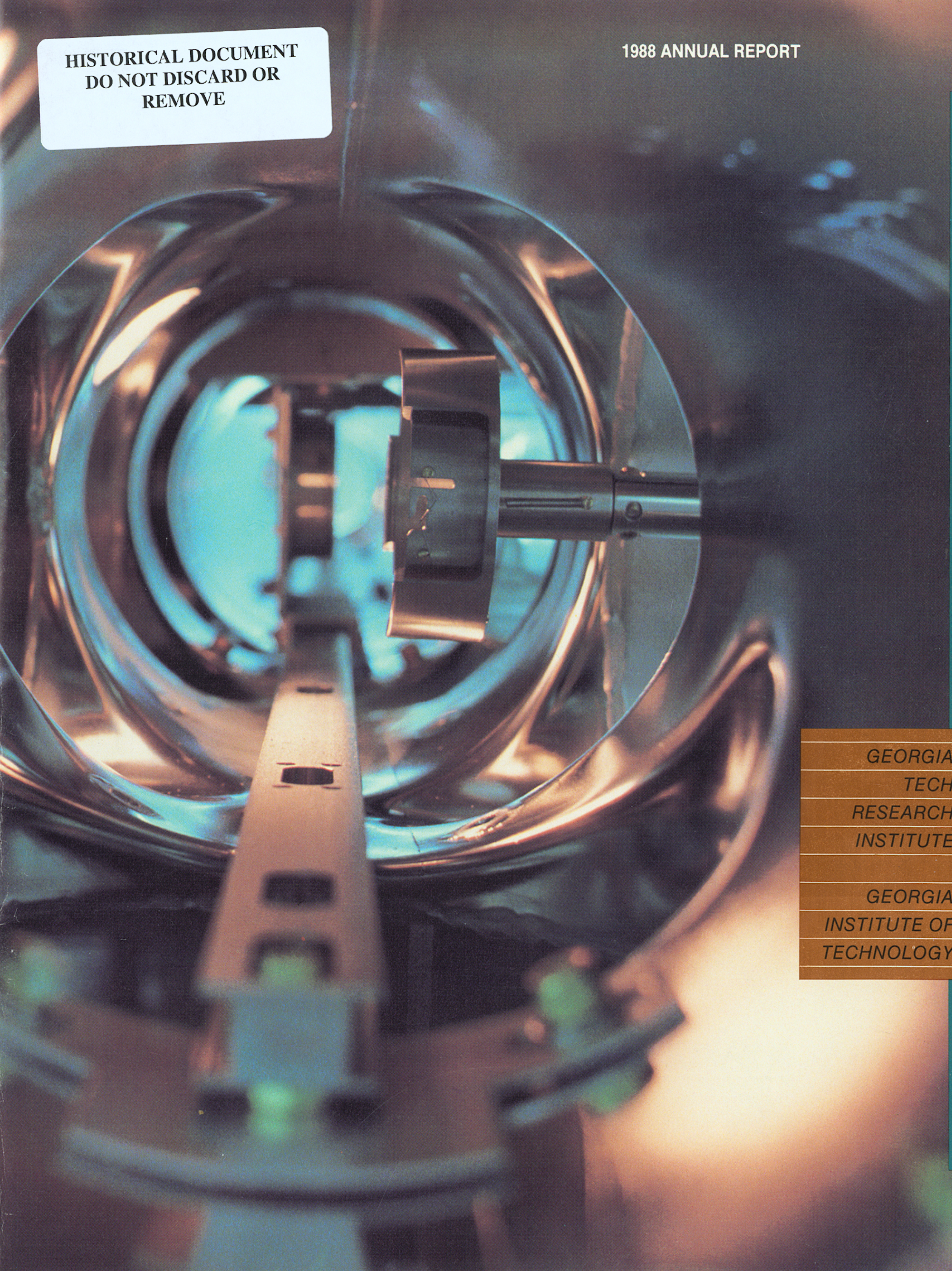
1988 ANNUAL REPORT



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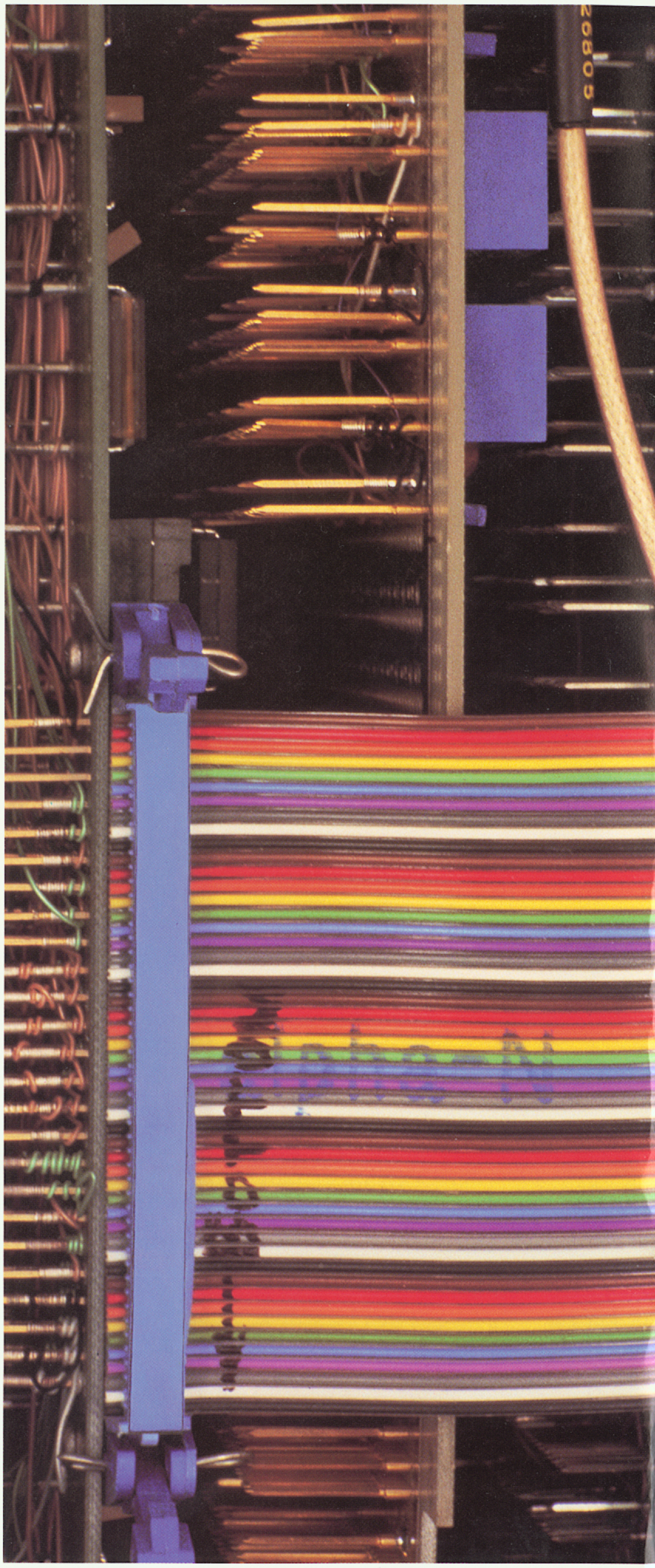


A new era of opportunity has begun at the Georgia Tech Research Institute. After a decade of rapid expansion followed by several years of more modest growth, GTRI is well-established as a university research leader with broad-based expertise. A core of strong programs is in place, and we are reaching for the next rung of excellence.

GTRI is evolving in several important ways. During the past year, a group of senior researchers established a set of key technologies for internal development, so that our R&D programs will remain at the cutting edge and continue to evolve with society's changing needs. In keeping with the interdisciplinary spirit of the times, we are also building strength through collaborations with outside organizations.

Some of these joint efforts involve campus-wide programs at Georgia Tech, such as the Microelectronics and the Manufacturing Research Centers as well as the university's budding effort to focus faculty expertise in the field of superconductivity. GTRI is entering into collaborations outside the Institute as well — for instance, through Georgia Tech's participation with Emory University in a joint center for bioengineering research. Tech research administrators have also met with their counterparts from the University of Georgia, to explore ways to build closer working relationships in economic development, in science, and in outreach activities.

GTRI researchers are developing flame-sprayed ceramic coatings to protect a variety of materials.

Other types of collaborations are on the horizon. To cite one example, the Institute of Paper Chemistry will be relocating to a site on the Georgia Tech campus. Joint programs with research and academic faculty at Tech are planned.

With these innovations and others, GTRI's future is full of promise. We welcome Georgia Tech's new President and join him in evolving an even more prestigious and exciting Georgia Institute of Technology.

Dr. John Patrick Crecine
President
Georgia Institute of Technology

The Georgia Tech Research Institute is building strength through collaborations with a variety of outside organizations.

On the cover, *GTRI researchers continued to use molecular beam expitaxy instrumentation to grow a variety of advanced microelectronic materials.* At left *is a close-up view of some of the computer circuitry in a high-power, coherent radar under development at GTRI.*

LETTER FROM THE DIRECTOR

Donald J. Grace
Director
Georgia Tech Research Institute

For GTRI as well as the rest of Georgia Tech, the most significant event of the year was the selection of Dr. John Patrick Crecine as the ninth President of Georgia Tech. Dr. Crecine comes to the Institute from Carnegie-Mellon University, where he served as senior vice-president for academic affairs. At Carnegie-Mellon, he was instrumental in developing a campus computer network that is recognized as one of the finest at any American university. Dr. Crecine brings to Georgia Tech a keen appreciation and understanding of the research process. We look forward to a long and mutually happy relationship under his leadership.

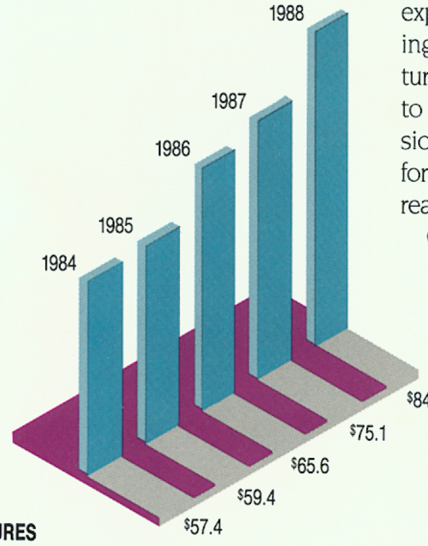
GTRI experienced a significant expansion in research activity during fiscal 1988. Research expenditures rose approximately 12 percent to $84.5 million, while the professional staff increased substantially for the second consecutive year, reaching 610 full-time researchers.

Our principal base of sponsorship remained the Department of Defense (DoD), with the percentage of GTRI contract research funds derived from DoD rising from 66 to 72 percent. Other federal agencies provided another 16 percent of GTRI's contract income, up by seven percent since the previous year. In turn, research sponsored by industry dropped from 24.6 percent to 11 percent, partly because of the completion of a major, multi-year industrial contract. Funds from state and local sources remained constant at one percent.

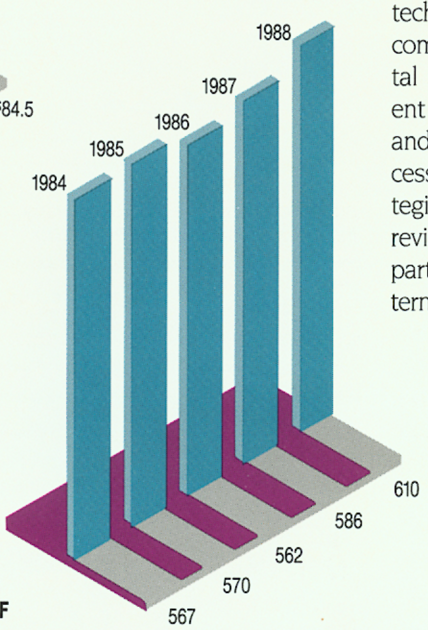
New Research Targeted

During the year, we took major steps to upgrade the quality and relevance of future GTRI research. Our Senior Technology Guidance Council targeted a list of 13 R&D areas for investment of internal development funds.

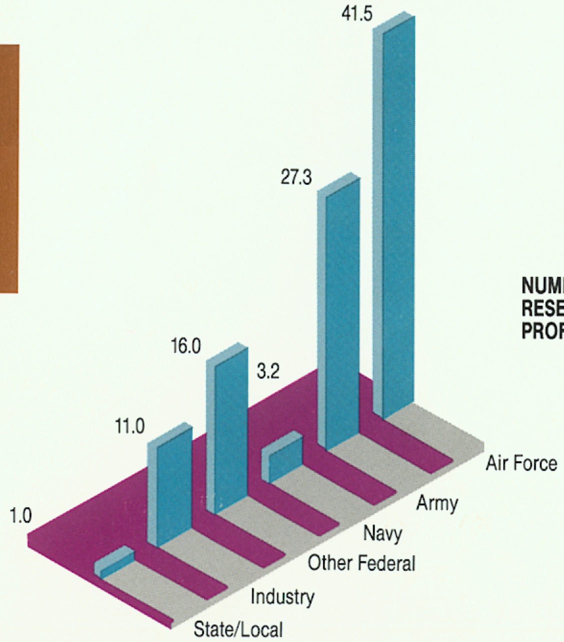
The council chose the following topics for near-term emphasis: low observables technology, software computer technology, coherent radar technology, antenna development, electronic defense techniques and technology, multispectral sensors, compressive receivers, environmental sensing, applications of coherent sources, electro-optic materials and applications, space power, process chemical technology, and strategic materials. These lists will be reviewed and revised annually as part of an ongoing program of internal investment in the future.



RESEARCH EXPENDITURES
(Millions of Dollars)



NUMBER OF RESEARCH PROFESSIONALS



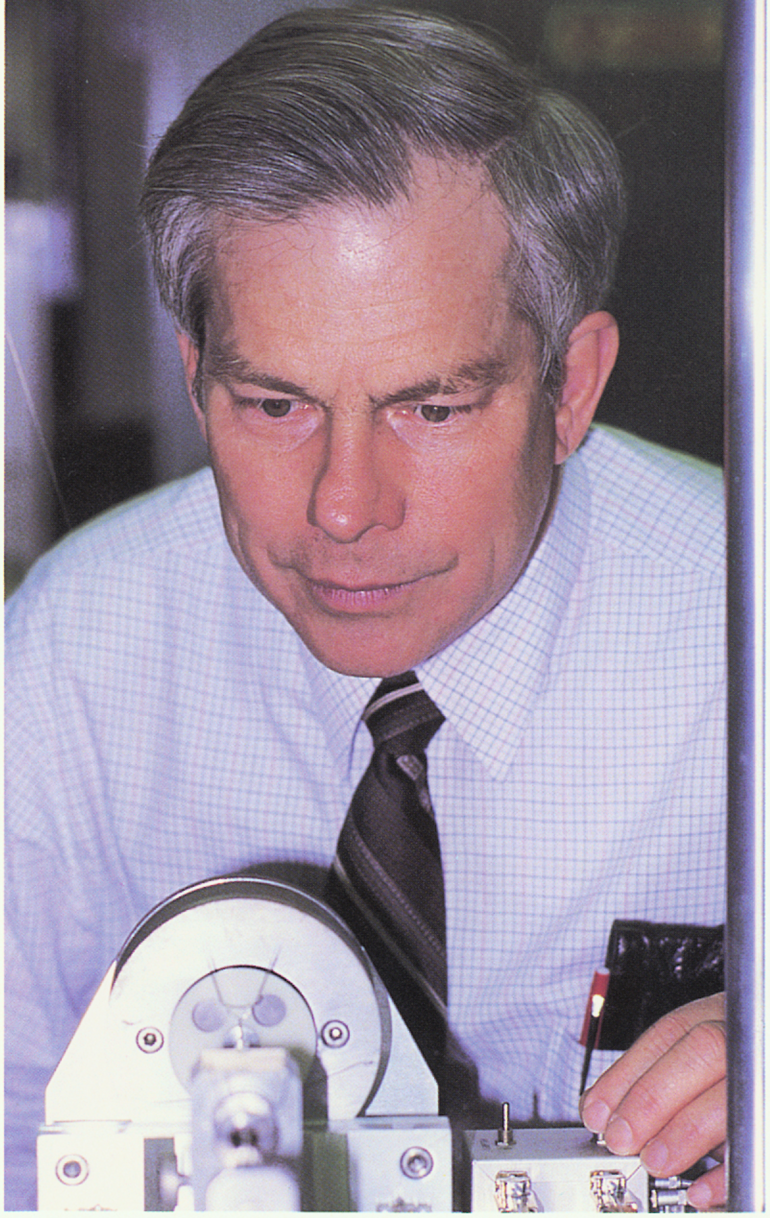
MAJOR SPONSORS
(In Percent)

Programs Diverse

Diversity continues to be one of GTRI's long suits. One of the year's most innovative research initiatives was the establishment of an Apparel Manufacturing Research Center, in cooperation with the Georgia Tech School of Textile Engineering and the Southern College of Technology. Working in concert with private industry, this federally funded center will attempt to apply the state of the art in automated processes to specific problems of military apparel manufacturing. One of the attractive features of this multi-year program is its use of a defense need to generate technology of broad civilian use.

FY 88 was also a year in which GTRI's economic development activities broadened. Funds from the Georgia General Assembly allowed us to strengthen GTRI's regional office in Rome, Georgia, so that it could become our sixth full-fledged technology center. GTRI's field offices in defense electronics also continued to thrive at Ft. Monmouth, New Jersey, in Huntsville, Alabama, at Eglin AFB, Florida, at Wright Patterson AFB, Ohio, and at Robins AFB in Georgia.

Administratively, the Office of the Director (OOD) and its Senior Staff initiated an evaluation of the effectiveness of alternative organizational structures to meet GTRI's changing modes of operation. We will continue looking at innovative management styles and structures to ensure that GTRI resources are optimally deployed for the future. In OOD itself, we began to prepare for the loss of an invaluable colleague, Howard G. Dean, Jr., our associate director of finance, retiring in August, 1988. Needless to say, we will greatly miss his loyalty, hard work and wise counsel.

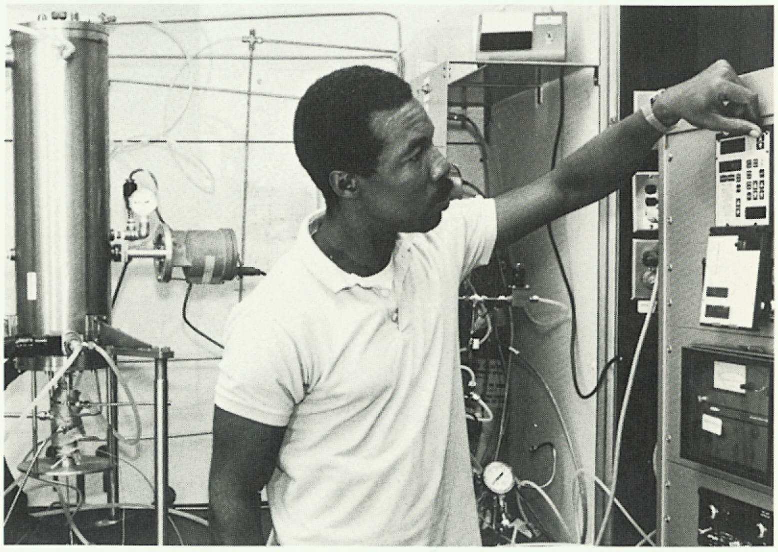


In FY 88, GTRI's staff of full-time research professionals increased substantially for the second consecutive year, to 610.

As always, I am grateful for the contributions of all GTRI staff members. We owe our success to these efforts. In the pages to come, I invite you to read about their accomplishments.

Donald J. Grace

Donald J. Grace
Director
Georgia Tech Research Institute



Near left, *one of GTRI's most innovative research initiatives concerns the use of chemical vapor deposition for a variety of materials development needs.* Far left, *GTRI developed this new surface decorative coating for Celanese Engineering Resins, Inc.*

In FY 88, GTRI implemented and expanded a number of new technologies, while extending the breadth and depth of more mature research and development programs. The following list includes some examples of technology initiatives and demonstrated capabilities:

ADVANCED CONCEPTS

Digital Terrain/Image Analysis
Manufacturing Technology
Atmospheric Characteristics/LIDAR
Off-wire guidance of automated guided vehicles
Solar-dynamic space power systems
Solar-unique materials processing
Digital coherent on receive radar
Automated palletizing
Artificial intelligence applications to autonomous work cells (robots)
Advanced radar warning receiver systems
Communications network analysis and simulation
Communications jamming
Communications surveillance
Military communications
Secure communications
Nuclear safety systems
Smart munitions (dual mode guidance)
Radar cross section reduction
Acoustic technology and systems
Bistatic radar and clutter analysis
Doppler weather radar
Identification noncooperative friend or foe (IFF) techniques
Electronic combat systems analysis
Human performance analysis and modeling
Automated speech
All-source intelligence analysis
Expendable countermeasures and decoys
Sub-array architecture
Automation development methodology
Automated network systems
Unexploited observables sensors
Coherent multi-aperture optical systems
Synthetic aperture radar concepts
Data compression
Organic non-linear optics
Millimeter wave imaging arrays
Optical feedback microwave and millimeter wave oscillators
Integrated optics chemical process sensors

SENSOR TECHNOLOGIES

Millimeter wave technology
Electro-optic simulation/modeling/fabrication
Modulated scattering technique for antenna measurements
Phased array antennas
Laser instrumentation and ranging systems
Low observables applications
Polarimetric radar technology
ECCM techniques
Target imaging/characterization
Spread spectrum and pulse Doppler countermeasure analysis
Direction finding

ELECTRONIC SYSTEMS AND COMPONENTS

Semiconductor materials and devices
Electronic durability
Superconducting microelectronics
High energy microwave systems
High temperature millimeter wave measurements
MMIC/VHSIC EM susceptibility/hardening
Modular radar threat systems
Foreign system simulation
Advanced array and special purpose antenna/microwave system (variable beamwidth, multiple object, geodesic lens)
Near-field and far-field antenna investigations
Gallium arsenide materials and devices

MATERIALS SCIENCES

Thermite synthesis
Chemical vapor deposition of ceramics
EM camouflage/scattering cross section
Zeolites and molecular sieves
High flux solar thermal research
Thermoelectric film technology
Radome and window technology
Conductive polymers
Very high efficiency solar cells
Quantum well superlattice structures
Bonding and shielding materials

COMPUTER APPLICATIONS

Cost/benefit analysis of automation
Command and control systems in missile defense
Artificial intelligence techniques in electronic defense systems
Machine vision
Automated air and ground vehicle performance
Software engineering and expert systems applications to manufacturing technology
Electronic defense
Communications
Autonomous vehicles
Integrated software support stations for ECM
Decision support systems
Geo-referenced database applications

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ENVIRONMENTAL SCIENCES

Anaerobic fixed-film reactor waste water treatment

Free radical chemistry in cloud water

Indoor air pollution

Stratospheric bromine chemistry

Use of nematode as a toxicological bioassay tool

Atmospheric remote sensing

Development of detectors for lead-based paint

Training in environmental health and safety issues

Research and training in asbestos abatement

Lignin extraction from wood for use as an environmental cleanup agent

Hazardous waste and materials management

Biosafety research and services

ECONOMIC DEVELOPMENT

Advanced manufacturing technologies: research and demonstration for the apparel industry

Research for the poultry and food processing industries

Energy conservation assistance for manufacturers and institutions

Energy demand forecasting

Management and technical assistance for imports-impacted firms

Market and production feasibility studies

Strategic and marketing planning

Cost-benefit analysis

Target industry analysis

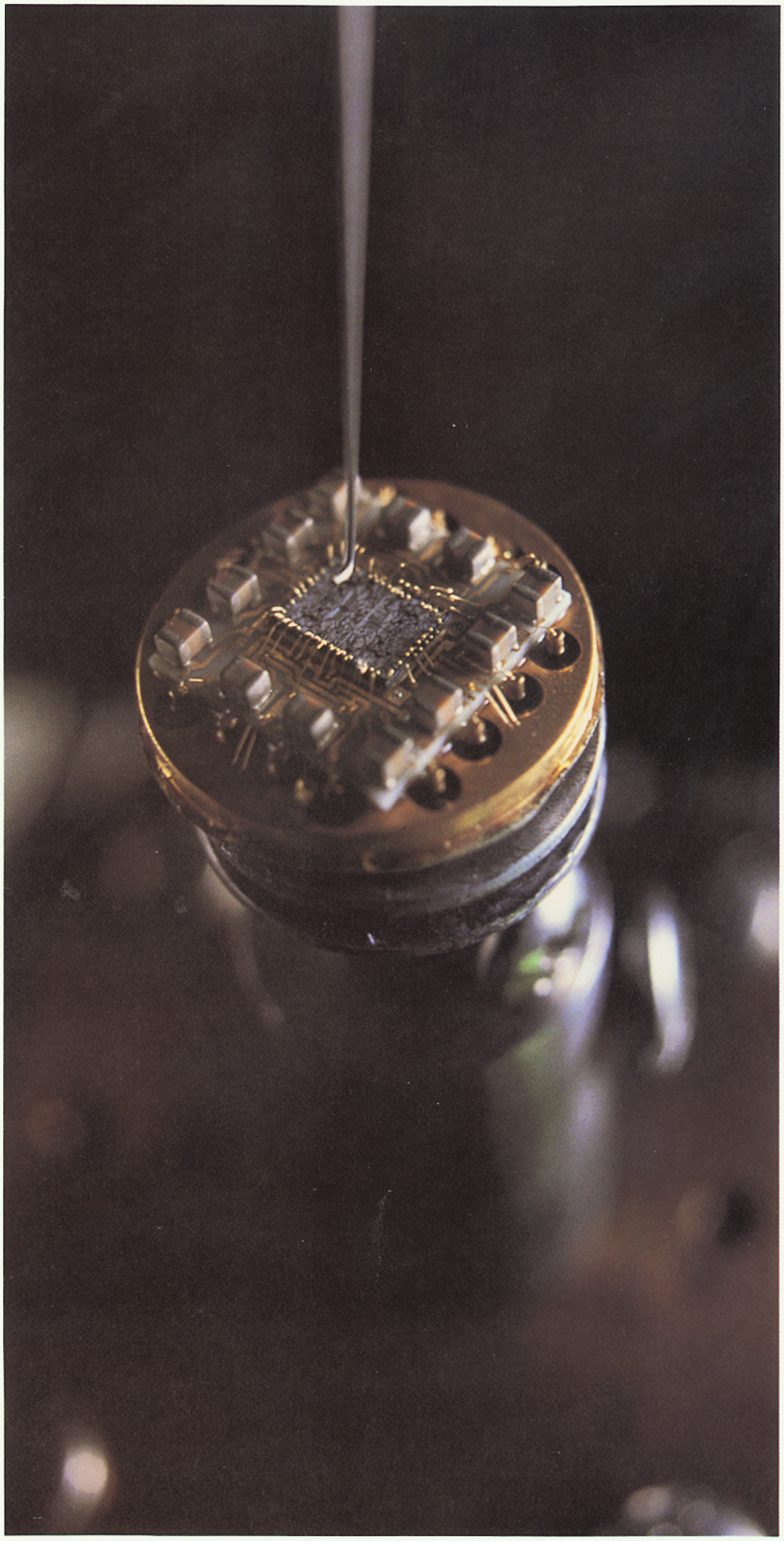
Government procurement assistance

Organization-wide productivity improvement strategies

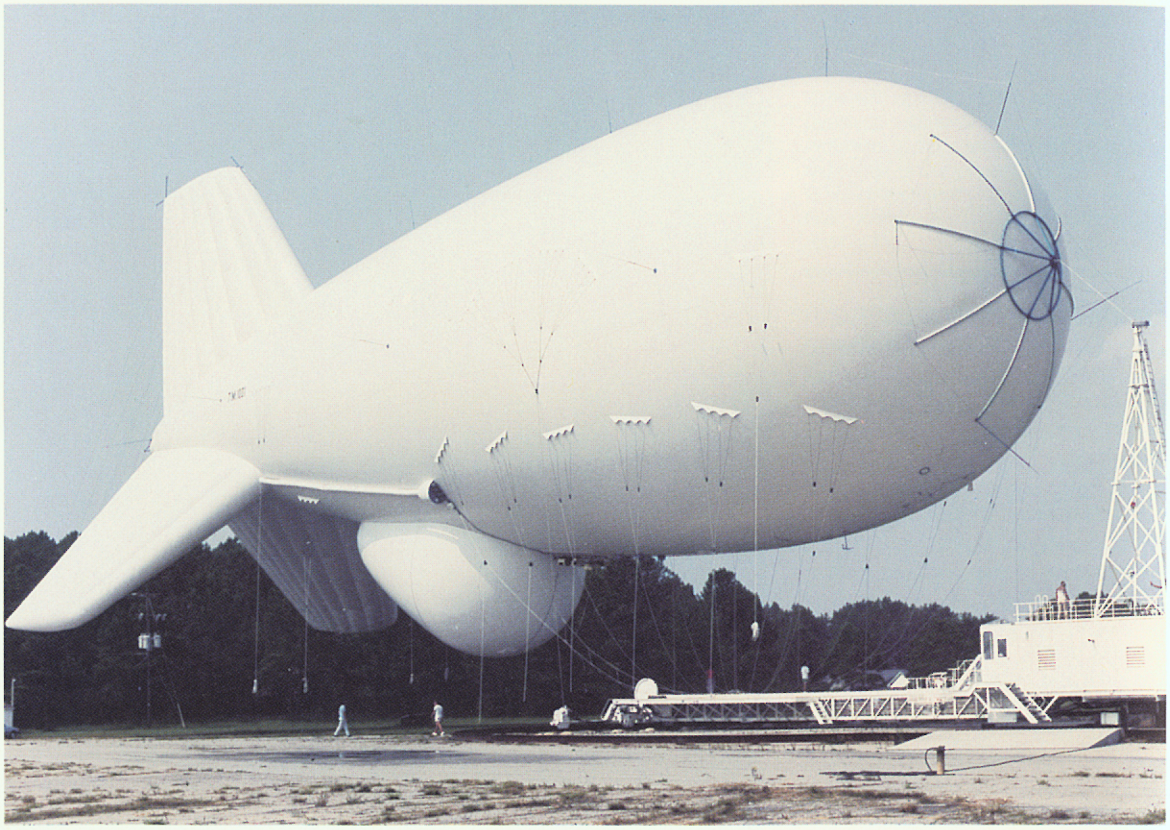
Industrial and manufacturing engineering for small firms

Start-up assistance for businesses

Training needs analysis, in-plant training, and continuing education courses



Mechanical tests are made on bond wires in an advanced hybrid microcircuit as part of GTRI's microcircuit reliability program.



Top left, *this 22.5-foot diameter turntable stands below the source tower at GTRI's far-field antenna range.* Above, *Georgia Tech helped the Customs Service instrument an aerostat with radar for detecting illegal entry into the United States by low-flying aircraft.*

One way to defend troops located in a forward battle zone is to deploy sensors capable of identifying hostile aircraft early enough to effectively direct weapons systems. To develop the necessary radar surveillance technology, the U.S. Army has initiated the Forward Area Air Defense (FAAD) program.

In FY 88, GTRI scientists began a multi-year effort to support technology evaluations of promising target identification techniques applicable to the FAAD program. This project encompasses the comparative evaluation of existing sensor packages, and recommendations for the further development of systems that identify aircraft. Under realistic field conditions at Eglin Air Force Base, Florida, GTRI researchers have collected performance data for evaluating more than 20 identification systems, including sensors operating in various bands of the electromagnetic spectrum.

In another related project, engineers collected high quality Doppler signatures of military helicopters in a look-down scenario. These radar signatures contain unique characteristics that can be used for research in the area of target identification. The 16 GHz measurements were made from atop a 300-foot tower at Eglin AFB, Florida.

In a major project for the U.S. Air Force, researchers have developed a method to compare the costs and benefits of new electronic counter-countermeasures (ECCM) techniques proposed by various vendors. Proposed techniques are incorporated into detailed simulations to quantitatively determine expected performance improvements. Costs are then estimated. A system optimization model then determines the lowest cost mix of ECCM techniques necessary to achieve the specified level of performance.

GTRI is helping to develop radar for improved detection of aircraft illegally entering into the United States.

In a program for the Office of Naval Research, GTRI engineers continued to develop the ability to rapidly capture the amplitude and phase of an unknown signal. Called Advanced Electromagnetic Sensing Technology (AEST), this rapid capture technique offers the advantages of a time-coherent signal without the generation of a coherent waveform. AEST compares samples of the transmitted wave with the returning signal, offering the potential of operating in a non-cooperative bi-static mode.

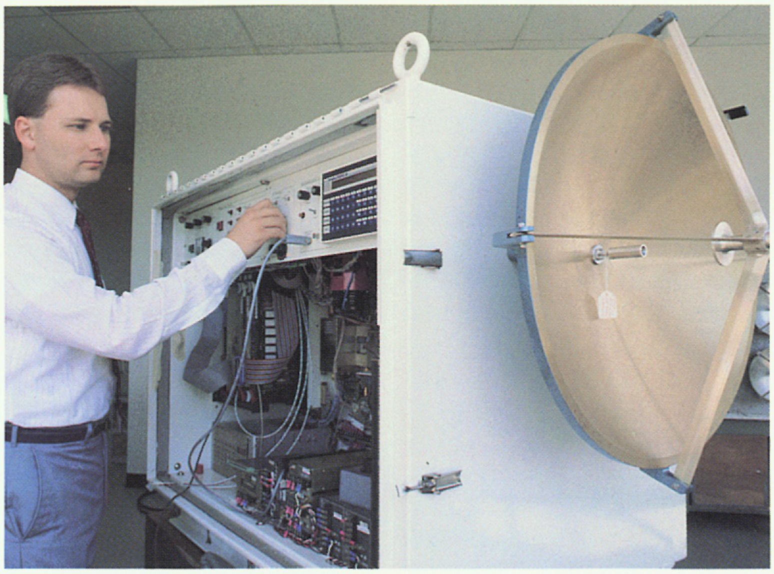
To locate positions of enemy artillery, mortars, and rocket launchers on a modern battlefield, the Army has acquired a synergistic radar system known as FIREFINDER. It is an active system, susceptible to threats such as jammers, countermeasures, and anti-radiation missiles. GTRI engineers are performing vulnerability and survivability studies on FIREFINDER to determine which threats pose the greatest danger, and seeking ways to improve capabilities against those threats.

In a project for the Strategic Defense Command, GTRI researchers are assisting in the development of a Lightweight Exo-Atmospheric Projectile (LEAP). Part of the Space-Based Intercept program (SBI) LEAP interceptors are envisioned to be deployed in satellites orbiting the Earth. In, addition to providing technical assistance, GTRI scientists are designing a six degree of freedom simulator to aid in analyzing guidance and control algorithms.

The illegal entry of aircraft into the United States from Mexico is a major concern of U.S. Customs officials. To detect aircraft flying through the rugged mountainous terrain, the Customs Service is acquiring a Doppler radar system. Suspended from a balloon hovering at elevations up to 7,500 feet, the radar system must pick out small radar cross section targets from the surrounding clutter. GTRI engineers are assisting Customs officials in performing acceptance tests to ensure that the radar system meets required specifications.

During FY 88, GTRI engineers continued to support the Army in designing appropriate architecture for use in digital beam-forming antennas. A prototype system under development will consist of 64 receiver modules arranged in a two-dimensional array. Unlike conventional phased-arrays, digital beam-forming radars will be phased in the data processor, allowing greater target resolution while controlling side lobe interferences.

GTRI engineers continued to enhance the capabilities of HIPCOR, a high-power, coherent 95 GHz radar system they developed.

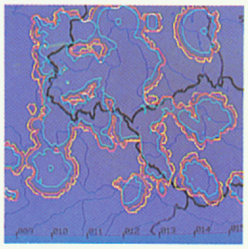


GTRI researchers are also developing an infrared imaging CO_2 laser radar capable of measuring relative range. The system's high angular resolution is ideally suited for target detection, identification, tracking, and three-dimensional imaging.

Other significant areas of research include:

- Assisting in developing radar sensor concepts to protect high value assets against airborne intrusion;
- Assisting the U.S. Navy in developing specifications to procure a new airport surveillance radar for the Marine Air Traffic Control and Landing System (MATCALS);
- Converting complex radar analysis software and graphics packages to run on small personal computers; and
- Assisting the U.S. Army Strategic Defense Command in developing the Terminal Imaging Radar (TIR).

COMPUTER SYSTEMS AND TECHNOLOGY



To simplify the vital but tedious task of writing building specifications, GTRI computer scientists developed an intelligent system for information retrieval for Heery International, a large architectural and engineering firm. The GTRI automated specifications writing system is composed of two cooperating software programs. EXPERTEXT allows expert specifications writers to develop query sequences and easily access the American Institute of Architects' huge data base. Architects can use SPECRITE on personal computers to produce accurate, fully documented building specifications automatically by making simple choices to program queries. The query sequence emulates an experienced specifications writer by causing irrelevant parts of the data base to be skipped while ensuring that all necessary sections are included. The GTRI system has successfully passed national software tests and has been purchased by McGraw-Hill. Scheduled for commercial release in 1989, this innovative product may become part of a revolution in electronic publishing.

The Air Force is fielding more than 700 copies of GTRI's penetration analysis aiding system.

In FY 88, GTRI researchers also continued work on Pen-Aids, a penetration analysis aiding system which has become a major component of the U.S. Air Force Mission Planning System. Using digital terrain elevation data, threat modeling, and intelligence reports on enemy radar and anti-aircraft systems, Pen-Aids determines the least dangerous route for an aircraft flying over a threat-defended area. Enhancements to the software package include improved graphics, a simplified human/machine interface, integration with other Air Force software, and enhanced optimization that allows full three-dimensional route planning. Also, in order to readily provide more information to the pilot, GTRI researchers are exploring new methods of graphically presenting data. Currently undergoing predeployment evaluation and operational testing, more than 700 of these planning systems are to be located worldwide.

To support the U.S. Army Aviation Modernization Plan, GTRI scientists are assisting in the development of the mission equipment package (MEP) for an experimental lightweight helicopter (LHX). Capable of performing multiple mission functions, this new light attack/armed reconnaissance helicopter will incorporate advanced computer architecture, automatic target recognition and countermeasures systems, and the latest in avionics technology. The sophisticated airframe also represents a quantum leap in aerial technology. GTRI is part of a team of contractors that will provide technical support during the multiyear program.

During FY 1988, GTRI developed standards for the certification of electronic voting and tabulation systems for the State of Georgia. Participation in this project also involved contribution to the federal standards and work for the Federal Elections Commission.

Other areas of interest included:

- Investigating electric power supply alternatives within the state of Georgia and preparing the framework for a regional power pool involving four different electric utilities;
- Creating a user level guide for Army personnel on how to build decision support systems; and
- Conducting preliminary design work on a prototype expert system for writing vehicle specifications for the Air Logistics Center of the U.S. Air Force.

Top left and above, *Pen-Aids, GTRI's penetration analysis aiding system, was fielded at military installations around the world in FY 88.*

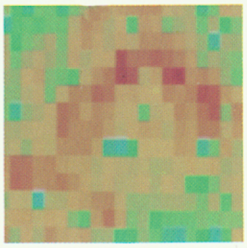
GEORGIA TECH RESEARCH INSTITUTE

Today, there is a growing emphasis on extending communications, radar, and sensing and surveillance systems to the millimeter wave band of the spectrum. GTRI researchers made a substantial contribution to this field in fiscal 1988 with the publication of *Principles and Applications of Millimeter Wave Radar.* This book, edited by GTRI engineers Nicholas Currie and Charles Brown, is the first hardbound volume of its kind on the topic of millimeter wave radar. Of the book's 18 chapters, all but one were authored by GTRI researchers.

In FY 88, GTRI engineers continued to augment the capabilities of HIPCOR — a coherent 95 GHz radar system developed for the U.S. Army Missile Command (MICOM) in Huntsville, Alabama. The system utilizes a high power extended interaction oscillator to emit a 1.5 Kw radar signal with a bandwidth of 350 MHz. The system can also operate in a power mode utilizing a traveling wave tube that generates a 100 watt signal with more than 2 GHz bandwidth. In FY 88, researchers developed a powerful data acquisition system to support HIPCOR as a research tool for investigating target, clutter, and millimeter wave propagation phenomenology.

In another major project for MICOM, GTRI researchers quantified the effects of varying amounts of rainfall on target signatures. Moisture on an object may alter signature characteristics, particularly at millimeter wave frequencies. Researchers used a modified snowmaking machine to produce "rainfall" at various controlled rates over selected targets while measuring backscatter at both 35 and 95 GHz.

GTRI engineers also performed quick reaction measurements on a number of high-value targets at Eglin Air Force Base. Using GTRI-owned instrumentation radars, target backscatter characteristics were recorded at both 35 and 95 GHz. Inverse Synthetic Aperture Radar images (ISARs) were also generated, enabling researchers to study each target's internal scatter and develop appropriate target recognition algorithms.



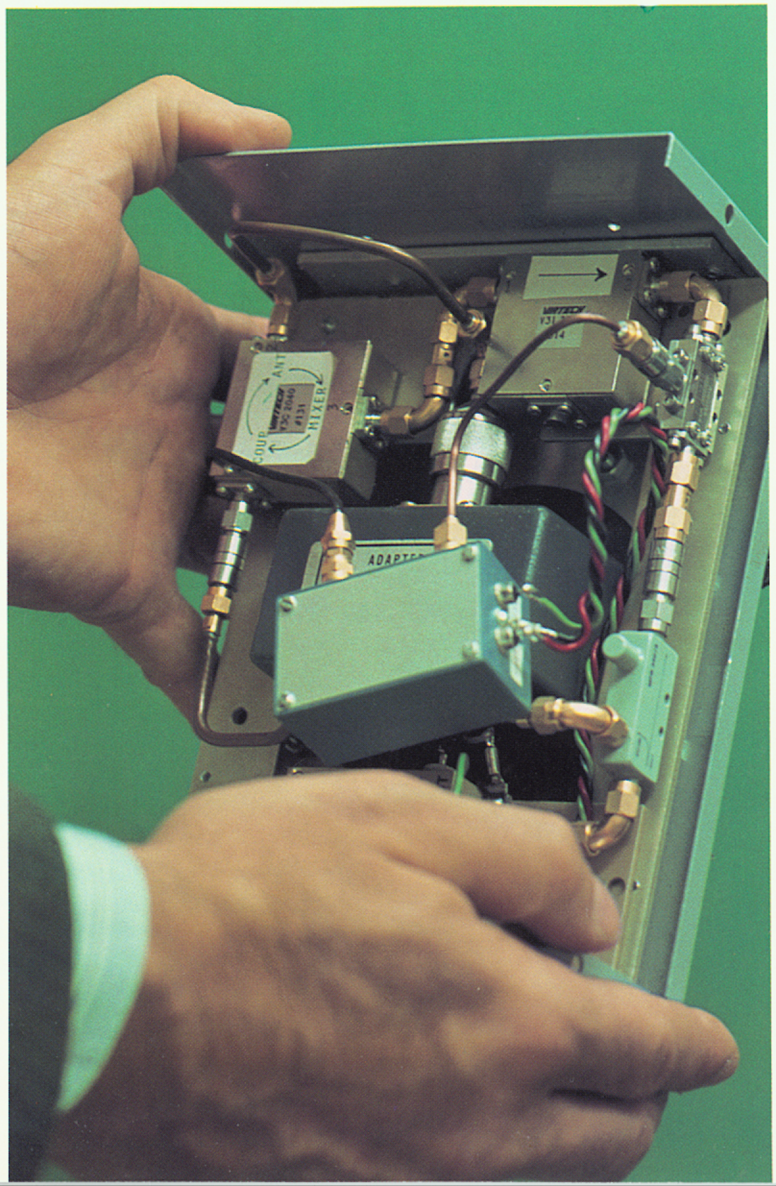
During FY 88, GTRI researchers continued to investigate materials for potential use in millimeter wave radomes. These protective housings must be both structurally sound and electromagnetically compatible. Ideal properties include low dielectric constant, low loss tangent, and high resistance to abrasion and aerodynamic heating. Researchers

Engineers continued to augment the capabilities of HIPCOR — a coherent 95 GHz radar system.

conducted permittivity, permeability, and environmental exposure tests on a variety of composites, fibers, ceramics, and coatings potentially useful in radome construction.

Other major areas of interest include:

- Designing a multi-channel microwave radiometer for detecting thermal radiation at 10, 18, 37 and 85 GHz;
- Developing camouflage materials and new techniques to measure and characterize them;
- Performing high temperature dielectric measurements (up to 2500° C at 35 GHz) of millimeter wave radomes; and
- Exploring new techniques in airport weapons threat detection.



Top right, *GTRI engineers generated a millimeter wave image of an automobile with one-foot resolution using an inverse synthetic aperture radar (ISAR).* Left, *researchers continued development of a vital signs monitor that detects cardiovascular activity in humans at a distance.*

1988 marked the tenth anniversary of GTRI's Electronic Warfare Techniques Analysis Program. This activity has been an essential factor in the growth of electronic defense research at Georgia Tech. The research performed through this program is geared toward helping Air Force decision-makers choose directions for future R&D thrusts. Over the past 10 years, the Avionics Laboratory of Air Force Wright Aeronautical Laboratories has invested more than $22 million on this program, developing, testing and analyzing a variety of new electronic defense concepts.

The program has greatly enhanced GTRI's reputation in the defense community. More than 120 technical reports have been generated and distributed to more than 250 Department of Defense (DoD) agencies with interest in electronic defense.

Over 10 years, GTRI has received more than $22 million to develop, test and analyze new electronic defense concepts.

In FY 88, researchers at GTRI continued a multi-year program to develop the Jamming Analysis Measurement System (JAMS), an instrumentation concept for radar systems used by DoD test agencies for evaluation of electronic warfare equipment.

GTRI also recently began to develop an all-software testbed to support joint research by the Air Force and its contractors on an Electronic Countermeasures (ECM) Resource Manager based on artificial intelligence techniques. The ultimate objective of this program is to develop a flyable brassboard of an ECM system capable of continuous resource use planning, real-time ECM resource allocation, and real-time ECM effectiveness monitoring.

The production of spare parts to keep fielded military equipment operational is frequently curtailed by rapid advances in microelectronics technology, changes in industrial product lines, business failures and other factors. The Army has had to obtain unavailable replacement parts through a process known as "reverse engineering," a time-consuming analysis of the old part and its role in the overall system.

GTRI researchers have joined forces with the U.S. Army Laboratory Command's Electronics Technology and Devices Lab to solve the problem of obsolete electronic components. They are developing a methodology that makes it possible for today's designs to be easily upgraded as new technology becomes available.

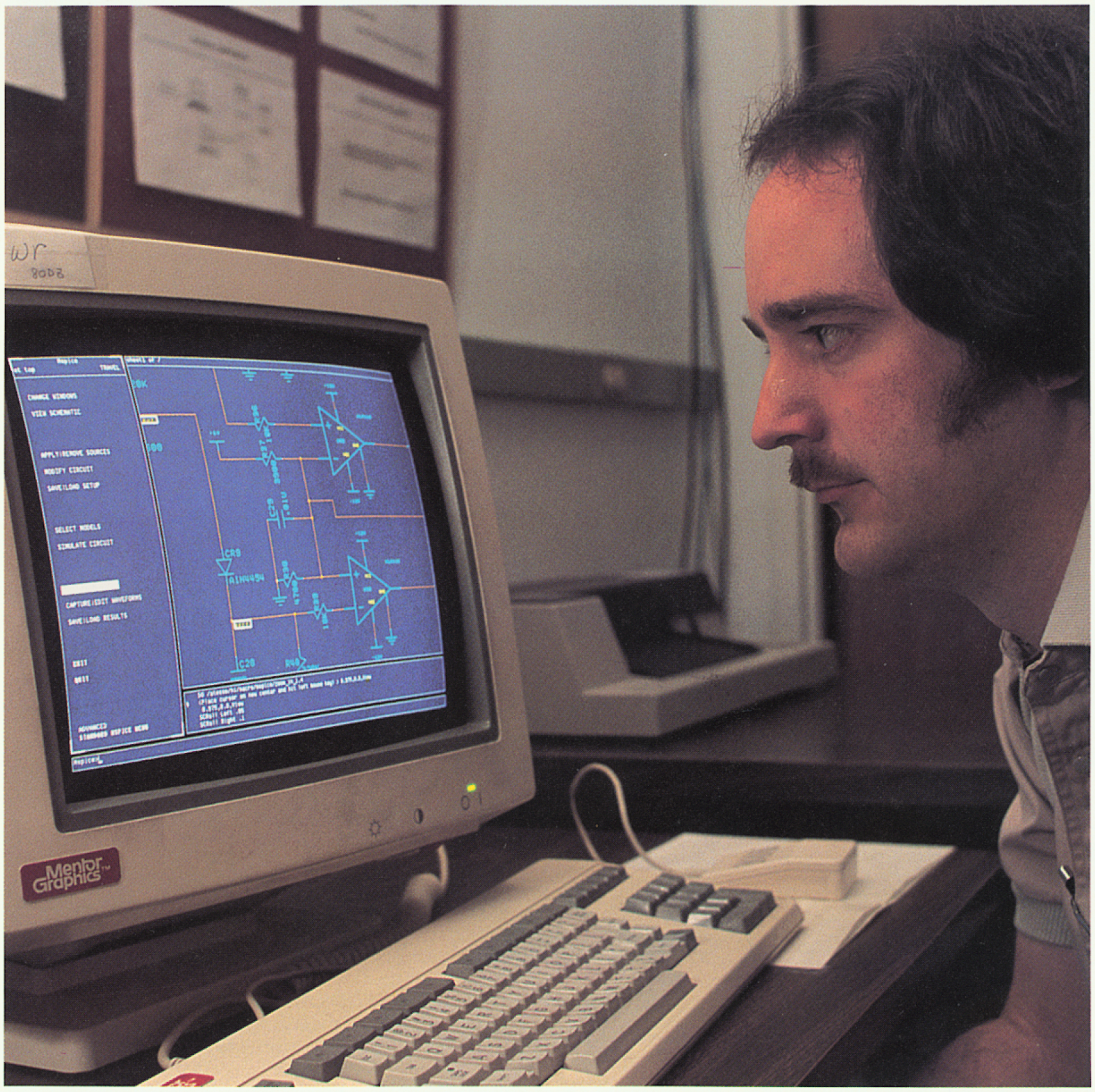
In FY 88, a GTRI scientist achieved a breakthrough in improved angle resolution in radars by developing a new concept for compressing radar antenna beamwidths. The researcher was able to develop a method to encode antenna angle information in a way analogous to time-encoding in pulse compression systems. His concept employs a broad beam pattern for transmission and uses matched filter techniques in the receiver to synthesize a narrow high-resolution received antenna beam.

Top left, *engineers are continuing to enhance the ALR-69 radar warning receiver, which displays threats on this computer display.* Above, *GTRI has developed engineering support stations for controlling and collecting data from the ALR-69.*

GTRI researchers have also developed an automated data base system to enhance analysis of defense systems. The quality of defense systems analysis is directly related to the data bases used. The software is capable of storing, retrieving and updating defense system parameters and provides improved quality control of the data base. The data base offers ease of user interaction for maintenance and verification of data, as well as ease in downloading data for use in various software simulation models.

In FY 88, GTRI made major advances in the development of work stations that generate software to control automatic test devices. These advances are needed because automatic test equipment (ATE) provide the only practical means of diagnosing failures in the complex avionics on today's military aircraft. Manual diagnoses would require too many skilled repair technicians. A few skilled engineers develop the sequences of tests to be performed by the ATEs, and, until now, they have also written the computer programs that control the ATEs. This process of software development is time-consuming and expensive, particularly if the circuits to be tested are analog, not digital. In FY 88, GTRI software engineers neared completion of a set of software tools that will greatly aid and partially automate the development of the ATE control software, and thereby substantially reduce its cost. GTRI's ATE Software Support Environment (SSE) will take the engineer's description of the test sequence to be performed, and automatically generate much of the software that will operate the ATE. The first ATE SSE is designed for use on the avionics of the F-16 aircraft.

GEORGIA TECH RESEARCH INSTITUTE



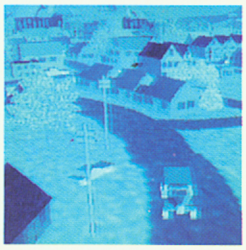
During FY 88, a GTRI engineer developed a concept for using personal computer technology to improve cost-effectiveness in defense electronics systems. Development began on a modification kit to improve the reliability of the test console used to maintain a modern electronic warfare system. Researchers designed and built a plug-in interface card and developed supporting software to allow a personal computer to control the electronic countermeasures (ECM) pod.

Other major areas of interest included:

- Designing a modular Software Simulation Station to support testing of the AN/ALQ-161A defensive electronic warfare system for the B-1B bomber;
- Providing technical support of the modification and laboratory integration of a closed-loop hybrid laboratory simulation (HLS) derived from the Crossbow Generic Radar. The HLS will be utilized in conjunction with an aircraft-sized anechoic chamber and other simulation assets for the testing and evaluation of electronic warfare systems;
- Assembling an in-house Modular Electronic Warfare Research Facility (MEWRF) to support development of new EW hardware and software technologies;
- Continuing the development and flight-testing of towed decoys designed by GTRI engineers for potential use with Unattended Air Vehicles (UAVs); and
- Investigating individual differences in brain organization on human performance, particularly in high-workload situations, for the Army Research Institute.

GTRI neared completion of the Automated Test Equipment Software Support Environment (ATESSE). This set of software tools will be used by the Air Force to develop programs for testing F-16 avionics circuit cards.

INFRARED/ ELECTRO-OPTICS



Georgia State University has contracted with GTRI researchers to design and test an Optical Path Length Equalizer, a vital component in a proposed two-dimensional stellar interferometer. The Georgia State array will consist of seven 1-meter telescopes arranged in a "Y" configuration. The interferometer will alternately combine images from different pairs of telescopes to study interference patterns and record geometric features of stars. A unique system of fixed and movable mirrors will couple light from pairs of telescopes and equalize the respective path lengths. GTRI scientists are designing this Optical Path Length Equalizer and the special optical "pipes" that will carry images from the telescopes to the detector.

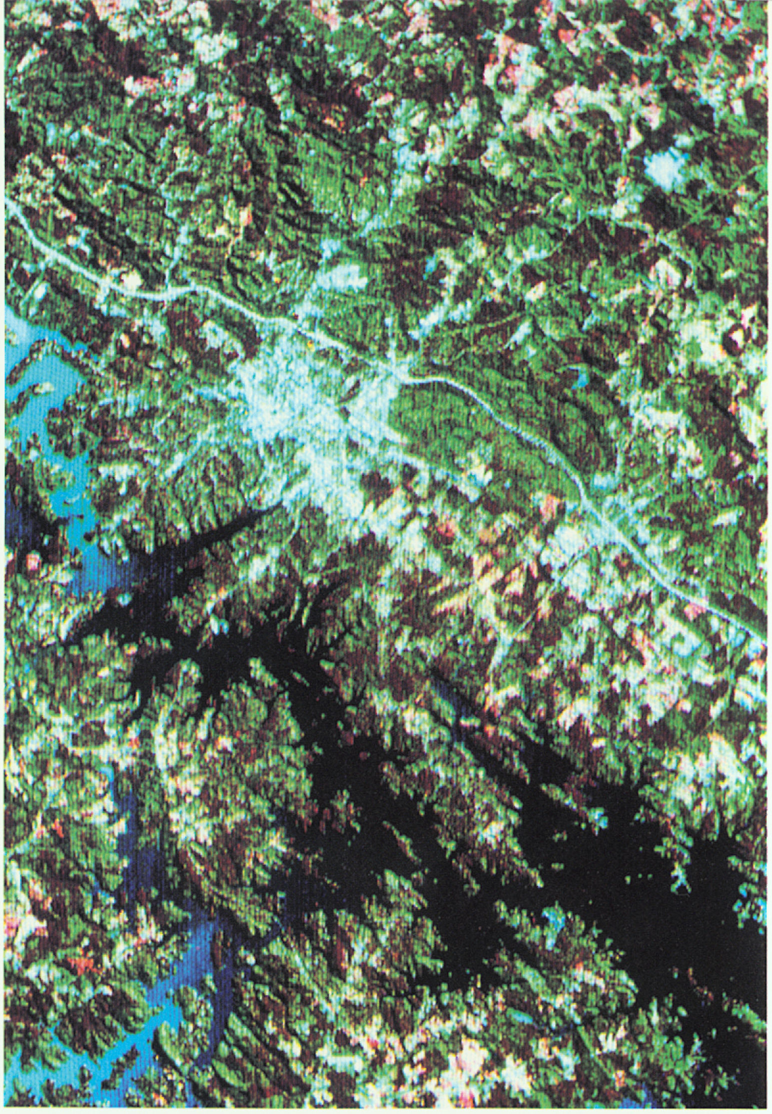
In FY 88, GTRI continued to provide support for a joint-government, joint-U.S. armed services multispectral signature measurements program. Funded by the U.S. Army Missile Command (MICOM) in Huntsville, Alabama, this activity was part of an extensive test and evaluation program conducted under the code name Chicken Little. Primary objectives included obtaining fundamental millimeter wave radar and infrared signatures of a variety of armored vehicles, and evaluating performance capabilities of a variety of seekers against these targets.

GTRI continued a multispectral measurements program to obtain fundamental electronic signatures of armored vehicles.

To distinguish features on the ground while flying at night, B-52 bomber pilots rely upon a sensitive electro-optical viewing system. In a project funded by the Warner Robins Air Logistics Center, GTRI engineers are replacing the vidicon/intensifier tubes currently in use with a modern solid-state CCD camera system. Benefits include improved performance, reliability, and lower maintenance and repair costs.

Other significant areas of research included:

- Devising methods for erasing highly sensitive information from damaged or malfunctioning B-52 bomber magnetic core memory cards prior to vendor repair;
- Creating a three-dimensional high resolution infrared database to correlate with a real-time forward-looking infrared (FLIR) sensor display; and
- Analyzing how infrared signatures change with time of day and weather conditions to determine appropriate lock-on ranges.



Top left, *in FY 88, GTRI studied the ability of human observers to use infrared imaging systems to distinguish military vehicles from urban background clutter.* Above, *researchers used LANDSAT data to produce this image of a portion of Lake Lanier in Georgia.*

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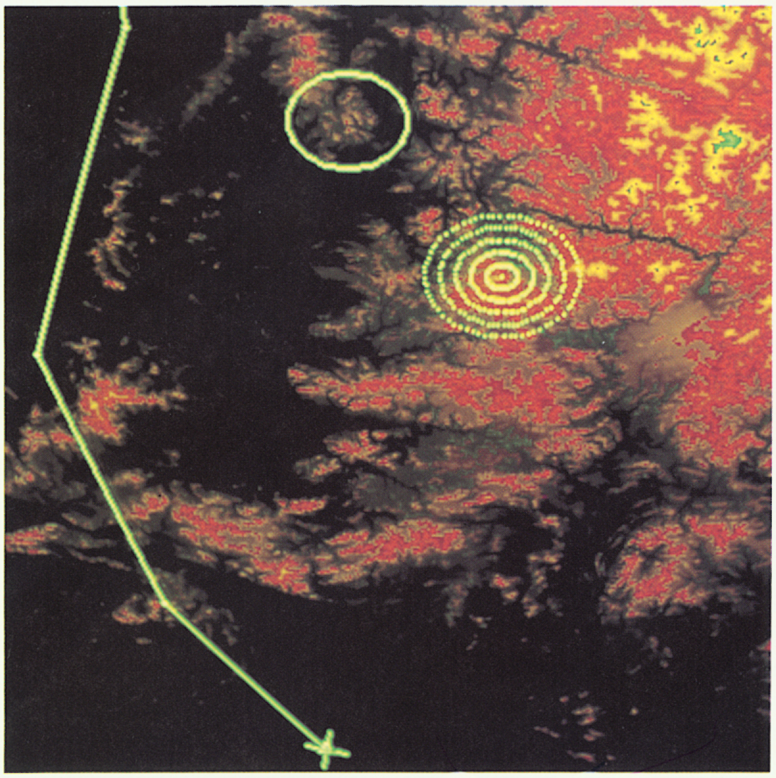
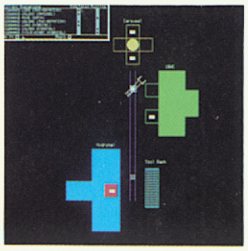
Bridging a gap in palletizing technology, GTRI engineers have developed an expert system to palletize unequally sized containers. Given an order manifest, the system determines proper loading of the pallet and generates a graphical representation for the human worker. Factors such as container size, shape, crushing capacity, and stability are taken into consideration for optimized stacking. Benefits include higher quality control, simplified material tracking, and reduced labor costs.

In FY 88, GTRI software engineers improved the versatility of the Generic Expert System Tool (GEST) by converting it into a blackboard system. GEST, a full-scale tool for developing applications-oriented expert systems, features evidential reasoning, adaptive control strategies, multiple knowledge representation schemes, and a user-friendly display system. The new blackboard architecture allows multiple expert systems to communicate and share relevant information. Researchers are experimenting with running GEST on five Symbolics LISP machines in a parallel architecture.

GTRI researchers also upgraded the route-planning capabilities of an autonomous helicopter by fully integrating local and global vision systems. By comparing live input from onboard cameras and sensors with stored DMA (Defense Mapping Agency) data, the route planner can detect and avoid threats, and perform real-time flight replanning.

Engineers continued to develop a multi-purpose image processing system called BUZZ. BUZZ provides the user with a selection of image enhancement, segmentation, feature extraction, and classification techniques. BUZZ image processing techniques are available to users in both menu and subroutine library formats.





GTRI researchers developed the Generic Expert Systems Tool (GEST) for numerous artificial intelligence applications, including, above, *helicopter route-planning and,* top right, *control of a robot work station.*

Researchers improved the versatility of GTRI's Generic Expert System Tool by converting it to a blackboard system.

Other significant areas of research in FY 88 included:

- Development of faster correlation algorithms and implementation of parallel data processing techniques to enhance positional accuracy in off-wire automated guided vehicles;
- Design of a vision system that combines artificial intelligence with image processing techniques to classify scenes and automatically detect infrared targets; and
- Application of artificial intelligence to the routing of complex military communications networks.

MICROELECTRONICS

In FY 88, GTRI scientists continued development of a promising initiative in superlattice device technology. For the first time, they were able to build variably spaced superlattice energy filters (VSSEF) that exhibited resonant tunneling and negative differential resistance effects. Grown by molecular beam epitaxy (MBE), the unique devices incorporate aluminum gallium arsenide (AlGaAs) barriers and gallium arsenide (GaAs) quantum wells designed for electron injection at 0.20V. When an applied bias brings energy levels in adjacent quantum wells into alignment, electrons can tunnel through the barriers and conduct through the whole structure. The superlattice energy filters create a nearly monoenergetic stream of electrons and inject them at high energy into an adjacent semiconducting layer. They are potentially useful in electroluminescent displays, photodetectors, and high frequency microwave oscillators.

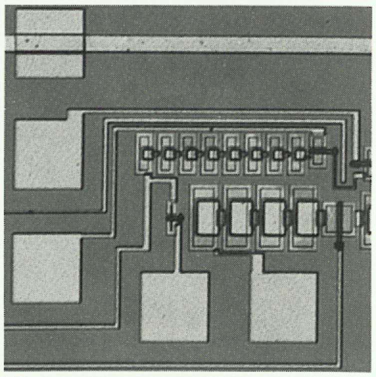
GTRI engineers began investigation of a novel solar cell that relies on a variably spaced superlattice device.

Researchers are using the variably spaced superlattice energy filter concept to design an avalanche photodiode structure. The new solid state detector, analogous to a photomultiplier tube, enables photogenerated electrons to be injected into a doped contacted quantum well. The device promotes high-efficiency intraband impact ionization, thereby producing extremely high gain and very low noise at a small bias voltage. They are also investigating applying the techniques of charge multiplication to infrared detection by using the VSSEF to inject photogenerated electrons from a small bandgap semiconducting layer into a large bandgap semiconducting layer. Applications include cameras and imaging arrays that rival the fastest film speed.

In FY 88, GTRI engineers also began investigation of a novel solar cell that relies on a variably spaced superlattice. Sensitive to a wide range of solar energy, the mercury cadmium telluride (HgCdTe) and manganese cadmium telluride (MnCdTe) variably spaced superlattice device might boost photovoltaic conversion efficiency to nearly 45 percent. The current state of the art is now 20-25%, while the normal commercial system offers a 6-12% yield. This project is sponsored by the Solar Energy Research Institute through the U.S. Department of Energy.

To more efficiently monitor the MBE growth process used for superlattice devices, GTRI scientists employed an electron beam diffraction technique which records oscillations in reflected intensity as atomic monolayers are deposited. Called RHEED (Reflection High Energy Electron Diffraction) oscillations, the technique allows measurement of the atomic spacing and thickness of quantum wells. Growth accuracy at the angstrom level can now be achieved.

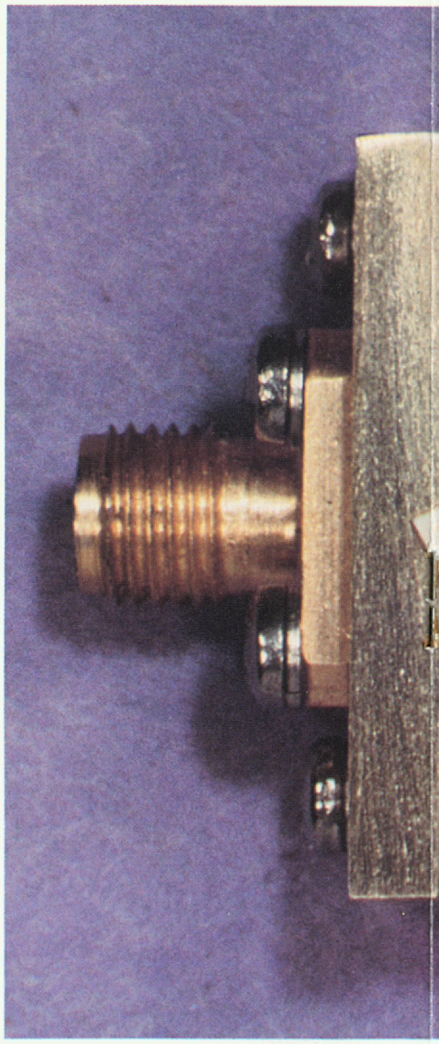
As microchips become more sophisticated, the number of input/output leads increases dramatically. To facilitate mounting large chips closer together, industry is moving from old plated-through-hole techniques to modern surface-mount technology where small pads of solder secure the device. Crucial in the interconnections of electronic devices, solder must now supply superb mechanical attachment in addition to excellent conductivity and thermal transmission. In an effort to make ordinary solder into a high performance material,



Above, *GTRI researchers fabricated this gallium arsenide integrated circuit for high-frequency analog applications.*

GTRI engineers have been investigating the properties of a variety of solder alloys. Tests to determine mechanical fatigue, thermal fatigue, and creep have been conducted. Researchers are also studying the recrystallization effects of solder at room temperature, and applications where devices operate close to the melting point of solder.

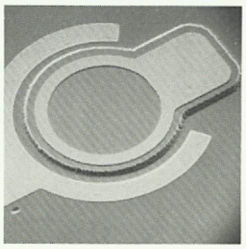
Microcircuit failure due to electromigration is becoming another



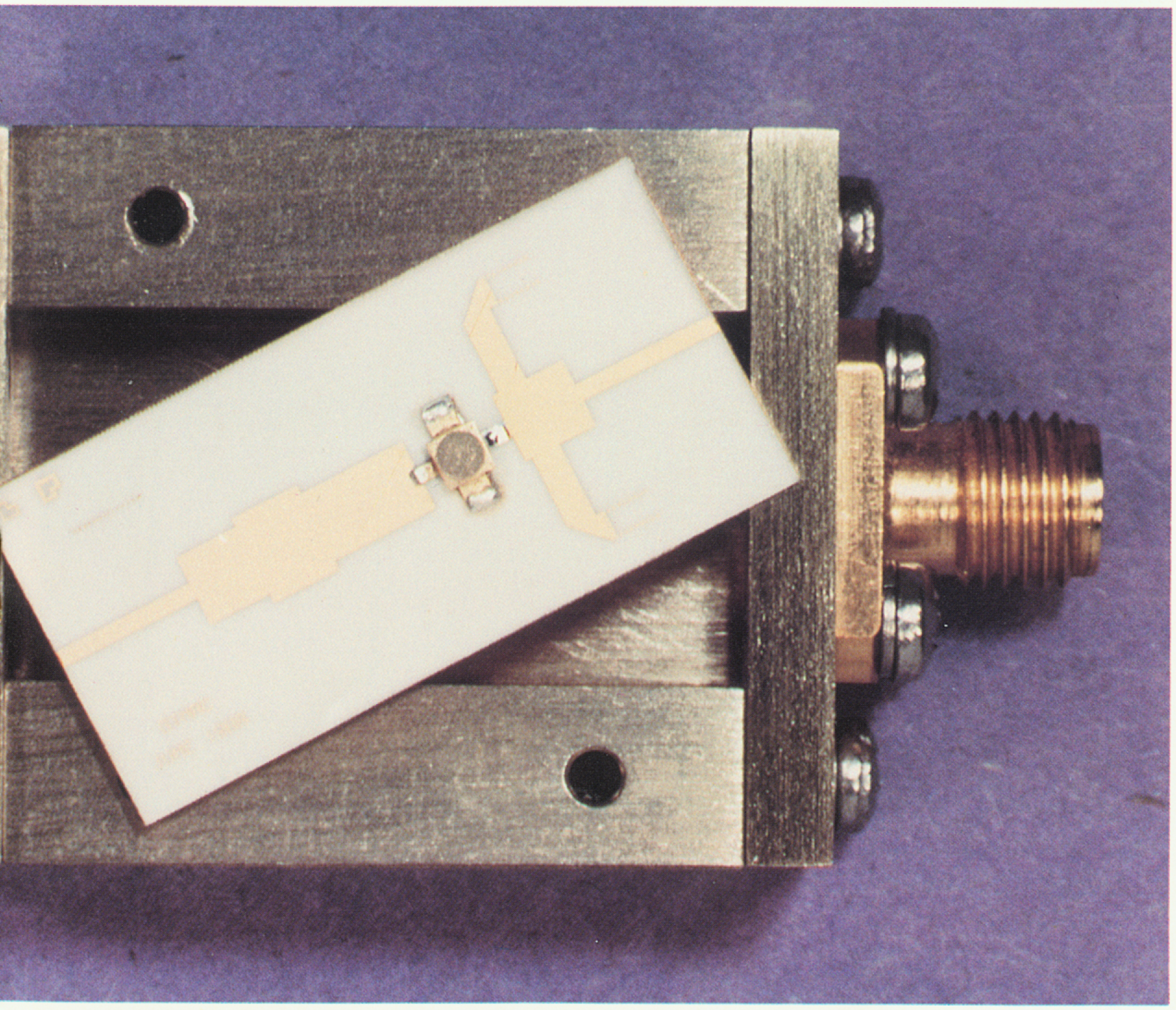
major industry concern. Modern microcircuits consist of thousands of transistors connected by extremely narrow thin film conductors. The high current density across these sub-micron widths acts as an "electron wind," causing atoms in the film to move forward. The resulting valleys and hillocks can be seen with a scanning electron microscope. In FY 88, GTRI scientists continued studying the mechanisms behind electromigration and sought ways to reduce this undesirable phenomenon.

Other significant research efforts included:

- Experimenting with AlGaAs/GaAs multiple quantum well optical resonators that exhibit nonlinear response characteristics and may be suited for optical switching applications;
- Fabricating multiple quantum well AlGaAs/GaAs photodiodes that exhibit very low leakage currents (10 picoamps) while maintaining breakdown voltages of more than 100 volts;
- Using MBE capabilities to greatly improve the performance of field effect transistors in GaAs based materials;
- Growing superlattice structures in zinc telluride (ZnTe) and cadmium telluride (CdTe) to suppress various undesirable diffusion effects when grown on foreign substrates such as GaAs;
- Exploring dry processing techniques such as reactive ion etching to achieve isotropic etching of submicron features in CdTe;
- Developing the technical rationale to refine specifications for incoming inspections and also to determine the level of reliability of passive parts for the U.S. Army Missile Command;
- Studying the mechanical properties of reinforcement fibers for advanced composite materials; and
- Investigating the adhesive forces necessary for dispensing optical fibers in a novel missile guidance system.



Below, GTRI researchers fabricated a gallium arsenide field effect transistor, bonded it on a 70 mil microstrip package, and mounted the package on an alumina substrate matching network. The device serves as an X-band amplifier. Top right, this aluminum gallium arsenide avalanche photodiode was grown by molecular beam expitaxy.

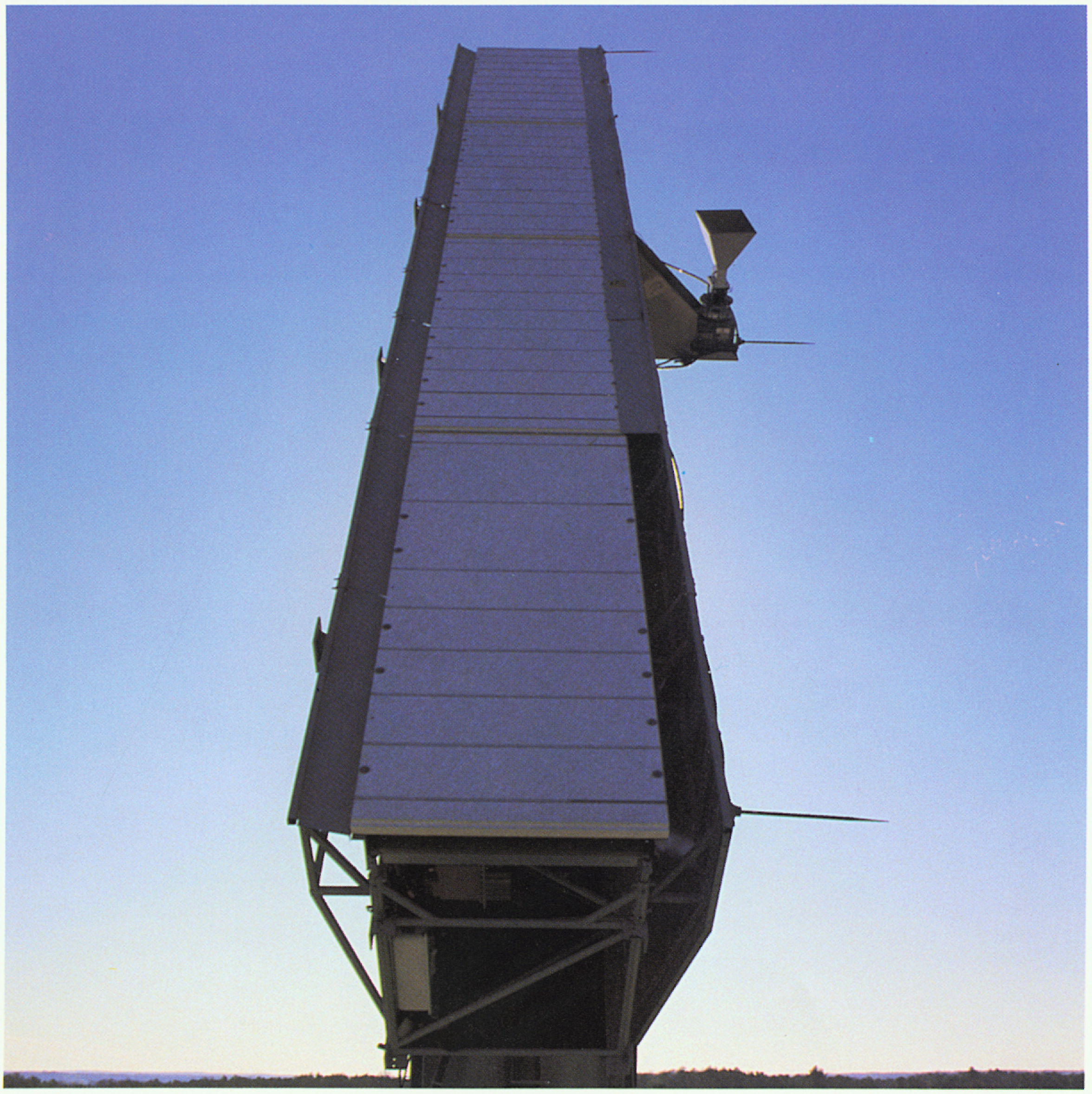


ANTENNA DEVELOPMENT

In FY 88, GTRI scientists investigated a new modulated scattering technique as a means to rapidly characterize antennas. By electrically modulating the reflectivity of an array of small probes placed in the near-zone of an antenna under test, the modulated scattering technique quickly determines the near field, thereby enabling determination of the far-field antenna pattern. Significantly reducing characterization times, this measurement technique could also be used to quickly evaluate the performance of an aircraft- or ship-mounted antenna without requiring costly removal and placement in a special range.

GTRI researchers also continued to enhance the capabilities of compact range technology. A compact range significantly reduces the space requirements for measuring far-field characteristics of large antennas by creating an electromagnetic field within the target vicinity that simulates great distance. In FY 88, GTRI scientists continued to find ways to accelerate measurement rates and improve both resolution

GTRI scientists assisted NASA in developing a very large near-field range for Johnson Space Center.



Top left, *the receive tower at GTRI's Electromagnetic Test Facility accommodates state-of-the-art antenna measurements.* Above, *in one experiment at the facility, engineers tested a phased array antenna built at GTRI that will be one of the largest ever to fly on an airplane.*

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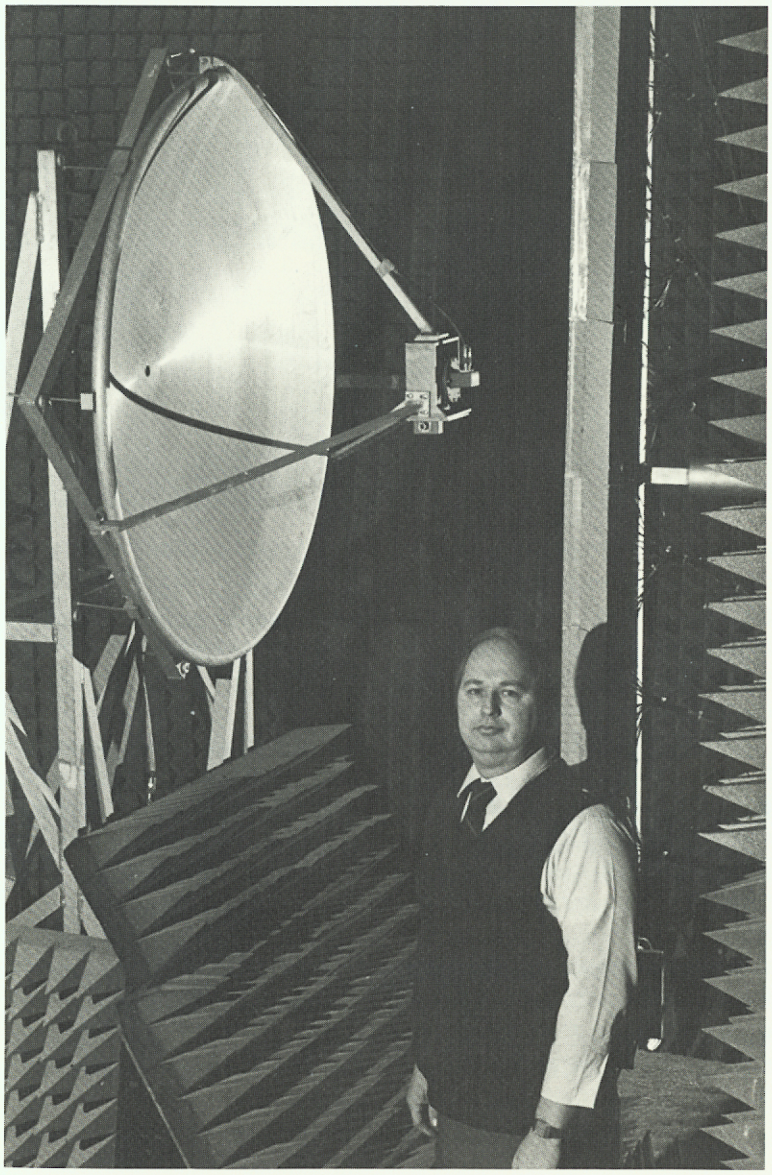
and sensitivity on compact ranges.

In related work, GTRI engineers designed a compact range for the U.S. Army test facility at Fort Huachuca, Arizona. The system includes a 70-foot diameter reflector and a novel positioner capable of supporting even heavy tanks at various attitudes above the ground. GTRI is developing the necessary software systems, designing support instrumentation, and overseeing fabrication of all hardware components. The Army will use the new compact range to investigate antenna patterns and gross interference effects on tanks, helicopters, and light aircraft.

During FY 88, GTRI scientists assisted NASA with developing a very large near-field range for the Johnson Space Center in Houston, Texas. Designed to accommodate space-deployable antennas up to 30 feet in diameter, the system will perform rapid characterization measurements by probing the near-field aperture distribution with a planar scanner. To improve positional accuracy, the scanner's position will be constantly monitored by laser metrology. GTRI engineers designed and built the RF system, developed control and data processing software, and served as overall project consultants.



GTRI engineers also continued to investigate ways to reduce the cost of complex phased array antennas. One promising approach uses a monolithic microstrip patch that combines 300 elements into one package, complete with phase shifters and control circuitry. The patches can be arrayed and electronically steered like a conventional array, but at much lower cost.

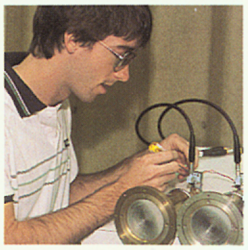
In a project for the Navy, GTRI engineers built a variable-beam-width antenna. The antenna's unique design uses computer-controlled stepper motors to vary the position of a subreflector, allowing a linear change in beam-width over a 1-7 degree range.

Other major areas of research included:

- Developing camouflage materials and systems that simultaneously reduce visibility in the visible and other portions of the spectrum; and
- Developing techniques to analyze radar scattering effects caused by engine ducts and other cavities in aircraft.

Left, *GTRI engineers developed the Modulated Scattering Technique for making near-field measurements in minutes or seconds instead of hours.*

COMMUNICATIONS



Communications systems are becoming more complex and increasingly dependent upon sophisticated signaling waveforms. Issues such as interceptability and vulnerability are of fundamental importance, particularly in military networks. In FY 88, GTRI communications engineers continued to develop new methods for communications design, placing special emphasis on signaling methods with greater immunity to electronic countermeasures.

Signals used in command, control and communications networks are propagated over large areas. For this reason, vulnerability to surreptitious monitoring or deliberate jamming are major concerns. GTRI engineers applied techniques to precisely define such vulnerabilities, and suggested methods to overcome potential problem areas. The effectiveness of electronic countermeasures is being analytically modeled, and communications equipment is being laboratory tested. Extensions to modulation techniques such as frequency-hopping and direct sequence are also being subjected to extensive laboratory analysis. An example of related research is a project for the U.S. Air Force which combines automatic signal adaptation to the environment with spectral dispersion.

GTRI developed new methods for communications design, with emphasis on immunity to electronic countermeasures.

To acquire additional information about signals in the environment, GTRI researchers studied numerous passive signal collection techniques. Based on equipment designed for the U.S. Army under an earlier project, modifications and improvements were made to increase the capability to acquire wideband signals at millimeter wavelengths. In another project for the Army, researchers worked on a computer model to characterize receiver response to a distribution of communications signals. FY 88 also saw the initiation of a major research effort with the Rome Air Development Center of the U.S. Air Force. This new research program involves communications technology as applied to command, control, communications and intelligence. Assisted by a team of industrial laboratories, GTRI serves as the prime contractor. Research topics include photonic communications, evaluation of an Air Defense Initiative network, and interactive modeling of communications.

Other important projects during the year included:

- Evaluation of a local area network (LAN) for use by the U.S. Navy;
- Design of a special processor for telemetry data acquisition; and
- Determination of processing speed requirements and identification of specific communications circuits benefitting most from high speed digital implementation.

Top left, *GTRI engineers redesigned a millimeter wave assembly to improve gain and sidelobe characteristics. The assembly will be used in signal surveillance and direction-finding.* Above, *researchers have performed computer-aided design of communications systems hardware.*

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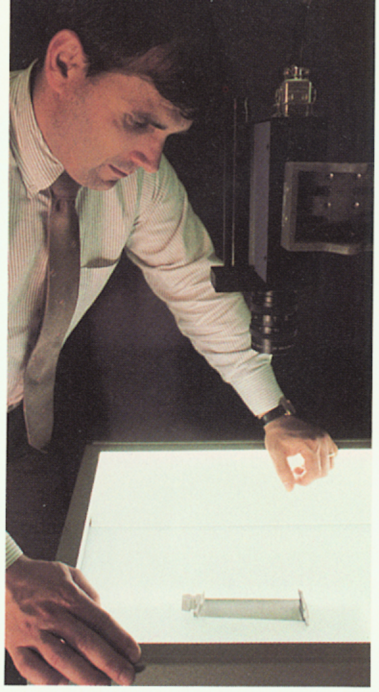
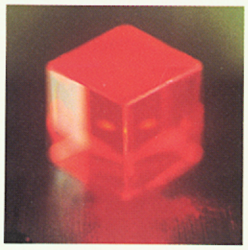




Above, *as part of a machine vision development effort, GTRI engineers measure spectral reflectance properties of machine parts.* Top right, *an integrated optic wave guide used for interferometric sensor studies. Integrated optics shows promise for industrial sensing applications.*

One of only three apparel advanced manufacturing technology demonstration centers in the nation was created at Georgia Tech in FY 88 with three-year funding by the Defense Logistics Agency. Administered by GTRI in cooperation with the School of Textile Engineering and the Southern College of Technology, the center will recruit member companies to support long-term, self-sustained operation. It will perform research and development of advanced technologies, demonstrate commercially available advanced manufacturing equipment in a pilot plant, and provide education and training to students and industry. The goal is to revitalize the U.S. apparel industry by enabling manufacturers to improve their productivity and the quality of their products through high technology, offsetting low-wage competition from abroad.

Plans for a $30-million Manufacturing Research Center were announced jointly by Georgia Tech and the Governor of Georgia, with groundbreaking scheduled for September 1988. The building will provide a unique, highly flexible environment in which to conduct research in processing and assembly methods. The center's initial focus will be electronics manufacturing. GTRI will play a major role in the interdisciplinary research conducted at the center.

A new program in metals processing started during the year, emphasizing the processing of metals for rod, wire and sheet materials. Studies began on lubricant contamination by metallic fines during metalworking and detrimental effects of organic additives used during electroplating of copper cathodes. Another study focused on the processability of continuously cast aluminum and copper alloys with a view to increasing processing speed and improving surface quality through stringent process and statistical quality control. Industry donated several key items of equipment, including a wire drawing machine that simulates actual manufacturing conditions, as well as an automated computerized laser cutter for metal fabrication and a multi-wire drawing machine to produce twisted bundles of fine wire.

In response to the growing importance of sensors in industry, GTRI embarked on a major effort to develop advanced optoelectronic sensors based on fiber optics and integrated optics for use in sensing and inspection operations. These systems provide sophisticated, extremely sensitive sensing techniques in compact, low-cost packages. They also employ passive measurement techniques, making them useful in hazardous environments and areas with high electromagnetic interface. Engineers are developing integrated optic chemical sensors for process control and hazardous agent detection, surface inspection systems, non-contact torque sensors for rotating shafts, and surface motion measurement sensors.

Another emerging research area was strategic logistics planning. Studies on optimizing warehouse and distribution systems included warehouse location, distribution of inventory among warehouses, and logistics of transportation to the customer. In a truck routing and scheduling study, researchers developed a program for selecting the most efficient pickup and delivery route for a fleet of vehicles, and began refining the program to consider critical time constraints.

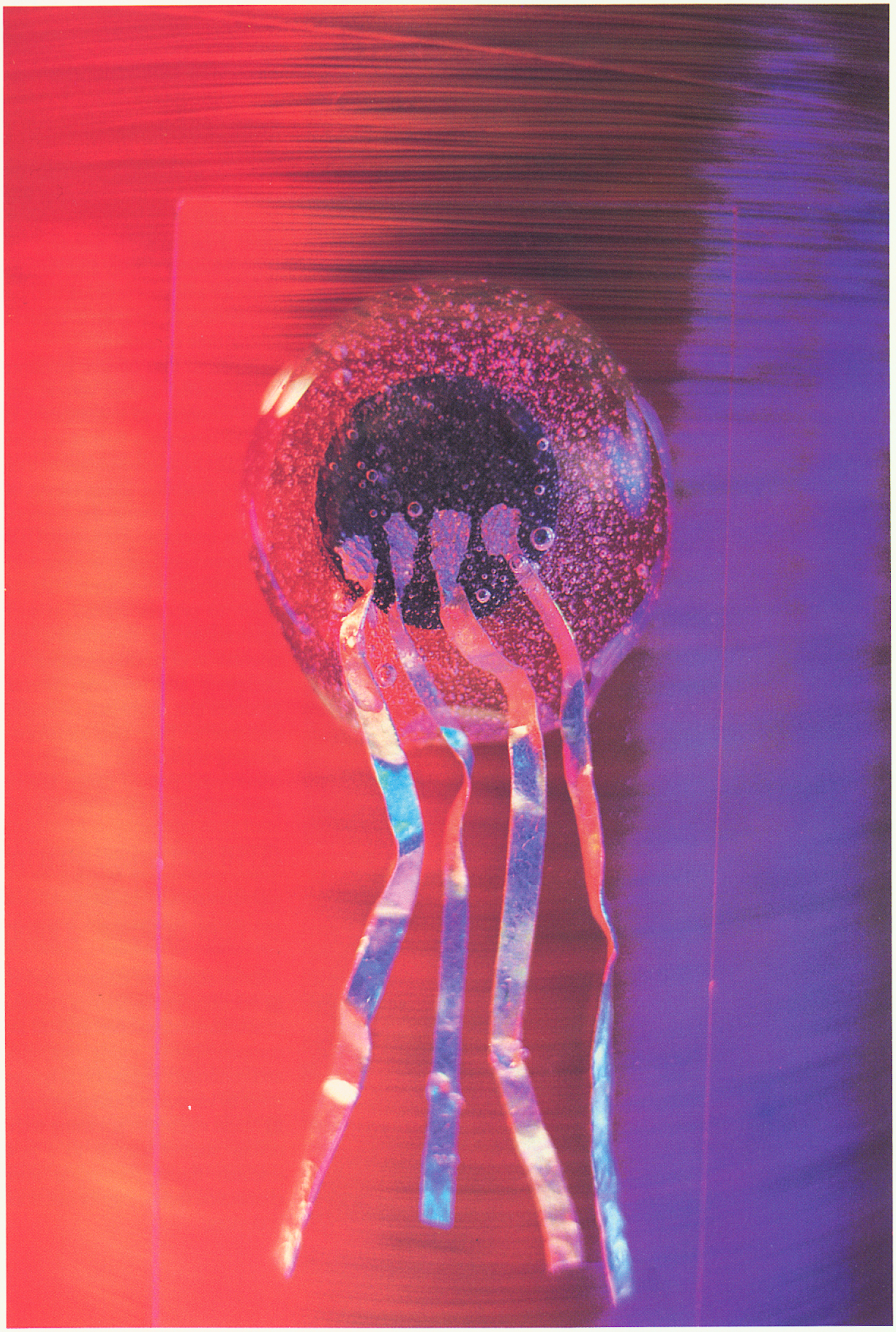
Research into off-wire guidance of automated guided vehicle systems advanced to investigation of how to program a fleet of vehicles to efficiently take advantage of their off-wire flexibility. Other efforts focused on improving the human/system interface.

Researchers began working with the food industry to apply machine vision to process control in such applications as determining the orientation of products undergoing packaging and spotting oversize products that might jam packaging equipment. They also developed imaging software for inspection of commercial printed circuit boards prior to shipment from the factory.

GTRI embarked on a major effort to develop advanced optoelectronic sensors based on fiber optics and integrated optics.

Other significant efforts included:

- Adoption by the State of Georgia of standards developed at GTRI for computer-based voting machines and continued evaluation of equipment by various manufacturers; and
- Made electronic soldering technology studies leading to a new research thrust concerning interconnection technology for electronic devices.



Above, *GTRI scientists helped Tech physicist Ahmet Erbil analyze a sample material that shows indications of superconductivity at very high temperatures.* Top right, *engineers developed materials with unique properties using solar thermal energy and chemical vapor deposition. An example is this hafnium carbide whisker formation.*

In FY 88, GTRI scientists modeled a new chemical vapor infiltration process to fabricate ceramic composites, developed by researchers at Oak Ridge National Laboratory. The technique uses pressure and temperature differentials to decrease fabrication time from several weeks to approximately five hours, and optimizes the densification process as well, creating stronger and tougher ceramics. The analytical model will indicate the process to be used for larger and more complex shapes.

GTRI stepped up the tempo of its research into another process — chemical vapor deposition — as a way to make and reinforce many materials: from fiber-reinforced ceramic composite materials for high-temperature structural applications to superconductor components. This year, for the first time, Tech scientists were able to grow hafnium carbide whiskers (crystals) comparable in size to commercially available whiskers for use as reinforcing fibers to make ceramics less brittle. A new research thrust involved chemical vapor deposition as a way to deposit thin films of high-temperature superconducting oxide materials onto a ductile substrate or "wire," as well as onto microchips.

Scientists also investigated a unique method of chemical vapor deposition using a solar furnace. When the assembly is heated by sunlight, the reaction is limited to the zone where the sunbeam is focused. Rapid heating and cooling take place, preventing unwanted secondary reactions.

Other solar thermal processing activities included:

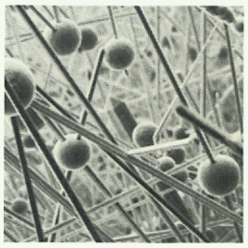
- Producing new grades of carbon fibers with much improved properties that cannot be produced by other methods; and
- Heat-treating carbon steel with nitrogen gas by solar exposure, modifying the metal surface to increase surface hardness.

In FY 88, scientists achieved considerable improvement in the oxidation resistance of carbon fibers, thus extending their usable temperature range. Carbon fiber composites show promise for space applications and any other process where high temperature resistance is required.

The GTRI computer-controlled plasma spray equipment was used in several industrial projects involving the coating of refractory metals and ceramics. In one project, ceramic materials were sprayed onto parts used to make the mold for jet engine turbine blades. The technique improves resistance to high temperatures and corrosion. Engineers also formulated new coatings to produce unique thermoelectric devices. For a prominent international automotive manufacturer, they designed a unique thermoelectric generator that uses engine exhaust gas to produce electricity and delivered a complete prototype to the sponsor.

GTRI researchers proved the economic and engineering feasibility of the thermite process for synthesizing titanium diboride powder. Patents are pending on the technology, which is ready to be scaled up for commercialization. They achieved hot pressing of large, highly dense shapes from the powder. Because the material is extremely hard, chemically inert, and electrically conductive, it is useful in a broad range of industrial, space and defense applications.

Work continued on electroactive polymeric materials for tactile sensing. One application would give industrial robots the touch sensitivity of human fingers. Polymer scientists also began developing pressure-sensitive pads for medical uses such as pads to place in the shoes of persons who have lost feeling in their feet.



For the magnetic recording tape industry, scientists formulated improved magnetic coatings, providing better dispersion of magnetic particles and reducing their volatile organic content to make these coatings less toxic. They also developed aircraft coatings with lower volatile organic content.

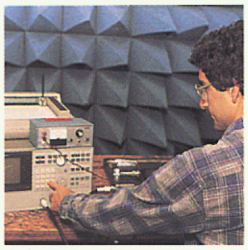
A new materials development program was initiated at GTRI, focusing on development of new nonferrous metal alloys for mechanical and electrical applications. Researchers hope to improve material properties through microstructural control made possible by better thermo-mechanical processing.

GTRI stepped up the tempo of its research into chemical vapor deposition as a means of making and reinforcing materials.

Other research included:

- Applying GTRI's oriented molecular monolayer technology to optoelectronic devices to give them unique optical properties; and
- Developing methods for testing the effectiveness of various materials used to encapsulate asbestos in buildings, as well as recommending the best formulations and applications methods.

ELECTROMAGNETIC COMPATIBILITY



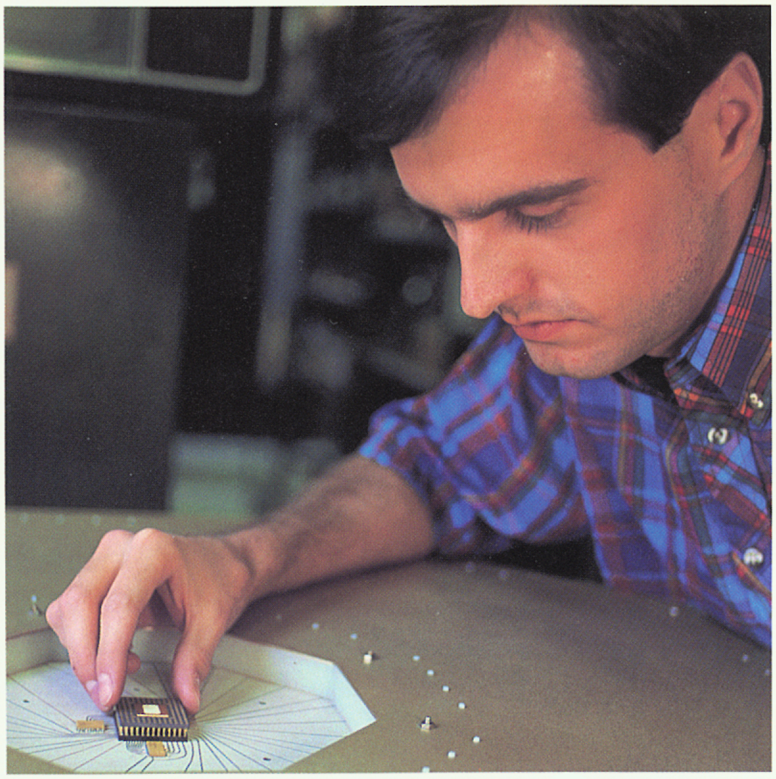
In FY 88, GTRI continued its research into the electromagnetic effects of various electronic devices upon each other and assessed their susceptibility to electromagnetic interference.

A major ongoing area of research focuses on the effects of external radio frequency sources on high-speed, high-density integrated circuits. GTRI engineers developed and used built-in test circuits to monitor these effects. They assessed the merits of currently available computer analysis models to evaluate the nonlinear behavior of monolithic microwave integrated circuits (MMIC), and pursued an extended program to perform laboratory evaluations of the effects of electromagnetic interferences on these circuits.

Development continued on an automated testing facility for examining the effects of electromagnetic energy on aircraft. GTRI serves as the prime integrator of this major program, which involves several subcontractors. GTRI is performing the overall systems design and integration, and is developing the automation software.

Engineers completed a program to develop techniques for protecting electronic traffic control equipment from lightning and other fleeting overvoltages. They also prepared four video training tapes and a manual for use by traffic engineers and installation/maintenance personnel nationwide.

GTRI researchers analyzed an Air Force test facility for investigating electromagnetic environmental effects. They defined the facility's capabilities and determined what modifications needed to be made to investigate the effects of high-powered microwave energy on electronic equipment.



Above, *GTRI developed simplified measurement techniques using built-in-test for assessing the electromagnetic susceptibility of VLSI devices.* Top left, *engineers assessed the shielding-effectiveness of experimental flex cable shields at cryogenic temperatures.*

Engineers developed techniques for protecting electronic traffic control equipment from lightning and other fleeting overvoltages.

Other activities included:

- Investigating the performance properties of shielded ribbon cables under operating conditions such as extreme cold;
- Continuing tests of cardiac pacemakers for various manufacturers;
- Continuing development of standards for electronic hardware that would be used for computer control of the "smart house" of the future;
- Analyzing and measuring the electrical behavior of bonding straps used on ships at sea; and
- Verifying the compatible performance of a large airborne phased-array antenna designed and built at Georgia Tech.

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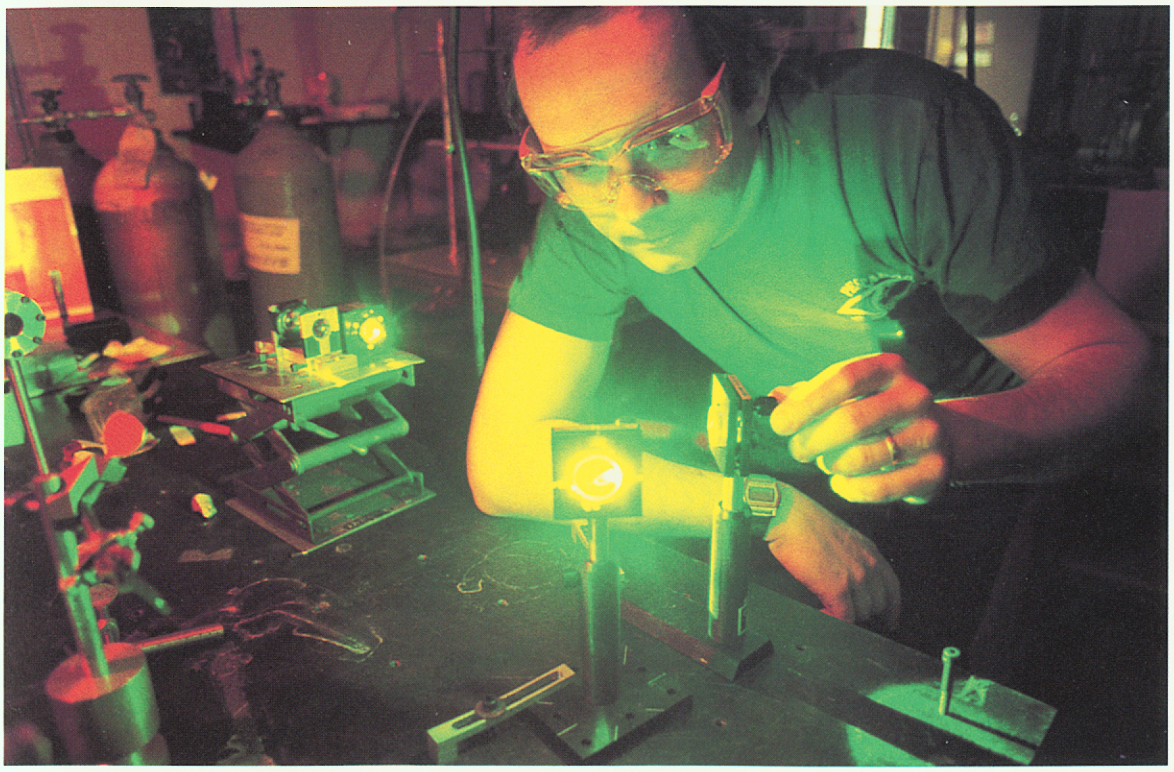


Above, *a researcher aligns a pulsed dye laser beam as part of an atmospheric chemistry experiment.* Top right, *GTRI scientists used the rare mineral, cacoxenite, to search for keys to making molecular sieves with cacoxenite's ultra-large pores.*

Atmospheric chemistry research at GTRI is making important contributions to the understanding of how human activity affects the environment. In FY 88, researchers began studying moderately long-lived oxygenated organic compounds that may affect the concentration of ozone and OH radicals in the lower atmosphere far away from man-made sources of pollution.

Construction of a new resonance Raman spectroscopy apparatus improved GTRI's experimental capability to identify and measure atmospheric free radical reactions in the aqueous phase. Scientists continued to use the long-path absorption method to detect minute concentrations of free radicals, but the Raman spectroscope enabled them to be much more selective in identifying the specific molecules detected. These studies are conducted primarily to aid in understanding the oxidation of sulfur in clouds, a process that is related to the production of acid rain.

In other acid rain-related research, scientists continued their pioneering identification and characterization of gaseous ions in the lower atmosphere, identifying several new ion species as well as neutral chemical species.

They also initiated studies of large ion clusters that could grow into aerosols or droplets, using a newly acquired aerosol monitor that detects nanometer-size particles and determines their concentrations as a function of size. This instrument will be used to look for ion-induced growth of the condensation nuclei that trigger the formation of rain and smog.

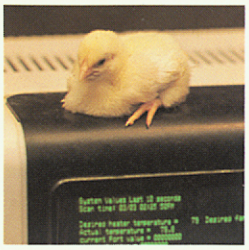
Identification and measurement of ion species under high-voltage DC power lines continued as an aid in assessing their potential biological hazards. Research also continued on the roles of halogens as catalysts in destroying the stratospheric ozone layer that protects the Earth from excessive ultraviolet radiation.

Scientists in the molecular sieve and zeolite program secured samples of cacoxenite, a rare natural mineral with an ultra-large pore structure, analyzed it, and studied its properties with a view to synthesizing it and related materials. These materials would be used as catalysts for more efficient and complete conversion of crude oil.

They also made progress on two more programs for production of usable fuels. Researchers worked on converting gasified coal directly into gasoline in a one-step process using a GTRI-patented ferrisilicate molecular sieve. They also tested several zeolites for use as catalysts to stabilize and improve the quality of the oil resulting from the Georgia Tech entrained pyrolysis process for converting biomass to fuel.

GTRI scientists continued their pioneering identification and characterization of gaseous ions in the lower atmosphere.

GTRI also applied for a patent on a zeolite process to synthesize a substitute pigment for ultramarine blue.



Continuing a tradition of cooperation with the Georgia Poultry Federation to bring the latest technological developments to Georgia's largest agribusiness, GTRI engineers addressed several priority areas in FY 88.

Most poultry processors treat wastewater in a way that produces a large volume of treatment skimmings consisting of at least 90 percent water. The expense of dewatering these skimmings for product recycling is high, and disposal costs are even higher. In FY 88, GTRI engineers completed field tests on

GTRI engineers developed a pilot-scale Thermally Enhanced Dewatering System to recycle nutrients in poultry plant wastewater.

their pilot-scale thermally enhanced dewatering unit with promising results: more than half of the water was removed in less than four hours. They then modified the unit for continuous rather than batch operation and again put it through field tests at several poultry plants. Preliminary results indicate that it is a highly cost-effective way to dewater skimmings under actual plant operating conditions.

Engineers also expanded their studies of anaerobic packed-bed reactor treatment of poultry processing wastewater, testing a pilot unit at a poultry plant throughout the year. Concurrently, they continued laboratory studies to better measure the effects of temperature and wastewater concentration on the digestion processes. This treatment method offers a number of advantages over conventional treatment techniques, including the virtual elimination of skimmings.

GTRI's efforts to enhance the productivity of poultry processors focused in FY 88 on a long-term project to develop a computerized machine system for the processing line. During the year, the system was developed to the point that it could reliably identify cut-up parts in fractions of a second and perform basic sizing and grading functions. Engineers developed the software for interpreting the images and looked at ways to protect the hardware (camera) from harsh and humid conditions in the plant. They also conducted lighting enhancement studies and began exploring long-term applications for machine vision, including its use in U.S. Department of Agriculture inspection of whole birds on the processing line.

With recent national publicity on salmonella contamination of fresh meat, the poultry industry is taking

a closer look at possible sources of cross-contamination in the processing operation, particularly when new equipment is introduced. Tech and University of Georgia researchers collaborated in a pioneering effort to help define a more detailed microbiological screening procedure for new equipment approval, establishing a new benchmark for safety evaluation.

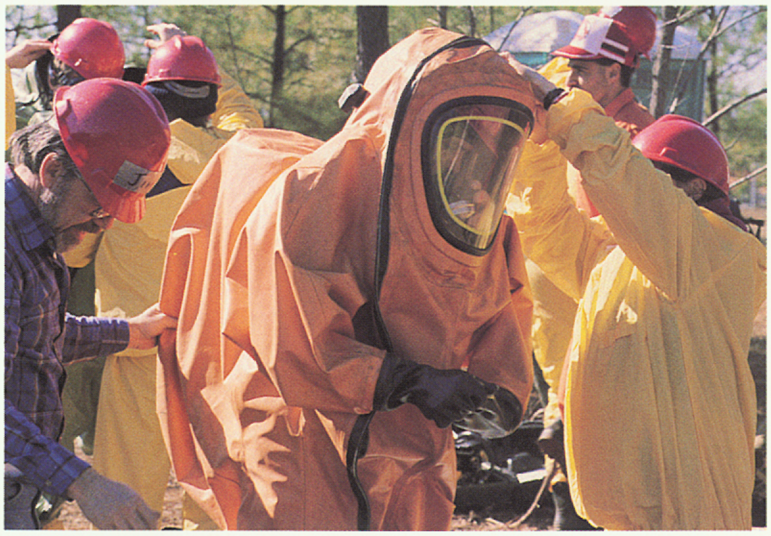
Tech engineers continued work on the farm computer for environmental monitoring and control of broiler houses. The latest improvements incorporate low-cost microprocessors to enable farmers with multiple growout houses to link them to one central computer, thus reducing costs. Researchers also worked to enhance system reliability, particularly in the area of sensor accuracy. They refined the system to incorporate the latest technology and upgraded computer control sequences to improve environmental growout conditions. The system's performance continues to be constantly monitored to determine the extent of its impact on flock quality. Researchers also began developing an expert system to help the farmer optimize the set points for the farm computer system.

Other activities included:

- Assessing poultry industry energy needs and publishing a guidebook on how to use biogas;
- Transferring technology through workshops, publications and trade show exhibits;
- Providing technical assistance in response to industry requests; and
- Mailing more than 8,000 copies of newsletters and research summaries.

Top left, *GTRI researchers helped install computers in poultry growout houses.* Near left, *a Thermally Enhanced Dewatering System was developed at GTRI for recycling nutrients in poultry processing plant wastewater.*

GEORGIA TECH RESEARCH INSTITUTE



Above, *GTRI continued its popular hazardous material control and emergency response school.* Top right, *environmental specialists tested homes for radon pollution as part of a new research emphasis.*

GTRI continued to gain national recognition for its expertise in the environmental sciences in FY 88.

Researchers completed the first phase of a comprehensive study of the relationship of building design to indoor air pollution and the health of occupants. They compared several types of buildings, including a specially constructed prototype designed to be pollution-free. The multi-agency study, the only one of its kind, is continuing.

In a more focused study, indoor air specialists investigated the evolution of volatile organic compounds and other pollutants emitted by building furnishings and construction materials, such as pressed woods, paints, wallpaper, glues, upholstery fabrics, and carpeting. Environmental chambers were used to test items submitted by manufacturers. The results will help determine how to create healthy office environments.

In response to concern about concentrations of radon gas within structures, GTRI conducted bimonthly radon awareness seminars for the public and initiated a research program. Specialists tested homes and public buildings for radon levels and looked at ways to mitigate the problem.

Other research tackled the lead-based paint problem. Researchers established performance criteria for portable x-ray fluorescence analyzers used to detect lead in paint, as well as in other heavy metals. They tested commercially available equipment and recommended modifications to achieve maximum performance. They also began determining design specifications for a more versatile analyzer that could be used for lead detection in both paint and soils. Preliminary design studies involved analysis of heavy metals using x-ray fluorescence. Scientists also established the most appropriate method to identify heavy metals in soil samples, an important aspect of evaluating hazardous waste sites.

The Research Institute continued to be a world leader in asbestos-related information and training. A new two-week course provided training in asbestos analysis by transmission electron microscopy. Multiple offerings of several different courses on asbestos abatement and management were conducted in locations across the nation, and West Germany was added to the list of international course sites. A special training program in asbestos abatement was conducted to help the Georgia Department of Education in the enormous evaluation and abatement problems it faces.

Concern with environmental safety led GTRI to offer a wide array of other courses. To deal with the national problem of leaking and underground storage tanks, GTRI developed the only two hands-on training courses in the U.S. to demonstrate tank installation, leak detection procedures, and remedial actions. Another new course dealt with lead-based paint issues. The Research Institute also declared a safety courses week in April, presenting seven courses on construction safety. Others of the more than 100 course offerings included the five-day hazardous material control and emergency response school which is presented monthly, as well as occupational safety and health, ergonomics, food processing, and machine vision.

Other significant activities included:

- Conducting an international Food Processing Waste Conference that attracted more than 200 environmental professionals and resulted in the presentation of more than 40 technical papers on topics ranging from process control to by-product utilization;
- Joining forces with four academic schools at Georgia Tech on a major study sponsored by the U.S. Environmental Protection Agency on the transport and fate of environmental contaminants; and
- Establishing a new program of technical consultation and training in biosafety aimed at hospitals and medical and biotechnology laboratories.

GTRI continued to be a world leader in asbestos-related information and training.

GTRI industrial extension specialists helped a manufacturer of bathroom fixtures solve technical problems and improve competitiveness.

In FY 88, GTRI completed its 28th year of fulfilling its state charter "to aid the industrial and economic development of the state." It accomplished this mission through research, technical assistance, and education.

An economic development research program begun in 1985 to aid the economic development of rural Georgia began to show big results in FY 88. A number of these studies provided key information to industries looking at Georgia as a potential site for their plants. Three of them — on the oriented strand board, aerospace and cold storage industries — resulted in the construction or announcement of six plants totaling $213 million in capital investment and 1,830 in projected jobs. All but one of these plants were located in rural areas.

The dozen applied research studies conducted in FY 88 included topics such as the market potential for manufacturing film-face plywood in Georgia, the feasibility of commercially producing cut flowers, the tourism potential of a multi-county area in north Georgia, and an update of GTRI's popular metalworking job shop directory. Economic researchers also continued to perform computerized target industry analyses in which a community's resources are matched with specific industries' requirements, as well as market studies for business and industrial sponsors.

GTRI began a cooperative relationship with the University of Georgia to promote the economic development of the state. An initial project was a seminar on the banker's role in economic development which they jointly sponsored in several low-growth areas of the state.

GTRI strengthened its relationship with the University of Georgia to promote the economic development of the state.

GEORGIA TECH RESEARCH INSTITUTE

Economic development specialists at GTRI also served in supportive and advisory capacities for the Georgia Rural Economic Development Study and the Governor's Growth Strategies Commission. In this way they helped shape the future policies of the state.

Economic development assistance ranged from helping a chamber of commerce better utilize its computers to developing a desktop publishing program to facilitate the Georgia Department of Industry and Trade's production of community fact sheets for prospective industry.

Early in the year, the Rome regional office expanded its staff to become a Georgia Technology Center. It joined five other technology centers in providing an increased volume and array of technical assistance to industries and community organizations in their areas. The Columbus office added a second engineer. These centers and five other regional offices in the statewide industrial extension network assisted more than 2,000 businesses and some 65 economic groups in FY 88.

The Georgia Procurement Assistance Center went into its third year of helping Georgia businesses obtain federal and state government contracts. In FY 88, the service assisted some 150 firms, including approximately 50 small, disadvantaged businesses. Since its inception, the center has helped Georgia firms obtain approximately $3 million in new awards, and more than $4.5 million in awards were pending in mid-FY 88. The center also started a computer-based service to match government procurement needs with the capabilities and products of subscriber companies.

Other federally sponsored programs of technical assistance continued. GTRI specialists advised companies impacted by foreign imports and helped industries in rural areas to survive and grow. They rendered technical assistance to more than 600 Georgia companies on hazardous waste management and workplace safety and health. They also provided expertise to minority business groups, such as evaluating the technical feasibility of manufacturing a stand-alone power system patented by a minority inventor.

The state-sponsored Georgia Productivity Center provided in-depth analysis of the strengths and weaknesses of some 30 firms and helped them set goals for productivity improvement. Center personnel also conducted audits of quality control and performance measurement systems, and served as a resource to firms interested in adopting participatory management strategies.

Above, *GTRI economic research reports assisted the State of Georgia in its marketing efforts to attract new industry to Georgia.* Top right, *a GTRI field engineer helped an Atlanta minority firm improve its in-plant layout for future growth.*

In the energy conservation field, engineers conducted energy audits of 90 industries, 140 schools and hospitals, four youth development centers, and 12 low-income housing communities. They also provided nearly 200 telephone assists and conducted two industrial energy workshops.

GTRI demonstrated its commitment to education and training in several ways. The Macon Technology Center continued to act as an open site where industry representatives could come to take televised continuing education courses via satellite downlinks. An average of five specialized engineering courses a month were offered to a small but steady stream of participants from area industry. GTRI also worked with larger industries in the state to set up off-campus video-based graduate engineering courses for academic credit.

The Industrial Education Group expanded its new technical curriculum while continuing to offer on-site human relations and supervisory courses to Georgia industry. Successful new courses included statistical process control and quality control concepts. Service industries such as hospitals were added to an ever-increasing client base. The demand also increased for other training services, such as needs analysis and custom course design.

From left are: *Patrick J. O'Hare, Gerald J. Carey, Howard G. Dean, Jr., Robert G. Shackelford, James C. Wiltse, and Donald J. Grace.*

OFFICE OF THE DIRECTOR

Dr. Donald J. Grace, GTRI Director (404) 894-3400

Gerald J. Carey, Associate Director (404) 894-3479

Howard G. Dean, Jr., Associate Director (404) 894-3492

Robert G. Shackelford, Associate Director (404) 894-3404

Dr. James C. Wiltse, Associate Director (404) 894-3494

Patrick J. O'Hare, Assistant Director Administration (404) 894-3490

LABORATORIES

Economic Development Laboratory
Dr. David S. Clifton, Director
(404) 894-3841
Agricultural Research, Cost-benefit Analysis, Energy Economics, Hazardous Waste Management, Industrial Energy Conservation, Industrial Hygiene, Industrial Market Research, Local Economic Development, Productivity, Safety Engineering, Technology Transfer

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(404) 421-7035
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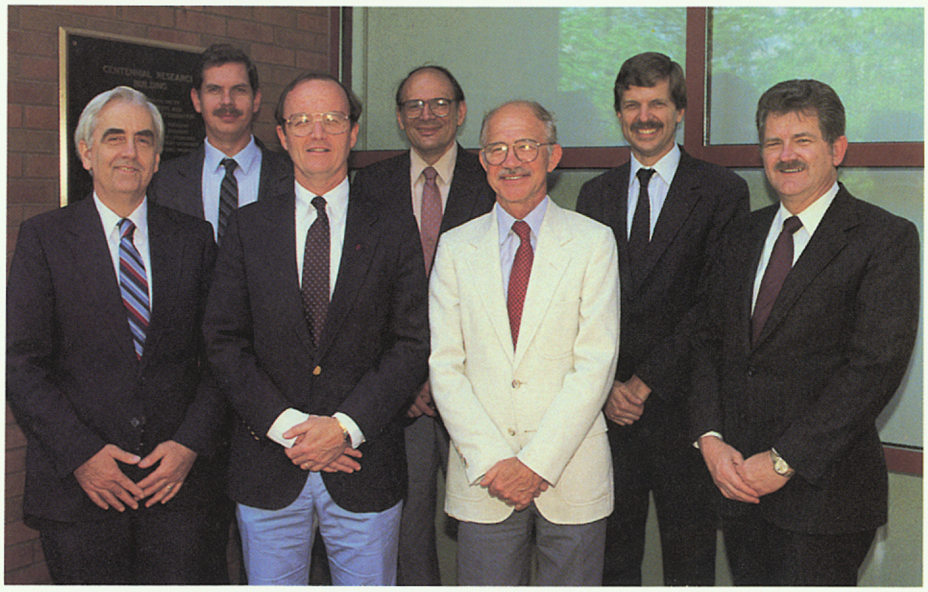
From left, GTRI's laboratory directors are: *Fred L. Cain, Devon G. Crowe, Dr. Edward K. Reedy, Robert P. Zimmer, Dr. Hans O. Spauschus, Dr. David S. Clifton, and Dr. Charles K. Watt.*



Systems & Techniques Laboratory
Dr. Charles K. Watt, Director
(404) 421-7010
Defense Electronics, Systems Development, Microwave Systems, Antenna Systems

Electronics & Computer Systems Laboratory
Fred L. Cain, Director
(404) 894-3542
Antenna Development, Biomedical Electronics, Command and Control, Communications, Computer Applications, Electromagnetic Compatibility, Millimeter Wave Technology, Manufacturing Technology, Electromagnetic Analysis

For further information about the Georgia Tech Research Institute, please call or write:
Office of the Director
Georgia Tech Research Institute
Centennial Research Building
Georgia Institute of Technology
Atlanta, Georgia 30332
(404) 894-3400

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Mark Hodges, Editor
Joe Schwartz, Photographer
Martha Ann Stegar, Staff Writer
James E. Kloeppel, Staff Writer
Tish Grimes & Associates, Designer

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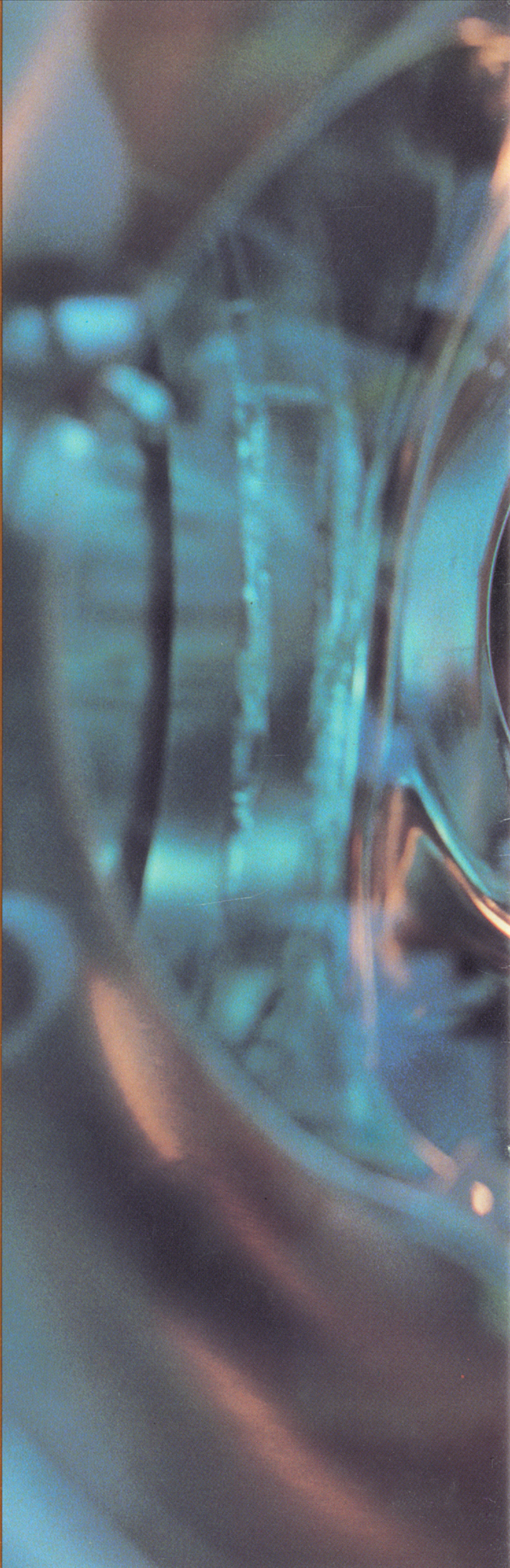

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