6.2.1A, it has been implied that an individual at maximum could be qualified in only four methods, and this would be true only if he could show that exactly 25 percent of his work time was spent in each of four methods. Was this the intent of SNT-TC-1A?*

Response:

1. No. Table 6.2.1A applies only to initial experience required for qualification; it is not applicable to requalification.
2. No. The candidate may be qualified in as many methods as desired. The 25 percent work time experience only applies to the work time experience required for initial qualification in each Level for each method. The 25 percent is not applicable and is not required for the individual to remain qualified in a particular method at a specific qualification Level.

General Comments:

Paragraph 6.2.1, like the rest of SNT-TC-1A, is only a guide. The employer's written practice should detail all such requirements, which may differ from the recommendations of Paragraph 6.2.1.

Inquiry 76-3:

Is it the intent of SNT-TC-1A that the Level I NDT persons described in Paragraph 4.3(a) of the 1975 June Edition of this document be the same as the Level I individual described in the 1968 SNT-TC-1A Edition Paragraph 4.1(a) with both having the same capabilities?

Response:

Yes. The changes in wording between the 1975 and the 1968 versions of SNT-TC-1A, insofar as the duties and capabilities of Level I personnel are concerned, were intended only to clarify the intent of the document. None of these changes in wording were intended as substantive changes.

Inquiry 76-4:

Paragraph 1.1 of SNT-TC-1A refers to individuals who "perform, witness, monitor or evaluate" nondestructive tests. Is it intended that individuals whose principal functions are to witness, monitor, or evaluate nondestructive tests be qualified in the same manner as those whose principal function is to perform nondestructive tests?

Response:

It is intended that the employer designate through the written practice as recommended in Paragraph 5 specific jobs that require knowledge of the technical principles of nondestructive testing. The employer should test the statement of Paragraph 1.1, ". . . personnel whose specific jobs require appropriate knowledge of the technical principles underlying the nondestructive tests they perform, witness, monitor, or evaluate," against the specific job elements of the personnel in question in order to establish whether or not the specific job requires knowledge of nondestructive testing.

Inquiry 76-5:

In accordance with SNT-TC-1A, 1975, may a Level I NDE person who has been trained, qualified and certified in accordance with SNT-TC-1A, 1975, be the sole person to perform, evaluate and sign for final acceptance of NDE examinations in accordance with written procedures and acceptance standards with occasional surveillance and guidance from a Level II or III?

Response:

Yes. The intent in SNT-TC-1A is that the Level I person may perform the above functions provided they are in accordance with written procedures and so documented in the employer's written practice.

Inquiry 77-1:

1. *Is it intended that the June 1975 edition of SNT-TC-1A including all recommendations therein completely replace prior editions of SNT-TC-1A?*
2. *Is it intended that personnel qualified and certified as recommended in the June 1975 edition of SNT-TC-1A be considered equivalent to those qualified and certified as recommended in previous editions of SNT-TC-1A?*

Response:

The answer is yes to both parts of the inquiry.

Inquiry 77-3:

With respect to Paragraphs 9.4 and 9.5 of SNT-TC-1A:

1. *Is it the intent to restrict an employer to engage only Level III services from an outside agency, or may Level I and Level II services also be utilized?*
2. *Is it intended in Paragraph 9.5 that an employer may subcontract training, examination and certification for all levels, provided the employer's audit results are found to be satisfactory?*
3. *Paragraph 9.1 states that the certification of all levels is the responsibility of the employer. Paragraph 9.5 recognizes the use of outside certification services. May an employer subcontract nondestructive testing to an outside organization utilizing that organization's certifications for Levels I, II and III provided the results of the employer's audit of that organization are satisfactory? Must the employer personally certify NDT personnel, or may he accept the outside organization's certification?*

Response:

1. It is intended that Level III services may be obtained from an outside agency for the purpose of training and examining NDT personnel. It is beyond the scope of SNT-TC-1A to recommend whether or not outside *inspection* services should be obtained. It is definitely *not* intended that the employer be restricted from utilizing *any* outside NDT services.
2. The intent of Paragraph 9.5 is to emphasize the responsibility of the employer to assure by audit that any and all parts of purchased services attendant to qualification and certification of NDT personnel are within the same guidelines that the employer himself would follow in accordance with his written practice.
3. The intent underlying Paragraph 9.1 is fundamental. When outside Level III services are used for the purpose of qualifying and certifying personnel, it is intended that the employer utilizing such services be responsible for assuring that those services are properly performed and audited. Whether or not the employer uses outside Level III services for training and examining his NDT personnel, the total responsibility for certification of all levels rests with the employer of the individuals.

SNT-TC-1A only provides guidelines for qualification and certification of NDT personnel. Outside services referred to in Paragraph 9 are those intended to be used by an employer only for the purposes of training, examining or otherwise qualifying individuals directly employed by the employer.

When the performance of NDT is subcontracted to an outside organization and the outside organization is the direct employer of the individual performing NDT, the outside organization is the "employer" in terms of SNT-TC-1A. Whether the outside organization is properly qualifying and certifying its NDT personnel can only be determined by the purchaser of such outside services, and how such determination is made is a contractual matter between the purchaser and the outside organization.

Inquiry 77-4:

May the experience requirements expressed as "certified NDT Level II" in Subparagraphs b., c., and d., in Paragraph 6.3.1 of the June 1975 edition of SNT-TC-1A, be considered to include experience gained in "an assignment comparable to that of an NDT Level II" (as stated in Paragraph 6.3.1[a]) in determining the prerequisite requirements of a candidate for certification as a Level III? If so, may this acceptance of experience in "an assignment comparable to" be extended to include similar subparagraphs under Paragraph X 2.5 of the earlier editions of SNT-TC-1A?

Response:

Paragraph 6.2 of the 1975 edition of SNT-TC-1A states, "Documented training and/or experience gained in positions and activities equivalent to those of Level II or Level III prior to establishment of the employer's written practice and a certification program in accordance with this document shall be considered as satisfying the criteria of Paragraph 6.2.1 and 6.3." If documentation was not produced during such prior experience, an affadavit or other suitable testimony regarding such experience may be evaluated by the employer to aid in determining equivalence. This response applies to the 1975 edition and all prior editions of SNT-TC-1A. (See 77-1 above.)

Inquiry 77-5:

With reference to Paragraph 8.5 of the 1975 edition of SNT-TC-1A, is it intended to limit the written specific examination to a closed book examination, without access to codes, specifications, and/or procedures?

Response:

It is intended that codes, specifications, and/or procedures are "necessary data" under Paragraph 8.5 of the 1975 edition of SNT-TC-1A, provided that examination questions are asked that require reference to such data and that such data cannot be used to answer questions related to other closed book portions of the examination.

Inquiry 77-6:

1. *Is it the intent of SNT-TC-1A that Level I, II, and III individuals certified to the recommendations of the 1968 edition meet the recommendations for certification in the 1975 edition?*
2. *If certification is transferred from the 1968 edition to the 1975 edition recommendations, which recommendations prevail regarding recertification?*

Response:

1. It is intended that individuals certified according to the recommendations of earlier editions of SNT-TC-1A meet the recommendations for certification in the 1975 edition.
2. The 1975 edition recommendations prevail regarding recertification.

Inquiry 77-8:

Level III personnel certified by ASNT do not receive examination grades. Paragraph 8.6 of SNT-TC-1A recommends arriving at a composite grade. How can this be accomplished since ASNT only

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supplies examination results in terms of pass or fail?

Response:

Published in *Materials Evaluation*, May 1978, page 21, is the "ASNT Position Paper on the Use of SNT-TC-1A and the ASNT Level III Certification Program." Under the heading "Certification Options" is the following:

> [The employer can] Incorporate into his written practice acceptance of ASNT Level III Certification as permitted in 9.4 of SNT-TC-1A for meeting *any or all* examination requirements of 8.5.3 (General, Specific and Practical) and assigning grading weight factors based on satisfactory performance, in accordance with 8.6.3 and 8.6.4.

Inquiry 77-10:

What is the intent regarding employers' attempts to verify an individual's experience and performance with past employers in order to maintain the documentation recommended in Paragraph 9.6.1?

Response:

The specific documentation to be furnished by new employees and past employers and the means for obtaining documentation is referenced in Paragraphs 9.6 and 10.2 of SNT-TC-1A. Details should be included in the employer's written practice.

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General Comment:

As published in *Materials Evaluation*, October 1977, in response to Inquiry 77-4, "If documentation was not produced during . . . prior experience, an affidavit or other suitable testimony regarding such experience may be evaluated by the employer . . . " While Inquiry 77-4 was related to a somewhat different matter, the intent behind the response applies equally to this inquiry (77-10).

Inquiry 77-12:

1. *Is it intended that an employer may use more than one outside agency for providing Level III services?*
2. *Is it intended that an employer may use Level III individuals in his direct employment and also use an outside agency for Level III services?*
3. *Is it intended that certification examinations may be administered without direct supervision and monitoring?*

Response:

1. There is no intent to restrict the number of outside agencies from which an employer could use Level III services.
2. Yes, both the above and this situation may be used under circumstances as described in the employer's written practice.
3. It is not intended that unsupervised examinations be administered.

Inquiry 77-13:

Regarding Paragraph 8.5.3.(a) of SNT-TC-1A, is it intended that the "30 questions from the NDT Level II questions for other applicable NDT methods" be selected from and represent every test discipline listed in Paragraph 8.5.2?

Response:

No, it is intended that the examiner select the questions *applicable* or appropriate to the product requirements of the particular case. This is a specific recommendation for examining Level III's and in no manner conflicts with the Level III qualifications of Paragraph 4.3.(c) of SNT-TC-1A.

Inquiry 78-1:

If a Level II examination is administered to a Level I individual, is there a need, when that individual is eligible for Level II Certification, to readminister the same Level II examination provided that all other criteria, for example, education, training and experience, have been satisfied?

Response:

It is not intended that the individual should be reexamined, provided the original Level II examination was passed and all applicable requirements of the employer's written practice have been met per Paragraph 8.1 of SNT-TC-1A.

Inquiry 78-2:

(Reference Inquiry 77-6, first published in Materials Evaluation, *October 1977). In order to clarify the response, is it intended that Level I, II and III individuals who have been certified to the recommendation of the 1968 edition automatically meet the recommendations for certification in the 1975 edition?*

Since the training hours were increased in the 1975 edition for certain level and discipline combinations above those recommended in the 1968 edition, is additional training and reexamination required to upgrade these individuals?

Response:

It is the intent that individuals certified in accordance with the recommendations of the 1968 edition can be automatically certified to the recommendation of the 1975 edition without additional training or experience. For recertification, it is intended that individuals should meet the guidelines of the 1975 edition as reflected in the employer's written practice.

Inquiry 78-3:

With reference to the note in Table 6.2.1A, "Credit for experience may be gained simultaneously in two or more disciplines. The candidate must spend at least 25% of his work time on each discipline for which experience is being claimed," is it intended that an individual being qualified in only one Method could obtain the work time experience in 25% of the times tabulated in Table 6.2.1A?

Response:

No, an individual being qualified in only one Method should spend at least 25% of his work time in that Method and should obtain the total work time experience as recommended in consecutive months as though the remainder of his work time was spent in qualifying for other NDT Methods simultaneously.

Inquiry 78-4:

1. *Regarding Paragraph 10.2 of SNT-TC-1A, does " . . . based on examination . . ." refer to examinations administered during prior employment or does it refer to new examinations to be administered by the new employer?*
2. *An individual can provide evidence or prior certification per Paragraph 10.2(a), but does not meet either paragraphs 10.2(b) or 10.2(c) which recommend that the individual was working in the capacity to which he had been certified and is being recertified within six months of his termination. What should be the basis of qualification for such an individual?*

Response:

1. It is intended that the examinations referred to in Paragraph 10.2 be administered by the new employer.
2. It is intended that an individual who has neither worked in the capacity to which previously certified in the past six months nor is being recertified within six months should have additional training and experience prior to recertification. The employer's written practice should detail such provisions.

Inquiry 78-6:

Is it the intent of SNT-TC-1A to recommend that the percentile weight factors of Paragraph 8.6.3 may be applied based upon differing job requirements of individual candidates, or should they be applied equally to all individuals within a particular level?

Response:

Percentile weight factors used should be within the ranges shown in SNT-TC-

1A, Paragraph 8.6.3. The specific percentile weight factors used should be clearly stated in the employer's written practice and should be based on the particular needs of the employer. The same weight factors should be used uniformly for all the employer's personnel seeking certification for given job requirements; however, the employer may change or modify the weight factors for different job requirements within a single level provided they remain within the ranges recommended in Paragraph 8.6.3.

Inquiry 78-7:

1. *Should personnel who operate digital thickness measurement equipment be qualified and certified?*
2. *To what level should such personnel be certified?*
3. *Does ASNT anticipate a change in SNT-TC-1A that would provide specific recommendations for qualifying and certifying such personnel?*

Response:

1. Whether any NDT personnel should be certified depends solely upon the needs of the employer and the requirements of the employer's customers or clientele.
2. Likewise, the level to which personnel should be certified depends upon the same factors as in 1., above. Note that Paragraph 4.1 of SNT-TC-1A provides for subdivision within the levels as needed.
3. Paragraph 1.4 and Paragraph 4.1 of SNT-TC-1A are intended to provide the employer with adequate flexibility to accommodate a variety of special needs as documented in the written practice. While the recommended Training Course Outline of SNT-TC-1A does not specifically address digital thickness measurement, the principles of pulse-echo techniques are those involved. The training course outline does provide for instruction in the employer's specific equipment uses, and, as with the remainder of SNT-TC-1A, the training course outline should be modified, if necessary, to meet employers' specific needs.

Inquiry 78-9:

Is it intended that personnel currently certified as NDT Level III within the guidelines of SNT-TC-1A who also regularly perform Level II functions be qualified as recommended in Paragraphs 8.2, 8.5.2, 8.6, and 9.7?

Response:

It is the opinion of the Panel that personnel currently certified as Level III may regularly perform Level II functions without specifically being qualified as Level II as recommended in Paragraph 8.2, 8.5.2, and 8.6 of SNT-TC-1A; however, as recommended in Paragraph 9.7, all levels should be periodically recertified.

General Comment:

Implicit in the definitions of Levels I, II, and III as outlined in Paragraphs 4.3(a), 4.3(b), and 4.3(c) is the concept that the qualifications for Level III equal and exceed those of Level II. The employer must be satisfied with the *proficiency* of any individual at any level to handle work tasks. SNT-TC-1A is not intended for use to determine an individual's *proficiency*. It is intended as a guideline to establish *qualifications*.

Inquiry 78-10:

1. *When an employee returns to work for a former employer where he was certified, may this employee's certification(s)be reinstated without examination if the provisions of Paragraphs 10.2(b) and 10.2(c) are met?*
2. *If an employee has been continuously working for another employer certified in the same capacities, may his certification(s) be reinstated for the remainder of the original three-year period of certification in accordance with Paragraph 9.7?*

Response:

1. The provisions of Paragraph 10.2 apply only to a new employer. For this part of the inquiry, the provisions of Paragraph 9.7.3 would prevail.
2. For this part of the inquiry, the receiving employer would be considered a new employer and the provisions of Paragraph 10.2 would apply. If, however, the employee in question was previously employed by the receiving employer, Paragraph 9.7.3 would prevail.

General Comment:

The principle behind "evidence of continuing satisfactory performance" in Paragraph 9.7.1(a) applies to employees originally certified by, and in continuous employment of, one employer. It is not envisioned that a new employer should prudently accept "evidence of continuing satisfactory performance" from a previous employer. Note that Paragraph 10.2 recommends recertification by examination of an employee by a *new* employer even if the conditions of 10.2(a), 10.2(b), and 10.2(c) are met to the new employer's satisfaction. The employer's rules covering the duration of interrupted service (Paragraph 9.7.3) should bear a reasonable relationship to the recommendations in Paragraph 10.2; however, in the case of interrupted service, the employer has direct knowledge of the employee's prior performance and can best judge the need for reexamination as a function of duration of interrupted service.

Inquiry 78-11:

1. *Regarding Paragraph 8.2.(a1) of SNT-TC-1A, is it intended that the personnel referred to in the statement, "The examination shall be administered by qualified personnel . . .," be qualified medical personnel or may a Certified Level III person administer the near distance acuity vision examination when a standard Jaeger test chart is used? It would appear that the qualifications necessary to administer such examinations would only include the capability to read, to identify the Jaeger chart and the appropriate parts thereof, and to be able to measure and maintain the 12-inch required reading distance.*
2. *Regarding Paragraph 8.2(a2), is it intended that the statement, ". . . as demonstrated by the practical examinations or test performance," refers to the practical examination of Paragraph 8.2(d), or does it refer to a special standardized eye test for color vision?*

Response:

1. It is intended that Level III personnel be allowed to administer the near distance vision acuity examination using the Jaeger chart. However, if the employer elects to use other methods of vision examination or the employer requires additional physical requirements as referred to in Paragraph 8.2(a3), it may be necessary to use personnel with other specialized qualifications to administer examinations for such additional requirements. The employer should include details of specific physical requirements and the qualifications required of examiners in the written practice.
2. It is intended that the practical examination referred to in Paragraph 8.2(a2) is that of Paragraph 8.2(d) and that such practical examination include checkpoints as appropriate to verify that the candidate's color vision capabilities are adequate to satisfy the specific needs imposed by the NDT method in question, the employer's test equipment, procedures, and products.

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Inquiry 79-1:

In maintaining records, if an individual is working simultaneously in more than one method, should the records reflect the total time spent for each method or should the time be divided proportionately for each of the methods? For example, if an individual spent 50% of his time on ultrasonic testing and 50% of his time on radiographic testing for a period of 9 months, should the record show experience in ultrasonic testing of

4½ months or 9 months?

Response:

It is intended that the employer's written practice should include details of maintaining records. It is intended that records should reflect the facts of each individual's work time with regard to the amount of time spent on each method and the periods of time during which the work was performed.

Inquiry 79-2:

Since NDT Level III general examination questions in some methods are available from ASNT (Questions and Answers for Qualifying NDT Level III Personnel, October 1977), is it intended that the Level III questions referred to in Paragraphs 8.4 and 8.5.3(a) be selected from those published by ASNT?

Response:

It is intended that the recommended 30 questions devised by the examiner for the appropriate method (Paragraph 8.5.3[a]) be devised or selected as appropriate to the degree required by the employer's written practice. As with all questions and answers provided by ASNT, they are suggested as guidelines and supplied as an aid to employers in preparing examinations. It is intended that the provisions of Paragraph 8.4 be superceded when questions of a character unique to Level III qualifications as delineated in Paragraph 4.3(c) are devised or selected by the employer for use in the Level III general examination. The additional 30 questions from Level II questions for other applicable NDT methods as recommended in Paragraph 8.5.3(a) are intended to be selected from methods other than that for which the candidate is being examined. It is intended that the employer use such questions to determine that the candidate has sufficient knowledge of other NDT methods that might be applicable to the employer's particular circumstances. For example, it could be appropriate that a candidate being examined for Level III qualification in a particular method be required to demonstrate basic knowledge in one or more other methods in order to "designate the particular test method and technique to be used." (See Paragraph 4.3[c])

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Inquiry 79-4:

1. *In Paragraph 8.2(a1), reference is made to a "standard Jaeger test chart." Of several reading cards available, which is considered standard?*
2. *In Paragraph 8.2(a1), the recommended distance for reading Jaeger Number 2 letters is "not less than 12 inches (30.5 cm)." On the reading card currently available from ASNT, the "designated distance in decimeters" for J2 letters is 5 decimeters or approximately 19.7 inches. Is it intended that the near distance vision acuity requirements be reduced by such a significant factor?*

Response:

1. The reading card intended to be considered standard is currently available from ASNT and was previously supplied by Bausch and Lomb. Bausch and Lomb no longer supplies such cards, but those bearing the title, Reading Card (Metric), with the notation at the bottom of the card reading, "The above letters are Snellen sizes at the designated distance in decimeters, with Jaeger notations at right," as previously supplied by Bausch and Lomb are equivalent to the card currently available from ASNT. Other cards bearing equivalent type size and body are also intended to be used.
2. The intent in Paragraph 8.2(a1) was to recommend a minimum distance. The employer's written practice should state the near distance vision acuity requirements for the particular circumstances of the employer.

Inquiry 79-13:

If an employee performs NDE to multiple codes, specifications and acceptance standards, is it necessary to include questions relating to each code, specification or acceptance standard in this specific examination?

Paragraph 9.6.1(c) requires records of educational background to be included in personnel records. Is information supplied by the employee (i.e., such as a resume or employment application) satisfactory evidence of educational accomplishments or is conclusive evidence (i.e., such as a copy of a diploma or transcript) required for verification?

Response:

It is the intent of Paragraph 8.2(c2) that the specific examination cover all codes, specifications and acceptance standards applicable to the employee's activities.

For further information, responses to similar questions were published in the October 1977 and October 1978 issues of *Materials Evaluation.*

Inquiries 79-14 and 79-15:

Is it intended per SNT-TC-1A 1975 that the time spent in a laboratory exercise during a long term NDE course be considered the only qualifying work time experience?

May the laboratory time be given any credit at all as "work time experience" to satisfy all the requirements in Table 6.2.1A?

Response:

It is not intended that laboratory experience in an educational program be directly applied to the work time experience. Laboratory experience is not necessarily applicable to the employer's product or to the specific codes, standards or specifications in use. However, in recognition of the benefits accruing from laboratory experience, the employer may include such consideration for adjustment to the work experience in his written practice. Should the employer decide to do so, he should thoroughly evaluate the curriculum to determine its applicability.

Inquiry 80-2:

In reference to the practical examination, there are several approaches that may be taken. For example, grades on check points could be given as 1 (correct) or 0 (incorrect) or could be given in a graduated fashion, say 0 to 5, depending on the correctness and efficiency of the application. Which approach is correct? Could a questionnaire for which written answers would be prepared as an alternative method of grading be used?

Response:

Please refer to Paragraphs 8.5.1(c) and 9.6.1(f). Either of the proposed grading methods is permissible depending on the needs of the employer. Other approaches may also be taken. The approach which meets the needs of the employer should be described in his written practice and followed for the practical examination. The last technique proposing a questionnaire for which written answers would be prepared would fall more appropriately under the specific examination category.

Inquiry 80-3:

A candidate spends 50 percent of his time performing radiography, 25 percent performing magnetic particle examinations and the remaining 25 percent performing liquid penetrant examinations. At the end of a one month period, assuming a 144 hour month, is Method A or Method B a correct computation of working time experience for certification to a Level I rating?
Method A: The candidate claims work time experience of 144 hours for each of the three methods.
Method B: The candidate claims work time experience of 72, 36 and 36 hours for radiography, magnetic particle and liquid penetrant, respectively.

Response:

These questions have been addressed in Inquiries 76-1, 76-2 and 78-3, which were published in *Materials Evaluation* in October 1977 and October 1978. As further clarification, the method described in Method A is that intended by the document. In other words, the examiner may claim full-time for all the NDT methods in which he works simultaneously. It is not intended he claim time for work hours spent in work other than nondestructive testing.

Inquiry 80-4:

NDE examiners in our employ who perform examinations using liquid penetrant use only the visible dye, solvent removable, penetrant technique. Since our examiners do not have need to be qualified in the other liquid penetrant techniques, is it permissible to modify the number of general and specific questions as well as the hours of training and work experience to satisfy requirements of SNT-TC-1A for Level I and Level II examiners?

Response:

Please refer to Inquiry No. 76-2, published in *Materials Evaluation* in October 1977, and Inquiry No. 77-13 published in *Materials Evaluation* in October 1978. It is the intent that SNT-TC-1A is a recommended practice and that it is a guideline which should be modified by the employer as necessary to meet his particular needs. The employer should determine his needs, determine the necessary qualifications of his examiners to meet those needs and describe those in his written practice.

Inquiry 80-6:

1. *How may we qualify supervisory personnel in accordance with SNT-TC-1A? Supervisory personnel would include quality control engineers in plants doing surveillance-type inspection.*
2. *Table 6.2.1A for SNT-TC-1A provides: "credit for experience may be gained simultaneously in two or more disciplines. The candidate must spend at least 25 percent of this work time on each discipline for which experience is being claimed." Does this statement mean (as it regards Level I PT) that if the candidate is already a qualified Level I or Level II radiographer, the one month work experience can be reduced to 44 hours?*

Response:

1. This inquiry is similar to Inquiry No. 76-4 which was answered in the October 1978 issue of *Materials Evaluation*. It must again be emphasized that SNT-TC-1A is a guideline to aid an employer in certifying his employees and the guidelines contained in that document should be modified to meet the employer needs.
2. It is the intent of this statement that a candidate may take credit for work performed in two methods simultaneously because of the knowledge interchange factor believed to be present in such activities. It is not intended that an examiner certified in one method could at some time later reduce the requirements for certification in another method except as defined in the employer's written practice.

Inquiry 80-7:

In the NDT Level II practical examination, 8.5.2(c), is it intended that the NDT Level II candidate demonstrate proficiency in all phases of the NDT operation, i.e., set up, calibration, inspection and interpretation?

Response:

Yes, it is intended that the Level II demonstrate proficiency in all phases of the operation for which the candidate is being certified. The employer's written practice should define the duties and needed knowledge.

Inquiry 80-8:

1. *May an employer deviate from the guidelines to meet his specific needs?*
2. *Is our company's specific written practice acceptable?*

Response:

1. Yes, in accordance with Paragraph 1.4 of SNT-TC-1A, the employer *should* modify the guidelines to meet his needs.
2. It is against ASNT policy to judge the applicability of company documents. As a general comment, it is the employer's prerogative to establish his criteria for certification. It is then his customer's prerogative to accept or reject those criteria.

Inquiry 80-9:

Is there an acceptable method by which a Level III may be certified by a new employer on the basis of Level III certification examinations administered by the former employer without examination?

Response:

As outlined in Paragraph 8.5.4, an employer may waive examination for an NDT Level III based on the candidate's demonstrated and documented ability, achievement, experience and education as defined in Paragraph 4.3(c) and 6.3. However, if the new employer desires that the certification be based on examination, then the employer must reexamine the candidate or obtain copies of the examinations taken by the candidate at the previous employer. This step is necessary to ensure the quality of the examination and to meet the documentation needs of Paragraph 9.6.1(f).

Inquiry 80-12:

1. *If a candidate does not spend 25% of his time in the method in a given period, e.g., one month, can he accumulate one month's credit, over a longer period, e.g., two months, and claim one month's experience?*
2. *What constitutes an NDT-related activity that may be identified in the employer's written practice? What percentage of time may be NDT related?*
3. *Can work experience prior to and in excess of the Level I requirements be applied to Level II experience requirements?*
4. *May documented experience at a level equivalent to NDT Level II in a company without a certification program be used by a new employer to fulfill experience requirements for Level II?*

Response:

1. No, the intent of the note to Table 6.2.1A (6.3.1) is that work time experience claimed for a specific period should be accumulated in that period. For example, to claim one month work time experience, the candidate should spend at least 44 hours (one-fourth of 175) in the method and the remaining work time (75%) of that month in NDT-related activities.
2. As stated in the note to Table 6.3.1 (1980 edition), the employer should define NDT-related activities. It is also intended that all work time experience claimed should be in NDT or its related activities.
3. Note (1) to Tables 6.3.1 (1980 edition) and 6.2.1A (1975 edition) indicate that the total NDT experience of the candidate may be applied to the requirements for Level II.
4. Yes, provided the experience is documented to the requirements of the new employer's written practice and the candidate passes the necessary examinations.

General Comment:

Please note that experience required for Level II includes work at both trainee and Level I levels. Work experience claimed for Level II should meet the experience required at these levels.

Inquiry 80-14:

There are certain differences in the 1975 and 1980 editions of SNT-TC-1A. Is it the intent that individuals qualified to the 1975 edition be certified as qualified to the 1980 edition without reexamination (where examinations have been used as the basis for qualification) when an organization chooses to upgrade their written practice to the 1980 edition?

Response:

Yes, it is the intent that individuals certified to the 1975 edition, whether by

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examination or by waiver in accordance with Paragraph 8.5.4 (1975 edition), are automatically certified to the 1980 edition when the employer chooses to upgrade his written practice to the 1980 edition. Subsequent recertifications should be to the guidelines of the later edition.

Inquiry 80-15:

What is the definition of "annual" as used in SNT-TC-1A, 1980 edition, Paragraph 8.1.1(4), "The examination should be administered on an annual basis."

Response:

The intent of this statement is that the examination should be administered every year with the interval between examinations not to exceed 12 months from the month of the examination.

Inquiry 81-1:

Is it the intent of Paragraph 8.2(a2) that individuals demonstrate the capability of distinguishing and differentiating contrast between colors on an annual basis or only upon certification and/or recertification?

Response:

The individual should demonstrate this capability upon original certification and upon recertification by practical examination or work performance. Normally, recertification occurs at three-year intervals.

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Inquiry 81-3:

The ASNT examinations for Level III are referred to as General and Practical. In the 1980 edition, these are Basic and Method. May I assume this is a change in terminology and that the examinations are equivalent?

Response:

The ASNT Level III examinations are titled "Basic" and "Method" as are the designated examinations in SNT-TC-1A, 1980 edition. It is intended that the ASNT Level III examinations satisfy the "General" and "Practical" examinations of SNT-TC-1A, 1975.

Inquiry 81-5:

Do the requirements identified in Table 6.2.1A (1975 edition) include (a) required performance of the test method by personnel for certification, or (b) personnel are to be employed where the test method is being utilized?

Response:

The intent of SNT-TC-1A is clear. Actual performance of work in the method is required for that time to be claimed as work experience.

Inquiry 81-9:

1. *May the President of an NDT company appoint himself as a Level III provided he is qualified?*
2. *May a Level III qualify NDT personnel for another company?*

Response:

1. An employer may certify any employee as Level III provided the individual has the qualifications required by the employer's written practice.
2. Yes, he may attest to the qualifications of an individual in another company. However, the individual must be certified by his own employer, not the aforementioned Level III.

Inquiry 81-12:

Paragraph 9.6.1(f) (1975) states that qualification records should include "copies of current examinations and of grades for all previous examinations and . . ." Does the phrase "grades for all previous examinations" imply grades for examinations by the present employer and/or previous employers and outside agencies?

Response:

Paragraph 9.6.1(f) (1975) applies to examinations administered by the present employer.

Inquiry 81-13:

Does on-the-job training in lieu of classroom training satisfy the requirement for organized training?

Response:

Paragraph 7.1 (1980) states that the personnel "should complete sufficient organized training to become thoroughly familiar with the principles and practices of the specified test method . . ." It is intended that the training be organized into a definite training program although the form of that training is not specified.

Inquiry 81-15:

Paragraph 8.1.1(2) states, "The examination should demonstrate the capability of distinguishing and differentiating contrast between colors used in the method." Does the Ishihara color chart satisfy this requirement?

Response:

Any means used to determine the individual's capabilities of color differentiation and distinguishing which (1) actually accomplishes the determination and (2) which is satisfactory to the employer and its customer should fulfill this requirement.

Inquiry 81-16:

Is it the intent of SNT-TC-1A that employers may prorate classroom training hour requirements for personnel with an education level between the educational levels defined in the document?

Response:

Table 6.3.1 and Paragraph 6.3.2 (1980 Edition) prorate classroom training hours based on education levels and experience for Levels I, II, and III certification. Prorating between those specified is a logical progression well within the intent of the 1975 and 1980 Editions.

Inquiry 82-1:

1. *Does Paragraph 4.1 (1975 Edition) permit qualification and certification under restrictive conditions, i.e. NDT Level II-R or Level II-S (restricted or surveillance)?*
2. *Do these subdivided levels referenced in Paragraph 4.1 need to comply with education, training, and experience requirements in Paragraph 6 and Table 6.2.1(a)?*

Response:

1. Paragraph 4.1 permits subdivision of the basic levels of qualification as needed to fit the employer's needs. The scope of these subdivisions may be greater or less than the guidelines of SNT-TC-1A.
2. Education, training, and experience guidelines of Paragraph 6 and Table 6.2.1(a) should be modified as appropriate to meet the needs of the subdivisions in accordance with Paragraph 4.1.

Inquiry 82-3:

Do the passing grades for Level III examinations of the 1980 Edition (i.e., 80 percent composite and 70 percent minimum on each examination) satisfy the requirements of the 1975 Edition (i.e., 90 percent and 80 percent, respectively)?

Response:

The passing grades for Level III examinations in the 1975 Edition are based on the use of Level II questions. Grades for the 1980 Edition are based on the use of Level III questions and are considered to meet the guidelines of the 1975 Edition.

Inquiry 82-4:

Table 6.3.1 (1980 Edition) requires experience in excess of one month in certain circumstances. May credit for one of those multimonth "specific periods" be given if the candidate spends at least 25 percent of the applicable period in the method and the remaining work time (75 percent) in that period *in NDT-related activities?*

Example: Three months' work time experience credited when a total of at least 132 hours are spent in penetrant testing during a three-calendar-month period while the remaining WTE (75 percent) in that period is spent in NDT-related activities.

Response:

The work time experience guidelines of Table 6.2.1(a) (1975 Edition) and Table 6.3.1 (1980 Edition) are total, accumulated work time experience levels. In accordance with Inquiry No. 76-1, the employer's written practice should specify the time period over which simultaneous experience shall be credited.

Inquiry 82-6:

SNT-TC-1A, 1975 Edition, Section 8.5.3(a) states: *"General Examination—Thirty questions devised by the examiner for the appropriate method, plus 30 questions from the NDT Level II questions for other applicable NDT methods, are to be answered." Inquiry No. 1—For each NDE method, must each Level III general examination contain a minimum of 60 questions? Inquiry No. 2—If Level III general examinations are administered in more than one method, is it permissible to not include the 30 Level II questions from other methods (i.e., general examinations consist of only 30 questions in method under consideration) and assume that the requirements of Section 8.5.3(a) have been satisfied?*

Response:

Paragraph 8.5.3, 1975 Edition, states that each General Examination should comprise 60 questions, 30 for the appropriate method and 30 NDT Level II questions for other applicable NDT methods.

Inquiry 82-7:

Who within a corporation is the employer as the term is used in SNT-TC-1A?

Response:

No one "within" the corporation is the "employer." The employer is the "corporation" as stated in Paragraph 2.1.(5): "Employer—The corporate, private, or public entity which employs personnel for wages, salary, fees, or other considerations." The employer's written practice should designate the Level III responsible for certification of Levels I and II individuals and the person responsible for certification of Level III personnel.

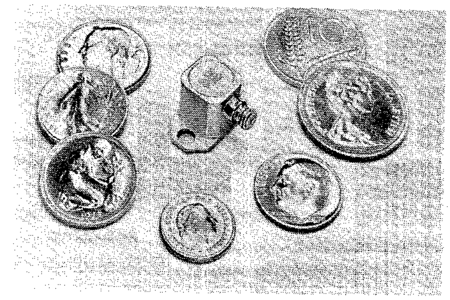
Rendezvous with Halley's Comet Scheduled for Acoustic Sensors

Early in 1986, dust impact sensors designed by Ching Feng of Dunegan/Endevco's research and application staff, San Juan Capistrano, CA, will help analyze the physical composition of Halley's Comet, heretofore approachable only by telescope and camera. This time it will be intercepted by a satellite equipped to learn more in a four-hour encounter than the total knowledge about comets accumulated by mankind to date.

The tiny sensors, which are highly sensitive microphones made by Dunegan/Endevco, are part of the Dust Impact Detection System (DIDSY) project being planned by scientists from the University of Kent in England as one of ten major scientific experiments making up mission Giotto, an undertaking of the European Space Agency.

Though Halley's Comet comes within sight of earth only once in a long human lifetime, every 75 years or so, it does that predictably. Every appearance since at least 239 BC in China, the comet's appearance has been recorded. The Italian painter Giotto had a chance to see it in 1301; he knew it had appeared around 11 BC and made it prominent in the sky when he painted "The Adoration of the Magi" on a chapel wall in Padua. The English astronomer Edmund Halley saw the comet a few cycles later, in 1682. He calculated its orbit, correctly predicting its next return (after his own death), and his name became its name.

Now, space contractors from nine European countries, led by the Space and Communications Division of British



Dunegan/Endevco's Dust Impact Sensor.

Aerospace, are preparing to construct the satellite Giotto, and international teams of scientists are specifying and testing equipment that will go aloft to carry out the planned experiments.

Giotto will intercept Halley at about 93 million miles from earth in February 1986, eight months after its send-off by the European satellite launcher Ariane from Kourou, French Guiana. During the encounter, dust particles in the comet's tail will strike the satellite, and the DIDSY sensors will pick up the sound of that impact, sending the resulting signals back to mission Giotto monitoring stations on earth. Because those acoustic signatures will be related to the detected momentum of impact, they will provide potentially useful evidence about the mass of the dust particles. That information, along with photographic, magnetic, and chemical data gathered by other Giotto experiments, should help answer some long-standing questions about the composition and origin of comets.

Halley's Comet as seen from Flagstaff, AZ, May 10, 1910.

Section News

President's Award Winner: Cleveland
Runners-up: Old Dominion, Northeast Florida, Houston

Arizona

Twenty-two members and guests attended the January 12 Section meeting, which was the Annual Guest Night and Award's Presentation. Everyone enjoyed barbecued steak, baked beans, and salad; Kachina Testing Laboratories sponsored the bar for the evening.

Twelve awards were presented, and a special award was given to Doug Watson for his outstanding contributions to the Section.

Boston

The Section's January 12 meeting was out of the normal routine: For the first time, the Section attempted a "Stump the Experts Night." All 22 members in attendance had a chance to participate. Each member was assigned to a team, and the MC and questioner for the event, Ken Baker, then asked each team an NDT question. A correctly answered question scored one point for the team. If answered incorrectly, the question was passed on to the next team.

Everyone who participated thought it was a great night and learned something as well. The winning team, by the way, earned a "congratulations!" The team consisted of Section Chairman Tom McCarty, Jimmy Rowe, Dave Garland, and Al Broz.

Brazosport

Twenty-six Section members and guests met in Lake Jackson, TX, for the January 11 Section meeting. They heard a presentation by Syl A. Viaclovsky of McClellan Engineers of Houston.

Viaclovsky, a registered engineer and a member of the ASNT Visual Inspection Task Force, spoke on visual testing as a primary method as well as how it interrelates with other methods.

Chesapeake Bay

The January 17 Section meeting was attended by 45 members and guests. James W. Wagner, Food and Drug Administration (FDA), Center for Medical Device Analysis, presented a talk on "Holographic Nondestructive Testing of Medical Devices." His talk focused on the ongoing work at the FDA center and the development of holographic techniques for measuring surface roughness and contour of medical implant devices such as pacemaker packages.

Chicago

Forty-two members and guests attended the Section's annual Vendor's Night on January 3 in Countryside, IL.

Current products and services and a preview of new equipment were presented by ten area representatives, including Balteau Electric, Berg Engineering and Sales, Conam Inspection, K. J. Law Engineers, LIXI Inc., Magnaflux Quality Services, Magnaflux Corp., NDX Corp., Sigma Research Inc., and Sonoscan Inc.

Cleveland

Twenty-seven members and guests attended the January 17 Section meeting in Brecksville, OH.

Guest Speaker Kenneth C. Walla of Babcock & Wilcox discussed "Nondestructive Examination Techniques Developed for Breeder Reactor Steam Generator Tubing Welds." This was the first time information of this type had been presented in the area, and everyone enjoyed the new material.

In addition to the normal program, the Section hald a 50/50 raffle with the proceeds going to a charity in the name of the Cleveland Section.

Colorado

A joint ASNT/ASQC meeting was held on January 17 with 167 members and

Cleveland Section Vice-Chairman Louis J. Elliott, right, presents a gift to Guest Speaker Kenneth C. Walla.

In Memoriam

Larry Barrett, an ASNT Fellow and an officer of the Old Dominion Section, died February 13 of a heart attack.

Barrett worked for General Electric Co., Apparatus Service Business Division, where he managed manufacturing engineering and quality assurance in the Richmond, VA, shop.

A 25-year member of ASNT, he had been previously active with the Miami Valley Section (1966–71) and the Mohawk Hudson Section (1972–80). He served the Old Dominion Section as Educational Chairman for the past two years.

Barrett belonged to the Personnel Qualification Division of the ASNT Education and Qualification Council.

He is survived by his wife, Mary Lou, and son, Robert.

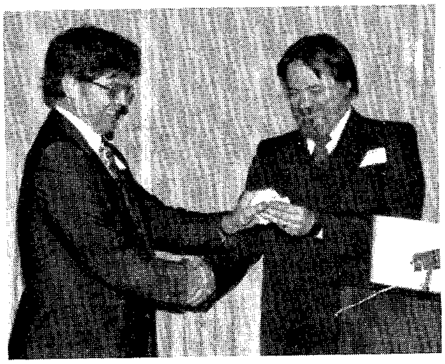
Julian R. Frederick of Ann Arbor, MI, passed away February 28. A longtime ASNT member, author, 1978 ASNT Lester Honor Lecturer, 1980 ASNT Tutorial Citation winner, and an ASNT Fellow, Frederick retired from his post as professor of mechanical engineering at the University of Michigan in May 1981. He had taught in that department since 1957.

He was a Past Chairman of the Detroit Section of ASNT and a past chairman of the Acoustic Emission Working Group. He was also active in ASTM and in boiler and pressure vessel code work in ASME.

Frederick received his Ph.D. in physics from the University of Michigan in 1947. As a research associate working at the university from 1940–45, he assisted F. A. Firestone, the inventor of the ultrasonic reflectoscope. Frederick participated in the design and construction of early reflectoscope models in the investigation of the properties and uses of ultrasonics in NDT.

His last work at the university had involved NDT research and failure analysis.

Julian Frederick



Frank J. Sattler, left, receives from Louis Elliott the prize from the **Cleveland** Section 50/50 raffle.

From left, Mary and Dan Ford, Cyrilla Quinn, and Rene and Ron Phillips enjoy **Connecticut Valley's** Ladies' Night.

guests in attendance. They heard Rudolph J. Dichtl of The Ball Aerospace Division give a review of the background and research of "The Shroud of Turin" research project. Dichtl was one of three formative members of the project.

A special thanks goes to T. Tedrow, Vice-Chairman of the Section, for putting the cosponsored event together.

Connecticut Valley

Twenty-six members and wives attended the Section's Ladies' Christmas Party on December 4.

On January 18, 22 members attended a Section meeting at which Al Vargas, field applications manager of Physical Acoustics Corporation, presented a talk on acoustics as a major NDT technology. Plans for the annual Spring Social as well as the J. Geagan annual golf tournament were announced. The J. M. Devine Company hosted cocktails prior to dinner.

Don Naber, right, thanks Al Vargas for his presentation to the **Connecticut Valley** Section.

Detroit

Twenty-nine members met on January 17 for a technical session chaired by George Nygaard. Guest Speaker R. M. Grant, president of Industrial Holographics, a company that manufactures laser-interferometric NDT equipment, discussed his recent work.

Grant has a distinguished background as an inventor and developer of NDT systems based on laser interferometry; he reported to the well-attended Section meeting of his work in the development and application of state-of-the-art laser interferometry and shearography for full-field optical inspection techniques.

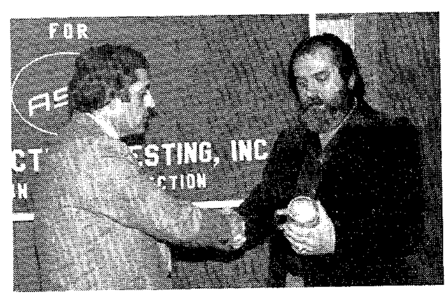
Section Chairman Jerry Nelson reported that the Section meetings have had good attendance in support of a strong technical program.

Greater Philadelphia

Twenty members and guests attended the January 6 Section meeting in Lionville, PA. ASNT National Treasurer William E. Widner of the General Electric Company spoke on the state of ASNT's national organization in an after-dinner talk titled, "Where We Are and Where We Are Going."

Hampton Roads

Fourteen members and guests attended the January 11 technical meeting of the Section in Hampton, VA. Guest Speaker Jerry Whitlock, chief of operations for the NASA Langley/City of Hampton Refused Fired Steam Plant, discussed the engineering, construction, and operational characteristics of this unique plant.



Guest Speaker Jerry Whitlock, right, accepts a pewter mug from **Hampton Roads** Vice-Chairman Trent.

Enjoying the dinner are **Colorado** Section members and guests (l-r) Darlene Corbin, Molly and Bruce Peters, and Bill Yeager.

Metro New York-Northern New Jersey

Fifty-three members and guests attended the Section's Sponsors' Night on January 12 in Totowa, NJ.

Twelve of the Section's 22 sponsors elected to participate with a tabletop display. Instead of a guest speaker, sponsor representatives were given the opportunity to speak briefly about their companies and to answer any questions.

Mid-Indiana

J. T. Schmidt, manager of chemical services, Magnaflux Corporation, Chicago, was the guest speaker for the Section's "Magnetic Particle Night" on January 10.

Twenty-two members heard Schmidt's talk, which covered the testing of magnetic particle inspection materials to determine their abilities and short-comings. Also discussed were the properties that make a good material. A short question and answer session followed, and Section Chairman Ralph Forthman announced the details of the new ASNT membership contest.

Minnesota

The second annual "Stump the Experts" night was held by the Section on January 20 in Minneapolis. Six teams competed with 33 people in attendance.

The glory and a floating trophy were garnered by the MPL Central team in a heated competition. Special thanks go to the Hutchinson Vo-Tech Institute for their work in organizing and presenting the event.

Missouri Valley

Thirty-one members and guests attended the January 5 Section meeting at which Steward Slykhous, West Coast regional manager of the Physical Acoustics Corporation, was the guest speaker.

Slykhous' program was "Acoustic Emission for Industrial Application"; it included a slide presentation along with a detailed talk on acoustic emission. Slykhous also demonstrated the use of acoustic emission instruments and received a wall plaque from Section Chairman Glenn Miller.

Nashville

After a Section business meeting, 14 members and 3 guests traveled to Avco Aero Structures Plant in Nashville on January 10 for a tour of the plant's facilities.

A. O. Arnold of the NDT Department of Avco Aero Structures conducted the tour; he was assisted by Randy White of the Testing Lab. At the lab, the different NDT uses were displayed. A tour of the plant followed the lab visit and was concluded nearly three hours later.

John Godfrey of the Pittsburgh Testing Lab was the winner of the Section's monthly $25.00 door prize.

New Orleans

The Section met on January 20 in Gretna, LA, with 31 members and guests present. A short business meeting was followed by a talk from Guest Speaker Charles Saucier, quality auditor for POSSI (Petroleum Operations and Support Services Inc.).

Saucier discussed the true meaning of quality, beginning with the dictionary's definition and ending with the way females choose their husbands.

Door prizes were won by Mel Sorrells of Mobile Labs Inc., Joe Bush of Avondale Shipyards Inc., and Dennis Ross of Magnaflux Inc.

New Orleans Chairman Bill Summerville, standing, conducts business.

Northeast Florida

Twenty-eight members and guests were present at the Section's January 25 meeting at the Jacksonville Shipyards. The Section's Educational Committee reported that the "hands on" program scheduled to be given to classes in April was progressing well and would be held at the Jacksonville Shipyards for all members. W. Strate introduced Robert Metzler, a new member, and two prospective new members.

After other business was reported, Section Chairman Charles Moore introduced Beth Risinger from ASNT National Headquarters. She presented a slide show and a running documentary of her trip to Moscow for the Tenth World Conference on NDT, August 22–28, 1982. Risinger was presented a plaque in appreciation for her visit to the Section.

Northern New England

Thirty members and guests attended the January 26 Section meeting in Portsmouth, NH. Guest Speaker Chuck Hellier, Operations Manager of Brand Examination Services and Testing Company, spoke on "Innovations Within the NDT Disciplines."

During the meeting, members were notified of the spring social that would be attended by all the New England Sections.

Oak Ridge

Twelve members attending the January 11 meeting in Oak Ridge, TN, heard Guest Speaker James H. Smith, a local member, discuss the "Application of Eddy Currents to Seam Weld Inspection." Smith, employed by the Metals and Ceramics Division of the Oak Ridge National Laboratory, substituted for the scheduled guest speaker, John Aman of E. I. du Pont de Nemours, who was unable to attend.

Guest Speaker J. H. Smith gives a presentation to the **Oak Ridge** Section.

Oklahoma

Forty-two members attended the January 20 Section meeting. All officers and committee chairmen gave reports concerning their areas of responsibility.

Because the Section owns several good audio-visual educational programs, its usual format of having a guest speaker for the meeting was waived. Instead, two short filmstrips were shown; one covered basic metallurgy, and the other was from the radiography training program. The Section hopes more of its members will utilize these training programs.

Old Dominion

Forty-one members and guests gathered on January 25 in Richmond, VA, to hear H. L. Travis of the Virginia Electric and Power Company (VEPCO) give a presentation on "The Role of NDE in the Nuclear Power Industry."

Travis is an NDT Level III and a Charter Member of the Section. In his talk, he stressed the many NDE inspection techniques used in the nuclear industry and provided examples to show how NDE is used to verify the reliability of operation of the VEPCO installations.

Pacific Northwest

Forty-one members, including ASNT National President Bill Kitson, attended the January 7 Section meeting.

Guest Speaker Marty Martinez of ATACS Products, Renton, WA, discussed the repair of composites in the field and in-house. He stressed that the relationships with the parent material and the repair are of prime importance for all composite repairs.

Pittsburgh

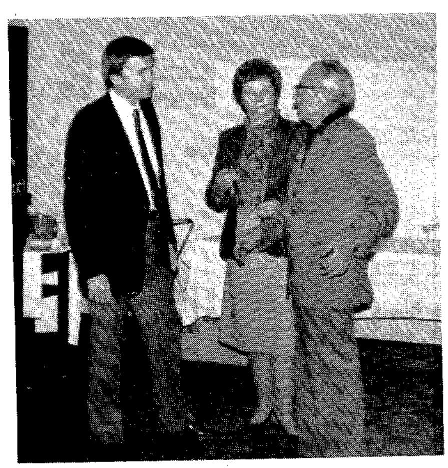
A record crowd of 51 members and guests attended the Section's January 20 meeting in Monroeville, PA.

The group welcomed Guest Speaker Bill Kitson, ASNT National President, and his wife, Jean, and listened to a talk on "ASNT and Nondestructive Testing."

Pittsburgh Section Program Chairman Pete Gabriele, left, presents Guest Speaker William Kitson, ASNT National President, a token of appreciation.

Sacramento

Thirty-nine members and students attended the December 8 Section Christmas dinner-meeting. Guest Speaker Bill Kitson, ASNT National President, discussed the philosophies and future directions of ASNT. In addition to Bill and his wife Jean, also present were Bill Widner, ASNT National Treasurer, and Ken Jakabcin, an ASNT National Director.



From left, Bill Kitson, Jean Kitson, and Bill Hitt, ASNT Past National President, discuss an NDT item at the **Sacramento** meeting.

From left are Bill Kitson, Claude Dunn, Luke Lee (Education Chairman), and Kathleen O'Hara. Bill Kitson presents O'Hara with a $50 Student Grant from the **Sacramento** Section.

Winner of the $50 Student Grant provided by the Section was Kathleen O'Hara of Sacramento City College. Winner of the Logo Contest was Section Chairman Claude Dunn.

The meeting was topped off with Santa Claude handing out door prizes to lucky winners.

St. Louis

Approximately 35 members attended the January 12 Section meeting. Guest Speaker Don Earl Edwards of Intec Inspection Inc. made a presentation of "Oilfield Pipeline NDT."

The highlight of Edward's program was a 16-mm film on the trials and tribulations of constructing the Alaskan Pipeline.

As a member of the ASNT National Board of Directors, Edwards also discussed ASNT's national organization.

South Bay

Eleven members attended the January 12 "Problems/Solutions Night" in San Jose, CA. After a preliminary business meeting, Section members were encouraged to participate in the discussion of unique, interesting, and challenging NDT problems.

Guest Speaker Gary Dau of the Electric Power and Research Institute informed the group of the inroads being made in the nuclear power industry NDE program. In particular, he discussed the Nuclear Regulatory Commission (NRC) and its concern for certification of nuclear NDT workers, utility plant qualification, and pressure vessel inspection. With NRC support, an Ad Hoc Committee consisting of the utility members was assembled to draft qualification and certification standards with ASNT acting as technical liaison. A draft proposal is due for review by April. The NRC supports the utility industry's move for self-regulation.

South Florida

Fourteen members and guests attended the January 18 Section meeting. Guest Speaker Chuck Hellier of Brand Ex-

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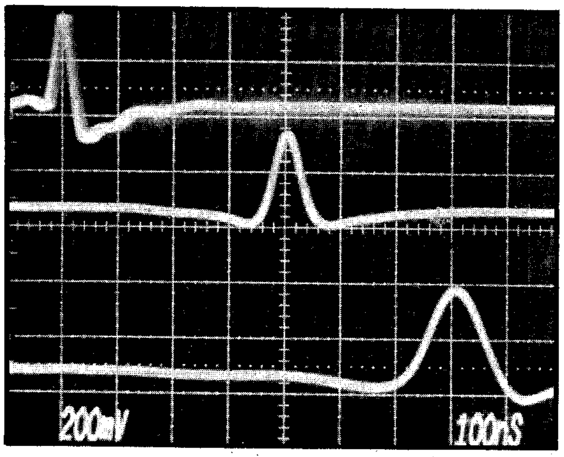
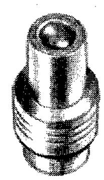
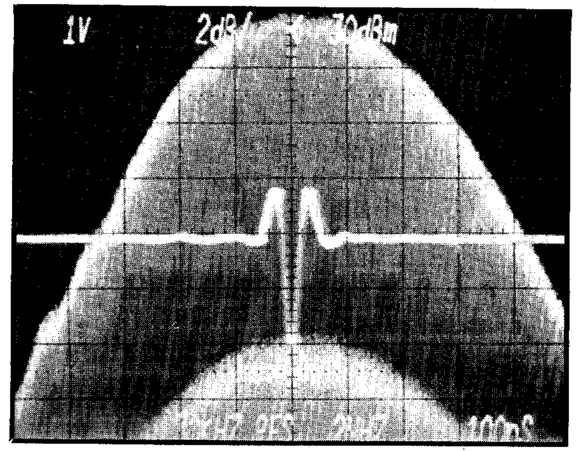
LAMBDA TRANSDUCERS:
For Optimum Resolution







Top: RF envelope of a 10MHz LAMBDA; 50 nanosec.
Middle: RF envelope of a 5MHz LAMBDA; 100 nanosec.
Bottom: RF envelope of a 3MHz LAMBDA; 200 nanosec.

Typical real time and frequency analysis of a 10MHz LAMBDA transducer. Peak frequency: 10MHz; Bandwidth at -6dB: 13MHz.

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- Characterization of advanced composites and ceramics
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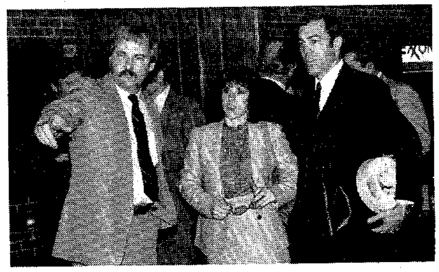
South Florida Section Chairman Dan Schacter, left, presents a plaque to Guest Speaker Chuck Hellier.

amination Services and Testing Company gave a talk and presentation on "Innovations in NDT."

Tri-State

Thirty-three members and guests attended the January 6 Section meeting in Barboursville, WV. It was an occasion for the Section's first annual "Bosses' Night" in which there was a good representation of management present.

The program, titled "ASNT—What It Can Do for You," was presented by Scott W. Matheson, ASNT Managing Director, and Karen Konich, Supervisor of Membership Services. It was a very enlightening presentation that was well received by all present. The Section learned a lot about ASNT and was impressed by the facilities in Columbus, OH.



From left are **Tri-State** Vice-Chairman Delbert Artrip, Karen Konich, and Scott Matheson.

Tri-State Membership Co-Chairman David F. McLaughlin, left, Karen Konich, and Membership Co-Chairman Ron F. Lewis discuss Section membership.

Western New York

Twenty-five members attended the Section's January 12 meeting.

Section Contributes to Karr Fund

Gratitude is expressed to the **ASNT Golden Gate Section** for its generous contribution to the ASNT Karr Fund. Golden Gate is one of only two Sections (the other is Cleveland) that have contributed to help sponsor ASNT staff member Darlene Karr in her competitions as a member of the U.S. Women's Karate Team.

Karr now readies for competition in Caracas, Venezuela, this summer. Contributions of any amount are welcome and should be sent to **ASNT Karr Fund, 4153 Arlingate Plaza, Caller #28518, Columbus, OH 43228.** To date, 50 individuals, 3 companies, and the two Sections have made donations.

ASNT welcomes new corporate members for the month of February.

Diversified Measurements Instruments, Inc.
Laguna Hills, CA
Elano East Corp.
Rowley, MA
Ico-Universal Tubular Services
Houston, TX
S & H Diving Corp.
Houston, TX
United States Testing Co. Pte. Ltd.
Singapore

Handbook Chapter Released

ASNT has released Chapter 5, "Film and Paper Radiography," from the *Nondestructive Testing Handbook*, second edition, Volume 3, *Radiography and Radiation Testing*.

Co-author Richard Quinn of the Eastman Kodak Co. has updated portions of the classic *Radiography in Modern Industry* for this chapter. The text covers radiographic geometric principles, exposure variables and their relationships, radiation absorption in the specimen, radiographic screens, radiographic films, and more.

Co-author J. C. Domanus of Risø National Laboratory, Denmark, has contributed information on paper radiography. Characteristic curves, exposure charts, applications and interpretation of paper radiographs are included. Storage, handling, and processing of paper, along with concise comparisons to film radiography conclude this comprehensive chapter.

Chapter 5, "Film and Paper Radiography," is available for $10 to ASNT members, $12 to nonmembers (ASNT catalog #005).

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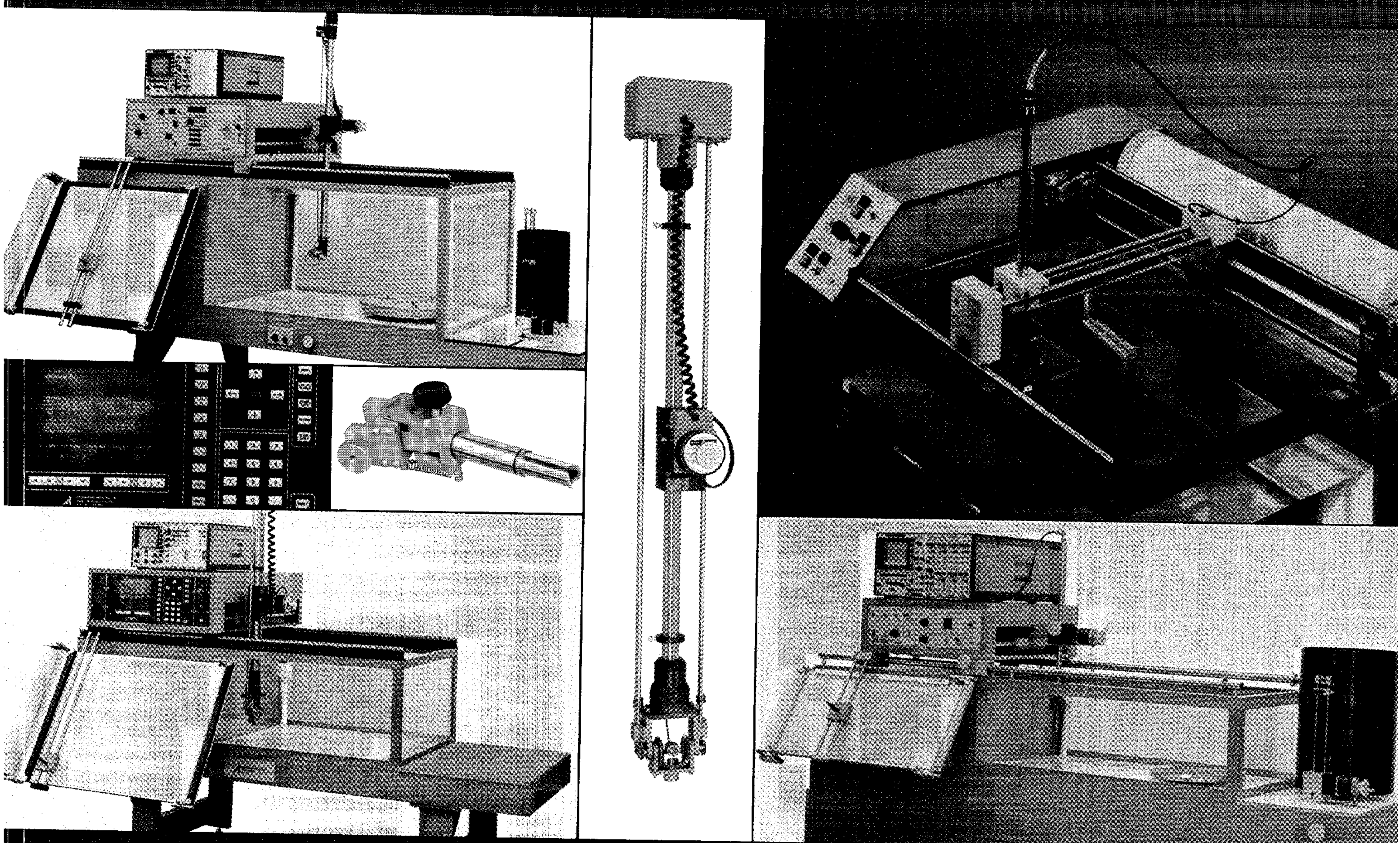
Are you looking for... cracks... inclusions... porosity... lack of fusion... delamination... debonding... voids? Automation Industries lab scanners can help you find them.

Is your material shaped like... a cone... a bar... a disc... a cylinder... a shaft... a plate... a pipe, or is it irregular? Automation Industries lab scanners can scan it.

Do you need rectilinear, polar, or helical C-scan recordings? Automation Industries lab scanners can plot them.

Whatever your requirements, we probably manufacture a standard ultrasonic lab scanner for your needs. In fact, you might be pleasantly surprised to learn your specific application may be quite similar to an application problem we've already solved from our years of ultrasonic experience. You could find out by calling today.



AUTOMATION INDUSTRIES, INC.
SPERRY PRODUCTS DIVISION
20327 NORDHOFF STREET
CHATSWORTH, CALIFORNIA 91311
(213) 882-2600

New Products & Services

For additional information on any of these items, circle the corresponding number on the reader service card at the back of the magazine. Listed items are not endorsed or recommended by ASNT.

RT Tape Identification

Inspection and Technical Research (ITR) Services Ltd., Norfolk, United Kingdom, has introduced a method for identifying components on radiographs.

Called Pressident Tape, it has been designed to aid the technician in the accurate, speedy, and neat production of "idents." The idents are printed out using a handheld embossing gun. A 20-letter ident can be made in approximately 45 to 60 s, as compared to 4 to 5 min using the conventional lead letter system.

The ITR tape is compact and lightweight—only 540 g for the dispenser with sufficient tape for approximately twenty-five 20-letter idents. The tape is self-adhesive and will adhere to most surfaces under normal conditions. The idents can be left on the component if a permanent record of inspection is required. The practical range of the tape is from 25 kV up to 300 kV, and it can be used for most techniques.

Circle 211

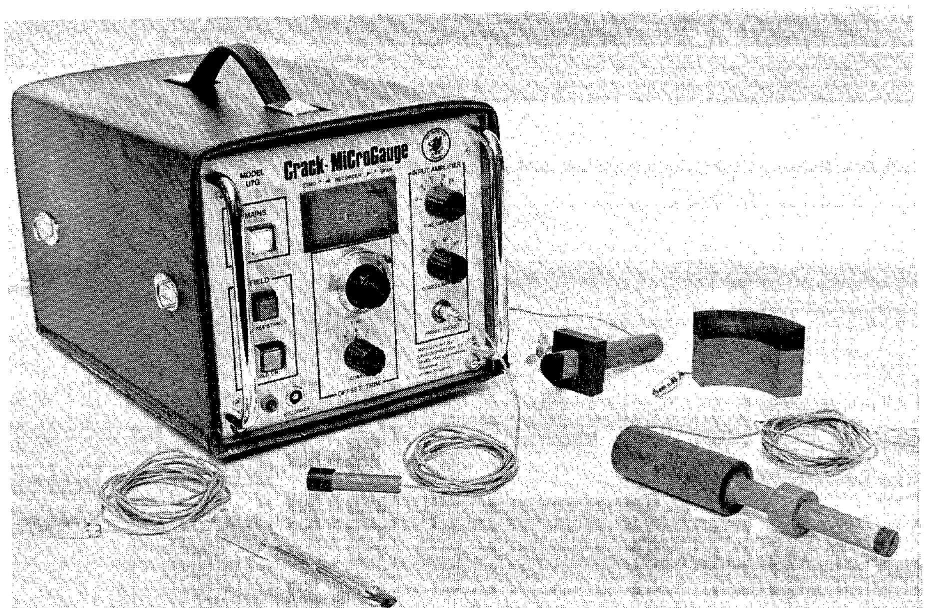
Crack Depth Instrument

Hocking Electronics, Temple Hills, MD, is the U.S. distributor for the Crack MiCroGauge, manufactured by the Unit Inspection Company, Sketty Hall, Swansea, England. The instrument uses alternating current field measurements to determine the depth of surface cracks in metals. An "Instrument Review" on the Crack MiCroGauge, including its theory and applications, appeared in the February, 1983, issue of *Materials Evaluation.*

The instrument can provide accurate and repeatable crack depth values in virtually any metal. A variety of probe configurations allow testing on corners, edges, and bolt holes, as well as on flat surfaces. Typical applications include on-site measurement of cracking in steel structures, process plants, and engineering components.

The instrument is easy to set up and operate. Test results are not influenced by the usual material variables. As a result, there is no need for calibration prior to testing different metals, and measurements are not influenced by variations in test material temperature.

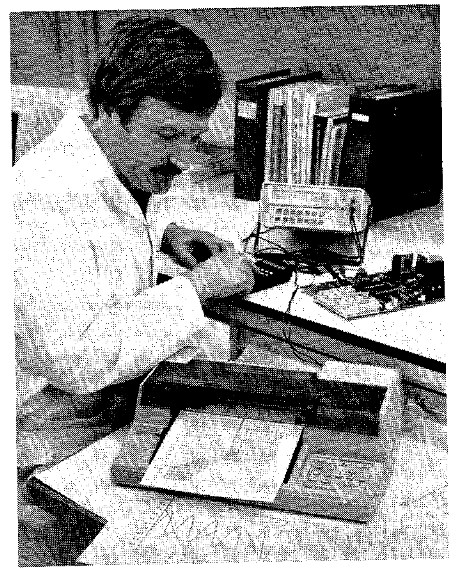
Circle 212



Plotter Module for Handheld Computers

A system for generating graphics and bar code with handheld computers has been introduced by the Hewlett-Packard Company, Palo Alto, CA. With the introduction of a plotter module, handheld computers can be linked to a color graphics plotter, and users can plot charts, graphs, and bar code.

The HP-41 handheld computer, with the plotter module, is connected to the HP 7470 graphics plotter via the Hewlett-Packard interface loop (HP-IL). A new HP-IL-compatible version of the plotter (HP 7470 Option 003) is being introduced concurrently with the plotter module. The HP-41, with the attachments, can be used for remote data collection and quick creation of graphic presentations of the data for interpretation, analysis, and review. Data such as temperature and stress can be charted after recording in remote areas and hostile environments with the HP-41C. In addition to bench-top laboratory measurements, major remote applications include stress testing, portable medical measurement systems, and data gathering on the factory floor where it is impractical to carry around large instruments to check or monitor manufacturing processes.



Bar code can be created for the HP 82153A optical wand and scanning devices in other bar-code systems. The plotter module also permits users to create HP-41 bar code on the HP 82162 thermal printer. The plotter module's utility plotting program contains five plotting routines that can generate a math-function plot or a series of points. Multicolor line graphs, bar charts, and text pages also can be created.

Fast plotting is made possible by special paper-moving technology. The plotter grips paper or overhead-transparency film and moves it back and forth across the platen for plotting along the X-axis, while pen movement locates points along the Y-axis. This movement of both paper and pen allows plotting of lines at speeds of up to 15 in. (38 cm) per second.

Circle 213

Thermoplastic Recording Film

Newport Corporation, Fountain Valley, CA, has introduced a thermoplastic recording film with improved spectral sensitivity to include efficient operation at the ruby laser wavelength (6943A). Holographic diffraction efficiencies exceeding 10 percent can now be obtained with exposures of less than 10 ergs/cm^2. This compares favorably with the fastest conventional silver halide materials that require 20 ergs/cm^2 for holograms with less than 3 percent efficiency before bleaching. As before, the image quality is better both in clarity and resolution. The cost per shot is also reduced. The automatic controller can be set so that each erasable film plate can be used between 800 to 1200 times, making the cost per shot less than 25 cents.

Holograms recorded in reusable thermoplastic film have become a cost effective way to do production testing and quality control. Add to this the convenience of fast, electronic, chemical-free, in situ processing, and one can see why holography is finding better acceptance as an engineering tool.

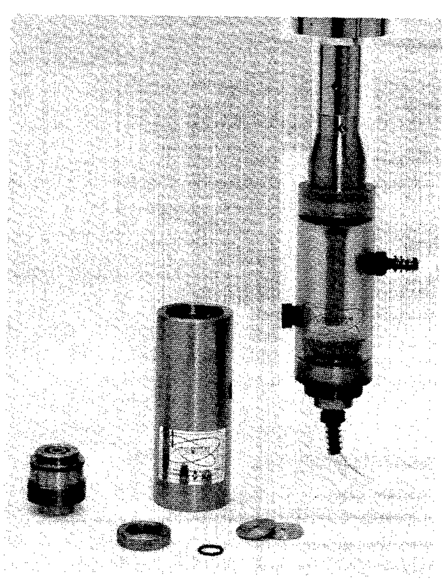
Circle 214

Continuous Ultrasonic Processing Cells

Heat Systems-Ultrasonics, Inc., Farmingdale, NY, has introduced Flocell® continuous processing cells, which are specifically designed for the ultrasonic treatment of liquids. Now available in Teflon® and Nylon® as well as in Lexan® polycarbonate and stainless steel, these chambers fit directly on the Sonicator® cell disruptor/liquid processor and similar devices. With variable sonication annulus and orifice size, the units are built to assure 100 percent treatment of the product, allowing introduction of one or more constituents into a controlled, intense ultrasonic field.

Flocell chambers are used in any area of research or production where homogenization, emulsification, or disruption of flowing materials is required. Typical applications for the product include large scale production of vaccines and antigens, emulsification of oil and water, removal of cell walls, dispersement of metal oxides in solvents, and on-line degassing. Flocell chambers can also be used to develop up-scale data for large scale processing requirements.

Circle 215



On-Line Automatic Laser Inspection System

Intec Corp., Trumbull, CT, has introduced a microprocessor-based system for real-time quality management. Mounted directly on the process line, the Intec System 6000 high-speed scanner sweeps (up to 6000 times per second) a laser beam across the width of the moving web. An optical receiver is positioned to collect either reflected or transmitted light. Variations in the light intensity correspond to variations in the web or defects.

The operator interface has been simplified with a centralized console—the Quality Control Center—that features an interactive color video to guide even an untrained operator in the use of the system. After the operator enters the product code on the touch-sensitive keyboard, for example, the system takes over, identifying defects at full line speeds, alarming when defects exceed quality specifications, and marking defective areas of the web. When operator intervention is necessary, the video displays present an instantaneous yet accurate snapshot of current roll quality, all in operator language. Process correction may be made at once, saving thousands of feet of out-of-spec product.

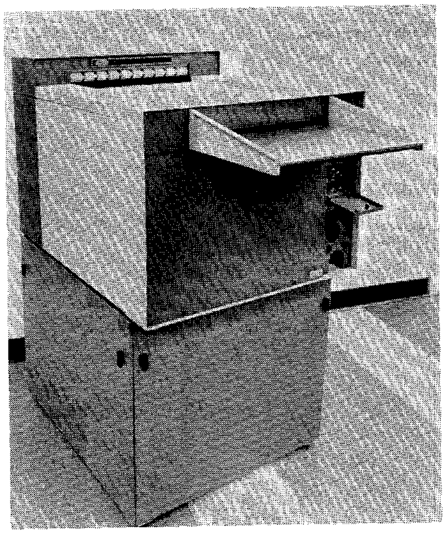
The system can be configured to fit a variety of production requirements, from single-line inspection to multiple-line. Enhancing the modular digital design is Intec's FLEX® software, which allows users to modify defect types, data processing, even reports and displays, as the product mix changes and inspection requirements evolve. Moreover, for every roll inspected, the system generates hardcopy reports showing the number, type, and location of all defects on the web. These summaries are often used to optimize subsequent converting operations, such as slitting or sheeting.

Circle 216

Radiographic Testing Processor

The DuPont Company, Wilmington, DE, has introduced the "Cronex" NDT 100 processor for radiographic testing; it reduces operating costs through an adjustable, dual-speed film drive and energy saving features. Two speeds permit processing of different NDT films, up to 175 an hour, from the same unit, which eliminates the need for two separate processors for most industrial applications.

Energy saving features include cold



water operating capability and a built-in standby control circuit that automatically shuts off power and water during periods of inactivity. The standby system also cycles the machine during inactive periods to keep processing systems at operational levels. A water recirculation system enables the unit to operate using only ¾ of a gallon of water per minute.

Separate developer and fixer drains meet government waste disposal standards, and molded PVC tanks eliminate rust, corrosion, and possible leaks that damage equipment. The compact processor is 28 in. wide by 35 in. long by 27 in. high.

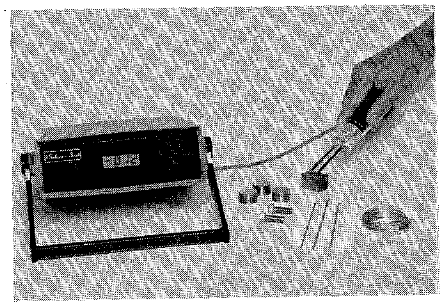
The NDT 100 Processor is part of Du Pont's Daylight Equipment Module consisting of a newly motorized film dispenser, film cassettes, and processor loader designed to permit development of industrial radiographs on the production line without a darkroom.

Circle 217

Alloy Sorting and Identification Device

Salvonics, Inc., Oak Ridge, TN, has introduced the Identomet, a new thermoelectric alloy sorting and identification device. The instrument is operated by applying two probes, one hot and one at ambient temperature, to a sample of an unknown metal and noting the induced thermoelectric voltage. Sorting or identification is accomplished by comparing the measured voltage against that induced in standard specimens or by reference to a table. Because the thermoelectric voltage depends on only the materials and the temperature difference between the hot and cold side, the instrument can be used on specimens of all sizes and shapes from tiny wires to giant girders.

Emphasis has been placed on simplicity and reproducibility. No knob appears on the front panel to vary the gain for stronger or weaker signals. Instead, the

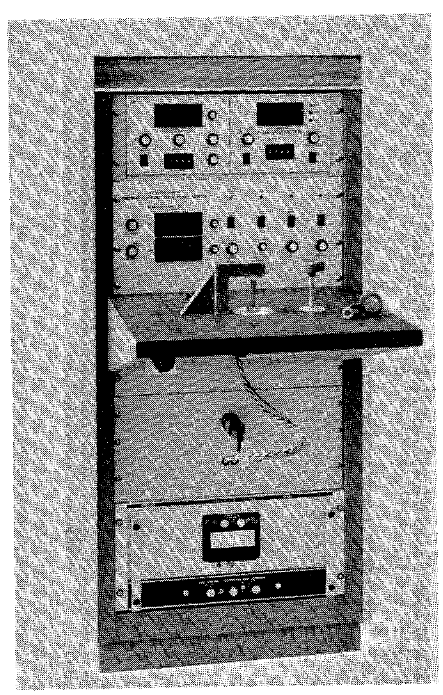


designers elected to use a sensitive voltmeter with a wide range and an unusually hot (450°F) tip. Controls for calibration are located inside the instrument case. These are set at the factory and almost never need to be touched. Except for the meter, the only external features are two LEDs, one indicating that the power is "on" and the other that the probe is at operating temperature. Because LEDs are difficult to interpret under conditions of high illumination as, for example, in a field application, an optional feature supplements the signal for the temperature-indicating diode with a special signal on the meter face. The standard unit is operated by 6 V ac drawn from an UL-approved transformer. A rechargeable battery-powered unit suitable for five hours of field operation is also available.

Circle 218

Constant Current Flux Reset Tester

With the increasing use of magnetic cores has come the need for improved quality control test methods and better knowledge of the performance of magnetic cores. The LDJ Model 7000RC constant current flux reset tester (CCFR), introduced by LDJ Electronics, Inc., Troy, MI, fills these needs by providing a precise, simple nondestructive method of measuring core magnetic parameters.



The CCFR tester determines the magnetic performance of fully processed cores. The testing is done at 50, 60, 400, or 1600 Hz. The size of the core is limited by the available power supplies and the sensitivities of the measuring instrumentation.

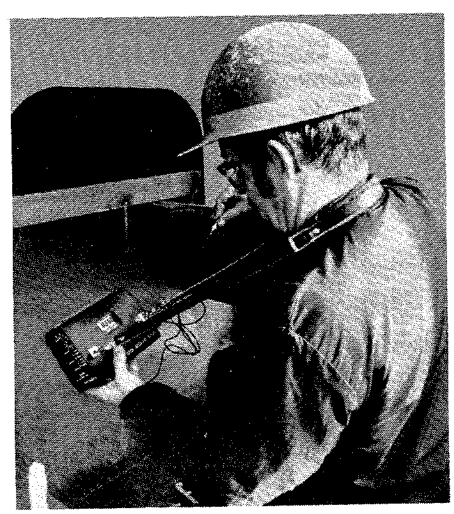
The 7000RC comes complete with a standard test fixture that will test cores with a minimum inner diameter of 11 mm, a maximum core height of 38 mm, and a maximum thickness or build (radial) of 33 mm.

Circle 219

Backlighted Display for Thickness Gage

Sonic Instruments, Inc., Trenton, NJ, has introduced a design innovation to its Digi-Sonic 502 portable ultrasonic digital thickness gage—the backlighted liquid crystal display (LCD). The addition of the backlighted display gives the instrument more flexibility and allows it to be used in poorly lighted locations.

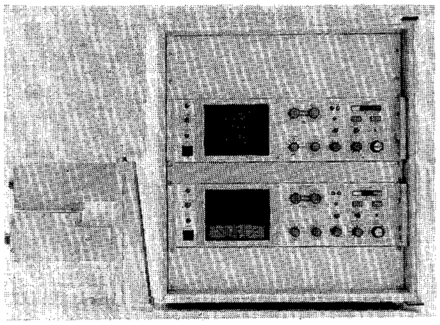
The backlight feature is the result of the addition of a fluorescent flat panel that both reflects and transmits light through the rear of the LCD. A small power supply is added to the unit that is activated by an on/off switch. Emitting a soft greenish glow, the backlight allows the digits to remain black and does not affect readability under normal lighting conditions. This optional backlight feature, number OPT-MF-5001, eliminates the need for cumbersome flashlights and other lighting devices. Because it is low on power consumption, the backlight causes no significant reduction in battery life.



Circle 220

Titanium Sheet Test System

For the primary circulation system of a reactor, much attention is paid to the safety aspects of the materials that are used. For this reason, the titanium sheet



used in making the heat exchanger tubes is already subjected to nondestructive testing. Foerster Instruments Incorporated, Coraopolis, PA, has developed for this application a test system that, using the Defectomat C 2.820, finds and marks the smallest of flaws.

Titanium sheet of 60 mm width and 0.5 mm thickness, for example, is passed between two probe combs. The separate combs, each having up to 10 individual probes, are arranged to test the upper and lower sides of the titanium sheet in application of the difference method of scanning. Using continuous pass-through, test velocities of up to 1 m/s are achieved.

Circle 221

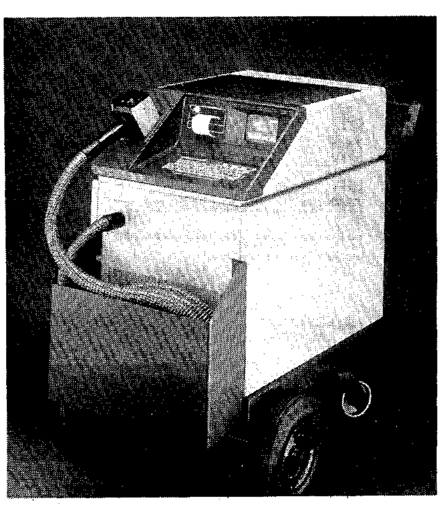
Mobile Metal Analyzer

Bausch & Lomb, Sunland, CA, has introduced a mobile metal analyzer that has the ability to conduct nondestructive, automatic testing of not only the quality but also the composition of metals in virtually any locale.

The analysis and identification of hundreds of alloys is ensured by the Model 3600, which is capable of detecting light elements such as carbon, magnesium, aluminum, and silicon as well.

The low-voltage remote pistol features a five-meter fiberoptic cable that allows testing of even the most awkwardly placed materials. A light-emitting diode display gives results from one of four testing modes: "Fast Profile," "Pass/Fail," "Alloysort," and "Quantitative."

The chassis of the 3600 is compact,



shock-resistant, and easily maneuverable. For use in situations where there is no electrical outlet, the 3600 features an accessory 2 kW motor-generator.

The microprocessor is user-friendly, providing understandable English program menus with step-by-step video-screen instructions, full-size membrane keyboard, and internal diagnostics. The possibility of interpretative error has been virtually eliminated.

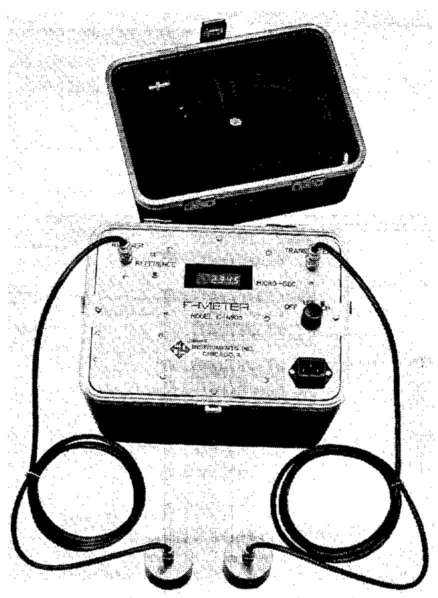
Accessories include a data printer; wire adapter, allowing for the analysis of wires from 1 to 18 mm in diameter; the motor generator; battery backup system to prevent loss of data in a power failure; and a 10-m fiberoptic cable.

Circle 222

Ultrasonic Tester

James Instruments, Inc., Chicago, IL, has introduced an ultrasonic system for broad field testing of concrete; the simplified tester allows easy expansion of quality control to all concrete construction.

The "F-Meter" ultrasonically measures velocity through concrete slabs, columns, and beams to identify cracks, voids, and honey-combed defects. These data can be correlated to concrete strength. The test instrument is compact and portable, in a high-impact case, battery operated with digital readout and easy-to-use transducers. The F-Meter measures 8 by 10½ by 8½ in. and weighs less than 12 lb.

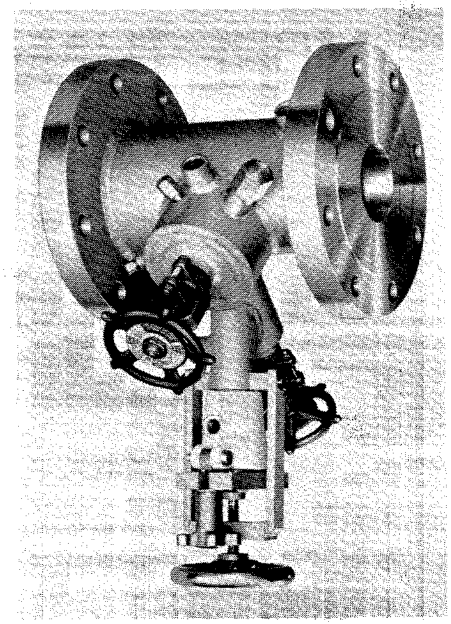


Circle 223

Jacketed Sample Valves

A line of custom, jacketed sample valves for quality control analysis of high-temperature viscous materials in continuous production lines has been introduced by Parks Cramer Company, Fitchburg, MA.

The valves are rugged integrated sys-



tems featuring a nonrotating contoured stem for flush seating that prevents product buildup. Providing a safe way to withdraw high-temperature viscous materials, they come with pressure relief and purging connections. Made of stainless and carbon steel to ASME and ANSI standards, each handles 2000 pounds per square inch gage pressure, 650°F temperatures, and 4000 poise fluids. Options include air/water-cooled bombs, double walls, and remote or manual controls.

Circle 224

Temperature-Limit Indicating Labels

Colorful temperature-limit indicators are available from Liquid Crystal Applications, Inc., Clark, NJ, from 14° to 140°F in nonreversible as well as reversible types. The loss of color in the indicator is readily observed when its temperature limit has been exceeded.

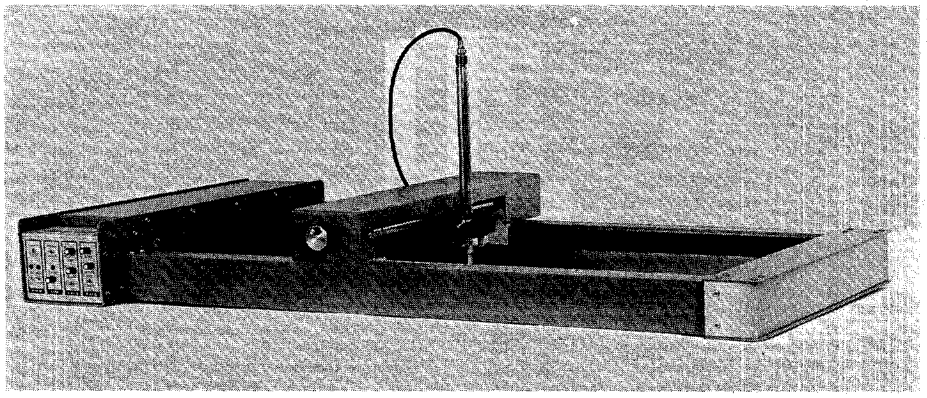
The colored indicators are available in red, green, or blue. Reversible types have a color return when they cool below their temperature limit, making them useful for long-term temperature monitoring. Nonreversible types can be reused if rubbed to reactivate the indicator and return its color.

Designed with disposable applications in mind, suggested uses include reconstituted medications; temperature sensitive pharmaceuticals; dairy products; comfort applications, such as soaking baths (sitz baths), enema bags, foot baths, and so forth; photography development; electronic components; and frozen products.

Circle 225

C-Scan Bridge Module

Trienco, Inc., Montrose, CO, has introduced a general purpose unit for immersion ultrasonic inspection and applications engineering. A structure integral to itself, the Model 705 C-scan



bridge provides user flexibility for difficult jobs.

It is available as a computer slave or with full control logic, with or without the direct coupled or remote dry paper recorder module, and is directly compatible with rotating fixture, Z-axis, and manipulator modules. The search tube assembly is removable at the spin of a knob. Controls are user oriented.

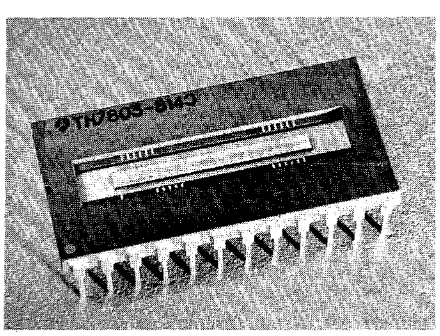
Circle 226

Image Sensors

Thomson-CSF Electron Tube Division, Rutherford, NJ, has introduced several image sensors.

The TH X31133 is composed of 576 rows of 384 points, giving a total of 220-000 23 μm by 23 μm photoelements. This device is four phase and fully compatible with the CCIR European 625-line TV standard. The frame-transfer organization effectively reduces the moiré effect or aliasing. The sensor offers a dynamic range of 1500:1 and high reliability. It can be used in high-resolution imaging (black and white or color), physical measurements, and instrumentation, etc., and can be incorporated into a compact camera that gives a video output signal directly compatible with a European-standard TV monitor.

The TH X31135 and TH X31138 are image sensors composed of a matrix array of 288 rows by 208 vertical columns and are designed for image pickup in industrial and scientific applications. They are particularly well suited for use in medium-resolution cameras of the surveillance type. The TH X31138 has built-in anti-blooming, which allows back-lighted image pickup without any loss of information.



The TH 7803 is a solid-state linear-array image sensor, composed of a linear array of 1728 photodiodes, each photodiode measuring 10 by 13 μm, with 10 μm center-to-center spacing. It includes associated integrated circuits, dark reference level, and requires only two external drive phases. It exhibits a wide spectral range (350 to 1000 nm), uniform spectral response, small dark signal, high sensitivity, and 3500:1 dynamic range. This sensor has been designed for imaging-scanning systems where relative movement between the image and the linear-array image sensor permits line-by-line scanning. It is suitable for all applications where high resolution and great sensitivity in the visible spectrum or near infrared are required.

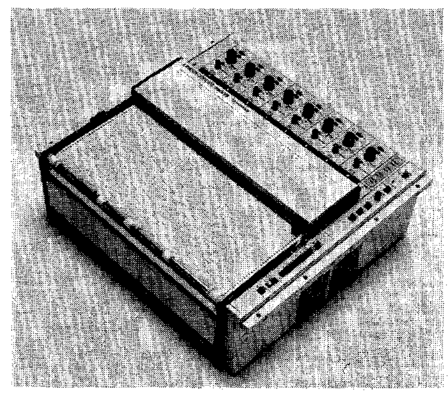
Circle 227

Multichannel Oscillograph

Watanabe Instruments, Costa Mesa, CA, has introduced its high-speed Linear Corder Mark VII. It boasts a multichannel feature of 2, 4, 6, 8, or 12 channels and is available in either roll or Z-fold chart models.

The oscillograph can accommodate a variety of pre-amplifiers; a maximum of 12 are available and can be interchanged as required. The unit is totally modular in design and is not motion or altitude sensitive. It can be operated vertically or horizontally. Compact and lightweight, it requires only 19 in. for rack or bench mounting. The unit also features a stepper motor chart drive for a wider speed range and better accuracy.

The standard Mark VII version is



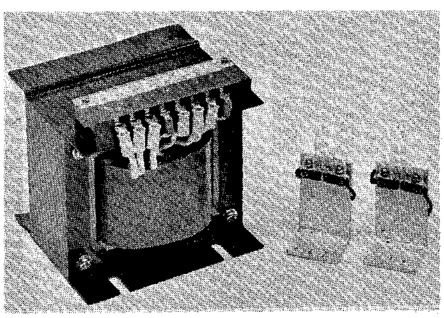
shipped with two event markers; however, a total of 9 markers are available. A digital annotator, with a thermal print head, automatically prints the year, month, day, hour, minute, second, data number, and chart speed and is also part of the original equipment.

Circle 228

Retrofit Kit

Radiation Equipment Co., Inc., Highland Park, IL, has introduced a high-intensity, retrofit kit to increase image intensity on the screens of optical comparators.

The Hi-Intensity Retrofit Kit, dubbed with the acronym H.I.R.K., has been designed specifically for use on Nikon's Model 6C-12 in. and Mitutoyo's Model PH350-14 in. optical comparators. Using quartz-halogen lamps, H.I.R.K. yields high lumen output. The complete kit includes replacement sockets on brackets for both shadow and surface; a special transformer that mounts exactly in place of the old unit; complete schematic diagram for simple do-it-yourself installation; and four quartz-halogen lamps.



Circle 229

Defect Analyzer

An instrument that analyzes the integrity of composite materials by sensing acoustic emission signals has been introduced by AE International, Richland, WA.

The Composites AE Tester quickly and reliably establishes the level of integrity or failure expectancy in fiber-reinforced plastic (FRP) piping or vessels under a variety of services. The portable system senses acoustic emissions from up to 16 transducers, automatically analyzes their signals, and identifies dangerous growing defects. Although FRP vessels and tanks are the most common applications, almost any composite material under stress can be tested.

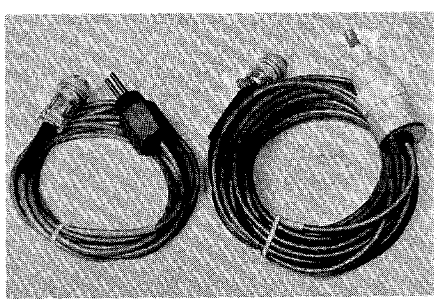
The unit is fully programmable and includes a full event CRT display, full keyboard Z80 central processing unit, and printer. Test setups are menu driven.

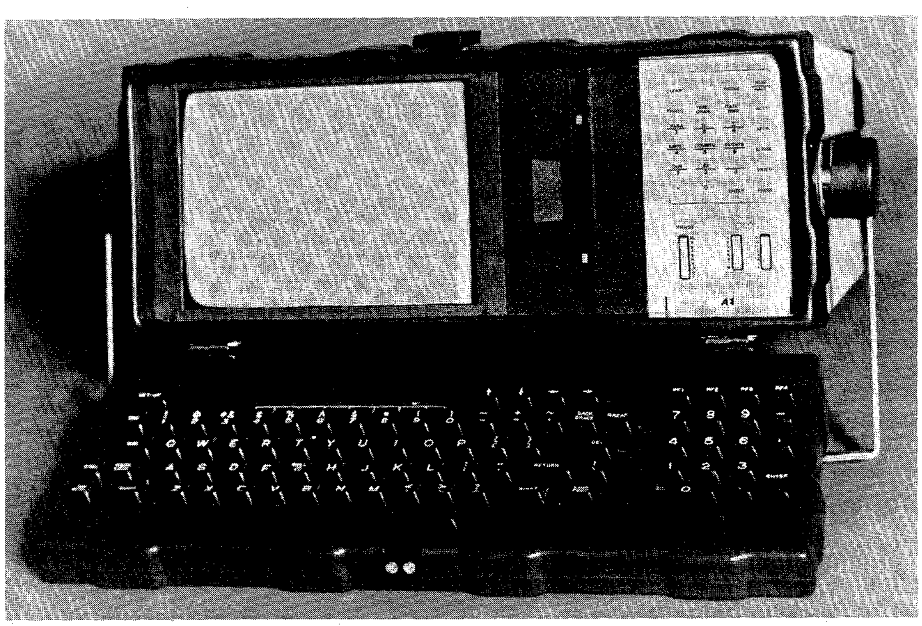
Signal analysis includes events, counts, peak amplitude, rise time, and duration. Stress event signals from each transducer can be isolated and analyzed on discrete channels. In addition, tests can be divided into ten time phases that can be viewed individually.

Circle 230

Continuous, On-Line Probes

A complete line of continuous, on-line probes designed for easy access has been developed by McNab, Inc., Mount Vernon, NY. Removal of the probes, which connect with McNab's Aqua Purometer II series of monitor/controllers for measuring pH or conductivity in water and process fluids, is simple. The probe is unplugged from the monitor, and the probe fitting unscrews from a standard pipe tee. No special tools or highly skilled personnel are required.



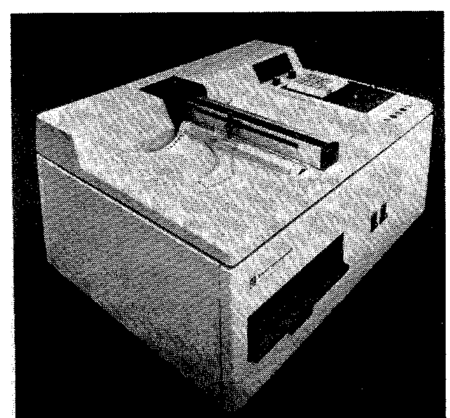


Each probe has a self-contained, temperature-compensating network and is built into a ¾-in. or 1-in. threaded body that fits the standard pipe tees. When these probes are reinserted into the line, no calibration or restandardization is required. The system automatically returns meter readings to their original values.

Circle 231

X-Y and Strip-Chart Electronic Recorders

Bascom-Turner Instruments, Newton, MA, has introduced two high-speed electronic recorders. These two-channel, combination X-Y/strip-chart recorders feature 0.05 percent accuracy, full scale ranges from 10 mV to 10 V, and speeds up to 1 in. per 2.5 ms. Analog voltage signals are automatically digitized with 12 bit precision, stored and plotted. Stored data can be processed (e.g., integrated or differentiated) and transmitted to a computer through an RS232C interface. Model 2120 has a storage capacity for 8000 data points, and Model 4120, with a built-in 8 in. floppy disk, has a storage capacity for 140 000 data points.

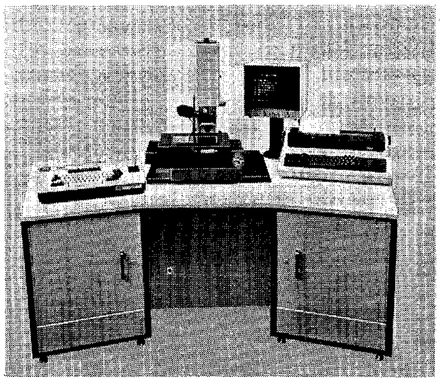


Circle 232

Automated Measurement System

LogE/Spatial Data Systems, Inc., Goleta, CA, a wholly owned subsidiary of LogEtronics, has introduced their Parts Measurement System (PMS), a noncontact video inspection system that automates measurement and quality control procedures for small parts. It is easily adapted for incoming or production inspection departments that require precise and repetitive measurements.

PMS can be programmed to determine the physical dimensions of parts,



the presence or absence of components, or find surface flaws automatically. Inspection routines for a large variety of different parts may be programmed and stored for future use. All subsequent parts are automatically aligned and measured in accordance with the stored instructions.

Automated inspection using the PMS can be performed quickly; with speeds of 2/10 of a second per measurement, it can inspect an average part with ten dimensional measurements in less than a minute. Accuracy to 40 millionths of an inch is consistently achieved. The PMS outputs a complete and accurate printed record of each inspection procedure. Part traceability and quality are recorded in a complete, printed, accept/reject record.

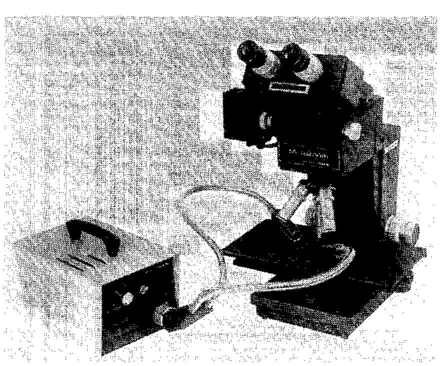
Circle 233

Fiberoptic Illuminators

Five fiberoptic illuminators have been introduced by Bausch & Lomb, Rochester, NY. Made especially for use with the company's StereoZoom® and MicroZoom® microscopes, the systems provide consistent, even, shadow-free illumination with low noise and vibration.

The systems can be used in research, quality control, production, closed-circuit television, and teaching applications because they provide the optimum illumination necessary for accurate inspection, documentation, and investigation.

Fiberoptics provide benefits not available with conventional illumination. With a 95 percent reduction in the heat/footcandle ratio, they offer cool illumination that will not damage heat-sensitive specimens. All five Bausch & Lomb systems feature a 3200°K color-temperature rating, making them useful for color-slide photography with tungsten film or for black and white photomicrography.



All five illuminators also feature a 150-W, quartz-halogen power source that provides up to four times the light output of conventional sources. Rugged and dependable, the all-metal power source is rheostat-controlled for 50 percent of the rated lamp voltage. This prevents filament evaporation, extends lamp life, and permits easy maintenance of comfortable viewing levels.

Circle 234

Through-Hole Testing Device

UPA Technology, Inc., Syosset, NY, has introduced the Caviderm® (Model CS-106B) for plated through-hole testing. This solid-state instrument is an important aid to incoming inspection, quality control, and production line testing.

Operating on the microresistance principle, it nondestructively measures the thickness of the copper in circuit board through-holes anywhere on the board and detects cracks, voids, and insufficient plating, even through solder and gold. High-precision measurements to the nearest microhm are displayed. The microhm readings are converted to thickness measurements by means of a special slide rule supplied.

The device is self-calibrating and self-standardizing; minimum operator training is required. It has handheld probes and can measure the copper plating thickness without having to destroy the circuit board. By providing a uniform current injection around the perimeter of the hole, measurement accuracy is ensured and errors due to pad size are avoided. An optional probe-positioning stand further ensures that the probe tips are located in the hole under test.

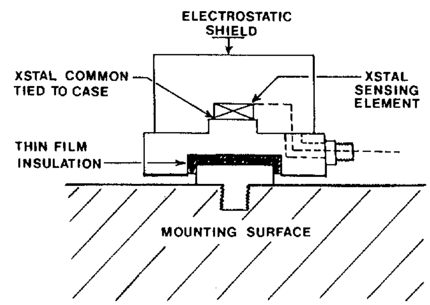
Accelerometers

Vibra-Metrics, Inc., Hamden, CT, has introduced two series of accelerometers that have been specifically designed to have base-coupled noise screened out.

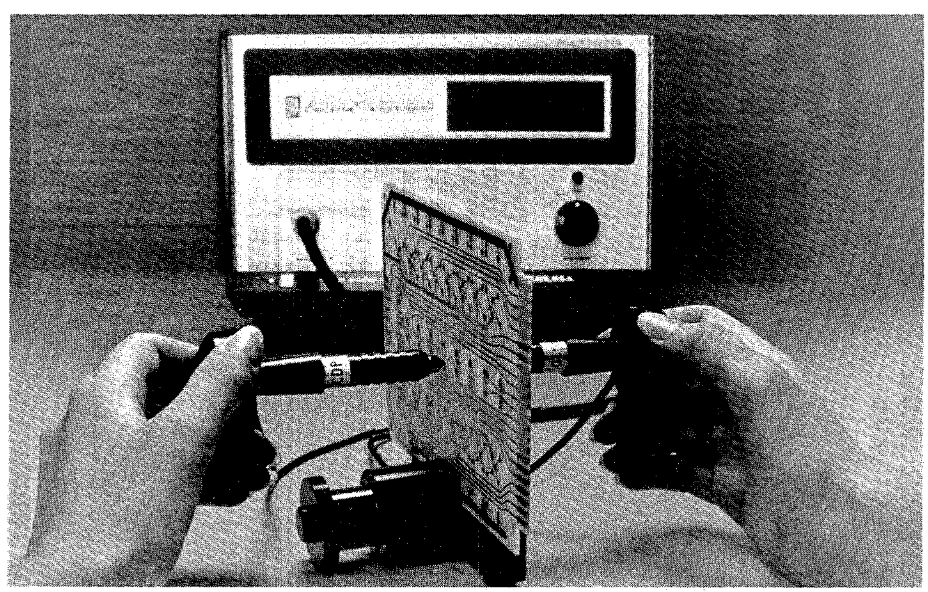
Models 2000 and 6000 series of accelerometers incorporate Isoshield™, which is an electrostatic Faraday shield placed inside the base. Such a placement helps screen out ground noises, or unwanted electrical signals, that enter through the base and interfere with the true vibration signal. The shield is an integral part of the accelerometer, does not interfere with a signal that is being read, and cannot be lost or damaged. Moreover, it reduces base-coupled noise by 80 dB (10 000 to 1).

The miniature, low-impedance Model 2000 accelerometers have subminiature connectors; provide a low noise floor of 0.002 g (rms) and 10 mV/g output standardized with ±2 percent for interchangeability; and can be used in air foil and flow tests, high frequency impact studies, bearing analyses, and structural, resonance, and acoustic testing.

The 6000 model, used primarily in machinery monitoring and bearing analysis, offers 100 mV sensitivity, 5 to 10 kHz response, and 0 to 75 g range.



Circle 236



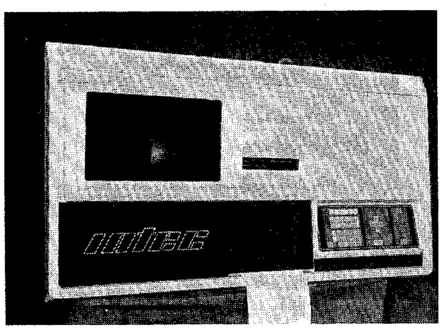
Circle 235

On-Line Laser Inspection System

Intec Corp., Trumbull, CT, has introduced a compact on-line laser inspection system that performs 100 percent surface inspection at full line speeds, detecting up to five defect types, such as gels, holes, coating skips, contaminants, and streaks in plastics, paper, and coating lines. Benefits of this system include higher yields, increased throughput, and improved product quality.

The three-part System 4000 features a laser scanner that sweeps a laser beam across the moving web up to 4800 times per second; an optical receiver that collects reflected or transmitted laser light and converts it to electronic signals; and a rugged, compact operator console that identifies and categorizes defects. The console's touch-sensitive keyboard enables operators to enter product codes and inspection parameters with ease. Defects that exceed these preestablished specifications trigger real-time alarms for immediate corrective action.

Options include a black and white CRT for real-time quality management of defect levels and trends. A hardcopy printer that provides web maps and management summaries for subsequent slitting/sheeting and grading decisions is also available.



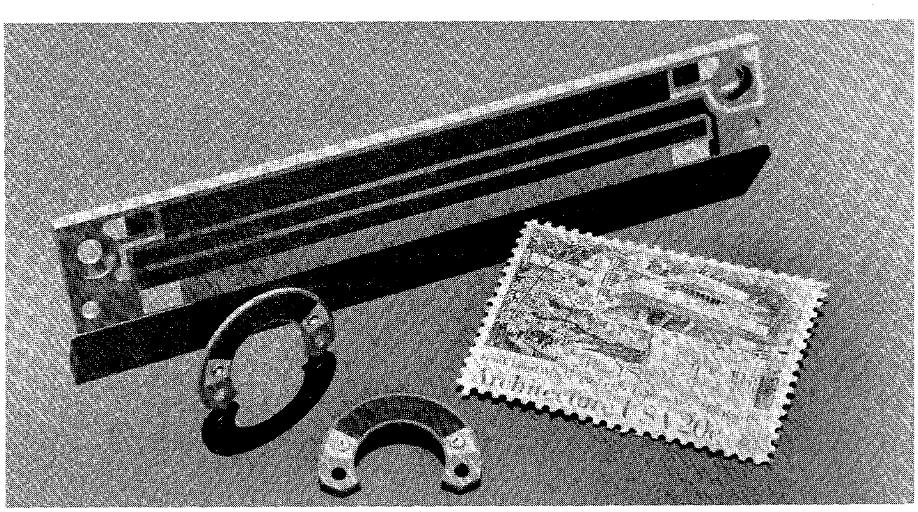
Circle 237

Conductive-Plastic Potentiometers

Waters Manufacturing, Inc., Wayland, MA, has introduced space-saving potentiometers that use a conductive plastic printed directly onto a structural base made of Ryton polyphenylene sulfide. The company uses MystR, a conductive thermoset, for the printing.

The Ryton-molded part provides a smooth surface, with no secondary machining required. Dimensional stability of the engineering plastic is a critical property. Any change in dimensions, no matter how slight, would affect the electrical results. The potentiometers produce an electrical output in proportion to mechanical motion and are adaptable to harsh working environments.

When the company selected polyphenylene sulfide for the structural base, it eliminated an extra manufacturing step. Previously, the conductive plastic was first printed on flexible film that then was assembled to the structural member, usually made of epoxy fiberglass. The flexible film technique is still in use, however, when potentiometer size exceeds six inches. Waters' potentiometers range in size from a fraction of an inch to eight feet.

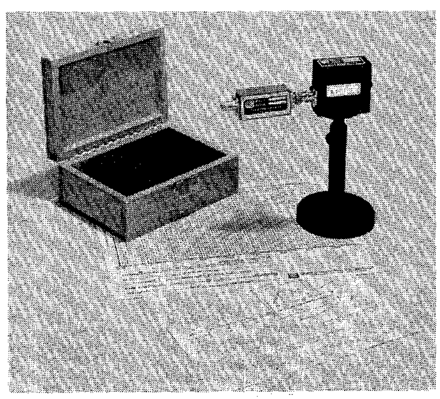


Circle 238

Photodetector Reference Standard

United Detector Technology, Culver City, CA, has introduced a visible wavelength quantum efficient photodetector reference standard.

The QED-100 combines four of the company's inverted layer silicon photodiodes in a retroreflective arrangement to produce an absolute radiometric standard whose performance approaches the theoretical maximum. In tests performed by the National Bureau of Standards, quantum efficiency was determined to be 99.9 percent (± 0.1 percent) throughout the visible wavelength region of 400 to 700 nm at laser power levels up to 2.5 mW. The QED-100 thus allows calibration of light levels to a high degree accuracy.



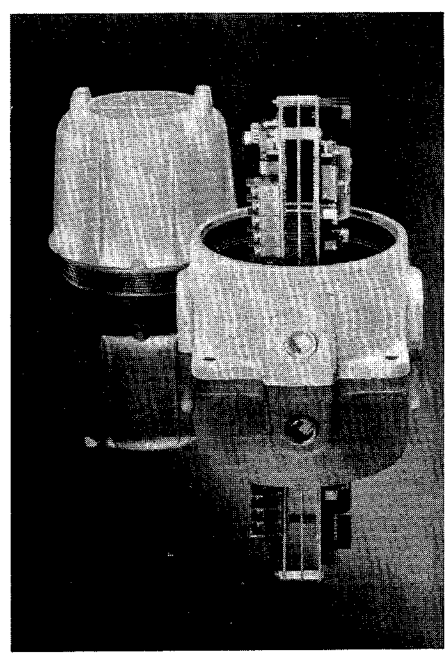
Circle 239

Corrosion Monitoring Transmitter

Rohrback Instruments, Santa Monica, CA, has introduced a two-wire corrosion monitoring transmitter to provide a direct link between its corrosion sensing probes and process receivers, process computers, and recorders.

In operation, the Model 4020 provides an output proportional to the metal loss as sensed by the company's Corrosometer® electrical resistance probe. Power for the transmitter is provided by the plant's standard 4 to 20 mA current loop. The loop current at the beginning of sensor life is 4 mA and at the end of life is 20 mA. Formulas relating loop current to metal loss for various sensor geometries are supplied by the manufacturer.

The transmitter is housed in an explosion-proof enclosure and is connected to the Corrosometer probe with a short flexible cable. The housing is UL rated for use in Class I, Group E; Class II, Groups E, F, and G; and Class III. The unit is designed to operate from 0 to +140°F (−18 to +60°C) so it can be used in a wide variety of field applications.



Circle 240

New Literature

A *Study Guide to the Professional Engineers' Examination for Industrial Engineers* is now available, with information divided into eight sections that include review notes, references, review problems, and practice problems.

Published by Industrial Engineering and Management Press for the Institute of Industrial Engineers, Norcross, GA, the study guide is designed to allow students to test their understanding of tools and techniques used by industrial engineers before taking the exam used by many state boards of registration for testing and registering. Properly titled "Principles and Practice of Engineering Examinations," the exams developed by the National Council of Engineering Examiners are often referred to as "P. E. Exams."

The study guide, which is prepared by three practicing industrial engineers and two other professional engineers, includes sections discussing work methods and measurement, engineering economy, statistical analysis, project planning and control, manufacturing processes, linear programs, production and inventory control, and plant layout/material handling.

Circle 241

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A catalog describing intensive educational courses on metals and materials has been published and is now available free of charge from the American Society for Metals, Metals Park, OH.

The 32-page, four-color catalog describes 17 Metals Engineering Institute (MEI) courses available from the society through July 1983. MEI is one of the primary educational arms of ASM. Home for most of the courses is ASM's world headquarters in Metals Park, OH, while others will be held in Toronto, Houston, Chicago, and Columbus, OH.

Courses described include such subjects as stainless steel; tool materials: metallurgy and application; elements of metallurgy; corrosion; metallurgy for the nonmetallurgist; principles of machining; electroplating; and powder metallurgy.

Also included are subjects covering the fundamentals of NDT; principles of failure analysis; metallographic techniques; metallographic interpretation; mechanical testing; welding inspection and quality control; principles of heat treating; heat treatment of steel; and an advanced heat treating seminar.

Nationally recognized MEI courses are designed to benefit participants on a broad level. The courses present fundamental technology in metals and metalworking, treating subjects in-depth, yet in an easily understandable manner.

Circle 242

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ASTM, Philadelphia, PA, has published a book that will provide students, researchers, and engineers with an awareness of the possible magnitude, nature, and consequences of residual stress effects in fatigue of materials.

Residual Stress Effects in Fatigue (STP 776) is based on a symposium held in Phoenix, AZ, in May 1981. Many of the 15 papers comprising this book's contents indicate that the newest developments of knowledge in the field are strongly influenced by the concepts of local strain analysis and linear elastic fracture mechanics. Other papers treat recently developed techniques for observing the effects of residual stresses experimentally by ultrasonic methods, fretting fatigue experiments, and *in situ* observations of surface microcrack opening displacements in a scanning electron microscope.

Circle 243

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ASTM, Philadelphia, PA, has made available a book devoted entirely to the problems of rolling contact fatigue testing of bearing steels. Based on a symposium held in Phoenix, AZ in May 1980, *Rolling Contact Fatigue Testing of Bearing Steels* (STP 771) contains 21 papers that detail the results obtained by past researchers and review the up-to-date state of the art.

Developers and designers of the most widely recognized test machines present the thinking behind the designs, the goals of their tests, the tests' merits and demerits, and the significant results obtained from the tests.

Circle 244

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The Steel Founders' Society of America, Des Plaines, IL, has announced that it has resumed publication of its *Steel Founders' Research Journal*.

In a revised and expanded format, the quarterly journal, edited by John M. Svoboda, is dedicated to presenting top-quality information to steel foundry personnel, and its editorial board takes an active role in the selection, preparation, and review of the papers presented. The journal will offer papers on original research, information on foreign technology, capsule summaries of recent work on the various aspects of foundry practice, and translations of important papers from overseas.

Circle 245

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A complete handbook for everyone writing technical materials, *Technical Writer's Handbook*, by Harry E. Chandler, has been published by the American Society for Metals, Metals Park, OH.

The book is three reference books in one. Eight chapters in the first section explain the art of writing for the busy reader. The second section, on writing formats, patents, and trademarks, and copyright and libel law, offers a look at writing technical reports, abstracts, papers, articles, books, news releases, committee reports, standards, specifications, proposals, directions, memos, and correspondence. The final section is an anthology of technical writing stylebooks, including such practical information as handling metric conversion, abbreviations, preferred style for listing references or presenting equations in text, tips on punctuation, preferred spellings, and more.

Circle 246

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Quantitative NDE in the Nuclear Industry, a conference book on the state of the art and the nature of problems and possible solutions, has been published by the American Society for Metals, Metals Park, OH.

The reactor pressure vessel, the primary pressure piping, and the steam generator are three main problem areas covered in the 488-page book, edited by R. B. Clough. Fuel materials problems, radiography, acoustic emission, ultrasonics, new techniques, and leak testing of valves are also discussed. Eddy current methods are presented in detail in the steam generator session. Codes, standards, and an update are provided on the latest trends in advanced NDE applications programs.

Circle 247

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ASTM, Philadelphia, PA, has introduced a comprehensive guideline on test apparatus planning, testing procedures, data analysis approaches, and reporting requirements. These items are addressed in the new standard G 73, "Standard Practice for Liquid Impingement Erosion Testing."

The standard is under the auspices of ASTM Committee G-2 on Erosion and Wear and is the culmination of a 12-year effort, including an international interlaboratory test program involving ten laboratories in five countries (United States, United Kingdom, Federal Republic of Germany, France, and Sweden).

The practice deals with the characterization of material response to liquid impacts as experienced, for example, by steam turbine blades in wet steam, by aircraft and spacecraft structures in rainstorms, and by hydraulic equipment such as dynamometers, pumps, propellers, and turbines, with two-phase flows or large-scale cavitation.

According to F. J. Heymann, of Westinghouse Electric Corporation, because of the wide range of conditions, a specific test method was not deemed appropriate; however, this practice is intended to serve as a tutorial guide even for those not previously familiar with liquid impact erosion testing.

Among its innovations are standardized procedures for data reduction, both for simple comparative materials tests and for more in-depth research programs, and a new standardized scale for "erosion resistance numbers," to permit rational comparison between results of different laboratories and facilities. The standard also includes generalized prediction equations for estimating erosion rates in the field when impingement conditions and the erosion resistance numbers of the material are known.

Technical questions concerning this standard may be addressed to F. J. Heymann, N-206, Westinghouse Electric Corporation, P.O. Box 9175, Philadelphia, Pennsylvania 19113, (215) 237-7085. Copies of Standard G 73 are available from ASTM.

Circle 248

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Technical Articles

Materials Evaluation is an archival journal in nondestructive testing/evaluation/inspection. The journal's technical articles are refereed by experts in their fields, and the papers are abstracted by all of the major technical abstracting services, including *Applied Mechanics Review; Applied Science and Technology Index; Ceramics Abstracts; Chemical Abstracts; Engineering Index; Metals Abstracts; Science Abstracts (Physics Abstracts, Electrical and Electronics Abstracts,* and *Computer and Control Abstracts); Science Citation Index;* and *World Aluminum Abstracts.*

CONTENTS, UNDERWATER NDT ISSUE

TECHNICAL PAPERS

TECHNICAL NOTES

Paper submitted October 1982

Automated Inspection of Corroded Steel Structures*

by A. Singh, R. McClintock, T. W. Rudwick III, and R. L. Brackett

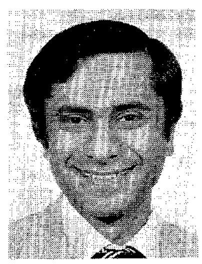
Abstract

Deterioration caused by corrosion of steel can result in catastrophic failures of waterfront facilities and other offshore structures.[1] Inspection of corroded steel structures is largely limited to visual examination. However, this is not a reliable nondestructive method for thickness measurement because it is limited to assessing surface damage. A novel ultrasonic concept has been developed and integrated into an automated scanning system. This concept uses a focused ultrasonic transducer centered over a corroded pit so that the pit acts as an acoustic lens. Special transducer modification and pattern analysis techniques have been developed to overcome the effects of spurious signals. Scanning of the corroded area, alignment of the focused transducer over the pits, and acquisition and processing of the signals to determine the thickness of corroded steel are performed by the computer-controlled system. An average thickness measurement error of only four percent was achieved using this system.

INTRODUCTION

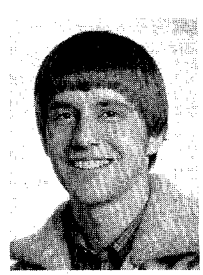
Corrosion caused by seawater deteriorates the structural integrity of offshore and waterfront steel structures. This structural deterioration can eventually lead to a catastrophic failure, resulting in direct dollar losses and safety problems. Inspection methods to evaluate corrosion[2] are largely limited to visual examination. However, visual examination is limited to surface inspection and does not provide information on the remaining thickness of structural steel that has been corroded from both sides. A reliable method was needed to determine the amount of wall thinning caused by corrosion and to establish the detailed maintenance and repair requirements necessary to maintain the facility.

Ultrasonic thickness testing is proposed as an alternate inspection approach. The approach presented avoids spurious signals caused by scattering in conventional ultrasonic methods



Anmol Singh received a B. Tech. in mechanical engineering from the Indian Institute of Technology, New Delhi, in 1978, and an M.S. in engineering mechanics from Iowa State University in 1980. At the Southwest Research Institute, Singh has been the principal investigator of a number of research programs in nondestructive evaluation. These include thickness measurement of corroded steel structures, detection of deterioration in timber piles, beam skewing in extruded stainless steel pipes, and photoelastic visualization. He can be contacted at (512) 684-5111, extension 2690.

Reed McClintock received his B.S. in computer science in 1973 and his B.S. in electrical engineering in 1980, both from the University of Maryland. He has worked at the Southwest Research Institute for the past six years in the Electronic Systems Engineering Department. During this period, he has assisted in the design and development of the Advanced Data Acquisition System (ADAS) and has participated in updating the hardware and software requirements for the Turbine Rotor Examination and Evaluation System (TREES) and for PaR device examinations.



Tom Rudwick will be graduating in 1983 with a B.S. in mechanical engineering from the University of Texas at Austin. He works as a student engineer at the Southwest Research Institute during vacations.

*This work was supported by the Naval Civil Engineering Laboratory, Port Hueneme, CA, under contract N68305-81-C-0011. ©1982 IEEE. Reprinted, with permission, from *Oceans 82 Conference Record*, September 20-22, 1982, pp 537-540, Washington, DC.

that generate noise and make it extremely difficult to resolve the back-surface reflection. However, strong front-surface and back-surface reflections are observed if the corrosion pits are used as acoustic lenses. This new approach for ultrasonic thickness measurement of corroded plates has been developed into an automated inspection system.

FOCUSED TRANSDUCER CONCEPT

Figure 1 illustrates the focused transducer concept for thickness measurement of corroded plates.[3] The pit acts as a lens when the focal point of the beam is placed above the center of the pit. As a result, the beam diverging from the focal point collimates as it enters steel. Thus, a parallel or slightly converging beam in steel can be obtained by positioning the focal point above the pit. Significant back-surface reflection is obtained under this condition. The standoff distance from the transducer to the plate remains slightly greater than the focal length.

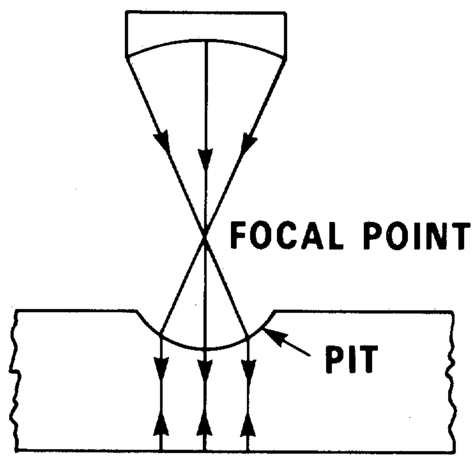


Figure 1—Focused transducer concept. The curvature of the pit collimates the diverging beam in the steel plate resulting in a strong back-surface reflection.

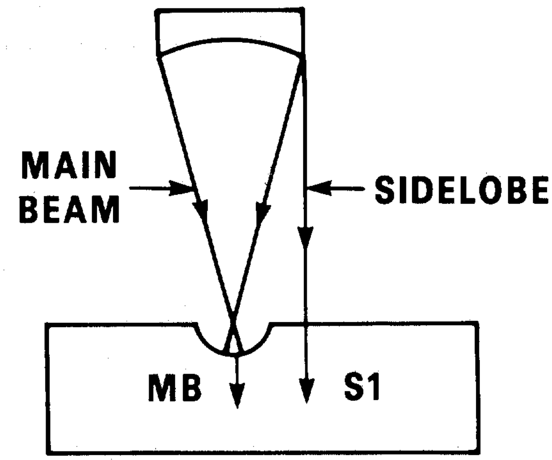
SPURIOUS SIGNALS

Even after using the focused beam technique, it was found that some spurious signals remained due to scattered ultrasound. These spurious signals were generated from the sidelobes, mode conversion to shear waves, or by interference of the waves reflected from the front surface. An over- or underestimation of the thickness can result if these spurious signals are mistaken for back-surface signals. The cause and removal of spurious signals are described in the following paragraphs.

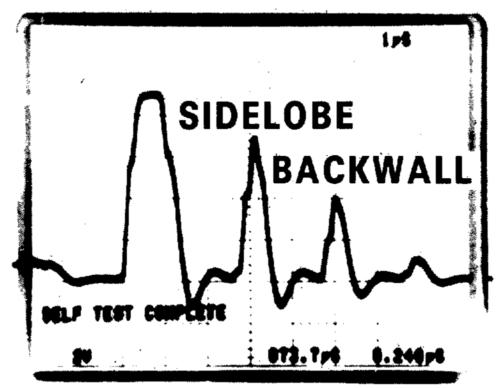
Figure 2a shows the spurious signal caused by a sidelobe that is generated from the periphery of the transducer. The sidelobe signal is incident at the side of the pit and thus travels more in steel than the main beam signal, which transmits through the pit center. Because the velocity of longitudinal waves in steel is higher than in water, the spurious signal arrives earlier in time than the back-surface reflection from the main beam, as shown in Fig. 2b, and, hence, underestimates the thickness. An acoustic mask with a small hole placed at the focal point removes the sidelobe signal. The acoustic mask attenuates the sidelobe signal and avoids spurious signal.

A second source of spurious signals was the mode conversion to shear waves. (See Fig. 3a.) Mode conversion to shear waves occurs when the longitudinal wave is not incident normal to the steel plate. This spurious signal arrives later in time (see Fig. 3b) than the back-surface reflection because shear waves propagate more slowly than longitudinal waves. This results in overestimation of the thickness.

Pattern analysis of the reflected waveforms removed spurious signals due to mode conversion. It was found that the ampli-

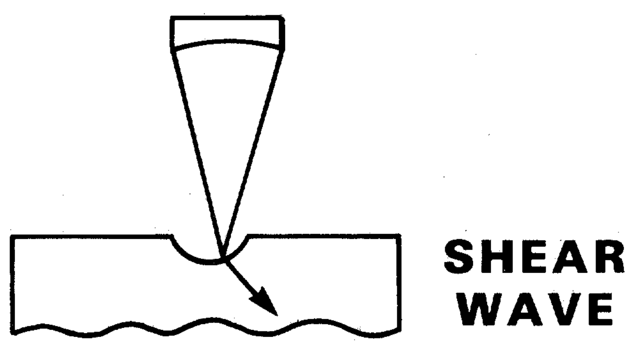


(a) Sidelobe generates spurious signal S1.

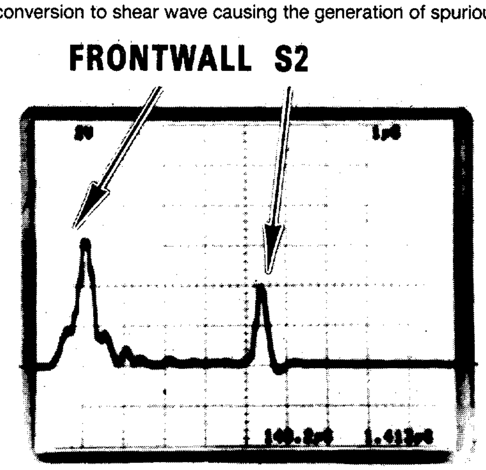


(b) Sidelobe signal S1 traveled more in steel and hence arrived earlier in time.

Figure 2—Spurious signal S1 caused by a sidelobe.



(a) Mode conversion to shear wave causing the generation of spurious signal S2.



(b) Spurious signal S2 is associated with low amplitude and large pulse width front-surface reflection.

Figure 3—Spurious signal caused by mode conversion.

tude of the front-surface reflection decreased and its pulse width increased whenever mode conversion occurred. Based on these characteristic front-wall signal patterns, the waveforms that have a higher probability of containing mode conversion spurious signals are eliminated from the analyses.

A third spurious signal closely followed the front-surface reflection. Interference of the waves reflected from the front surface of the pit caused this signal. It looked like a back-surface reflection but was found to have a significantly larger amplitude than the actual back-surface reflection. A time amplitude gate removed this spurious signal.

SYSTEM OPERATION

A microcomputer controls the automated system developed for thickness measurement of corroded plates. This system is capable of placing the ultrasonic transducer over the pit center, acquiring ultrasonic waveforms through the pit center, and analyzing waveforms for thickness determination. The ultrasonic transducer is centered over the pit center by maximizing the front-surface signal arrival time.

A schematic of the system is shown in Fig. 4. The pulser/receiver receives the signal from the focused transducer, which is digitized by a transient recorder and stored in the microcomputer for analysis. On processing the acquired signal, the transducer is moved to the next x-y position. The x-y movement is based on the front-surface arrival time of the previous signal acquired, and each step is determined by the computer.

The search algorithm that centers the ultrasonic beam over the pit center uses a step size that decreases as the pit center is approached. Data are acquired at five points in a plus-shaped (+) pattern with the center of the crossover as the pit center. These five waveforms are acquired from each pit to ensure a larger data base and to measure more accurately the plate thickness.

The display of thickness values determined at pit centers are shown in Fig. 5. The average plate thickness is determined by adding the average thicknesses determined at the pit centers to the root mean square (rms) of the front-surface signal arrival time during the x-y scan.

RESULTS AND DISCUSSION

Using the system that has been developed, the thicknesses of six samples [50 by 50 mm (2 by 2 in.)] were measured. Table 1 gives the values of the average thicknesses of corroded plates found by this method. The actual average thicknesses were determined using Archimedes' principle.

Table 1 shows that the average thicknesses of the pitted samples varied from 6.9 mm (0.27 in.) to 13.2 mm (0.52 in.)

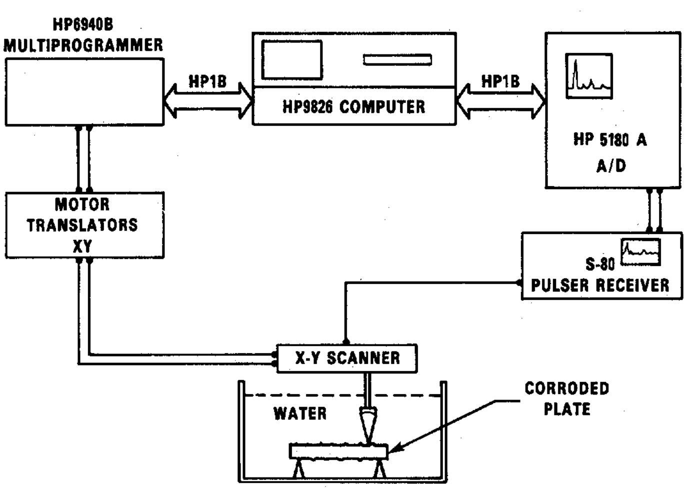


Figure 4—A sketch of the automated inspection thickness system for corroded plates. This system is built using commercially available equipment.

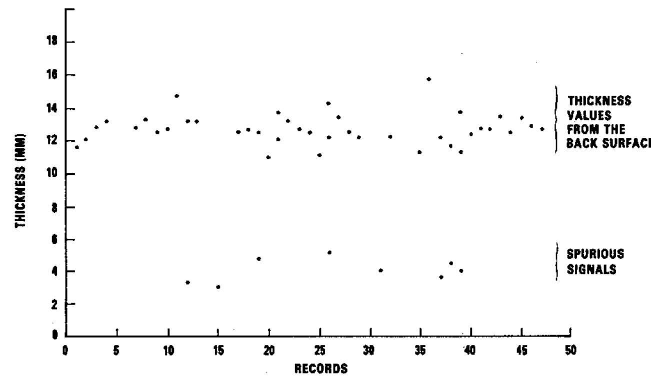


Figure 5—Thickness plot for a 13.0 mm thick pitted plate. The measured thickness of this plate was 13.5 mm using the automated system.

TABLE 1 Results from Thickness Measurements of Pitted Plates.

Corroded plate test sample	Actual thickness found using Archimedes' principle (mm)	Measured thickness (mm)	Error* (%)
TNP-1	7.0	6.8	−3
TNP-2	7.0	6.8	−3
TNP-4	6.9	7.1	+3
THP-1	13.2	14.2	+8
THP-2	13.0	13.3	+2
THP-3	13.0	13.5	+4

*Average absolute error: 4%.

and that the thicknesses were calculated with an average error of 4 percent and a maximum error of 8 percent.

The results show that the thicknesses of corroded plates can be measured accurately using the new thickness measuring system. The thicknesses measured using this approach can be used to determine the loss of strength of the structure. Necessary action can be taken for repair before a structural failure becomes imminent.

CONCLUSION

A new ultrasonic concept has been developed for thickness measurement of corroded structures. A prototype, automated inspection system based on this new concept has been found to work effectively for thickness measurement of corroded plates. This system is easy to operate and, hence, does not require extensive operator training. Only simple input parameters based on the area to be scanned are required. It is also easy to build the system because it uses commercially available instruments, except for the scanner. The scanner design is based on the cross section of the structure to be examined. This system can be used for thickness measurement of corroded structures in a wide variety of applications by modifying the scanner. These applications include offshore structures, waterfront structures, corroded pipelines, and other corroded structures in the marine, oil, and chemical industries. This portable system can be transported to an offshore or waterfront facility for inspection. The measurements made by this system can be used to determine the integrity and the predicted life of the structure.

References

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2. Department of Industry, *Industrial Corrosion Monitoring*, 1978. Her Majesty's Stationery Office, London, England.
3. Singh, A., Y. Hasegawa, and R. L. Brackett, "Underwater Nondestructive Thickness Measurement of Corrosion-Pitted Steel Structures," *Proceedings of the Fourteenth Annual Offshore Technology Conference*, Houston, TX, May 1982 (OTC Paper No. 4361).

Paper submitted December 1982

A Proposed Ultrasonic Inspection Technique for Offshore Structures

by M. D. Fuller, J. B. Nestleroth, and J. L. Rose

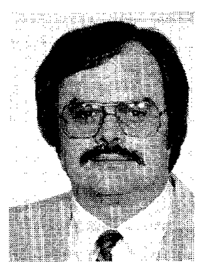
Abstract

The need for nondestructive evaluation (NDE) procedures for tubular joints in offshore structures is emphasized by every platform collapse. A new microprocessor-based ultrasonic inspection technique for tubular joints has been devised and preliminary tests conducted. The inspection concepts and the sensitivity of the technique to damage has been evaluated utilizing a 1/3 scale structural K-joint. The inspection concepts are discussed; in addition, the results of the 1/3 scale K-joint fatigue test are presented. Additional laboratory experiments were conducted to determine the effects of a marine environment and other limiting conditions on the sensitivity and feasibility of the technique. These results are also discussed.

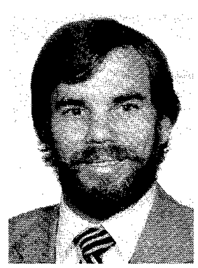
INTRODUCTION

The need for an in-service inspection system for the structural joints of offshore platforms has been underscored by several catastrophic collapses. Although some offshore platforms are currently inspected by divers (visually as well as by some magnetic particle techniques), the divers are limited in the depths and weather conditions with which they can cope. The need to advance inspection technology as it is applied to offshore structures has been recognized by the Office of Naval Research and the United States Minerals Management Service, who have funded activities in this concern.

As part of the funded activities in offshore structure inspection, Drexel University has pursued and developed a global ultrasonic inspection technique for monitoring the integrity of a structural joint. The goal of the research performed was to develop an ultrasonic inspection system that could indicate successfully the onset and accumulation of damage in a tubular joint, without the aid of divers. The fundamental concepts of the developed inspection system are presented in Reference 1.



Joseph L. Rose is a professor of mechanical engineering at Drexel University, and a consultant to Ultrasonics International, Inc., and Krautkramer-Branson, Inc. Rose has published more than 80 articles and two textbooks on the subjects of wave propagation and ultrasonic testing. His professional affiliations include ASNT, ASME, the British Society of Non-Destructive Testing, the American Institute of Ultrasound in Medicine, the Acoustical Society of America, and IEEE. He is an associate technical editor of *Materials Evaluation*, the journal of ASNT. His research activities include feature-based ultrasonic analysis, adhesive bond and composite material inspection, weld inspection, tissue classification in medical ultrasound, and global inspection developments for damage detection in a variety of structures.



John Bruce Nestleroth is a graduate student in mechanical engineering at Drexel University where he received a B.S. in electrical engineering and a M.S. in mechanical engineering. His major interests are in computers, wave propagation, signal processing, and pattern recognition as they apply to ultrasonic nondestructive testing. His research activities have included defect classification in welded plates, feature map concepts in composite materials inspection, and global inspection of various structures.

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The development program was conducted by utilizing 1/19, 1/10, and 1/3 scale models of a structural K-joint. Artificial flaws (sawcuts and side-drilled holes) were introduced in these models to simulate damage that is actually accumulated by tubular joints in the field. The resulting effects on the ultrasonic field were then studied in order to select a suitable inspection technique.

As a result of these studies on the behavior of ultrasonic energy, the microprocessor-based, through-transmission system shown in Fig. 1 was developed. The system shown takes advantage of the geometry of the casing by exciting a Lamb wave in the major column of the structural joint. This is done by considering the angle of the ultrasonic beam to the radius of the casing, the frequency of the transducers, and the thickness of the pipe. By exploiting the Lamb wave concept[1] and by utilizing a similarity coefficient-based algorithm, global inspection can be accomplished and damage can be detected.

In addition to the studies conducted on the aforementioned scale models, validation testing was undertaken at NASA Goddard Space Flight Center utilizing a 1/3 scale K-joint. By dynamically loading the K-joint, the structure was fatigued, producing cracks of a much more realistic fashion (than sawcuts and side-drilled holes) and of the nature that has actually been found in full-scale, in-service joints. By continuously acquiring and analyzing data as damage was inflicted, a suitable test bed for the evaluation of technique sensitivity was provided as the ultrasonic assessment of damage was made on-line at the test site.

As a result of preliminary studies conducted on offshore tubular joint inspection, a global ultrasonic inspection system has been developed and a dynamic validation experiment performed in a realistic damage situation. In addition, experiments were performed to determine the possible effects of a marine environment (as well as other factors) on the performance of the inspection technique. These results, as well as a brief review of the inspection concepts, and the results from the 1/3 scale model fatigue test are presented here.

GLOBAL INSPECTION CONCEPTS

For quite some time, the NDE community has made excellent use of high frequency ultrasonics for flaw detection. However, due to the very directional and attenuative nature of high frequency probes, which limits their use to local areas, an inspection protocol generally calls for scanning. (See Reference 1 for a more detailed development of the following wave propagation and signal processing concepts.) The global inspection technique developed for use on offshore tubular joints was designed to provide total surveillance of the inspection zone without the aid of scanning.

The principal problem to be overcome in the design of a global ultrasonic inspection system for application to offshore structures is that of signal attenuation because energy must be transmitted around the perimeter of the large tubular casing. This is on the order of 14 ft (4.2 m) in the full-scale case. Signal attenuation and the criterion that the total joint must be monitored are the design conditions that must be considered.

The transducer configuration shown in Fig. 2 was selected as a result of preliminary studies conducted on earlier models of a K-joint and because of its ability to meet both the attenuation and the global inspection criteria. A through-transmission system was selected because of the inherently shorter sound path distances, although experiments with promising results (presented in the following sections) have been conducted with pulse-echo. The frequency value of the matched transducers and the value of angle θ shown in Fig. 2 were selected in accordance to the wall thickness, t, of the casing. The goal was to select values of angle θ and the transducer frequency, which will excite a Lamb wave in the major column of the structure, while maintaining the minimum frequency value, which will ensure that a pulse of sufficient amplitude for analysis is detected by the receiver.

Lamb wave excitation provides the basis for the global inspection concept. Within a short distance from the transmitter, the Lamb wave is fully developed, the walls acting as wave guides and the material between being bathed in ultrasonic energy. Thus, if damage occurs anywhere between the transducers, it should be detectable as a variation in the ultrasonic field.

By monitoring the signal at the receiver, any changes in the ultrasonic field caused by damages may be detected and recorded. This change in the field or change in the received signal

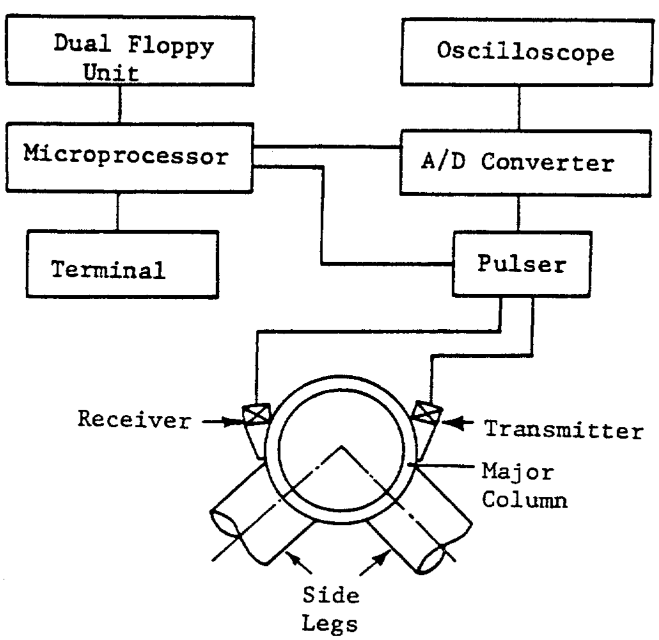


Figure 1—Microprocessor-based inspection system for tubular joints.

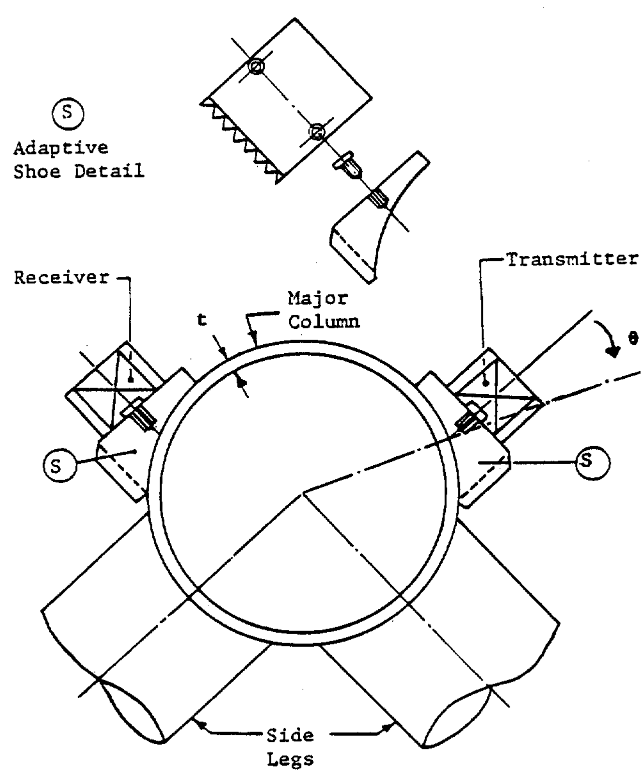


Figure 2—Transducer configuration for global inspection system.

when quantified becomes the key to damage detection. Because the signals may be digitally acquired and stored, it is convenient to use a numerical measure, a similarity coefficient, for the comparison of data. The similarity coefficient is primarily a statistical correlation-type technique that allows the comparison of any two conformable vectors. The vectors in this case are two ultrasonic waveforms in digital format, one taken from a reference state and the other taken when the integrity of the structure is in question. The formulation of the Tanimoto measure of similarity[2] used in this analysis is given as follows:

$$s(\vec{x},\vec{y}) = \frac{\vec{x}^t\vec{y}}{\vec{x}^t\vec{x} + \vec{y}^t\vec{y} - \vec{x}^t\vec{y}}$$

where

$\vec{x}$ = a digital representation of a reference (before damage) ultrasonic waveform (a vector),

$\vec{y}$ = a digital representation of an ultrasonic waveform obtained for comparison (a vector),

t = the vector transpose, and

$s(\vec{x},\vec{y})$ = the similarity coefficient between the two vectors $\vec{x}$ and $\vec{y}$.

If the Fourier transform of the ultrasonic signals is performed before the similarity measure is applied and the power spectrum is considered in preference to the time domain pulse, the analysis may be simplified greatly. The advantages are threefold. First, the effects of small amplitude variations in the signal are eliminated because power spectrums are generally area-normalized. Next, the effects of arrival time variations are eliminated because a pure time delay has no effect on the power spectrum. Lastly, the possible values that the similarity coefficient may take on are restricted to a simple range of zero to one; this is because all values in the power spectrum are positive. Thus, in the ideal case of two identical signals, the similarity coefficient assumes a value of one, and, in the complimentary case when the signal obtained for comparison is zero (total joint rupture), the similarity coefficient is also zero.

The inspection concept of structural joints of offshore platforms is as follows. Select the transducer angle and frequency such that an adequate signal is received and a Lamb wave is excited. Monitor the received signal digitally. Compare the monitored signals with a reference signal (from a joint when it is in good condition) utilizing a similarity coefficient. Variations in the ultrasonic field caused by the onset and accumulation of damage are reflected by the value of the similarity coefficient. Earlier studies conducted using this technique showed good results and were used to develop an on-line monitoring system for use in fatigue testing at NASA Goddard.

EXPERIMENTAL RESULTS

A series of static studies was conducted on 1/19, 1/10, and 1/3 scale models in order to develop and refine an inspection technique. In addition, studies were conducted to determine the sensitivity and limitations of the technique and the promise of technique transfer to the field. Finally, a 1/3 scale dynamic validation study was conducted at NASA Goddard. In the following paragraphs, the developed inspection procedure is discussed along with the results obtained from the sensitivity and validation studies.

In order to globally inspect a structural joint, the following protocol was established. The data inspection system shown in Fig. 1 was used in conjunction with the transducer system shown in Fig. 2 to pulse ultrasonic energy into the major column of the structural joint at approximately 800 kHz. Initially, the transducers are placed on the structure when there is no damage present, and a digital representation of the radio frequency (rf) waveform is obtained from the receiver, averaged, and then stored. A fast Fourier transform of the data is then calculated, and the power spectrum is stored. Subsequent data are acquired in a similar fashion when the joint may or may not have sustained damage. A similarity coefficient is then calculated from the comparison of the reference and subsequent signals; this value is then itself stored.

1/3 Scale Model Fatigue Testing

The experimental setup used in the fatigue test at NASA Goddard is shown in Figs. 3 and 4. A hydraulic ram was placed between the legs of the K-joint. The structure was then fatigued by loading the K-joint in a unidirectional sinusoidal fashion. The load spectrum for this experiment is shown in Fig. 5. The test protocol described earlier called for the acquisition of reference data before load cycling was initiated and for the acquisition of comparison data at various intervals in the fatigue life of the structure. Data were obtained from five locations on the structure with a set of 0.8 MHz probes that were specially manufactured. The data acquisition locations are indicated in Fig. 3.

The similarity coefficient analysis is very much dependent on the characteristics of the transducers used. To protect against day-to-day changes, reference data were regularly acquired from a standard. The probes were characterized following the acquisition of reference data so that transducer compensation could be performed if necessary. However, no compensation was warranted.

At approximately 75 000 cycles, the use of dye penetrant

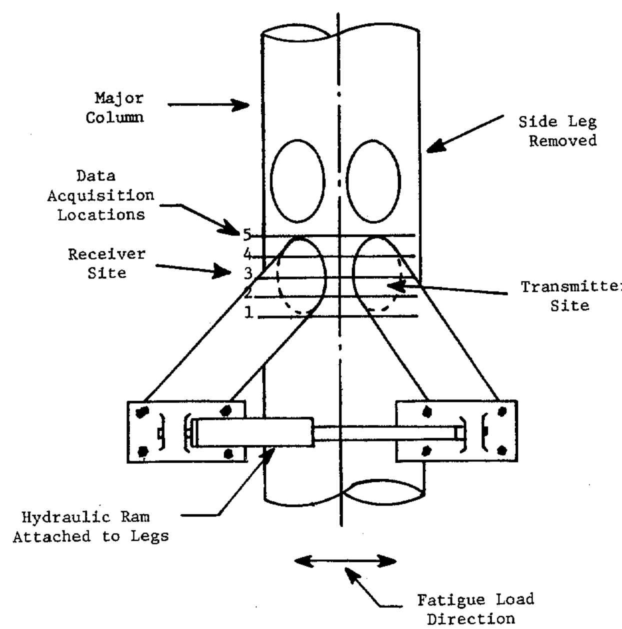


Figure 3—Fatigue test configuration for 1/3 scale K-joint model.

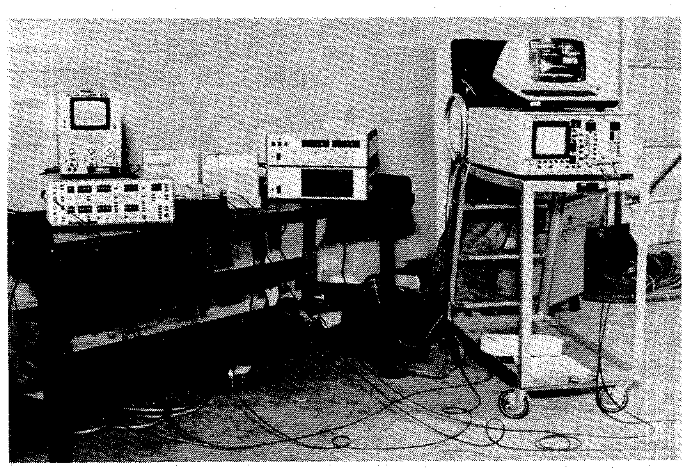


Figure 4—Ultrasonic data acquisition and analysis equipment. (Note transducers in the foreground.)

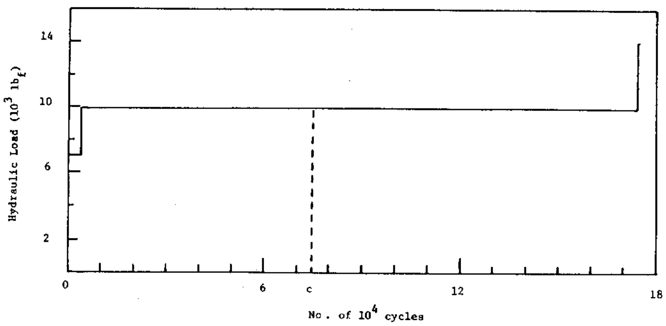


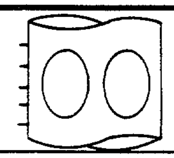
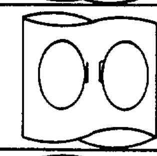
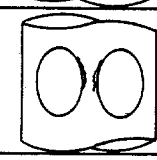
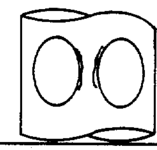
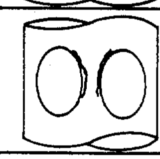
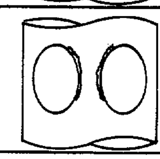
Figure 5—Hydraulic load pattern during fatigue test of 1/3 scale K-joint model. (Note, c is the crack initiation.)

indicated the presence of cracks in the crotch of the joint (see Table 1). The cracks continued to propagate in a uniform fashion until the K-joint was grossly overloaded on the last day of testing to facilitate total failure at 176 000 cycles.

Table 1 indicates the position and extent of the damage incurred by the K-joint. Table 2 indicates the value of the similarity coefficient at selected points during the fatigue life of the K-joint. Earlier studies indicated that consideration of specific portions of the power spectrum may improve sensitivity of the technique. In accordance with this, the power spectrum was split into quarters about the center frequency, and a similarity coefficient was calculated for each quarter. These are also tabulated in Table 2.

As can be seen from Table 1, the damage began in a zone on an axis opposing transducer location number three and then propagated into a zone opposing transducer location number four. At no time did damage accumulate in zones opposing transducer locations one, two, or five. Data in Table 2 behave accordingly. The value of the similarity coefficient for positions three and four correspondingly decreases as damage accumulates where no significant changes are seen for transducers locations one, two, and five. Shown in Figs. 6 and 7 is a two-point moving average (displayed on-line) of all similarity values

TABLE 1 Damage Status of 1/3 Scale Model K-joint Fatigue Test at NASA Goddard.

Data Point	No. of Cycles	Visual Indication	Crack Length (mm)		Overall* Similarity
			Left	Right	
1	37,000		0	0	.912
2	79,000		102	127	.925
3	102,000		165	197	.748
4	116,000		184	241	.737
5	126,000		228	260	.692
6	150,000		254	279	.667

*This data obtained from transducer location 3.

TABLE 2 Similarity Coefficient Analysis for 1/3 Scale K-Joint Fatigue Test at NASA Goddard.

Transducer Location	Data Point	Similarity Coefficient				
		Overall	Spectral Quarters			
			1	2	3	4
1	1	0.943	0.885	0.955	0.957	0.982
	2	0.909	0.826	0.932	0.967	0.566
	3	0.918	0.798	0.944	0.949	0.698
	4	0.880	0.801	0.919	0.852	0.362
	5	0.897	0.800	0.937	0.920	0.441
	6	0.924	0.881	0.935	0.968	0.543
2	1	0.973	0.941	0.981	0.972	0.921
	2	0.988	0.978	0.992	0.971	0.697
	3	0.983	0.991	0.983	0.970	0.643
	4	0.966	0.971	0.982	0.934	0.527
	5	0.963	0.923	0.976	0.948	0.555
	6	0.947	0.895	0.963	0.930	0.498
3	1	0.912	0.829	0.953	0.720	0.646
	2	0.925	0.889	0.946	0.807	0.442
	3	0.748	0.702	0.779	0.581	0.372
	4	0.737	0.693	0.763	0.637	0.397
	5	0.692	0.603	0.740	0.572	0.311
	6	0.667	0.549	0.740	0.503	0.260
4	1	0.954	0.874	0.968	0.934	0.988
	2	0.878	0.869	0.889	0.771	0.477
	3	0.727	0.904	0.693	0.733	0.448
	4	0.631	0.885	0.577	0.737	0.313
	5	0.602	0.898	0.551	0.756	0.303
	6	0.638	0.831	0.597	0.701	0.246
5	1	0.958	0.958	0.960	0.955	0.916
	2	0.831	0.756	0.861	0.791	0.388
	3	0.877	0.790	0.898	0.888	0.495
	4	0.820	0.724	0.857	0.802	0.357
	5	0.828	0.721	0.867	0.790	0.390
	6	0.859	0.775	0.886	0.839	0.408

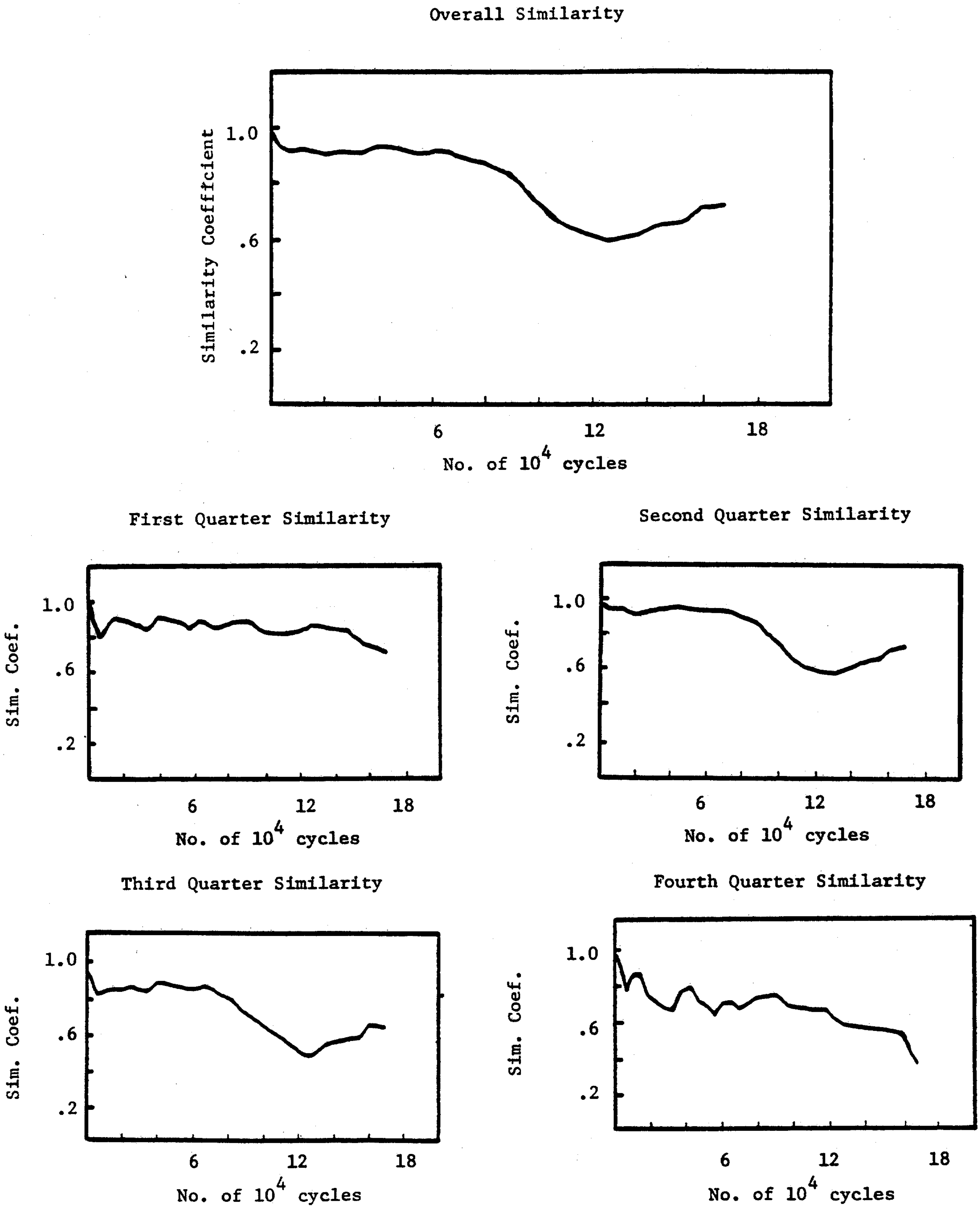


Figure 6—Similarity analysis for data acquisition position 3.

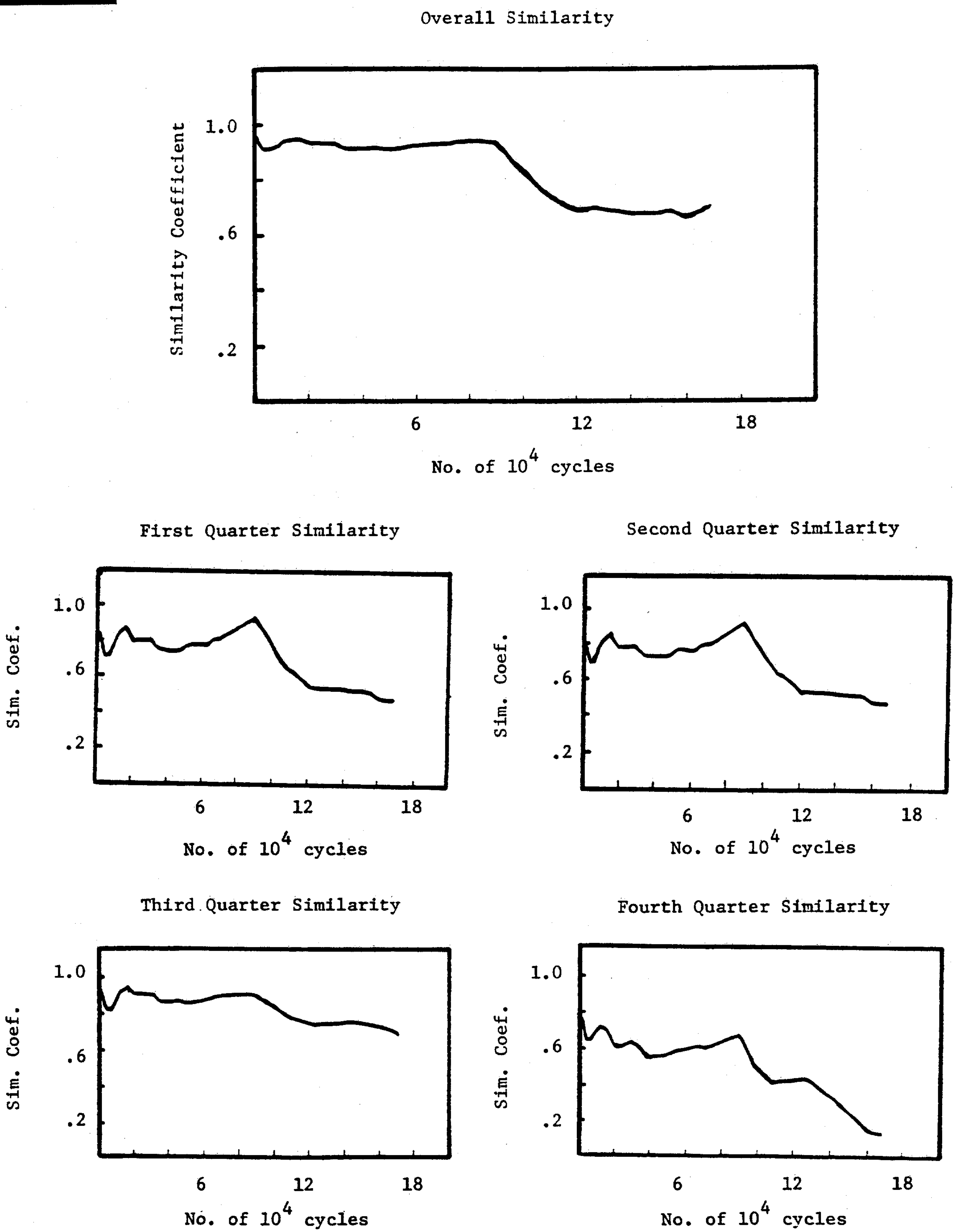


Figure 7—Similarity analysis for data acquisition position 4.

calculated for positions three and four. Damage is indicated by a marked decrease in the value of the similarity coefficient. Although the fourth quarter is somewhat noisy because of the low energy levels, this quarter can be a good indicator as well. In fact, this quarter seems to exhibit a greater sensitivity to small defects.

Laboratory Experiments

Data obtained from the 1/3 scale model raised the questions of technique sensitivity to off-axis damage as well as the stability of the lower energy spectral quarters for use in damage detection. Experiments were conducted in the laboratory to determine the limiting conditions. A 1/3 scale section of tubing was obtained, and sawcuts parallel and perpendicular to the direction of wave propagation were progressively made while varying the transducer position relative to the flaw location. The goal of this study was to determine the sensitivity of the technique to damage that is not on-axis with the transducer. In addition, data obtained at NASA seemed to indicate that pulse-echo may also offer a sensitive feature to damage; thus, pulse-echo was also investigated.

For the perpendicular sawcut experiment, transducers were situated on the tubing, as shown in Fig. 8; a previous experiment had indicated the minimum depth for sensitivity testing. By acquiring data in 15 different configurations, the sensitivity of the technique to off-axis damage (occurring perpendicular to the direction of wave propagation) was determined. The data from this experiment are tabulated in Table 3. Positions that reflect damage are 5, 10, and 15. These positions are those where the receiving transducer is on-axis with the damage. All other positions fail to reflect the damage inflicted. The results of using the Lamb wave inspection concept in a pulse-echo mode (on a perpendicular sawcut) are shown in Fig. 9. It appears that pulse-echo could be a key feature in detecting damage; however, it is a poor indication as to the severity and extent of the accumulated damage.

A similar experiment was conducted with a sawcut parallel to the direction of wave propagation. Sensitivity to damage in this case was exhibited in two situations: first, when the receiver was on-axis with the damage; and second, when the transmitter and receiver are on opposite sides of the damage, forcing the ultrasonic beam to pass through the sawcut and become the perpendicular flaw of the type previously discussed.

By referring to the data obtained in the sensitivity studies, it can be stated that the inspection technique utilizing the similarity coefficient analysis will reflect damage when it is present in a zone relatively close to the axis of the receiving transducer. It is difficult to extend the laboratory analysis to the question of stability and sensitivity of the individual spectral quarters to damage. The behavior of the individual quarters in the laboratory experiments does not correlate well to the trends observed in experiments with the 1/3 scale model K-joint because sawcuts do not adequately model the cracks that occur in an actual offshore structure during fatigue loading. This also points out the need to study the similarity coefficient in all four quarters of the spectrum for maximum sensitivity to any type of damage propagation.

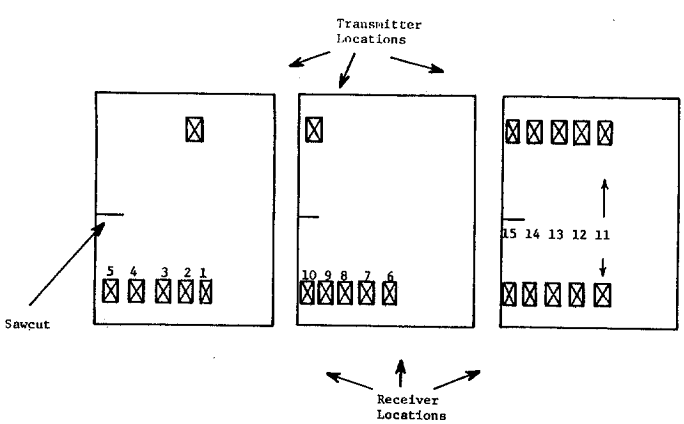


Figure 8—Transducer placement for evaluation of sensitivity to perpendicular damage.

TABLE 3 Sensitivity Analysis of Similarity Coefficient Technique to Off-Axis Damage.

Transducer Location	Similarity Coefficient				
		Spectral Quarters			
	Overall	1	2	3	4
1	0.927	0.821	0.690	0.403	0.743
2	0.922	0.701	0.586	0.695	0.913
3	0.915	0.853	0.630	0.803	0.895
4	0.907	0.600	0.624	0.700	0.827
5	0.743	0.562	0.384	0.521	0.748
6	0.959	0.821	0.864	0.989	0.960
7	0.976	0.847	0.661	0.981	0.940
8	0.976	0.725	0.696	0.801	0.826
9	0.975	0.898	0.667	0.803	0.932
10	0.766	0.817	0.624	0.962	0.946
11	0.946	0.926	0.735	0.953	0.947
12	0.975	0.901	0.773	0.952	0.928
13	0.979	0.931	0.637	0.813	0.888
14	0.936	0.913	0.767	0.914	0.902
15	0.768	0.783	0.757	0.399	0.746

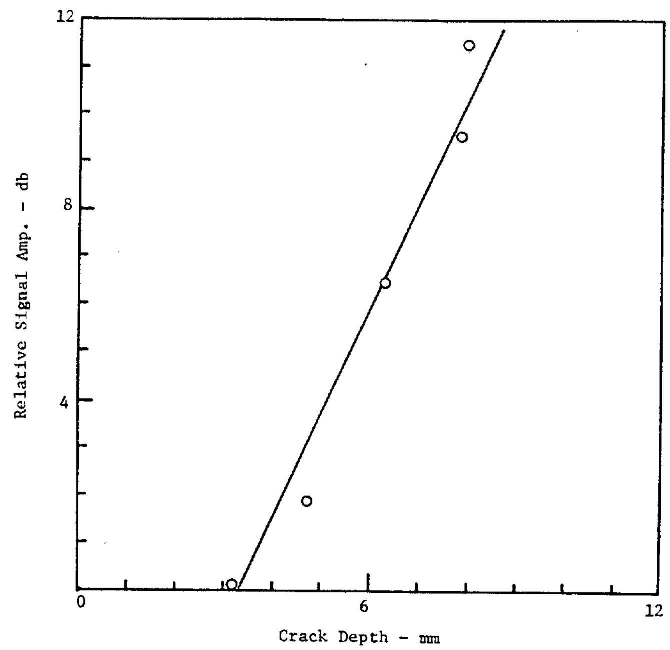


Figure 9—Pulse-echo data obtained from a perpendicular sawcut in 1/3 scale tubing section.

Finally, a set of experiments was conducted to determine the possible effects of a marine environment on the performance of the inspection technique and concepts discussed so far. Initially, a 1/3 scale section of tubing was immersed, and attenuation data were obtained. The negative effect of immersion was determined to be a 0.12 dB/cm additional loss. Although small, this factor becomes important when selecting transducer frequencies for the full-scale case. In addition, barnacle growth was then simulated by applying clay to the perimeter of the model so that 80 percent of the sound path was coupled to the clay. This resulted in an additional 0.06 dB/cm loss.

Although immersion and simulated marine growth had minor attenuative effects, there was a combined positive effect.

Because of the geometry of the problem, a surface wave of relatively high amplitude was generated by the transducer system. This wave mode was nominally extinguished by the combination of immersion and marine growth simulation, thus simplifying data acquisition.

CONCLUDING REMARKS

As a result of the studies conducted on the sensitivity of the Lamb wave/similarity coefficient inspection system, some interesting conclusions may be drawn.

1—Data obtained during the 1/3 scale model K-joint fatigue test (utilizing the global inspection concept) indicate that damage in the K-joint can be detected, and to some extent quantified, by considering the value of the overall similarity coefficient. The values of the similarity coefficients calculated for the various spectral quarters display sensitivity to smaller and varied types of defects. Monitoring their behavior is useful.

2—The limiting placement of transducers or sensitivity of the technique to off-axis damage has been determined. From the data gathered during laboratory tests involving sawcuts, the technique was determined to be sensitive to damage only when it occurs in a zone relatively close to the axis of the receiving transducer. For this reason, a higher sensitivity to damage that occurs perpendicular to the direction of wave propagation is observed.

3—The use of pulse-echo as a feature for damage detection was investigated as indicated by the signal amplitude versus crack depth data displayed in Fig. 9. This feature looks promising; however, pulse-echo in this context has shown little sensitivity in its ability to indicate the extent of the damage.

4—Transfer of the technique from the laboratory to field implementation calls for consideration of several logistical problems. Experiments conducted to date indicate that a marine environment will have no serious detrimental effects on the inspection concepts or its performance. Before actual field testing takes place, however, several additional factors should be considered:

(a) Permanent transducer placement must be considered, as well as the logistics associated with coupling.
(b) A method of monitoring transducer integrity must be devised because the transducer response highly affects the performance of the technique.
(c) Waterproof connections and coupling must be considered as well as the transmission of data via cabling or telemetry.

5—Experiments performed utilizing low frequency wave propagation in conjunction with signal processing techniques, now readily available due to the state of microprocessor technology, have shown that damage may be detected in the K-joint. It is anticipated that this technique may be applied to structural joints of similar geometry with little difficulty. Proper transducer design, placement, and frequency selection will allow the extension of this technology to other structures.

Acknowledgments

The authors would like to thank the Office of Naval Research and the United States Minerals Management Service for providing support for this project. Thanks is also extended to Michael D. Neary and Charles F. Dabundo for their assistance and efforts on this project.

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Paper submitted August 1982

Method for Measuring Transducer Movement During Underwater Ultrasonic Evaluation of Weld Flaws

by W. S. Burkle

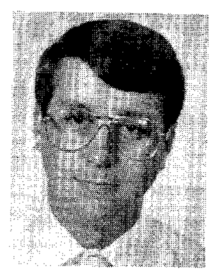
Abstract

Underwater ultrasonic weld testing is considerably more difficult than testing work conducted on the surface. A difficulty particularly present during underwater ultrasonic testing (UT) is the ability to accurately measure flaw dimensions using beam boundary intercept and other common defect-sizing techniques (see American Petroleum Institute [API] RP 2X, "Recommended Practice for Ultrasonic Examination of Offshore Structural Fabrication and Guidelines for Qualification of Ultrasonic Technicians"). Because flaw measurement constitutes a considerable portion of the data needed for critical evaluation of weld acceptability, accuracy is of the utmost importance. This paper discusses a method for improving flaw measurement accuracy utilizing ultrasonic echo-ranging techniques that employ a separate transducer and test instrument to monitor probe movement.

Ultrasonic testing (UT) is generally regarded to be the most effective nondestructive testing method for the examination of welded tubular T-K-Y connections. However, extending the application of ultrasonic inspection of these joints to the underwater environment, as is often done during the periodic in-service inspection of offshore platform structures, greatly complicates the testing procedure and introduces a wide range of possible test inaccuracies not otherwise normally encountered.

CURRENT PRACTICE

While current practice varies considerably, most underwater ultrasonic weld testing is accomplished using a two- or three-man team, consisting of trained divers and a nondiving UT specialist. The divers normally manipulate the weld test probe (transducer) and make physical measurements below the surface while the ultrasonic test specialist monitors the test instrument (CRT) and provides direction to the divers from a topside location. To assist in communication, the divers and test specialist are in continuous contact via audio/video equipment. Factors such as diver fatigue, reduced



Steve Burkle is a senior quality control engineer with the Materials Quality Control Branch of Phillips Petroleum Company, Corporate Services, in Bartlesville, OK. Prior to his current assignment, he served as a construction superintendent on the Sweeny Expansion Project for Phillips, and was involved with the welding, testing, and quality control of construction for that project. He has a degree in metallurgical technology, is a certified AWS welding inspector, is a certified ASNT Level III examiner in four nondestructive test methods, and has written a number of technical texts and articles related to welding and NDT. Before joining Phillips four years ago, Burkle worked as welding engineer, NDT engineer, and chief inspector for a number of different engineering construction companies and has served as an evening division instructor in the Department of Welding Technology at San Jacinto College in Houston. He is a member of the American Welding Society, ASNT, Welding Institute of Canada, Canadian Society for Non-Destructive Testing, and the Australian Welding Institute.

diver mobility, decreased diver tactile and manipulative ability, poor visibility, and considerable parallax when using conventional measurement tools (i.e., steel rulers and tape measures) all contribute to test inaccuracy. This inaccuracy is particularly apparent when critical flaw dimensions such as length and width are being measured underwater. The normal routine for measuring flaw dimensions is for the diver to manipulate the probe (transducer) as instructed by the test specialist so that the center of the sound beam traverses the flaw from edge to edge. The distance over which the probe has thus been moved corresponds to the flaws' dimensions in the direction of transducer movement and is measured using a standard 6 in. steel ruler. This information is verbally relayed topside and forms a critical portion of the data to be used in flaw evaluation.

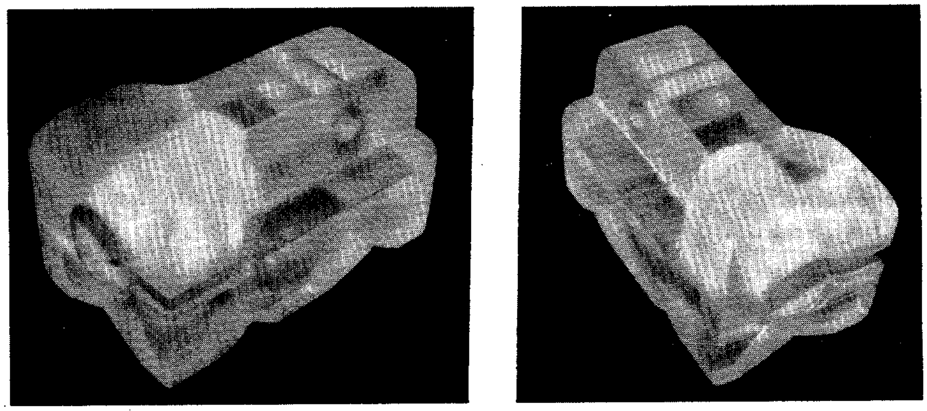


Figure 1—Nicknamed a "crab," this fixture aids in steady transducer positioning and facilitates handling.

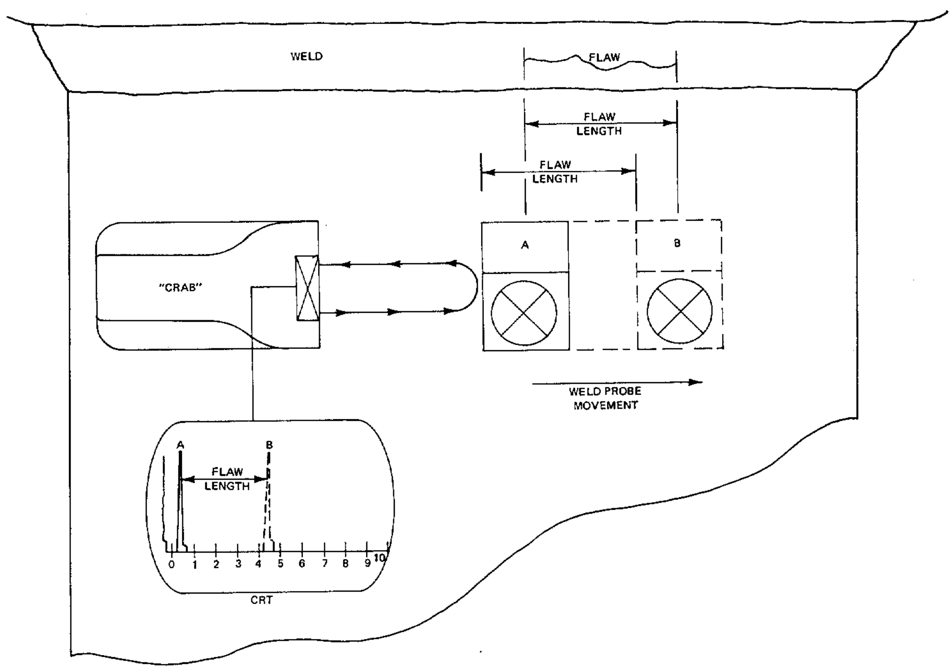


Figure 2—The crab is positioned facing the weld test probe. The longitudinal wave produced by the transducer in the crab creates CRT reflections that correspond to the distance between the probe and the crab.

ULTRASONIC ECHO RANGING

Relative to the difficulties encountered during underwater flaw sizing, some work has been performed utilizing an ultrasonic echo-ranging technique employing a separate ultrasonic test transducer and ultrasonic test instrument to monitor probe movement. This is accomplished by positioning a standard 2.25 MHz longitudinal wave transducer adjacent to the usual test probe being used for weld inspection. During use, the longitudinal transducer is held in a durable plastic fixture (Fig. 1), nicknamed a "crab"; it is specially designed to assist in steady transducer positioning. The longitudinal wave transducer is aimed at the side of the weld test probe (Fig. 2), and a sound wave is transmitted through the water. This wave is reflected from the side of the weld test probe, producing an echo that appears on a separate, topside CRT. As the weld test probe is moved, the echo will shift position. This echo shift represents increased water distance between the transducer and weld test probe, and the net shift corresponds to the amount of probe movement.

SYSTEM APPLICATION

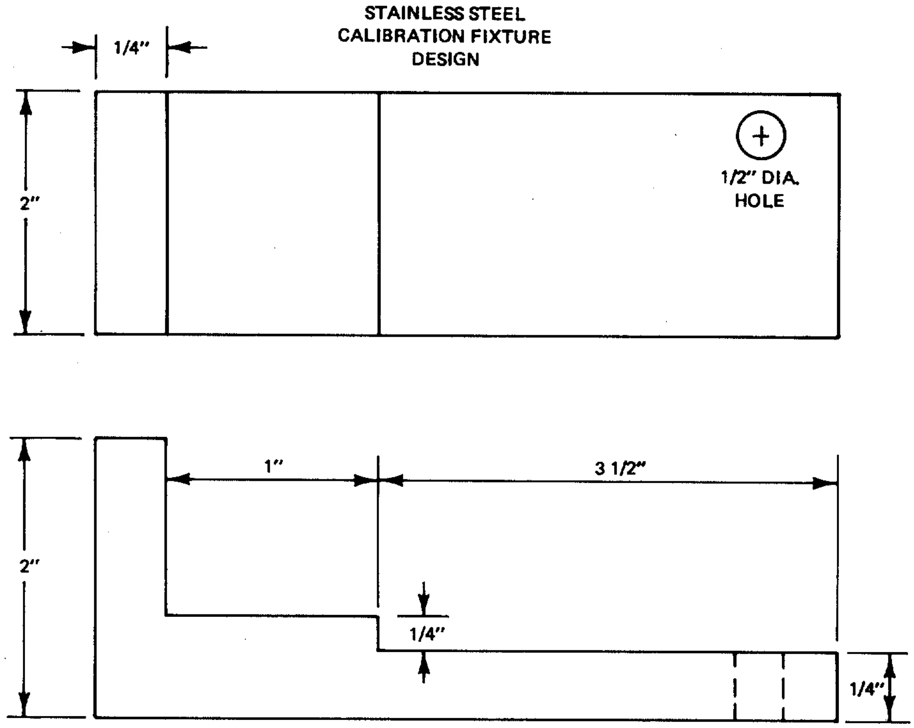
When a flaw has been discovered by using the weld test probe (transducer), the diver manipulates the probe to one edge of the flaw as instructed by the test specialist. He then positions the crab approximately 1 in. from the weld test probe and holds it stationary. The test specialist uses the sweep delay control to position the resulting reflection from the side of the weld test probe at increment zero (0) on the CRT screen. The diver then manipulates the transducer to the opposite edge of the flaw according to instructions from topside, and the net probe movement is read directly from the CRT. All of the data provided by this method of measurement is presented directly topside for interpretation by the test specialist, and the need for a diver to make and relay physical measurements of probe movement is eliminated. Furthermore, this system employs conventional ultrasonic test apparatus and may easily be applied by test specialists familiar with ultrasonic pulse-echo testing techniques.

CALIBRATION

If measurements are to be accurate, calibration must be accomplished under the exact conditions of intended use. Variations in water temperature and salinity could significantly affect readings. A special fixture designed for the system (Fig. 3) simplifies and expedites the calibration procedure. During calibration, the crab is clamped to the calibration fixture, and both are then lowered to the test level. The instrument is adjusted such that the back reflection and the first multiple from the calibration fixture target represent 1 in. and 2 in. of water sound path respectively on the CRT. A maximum screen length of 5 in. is recommended, enabling measurement to be made to the nearest one tenth of an inch. More accurate measurements are possible utilizing smaller calibration ranges. The probe is then removed from the calibration fixture, and the system is ready for use. Calibration may be rechecked periodically.

CONCLUSION

The primary limitation of the system is the need for the side of the weld test transducer and the "crab" face to be



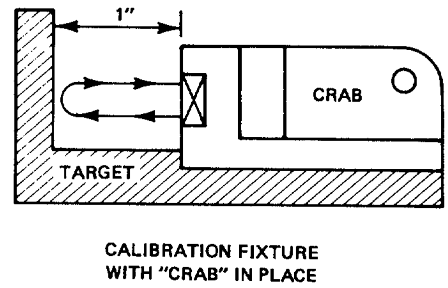


Figure 3—This fixture simplifies calibration of the echo-ranging system and renders increased accuracy.

maintained nearly parallel during measurement. For example, it was found that rotating the weld test probe face more than 30 degrees out of parallel would result in a loss of displayed reflection. Consequently, consideration is being given to the attachment of a spherical reflector to the side of the test probe. Other improvements such as attachment of a magnetic base to the crab appear possible based upon preliminary tests; however, the system is believed to be a practicable alternative to existing flaw measurement techniques.

Calls for Papers

Calls for papers have been issued for QualTest-2 in October 1983, and the 1984 ASNT Spring Conference.

Authors interested in presenting papers on NDT investigation, application, or research are asked to submit one-page abstracts to the Technical Program Chairman by the appropriate deadline listed below. Abstracts should clearly indicate the content of the proposed presentation. Possible subject areas include acoustic emission; electrical and magnetic; holography; infrared and thermal; leak testing; metallography; penetrants; penetrating radiation; sonics; visual; aerospace; automotive; marine; railroad; chemical and petroleum; construction materials; electronic components; military and government materials; nonferrous metals; energy systems components; rubber products; steel producers; utilities; and research (all phases).

Authors of accepted abstracts will be asked to make an oral presentation at the conference. Allow 20 minutes for presentation and an additional 10 minutes for questions and answers.

To maintain a high standard of excellence, authors must be prepared to submit complete information concerning their presentation to ASNT by the deadlines indicated.

Speakers wishing to have their **complete** paper published in the ASNT journal, *Materials Evaluation*, should submit it to the Editor, *Materials Evaluation*, 4153 Arlingate Plaza, Caller #28518, Columbus, OH 43228. The ASNT *Manual for Authors*, which gives complete details of publication requirements, will be supplied on request.

Conference Deadlines:

Deadline #1 Abstracts for unsolicited papers must be received by Technical Program Chairman.

Deadline #2 Technical Program Chairman will notify authors of acceptance or rejection.

Deadline #3 Speaker Information Sheet due from accepted and invited authors. Final abstracts for all papers (types on the ASNT Abstract Form) must be received by the ASNT Conference Department from accepted authors.

QualTest-2
October 24–27, 1983
Dallas Convention Center
Dallas, TX

November 1, 1982	**Deadline #1**
December 15, 1982	**Deadline #2**
April 15, 1983	**Deadline #3**

Please send abstracts to:

Art Lindgren
Technical Program Chairman
Magnaflux Corporation
7300 West Lawrence Avenue
Chicago, IL 60656

1984 ASNT Spring Conference
March 26–29, 1984
Shoreham Hotel
Washington, DC

June 1, 1983	**Deadline #1**
July 15, 1983	**Deadline #2**
October 14, 1983	**Deadline #3**

Please send abstracts to:

William Plumstead
Daniel Construction Co.
Daniel Centre, Third Floor
Greenville, SC 29602

Technical Note

Paper submitted January 1983

The Magfoil Method

by K. G. Walther

Abstract

During the past decade, man has gone higher into space and deeper into the oceans. Space vehicles and offshore structures have grown to gigantic dimensions. Inspection problems have increased proportionately with loads and stresses, as have the dangers of small defects in the structures. The testing methods transferred from onshore to offshore applications no longer meet actual needs. New techniques, methods, and systems need to be developed. The dangerous-to-man underwater environment puts limits on the activities of deep-sea diving personnel. The NDT methods must therefore be easy to handle, self-controlling, and reliable to evaluate.

INTRODUCTION

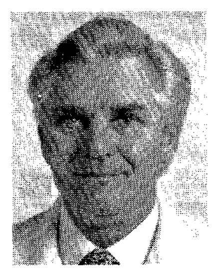
Inspection of offshore installations presents specific problems. Some difficulties are experienced when testing is performed in the building yard because the complex shape of the welding cross section causes problems. During testing after operation under hostile sea conditions, defects within the cross sections must also be found, and one must look for fatigue cracking. The selection of the testing technique has to be directed by this requirement. For this reason, surface-sensitive methods have primary preference, and magnetic particle testing (MT) is widely employed. A disadvantage to MT, however, is the lack of documentation of test results. A way of narrowing and perhaps eliminating this information gap is offered in the following paragraphs.

SOME PROBLEMS WITH UNDERWATER TESTING METHODS

High-resolution cameras nowadays allow the technician to make good visual inspections, but only after the material has been cleaned of marine life. Such limitations as a small field of view, reflections in the water, and other visibility problems allow one to find only large open cracks.

Ultrasonic testing is performed by several inspection companies. However, the testing of the seam of two inclined cylinder penetrations is a very difficult task. Figure 1 shows some conditions encountered on a relatively simple 45 degree connection.

Magnetic particle testing for many reasons is the most used method. Because it is the most sensitive method to use when detecting physical system-to-surface defects, it is predetermined for this purpose. Unfortunately, it is difficult to obtain the necessary documentation of a test.



Karl G. Walther, Joint Managing Director of Henrichs & Walther GmbH, has been involved in NDE since 1952. He began working for J. Krautkrämer and H. Krautkrämer in 1958 and, while doing a lot of traveling, he became educated in the English-speaking world. In 1965, he came to the U.S. as director of training to establish the training system for Krautkramer Ultrasonics. After inventing the Magfoil method, he and his partner, Klaus Henrichs, formed their own company. Since then, several developments in methods and products have been made. Walther is a member of ASNT and DGZFP, holds a Level III in UT, and has developed several patents.

The portion to be tested will usually be magnetized by magnetic yoke devices. Usually, ac magnets are preferred for use because of their skin effect with higher magnetic potential in the surface region of the material. With plate material higher than approximately 12 mm (0.5 in.), the permanent magnetic yoke is at a disadvantage. The field will penetrate deep into the material, and not enough polarity will be generated in the surface. In addition, when permanent yokes without field guidance are used, the large leakage flux will disturb the particle indication of a flaw. Figure 1a shows some of the difficulties that can be encountered when using permanent magnetic systems.

The complex geometry of most defects requires a flexible magnetic yoke, such as the Flexiyoke EL 60 system that is available for subsea applications. (See Fig. 3.) The unit is held to the steel wall by special holding current circuits, which free the diver's hands for work. The diver can leave the device at a resting position like a permanent yoke and move it into position after the preparation for the test is completed.

The magnetic yoke EL 60 is extremely powerful. At a pole distance of 170 mm (7.0 in.), it gives a current density of 12 kA/m (145 oersted). The poles can be separated to a distance of more than 250 mm (10 in.), depending on the geometrical requirements, and a flux density of 4 kA/m (48 oersted) still at the center line of the test is sufficient for a reliable indication of the smallest flaws.

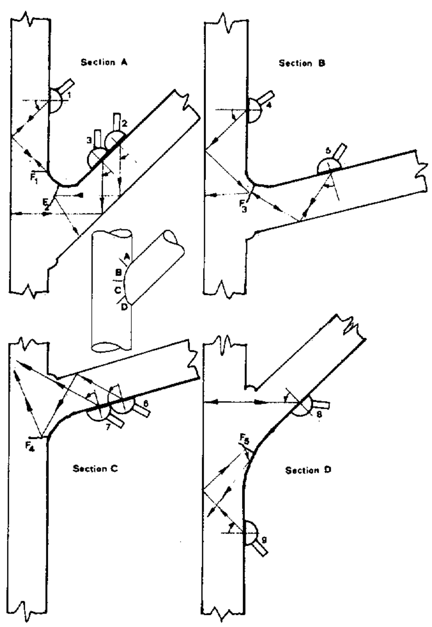


Figure 1—Geometrical difficulties encountered with ultrasonic testing.

Magnetic particle testing is usually performed by choosing a suspension of fluorescent-coated ferromagnetic material, which is sprayed on the weld under test, and the particles accumulate in the known manner. However, there are several problems that could occur after spraying. Not all of the particles are attracted by the magnetic flux; much of the fluorescent material is taken away by the water current; and, when the black-light lamp is used to light up the area being inspected, a bright shining cloud disturbs the visual control. Moreover, the particles often assemble around the diver's mask, causing additional problems. Sometimes a second diver is even needed to scare away schools of fish that are attracted by the ultraviolet high-intensity light.

DISCUSSION

Whenever a flaw indication is found, the diver has to explain verbally what he can see. It is difficult for the inspector aboard the support vessel to take the diver's information and make the necessary decisions to either repair a defect or to accept defect indications.

For several years, another documenting system using magnetic tapes has been operating and making subsea inspections. This system has overcome most of the previously mentioned MT problems, but the magnetic tape system is a very large and costly electronic package, the handling of which is a special job for experts only. Another drawback is the relatively thick magnetic tape material, which cannot follow the rough surface contours and causes different distances to the surface with different sensitivity levels for flaw indications. The lack of an indication of sufficient flux density on the tapes at the point of test is still another problem.

All of these difficulties do not appear when the new Magfoil* method is used. As with standard wet MT, Magfoils contain magnetizable particles. They are held with other substances in a flat, hose-type container made of flexible foil. Figure 2 shows such foils and their dimensions. In the Magfoils, there is a white "carrying substance" in one of the partitions and a mixture of fluids in another partition. Separated like this, the Magfoil can be stored for long periods of time.

When the Magfoil is to be used, the operator applies pressure to the partition containing the fluids. An inner wall then breaks, and the solid and fluid contents can be thoroughly mixed. For divers' undersea usage, the mixing period is adjusted for a maximum time of 1 minute. Within this time, the diver places the Magfoil against the section to be tested. When placed correctly—pressed to the surface—the material is magnetized for 30 seconds to 2 minutes. To reduce even more busy work for the diver, the whole timing of the Magfoil testing cycle is controlled by a special control circuit. Figure 3 gives a view of the complete testing package.

The Magfoil method consists of a series of easy-to-follow steps for underwater inspection. First, the diver gives a verbal command to start the cycle as he breaks the fluid partitions of the Magfoil. His partner aboard the boat or above-water structure then starts the device, which in the "ready" position delivers a dc holding current that keeps the yoke magnet at any suitable resting position near the testing point. After starting the device, green signal lights appear in selectable time sequences. The first sequence is for the initial 15 seconds, then the second comes on until 30 seconds have gone by. The third will come on for 30 to 45 seconds, and the fourth then blinks for the last 15 seconds. This process makes it easy to give the diver the correct time. After 60 seconds, the testing ac current will be switched on, and the holding current will decrease. The testing current will stay on for a selectable time, somewhere between 30 seconds and 2 minutes. Then the holding current will be reinstalled again. A signal shows the inspector when the time for reaction and hardening has lapsed, and he will give a command to the diver to take the Magfoil off its holder and to send it up by a buoy for evaluation. Handling is actually so easy that an average diver needs only five trials to become familiar with the method and to bring up usable documentation.

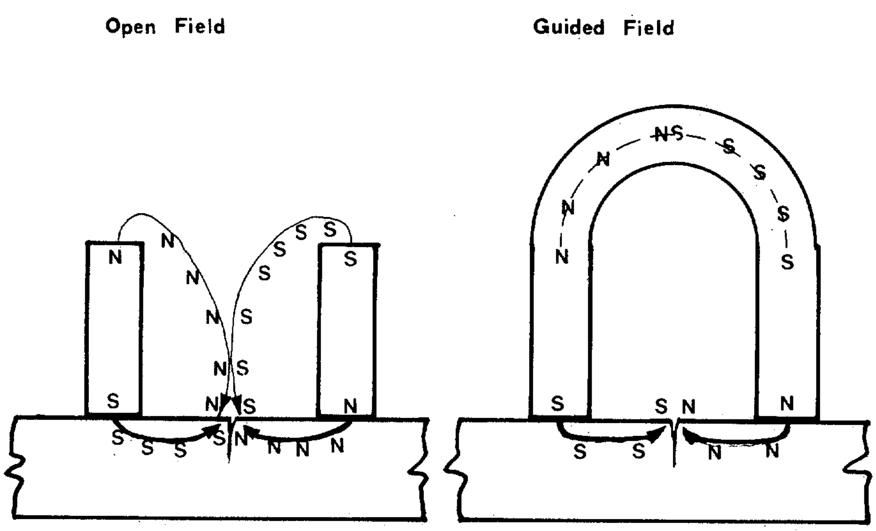


Figure 1a—Difficulties encountered with permanent magnet systems.

*Magfoil is available from Henrichs & Walther GmbH, Westend 23, Bocholt 4290, Federal Republic of Germany. The U.S. distributor is Mooney Sales & Engineering, Inc., 6 Cynthia Lane, Shelton, CT 06484.

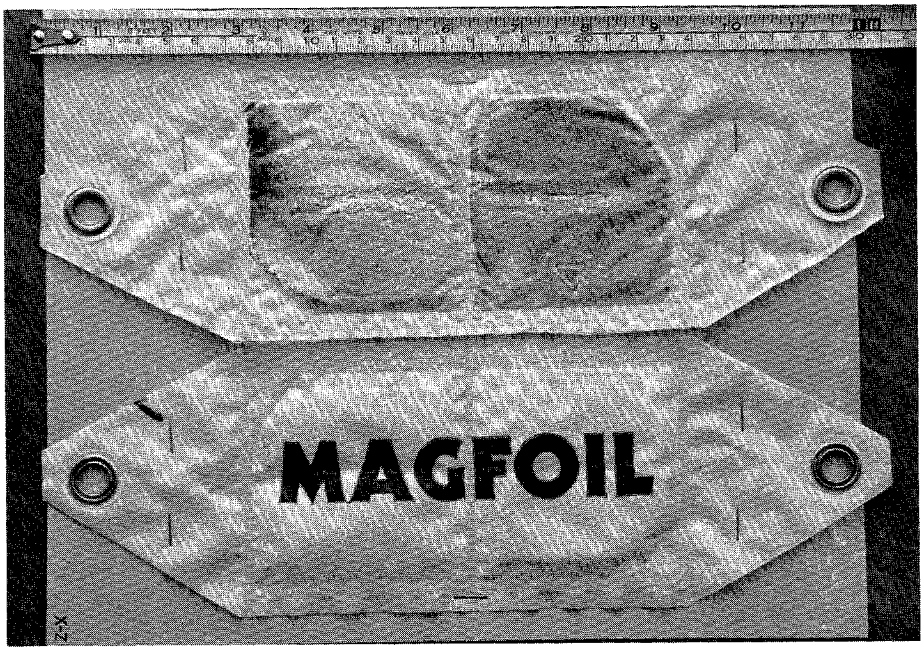


Figure 2—Standard Magfoils and their dimensions.

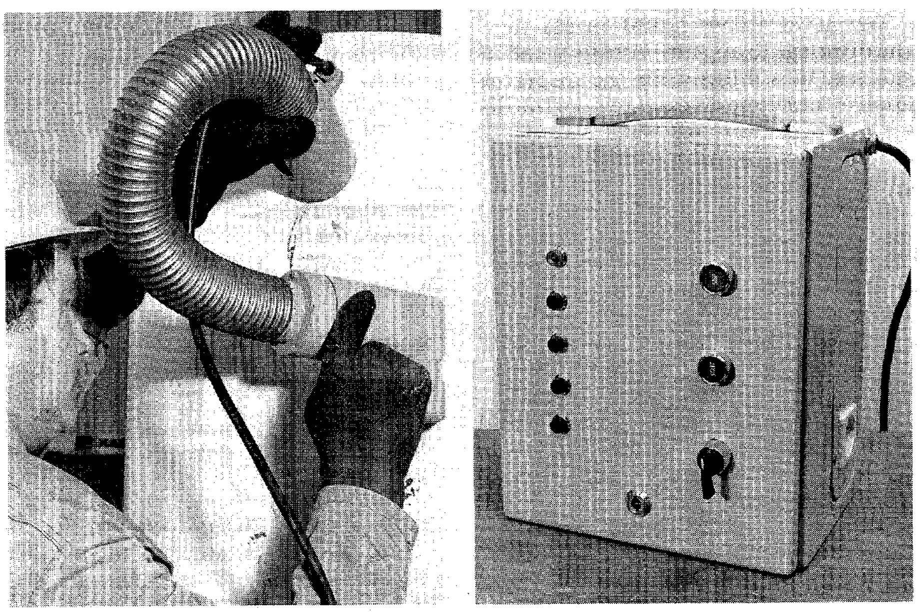


Figure 3—(Left) *The Flexiyoke EL 60 system.* (Right) *The complete EL 60 package.*

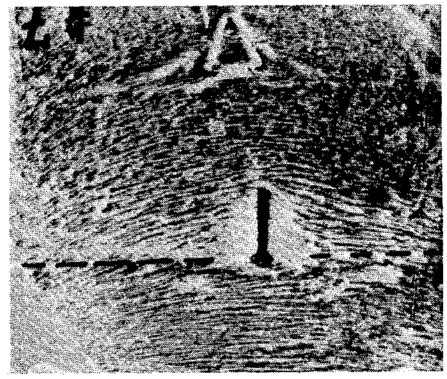


Figure 4—Triangular-shaped notch documented with Magfoil AF.

During the time of magnetization, the ferromagnetic particles accumulate in the known way along a flaw edge. It takes another two or three minutes of reaction time to harden the carrying substance to such an extent that the Magfoil can be moved away from the testing area without breaking the contents in the water current. The ferromagnetic particles are frozen into their position, and the display is preserved for evaluation purposes.

Figure 4 shows the results of a Magfoil test. In addition to the usual accumulation along the flaw's edges, more information is available. It is immediately visible that the particles settled to the sight foil following the flux lines, the direction of which clearly indicates a correct or incorrect direction of the magnetic field. At the top left and bottom right in Figure 2, two triangles can be seen. These are the indicators that accumulate particles when the magnetic field is applied, just as a flaw does. The indicators are welded to the Magfoil and can be ripped off after the exposure. Again, the field direction and the flux density can also be evaluated from the indicator image. The diver can prove that he did a correct job, and the inspector can judge if the test is valid or must be retaken. There will be no indication or very little indication of the triangle if the flux density was not sufficient or if the Magfoil was placed too late against the test specimen.

It can also be seen that the thin (0.05 mm [0.002 in.]) sight foil clings close to the surface, and the negative of the weld configuration is cast into the carrying substance of the Magfoil.

Even more important is the white area around an accumulation. It is something very new and cannot be obtained with other MT techniques. This information gives the inspector a chance to distinguish between real flaw indications and false accumulations along surface irregularities when performing wet tests. The Magfoils clearly show a permeability change with a more or less wide white area surrounding an accumulation. If there were only a valley, then the white zone would be missing.

The latest research also shows that there is a direct dependence of the width of the white zone to the depth of a crack. One example is given in Fig. 4 where a triangular-shaped notch is documented. The "stray flux action zone" is not influenced by flux density as long as a minimum field strength is generated. Figure 5 shows three Magfoils from two fatigue cracks. The flux density of Fig. 5a was 12 kA/m, and Fig. 5b's flux density was only 4 kA/m. In Fig. 5c, a second crack was documented with fully flexible extension poles that reduced the flux density to 1.4 kA/m. Both cracks had a maximum depth of 1.5 mm (0.06 in.). A different field strength can also be judged by the indicator images.

The above statements lead directly to the question of resolution quality. As with wet MT, the same resolutions hold true for working with Magfoil. For larger cracks, larger particle sizes will be used. Likewise, for the finest cracks, the finest particles are applied. The Magfoils printed in Figs. 4 to 5 are of the AF (fine) type, which contain medium-sized particles. Figure 6 gives an example of Magfoil type A with larger grains, and Fig. 7 shows the finest Magfoil ASF (super fine) with the highest resolution. (The documented MTU test piece is shown in Fig. 7.) The flux density was in the permanent field of 2.4 kA/m. The test piece is

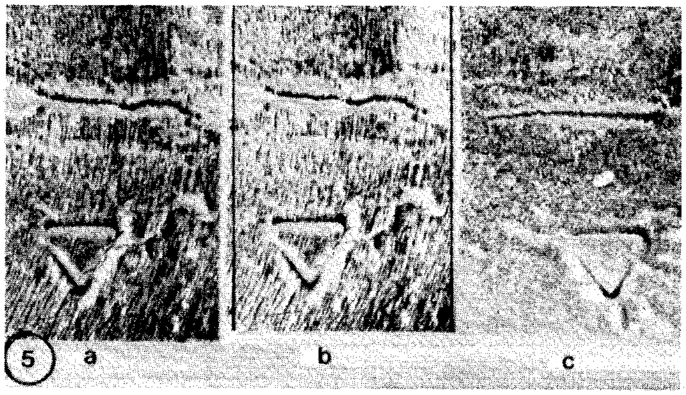


Figure 5—Magfoil of fatigue cracks.

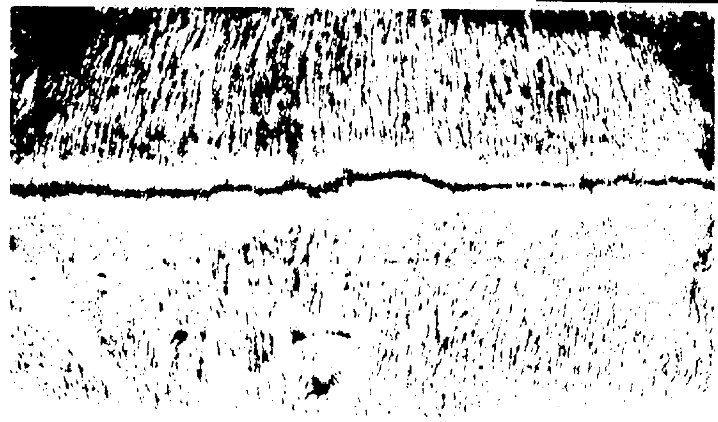


Figure 6—Magfoil A with large ferromagnetic particle size.

usually specified to test the usability (in respect to resolution) of magnetic particle suspensions for testing aircraft engine parts; this resolution requirement is the highest standard known in Germany. Magfoil documents can easily be copied with any standard dry copier. It goes without saying that the original Magfoil can also be stored without any information loss.

All of the results obtained encourage further experimentation toward finding applications for Magfoil in greater sea depths.

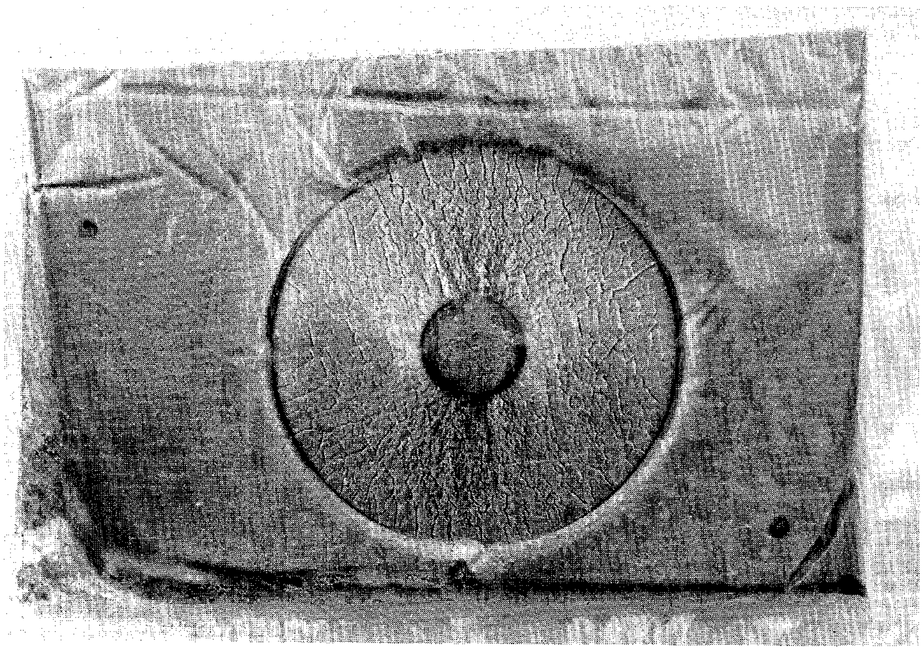


Figure 7—Magfoil ASF from MTU test piece.

CONCLUSION

Magfoils have been used in North Sea installations by various companies and platform operators. Diver training is in progress, and very encouraging results have been returned from the field. It seems that Magfoils can help to solve some of the subsea testing problems facing nondestructive testing inspectors today.

Acknowledgment

This project was carried out with the support of the German Ministry for Research and Development. Use of facilities such as the deep-sea simulators of GKSS in Geesthacht/Germany is appreciated.

Paper submitted January 1983

Magnetographic Weld Inspection System for Underwater Installations

by W. Stumm

Abstract

A new underwater tool for magnetic inspection of welds is described. This tool enables separation of a diver's work and the evaluation procedure. The results from the inspected weld areas are shown in a two-dimensional C-scan.

INTRODUCTION

Due to government safety regulations and economical reasons for preventing severe failures and losses, the integrity of underwater constructions such as offshore drilling and production platforms and pipelines has to be guaranteed by periodic inspections and appropriate repair.

Nondestructive defect examination methods contribute considerably to the reliability of such inspections. During the operation of a platform, mainly fatigue cracks in welds (besides corrosion) have to be detected at an early stage of their growth to allow time for acceptable repair. In particular, strong wave motion in the North Sea with wave heights of 2 to more than 15 m over long periods of time exerts heavy fatigue loads on the structures. Catastrophic failures of offshore platforms, with losses of many lives, highlight the necessity of inspections because fatigue cracks have contributed to these accidents.

Node, circular, and butt welds have to be inspected; each type of weld represents rather complicated geometries for the application of nondestructive, inservice inspection methods. Magnetic leakage flux techniques and magnetic fluorescent ink as a means of indication have proven to be acceptable tools.

The basic simplicity of the method should not lead to the misunderstanding that it is an easy way of implementing offshore inspection. Rather bulky underwater equipment is required for magnetizing and ink conditioning; the reproducible application of the ink is a problem even in dry plant installations and much more so underwater; and the same difficulty applies to the ultraviolet illumination and the visibility conditions. Rather high responsibility rests with the diver to decide whether he has detected a defect or not; in addition, magnetic powder traces do not reflect very well the defect severity. Permanent records require photographic methods with additional equipment to be handled by the diver.

THE MAGNETOGRAPHIC TECHNIQUE

The magnetic tape recording method—the so-called "Magnetographic or Magneto-Marine technique"—overcomes some of the previously mentioned problems. Moreover, it is approved by two classification societies: Det norske Veritas and Lloyds Register of Shipping.

The principle of the method is again very simple. A flexible magnetic recorder tape is stretched over the weld area to be inspected (see Fig. 1). In typical underwater applications, a weld length of about 0.5 m is inspected in one procedure. A short magnetizing pulse of about 15 ms duration, fed from a battery-supplied capacitor into a yoke, magnetizes the weld area over the yoke length and records the stray flux originating from cracks in this area onto the tape.

The yoke is moved stepwise over the

Wolfgang Stumm received his Masters in Physics from University of Saarbrücken in 1964. He began working at Institut Dr. Förster, Reutlingen, West Germany, in 1969 as head of the application laboratory. Presently he is executive vice president of Research and Development and Production at the institute.

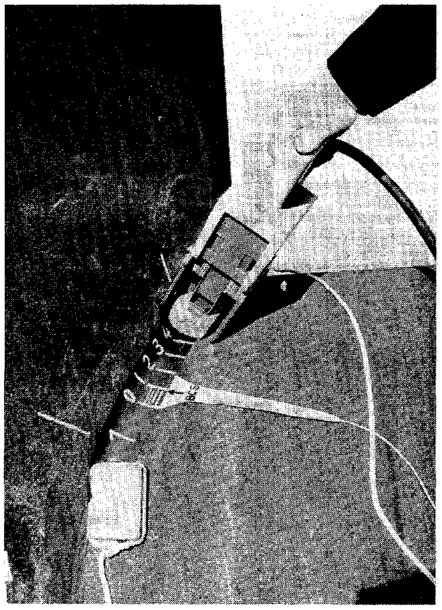


Figure 1a—Magnetization of a tape.

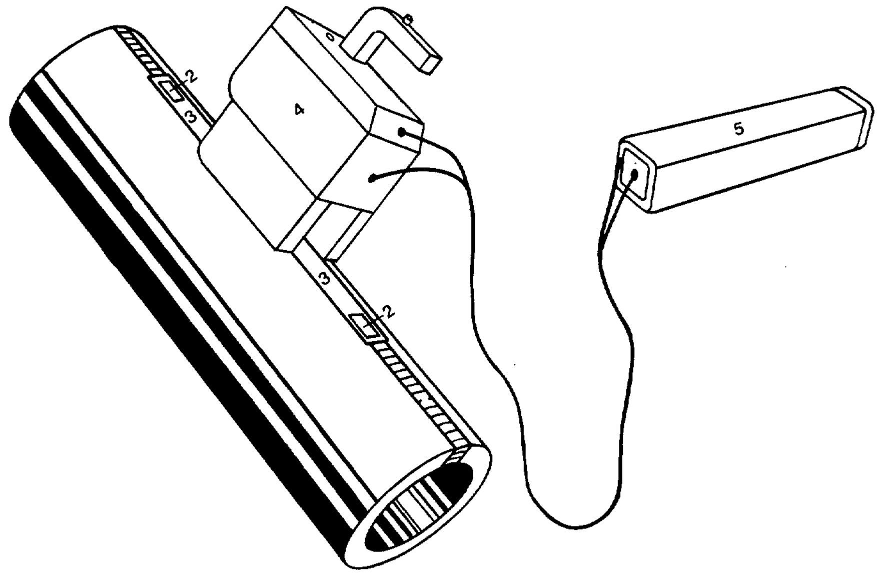


Figure 1b—1) Weld; 2) permanent magnet; 3) tape; 4) yoke; and 5) power supply.

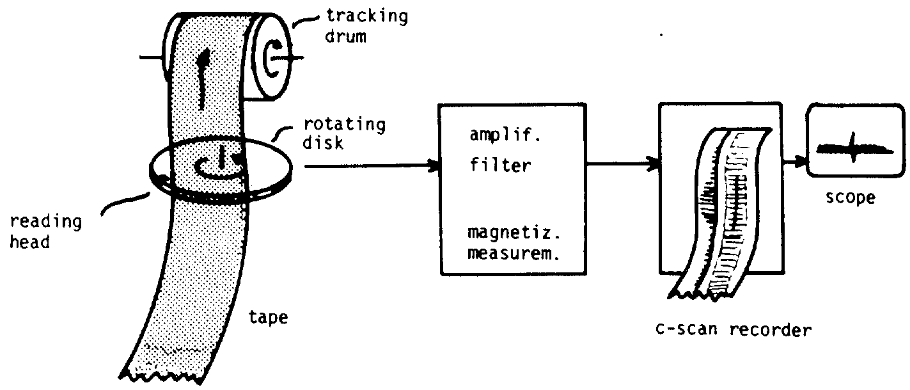


Figure 2—Magnetograph tape scanning and recording.

tape length. The tape is then sent onboard the platform of the supply ship, where it is processed by a scanning device. The scanner reads the recorded stray flux from the tape onto an oscilloscope and on a permanent C-scan record, providing a two-dimensional 1:1 scale record of the magnetic picture of the weld (see Fig. 2).

The tape plays a multiple role in this technique: (1) It reduces the required magnetizing power; (2) it acts as a recording means that allows the information transfer from underwater to the platform, thus separating the inspection procedure into (a) tape positioning and magnetizing by the diver underwater and (b) evaluation by the onboard inspector and supervisor; (3) and it allows transformation of the complicated weld geometry and the corresponding leakage flux into a geometry that can be scanned automatically onboard with magnetic probes, followed up by all of the electronic signal treatment and recording currently available.

THE UNDERWATER EQUIPMENT

The underwater equipment consists of yokes for different weld geometries, underwater power supply, tapes, fixing magnets, and some auxiliary parts. Two different yokes cover the various node-weld geometries. For welds between parallel plates (180 degrees) and 90-degree nodes, a yoke with parallel pole shoes is used (see Fig. 1). A foam rubber-coated, spring-loaded pressing shoe pushes the tape steadily onto the surface and into weld grooves. One pole shoe is movable around a horizontal axis to fit into nonsymmetric welds.

For nodes from 90 to 30 degrees, a yoke with hinged pole shoes is required (see Fig. 3). A flashing light on the top of the yoke shows that the electric system is charged and ready to fire a pulse. By pressing down a knob within the handle, the magnetizing pulse is fired. After a recovery time of 3 s, the system is ready for firing the next pulse. The yoke with an actual length of about 4 in. is then forwarded by a step of approximately 2 in. for the next shot. Thus, a 50 percent overlap of magnetization guarantees that the magnetic history of the weld has no influence on the recorded signal amplitude.

The underwater power supply with a shock-absorbing buoyancy plastic cover has low voltage, rechargeable batteries (see Fig. 3). The power supply lasts for at least an entire one-day operation with several hundred shots, and its operating depth extends to 300 m (900 ft). The complete underwater system complies with all safety regulations. The pulse produced by the system excites a field strength between 3 to 5 kA/m over a time of about 15 ms.

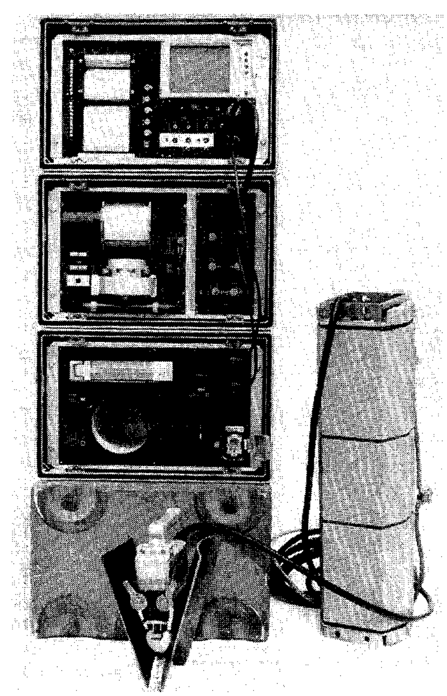


Figure 3—Evaluation system with underwater equipment.

THE EVALUATION SYSTEM

The onboard evaluation system is built into three shock and waterproof boxes to be opened for the operation (see Fig. 3). It consists of a power supply box with safety circuits, a battery charger, and a high-frequency tape eraser tunnel in the bottom. In the middle part is the tape scanner with the calibrated tape tracking drum, amplifiers, and filters. In the top are the scope representation of the actual defect signals and the two-dimensional raster strip-chart recorder. Brightness control for contrast enhancement of the recorded two-dimensional signal or for flashing in marks, i.e., from signal thresholds, provides an easy evaluation of the stray flux picture of the weld.

Figure 4 shows a record from a weld and consists of two different records. In the lower part is the two-dimensional magnetic picture shown in 1:1 scale to represent the field distribution over the weld area. This presentation enables the inspector to carry out a pattern recognition procedure similar to an evaluation of an actual magnetic ink picture on the weld itself. In the top of Fig. 4, the peak signal amplitude recorded over a scan covering the weld width is represented to allow signal amplitude measurement. The record of a Burmah Castrol strip on the beginning of the record in Fig. 4 is used to show correct functioning of the whole system.

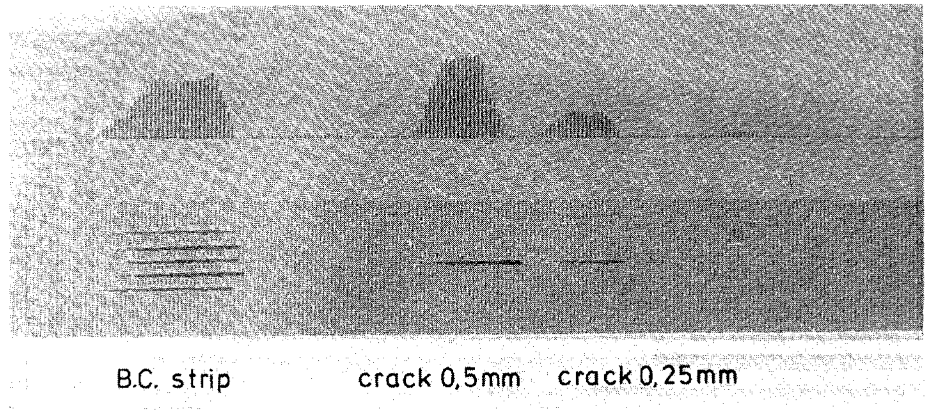


Figure 4—Two-dimensional record of magnetographic inspection (spark-eroded slits in a T-weld).

In general, the system is calibrated using weld samples with artificial flaws. Figure 4 shows the two-dimensional record of two artificial flaws (0.5 and 0.25 mm deep, 50 μm wide [0.020 and 0.012 in. deep, 0.002 in. wide]). The brightness control of the recording system was used for contrast enhancement. This record shows that the sensitivity that can be attained with this system is quite similar to that of magnetic powder inspection methods.

CONCLUSION

The magnetographic system represents a new method for underwater weld inspection. The diver's function is relatively simple and can be carried out by non-NDE qualified personnel. The system provides objective test results that are distinguished by reliability and reproducibility. These results can be stored and compared with results obtained in earlier inspections.

Erratum

Materials Evaluation has been notified that an error appeared in D. J. Hagemaier's technical paper, "Eddy Current Impedance Plane Analysis," which was printed in the February issue (Vol. 41, No. 2, pp 211–218).

On p 215, under the section heading titled "Metal Spacing," the first paragraph's last sentence should read as follows: "The frequency chosen should produce eddy currents that penetrate the upper layer to a depth approximately equal to δ and both metals only to a depth of δ_E (see the section on depth of penetration)."

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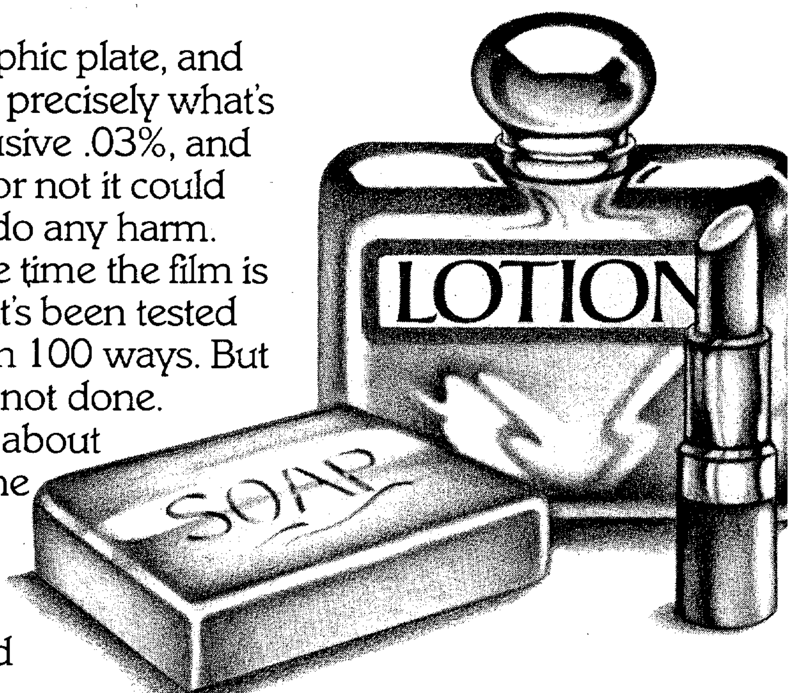

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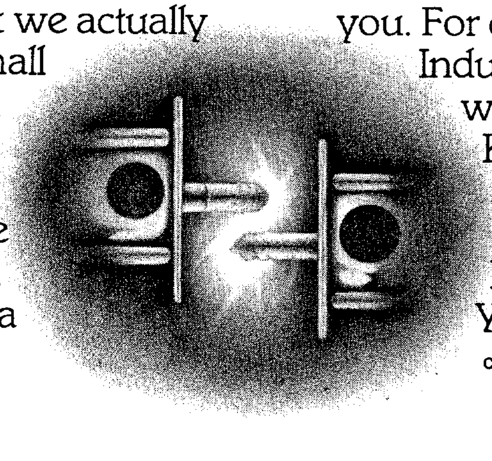

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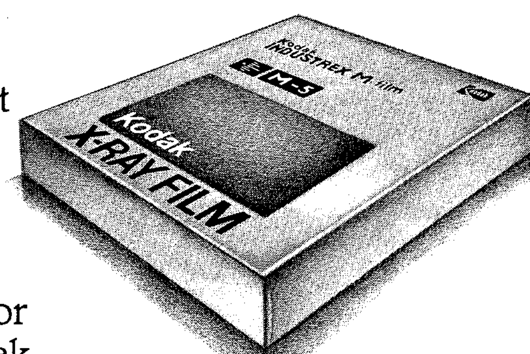

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