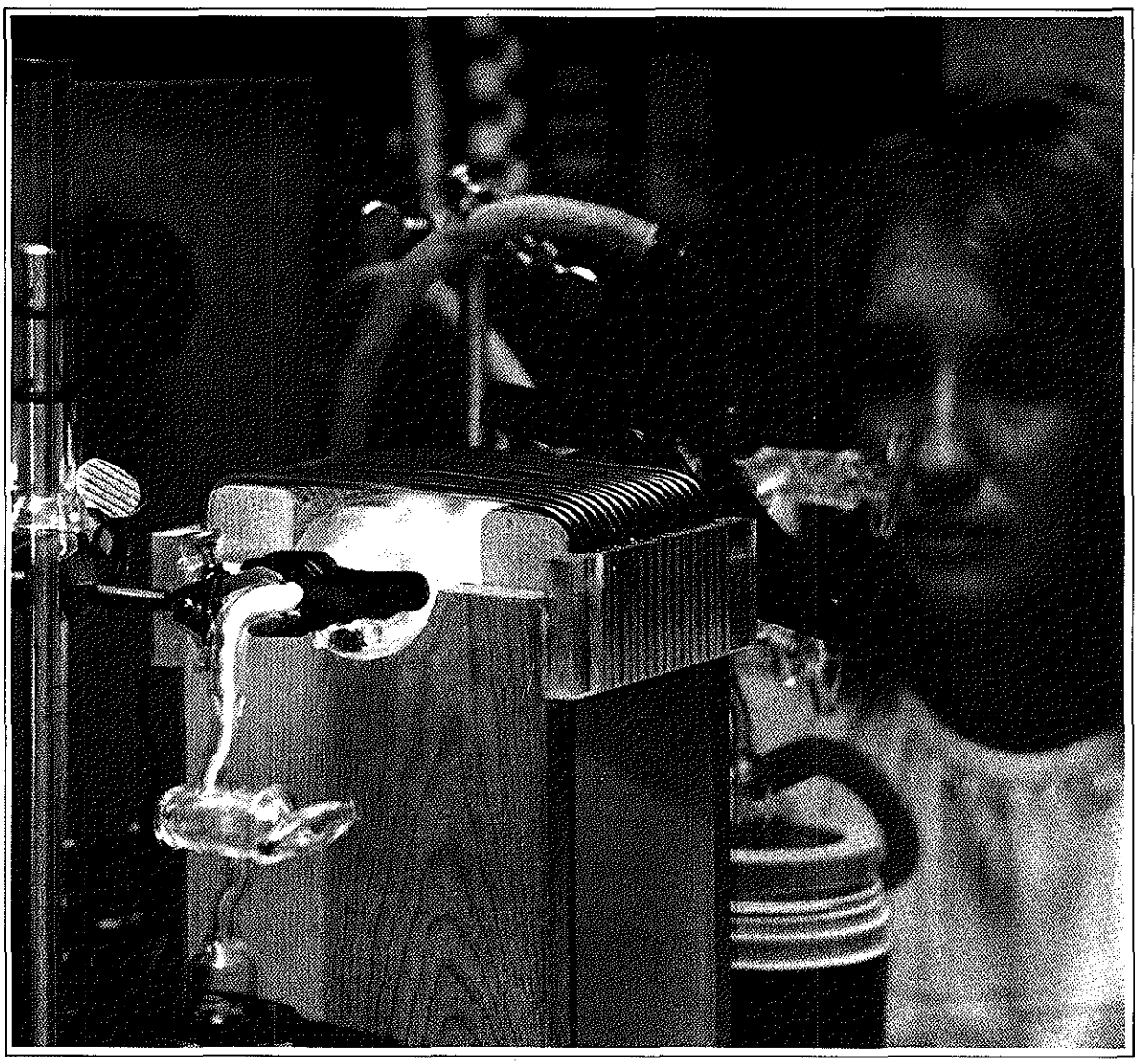
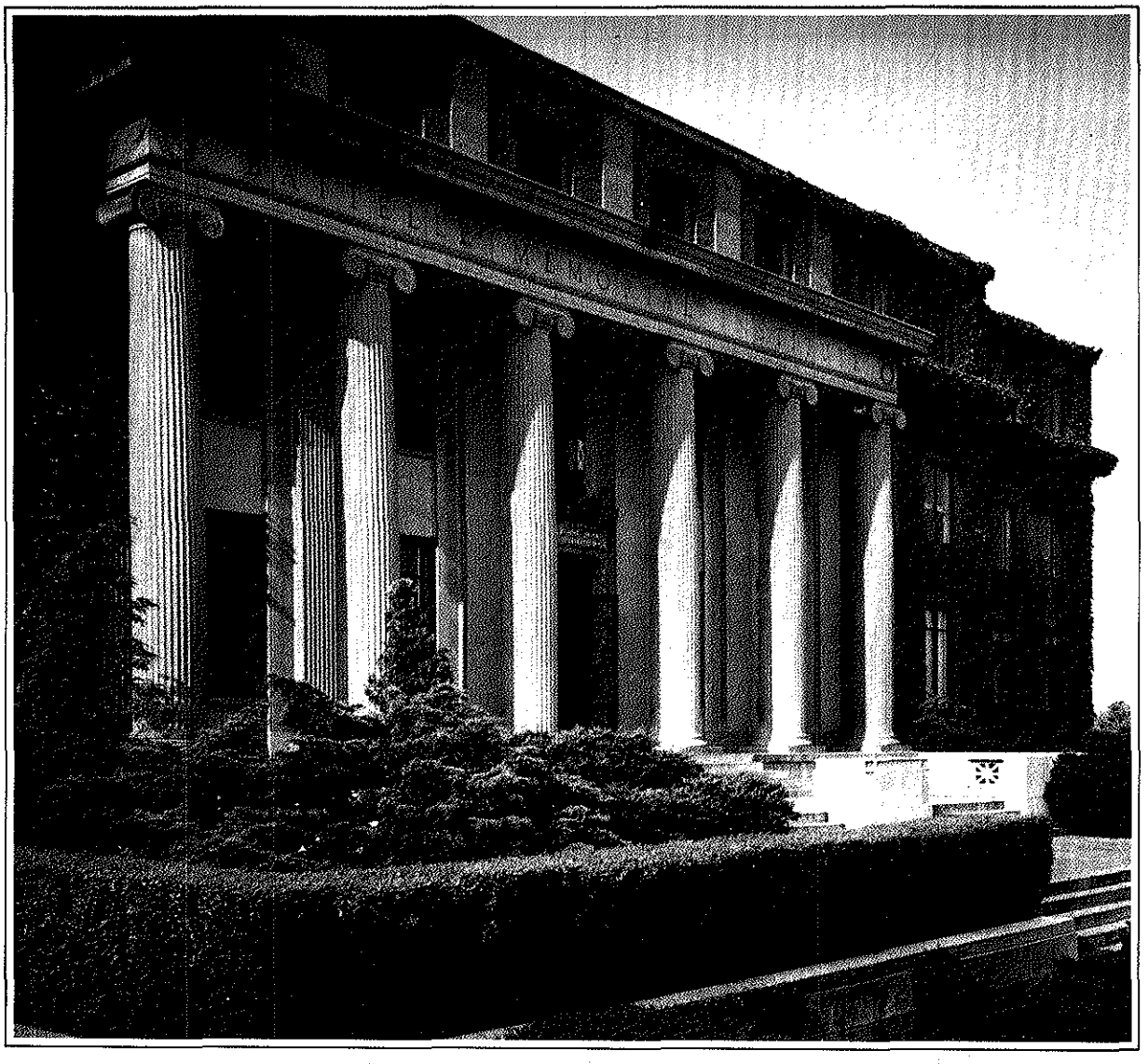
Battelle

The President's Report and Annual Review 1978



Cover: A Battelle-developed low-energy method—using low radio-frequency power levels—to deposit substrate coatings that are pinhole-free, adherent and solvent-resistant.

Now in its 50th year of operation, Battelle Memorial Institute has as its broad objective the benefit of mankind by the advancement and utilization of science through technological innovation and educational activities. The Institute was established in Columbus, Ohio, by the *Will* of Gordon Battelle and serves as a memorial to his family—leaders in Ohio's early steel industry. A pioneer in contract research, Battelle has major research centers in Columbus, Ohio; Frankfurt, West Germany; Geneva, Switzerland; and Richland, Washington; and other specialized facilities, offices, and representatives in many other locations throughout the world.



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Battelle in 1978

■ To meet the research needs of industry and government in 1978, Battelle conducted 2,849 studies for 1,720 industrial and governmental sponsors based in 41 countries.

■ Volume for Battelle's worldwide operations—including research, development, and demonstration activities—totaled $294.1 in 1978—a 31 percent increase over 1977 volume.

■ The Institute's worldwide staff totaled 6,884 at the close of 1978—a net increase of 411 over the staff total at the end of the previous year.

■ In addition to the thousands of reports prepared for sponsors of Battelle research, members of the Institute staff authored 796 articles and papers published in 1978, and they were the authors and editors of 18 books published during the year.

■ 88 inventions were patented in 1978 by members of the Battelle staff.

■ In May, the Institute established a new corporate operating division—the Project Management Division. The new component is designed to facilitate the organization and management of major projects and programs in which the emphasis is on demonstration of new technology as opposed to the research and development that precedes demonstration. The new Division is based in Columbus, Ohio.

■ Battelle was selected to manage a major U.S. Department of Energy program concerned with the long-term storage and ultimate isolation of commercial nuclear wastes. Objectives of the program, carried out within a Battelle-established Office of Nuclear Waste Isolation (ONWI), include exploring geologic formations in the U.S. as potential sites for a nuclear wastes repository and developing the technology for a repository. ONWI began operations officially on July 1.

■ Recognizing the growth and complexity of Battelle's operations, the Institute's Board of Trustees, in October, created the position of Executive Vice President and Chief Operating Officer. Dr. Ronald S. Paul, who was elected to this position, was previously Battelle's Senior Vice President.

■ Plans were announced in October to restructure Battelle's Geneva Division to better match its capabilities and resources to present research needs. The changes, completed at the end of 1978, resulted in the transformation of Battelle-Geneva from a multipurpose research center to several more specifically designated centers of research and development expertise. Collectively these centers are known as the Geneva Research Centers.

■ In December, Dr. Morris Tanenbaum was elected a member of the Battelle Board of Trustees. A physical chemist by training and currently President of New Jersey Bell Telephone Company, Dr. Tanenbaum brings to the Board a broad range of experience in research, engineering, manufacturing, and management.

■ A major research facility for experimental ecology projects was placed in service at Battelle-Columbus. The complex—believed to be the only one of its kind at a private research organization—enables scientists to conduct extensive studies in environmental toxicology, ecological monitoring, forest and agriculture management, and ecosystem structure and function. The new facility complements other facilities throughout the Battelle organization used for ecology projects.

■ Battelle, in 1978, made charitable distributions of $726,000 to a wide range of organizations and programs concerned with educational activities and community services. These distributions, made directly by Battelle Memorial Institute, are in addition to other distributions bearing the Battelle name and made by the Battelle Memorial Institute Foundation.

Contents

Comments From The President

Battelle, which is marking its 50th anniversary in 1979, has just completed one of the best years in its history.

On the pages that follow you will note some of the programs and projects of Battelle that suggest the breadth and diversity of the Institute's activities and the significance of its work. These examples are the latest in a long line of achievements that have helped industry and government meet the needs of people in many parts of the world.

Year-end statistical information provides still other evidence of the strength and vigor of Battelle as it passes the midpoint of its first century. Its staff—some 6,900 scientists, engineers, and supporting specialists—conducted about 2,800 studies in 1978 under contract with more than 1,700 industrial and governmental sponsors. Further, Battelle people were authors and editors of 18 books published in 1978, they wrote 796 papers and articles published during the year, and they received 88 patents for inventions.

There is, of course, an element of family pride in anniversaries; however, since most members of today's Battelle staff were not even born when the Institute opened its doors, we—the present staff—can take little credit for its early beginning. Nonetheless, it is instructive to consider the salient philosophy that undergirds Battelle and is responsible for its performance and success up to the present time.

In my view, the most important hallmark of the Institute has been its dependence upon and support of the efforts and inner motivations of individuals. The really significant developments in the life of the Institute, without exception, have come about because one person or a small group has been convinced that a particular activity was vital to Battelle and its objectives, and thus to society.

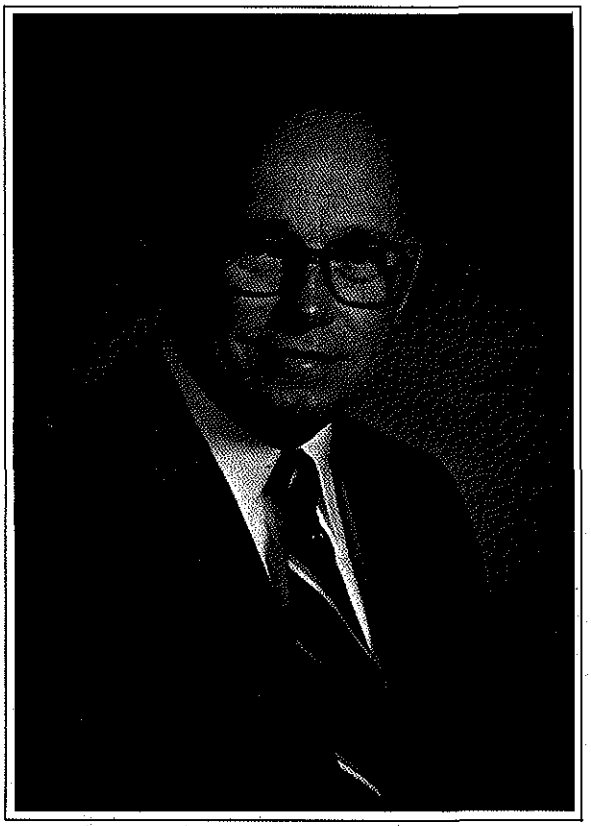
Battelle's entry into new research fields, the directions its research effort has taken, the growth of particular fields of work—all of these can be traced to the drive and zeal of one staff member or, at most, a small group of staff members, and to Battelle management support of these individual efforts.

This is as it should be, for the purpose of Battelle is the utilization of science and education to benefit humanity through technological innovation. Even though the organization and performance of research and development in modern times is large scale and often very complex, creativity and invention—the keys to useful science and technology—are basically individual acts. A new idea is born in one mind at a time even though later it often needs to be reinforced, revised, and supplemented by group actions to make it practical and usable. Thus, we at Battelle try to be ever mindful of the vital role of the individual—as an individual—in the affairs of Battelle.

This emphasis on the individual and his or her key function in research and development seems to be an anathema in the current social trend toward collective security and social action; equalization of all rights, benefits, and rewards; and policies that discourage risk-taking and innovation in products, processes, and enterprises on the part of private individuals and organizations.

It is noteworthy, too, that the scientist's or engineer's new idea—the product of solitary thought and probing—can drastically change the lives of many people. Such an idea—and the technology it spawns—can have an important bearing on the lives of nations as well.

The recognition of the vital role of new technology in solving the complex problems of the world has never been so clearly recognized as at the present time, although this recognition manifests itself in different ways. The concern in the United



States is that the nation is losing its technological edge to its trading partners among the developed nations. The other developed nations appear to recognize the need for technological advances in modern society and are vigorously pressing forward. The developing countries are eager to have technology "transferred" to them and seek it in the belief that it will solve almost any problem.

For all the public debate, at times it seems that almost no one understands the total process of technological innovation and all of its elements. We, at Battelle, see this process as a long chain. The links of the chain include definition of need, knowledge, research, invention and innovation, development, capital investment, marketing investment, and finally, commercialization to provide new products and services for the public. Unless *every* link is strong and meets the demand placed upon it, the chain is nonfunctional and *not one* link can be considered successful.

Battelle's activities lie in the first few links of this chain, including the generation of new ideas and the development of technology to put them into use. We foresee no shortage of ideas or innovative thinking to carry society forward. Battelle, however, depends upon its sponsors to extend the benefits of its work to the public by performing the activities represented by the remaining links, and thus they are vital partners.

Ultimately, though, responsibility for making the innovative process work for the benefit of the public rests with society, as a whole, and the government in particular. That responsibility is to provide the proper incentives and a climate of encouragement to stimulate and support those involved in the difficult decisions, the risk taking, and the large investments required in the subsequent links of the chain.

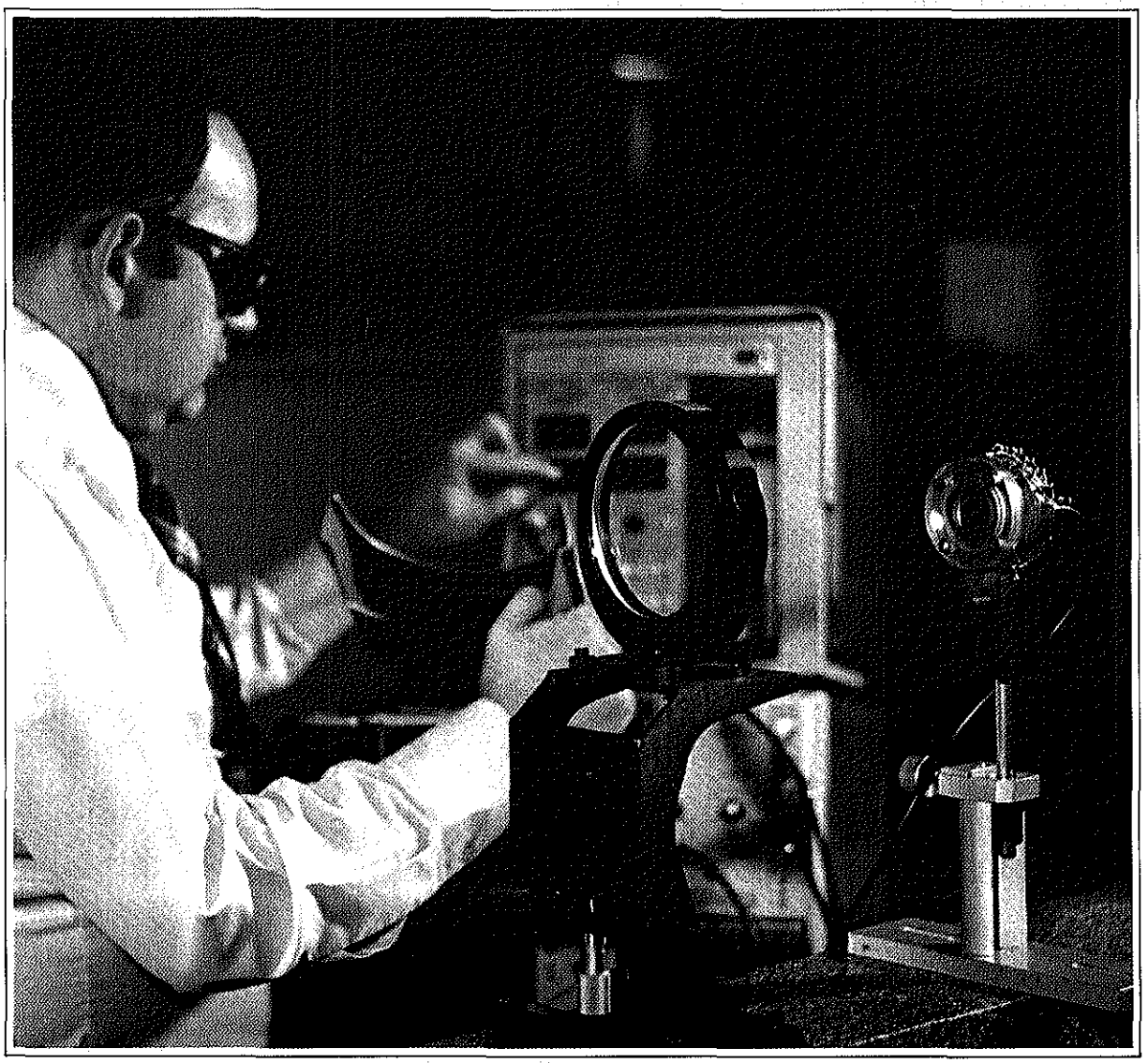
As Battelle passes the half-way mark in its first century of service, we—as individuals and as an organization—are dedicated to making our links in the chain of technological innovation as strong as possible. Clearly, for us, this is the best way to insure the Institute's future success in contributing to human progress, and that, of course, is Battelle's purpose in being.

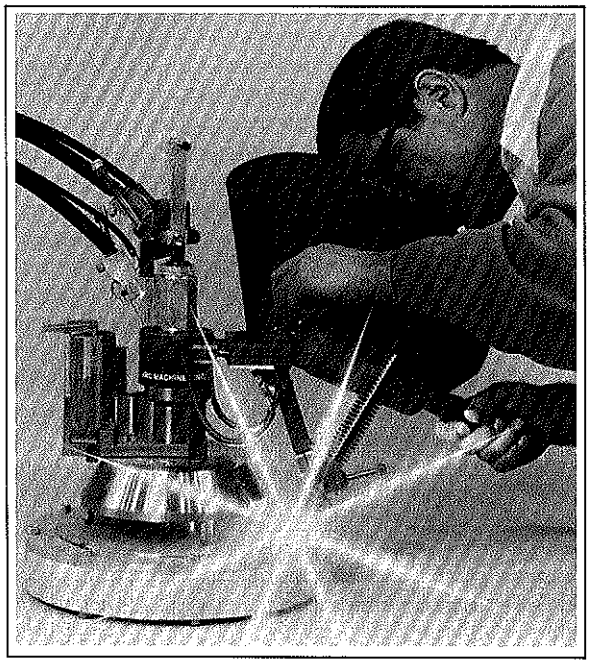
Industrial Processes

It was clearly the intent of the Institute's founder that Battelle should further industrial progress; and, since its beginning, it has been committed to this goal. Today, Battelle research encompasses a wide range of industrial activities. These include extracting and refining raw materials, manufacturing, creation of new products, quality control, reprocessing materials, plant health and safety considerations, and planning for future requirements in industrial processing.

As an example of Battelle's contribution to improved mining operations, researchers have designed the instrumentation for a blind-shaft boring machine now being evaluated in an Alabama coal field. The instrument package, which meets federal coal mine safety requirements, monitors and displays the machine's performance to the operator. Battelle researchers also assisted in selection and implementation of the machine's laser guidance system. The term "blind-shaft" is used to describe the machine, because it operates without the benefit of a pilot

Using the laser in ultrasonic nondestructive examination technology as a source for generating high-intensity, high-frequency acoustical pulses.





Arc welder designed by Battelle to remotely seal steel canisters of solidified radioactive wastes inside shielded radioactive work areas.

hole. The machine bores a shaft 24 feet in diameter which then is lined with a foot-thick concrete wall.

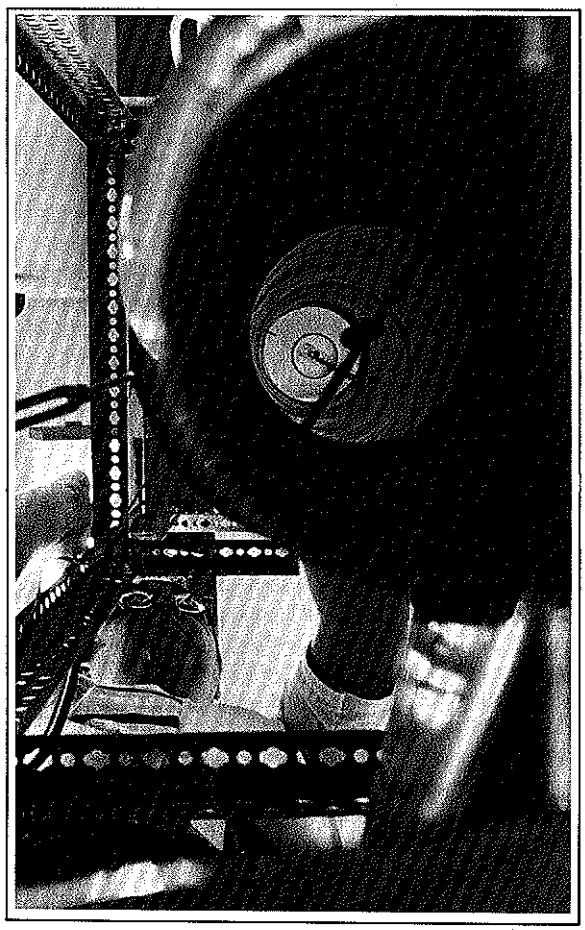
Institute research has led to many improvements in primary manufacturing operations. One recent example has been in its development of better means to preheat huge refractory-lined ladles that are widely used in steel plants, foundries, and other metallurgical plants to transport molten metal. Preheating these ladles by conventional methods was identified by researchers to be extremely low in thermal efficiency. Battelle developed improved methods for preheating—including heating with electricity and use of covers and recuperators in gas-fired systems—with substantially higher efficiencies. The results are now being applied in several plants and are expected to receive wide utilization.

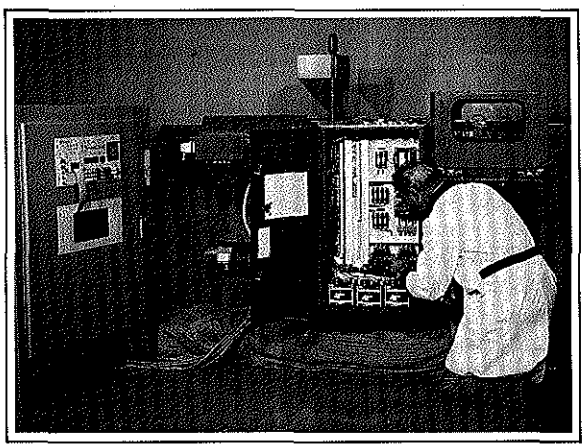
Exemplifying Battelle's research on manufacturing processes that assure better products is its development and fabrication of a plasma spray system to deposit wear-resistance and thermal-barrier coatings on complex shapes. The system includes a computer-controlled plasma gun, powder feeders, and a multi-axis manipulator. Coatings can be deposited on shapes as complex as the air foil surface of a jet engine's turbine blade, and coating thickness can be maintained to within 0.002 inch. This automated process assures coating uniformity and quality by eliminating the possibility of human error.

Some Battelle research involves adapting existing technology for wholly new purposes. As an example of this form of technology transfer, researchers have used an industrial metal polishing technique to help the nuclear industry decontaminate metal surfaces. Two commercial firms are using electropolishing for decontamination, which permits commercial reuse of contaminated reactor parts that otherwise would be scrapped. Scientists are assisting organizations in setting up the process and are researching process improvements.

Institute scientists are designing and evaluating a new emulsifier system for preparing homogeneous mixtures of liquids. The system is based on the use of

An experimental wet-wall, electro-inertial air cleaner developed to wash away electrically charged cotton dust particles generated in cotton gins and textile mills.





A microprocessor system to automatically control, monitor and record ceramic injection molding process variables in a variety of molding machines.

a cavitating flow section to break large drops into very fine droplets. The experimental emulsifier operates by using the pressure of one of the fluid streams to be mixed as the only energy source. It does not contain any moving parts, thus simplifying its operation. The prototype has been used to emulsify 5 to 30 percent of oil in water. This new system has promise for a wide variety of industrial applications.

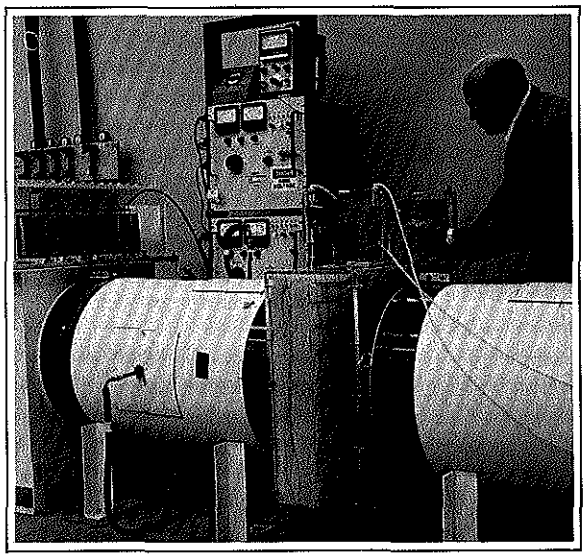
As an example of research directed toward new products, Battelle researchers have developed a new type of direction-finding data evaluation process which may provide the basis for a new device useful in small craft navigation. Such a device would make it possible to cheaply convert conventional manual direction-finders used in sailboats and small fishing vessels to automatic operation. The application is not restricted by the requirement of any special fixed or mechanically or electrically operated antenna pattern or any special receiver.

Battelle research, at times, is devoted to improved processing equipment. Researchers, for example, have developed an automatic process for detecting fine cracks in eggs passing through a machine for sorting and packing eggs. The entire surface of the shell is scanned by a laser beam focused on the egg. The laser light penetrates through any cracks into the inside of the egg; there it is scattered, the egg lights up and is identified by a photodetector. The crack-detecting process, when used with existing egg sorting and packing equipment, can check 40,000 eggs an hour.

Energy conservation is an important consideration in various processes, and Battelle is managing a three-year program for the United States government to develop and demonstrate methods for conserving energy used in irrigation. Scientists are reviewing research proposals from outside contractors and will select final projects to be funded. Possible topics include well drilling, pumps, distribution systems, and irrigation monitoring systems. In agriculture, irrigation is second only to fertilizers in energy consumption, and Battelle believes a 50 percent reduction in energy used for irrigation could be achieved during the next ten years as a result of the research.

In many cases, Battelle research involves assisting industry in planning for the future. As an example, Battelle conducted an in-depth assessment of current and projected trends in the chemical process industry which were likely to have an impact on the industry's need for high-performance materials. The study focused on the uses for carbon, titanium, nickel alloys, tantalum, columbium, zirconium, glass- and ceramic-lined materials, and high-performance plastic linings. Because this industry is large, complex, and ever changing, the Battelle forecasts have proved useful to producers and suppliers of such materials who found it difficult, by themselves, to keep abreast of the industry's needs.

Battelle-developed fiber bed to help minimize air pollution by removing submicron particles from process off-gases and building ventilation air.

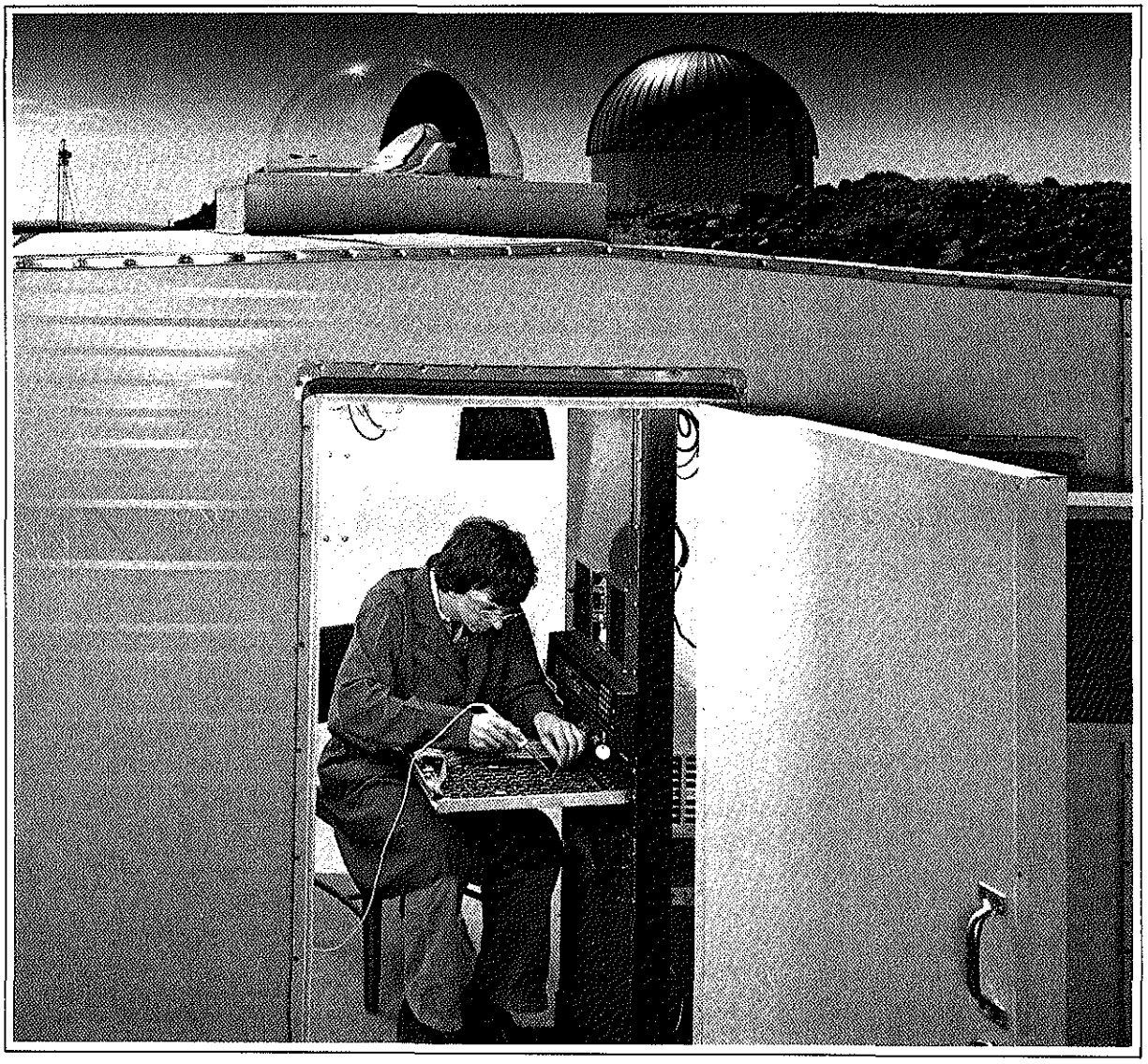


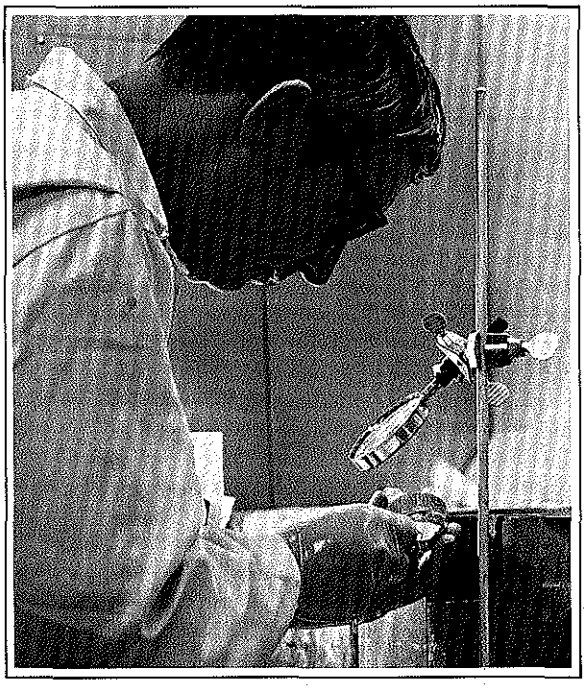
Energy

Energy has been the subject of research at Battelle since its earliest years, and great emphasis has been focused on it in the 1970's. This research covers the entire energy spectrum—from coal, gas and oil; to nuclear; to solar; to geothermal; and to such unconventional energy sources as agriculture products. Studies are concerned with the generation, conversion, and use of energy; its transmission; safety, health, and environmental factors surrounding energy usage; energy conservation; and public issues with respect to energy.

A notable development in 1978 in Battelle's efforts to assure an adequate future energy supply was its assumption of responsibility for operation of the Office of Nuclear Waste Isolation (ONWI). ONWI has two primary objectives: (1) to identify and characterize geologic sites for use as nuclear waste repositories; and (2) to manage the development and application of specific supporting data and base technologies. Based at Battelle in Columbus, Ohio,

Mobile unit for analyzing daytime sunlight and night sky radiation and supplying data for solar power plant siting and auroral and airglow studies.





Evaluation of fuel cladding subjected to simulated loss-of-coolant to determine the ability of a nuclear reactor's safety system to withstand such an incident.

ONWI is operated under a contract administered by the U.S. Department of Energy's Richland, Washington, Operations Office. ONWI's planned program embodies a straightforward, step-by-step approach to attaining an operational repository for nuclear waste. In simplest terms, its objective is to have a fully operational geologic repository in the 1990's.

With respect to new energy sources, Battelle research indicates that Midwestern farmers in the United States could soon have a high-yield energy crop in sorghum. Midwest growth rates of several varieties of sweet sorghum have been shown to be comparable to those in the South. Sorghum appears the best Midwest candidate energy crop because of its high sugar content, and because it requires low fertilizer levels relative to the amount of biomass produced. Research is continuing to understand the low fertilizer requirements and to further optimize yield.

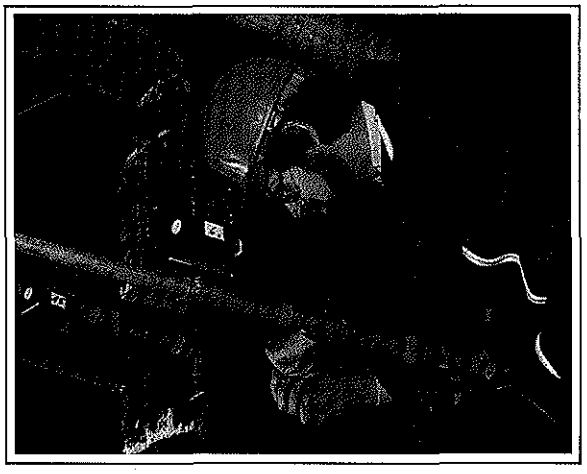
In another approach to the use of biomass for energy, Institute researchers are attempting to produce selected, relatively pure gas products from wood wastes. These wastes are used to produce hydrogen, methane, carbon monoxide, hydrocarbon synthesis gas, and ammonia synthesis gas. Catalysts will be used in an attempt to increase gas yields and reduce reaction times. The demonstration unit will help determine whether biomass can be converted to a particular product in a single-stage process by using the proper catalysts.

Solar energy is receiving considerable attention at Battelle, and in one study scientists are developing thin-film solar cells by electrodepositing amorphous (noncrystalline) silicon. This new proprietary process of silicon electrodeposition has been under development at Battelle for several years. The process eliminates several stages in conventional solar cell manufacturing technology and, thus, is a potential means for low-cost fabrication of large area solar cells for power generation. The thin-film amorphous silicon solar cells are being investigated as an alternative to the conventional cells of single-crystal design.

Other aspects of Battelle's solar energy research include the advanced design of two solar-energy systems for generating electric power. Both systems will use photovoltaic devices that convert sunlight directly into electricity. One system is being designed to supply up to 150 kilowatts of electricity to two commercial buildings. Excess electricity from the system would be fed into a nearby power grid operated by an electric company. The other system is a 100-kilowatt system to power a machining- and metals-fabrication facility.

Magnetohydrodynamics (MHD)—a method of electrical generation that could increase fossil-fuel

Unique research facility used to expose miniature swine to high-voltage electric fields in a study to help determine safe human exposure levels.



Reactor safety experiments simulating loss of coolant in light water nuclear reactors carried out to investigate the dispersion behavior of hydrogen.

power-plant efficiency by up to 20 percent—was the subject of increased Battelle research in 1978, with the focus on developing materials that can withstand the severe conditions of the MHD process. Studies included bonding methods, ability to withstand high temperatures and stresses, design and fabrication techniques, and thermophysical and electrical properties. This research is part of a United States/ Union of Soviet Socialist Republics venture to develop MHD.

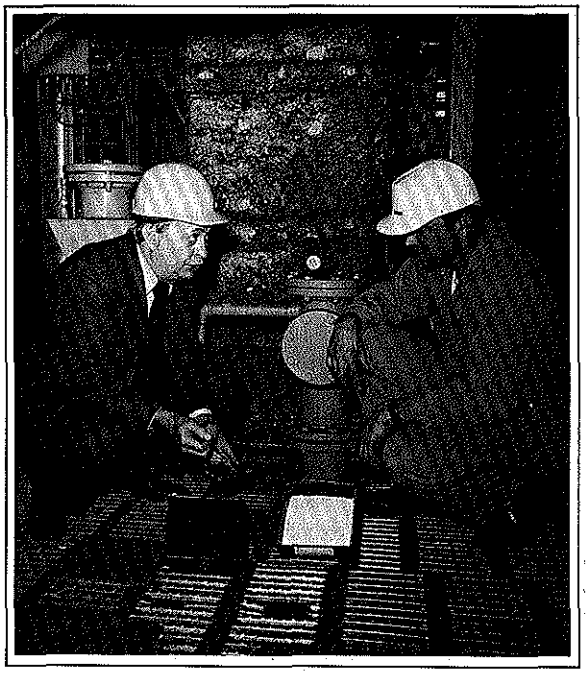
Battelle researchers are also deeply involved in efforts directed toward developing water-conserving systems for power plant cooling. They are overseeing preliminary and final designs for a $5.5 million dry/wet cooling test facility, and they are planning the test program which will begin when the facility is completed in 1981. The plant uses evaporating and condensing ammonia to transfer waste heat from a power-generating turbine to the air. Current work on the plant follows more than four years of Battelle research on dry cooling concepts.

Battery technology continues to be an important area for Battelle research. Scientists have been studying battery requirements for electric vehicles, where there is a need for high storage capacity and long life under deep-discharge cycling. The research indicates that recent developments make the iron-nickel battery a promising candidate among conventional systems. Normally, the iron electrode is the limiting element in this battery because of a progressive capacity loss due to disintegration of the sintered body during deep discharge cycling. This problem, however, has been overcome by a new electrode structure and electrode preparation process.

Some Institute research is concerned with the economic use of energy in urban development, as in the case of the Erlangen-West Development in Germany. Purpose of the study was to determine ways of incorporating conditions favorable to the economic use of solar energy for hot water and heating purposes into urban planning. The principal result of the investigation is a recommendation that building regulations specify a minimum distance between buildings so that no building casts a shadow over the facade of another.

Public understanding and attitudes with respect to energy are the basis of still other Battelle studies. In one such study, for example, researchers identified a broad spectrum of sociological issues associated with radioactive waste management. In their report, they note that, in making public policy decisions on nuclear wastes, close examination should be made of associated nontechnical issues—ethical, institutional, and political concerns. The issues involve transferring costs and risks to future generations, long-term needs and short-term responsibilities, and intergovernmental relations at local, state and national levels.

Developing a novel multisolid fluidized-bed combustion process to burn high-sulfur coal in an environmentally acceptable way.



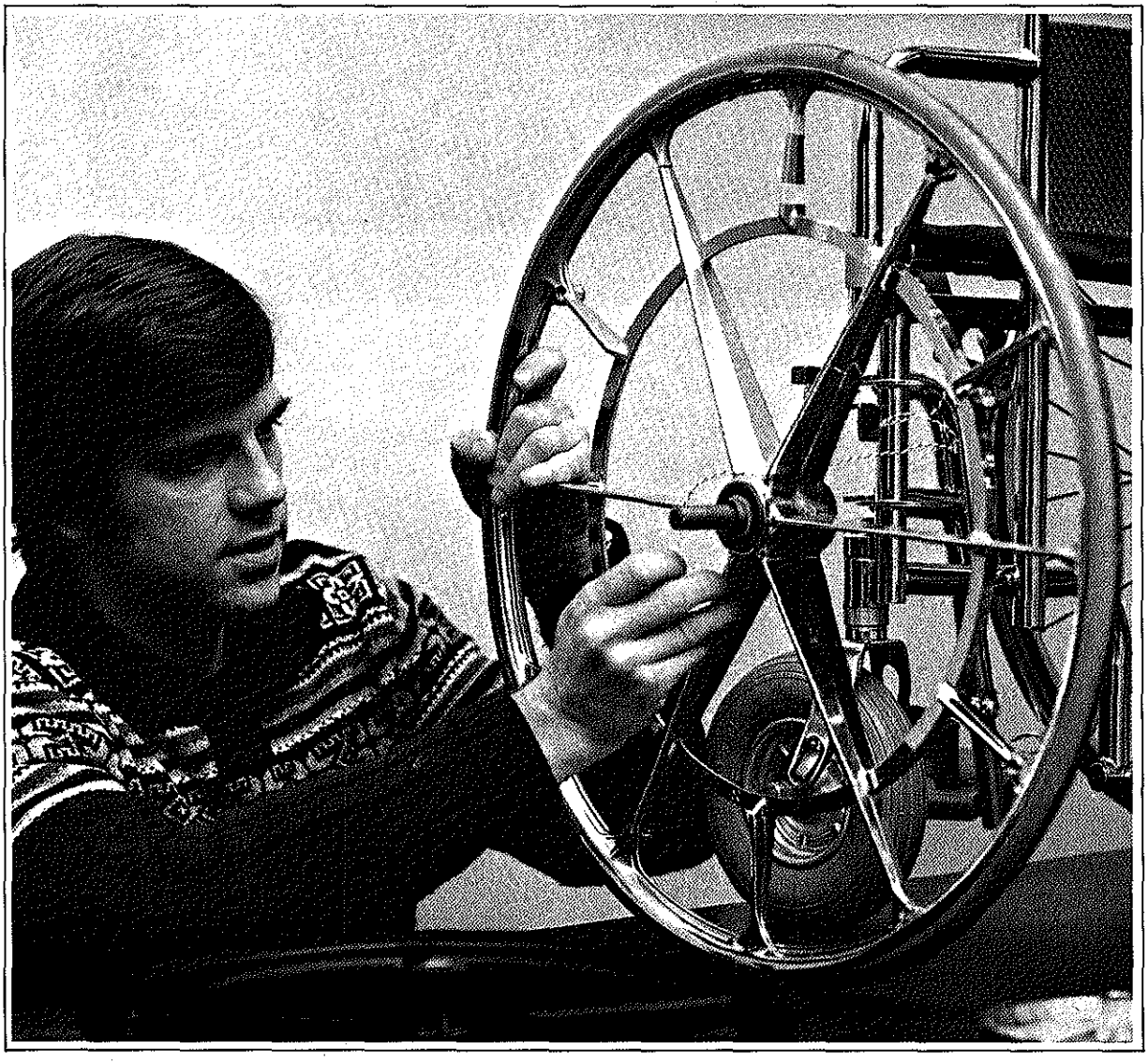
Human Services

Research directed toward improved human services is a particularly rewarding endeavor, and Battelle staff members are engaged in a wide variety of studies that have an important bearing on the quality of life and affect the well-being of people. These embrace education and training, health, safety, law enforcement, and community economic development.

One example, among many, of the Institute's educational efforts is a program to establish a number of technical training centers in Algeria to train young people in various trades and to retrain adults. The program involves establishing a national trade institute to promote all small-scale trades and setting up a pilot technical training center for artisans to train instructors and to experiment with new teaching methods. In addition, researchers will analyze the requirements for the training centers to be located throughout the country.

With respect to health, Battelle scientists are

A lightweight wheelchair developed by Battelle that features pneumatic tires, removable armrests and footrests, and easy stowability.

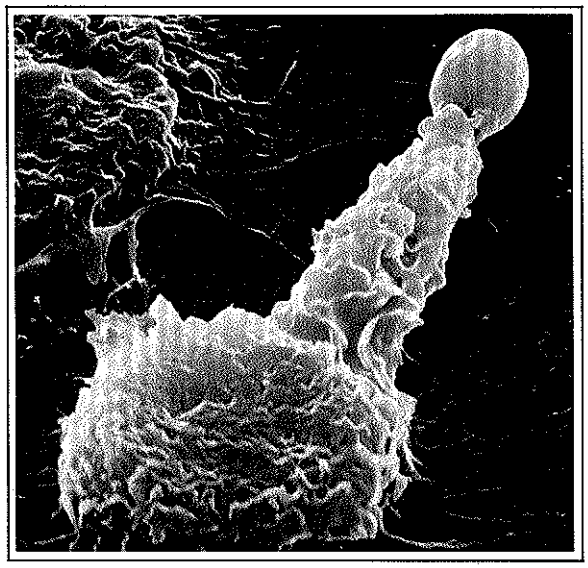


conducting a number of studies on cancer. For example, they are investigating the long-term cancer-causing potential of a dozen different chemical compounds. Rats and mice will be used in various repeated dose inhalation studies over a five year period to determine the potential carcinogenicity of these chemicals.

In other research concerned with cancer, researchers are developing a system of instruments for the automatic early recognition of cervical carcinomas from cell smears. In this two-step analytical system, the size of each cell is determined by the slit-scan method, and suspicious cells are then thoroughly scanned two-dimensionally by means of a laser scanning system, whereupon they are analyzed and classified.

Devices compatible with the human body represent another important area of health research at Battelle. Ceramic tooth roots developed by researchers, for example, have been implanted in laboratory animals and hold promise of replacing missing teeth or serving as an anchor for bridgework in humans. Made of ceramic-fired, high-density alumina, the roots are produced on a computer-controlled milling machine. Implants have remained rigid and in function for more than two years.

Battelle scientists are also engaged in the development of various drug delivery systems for the pharmaceutical industry. Efficient delivery of the drug to the target organ in the body is essential for the desired effect. A relatively high concentration of the drug at the site of action may be achieved by incorporating the drug into liposomes, normal components of some cells in the body; by binding the drug to a polymer; or by polymerization of the drug itself. Such procedures may also be used to prolong the pharmacological action or reduce the toxicity of the drug.

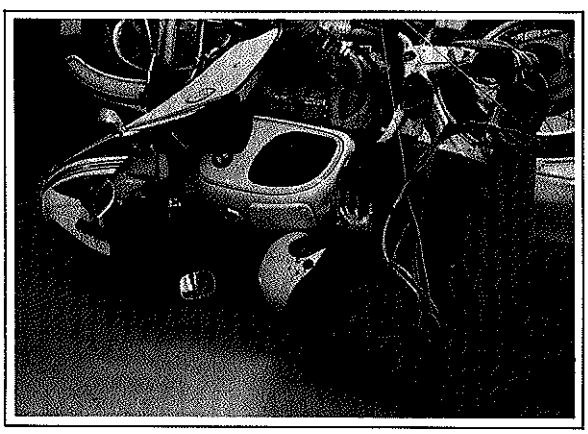


Scanning electron photomicrograph used to study alveolar macrophages that help to clean inhaled small particles from deep in the lung.

Working with other organizations, Battelle is collaborating on the development of an instrument that can be used to objectively assess the positioning of the stump in an artificial limb. Pressure ratios between the stump and the artificial limb can be determined and the results shown on a television-type color screen display. Information on the pressure distribution is shown immediately and repeatedly, as in a film where the speed can be varied, and the data can be used to make a series of adjustments to the test limb.

Institute scientists are working on safety problems involving both air and ground transportation. With regard to air travel, specialists have been assisting the United States government in the development of methods for using aircraft accident data to improve the design and development of safety programs. Researchers have examined some 800 air carrier accidents occurring over a 12-year period to study the primary causes of the accidents. Results of the study will aid in evaluating the effectiveness of existing aircraft safety programs and in pointing the way toward new, needed programs.

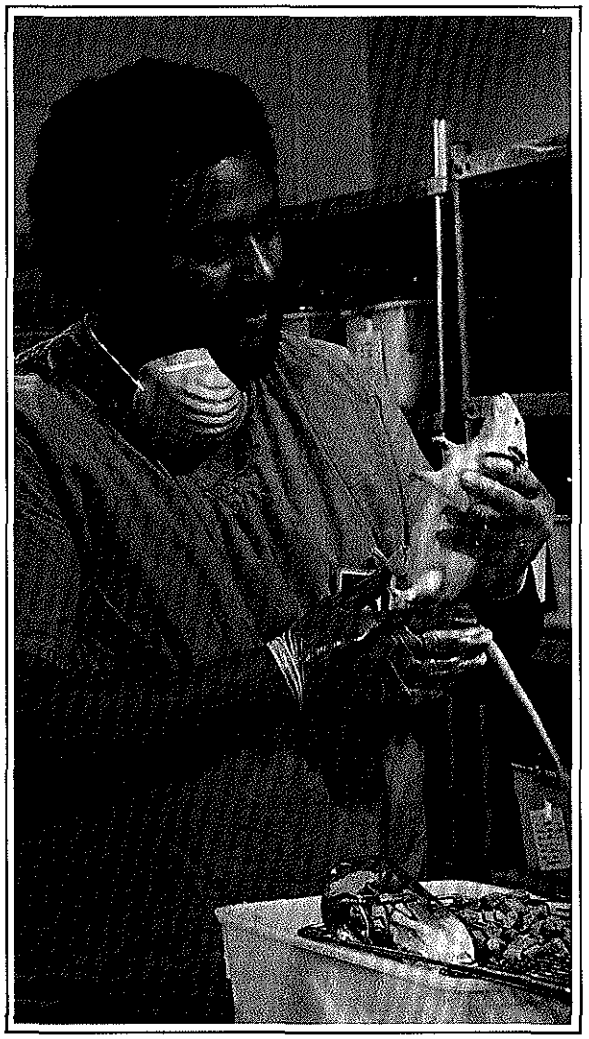
Simulating motorcycle accidents—first step in the development of improved safety features, including knee protectors and helmets.



Battelle research has also resulted in safety devices. Scientists have developed a microwave storm warning device that automatically indicates the direction of thunderstorms from 1 to 50 kilometers distant. The storm detector provides a valuable advance warning of thunderstorms, for example, where work is being carried out on poles and overhead cables.

Another device with important safety implications is a remote hydrant valve invented by Battelle researchers. The valve, which is being evaluated at fire departments throughout the United States, permits firemen to activate or shut off the water supply by remote control. It eliminates the need for assigning a fireman to manually operate the hydrant. The new type valve has an aluminum case with a fiberglass housing. An electric motor activated by a radio transmitter opens and closes a gate valve.

Using laboratory animals in cancer research to evaluate the potentially harmful effects of selected chemicals.



Evaluating the impact of noise from railroad freight cars operating at high speed.

Indicative of Battelle's concern for law enforcement, a comprehensive training course on white-collar crime enforcement was conducted by the National Center on White-Collar Crime—a component of Battelle's Law and Justice Study Center. A manual prepared by the Center was the basis for the instruction. The pilot program carried out in 1978 will be followed by a second course in 1979.

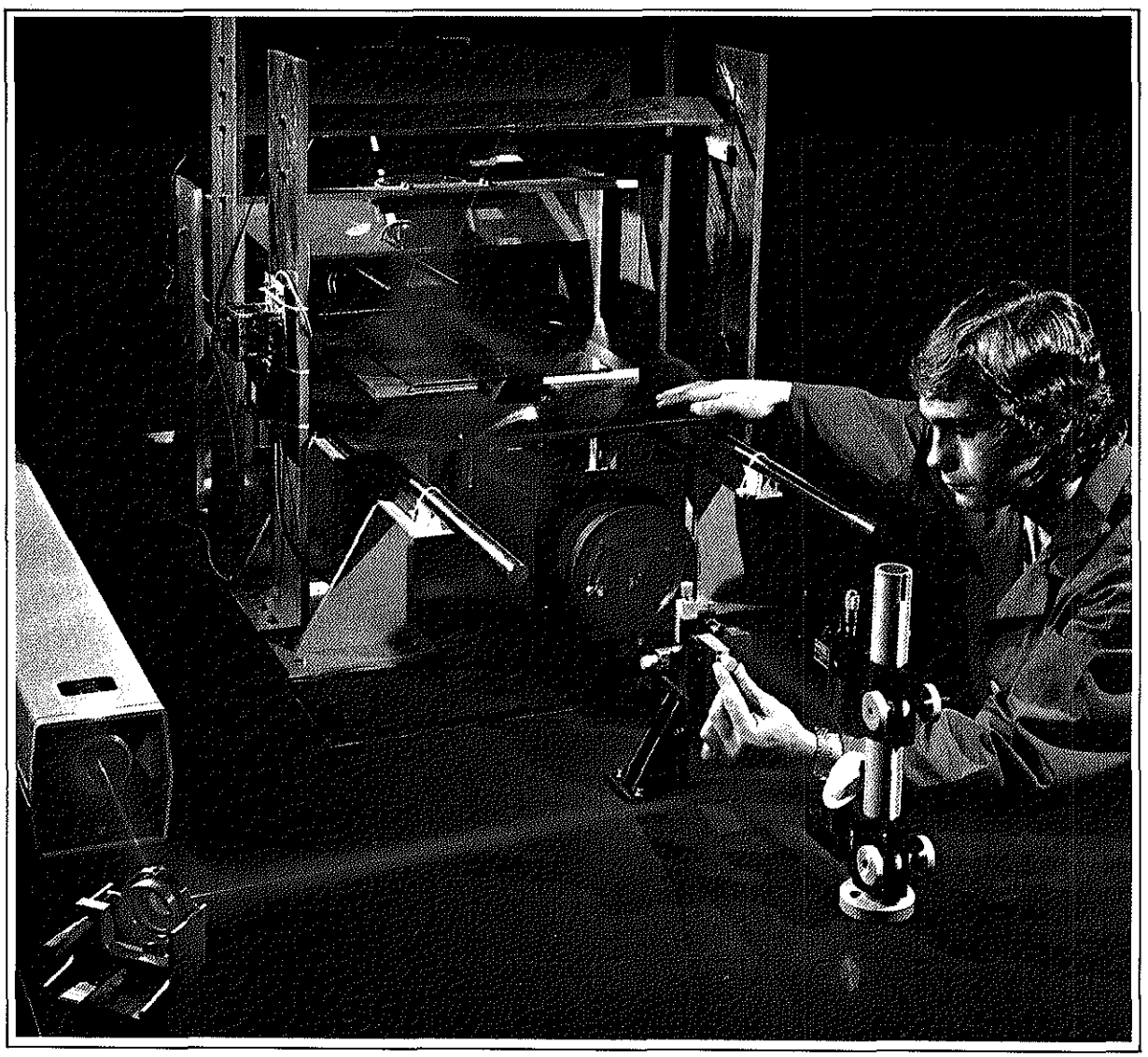
The economic health of a community or region has an important bearing on the well-being of citizens, and some Battelle research addresses this need. The Institute, for example, was engaged to develop a program for economic recovery of an economically depressed area in the United States. The region has been severely affected by the closing of a steel producing facility. As a result, the region faces a difficult task of finding ways to replace lost employment, income and production capability. Battelle developed a strategy for attracting new economic activities, for retaining and expanding local employment opportunities, for developing organizational mechanisms for promoting growth, and for creating a positive outlook on behalf of the business community in and around the affected area.

Materials Technology

Better and cheaper materials are basic to industrial and human progress, hence materials research has always occupied an important place at Battelle. The research covers a wide range of materials including metals, ceramics, concrete, glass, plastics, and composites. It is concerned with making new materials, tailoring material properties to specific needs, developing new methods for forming and applying materials, evaluating the properties and performance of materials, and finding better ways to produce materials in quantity.

In several fundamental studies, improving both materials and the design of parts to counteract wear and erosion is the research goal. Scientists are conducting research on the nature of surface effects produced during processes that damage materials moving at high velocities in a gas or liquid. In one study, for instance, single water droplets are impacted on lithium fluoride targets. Information obtained is useful in determining stresses. Better un-

Measuring the varying degree of waviness found in different glasses—part of research to identify quality materials for solar mirrors.



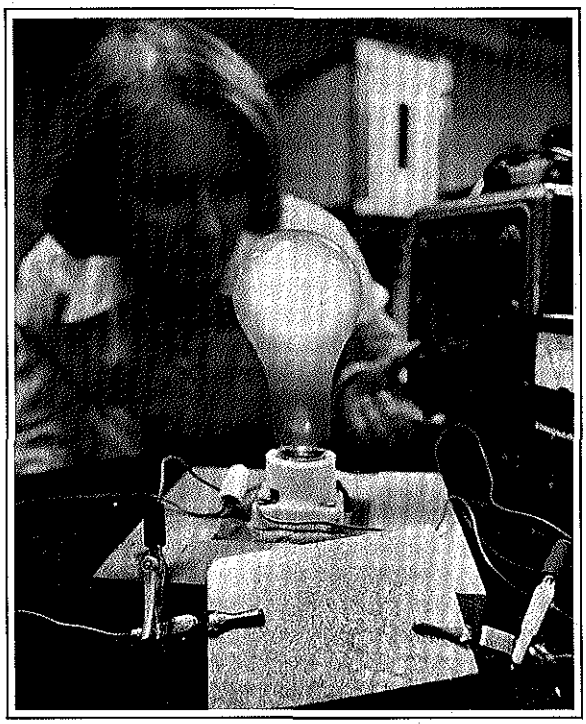
derstanding of the damage mechanisms resulting from such studies could help improve designs for helicopter blades, steam turbine blades, ship screws, or optical windows for heat-seeking missiles.

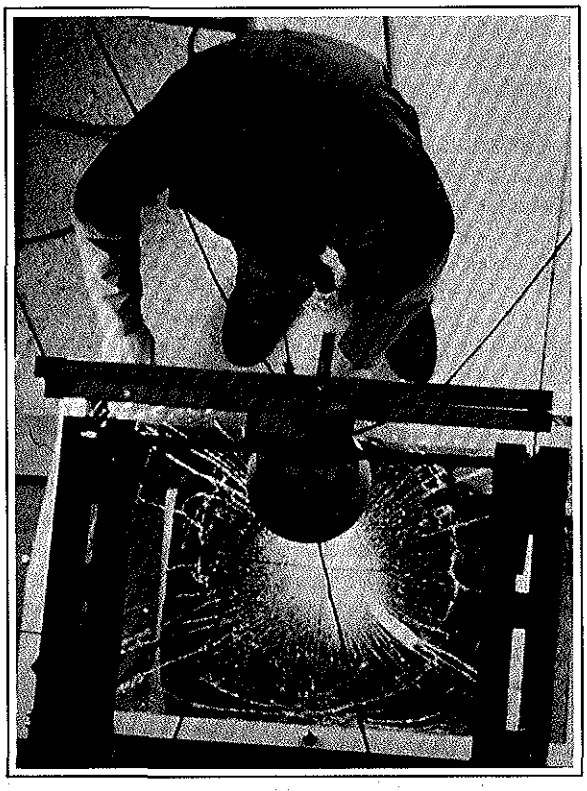
Some Battelle materials research is directed to a well defined use. In research concerning the effects of hydrogen on steel, for example, scientists have gained improved understanding of the behavior of pressure-vessel steels when exposed to this gaseous element at moderate temperatures and pressures. The research will help designers and operators achieve safer operation of petroleum refinery vessels by avoiding harmful effects that might be produced by hydrogen absorbed during service. In simulated service experiments, scientists determined that such steels do absorb hydrogen—the amount depending on the temperature, pressure, and other factors. Information was obtained to quantify the relationships among such critical parameters as hydrogen content of the steel, strength of the steel, and threshold stress intensity for hydrogen-assisted crack growth.

Development of a concrete joint that can withstand the stress of a severe earthquake represents another example of research directed toward a specific end use. The joints are made of Wirand® concrete—concrete reinforced by the addition of short lengths of metallic fiber developed by the Battelle Development Corporation. Conventional joint-to-column supports are reinforced with intersecting steel bars and hoops to withstand earthquake pressures. The concentration of steel increases fabrication costs and often complicates concrete placement. With the less expensive Battelle joint, many of the supporting hoops are eliminated. The reinforced concrete increases tensile strength and impact resistance and offers flexural (bending) strength two to three times greater than that for ordinary concrete.

Working with industry, Battelle scientists have also developed a new insulating material by foaming aqueous solutions that cure in a short time at room temperature to give a pressure-resistant, open-pore, rigid foam. This foam can be used to make simple shapes without developing internal pressure and lends itself to foaming in situ. The material is par-

Checking a Battelle-developed, fiber-filled polymeric composition which, with as little as eight volume percent of short aluminum fibers, can carry enough current to light a bulb.





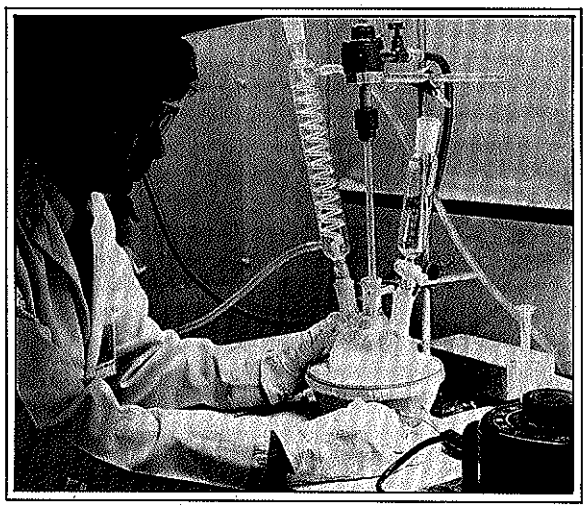
A Battelle-developed device is used to measure and evaluate the impact resistance of laminated glass.

ticularly well suited for use in the building sector and in the automobile industry. The new foam material is highly flame resistant.

Knowing how a material performs under certain circumstances is an essential first step in creating an improved material. Such is the case with Battelle scientists who have developed a device to measure and evaluate the impact resistance of laminated glass—glass that is layered and bonded. In a typical evaluation procedure, a standard steel ball of 80 mm diameter and weighing 2 kilograms is dropped from heights of between 1½ meters and 5 meters onto a sample of the glass held horizontally in a steel frame. The resistance to penetration can be determined by measuring deformation at the center of the sample. This research is directed toward development of a new type of safety glass for the automobile industry.

In some cases, Battelle researchers have developed special equipment to inspect materials under highly unusual conditions. For example, they have developed an X-ray process to inspect high-voltage, pipe-type, oil-filled electrical cables at Grand Coulee Dam in the State of Washington. Periodic X-ray inspection identifies potential defects—permitting scheduled maintenance during times of low power demand. The portable, 100-pound system's intense X-rays penetrate the steel pipe, cable sheathing, oil and insulating materials. Special screens and films produce individual X-rays within six minutes without interrupting power flow. Preventive maintenance of such cables is crucial.

A new method—using gel techniques—for preparing improved crystalline/noncrystalline high-temperature materials for applications in glass melting, fiber optics, and nuclear waste fixation.



Ultrathin layers of silicon sputter-deposited on solar test cells in research aimed at reducing solar cell costs through automation.

Shutdown for unexpected repairs may take months, cost thousands of dollars in lost revenue, and impact on power generating capacity throughout the region.

Institute scientists have also demonstrated a fast, economical method for analyzing earth cores from potential geothermal energy production sites. The analysis identifies contaminants which could be released by tapping geothermal wells. Samples from six geothermal sites were analyzed in an electron microprobe using wavelength dispersive and energy dispersive X-ray analyses. With the newer energy-dispersive analysis, a special detector "sees" energy levels from all heavy elements at once. Computer data analysis indicates the concentration of various elements in the samples. Wavelength dispersive analysis is costly, time consuming, and requires separate analysis for each element.

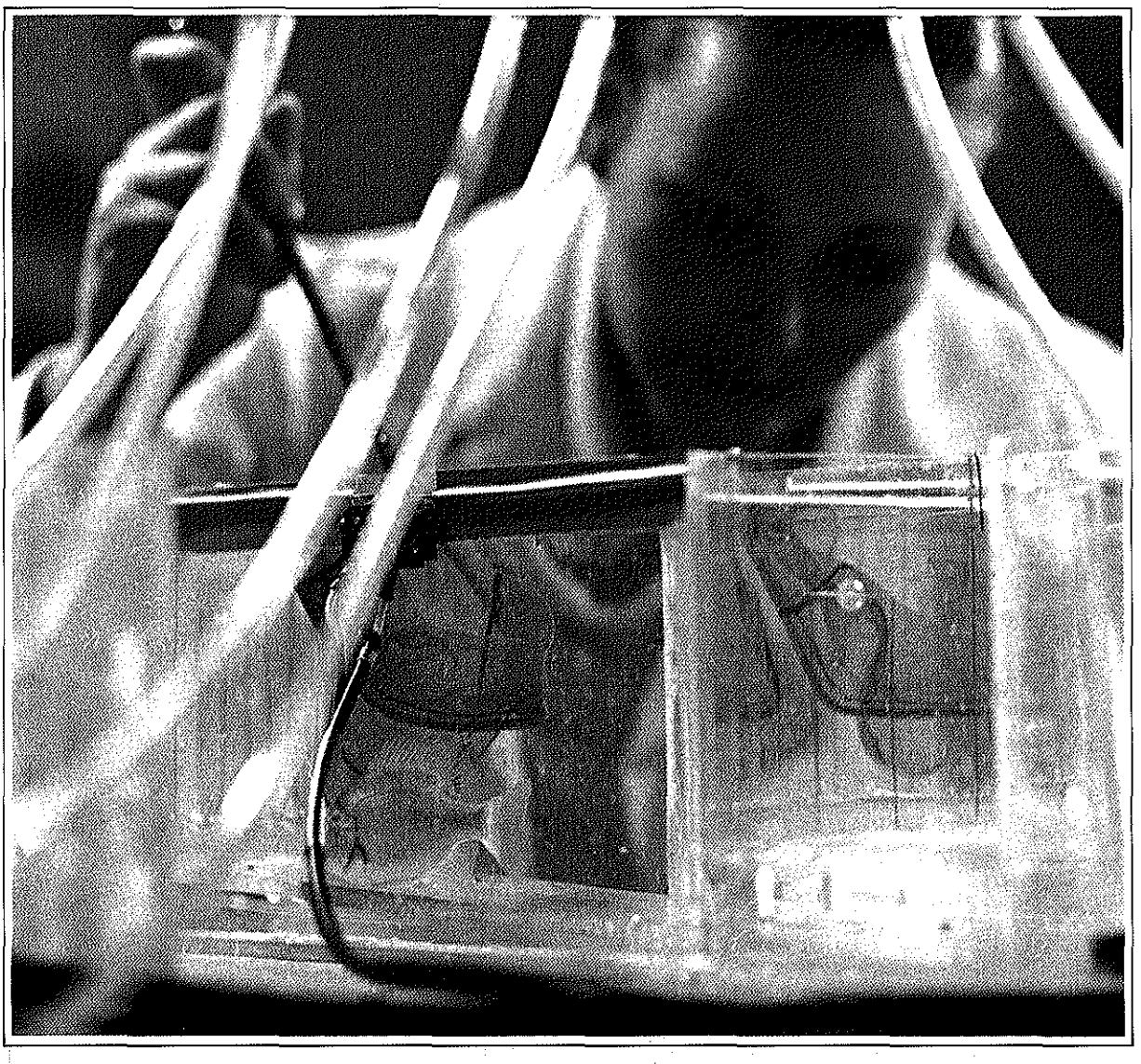
Some Battelle materials research is concerned with finding ways to cut the cost of producing materials. Institute researchers, for instance, are evaluating several chemical processes for silicon production with a view to reducing costs of silicon for solar arrays. Results from the study show zinc reduction of silicon tetrachloride to be the most promising process. High-purity silicon could be produced in a continuous process through zinc reduction of silicon tetrachloride on a fluidized bed of seed particles.

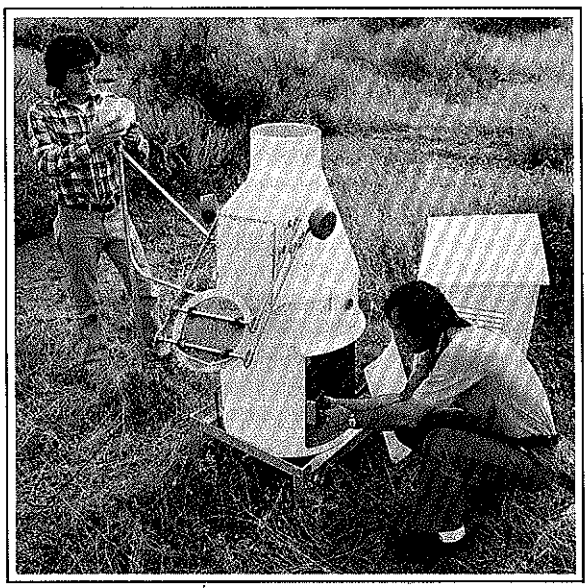
Environment

Much of Battelle's research is focused on the environment—ways to preserve it and ways to improve it—and environmental considerations enter into almost all of its research. Environmental studies are concerned with air and water quality, disposal of solid waste, land reclamation, and geologic stability. The research ranges from developing new scientific tools for studying the environment to improving industrial processes and power-generation systems that minimize pollution.

With respect to tools for studying the environment, Battelle has been at the forefront of remote sensing—acquiring, processing, and analyzing photographic and electronic scanning data from aircraft and satellites. These capabilities figured prominently in environmental studies in 1978. They were used to evaluate the geologic stability of the Columbia Plateau, which covers a large area in the northwestern United States, including a proposed

Exploring the use of automated biological monitoring systems to use as toxic-spill early warning devices for government and industry.





Fully automated precipitation sampler used in studying the environmental impact of coal burning in eight parts of the northeast United States.

nuclear waste repository site. Aerial scanning data helped identify geological anomalies that could affect the storage site. Remote sensing techniques were also the subject of research to determine the feasibility of applying these techniques to the detection, identification, and quantification of hazardous material spills.

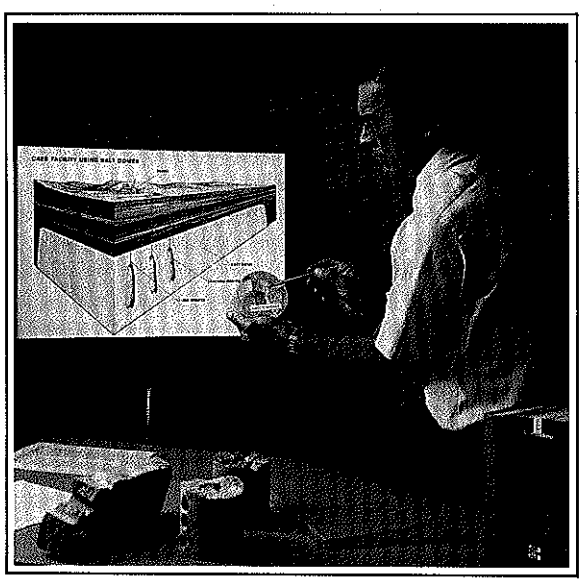
Some Institute research leads to new tools. For example, using the evolving technology of integrated optics, Battelle researchers are developing a device that can help simplify processing of environmental data collected from air- or space-borne monitoring sensors. The device is being designed to recognize redundant or useless data and reject them so that recording and storage equipment is not strained. In addition, it will classify data into broad categories so the data can be recorded and stored in presorted form for rapid distribution. The device will enable this simplification onboard the aircraft or satellite, thus conserving memory and recording resources.

The use of coal, and some of the environmental consequences, has been the subject of Battelle research. In one study, Institute specialists are examining possible environmental threats caused by cleaning coal—removing contaminants from the fuel before combustion—and environmental effects that result from storing and transporting the coal. They are developing a technology overview that describes all current coal-cleaning processes and their associated pollution-control problems. In addition, they are developing a program to obtain improved data on pollutants from commercial coal-cleaning plants. And they are evaluating the cost effectiveness of coal-cleaning as compared to other strategies for controlling sulfur dioxide emissions.

Another approach to controlling sulfur dioxide emission is, of course, cleaner combustion, and Battelle is evaluating a technique to burn high-sulfur coals and do it in a way that meets acceptable emission standards. The technique involves mixing limestone with finely ground coal to produce small cylindrical pellets. These limestone/high-sulfur coal pellets have been successfully burned in Battelle's steam plant spreader stoker. Results to date indicate that over 70 percent of the sulfur dioxide has been captured by the limestone, thus suggesting that the technique provides a potentially acceptable method for burning high-sulfur coal.

Institute scientists are also studying external recirculation of flue gas as a means of fighting pollution in combustion equipment. The research, being conducted for a group of companies, is expected to lead to a better understanding of flue-gas recirculation and its broader use by industry. It involves a critical study of present recirculation techniques, a mathematical model describing the influence of

Analyzing salt dome samples for compressed air energy storage—compressed air in underground caverns used to power auxiliary turbines during peak power demand periods.

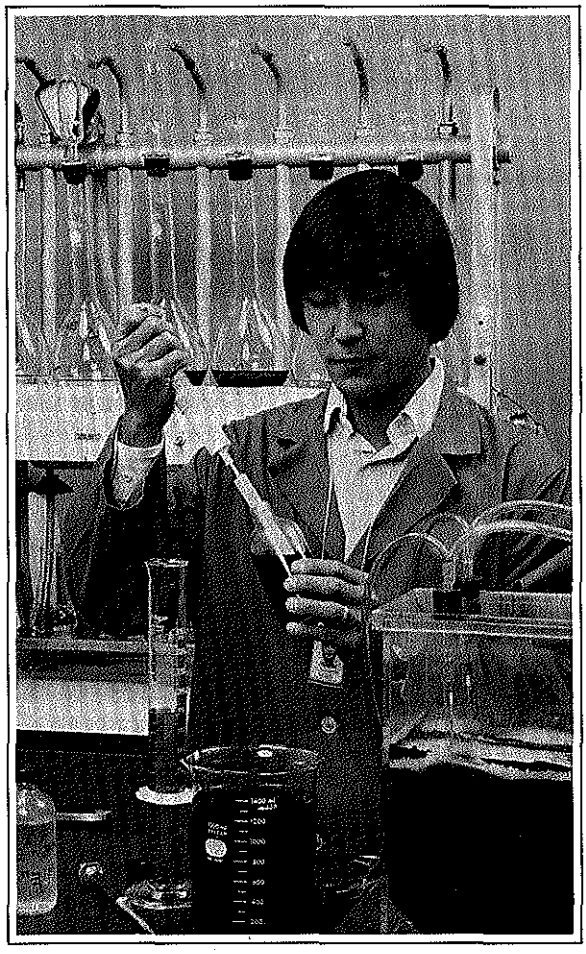


various parameters on recirculation, and formulation of recommendations for wider application of flue-gas recirculation in industry.

Another interesting example of Battelle research directed toward cleaner air is concerned with the relation between engine wear in automobiles and smoke emission. The study involved 15 taxicabs of the same type with different mileages. Smoke emissions and engine cylinder wall wear were measured. The results show a relatively close correlation between cylinder wall wear and engine mileage, and that the quality of engine maintenance has a remarkable effect on the quantity of smoke emissions.

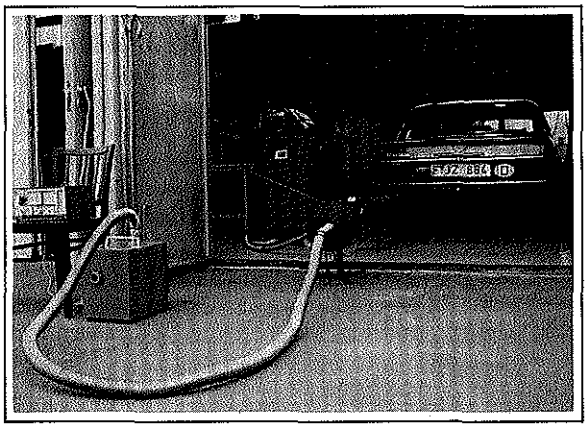
As an example of Institute research concerned with water pollution, scientists are studying the potential ecological damage associated with off- and on-shore production and transportation of petroleum. The work includes analysis of the demonstrated effect on individual organisms and on natural populations and communities in the marine environment. During 1978, researchers identified specific effects on clams. Other valuable information was collected on the relationship of time and concentration of petroleum-induced mortality for different species, and the routes of transport between water, sediments, and organisms.

Reclamation of strip-mined land has been the subject of Battelle research, and the past summer brought some encouraging results. A small crop of winter wheat harvested in July has demonstrated that marketable crops can be grown without irrigation on arid strip-mined land. The harvest followed three years of research on an energy-, money- and time-saving method of reclaiming arid strip-mined lands



Examining possible methods for treating contaminated water from oil shale for industrial or domestic reuse.

Studying the relation between engine wear and smoke emission in automobiles.



that eliminates major recontouring of the area and irrigation to maintain plant cover. With the Battelle method, crops are seeded in topsoil between spoil banks. Water is from rainfall runoff from the banks. Waterproofing the banks assures optimum water collection and slope stabilization.

The selection of sites for future nuclear power plants also figures in Battelle's environmental research. Scientists have developed a computer-assisted decision-making system for the preliminary selection of such plant sites. This decision-making system can be incorporated into the long-range development planning of the power supply network both for the evaluation of proposed individual sites and for the assessment of different site combinations from a regional point of view.

Overview

Battelle attempts to meet the charge of its founder and the challenge of today in a broad range of research, development, and demonstration programs, and in educational and invention and technology development activities. Its scientists, engineers, and supporting specialists bring their skills and training in the physical, life, and social/behavioral sciences to bear on the problems and needs of contemporary society.

The Institute pioneered the concept of contract research, and much of its work is sponsored by industrial companies, government agencies, and associations. Its scientific activities extend from fundamental studies for new knowledge to applied programs directed toward new products and processes. In addition to sponsored research performed for industry and government, Battelle maintains its own internal research and development and educational programs.

Battelle's interest in invention development is reflected in the worldwide activities of Battelle Development Corporation (BDC). A subsidiary of Battelle, BDC is devoted to the search for promising inventions and to their development, through scientific research, to a point where their usefulness is demonstrated. BDC provides the support necessary to develop inventions to the stage where they may be licensed or sold so that they will ultimately be made available for public use. Income derived from this activity is used for further research, thus sustaining the invention-development cycle.

Another wholly-owned subsidiary, Scientific Advances, Inc. (SAI), furthers the use of innovations and new technology, and provides support to promising new or existing technically based enterprises. It may represent Battelle interests when joint ventures are established with industry for commercializing a product or process.

In all of its activities, Battelle seeks to encourage the dissemination of new knowledge, and it places a high value on the publications of its staff, including papers, articles, books, and patents. Annually Battelle issues a listing of *Published Papers and Articles* and makes it broadly available to interested researchers and to the general public via libraries.

	1974	1975	1976	1977	1978
The Staff	6,098	5,990	6,111	6,473	6,884
Sponsored Research Revenues (millions)	$149.3	$173.1	$184.9	$224.4	$294.1
Property and Equipment (millions) Gross	$133.5	$136.2	$139.7	$142.8	$146.0
Additions	12.4	4.5	5.9	4.7	9.4
Published Articles/Papers	798	654	864	890	796
Books	30	25	23	18	18
Patents	110	96	91	110	88

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R. F. Dickerson
General Manager and Vice President, Battelle Development Corporation

Charles G. James
President, Scientific Advances, Inc.

Facilities

LABORATORIES

Columbus Laboratories
505 King Avenue, Columbus, Ohio 43201, U.S.A.

Battelle-Institut e.V.
Am Römerhof 35, 6000 Frankfurt/Main 90,
West Germany

Geneva Research Centres
7, route de Drize, 1227 Carouge-Geneva,
Switzerland

Pacific Northwest Laboratories
Battelle Boulevard,
Richland, Washington 99352, U.S.A.

OTHER FACILITIES

Florida Marine Research Facility
Sailfish Drive—Ponce Inlet,
Daytona Beach, Florida 32019, U.S.A.

William F. Clapp Laboratories, Inc.
Washington Street,
Duxbury, Massachusetts 02332, U.S.A.

Seattle Research Center
4000 N.E. 41st Street,
Seattle, Washington 98105, U.S.A.

Marine Research Laboratory
Route 2, Sequim, Washington 98382, U.S.A.

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15 Hanover Square, London W.1 England

9 Avenue Franklin D. Roosevelt, Paris 8 France

40 Via F. Turati, Milan, Italy

101 Marietta Tower, Atlanta, Georgia 30303 U.S.A.

2223 West Loop South, Suite 320,
Houston, Texas 77027 U.S.A.

Holiday Office Center,
Huntsville, Alabama 35802, U.S.A.

1710 South Amphlett Blvd., Suite 228,
San Mateo, California 94402, U.S.A.

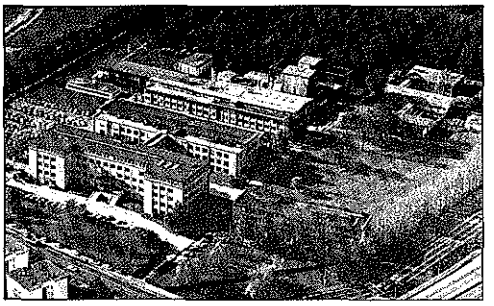
2030 M Street, N.W.,
Washington, D.C. 20036, U.S.A.

CORRESPONDENTS

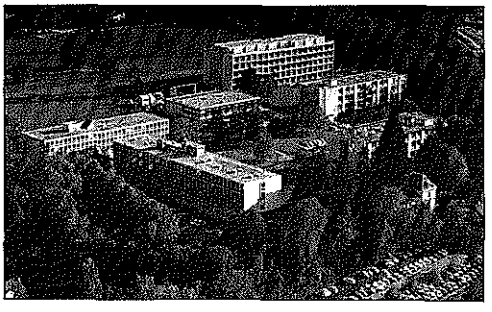
Brussels, Caracas, The Hague, Johannesburg,
Melbourne, Rio de Janeiro, Riyadh, Singapore,
Stockholm, Taipei, Tokyo, Vienna, Wellington

Columbus Laboratories

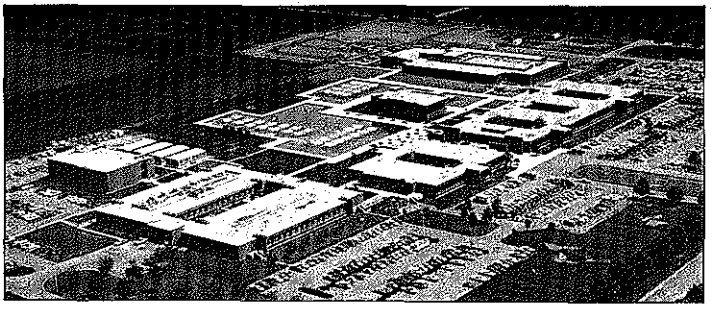
Battelle-Institut e.V.



Geneva Research Centres



Pacific Northwest Laboratories



Financial Statistics

Information appearing in this section is published in accordance with the Declaratory Judgment and Decree issued by the Court of Common Pleas, Franklin County, Ohio on May 7, 1975.

Distributions to Qualified Recipients by Battelle Memorial Institute—1978

Recipient	Amount
For Educational Activities	
Case Western Reserve University	$ 60,200
Columbia Basin College	3,000
Engineers Foundation of Ohio	3,600
George Washington University Medical Center	34,000
National Merit Scholarship Corporation	3,780
Ohio Foundation of Independent Colleges, Inc.	8,000
Ohio State University	11,138
Ohio State University Development Fund/BMI-OSU Partnership in Engineering Foundation	50,000
Otterbein College	12,500
Otterbein-Battelle Central Ohio Regional Science Fair	3,500
Pestalozzi-Stiftung	4,552
Rooney Fund	3,300
Seattle Pacific University	4,000
Seattle University	10,400
Stifterverband fur die Deutsche Wissenschaft	10,116
United Negro College Fund	8,000
University of California	30,000
University of Florida	30,000
University of Frankfurt	20,232
University of Washington	57,750
Verein zur Forderung des Universitats—Seminars der Wirtschaft	13,910
Washington International Trade Foundation	10,750
Washington State University	30,000
	$422,728

For Community Services	Amount
A Woman's Place	$ 5,000
Alpha Youth Center	3,870
American Cancer Society	10,000
Bailie Memorial Boys Ranch	6,000
Children's Hospital (Columbus)	3,000
Columbus Association for the Performing Arts Challenge Grant	12,500
Columbus Gallery of Fine Arts	15,000
Columbus Symphony Orchestra	12,000
Columbus Zoo	5,000
Conference Board	4,000
Creative Living	77,420
Hospital Gourgas	2,619
National Alliance of Businessmen	7,300
Near Northside Housing Development Corporation	19,750
Pathfinder Fund	8,000
Swiss Central Office for Help of Refugees	2,619
Tri-City Union Gospel Mission	3,000
United Way of Franklin County	3,482
	$200,560

Miscellaneous Recipients of $2,500 and Under — $95,461

1) Academy for World Trade, 2) Agricultural Research Institute, 3) Aide Aux Montagnards, 4) Air Force Historical Foundation, 5) American Association for Laboratory Animal Science, 6) American Defense Preparedness Association, 7) American Foundrymen's Society, 8) American Institute of Physics, 9) American Management Association, 10) American Society for Metals ANS/ASM Handbook Project, 11) American Nuclear Society Student Conference, 12) American Red Cross, 13) American Society for Metals, 14) American Society for Testing and Materials (ASTM), 15) American Welding Society, 16) Arbre de Noel Enfants Pompiers, 17) Arena Stage, 18) Arts in Education-Richland Schools, 19) Association des Interets de Carouge, 20) Association Europeene Officers Prof. des Sapeurs Pompiers, 21) Association for Women in Science Education Foundation, 22) Association Genevoise Protection Civile, 23) Association Hotel Maternel, 24) Association of the U.S. Army, 25) Association Suisse Pour L'Automatique, 26) Atlantic Council of the United States, 27) Beaux Arts, 28) Bellevue Philharmonic Orchestra, 29) Boy Scouts of America (Columbus), 30) Boy Scouts of America (Hillsborough, NC), 31) Buckeye Boys Ranch, 32) CEPIA, 33) CSO Women's Association, 34) Capital University, 35) Catholic Family and Child Service, 36) Center of Science and Industry Auction-1978, 37) Central Ohio Council Boy Scouts of America, 38) Centre Social Protestant, 39) Charles Louis Davis, D.V.M. Foundation for Advancement of Veterinary Pathology, 40) Childbirth—Parent Education Association of the Tri-Cities, 41) Children's Hospital of the District of Columbia, 42) Christian Record Braille Foundation, 43) Citizens Research, 44) Clallam County United Way, 45) Close-Up Foundation, 46) College Placement Services, 47) Colonie de Vacances Carouge, 48) Columbus Area Leadership Program, 49) Columbus Cancer Clinic, 50) Columbus Jewish Federation, 51) Columbus Recreation and Parks, 52) Columbus Technical Council, 53) Columbus Urban League, 54) Comite National Suisse UCJG Geneve, 55) Committee for Economic Development, 56) Crippled Children's Center of Central Ohio, 57) Croix Rouge Suisse, 58) Deutsche Gesselschaft fur Verkehrsmedizin, 59) Dublin-Worthington Rotary Club, 60) Ecole des Ingenieurs Geneve, 61) Educational Resources, 62) Electrochemical Society, 63) Enfants du Monde, 64) Engineers Foundation of Ohio (EFO) Chacey Scholarship Fund, 65) Fairfax County Council for the Arts, 66) Family Advocacy Coordinating Committee, 67) Federation of the Semi-Official and Private International Institutions of Geneva, 68) Financial Accounting Foundation, 69) Financial Executives Research Foundation, 70) Fondation Clair Bois, 71) Former Members of Congress, 72) Foundry Educational Foundation, 73) Frere de nos Freres, 74) Geneva Association of Parents of Handicapped Children, 75) Godman Guild Association, 76) Gonzaga University, 77) Goodwill Industries (Richland), 78) Goodwill Industries of Central Ohio, 79) Greater Columbus Arts Council, 80) Hospital Cantonal Universitaire, Lausanne, 81) IFO (Economic Research Institute), 82) ISMA (International Phospate in Industry Association, 83) Integration Pour Tous, 84) International Society for General Semantics, 85) IUPAC Associates (International Union of Pure and Applied Chemistry), National Academy of Sciences, 86) Journee de la Faim, 87) Junior Achievement, 88) Junior Achievement of Central Ohio, 89) Junior Achievement of Greater Atlanta, 90) KCTS/Public Television, 91) Mid-Columbia Emergency Medical Services, 92) Mid-Columbia Science Fair, 93) Mid-Ohio Health Planning, 94) Mohawk Senior High School, 95) Mu Phi Epsilon Memorial Foundation, 96) Multiple Sclerosis Society, Benton-Franklin Counties, 97) Municipal League of Seattle and King County, 98) Muscular Dystrophy Association, 99) National Association for Research in Science Teaching, 100) National Association for Retarded Citizens, 101) National Association of Corrosion Engineers, 102) National Council on Radiation Protection and Measurements, 103) National Information Bureau, 104) National League of American Pen Women, 105) National Planning Association, 106) National Safety Council, 107) Navy League of the United States, 108) Nouvelle Societe Helvetique, 109) Ohio Academy of Science, 110) Ohio Society for the Prevention of Blindness, 111) Ohio State Fair, 112) Ohio State University Comprehensive Cancer Center, 113) Oregon Museum of Science Industry, 114) Orientation Formation Professionale, 115) Pacific Lutheran University, 116) Pacific Science Center Foundation, 117) Pasco School District, 118) Patrons of Northwest Civic, Cultural and Charitable Organizations, 119) Perfectionnement de L'Association Vaudoise des Chercheurs en Physique, 120) Players Club Foundation, 121) Police Athletic League of Columbus, 122) Port Angeles Symphony Orchestra, 123) Pro-Infirmis, 124) Pro-Juventuto Geneve, 125) Project Handclasp, 126) Project Hope, 127) Prosser United Way, 128) Reticuloendothelial Society, 129) Richland School District/Hanford School, 130) Richland Schools Alpha Program, 131) Rio Grande College Free Enterprise Workshop, 132) Salvation Army-Berne, 133) Seattle Opera Association, 134) Seattle/Opportunities Industrialization Center, 135) Seattle Rotary Service Foundation, 136) Seattle Urban League, 137) Sequim Recreation Center, 138) Sequim School District, 139) Societe Suisse Pour Protection Milieu Vital, 140) Society for Occupational & Environmental Health, 141) Society of Women Engineers, 142) St. Stephens Community House, 143) Swiss Electricians Associations, 144) Swiss Electronic Association, 145) Swiss Optical Association, 146) Symphony Grand Ball, 147) Tri-Cities Chaplaincy, 148) United Foundation (Detroit), 149) United Fund of Durham & Durham County, 150) United Inner-City Development Foundation, 151) United States National Committee-World Energy Conference, 152) Navy League of the United States/State of Ohio, 153) United Way of the Bay Area, 154) United Way of Madison County, 155) United Way of Metropolitan Atlanta, 156) United Way of the National Capital Area, 157) United Way of Volusia County, 158) University of Geneva, 159) University of Idaho, 160) Variety Club Telethon, 161) WETA Television, 162) Washington State Penitentiary, 163) Whitman College, 164) World Affairs Council of Seattle, 165) World Association of Industrial and Technological Research Organizations, 166) YES (Eastside Youth Services)

Summary of 1978 Distributions to Qualified Recipients

For Educational Activities	$423,000
For Community Services	201,000
Miscellaneous of $2,500 and Under	95,000
Expenses Incurred in Making Distributions	7,000
Total 1978 Distributions to Qualified Recipients	$726,000
Distributions to Satisfy the Remaining 1977 Obligations	$286,000
Distributions Partially Satisfying the 1978 Obligations of $700,000	440,000
Total 1978 Distributions to Qualified Recipients	$726,000
Remaining 1978 Distribution Obligation to be Satisfied in 1979	$260,000

Computation of 1978 Required Distributions to Qualified Recipients

	Business	Non-Business
1978 Net Income (Loss)(a)	$(3,689,000)	$ 3,617,000
Imputed Federal Income Tax		(1,217,000)
Base for Calculating Distributions	$ -0-	$ 2,400,000
Distributions Required—1978	$ 100,000(b)	$ 600,000

(a) Net financial results of "business" and "non-business" activities of Battelle and Battelle affiliates as defined in the Decree.

(b) Minimum distribution requirement.

Computation of Location of Activities Measurement—1978

Facilities: (a) $\frac{\text{Columbus}}{\text{Total}} = \frac{\$\ 92,804,000}{\$159,029,000} \times 60\% = 35.01\%$

Payroll: (a) $\frac{\text{Columbus}}{\text{Total}} = \frac{\$\ 28,299,000}{\$\ 47,333,000} \times 40\% = 23.91\%$

Activity percentage in or near Columbus (b) 58.92%

(a) Facilities and payroll of Battelle and Battelle affiliates as defined in the Decree. Fourth quarter indices are not yet available for the computation, but this should not materially change the above percentages.

(b) Activity percentage in or near Columbus must be at least 51%.

Breakdown of Reimbursable Costs and Fees Earned—1978

	Government Sponsors	Industrial Sponsors	Total
Columbus Laboratories	$ 66,145,000	$23,598,000	$ 89,743,000
Pacific Northwest Laboratories	124,268,000	5,590,000	129,858,000
Geneva Laboratories	2,143,000	15,591,000	17,734,000
Battelle Project Management Division	23,565,000	10,000	23,575,000
Battelle-Institut e.V.	25,727,000	7,459,000	33,186,000
Total	$241,848,000	$52,248,000	$294,096,000
Less: Battelle-Institut e.V.	25,727,000	7,459,000	33,186,000
Reimbursable costs and fees earned from contract research per the Consolidated Statement of Revenues and Expenses	$216,121,000	$44,789,000	$260,910,000

Detail of Laboratory Cost of Performing Contract Research—1978

Salary & Wages (Direct Labor Charged to Research Projects)	$ 78,791,000
Technical Services, Equipment & Facility Usage	15,405,000
Materials & Supplies	13,088,000
Department Management Costs	16,822,000
Travel	3,567,000
Component Administrative Expenses Charged to Research Projects	50,812,000
Other Direct Costs—1830 DOE Contract	80,980,000
Subcontract Costs	28,658,000
Total	$288,123,000
Less: Battelle-Institut e.V.	33,236,000
Total Laboratory cost of performing contract research per the Consolidated Statement of Revenues and Expenses	$254,887,000

Financial Review

ACCOUNTANTS' REPORT

The Board of Trustees
Battelle Memorial Institute:

We have examined the consolidated balance sheets of Battelle Memorial Institute and subsidiaries as of December 31, 1978 and 1977 and the related consolidated statements of revenues and expenses, fund balance and changes in financial position for the years then ended. Our examinations were made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances. We did not examine the financial statements of Battelle-Institut e.V., which statements are summarized in note 4 to the consolidated financial statements. These statements were examined by other auditors whose reports thereon have been furnished to us and our opinion expressed herein, insofar as it relates to the amounts included for Battelle-Institut e.V., is based solely upon the reports of the other auditors.

In our report dated February 10, 1978, our opinion on the 1977 consolidated financial statements was qualified subject to the effect, if any, of the ultimate resolution of pending litigation relating to a fire which occurred in 1973 and the assessment of certain income taxes by foreign fiscal authorities. As described in notes 8 and 9, the litigation was settled in 1978 and management has determined that the outcome of the income tax matter will have no material effect on the consolidated financial statements. Accordingly, our present opinion on the 1977 consolidated financial statements, as presented herein, is different from that expressed in our previous report.

In our opinion, based upon our examinations and the reports of other auditors, the aforementioned consolidated financial statements present fairly the financial position of Battelle Memorial Institute and subsidiaries at December 31, 1978 and 1977 and their revenues, expenses and changes in financial position for the years then ended, in conformity with generally accepted accounting principles applied on a consistent basis.

Peat, Marwick, Mitchell & Co.

Certified Public Accountants

Columbus, Ohio
February 9, 1979

Battelle Memorial Institute and Subsidiaries

Consolidated Balance Sheets
December 31, 1978 and 1977

Assets	**1978**	1977
Current assets:		
Cash	**$ 1,475,000**	618,000
Marketable securities and certificates of deposit, at cost, which approximates market	**2,596,000**	3,434,000
Accounts receivable, net (note 2)	**33,274,000**	28,240,000
Other current assets	**1,576,000**	1,545,000
Total current assets	**38,921,000**	33,837,000
Investments, at cost:		
Bonds and notes (market value $16,928,000; 1977, $20,112,000)	**18,843,000**	20,956,000
Corporate stocks (market value $10,167,000; 1977, $9,475,000)	**11,077,000**	10,286,000
Other investments	**2,737,000**	2,387,000
Total investments	**32,657,000**	33,629,000
Property and equipment, at cost (note 3)	**145,976,000**	142,837,000
Less accumulated depreciation	**65,923,000**	63,285,000
Net property and equipment	**80,053,000**	79,552,000
Other assets:		
Investments in and advances to:		
Battelle-Institut e.V. (note 4)	**12,904,000**	12,417,000
Scientific Advances, Inc. (note 5)	**7,162,000**	6,730,000
Deferred charges and other assets	**1,318,000**	1,641,000
Total other assets	**21,384,000**	20,788,000
Total assets	**$173,015,000**	167,806,000

Liabilities and Fund Balance

Current liabilities:		
Accounts payable	**$ 4,311,000**	2,987,000
Advance payments from sponsors	**5,472,000**	4,178,000
Accrued other expenses	**6,592,000**	5,756,000
Total current liabilities	**16,375,000**	12,921,000
Fund balance:		
Retained for scientific and educational purposes of Battelle Will	**143,736,000**	143,207,000
Battelle-Institut e.V. (note 4)	**12,904,000**	11,678,000
Total fund balance	**156,640,000**	154,885,000
Contingent liabilities and commitments (notes 7, 8 and 9)		
Total liabilities and fund balance	**$173,015,000**	167,806,000

See accompanying notes to consolidated financial statements.

Battelle Memorial Institute and Subsidiaries

Consolidated Statements of Revenues and Expenses
Years ended December 31, 1978 and 1977

	1978	1977
Revenues:		
Reimbursable costs and fees earned from contract research (note 6)	**$260,910,000**	197,720,000
Investment income	**2,733,000**	2,784,000
Royalties, license, and patent income	**670,000**	707,000
Real estate operations	**1,596,000**	892,000
Other revenue, net	**610,000**	270,000
Total revenues	**266,519,000**	202,373,000
Expenses:		
Laboratory cost of performing contract research (note 6)	**254,887,000**	193,868,000
General and administrative expenses (note 8)	**6,209,000**	3,318,000
Internal research programs	**2,398,000**	2,407,000
Development of patents	**1,343,000**	1,254,000
Real estate operations	**1,585,000**	1,305,000
Total expenses	**266,422,000**	202,152,000
Excess of revenues over expenses before equity in net earnings of unconsolidated entities	**97,000**	221,000
Excess of revenues over expenses of Battelle-Institut e.V. (note 4)	**1,226,000**	581,000
Equity in net income of Scientific Advances, Inc. (note 5)	**432,000**	463,000
Excess of revenues over expenses (note 9)	**$ 1,755,000**	1,265,000

Consolidated Statements of Fund Balance
Years ended December 31, 1978 and 1977

	Retained for scientific and educational purposes of Battelle Will	Battelle-Institut e.V.	Total
Fund balance at December 31, 1976	**$142,523,000**	**11,097,000**	**153,620,000**
Excess of revenues over expenses	**684,000**	**581,000**	**1,265,000**
Fund balance at December 31, 1977	**143,207,000**	**11,678,000**	**154,885,000**
Excess of revenues over expenses	**529,000**	**1,226,000**	**1,755,000**
Fund balance at December 31, 1978	**$143,736,000**	**12,904,000**	**156,640,000**

See accompanying notes to consolidated financial statements.

Battelle Memorial Institute and Subsidiaries

Consolidated Statements of Changes in Financial Position
Years ended December 31, 1978 and 1977

	1978	1977
Sources of working capital:		
Excess of revenues over expenses	**$ 1,755,000**	1,265,000
Items which do not use (provide) working capital:		
Depreciation and amortization of property and equipment	**6,829,000**	7,425,000
Excess of revenues over expenses of Battelle-Institut e.V.	**(1,226,000)**	(581,000)
Equity in net income of Scientific Advances, Inc.	**(432,000)**	(463,000)
Gain on sales of investment securities	**(97,000)**	(458,000)
Working capital provided by operations	**6,829,000**	7,188,000
Proceeds from sales of investments excluding short-term transactions	**5,830,000**	12,575,000
Net book value of property and equipment sold	**2,077,000**	150,000
Repayment of advance by Battelle-Institut e.V.	**739,000**	—
Other, net	**—**	326,000
Total sources of working capital	**15,475,000**	20,239,000
Uses of working capital:		
Additions to property and equipment	**9,407,000**	4,740,000
Purchases of investments excluding short-term transactions	**4,411,000**	12,970,000
Other, net	**27,000**	—
Total uses of working capital	**13,845,000**	17,710,000
Increase in working capital	**$ 1,630,000**	2,529,000
Changes in components of working capital:		
Increase (decrease) in current assets:		
Cash	**857,000**	(430,000)
Marketable securities and certificates of deposit	**(838,000)**	(22,000)
Accounts receivable	**5,034,000**	4,574,000
Other current assets	**31,000**	103,000
	5,084,000	4,225,000
Increase (decrease) in current liabilities:		
Accounts payable	**1,324,000**	1,302,000
Advance payments from sponsors	**1,294,000**	(205,000)
Accrued other expenses	**836,000**	599,000
	3,454,000	1,696,000
Increase in working capital	**$ 1,630,000**	2,529,000

See acompanying notes to consolidated financial statements.

Battelle Memorial Institute and Subsidiaries

Notes to Consolidated Financial Statements
December 31, 1978 and 1977

(1) SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES

Battelle Memorial Institute's major source of revenue is from the performance of research and educational activities for government agencies and industrial sponsors. The corporate offices are located in Columbus, Ohio and research laboratories are located in Columbus; Richland, Washington; Frankfurt, Germany; and Geneva, Switzerland. A summary of significant accounting policies follows:

(a) Principles of Consolidation

The accompanying consolidated financial statements include the accounts of Battelle Memorial Institute (Battelle) and its subsidiaries, except Scientific Advances, Inc. which is included in the statements on the equity basis (see note 5). Battelle-Institut e.V., as more fully described in note 4, is also included in the accompanying statements on the equity basis. All material intercompany balances and transactions have been eliminated in preparing the consolidated financial statements.

(b) Translation of Foreign Currencies

The accounts of foreign subsidiaries and divisions have been translated from local currencies into United States dollars in accordance with accepted practice for the purpose of including the foreign accounts in the consolidated financial statements. Gains resulting from the translation of foreign currencies, amounting to $970,000 and $98,000 in 1978 and 1977, respectively, are recognized in current operations. The $970,000 gain in 1978 includes $748,000 resulting from the repayment by Battelle Institut e.V. of an advance from Battelle (see note 4).

(c) Investments

Investments are carried at acquisition cost. At December 31, 1978 the net unrealized loss on bonds and notes of $1,915,000 was comprised of unrealized gains of $1,000 and unrealized losses of $1,916,000. The unrealized loss on corporate stocks of $910,000 was comprised of unrealized gains of $1,062,000 and unrealized losses of $1,972,000.

(d) Depreciation and Amortization

Depreciation and amortization have been provided on the straight-line method based on the estimated useful lives of each major class of assets.

(e) Federal Income Taxes

Battelle and its eligible subsidiaries file a consolidated Federal income tax return. There are no timing differences between financial and tax reporting which require deferred income taxes. Investment tax credits are accounted for by the flow-through method subject to applicable statutory limitation.

(f) Revenue Recognition

Revenues from research contracts are recognized at the time the reimbursable costs have been incurred. Direct costs of research contracts are charged to projects when incurred and indirect costs are charged to projects by applying varying overhead rates to direct costs. Fees from research contracts are recognized using the percentage of completion method as the costs of performing the research are incurred. Research contracts in process are reviewed as the work progresses and provision is made for any estimated unrecoverable amounts. Costs of internal research projects are expensed as incurred.

Investment security transactions are accounted for on the trade date (date the order to buy or sell is executed), with the cost basis of securities sold being accounted for on a specific identity basis. Dividend income is recognized on the ex-dividend date. Interest income is recognized on the accrual basis.

Rental income included in real estate operations is recognized equally over the term of the leases which generally do not exceed one year.

Royalties, license and patent income are recognized substantially on a cash received basis.

(g) Pension Plans

Battelle and certain subsidiaries have pension plans covering substantially all of their employees. Battelle's policy is to fund pension costs which are composed of normal costs and amortization of prior service costs. For the U.S. plans, pension expense includes amortization of prior service costs over thirty years. In addition, certain foreign subsidiaries have pension plans conforming to local requirements. The pension expense under all of these plans amounted to $13,133,000 and $12,239,000 in 1978 and 1977, respectively.

(2) ACCOUNTS RECEIVABLE

A summary of accounts receivable follows:

	1978	1977
Sponsors and trade:		
Invoiced	**$17,350,000**	15,405,000
Unbilled research performed	**17,175,000**	13,161,000
Others	**1,018,000**	1,074,000
Total accounts receivable	**35,543,000**	29,640,000
Less allowance for doubtful receivables	**2,269,000**	1,400,000
Net accounts receivable	**$33,274,000**	28,240,000

(3) PROPERTY AND EQUIPMENT

A summary of property and equipment follows:

	1978	1977
Land and improvements	**$ 3,600,000**	3,529,000
Buildings and improvements	**75,584,000**	74,985,000
Machinery and equipment	**55,580,000**	55,629,000
Rental properties	**6,603,000**	6,988,000
Construction in progress	**4,609,000**	1,706,000
Total property and equipment	**$145,976,000**	142,837,000

(4) INVESTMENT IN AND ADVANCES TO BATTELLE-INSTITUT e.V.

Battelle-Institut e.V. is an Association registered in Frankfurt, Germany, whose members are officers of Battelle Memorial Institute. Under the provisions of the trust indenture, Battelle-Institut e.V. is prohibited from distributing its accumulated income to its members as such, and in the event of the Institut being wound up, its real property may only be utilized for purposes which are then recognized by the German authorities as being for the benefit of the community. In view of such restrictions, the investment in Battelle-Institut e.V. has been recorded by Battelle at a nominal amount. Since it is the intention of management to continue the operations of the Association, the consolidated financial statements, which are presented on a going concern basis, reflect such investment and advances at the underlying net equity. A note payable to Battelle Memorial Institute, which is included in the fund balance of Battelle-Institut e.V., has been translated from local currency (DM 19,987,000) to U.S. dollars in accordance with generally accepted accounting principles using the historical exchange rate. The court decree described in note 7 requires disclosure of the U.S. dollar amount of the note on a proforma basis assuming translation at currency exchange rates which were in effect at the end of each year. The proforma amounts, which have no effect on the consolidated financial statements, are $11,013,000 and $9,534,000 for December 31, 1978 and 1977, respectively.

The separate financial statements of Battelle-Institut e.V. at December 31, 1978 and 1977, and for the years then ended, are summarized as follows:

Balance Sheets	1978	1977
Current assets	$ 15,590,000	13,393,000
Investments	1,344,000	1,118,000
Property and equipment, net	9,530,000	8,611,000
Total assets	$ 26,464,000	23,122,000
Current liabilities	12,416,000	10,155,000
Other liabilities	1,144,000	550,000
Advances from Battelle Memorial Institute	—	739,000
Fund balance (including note payable to Battelle Memorial Institute)	12,904,000	11,678,000
Total advances and fund balance	12,904,000	12,417,000
Total liabilities, advances and fund balance	$ 26,464,000	23,122,000
Statements of Revenues and Expenses		
Reimbursable costs and fees earned	$ 33,186,000	26,647,000
Costs incurred	33,236,000	26,575,000
Excess of reimbursable costs and fees earned over (under) costs incurred	(50,000)	72,000
Other revenues, including currency conversion gains	1,276,000	509,000
Excess of revenues over expenditures	$ 1,226,000	581,000

(5) INVESTMENT IN AND ADVANCES TO SCIENTIFIC ADVANCES, INC.

Scientific Advances, Inc. (SAI), a wholly-owned subsidiary of Battelle, assists in the advancement of science and technology, which includes support to new or existing technically based enterprises, and the creation of capital values as a part thereof.

The separate financial statements of SAI at December 31, 1978 and 1977, and for the years then ended, are summarized as follows:

Balance Sheets	1978	1977
Equity in and advances to affiliates	$ 1,214,000	722,000
Marketable securities	2,764,000	2,437,000
Notes receivable	2,140,000	2,800,000
Other assets	1,113,000	813,000
Total assets	$ 7,231,000	6,772,000
Liabilities	69,000	42,000
Stockholder's equity	7,162,000	6,730,000
Total liabilities and stockholder's equity	$ 7,231,000	6,772,000
Statements of Income		
Revenues	$ 543,000	481,000
Expenses	635,000	472,000
Revenues over (under) expenses	(92,000)	9,000
Gain on sales of affiliates	—	137,000
Equity in net income of affiliates	524,000	317,000
	524,000	454,000
Net income	$ 432,000	463,000

(6) REIMBURSABLE COSTS AND FEES EARNED

Battelle is engaged in research and development work under a contract with the Department of Energy (DOE) which provides for operation of a consolidated laboratory. This laboratory is owned partly by the government and partly by Battelle. In prior years, Battelle has included only the fee on this contract as revenue; expenses incurred in the operation of the laboratory and directly reimbursed by DOE were not included in the consolidated financial statements. Battelle has reconsidered the accounting treatment of this contract and determined that it is more appropriate to include such directly reimbursed expenses as both reimbursable costs and fees earned from contract research and laboratory cost of performing contract research. Accordingly, the 1977 consolidated financial statements have been reclassified to include the reimbursed costs of $86,483,000 as revenues and expenses. In 1978, Battelle also obtained another contract from DOE to manage the Office of Nuclear Waste Isolation. Reimbursable costs and fees earned from contract research on this contract approximated $23,544,000 in 1978.

Government sponsors accounted for $216,120,000 and $159,343,000 and industrial sponsors accounted for $44,790,000 and $38,377,000 of the reimbursable costs and fees earned during 1978 and 1977, respectively.

(7) OBLIGATION UNDER THE WILL OF GORDON BATTELLE

Battelle Memorial Institute was formed in 1925 pursuant to the Will of Gordon Battelle. That Will as interpreted by court decree in 1975 requires, among other things, that Battelle Memorial Institute distribute annually to qualified recipients a portion of its net earnings, as defined. The amount to be distributed is determined under a formula which generally requires that Battelle distribute from 5% to 100% of its annual net earnings derived from activities which are carried on in direct pursuit of the purposes of Battelle (e.g., research and related income) and 25% of the annual net earnings derived from other activities of Battelle (e.g., investment income). The consolidated statements of revenues and expenses include charges amounting to approximately $700,000 in 1978 and $506,000 in 1977, to reflect Battelle's obligation as determined under the above formula, for distribution to qualified recipients as a result of activities during those years.

(8) LITIGATION

In 1973 a fire occurred in a liquid natural gas tank owned and/or operated by Texas Eastern Transmission Corp. and/or Texas Eastern Cryogenics, Inc. (Texas Eastern). Battelle had conducted research investigation for Texas Eastern relative to the construction and subsequent repairs of the tank. Texas Eastern had filed a claim against Battelle and others for damage to the tank and its facilities. During 1978 this claim was settled with Battelle paying $2,275,000 which amount is included in general and administrative expenses.

Battelle and its subsidiaries have been named as defendants in various other actions but in the opinion of management, the outcome of these matters will have no material effect on Battelle's financial position.

(9) INCOME TAXES

No provision for Federal income taxes has been made in the statements of revenues and expenses because the excess of revenues over expenses includes items which are not subject to Federal tax. The non-taxable items include the excess of revenues over expenses of Battelle-Institut e.V., unrealized gains resulting from translation of foreign currency and the excludable portion of dividend income.

At December 31, 1978 Battelle has net operating loss carryforwards available which expire as follows: $2.0 million in 1980; $6.7 million in 1983; $1.2 million in 1984; and $.7 million in 1985. In addition, Battelle has capital loss carryforwards approximating $.9 million expiring in 1981 and certain tax credits approximating $1.7 million expiring in varying amounts through 1985.

The Federal income tax returns of Battelle have been examined by the Internal Revenue Service through 1975.

Foreign fiscal authorities have assessed Battelle's Geneva division for certain income taxes which are being contested. Management considers it probable that some taxes will be ultimately payable, but the outcome of this matter will have no material effect on Battelle's financial position.

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