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NDE ACTIVITIES AND TECHNOLOGY TRANSFER AT SANDIA NATIONAL LABORATORIES[1]

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ABSTRACT

The NDE, Photometrics, and Optical Data Reduction Department at Sandia National Laboratories in New Mexico (SNL/NM) provides nondestructive evaluation (NDE) support for all phases of research and development at Sandia. Present facilities and personnel provide radiography, acoustic monitoring, ultrasonic scanning, computed tomography, shearography/ESPI, infrared imaging, high speed and ultra-high speed photometrics, and image processing. Although the department includes photometrics and optical data reduction as well as NDE, I will refer to the NDE department from now on for simplicity.

The NDE department has worked on technology transfer to organizations inside and outside the weapons complex. This work has been performed in all the Sandia business sectors: Defense Programs, Energy and Environment, and Work for Others. The technology transfer has been in the form of testing for product improvement such as validation of aircraft inspection equipment, consultation such as detecting lathe bearing slip for a major machine tool manufacturer, and products such as an acoustic sand detector for the oil and gas industry.

INTRODUCTION

Sandia National Laboratories (SNL) is managed by Martin Marietta for the Department of Energy (DOE). One of the growing missions of the laboratory is the transfer of technology to partners outside the laboratory. These partners include industry, other government agencies, universities, and other parts of the nuclear weapons complex. The technology has been developed over 40 plus years supporting nuclear weapons and energy engineering.

Sandia work is focused in three general areas of business: Defense Programs, Energy and Environment, and Work for Others. Customers in each of these business sectors represent possible technology transfer opportunities. The Nondestructive Evaluation (NDE), Photometrics, and Optical Data Reduction Department at SNL/NM provides NDE supports for all phases of research and development in these business sectors. Present facilities and personnel provide radiography (static, flash, real-time), acoustic monitoring, ultrasonic scanning, computed tomography, shearography/ESPI, infrared imaging, high speed and ultra-high speed photometrics, and image processing.

Government definition of technology transfer is continually changing and broadening. This means new technology transfer processes are constantly being implemented. Whatever the transfer process, technology transfer deliverables can be grouped in three general categories:

1. Development of products such as systems, software, or instruments
2. Consulting
3. Testing and modeling for product improvement

The SNL/NM NDE department has participated in programs which have produced deliverables in all these groups. The rest of this paper describes NDE activities and technology transfer that the department has done over the last few years.

DEFENSE PROGRAMS (DP) SECTOR

Defense programs is the traditional nuclear weapons business sector at SNL It is also the area where most of the DOE sponsored technology transfer funding resides. DP has major programs in maintenance of weapons engineering capability, restructuring of the nuclear weapons complex, nuclear weapons non-proliferation, advanced manufacturing, and technology transfer. The mechanisms for technology transfer outside the nuclear weapons complex are cooperative research and development agreements (CRADAs) and

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technology consulting agreements. The mechanism for technology transfer inside the complex are DOE funded projects.

Cooperative Research and Development Agreements

DOE CRADAs are agreements between national laboratories or weapons complex production agencies and industry to conduct joint research and development. The DOE will fund up to half the cost of a CRADA. The industrial partners can fund their part either in cash or "in-kind" contributions.

The NDE department is presently working on a CRADA with General Motors (GM) to improve the modeling of structural responses in car frames. A laser doppler velocimeter (VDT) and a shearography/ESPI system are being used to verify the modal response predicted by the finite element models being developed by Sandia. Figure 1. shows an example of modal testing using the VDT.

National Machine Tool Partnership

The National Machine Tool Partnership maintains Machine Technology Access Centers where U.S. machine tool producers can call a toll-free number and get help from the DOE national laboratories for problems related to machine tools. After the initial call, up to 80 hours plus expenses can be funded by DOE for a consultant to work on the problem. If necessary, this support can be extended another 80 hours.

Recently the SNL/NM NDE department was able to help a major machine tool manufacturer with a bearing skidding problem on a line of their computerized lathes. By recording and then analyzing high frequency sounds from the lathes, department personnel were able to tell under what conditions the bearings were sliding and make a recommendation on preventive measures. They were also able to discriminate between a clean and a dirty bearing. Technology developed previously at Sandiar for a prototype bearing monitor was used to quickly solve the customer's problem. A picture of the bearing monitor is shown in Figure 2.

Complex 21

Complex 21 is the name for the downsized and restructured nuclear weapons complex of the future. A major task of the new complex will be to continue to disassemble nuclear weapons as agreed to by international treaty. The majority of weapon disassembly is being done at the Pantex Plant at Amarillo, Texas.

Over the past two years personnel from the NDE department have consulted for Pantex on the purchase of a 9 MeV computed tomography system to support the disassembly process. Consultation has included providing proof-of-principle tomograms using our 2.5 MeV tomography system, helping write the system specifications, and working with Pantex personnel on the purchasing process. Consulting has also been provided by Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Allied Signal Kansas City Division personnel.

ENERGY AND ENVIRONMENT SECTOR

As the name implies, the Energy and Environment sector at SNL supports projects in the energy and environment arenas. Energy program areas include wind, solar, and geothermal energy, the oil and gas industry, and the nuclear power industry. Environment program areas include environmental protection and remediation. All projects are coordinated very closely with industry.

Wind Energy

For the last three years, the SNL/NM NDE department has been working with the Wind Energy Department at Sandia and the National Renewable Energy Laboratory to improve vertical axis wind turbine blades. Projects have included writing a review document of NDE techniques for composite blade inspection and developing techniques for blade inspection. Recently department personnel monitored static load tests of a 40 foot long composite blade using acoustic emission and shearography. The major objective of the NDE portion of the test was to see if these techniques could predict where the blade was going to fail under load. Other objectives were to see if these test methods could be used for blade inspection during manufacture and in the field.

The acoustic emission technique correctly predicted the area of failure on the blade. The shearography technique was able to show flaws in the composite material that contributed to the failure Figure 3. shows the test setup and some of the flaws detected with the shearography system.

Oil and Gas Industry

Personnel from the SNL/NM NDE department and the Atlantic Richfield Company (ARCO) in Plano, Texas worked together to develop an acoustic sand detector for detecting sand and other particulate matter in the flow of high rate gas wells. Particulate matter in these flows quickly erodes pipe bends and valves in the stream. The present solution is to cut the flow way below where any particles are detected allowing a large margin for error.

Working together, the project team came up with a novel way of using the acoustic information generated from particles impacting on a stainless steel rod in the flow to discriminate hard particles from the gas and liquid and to calibrate for mass flow readings. Figure 4. shows a block diagram of the system. The final product was a multi-channel prototype instrument controlled by a personal computer that provided particle detection alarms and mass flow rate information. The prototype is shown in Figure 5. The instrument is being beta site tested in Alaska and at a DOE storage field in Bakersfield, California. The instrument is covered by a joint ARCO/Sandia patent and is in the process of being licensed for manufacture.

WORK FOR OTHERS SECTOR

The Work for Others sector coordinates programs where government and non-government entities contract with Sandia

to do specific work. All work must be approved by the DOE and benefit Sandia's main defense mission.

Aging Aircraft NDI Center

The Aging Aircraft NDI Center (AANC) at Sandia is funded by the Federal Aviation Administration (FAA) Technical Center (FAATC) in Atlantic City, New Jersey as part of the National Aging Aircraft Research Program (NAARP). The purpose of the Center is to validate emerging NDE technology for the field inspection of commercial aircraft. The technology may come from universities, other FAA sponsored centers such as the Center for Aviation Systems Reliability (CASR), other government agencies such as the National Aeronautics and Space Administration (NASA), and industry. The deliverables from a validation include an assessment of how good the technology is for inspecting aircraft in the field and how cost effective it is.

The SNL/NM NDE department has supported a number of projects for the AANC which included a technology transfer component. Examples are

1. A survey of fieldable C-scan eddy current and ultrasonics systems,
2. A large number of demonstrations of equipment in the AANC hangar, and
3. Testing and suggested improvements of visual inspection tools.

The customer base for the AANC is multi-level and includes the FAATC, FAA field offices, other NAARP centers, aircraft manufacturers such as Boeing and McDonnell Douglas, airlines such as United and American, and third party maintenance facilities. Therefore projects can have a very broad impact on the industry.

The survey was based on demonstrations on aircraft test specimens and the AANC Boeing 737 aircraft. It was of major interest to the aircraft industry which is looking at purchasing instruments for improved inspection. Figure 6. shows examples of C-scans of the B737.

The demonstrations provided feedback to university and industrial participants on how well their equipment worked in field conditions. This allowed them to make changes to improve their techniques.

The visual inspection tool project produced suggestions for improvements in common tools such as flashlights and information on uses of other tools such as borescopes. This could have a particularly large impact since most aircraft inspection is done visually.

DISCUSSION

As mentioned previously, the opportunities for technology transfer from the DOE laboratories are continually growing. For example, the DOE is now providing funding for technical assistance from the laboratories to small businesses through its Small-Business Technology Transfer Initiative. Other funding sources include the Small-Business Innovative Research program and the Small-Business Technology Transfer Program. The Sandia NDE department is looking forward to doing a lot more technology transfer in the future.

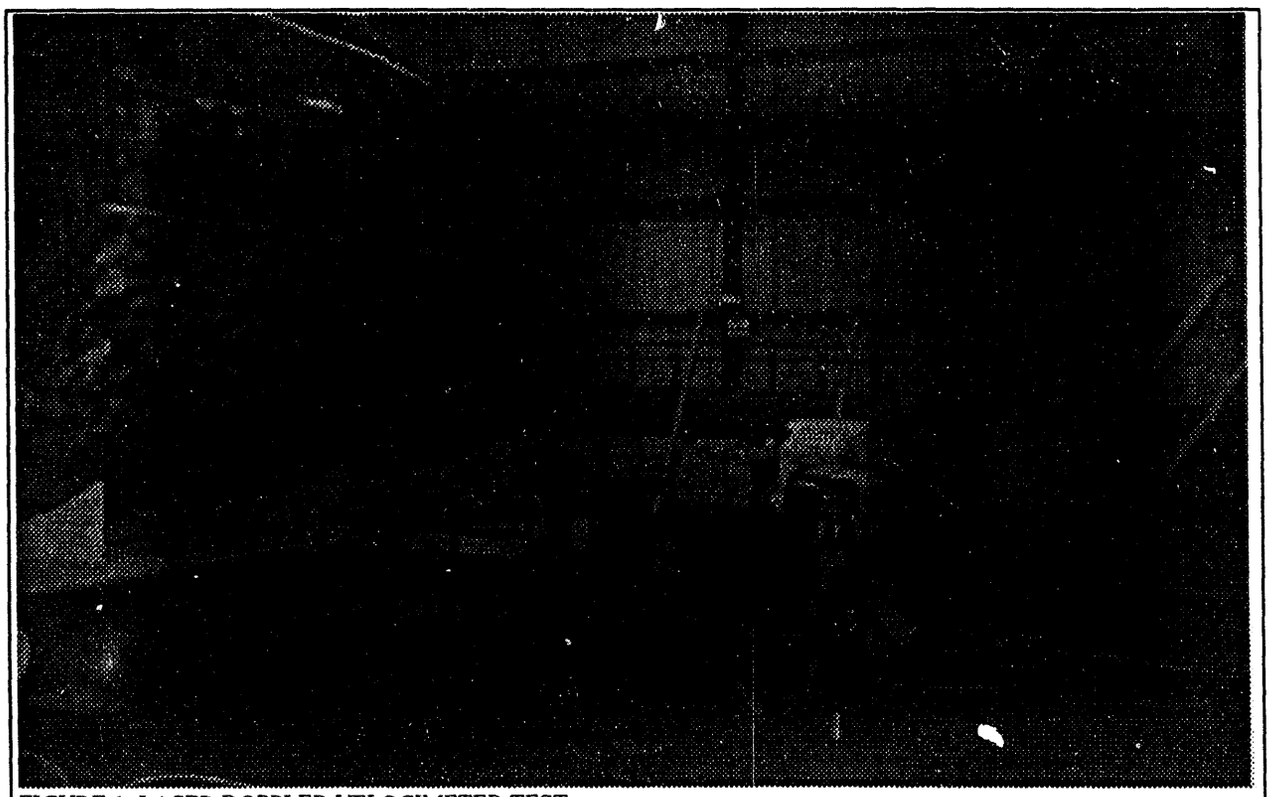

FIGURE 1. LASER DOPPLER VELOCIMETER TEST

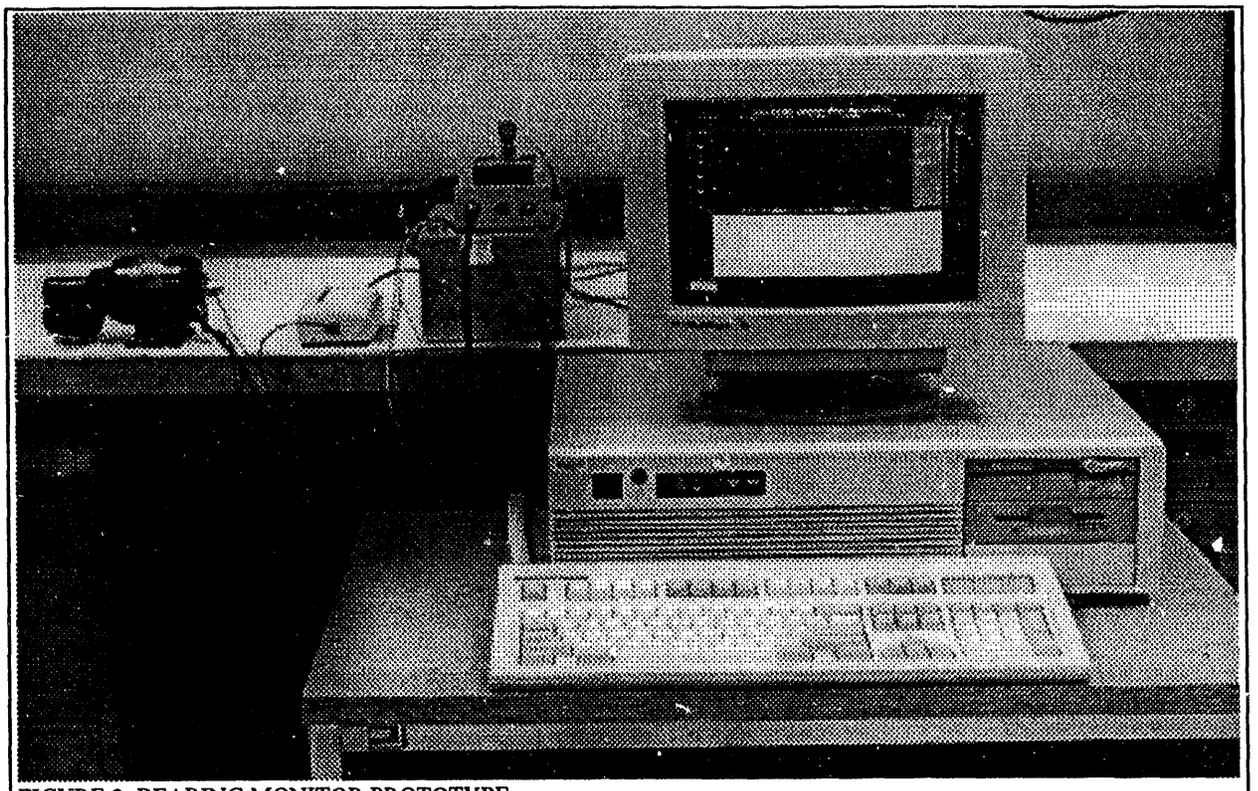

FIGURE 2. BEARING MONITOR PROTOTYPE

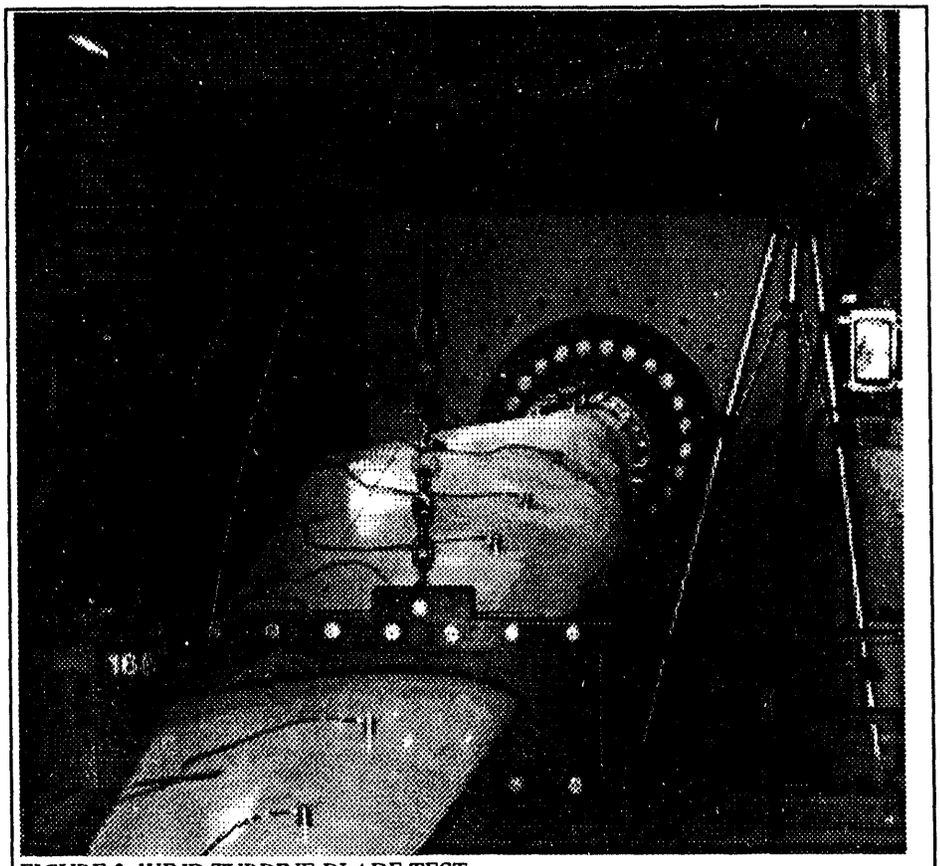

FIGURE 3. WIND TURBINE BLADE TEST

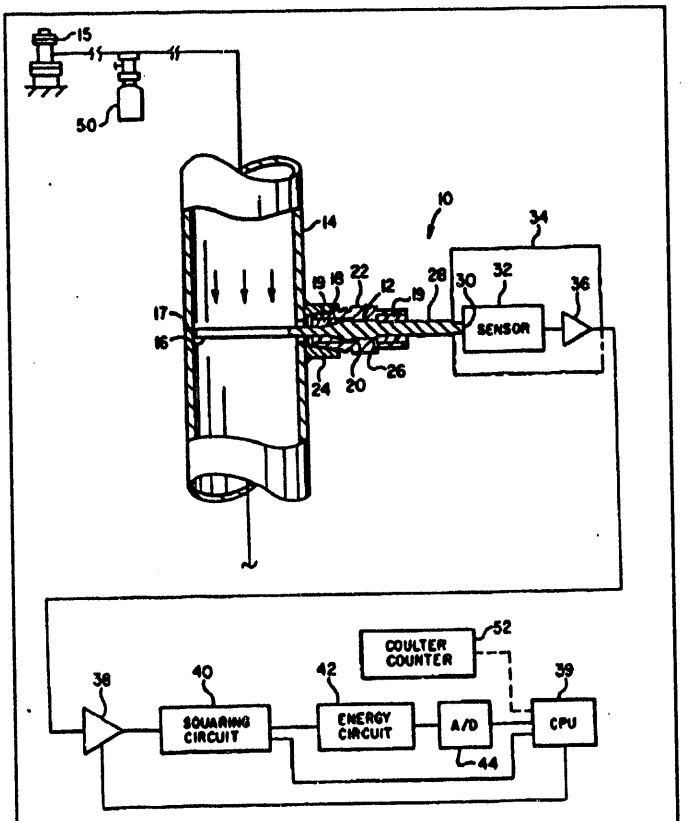

FIGURE 4. SAND DETECTOR BLOCK DIAGRAM

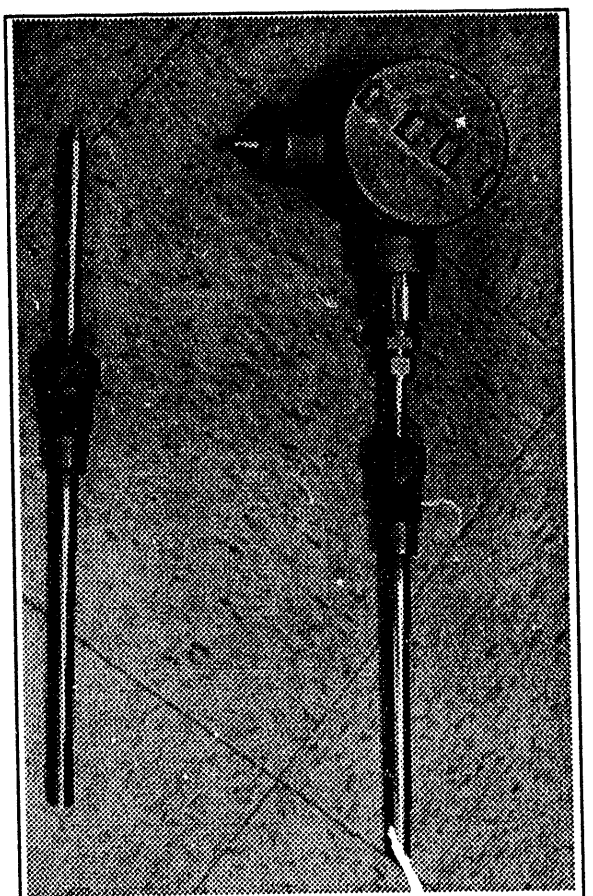

FIGURE 5. SAND DETECTOR SENSORS

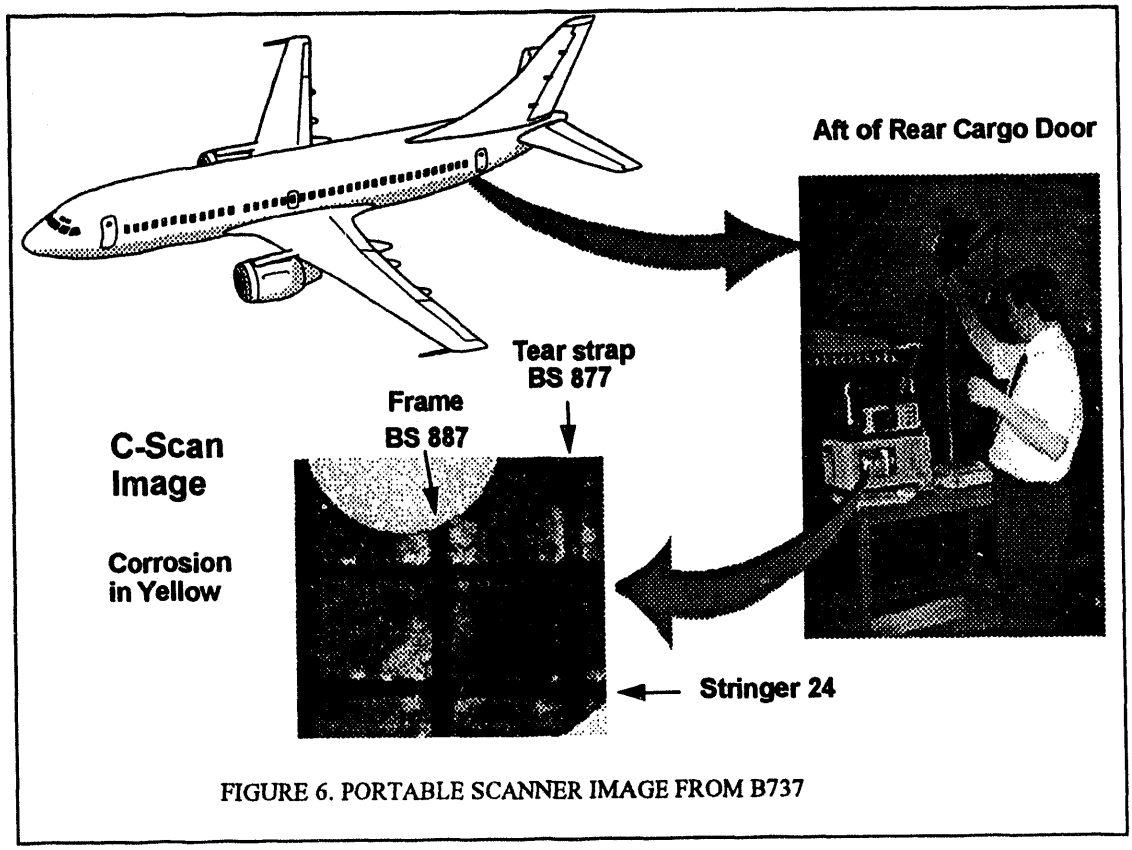

FIGURE 6. PORTABLE SCANNER IMAGE FROM B737

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