BNL 46467

on the cover:

Flux distribution in $\text{YBa}_2\text{Cu}_3\text{O}_7$ as revealed using a magneto-optic overlayer. The spacing of the domain labyrinth in this overlayer is proportional to the local field in the superconducting sample. The dark lines correspond to domain positions immediately after a 1006 field was removed, and the light lines reveal their position 30 seconds later.

SEPTEMBER, 1991

PRODUCED BY:

**THE OFFICE OF TECHNOLOGY TRANSFER
BROOKHAVEN NATIONAL LABORATORY
BUILDING 902-C
UPTON, NEW YORK 11973**

**FOR FURTHER INFORMATION,
CALL THE OFFICE AT:
516-282-7338**

a
word
about
**brookhaven
national
laboratory**

BNL--46467

DE92 007596

Brookhaven National Laboratory (BNL) is a multidisciplinary laboratory that carries out basic and applied research in the physical, biomedical and environmental sciences and in selected energy technologies. All this is done with the help of 3,300 employees, under the management of Associated Universities, Inc. (AUI).

AUI was formed in 1946 by a group of nine universities for the purpose of establishing and operating a major scientific laboratory in the Northeast. In January 1947, BNL became a fact. The nine original universities were Columbia University, Cornell University, Harvard University, The Johns Hopkins University, Massachusetts Institute of Technology, University of Pennsylvania, Princeton University, University of Rochester and Yale University. Today, AUI's Board of Trustees

includes members affiliated with other institutions as well, and AUI continues to manage BNL under a contract with the U.S. Department of Energy.

Within the heart of the Laboratory, a visitor might wonder about the mix of architecture among the 300-plus buildings. There are barracks erected before the Laboratory was formed, when the site was still the Army's Camp Upton during WWI and II. On the opposite end of the spectrum are eye-catching structures that house some of BNL's unusual machines.

Inside those big machines and the myriad other research labs on site, innovative science takes place, as BNL brings the resources of academia and the federal government together to carry out research that is beyond the capability of any single university.

APPLIED PROGRAMS at brookhaven

The Laboratory's efforts in applied programs is primarily carried out under the direction of two research departments, the Department of Nuclear Energy and the Department of Applied Science. The Office of Technology Transfer plays a major role in effectuating the orderly transfer of technology developed in these two departments to State and local governments and the private sector.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

office of **technology transfer**

The mission of this Office is to expedite the transfer of technology resulting from Brookhaven National Laboratory (BNL) research efforts to the private sector and to State and local governments. To accomplish this mission, the Office of Technology Transfer (OTT) has established the following goals:

- ▶ increase awareness and interest of the professional and scientific staff and Laboratory management in technology transfer and identify mechanisms to provide motivation for technology applications;
- ▶ seek means of approaching and informing private sector entities, State and local governments, and the university community that would benefit from implementing or utilizing Laboratory developed technologies or facilities;
- ▶ seek means of approaching private sector entities capable of commercializing Laboratory developed technologies;
- ▶ identify Laboratory efforts that need continued applied research and engineering development to commercialize and seek out means for effecting commercialization.

The OTT is the Laboratory's arm for commercializing technology developed at BNL. Brookhaven is an open Laboratory. Virtually all of our research results are unclassified and our staff publish their results and participate in professional meetings, symposia and workshops. The OTT maintains an overview of Laboratory research activities and

identifies efforts that have likely commercial potential. It acts as a conduit for industrial and commercial companies to visit the Laboratory and to interact with Laboratory scientists. It sponsors specific technology transfer efforts as part of the DOE laboratory/industry exchange program.

DESIGNATED USER FACILITIES

The Laboratory has a large number of research facilities that are available to outside users. Although each of these facilities has its own point of contact, the OTT will provide information on specific facilities or how to get in touch with the appropriate person for submission of a proposal for use.

Two options are available for access to the Laboratory's Designated

User Facilities. Non-proprietary, usually basic, research may be performed at the user facilities subject to facility availability and programmatic interest. Proprietary research may be performed at the Laboratory's user facilities. In this case, a formal Proprietary User's Agreement will be entered into between AUI and the outside user. This agreement calls for the user to pay full cost recovery to the Laboratory for the machine time and any related technical services which the Laboratory provides. In return, the outside user has the option to take title to any inventions resulting

from work at the facility and to treat as proprietary all data generated during work at the facility. For more detailed information concerning the opportunities for proprietary research at any of the user facilities at BNL, please contact Margaret C. Bogosian, Patent Counsel at (516) 282-7338.

DESIGNATED USER FACILITIES

National Synchrotron Light Source

Alternating Gradient Synchrotron

Scanning Transmission Electron Microscope

PETT VI Positron Emission Transaxial Tomograph

JSW168 Small Cyclotron

60-Inch Cyclotron

Double MP Tandem Accelerator Facility

OTHER USER RESOURCES

High Flux Beam Reactor

Medical Research Reactor

In Vivo Elemental Measurement Facility

Dynamitron Electron Accelerator

LICENSING TECHNOLOGY

Historically, patents generated from government sponsored work at BNL have belonged to the government. Since January, 1988, Associated Universities, Inc. who contracts to operate the Laboratory for the Department of Energy may retain title to patents resulting from Laboratory research. AUI negotiates agreements for the use of these patents.

In the first few years of its patent licensing program, AUI has entered into over eighty license agreements covering such diverse technology as a homogeneous catalyst system for the production of methanol and a method of labeling red blood cells with technetium-99m. For further information contact Margaret C. Bogosian at (516) 282-7338.

INDUSTRIAL INTERACTION

Centers of excellence in a wide range of technologies are resident at the Laboratory. Typical technologies are vacuum systems, magnet development, superconductivity, cryogenics, certain areas of electronics, certain kinds of instrumentation and materials characterization, biotechnology, electroconducting polymers, polymer cements, homogeneous catalysis, hazardous waste storage, and injury epidemiology. Laboratory experts can often act as resources for specific questions in these areas, and are often retained as private consultants.

Visiting appointments and housing facilities can be made available for scientists and engineers from industry who can benefit from using BNL's research facilities and interaction with the resident staff. In keep-

ing with the current emphasis on increasing access to government facilities by the private sector, Brookhaven is encouraging collaborative research activities with industry.

BNL maintains an effective work-for-others program with private industry, universities, and state and local governments. Several options are available to industry for funding research at BNL:

The industrial sponsor can make a grant to the Laboratory with an indication that this money is to be used to support a basic R&D effort in a general research area.

The industrial sponsor could fund a specific non-proprietary research project at the Laboratory with the results going into the public domain.

The industrial sponsor could fund a specific proprietary research project at the Laboratory.

BNL's OTT can assist potential industrial researchers in making arrangements to use Brookhaven's unique facilities and capabilities. To find out more about opportunities for industrial research at BNL, please contact the Office of Technology Transfer.

utility industry. Such programs bring BNL staff into direct contact with working level utility technical staff. These interactions serve to keep utility people apprised of work going on at BNL under the sponsorship of DOE or NRC and enable utility staff to identify areas of new and unique expertise at BNL which could be involved in a utility sponsored research program at BNL.

BNL UTILITY RESEARCH AND DEVELOPMENT CENTER

The important role of the DOE mission in energy related R&D is reflected in the BNL technology transfer outreach to the utility industry, accomplished through the BNL Utility R&D Center. Since BNL is a major national laboratory as well as a regional technological resource, the BNL Utility R&D Center can focus on the needs of the regional utilities and the special needs of the highly urban northeast U.S. Member utilities include Baltimore Gas & Electric, Consolidated Edison of New York, Empire State Electric Energy Research Corporation, Long Island Lighting Company, New York State Electric & Gas, Niagara Mohawk Power Company of New York, Orange & Rockland of New York, New York Power Authority, and Public Service Electric & Gas of New Jersey.

The basic format of the Utility R&D Center is for BNL to conduct each year four or five interactive tutorial workshop programs on technical topics of interest to the

department of **applied science**

The Department of Applied Science has as its mission the performance of basic and applied research in energy-related physical, health, and environmental sciences and mathematics.

Twin goals of this research are the development of a knowledge base necessary for the understanding of phenomena that underlie technologies of interest to the Department of Energy for the production, conservation and utilization of energy — and the environmental consequences of such use. The second goal is the transfer of useful results and knowledge gained to the industrial, commercial, and academic sectors.

ENERGY SCIENCE AND TECHNOLOGY PROGRAMS

Energy Science and Technology Programs are carried out by four divisions within the Department in research areas such as applied physics, chemical, material sciences and energy efficiency and conservation. Applications of these disciplines and transfer of technology to industry also plays an important role.

APPLIED PHYSICS

In Applied Physics, coal constituent research, fundamental inner shell photoionization processes, and high speed biological crystal diffraction studies are carried out at the National Synchrotron Light Source.

Positrons, a form of antimatter, are used to probe the first few layers of an atomic surface. At higher energies these particles are used to examine "buried" surfaces — or

interfaces — in order to better understand deposition processes and epitaxial crystal growth. Applications of the knowledge opened by this technique are useful to the semiconductor industry and to the scientific understanding of catalytic reactions.

The effects of corrosion cost the industrial world untold numbers of dollars as it impacts our infrastruc-

ture. Understanding the fundamental mechanisms which initiate and allow propagation of corrosion in metals and alloys will enable us to develop better protective coatings.

METAL CORROSION AND MATERIALS PROTECTION FROM THIS PROCESS IS OF GREAT ECONOMIC IMPORTANCE AS WELL AS SCIENTIFIC INTEREST. EXPERIMENTAL WORK ON STRESS CORROSION PROCESSES AND THE CHARGE STATE OF THE CHEMICAL SPECIES PRESENT IN PROTECTIVE COATINGS ARE BEING INVESTIGATED AS A FUNCTION OF POSITION ON THE SAMPLE SURFACE.

The NSLS is a valuable tool for applied physics research. Microtomography used to "section" mineral samples and fundamental crystallographic studies on biological samples are only two of the research projects in place.

CHEMICAL SCIENCE

In Chemical Sciences, the mechanisms of metal hydride reactions and the elucidation of the crystal structure of new materials for hydrogen storage is ongoing. Electro- and photoelectrochemistry, applied to understanding the kinetics of interfacial reactions as well as high temperature alloy and molten salt studies which will answer questions about the efficiency of electrolysis in the production of metals.

The study of porphyrin derivatives to better understand their electronic properties will reveal the mechanisms of solar energy conversion and biocatalytic energetics. This knowledge is vital if we are to more efficiently use our energy resources.

FIRST LAUE DIFFRACTION PHOTO AT BROOKHAVEN NSLS X26C BEAM LINE. CHICKEN HEN EGG WHITE LYSOZYME (P4.2.2; $a = b = 79.1$, $c = 37.9$ Å) CRYSTAL SIZE = 0.35 MM DIAMETER; EXPOSURE = 0.6 SECONDS; DISTANCE FROM CRYSTAL TO FILM = 100 MM.

STRUCTURAL FORMULA AND EDGE-ON VIEW OF A Ni(II) HYDROPORPHYRIN DETERMINED BY SINGLE CRYSTAL X-RAY DIFFRACTION. THE COMPOUND IS USED TO MODEL TERMINAL STEPS IN THE BIOGENESIS OF METHANE FROM CARBON DIOXIDE. THE WORK IS PART OF A BROADER STUDY OF THE INFLUENCE OF CONFORMATIONS ON THE PHYSICS AND CHEMICAL PROPERTIES OF PORPHYRIN DERIVATIVES.

James Sutherland (LEFT) AND Bruce Klemm ADJUST AN ABSORPTION PHOTOMETER ON THE SHOCK TUBE.

Fire has benefited and intrigued mankind for thousands of years. Recent techniques in the study of combustion kinetics, the action of burning, have revolutionized scientific understanding of how gases burn.

MATERIAL SCIENCE

Within the Materials Science Division, topics such as high temperature superconductor structure studies, synthesis and forming techniques are underway. The understanding of electrically and optically active polymers and the development of polymeric solid electrolytes is another area of research and development. The efficient use of energy is ultimately coupled with our ability to store it for use as it is needed. Research on battery materials and cell mechanisms aid in that pursuit.

The ability to visualize materials in an atomic scale cuts across all solid state research. Tools such as x-ray diffraction and both scanning

and transmission electron microscopy are invaluable in materials research. Recently, the atomic force — or scanning tunneling — microscope has been added as yet another surface sensitive tool.

EVIDENCE OF SCREW DISLOCATIONS IN THE HIGH TEMPERATURE SUPERCONDUCTOR, $\text{YBa}_2\text{Cu}_3\text{O}_{7.8}$, AS SEEN BY THE ATOMIC FORCE MICROSCOPE.

HIGHLY ORIENTED PYROLYTIC GRAPHITE (HOPG). APPROX. $20 \times 20 \text{ \AA}^2$ STM* DATA TAKEN WITH THE DAS-MICROSCOPE. STM = SCANNING TUNNELING MICROSCOPE.

ENERGY EFFICIENCY AND CONSERVATION

Technology programs in the Energy Efficiency and Conservation Division are in support of the efficient use of our existing energy resources as well as the develop-

ment of new sources. Such topics as district heating and cooling, improvement of the thermal efficiency of oil burners and HVAC distribution systems in buildings, have obvious energy implications.

More recently, we have been asked to play a role in the clean up of energy sources in Eastern Europe. We will do research and transfer technology to this end.

Geothermal sources of energy have great potential, but are as yet little utilized. The environment is hostile to most materials because of temperature, pressure, and chemical activity. New classes of chemical sampling materials are being demonstrated.

OIL ATOMIZATION SPRAY ANALYSIS - BNL HAS APPLIED A LASER PARTICLE SIZING SYSTEM TO MEASURE DROPLET SPRAY DISTRIBUTIONS FOR VARIOUS CANDIDATE ATOMIZATION TECHNIQUES IN ITS EFFORT TO MEET PROJECT OBJECTIVES IN DEVELOPING THE TECHNOLOGY BASE REQUIRED FOR FUTURE OIL-FIRED APPLIANCES. THESE HEATING SYSTEMS WHICH ARE DESIGNED FOR USE IN LOW ENERGY LOSS HOMES AND WILL PROVIDE MAXIMUM EFFICIENCY WITH SIGNIFICANT REDUCTIONS IN EMISSIONS WHEN COMPARED WITH CURRENT DESIGNS.

MEMBERS OF THE COMBUSTION EQUIPMENT TECHNOLOGY PROGRAM (CETP) IN THE DEPARTMENT OF APPLIED SCIENCE PERFORM AN EMISSIONS ANALYSIS MEASUREMENT TO DETERMINE THE OPERATIONAL CHARACTERISTICS OF A PROTOTYPE RESIDENTIAL OIL BURNER UNDER DEVELOPMENT AT BNL. ADVANCES IN HEATING TECHNOLOGY R&D HAVE RESULTED IN HEATING SYSTEMS WITH HIGHER EFFICIENCY AND HAVE ALREADY GENERATED SIGNIFICANT ENERGY SAVINGS AND ENVIRONMENTAL BENEFITS FOR MILLIONS OF HOMEOWNERS ACROSS AMERICA. THIS PROGRAM WAS AWARDED THE 1991 NATIONAL ENERGY RESOURCES ORGANIZATION RESEARCH AND DEVELOPMENT AWARD FOR ITS MAJOR CONTRIBUTIONS TO ENERGY CONSERVATION.

Infrastructure maintenance and repair is a critical engineering topic. The use of new materials to avoid energy production related deterioration as well as for rapid repair of roads or bridges, for instance, with short shutdown times — are areas with large financial and social impacts.

IN DEVELOPING THEIR 1991 FEDERAL LABORATORY CONSORTIUM "EXCELLENCE IN TECHNOLOGY TRANSFER" AWARD WINNING INSULATING POLYMER CONCRETE MATERIAL, Jack Fontana (LEFT) AND Lawrence Kukacka BUILT A SECTION OF A DIKE TO USE IN EVALUATING THEIR MATERIAL.

FLAME QUALITY INDICATOR - FOR RESIDENTIAL OIL-FIRED FURNACES USUALLY OPERATE AT LESS THAN OPTIMAL EFFICIENCY FOR MANY REASONS. BNL HAS DEVELOPED A LOW-COST OPTICAL FLAME MONITOR CALLED THE FLAME QUALITY INDICATOR (FQI) THAT SHOWS WHEN THE FURNACE IS CORRECTLY OPERATING AND ALSO INDICATES, EARLY ON, ANY CHANGES IN THE FLAME QUALITY SUGGEST THE SYSTEM SHOULD BE SERVICED TO MAINTAIN PEAK EFFICIENCY.

ENVIRONMENTAL HEALTH AND MATHEMATICS PROGRAMS

Environmental Health, and Mathematics programs are carried out in four Divisions within DAS. Research crossing Division lines involves programs related to the understanding of *global climate change* — that may be caused by energy production and use. The fate of these by-products, such as unburned hydrocarbons, exhaust gases, and — more recently — some industrial chemicals, to which our ecosystem is sensitive, are studied. Links between the atmosphere, ocean, and plant uptake and releases must be better understood. Computer modeling, tracer development and use in field experiments all give insights to this complex topic. Analytical approaches to the study of loosely coupled global systems is a challenging new field.

ANALYTICAL SCIENCES

In the Analytical Sciences Division, environmental risk assessments and associated costs relating energy systems are important topics as are aspects of injury prevention and analysis in the workplace.

The High Performance Computing & Communications Initiative involves the development of improved mathematical models for solving partial differential equations on massively parallel computers. These devices promise increased computational speed over current hardware and Analytical Sciences

staff members are involved with other national laboratories and universities in developing software for calculating such topics as materials properties and contaminant transport in ground water.

BIOSYSTEMS AND PROCESS SCIENCES

The Biosystems & Process Sciences Division studies biochemical processes involving selected strains of microorganisms which are prov-

ing useful in such diverse areas as oil spill remediation and the control of low levels of radioactives associated with geothermal energy sources. Bioorganisms can and do enhance the corrosion of metals. Understanding how to prevent attack is economically important to a variety of industries. On the plus side, some bioorganisms can enhance the process of oil recovery by increasing the lighter hydrocarbon fractions.

A FLUIDIZED BED TYPE BIOREACTOR FOR DETOXIFICATION OF GEOTHERMAL BRINES.

SOLVING EQUATIONS WITH THE NEW INTERACTIVE SOFTWARE DEVELOPED BY BRUCE STEWART (RIGHT), DEPARTMENT OF APPLIED SCIENCE, AND HAO BAI-LIN, WHO VISITED BNL FROM THE INSTITUTE OF THEORETICAL PHYSICS IN BEIJING, CHINA. THE ATTRACTOR ON THE SCREEN REPRESENTS THE COMPLEX BEHAVIOR OF A DYNAMICAL MODEL.

Associated with global change phenomena is the fate of carbon dioxide from a variety of energy sources. The impacts of CO₂ enrichment on plants and ecosystems are evaluated by a specially designed system called FACE. This concept is easily expanded to expose various crops to increased levels of other gases associated with energy production.

A 23 METER DIAMETER FREE AIR CO₂ ENRICHMENT (FACE) ARRAY DEPLOYED IN A COTTON FIELD IN MARICOPA, ARIZONA. FOUR OF THESE ARRAYS ARE BEING USED AT THIS SITE TO EXPOSE A COTTON CROP TO ELEVATED LEVELS OF CO₂ THROUGHOUT THE GROWING SEASON. IN AN EFFORT TO PREDICT HOW INCREASING CONCENTRATIONS OF ATMOSPHERIC CO₂ WILL AFFECT THE GROWTH OF TERRESTRIAL PLANTS. THIS VIEW IS AT THE START OF THE GROWING SEASON.

Keith Lewin CHECKING A WIRING PANEL ON A FREE AIR CO₂ ENRICHMENT (FACE) ARRAY BEING USED TO STUDY THE EFFECTS OF ELEVATED ATMOSPHERIC CO₂ CONCENTRATIONS ON THE GROWTH AND YIELD OF COTTON SEEN 2 MONTHS INTO THE GROWING SEASON.

ENVIRONMENTAL CHEMISTRY

Understanding the chemistry of aerosols, finely divided solids or liquids present in the atmosphere, is critical. Our industrial society emits these materials from a variety of sources. Within the Environmental Chemistry Division, research to establish how these products are formed, transported, changed, and are finally removed, is critical in such diverse areas as farming, infrastructure maintenance, and public health. Instruments to detect these materials and their transformations as well as the use of tracers to follow the dispersion of aerosols provide much needed understanding in the effort to control them. Modeling the data obtained in the field to provide a consistent framework is a multilab effort with PNL and ANL. The massive oil field fires in Kuwait represent an unprecedented pollution source. Our work here will help to assess the potential impacts of the plume regionally and globally.

BNL's Tracer Technology Center uses perfluorocarbon tracers to determine leaks in underground power transmission lines and fuel storage tanks, geophysical experiments for reservoir determination at Prudhoe Bay and in the North Sea, and boiler integrity at power

plants. The National Association of Home Builders routinely uses these tracers to measure air infiltration properties of building materials. Other prospective uses include integrity of sealed packages and determination of wear of materials.

A SHASTA MOTOR HOME HAS BEEN MODIFIED TO SERVE AS A MOBILE RESEARCH VEHICLE FOR FIELD OPERATIONS. THIS VEHICLE WAS PLUGGED INTO ELECTRIC FROM THE POLE (EQUIPMENT ON ROOF). CONTINUOUS SAMPLING (AIR POLLUTION) WAS CONDUCTED ON A 24-HOUR BASIS. MANY PARTS OF THE U.S. HAVE BEEN VISITED BY THIS LABORATORY ON WHEELS.

CHEMICAL ENGINEER Russell Dietz, HEAD OF BNL'S TRACER TECHNOLOGY CENTER, INJECTS A SAMPLE OF A STANDARD GAS PERFLUOROCARBON TRACER (PFT) INTO ONE TRAP OF A DUAL-TRAP ANALYZER (DTA). MEANWHILE, THE DTA'S GAS CHROMATOGRAPH ANALYZES THE SAMPLE IN THE OTHER TRAP, THE RESULTS OF WHICH ARE PLOTTING OUT AT THE TOP OF THE MACHINE.

OCEANOGRAPHY AND ATMOSPHERIC SCIENCE

The oceans represent the larger fraction of the earth's surface. Mankind depends upon the ocean for food; and we use coastal areas in many energy-related activities, both deliberate and accidental. The global carbon cycle is an accounting of the fate of fuel burning. Much of the carbon dioxide produced in burning or other biogenic processes cannot be accounted for in this cycle. The Oceanographic & Atmospheric Sciences Division studies have shown that the ultimate fate of much of this carbon is in the form of organic matter on the edges of

the coastal shelf. Ocean cruises enlarge the knowledge base in this area. Coastal shelf productivity, food chain dynamics, and marine ecology complete the picture. Novel instrumentation development is a cornerstone for this work.

Meteorological monitoring and modeling on large and small scales add to the knowledge base and support work described above. To complete our world view, the Department is moving into the area of satellite data analyses, both atmosphere and ocean views.

Most recently the role of the ocean as the key to the rate at which the world's temperature might change is under investigation. As the oceans are difficult to monitor with conventional techniques, satellite remote sensing provides an important tool in this area. The for-

mation and motion of ocean currents is of great importance in the understanding of the global heat budget.

SUMMARY

An interdisciplinary team of scientists, engineers, economists, physicians and environmentalists work together to analyze how alternative energy technologies and policies affect not only the U.S. as a whole, but also its various regions. Assistance is also provided on a local, national, and international level.

DEPLOYING AN ACOUSTIC DOPPLER CURRENT PROFILER AND ITS FRAME CONTAINING FLOTATION SPHERES FROM THE DECK OF THE R.V. ENDEAVOR OFF THE COAST OF VIRGINIA DURING THE SHELF EDGE EXCHANGE PROCESSES (SEEP-II) RESEARCH PROGRAM IN 1988. IN THE FOREGROUND ARE TWO SEDIMENT TRAPS YET TO BE DEPLOYED.

THE METEOROLOGY TOWERS, "TOWER 10" (LEFT) and "SHORT TOWER" SHOWN ABOVE PROVIDE METEOROLOGICAL SERVICES ON A 24 HOUR BASIS IN SUPPORT OF MANY BNL SCIENTIFIC PROGRAMS

THE REAR DECK OF THE R.V. ENDEAVOR LOADED WITH GEAR IN PREPARATION FOR DEPLOYING INSTRUMENTATION MOORINGS DURING THE SEEP-II RESEARCH PROGRAM. ON THE LEFT ARE ACOUSTIC DOPPLER CURRENT PROFILERS AND THEIR FRAMES CONTAINING FLOTATION SPHERES AND ON THE RIGHT ARE LARGE METAL FLOATS WHICH HAVE STROBE LIGHTS AND ARE DEPLOYED AT THE SURFACE AROUND THE CURRENT METER MOORINGS AS GUARD BUOYS WARNING SHIPS TO KEEP CLEAR OF THE AREA.

department of **nuclear energy**

The Department of Nuclear Energy (DNE) is one of nine major scientific departments of Brookhaven National Laboratory (BNL). Work is performed primarily for the Department of Energy (DOE), the Nuclear Regulatory Commission (NRC), and the Department of Defense (DOD) with some industrial support. The activities of the Department include theoretical and experimental studies on the safety of commercial nuclear power plants, development of designs for advanced, compact nuclear power plants, development of improved methods for safeguarding nuclear material, nuclear waste management studies, compilation and evaluation of nuclear data required for users throughout the world, the operation of a radiation effects facility using the BNL 200 MeV proton LINAC. A new experimental program involving high temperature combustion of hydrogen-air mixtures is currently being conceptualized at BNL.

BEING PREPARED

The consequences of a reactor accident will depend on the specific sequence of events involved in the accident. Brookhaven's Department of Nuclear Energy studies the best ways to prevent and mitigate the amount of radiation that might escape into the environment in the case of a severe accident.

CORING OF A SOLIDIFIED RADIOACTIVE CONCRETE WASTE FORM RECOVERED FROM THE 2800 METER ATLANTIC OCEAN DUMPSITE. CORE SAMPLES ARE USED TO DETERMINE THE RADIOISOTOPE CONTENT OF THE WASTE FORM AFTER EXPOSURE TO THE OCEAN ENVIRONMENT FOR 16 YEARS.

SAFE DISPOSAL OF HIGH-LEVEL NUCLEAR WASTE

Can scientists predict how certain materials will perform after 10,000 years? That is the task of specialists at Brookhaven's Department of Nuclear Energy who evaluate materials to contain high-level radioactive waste at disposal sites.

SAFETY IN COMPUTER CODES

How reliable are computer codes which deduce probable causes and results of simulated reactor accidents? Computer codes created by Brookhaven's Department of Nuclear Energy were used to plot what probably happened at the Chernobyl reactor accident. Our results compared favorably with what was reported by the Soviets.

NUCLEAR SAFETY AND OPERATIONS

One of the major activities of the Department is research on nuclear safety and operations. This work is spread among three Divisions. One of these looks at reactor behavior under accident conditions, another studies the probabilities and risks of various accident scenarios and the third investigates engineering and human factor approaches to decreasing the risk probabilities and ameliorating the consequences of the various accident scenarios.

The Reactor Analysis Division undertakes reactor safety programs directed to improving the under-

standing of the behavior of various reactor types under anticipated and hypothetical accident conditions. The effort includes running computer codes that analyze nuclear accidents. The results are provided to the Nuclear Regulatory Commission and the utility industry. Research and technical assistance activities are undertaken for light water reactors (LWRs), high temperature gas cooled reactors (HTGRs), and liquid metal cooled reactors (LMRs) in support of reactor regulation as well as specific industry needs.

A BROOKHAVEN SCIENTIST USING THE BNL PLANT ANALYZER TO ASSESS THE IMPACT ON SAFETY OF AN ACCIDENT SCENARIO FOR A NUCLEAR POWER PLANT. THE PLANT ANALYZER APPROACH HAS POTENTIAL FOR USE IN POWER REACTORS IN RESPONSE TO ABNORMAL CIRCUMSTANCES, THEREBY INCREASING PLANT SAFETY.

INSTRUMENTATION DEVELOPED AT BNL TO BE TRANSFERRED TO INDUSTRY.

The Safety and Risk Analysis Division performs analytical studies for the Nuclear Regulatory Commission in the field of nuclear reactor safety. This group undertakes research and studies in four areas: risk evaluation, accident analysis, facilities risk analysis, and safety integration. The major engineering research activities are in core meltdown studies, reactor reliability, and risk studies and reactor system studies.

The Engineering Technology Division performs studies of nuclear reactor operations and safety. Although most of the work is undertaken for the NRC, some work is supported by DOE and the private sector. Primary areas of work are: research and technical support activities on system design and performance, probabilistic and deterministic research into effects of system performance and phenomenological events on plant operations, and analyses in support of NRC resolution of generic safety issues.

REACTOR PLANT DESIGN

The Department carries out three activities in support of designing advanced concepts in nuclear reactors. One of these is a group that performs R&D on a specific advanced reactor design concept, a second group performs studies and analysis of seismic and other terrestrial factors of importance in decisions relating to the structural integrity and location of reactors, while the third provides the primary source of worldwide data and an information service on cross sections and decay rates.

The Reactor Systems Division is involved in research and development activities connected with the Particle Bed Reactor concept. These activities include both experimental and analytic studies. In addition, detailed neutronic and thermal

hydraulic analysis of the various reactor types are carried out.

The Structural Analysis Division provides technical assistance to the NRC in the area of seismic design and analysis, soil structure interaction, structural behavior, stress analysis, structural failure analysis and structural reliability. Current programs are: Seismic Component Fragilities and Ruggedness, Validation of Seismic Computational Methods, Exchange of Technical Information with Japan, Energy Absorbing Supports, Computer Analysis for Rapid Evaluation of Structures, Seismic Response Analysis of Earthen Dams, Evaluations of Mechanical, Civil and Structural Engineering Issues Related to Nuclear Power Plant Structures, Equipment and Piping Systems, Evaluation of Snubber Surveillance Requirements, and Evaluation of the Comanche Peak Corrective Action Program.

The National Nuclear Data Center provides primary nuclear information services to the scientific and industrial nuclear science community. The services include information on nuclear structure and decay data, neutron physics, and charged particle reactions. It acts as coordinator for the US Nuclear Structure and Decay Data Centers that have been set up as part of an international network by the IAEA. It maintains, updates and distributes a Nuclear Structure Reference Bibliographic File. This file is used by the Center to produce the Recent Reference Issues of the Nuclear Data Sheets published by Academic Press.

NUCLEAR WASTE DESIGN AND MANAGEMENT

The Department has three activities related to the important problem of nuclear waste management. One of these is an effort designed to

model the flow of radionuclides from low level waste radioactive sources. A second provides technical support and assistance to the NRC in the area of waste packaging and containers. The third is an

THE VALVE CYLINDERS CONTAINING UF_6 NEED TO BE SEALED TO PREVENT POTENTIAL DIVERSION OF NUCLEAR MATERIAL. THOUSANDS OF THESE CYLINDERS AT PLANTS SAFEGUARDED BY THE IAEA ARE COVERED WITH A SHRINK-TUBING SEAL DEVELOPED AT BNL. THE PICTURE SHOWS THE VALVE COVERED BY THE SEAL. ONCE THE SEAL IS IN PLACE IAEA INSPECTORS CAN EASILY AND REPEATEDLY VERIFY THE SEAL'S UNIQUE ID PATTERN.

effort to assist the Department of Energy in providing low level measurements of radiation directed toward minimizing the amount of exposure and developing standards for radiation safety in the industrial workplace.

The Nuclear Waste and Materials Technology Division performs work for the NRC. Major efforts include modeling the low-level waste radioactive source term from a shallow land burial trench, managing reactor system decontamination wastes, and the behavior of low-level waste barrier materials. The Division provides low-level waste management assistance in three areas: development of low-level waste form crite-

THE LOCATION AND RATES OF CORROSION OF AN ION SURFACE WERE MEASURED IN-SITU AND ARE SHOWN AT VARIOUS TIMES. AFTER IMMERSION INTO A DILUTE CHLORIDE SULPHATE SOLUTION, THE CORROSION FIRST STARTS AT LOCALIZED SITES AND GROWS IN INTENSITY. AFTER 10 HOURS, THE CORROSION BEGINS TO SPREAD OVER THE SURFACE AND AFTER 20 HOURS HALF THE SAMPLE WAS CORRODING AT A LOWER RATE.

ria, analysis of special waste problems, and development of criteria for materials used at near-surface sites. The Division also carries out technical assistance programs in materials: stress corrosion cracking of steam generator vessels, pipe cracking phenomena, and resolution of allegations of improper welding at nuclear construction sites. This expertise is available to industry for their use.

The Radiological Sciences Division conducts research related to physical, biological and engineering aspects of radiation production. Currently there are two DOE-funded projects on radiation protection, dosimetry and interpretation of radiation protection measurements. There are two NRC-funded projects aimed at the assessment of occupational radiation exposure at nuclear power plants and the implementation of the principle of keeping radiation exposure of industrial workers to a level as low as reasonably achievable (ALARA). In addition, the Nuclear Waste Research Group concentrates on low-level

waste management and is supported by DOE and EPA for experimental studies and assistance in formulation of criteria.

NUCLEAR SAFEGUARDS AND SECURITY

The Department supports two activities that provide increased assurance that nuclear materials are not diverted from the nuclear fuel cycle. One of these is directed to domestic nuclear materials both in the weapons and research programs of the government and in the private nuclear fuel cycle. The second is in support of the International Atomic Energy Agency's (IAEA) safeguards program that provides assurance that materials are not diverted from foreign fuel cycles by unreliable governments, saboteurs or terrorists.

The Technical Support Organization (TSO) provides technical assistance to the DOE Office of Safeguards and Security in the development of policies and procedures to respond to potential threats of sabotage to domestic nuclear facilities and theft or misuse of domestic nuclear material. It provides technical assistance to the

THE EQUIPMENT PICTURED ARE MOTOR STATORS FROM POWER PLANTS WHICH WERE STUDIED FOR THE PURPOSE OF EQUIPMENT LIFE EXTENSION. ONE WORK SHOWED THAT EXTREME ENVIRONMENTAL CONDITIONS, E.G., EXCESSIVE VIBRATION AND/OR INTRODUCTION OF WATER AND STEAM SHORTEN MOTOR LIFE, WHILE THEY WERE ABLE TO IDENTIFY INDICATORS OF REDUCED LIFE AND STRATEGIC APPROACHES TO MOTOR LIFE EXTENSION.

DOE Office of Classification in the development of a rational classification policy for safeguards and fuel cycle technologies, for the implementation of such policy and for the training and appraisal of personnel involved in classification programs. Technical assistance is provided for the IAEA in connection with international safeguards focusing on the possibility of unreported production or national diversion of safeguarded material for use in nuclear weapons production.

The program of Technical Assistance to IAEA Safeguards is under the technical management of the International Safeguards Project Office. Since inception of the program in 1977 tasks have been mutually agreed upon by the IAEA and the U.S.: 325 tasks have been completed and 85 are currently active. Assistance is provided in the form of equipment, cost-free experts, systems studies, techniques and procedures, and training. Most of the research, development and expertise is provided by Department of Energy laboratories.

MOTOR AGING STUDIES

BNL FACILITIES APPROPRIATE FOR APPLIED RESEARCH

There are facilities at the laboratory that are used for internal research, and for collaborative research by outside groups. All of these are available for qualified researchers to conduct experiments. Industrial researchers are encouraged to explore the possibilities of using these facilities for experiments with commercial potential.

The four facilities described below have applications to analytical and other applied research programs. All arrangements for proprietary research at any BNL facility are made by the ORR at (516) 282-7338.

HIGH FLUX BEAM REACTOR

This reactor is one of the most advanced research reactors in the world. The reactor provides intense beams of thermal neutrons at a maximum of 1×10^{15} (one quadrillion) per square centimeter per second for use by experimenters in their quest for basic scientific information as well as in unique studies for industry.

Major research programs are carried out at the HFBR in several different areas. In nuclear physics, beams of neutrons from the reactor are used as probes to investigate the structure of the nucleus. Neutron-induced reactions play an important role in the application of fission and fusion reactions to energy production, since both processes are accompanied by the intense production of neutrons.

In solid state physics, research provides information on the atomic lattice including dynamics of lattice

variations, long-range ordering of the atoms in a lattice, and studies of magnetism. Beams of neutrons from the reactor are used as unique probes which can be scattered from the materials under investigation in order to analyze their microscopic behavior. A current area of interest is to study material interfaces which are expected to be important to specific industries.

Research in chemical physics includes neutron diffraction studies which investigate chemical bonding and molecular structure of crystals. One area of research which is of particular importance for commercial energy storage devices is the study of solid electrolytes for use in batteries.

In biology, neutron scattering studies are used to investigate the three dimensional architecture of proteins, membranes and large molecular complexes. The ultimate goal of this research is to understand biological functions in terms of molecular structure, to determine the causes of molecular induced diseases, and to provide solutions that may effect cures.

In addition, service irradiations are performed at the HFBR in support of many other research programs. Among them are the production of radioisotopes, chiefly for medical and nuclear chemistry research, as well as the study of archeological artifacts, and radiation damage studies in superconductors and other materials under investigation for the Controlled Thermonuclear Reactor program — important to the search for alternative energy sources.

RADIATION EFFECTS FACILITY

This facility addresses research concerning radiation effects of particle beams on targets of interest. It was completed in 1986 and is the

site of a productive research and testing program. It has been used to study the effects of a particle beam on initiating detonations of high explosives, the alteration of vehicle propellants, and other systems and subsystems that could result in mission failure. A major application is the study of failure of integrated electronic circuits through single event upset, ionization damage or displacement damage of electronic components. These studies indicate the kind of hardening needed to assure reliable operation. This is particularly important for commercial space applications such as communications and weather satellites. As future generations of high density semiconductors increase in resolution and refinement, the likelihood of damage by cosmic rays increases even in terrestrial settings. This facility provides a means of identifying the most effective, lowest cost protection techniques that can be adopted by industrial manufacturers. It also has application for space qualification of electronic components.

NEUTRAL PARTICLE BEAM FACILITY

This facility was completed in 1988. Like the Radiation Effects Facility, it operates parasitically off of the high-energy end of the LINAC (Brookhaven's linear accelerator used to provide pulsed beams for the Alternating Gradient Synchrotron). In addition to experimental work to support development of a neutral beam concept and related measurement instrumentation, this facility is being considered for particle beam therapy. There are plans to use this beam for the treatment of ocular melanoma, artereous malformations, and other such maladies.

national synchrotron light source

The National Synchrotron Light Source (NSLS) is the nation's largest facility dedicated to the production of synchrotron radiation. The facility has two electron storage rings: a vacuum ultraviolet (VUV) ring which operates at an electron energy of 750 MeV designed for optimum radiation at energies between 10 eV and 1 keV, and an X-ray ring which operates at 2.5 GeV to optimize radiation between 1 keV and 20 keV. The X-ray ring accommodates 30 experimental ports and the VUV ring accommodates 17. Each of these ports are split into two to four beam lines. By the end of 1991, the Light Source will have 85 operational experimental beam lines. Of these, 10 lines are dedicated to beam diagnostics and R&D.

From their conception, the designs of the storage rings included long, field free straight sections for special radiation sources (wigglers and undulators). The two straight sections on the VUV ring and the five available on the X-ray ring now have a variety of wigglers and undulators providing radiation that is anywhere from one to several orders of magnitude brighter than the comparable bending magnets. These devices are the sources for a wide variety of experiments in the biological, chemical, and materials sciences.

Photons, as a probe, provide information about the electronic and atomic structures of interest to the chemical, biological, and materials sciences. The techniques fall broadly into two areas: spectroscopy and scattering. At the NSLS, they are applied to forefront research: imaging in both real space

(e.g., X-ray microscopy, tomography, angiography) and reciprocal space (e.g., protein crystallography, X-ray topography), surface science (e.g., photoemission, surface diffraction, infrared spectroscopy), and recently magnetism (e.g., magnetic X-ray scattering, spin polarized photoemission). These are but a few of the exciting research opportunities at the NSLS. By January 31, 1991, 2250 scientists from 292 universities, laboratories, corporations and foreign institutions were using the research tools available at the NSLS. This is an increase of 900 Users and 78 institutions over January 1990.

END

**DATE
FILMED**

3 / 11 / 92