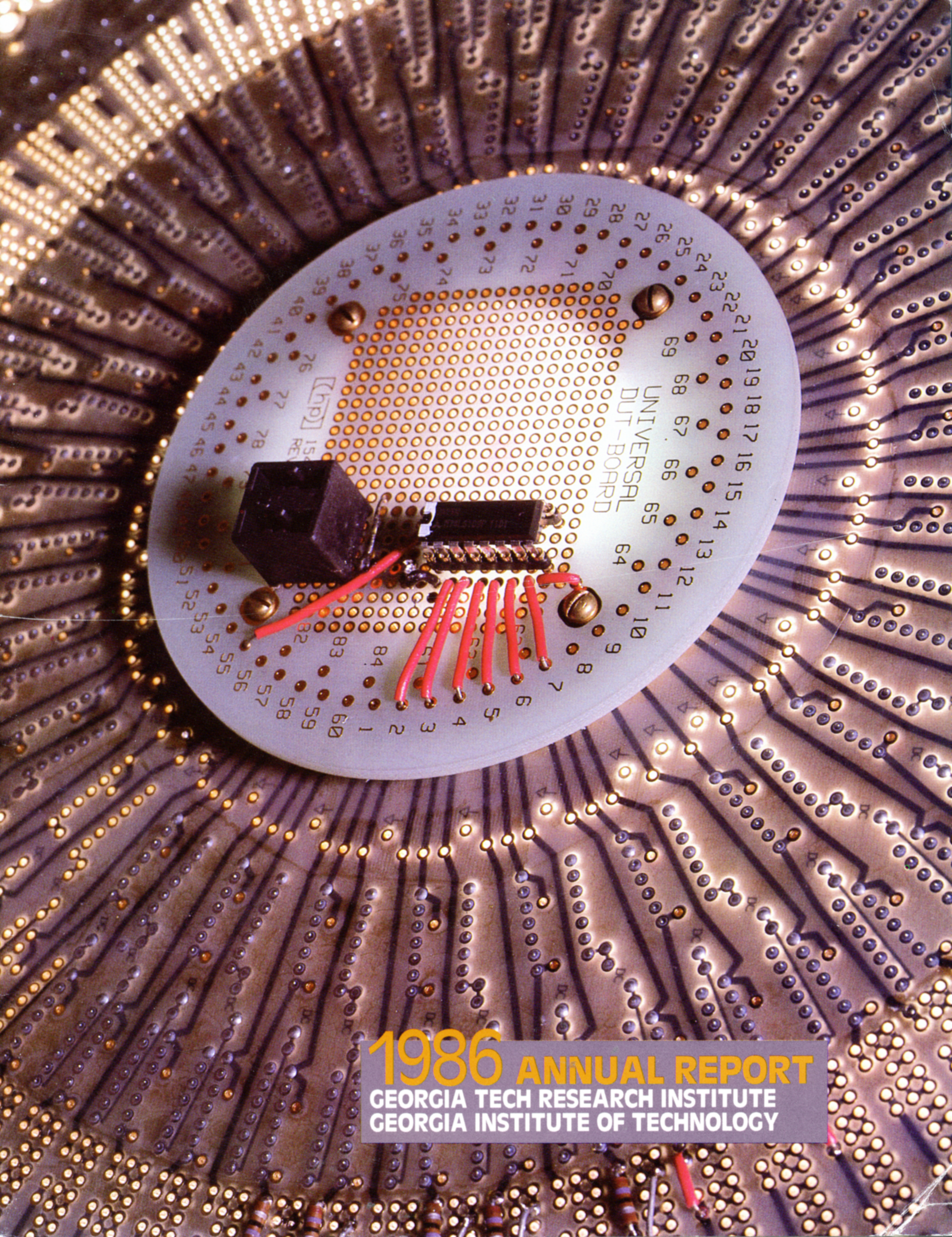
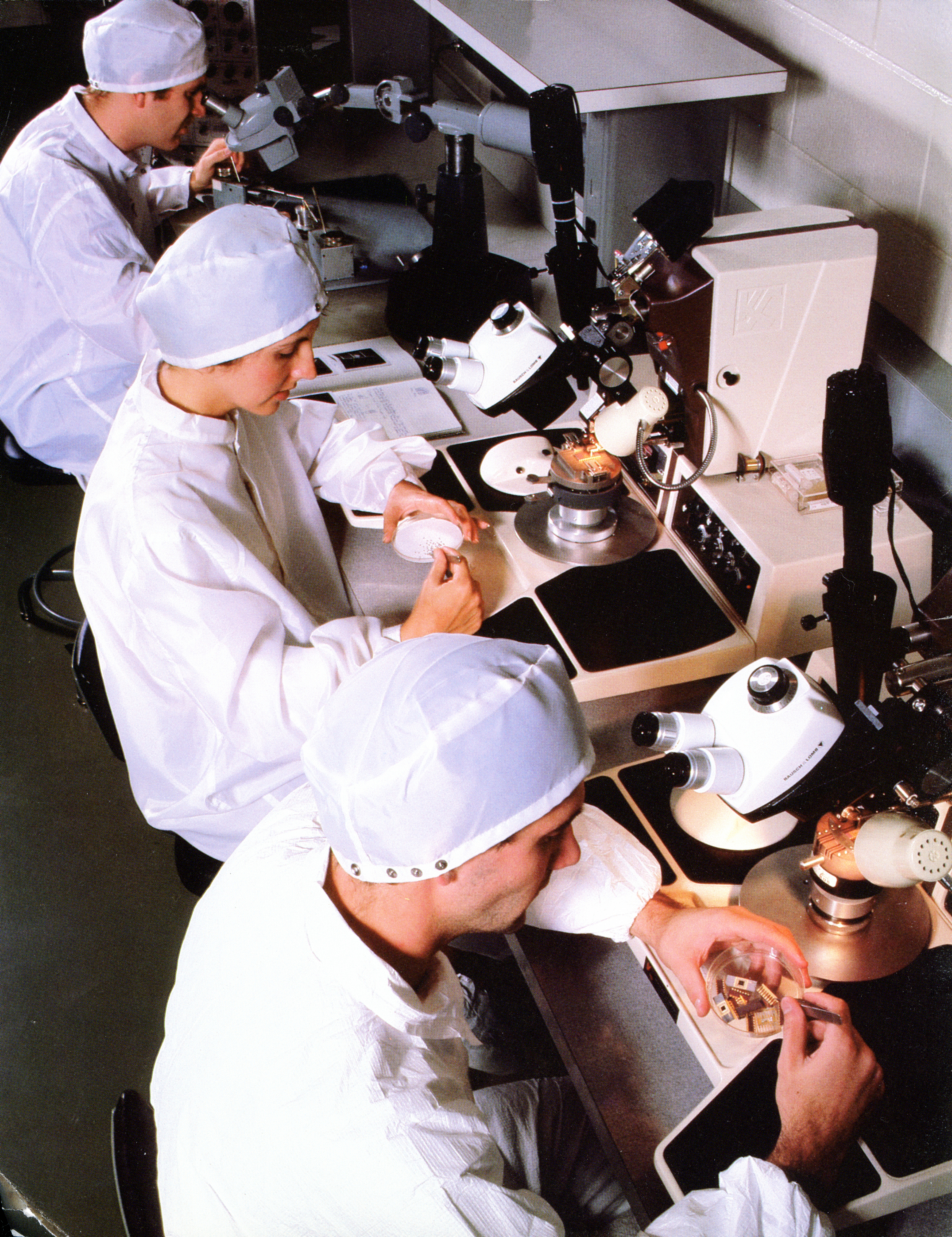


1986 ANNUAL REPORT

GEORGIA TECH RESEARCH INSTITUTE
GEORGIA INSTITUTE OF TECHNOLOGY

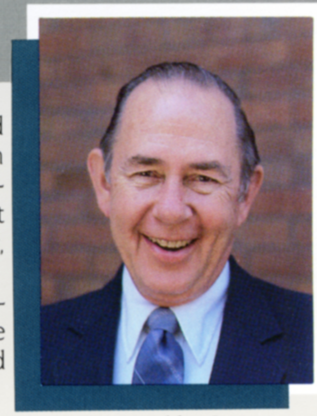


GEORGIA TECH RESEARCH INSTITUTE
1986 ANNUAL REPORT

CONTENTS

GTRI is a leader in developing new technologies for microelectronics applications. *Cover photo,* **researchers developed a methodology for measuring the electromagnetic susceptibility of high-speed, high-density integrated circuits.** *Facing page,* **engineers use a GTRI process to fabricate high-performance, low-noise, gallium arsenide field effect transistors.**

LETTER FROM THE DIRECTOR



Dr. Donald J. Grace

Two major developments dominated FY 86 at the Georgia Tech Research Institute. Spurred by increased competition in the research marketplace brought on partly by changes in federal funding, GTRI moved to:

- Conduct larger, multi-laboratory research programs for more cooperative and economical use of resources and personnel.
- Increase industrial sponsorship.

These moves, along with accompanying changes in organizational structure, have served to sharply focus GTRI's technological capabilities and thrusts, allowing more flexibility and integration in meeting clients' needs.

A good example of such increased flexibility and integration is GTRI's work for the Strategic Defense Initiative (SDI). SDI research at GTRI is strongly supported, with one contract alone totaling \$4.8 million. It is a broad-ranging effort, involving six of GTRI's seven laboratories. To coordinate these activities, the Research Institute established an SDI program office in the Office of the Director. Other areas in which GTRI is organizing large, multi-laboratory research programs are artificial intelligence, environmental health sciences, and electromagnetic signature analysis and reduction (for example, shielding our forces from enemy radar). Such programs involve cooperative efforts among researchers from different GTRI laboratories, as well as from Georgia Tech's academic colleges and schools.

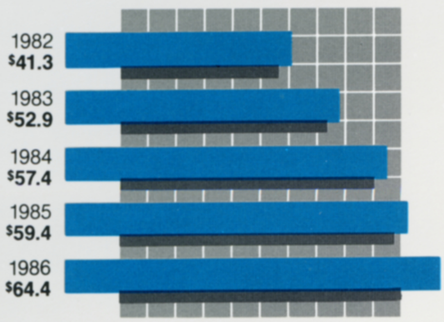
FY 86 was a year in which GTRI pursued and won such awards as:

- A \$7.3 million contract to develop and build one of the largest phased-array antennas ever to fly on an aircraft.
- A \$16.9 million contract from the U.S. Air Force to develop an advanced threat simulator — the single largest contract in GTRI's history.

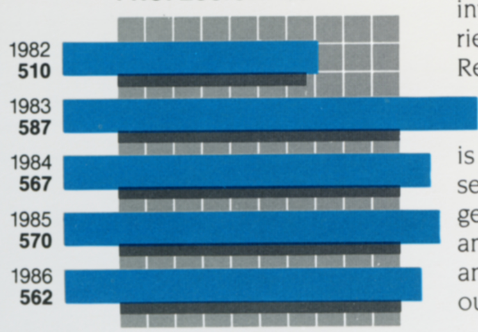
The Research Institute also responded to changes in the structure of federal funding by sharply increasing its industrial sponsorship. During FY 86, industry accounted for 21.9% of GTRI research dollars, compared to 14.0% in FY 85.

GTRI has played an especially significant role in fostering economic development in Georgia. Last year, the legislature provided funds to increase personnel and upgrade the level of services in five regional field offices. These offices, called Georgia Technology Centers, are located in Albany, Augusta, Gainesville, Macon, and Savannah. Their function will be to help businesses adopt new technologies, improve productivity, and gain access to GTRI's computerized technology and productivity

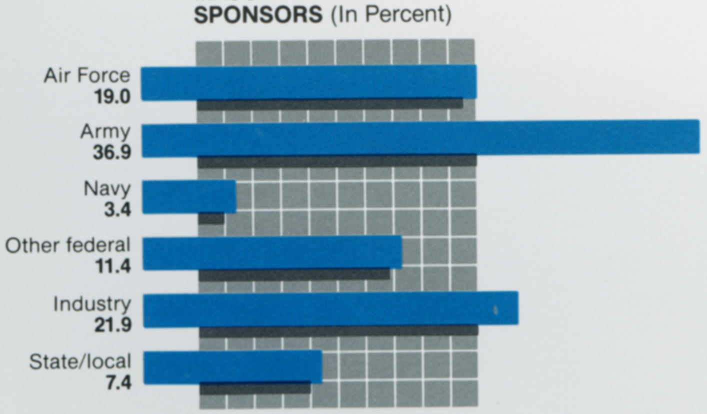
RESEARCH EXPENDITURES (Millions of Dollars)



NUMBER OF RESEARCH PROFESSIONALS



MAJOR SPONSORS (In Percent)



information retrieval service. The Centers grew out of the Georgia Tech Industrial Extension Service, which was established by the Georgia General Assembly in 1960, and today provides technical and management assistance to more than 1,500 industries annually.

Of special note is the expansion of GTRI's work in hazardous waste management. This program provides direct on-site consultation to companies that generate small quantities of hazardous waste, helping them to comply with new government regulations. Staffed by specialized scientists and engineers trained to deal with the full spectrum of Georgia's industry, the program has already provided assistance to hundreds of businesses throughout the state.

GTRI is also stepping up its efforts to provide technical assistance to industries on a national level. Among the highlights last year was the establishment of the Southeastern Procurement Technical Assistance Center at Georgia Tech. Cosponsored by the Defense Logistics Agency and GTRI, the Center helps businesses in seven southeastern states sell their products and services to the Department of Defense. In addition, the Research Institute conducted more than 60 training programs and workshops throughout the U.S. in such areas as radar reflectivity, millimeter waves, asbestos abatement, ergonomics, industrial toxicology, and indoor air quality.

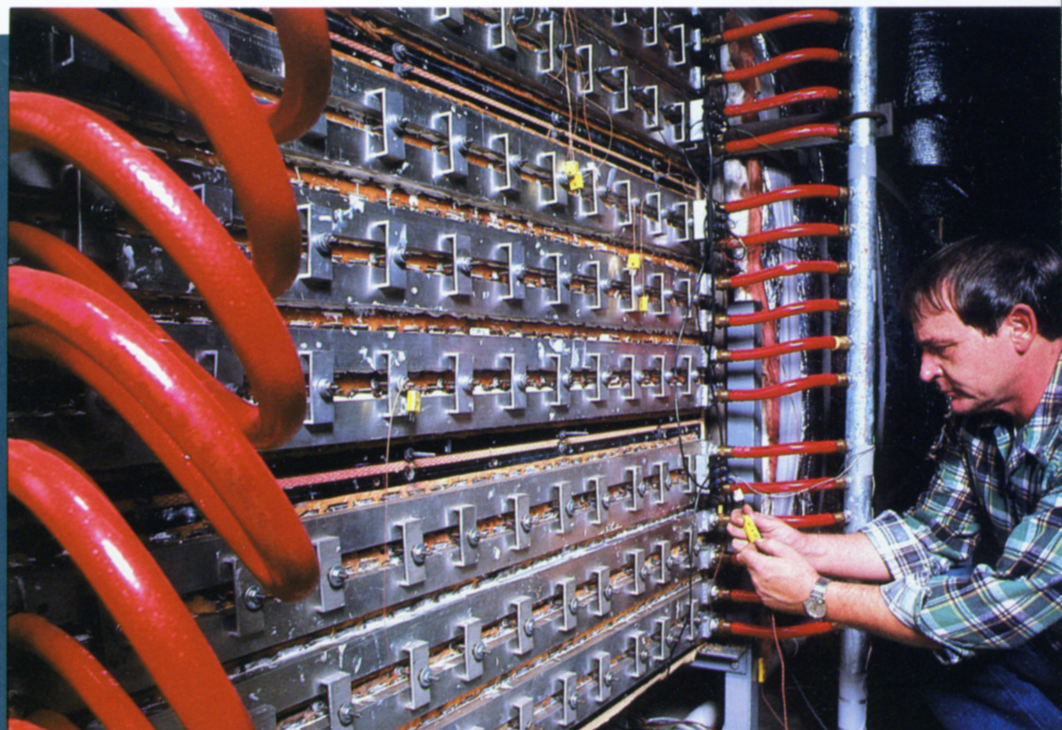
GTRI is proud of the strides it made during FY 86 to incorporate the computer into the workplace. The Research Institute has made agreements with several computer vendors to put in place over 100 state-of-the-art computer work stations. These stations are in addition to the hundreds of microcomputers, most of them PCs, which link staff and research professionals. During its first 18 months of operation, GTRI's Research Software Training Facility provided almost 10,000 hours of instruction to faculty and staff from the Tech community.

FY 86 was a difficult year for research universities because of changes and restrictions instituted by the federal procurement system. GTRI was particularly affected, and continues to be challenged to find new ways to cope successfully in a rapidly changing environment. I am confident, nonetheless, that we will overcome existing difficulties and increase the quality, breadth, and stature of our research.

That we were able to achieve as much as we did in FY 86 is due to the creativity, dedication, and motivation of our staff. To them I wish to express my deepest gratitude. What follows is a summary of their achievements during the last year.

Donald J. Grace

Donald J. Grace
Director
Georgia Tech Research Institute



Above, **GTRI engineers designed and built this prototype of an industrial-scale thermoelectric generator for Omnimax Energy Corporation.**

TECHNOLOGY INITIATIVES

In FY 86, GTRI implemented and expanded a number of new technologies, while extending the breadth and depth of more mature R&D programs. This research involved such topics as:

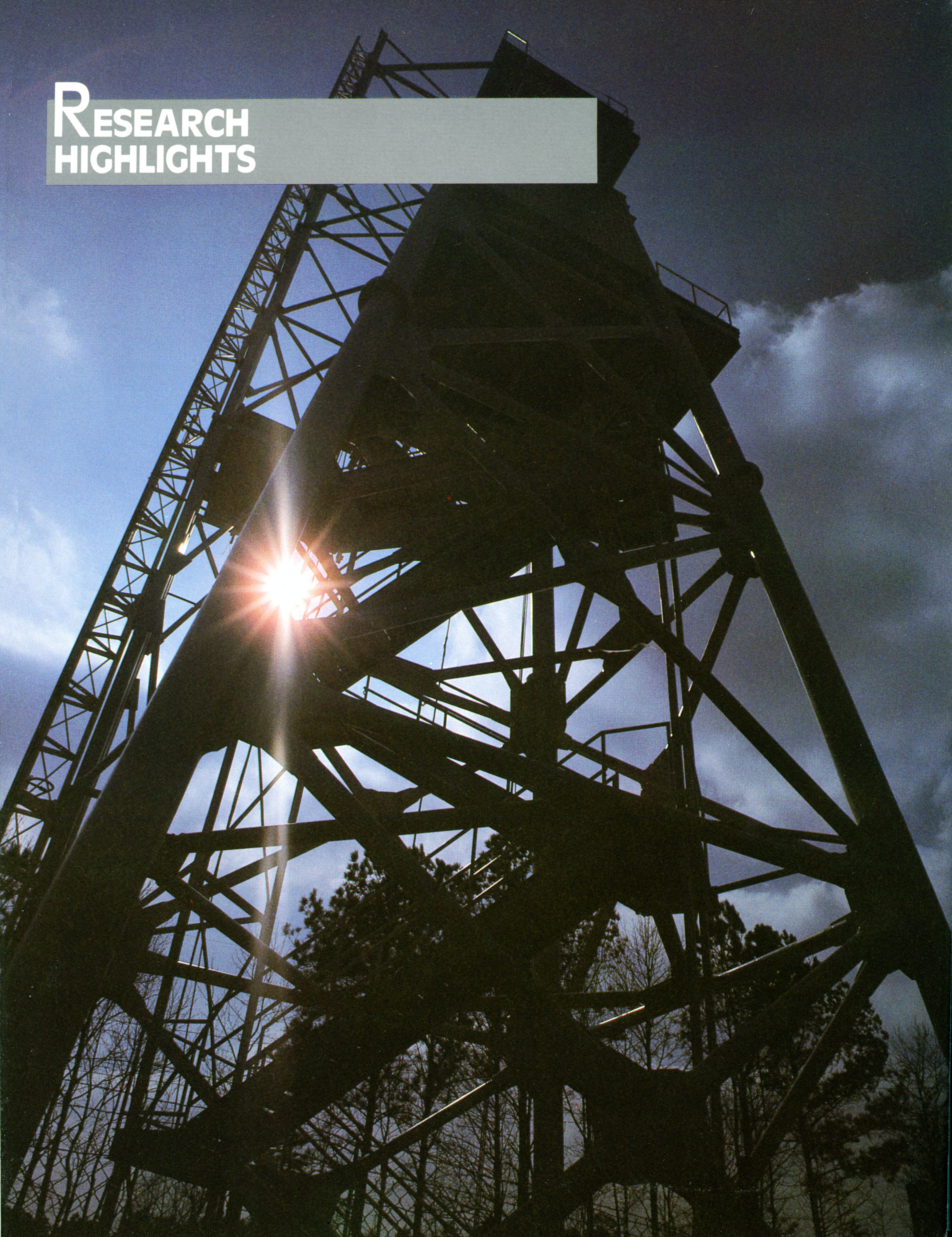
- ☐ **Advanced radar warning receiver systems**
- ☐ **Anaerobic filtration of wastewater**
- ☐ **Artificial intelligence techniques for diagnosing cardiovascular disease**
- ☐ **Asbestos and hazardous waste management**
- ☐ **Automated handling of mail parcels**
- ☐ **Automated truck loading and unloading**
- ☐ **Autonomous route planning for aircraft**
- ☐ **Carbon fiber composites**
- ☐ **Ceramic coatings**
- ☐ **Computer vision and optoelectronics**
- ☐ **Electromagnetic facilities for antenna and radar reflectivity measurements**
- ☐ **Electromagnetic monitoring of human vital signs**
- ☐ **Electromagnetic susceptibility measurements of integrated circuits**
- ☐ **Electronic systems for acoustically conveying information to pilots**
- ☐ **Free radical chemistry in cloud water**
- ☐ **Hierarchical systems for planning factory orders**
- ☐ **High-power, coherent radars**
- ☐ **Indoor air pollution studies**
- ☐ **Industrial toxicology**
- ☐ **Infrared scene simulation**
- ☐ **Infrared tracking systems**
- ☐ **Low-noise superheterodyne receivers**
- ☐ **Microbending loss in optical fibers**
- ☐ **Microwave imaging of biological targets**
- ☐ **Molecular sieves and zeolites**
- ☐ **Monolithic microwave integrated circuits**
- ☐ **Phased array antennas**
- ☐ **Photochemistry of materials**
- ☐ **Robotic systems for automated work cells**
- ☐ **Solar attics for poultry growout houses**
- ☐ **Solar heating of salt for power generation**
- ☐ **Thermite synthesis of ceramics**
- ☐ **Triple mass spectrometer for atmospheric measurements**

Above, **this 30-40 GHz receiver is part of a tactical millimeter wave direction finding system developed for the U.S. Army.** *Facing page,* **GTRI's Electromagnetic Test Facility is a state-of-the-art complex for precision antenna measurements, radar cross section measurements, electronic system measurements, and propagation studies.**

Distribution of SPONSORED RESEARCH AREAS – FY 1986

30%	Electronic Defense
18%	Electronic Systems
13%	Antennas, Electromagnetics & Optics
11%	Electronic Techniques & Components
9%	Computer Technology
6%	Physical, Chemical & Materials Sciences
6%	Economic Development/ Technical Assistance
2%	International Development
2%	Energy Conservation
2%	Alternate Energy
1%	Manufacturing Technology

RESEARCH HIGHLIGHTS



RADAR

GTRI researchers have developed, built, and evaluated radar systems for ground vehicles, ships, and planes throughout the western world. In one major program conducted during FY 86, engineers determined the basic MMW (millimeter wave) radar and IR (infrared) signatures of tactical military vehicles. They also evaluated the effectiveness of several developmental missile guidance seekers designed to operate against such targets as tanks.

The basic signature measurements were made with the instrumentation on a 300-foot tower and the targets on a ground-level turntable. The seeker tests were performed on military vehicles that had been dispersed to simulate combat conditions. Data obtained from these and other tests are being used to predict how MMW radar, IR, and dual mode seekers will perform in such locations as the deserts of the Middle East and the plains of central Germany.

Facing page, **researchers developed a hierarchical data base graphics editor for modeling studies of radar cross section performed at GTRI.** *Above,* **scientists are studying the way light is attenuated in optical fibers as a result of microscopic bends in the fiber.**

Engineers also continued work on a high-power, coherent, 95-GHz radar (HIPCOR-95) developed for the U.S. Army MICOM. HIPCOR-95 is a unique and versatile research tool for collecting target, clutter, and atmospheric propagation data. The combined coherence and high power of this system enable it to measure doppler frequencies and amplitude and thereby extract more information from signals. In addition, the HIPCOR radar incorporates polarization agility and extremely wide bandwidths. These features will enable researchers to extract the full set of scattering parameters from individual scattering elements separated by as little as several inches. Design, fabrication, and assembly have been completed, and testing of selected military vehicles will begin in the fall of 1986.

Another project focused on the way light is attenuated in optical fibers as a result of microscopic bends in the fiber. This attenuation is called microbending loss. Georgia Tech researchers developed theoretical models of, and performed experiments on, microbending loss in optical fiber delay coils. The work is enabling them to develop criteria for the design of optical fibers used in helicopter flight control systems.

GTRI continued to be active in the hardware simulation of advanced radar systems. Following a two-year preliminary study, engineers began building a simulator of an advanced surface-to-air radar-controlled missile system. The $16.9 million contract from the U.S. Air Force is the largest in GTRI's history. The simulator will be a full emitter-receiver-processor and will include target acquisition and tracking radars, command transmitter, missile tracking radars, and display systems.

In other work, researchers designed and assisted in the development of a monopulse radar receiver test set. The test set provides monopulse equivalent signals for an airborne monopulse fire-control radar receiver.

Researchers are also assessing the feasibility of digitizing the output of magnetrons (radio frequency oscillators) in order to make them coherent. Conventional magnetrons are inexpensive per watt of output power. However, they are limited in the functions they can perform because they are noncoherent. A radar based on a digitally coherent magnetron would be both inexpensive per watt of output power and able to perform sophisticated functions such as distinguishing between stationary and moving objects. This project is part of a broad-scale investigation prompted by the increasingly high speed at which digital components work. Tech researchers are exploring how radars (which are mostly analog devices) could be redesigned to incorporate high speed digital components.

GTRI's $16.9 million contract to build an advanced radar simulator is the largest in the Research Institute's history.

Finally, GTRI researchers developed a hierarchical data base graphics editor called MAX which permits the user to specify, design, and control three-dimensional objects. MAX was created for modeling studies of radar cross section (RCS) performed at GTRI. The system can store, display, and edit all of the information needed to accurately describe target geometry and material properties. In addition to RCS work, MAX is used for studies in infrared, magnetics, and flight simulation. □

COMPUTER APPLICATIONS

The information required to solve difficult problems in manufacturing and other environments cannot be simplified, but it can be efficiently organized and managed by knowledge-based systems. Knowledge-based systems can synthesize information, evaluate conditions, and generate alternatives to help managers solve such problems as assessing the impact of introducing new technologies. GTRI is developing knowledge-based systems for a wide range of applications.

One such application involves production standards for an architectural firm's prototype software system. The system is designed to simplify a critical task of the architect — the preparation of building specifications. GTRI's contribution consisted in developing two cooperating software programs. With this knowledge-based system, an architect at a personal computer can produce accurate, fully documented specifications by responding to program queries.

Engineers also developed a microcomputer controller based on the Intel 80286 microprocessor. The controller is part of an airborne telemetry system designed and developed by GTRI researchers. The controller simultaneously tracks up to five independent targets and is simple to operate. It uses compact and reliable MIL-SPEC computer components and a specially developed interface processor to steer the GTRI phased-array antenna.

In a project for Federal Express, researchers evaluated the design and performance of a hand-held keyboard device that helps to track parcels and mail packages from pickup to delivery. The device is linked by radio to central computers.

Another project involves making computers easier for engineers to use. In a project for IBM, researchers are developing a user environment and conversion programs that will facilitate the use of the IBM mainframe by scientists, engineers and other technical professionals.

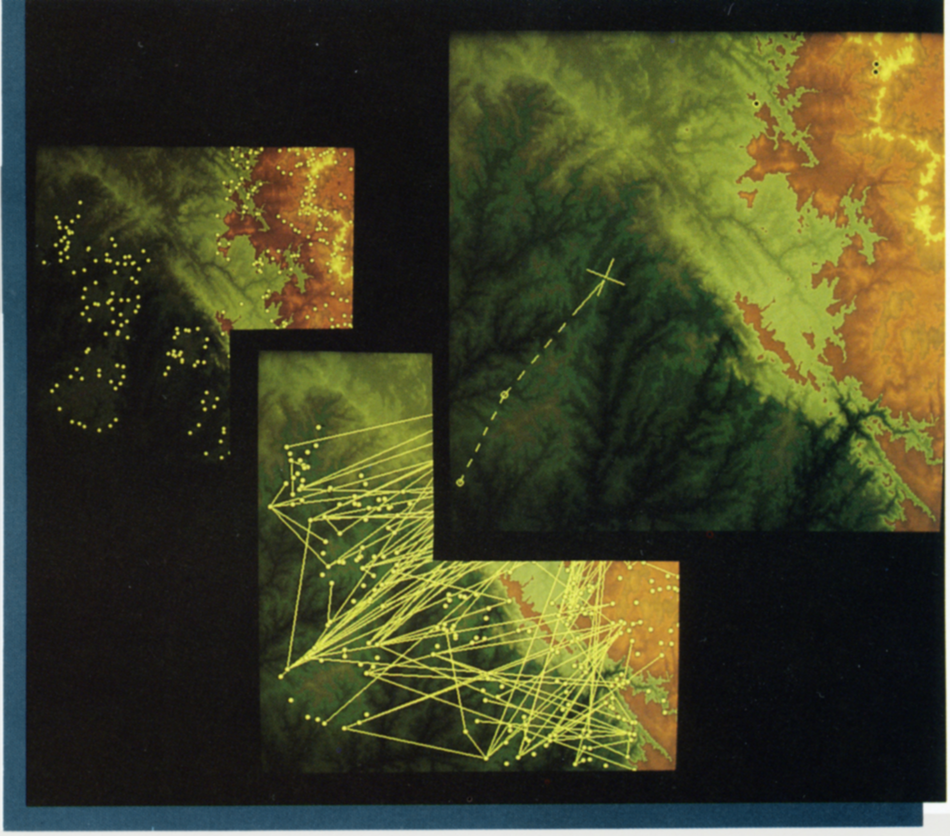
Researchers are also working on a comprehensive office automation program that integrates graphics and texts into what are called compound documents. The key idea behind this project is that no single piece of hardware or software is sufficient to meet the complex needs of the modern workplace. GTRI researchers are therefore examining the problem from an overall systems point of view. The solutions which they provide will be applicable to a wide variety of office and other environments. □

Tech researchers helped Federal Express to evaluate a hand-held keyboard device that tracks mail packages from pickup to delivery.

ARTIFICIAL INTELLIGENCE

In a typical factory, orders for the production of items arrive continuously and must be scheduled to minimize tardiness and maximize the use of existing resources. In many cases, arriving orders generate manufacturing requirements beyond the capacity of the plant. Needed is the capability to rearrange the backlog of orders to expedite higher priority items.

Rather than trying to grasp the problem as a whole, GENSCHED considers only the information relevant to the current goal.



At GTRI, researchers have designed and implemented a hierarchical planning system which meets this need. The system, called GENSCHED, takes advantage of the repetitive nature of planning operations to generate valid schedules efficiently. Rather than trying to grasp the problem as a whole, GENSCHED is designed to consider only the information that is relevant to the current goal. Less important details are abstracted out and dealt with later, when lower level goals are to be expanded. This hierarchical approach makes the planner less sensitive to increases in the size of problems.

GENSCHED also features a user interface that allows manual and automatic scheduling and "what-if" processing of production orders. A rule-based subsystem for entering and maintaining domain-specific knowledge is exploited to improve schedules and minimize search.

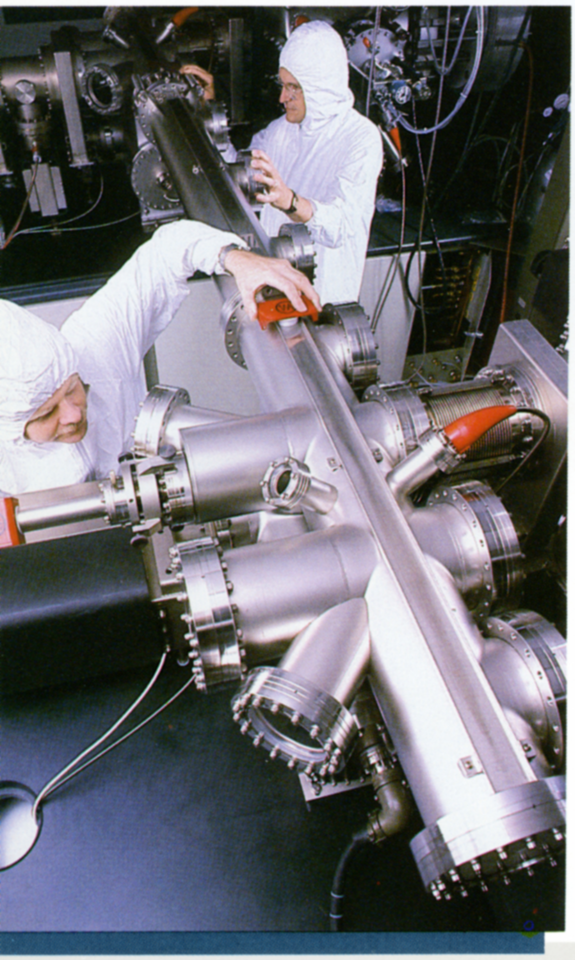
During FY 86, researchers continued work on the development of an Autonomous Helicopter System (AHS). The AHS takes cockpit automation to the limit by creating a completely autonomous, multi-function aircraft. The system consists of three sections: vision, planning, and control. The vision section provides local and global scene analysis, thereby enabling the aircraft to avoid collision with objects and regions contained in the field of view. The planning section assesses the current situation as identified by vision and generates a plan of action that will safely achieve mission goals. The control section validates the path selected and either executes the given route or feeds back to previous sections in order to resolve conflicts.

Also under development is an autonomous fork lift that automatically loads and unloads trucks. The fork lift will be guided by a vision system that is able to distinguish different types of pallet openings in different kinds of boxes and other items.

Tech researchers continued during FY 86 to develop a package of generic expert system tools for licensing to government and industrial users. These tools include VEST (visual expert system testbed) and GEST (generic expert system tool). Among the capabilities built into these tools are advanced error recovery, adaptive algorithm control, multiple knowledge representation schemes, reasoning in light of uncertainties, and global image recognition. □

GTRI's Autonomous Helicopter System takes cockpit automation to the limit by creating a completely autonomous multifunction aircraft. In the sequence shown above, defensive points in the scene are identified *(left)*, **all possible routes are drawn in** *(center)*, **and the best route is selected** *(right)*.

MICROELECTRONICS



Molecular beam epitaxy is used to grow aluminum gallium arsenide and gallium arsenide superlattice structures.

Future high-speed integrated circuits may be made not of silicon but of such materials as gallium arsenide (GaAs) and aluminum gallium arsenide (AlGaAs). Some of these materials have already achieved operating speeds up to five times that of the fastest silicon computer chips available. Other advantages include low power consumption and high electrical resistance. GTRI is a national leader in developing these technologies.

During FY 86, researchers used advanced lithographic, deposition, and etching techniques to fabricate microwave FETs (field effect transistors). GaAs FETs are the building blocks of monolithic microwave integrated circuits — circuits that may be applied in the future to high-frequency signal processing. Researchers moved the nation a little closer to that application by developing a high-performance, low-noise GaAs FET process. The process uses plated-gate metallization to reduce gate resistance and features low-loss air-bridge interconnections. Researchers are currently extending their work in this area to fabricate low-noise amplifier circuits that will operate between 17 and 22 GHz.

Also fabricated were microwave and millimeter wave IMPATT diodes and millimeter wave mixer diodes. IMPATT diodes are among the more powerful microwave/millimeter wave solid state sources. Researchers developed a novel method of fabricating up to six devices on one chip. The method involves connecting each device with column metal electrodes. The result is an essentially monolithic series-parallel combination of diodes. Such innovations are expected to do much to improve the cumbersome circuit technology used presently for millimeter wave power-combining.

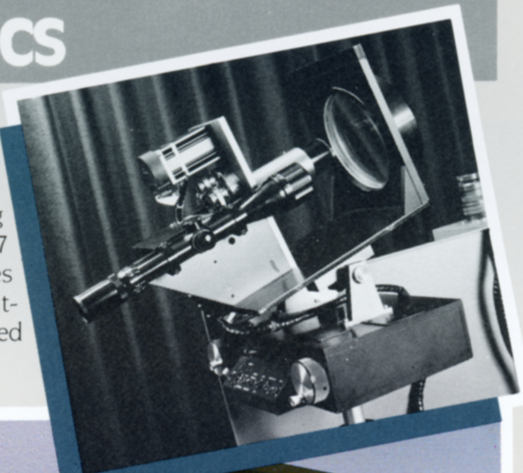
A still more futuristic technology being pursued at GTRI is the development of devices based on superlattices. The superlattices grown at Tech (by molecular beam epitaxy) are extremely thin films of GaAs alternating with thin films of AlGaAs. Whereas ordinary semiconductor junctions join oppositely doped layers (n and p) of the same material, heterojunctions used in superlattices join two different materials that may have the same or different dopings. This effectively opens up solid-state device physics by exploding the limits on the kinds of materials used. Superlattices also allow for higher circuit speeds without decreasing the size of the device.

New superlattice technologies are effectively opening up solid-state device physics by exploding the limits on the kinds of materials used.

Tech researchers are investigating superlattice schemes to develop new avalanche photodiode and laser diode structures in the AlGaAs and mercury cadmium telluride semiconductor systems. These will be integrated into optical circuits. Researchers are also working on new display devices that may eventually replace the CRT screen used in computer terminals and televisions. □

INFRARED/ ELECTRO-OPTICS

The Research Institute has extensive experience in a wide range of infrared (IR) systems. Last year saw the completion of an infrared tracking system that operates in the 0.8-1.7 micrometer spectral region. It provides tracking information on infrared-emitting "hot-spots" or rocket flares viewed through a sighting telescope.



Top, **GTRI's infrared tracking system provides information on rocket flares by calculating the deviation from the line of sight.** *Directly above,* **data obtained by Landsat satellites can be displayed as photo-like images on a color TV screen, as in this image of the Atlanta area.**

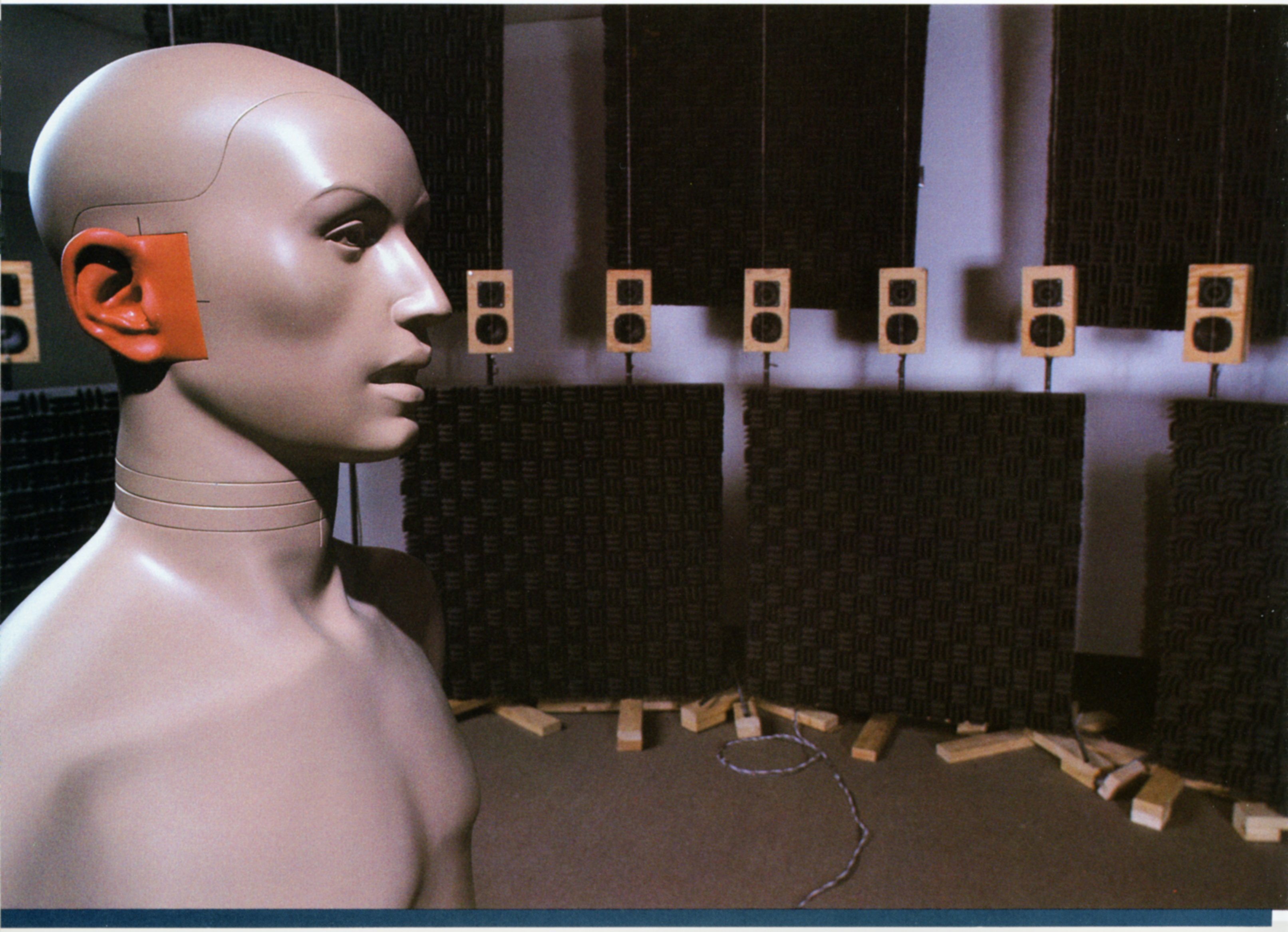
The IR tracker consists of a wide and narrow field-of-view optical system operating in the infrared, as well as a visible wavelength sight for the human operator. The scope is sighted on a target, and the deviation of that object from the line of sight is calculated. The calculation is performed by means of reticles. These reticles are plates with transparent and opaque regions that enable the incoming beam to be modulated. Such modulation yields position and size information about the object being tracked. The electronics design makes extensive use of integrated circuits and provides several displays for the operator.

Researchers in IR systems also continued and expanded their programs in remote sensing. Remote sensing data are used in land planning and the management of natural resources. The data are obtained by "Landsat" satellites orbiting 600 miles above the earth. The satellites transmit the raw data to the ground, where they can be displayed as photo-like images on a color TV screen.

The computer system developed at Tech can display highways, urban areas, and forests, as well as produce maps, color slides, and acreage figures. Such computer-generated images have proven to be cost-effective for resource analysis when compared with conventional methods using aerial photography. Image data have been combined with other geographic data bases to provide three-dimensional visual images of potential areas of mineral deposits in Alaska, water resources in China, and firestricken sections of forest in the northwestern U.S.

Researchers have also developed a system that uses data obtained from aerial photography in a similar way to that obtained by satellites. Ultimately, the two data sets will be combined to produce simulations that give detailed views of extremely large areas of terrain.

Another research thrust during FY 86 was IR scene simulation. The technique developed at GTRI uses computer generated imagery to simulate cluttered terrain landscapes in any spectral region. The computer software takes the desired data base information and constructs a scene from any specified vantage point. Included in such scenes are fogs, clouds, and other atmospheric features. The technique is used to simulate aircraft or missile flight, to determine the suitability of terrain for navigation, and to familiarize tank operators with scenery as imaged by infrared sensors. □



Above, **this model of the human head and ears is helping GTRI researchers to develop an electronic system for conveying directional signals to pilots.** *Facing page*, **GTRI researchers have developed instrumentation to evaluate Electronic Warfare and other systems in the RF (radio frequency), analog, and digital domains.**

ELECTRONIC DEFENSE

Human observers have the remarkable ability to localize sound with an accuracy of better than one degree. Yet this ability is largely neglected in modern aircraft, where information is conveyed to pilots mainly through visual cues. To make use of human auditory capabilities, GTRI researchers have developed an electronic system for conveying accurate directional information by way of acoustic signals to listeners wearing earphones.

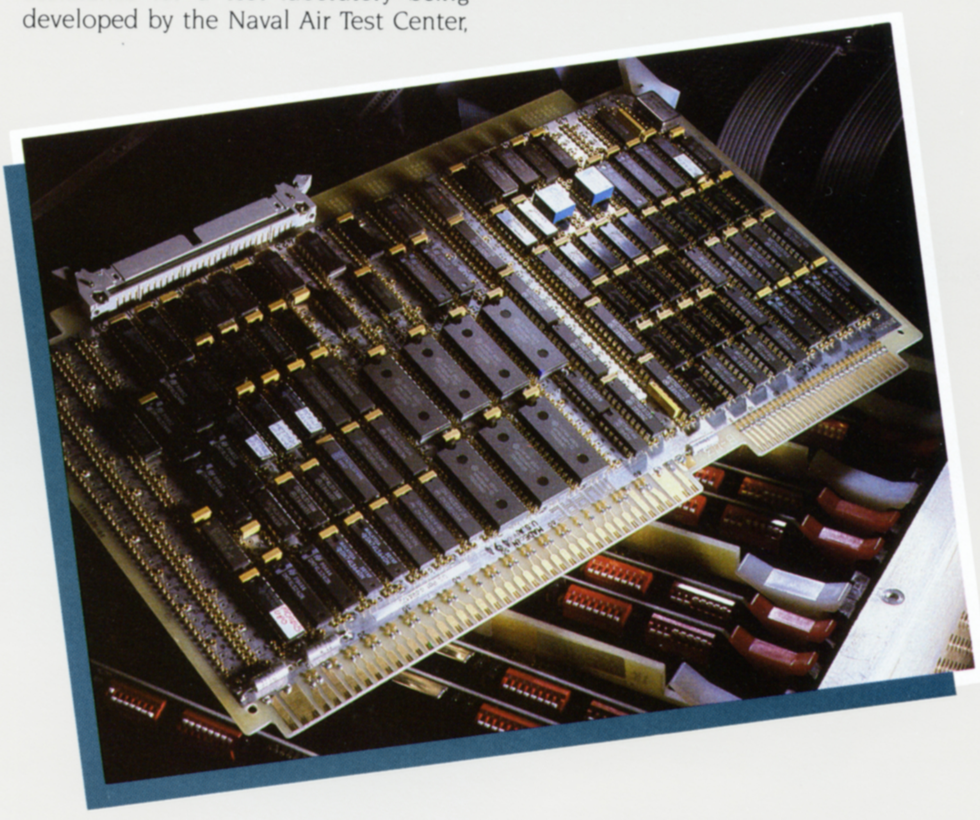
Such a system could be used to cue pilots where to look; to help keep pilots aware of which direction is up when visibility is poor (this is called attitude "awareness"); to warn them of threats or of closing terrain when visual attention is directed elsewhere; and to enhance the intelligibility of audio messages and radio communications by giving each a different apparent direction.

Researchers have developed a physical simulation using a dummy with artificial ears. This simulation is helping them to determine the requirements for an electronic simulation that will recreate the differing spectral qualities of sounds coming from different directions. The completed system will have the ability to impress directional qualities on incoming signals and messages, and to alter the direction of the sound as the listener's head moves. The project is sponsored by the United States Air Force, AMRL/HEA, under a MacAulay-Brown, Inc. subcontract.

GTRI design teams continued to upgrade circuit boards for a family of Air Force radar warning receiver (RWR) systems. These systems are used on military aircraft missions to warn pilots when they are being detected by radar or actually attacked by radar-guided weapons. Prototypes of several very large scale integrated (VLSI) circuits were fabricated, tested, and evaluated. Also developed was a reprogrammable (E^2PROM) memory board. Such boards enable aircraft crews to revise their mission data files in minutes rather than hours. Other work included developing a new interface for RWR and ECM (Electronic Countermeasures) communications and a design for injecting pseudo-threat signals into a RWR display. The latter will allow aircrews to be trained for electronic combat under realistic conditions.

Another program focused on engagements between a single aircraft and ground-based defensive threats. Researchers developed a model that assesses the best combined RF (radio frequency) and EO (electro-optic) countermeasures to be used by an aircraft to penetrate a weapon system network.

GTRI engineers are providing design assistance for a test laboratory being developed by the Naval Air Test Center, Patuxent River. This laboratory evaluates the performance of Electronic Warfare systems installed in aircraft. It consists of an anechoic chamber (a chamber lined with materials that reduce RF reflection) in which an entire aircraft is suspended. The chamber enables the flight of aircraft during combat to be simulated. GTRI is also providing an engineering work station for the development of Automatic Test Equipment software used in analog circuits, as well as developing a facility (the Advanced Extendable Integration Support Facility) to support the software change process. This process is especially critical for computers that are embedded in weapons systems. □



COMMUNICATIONS

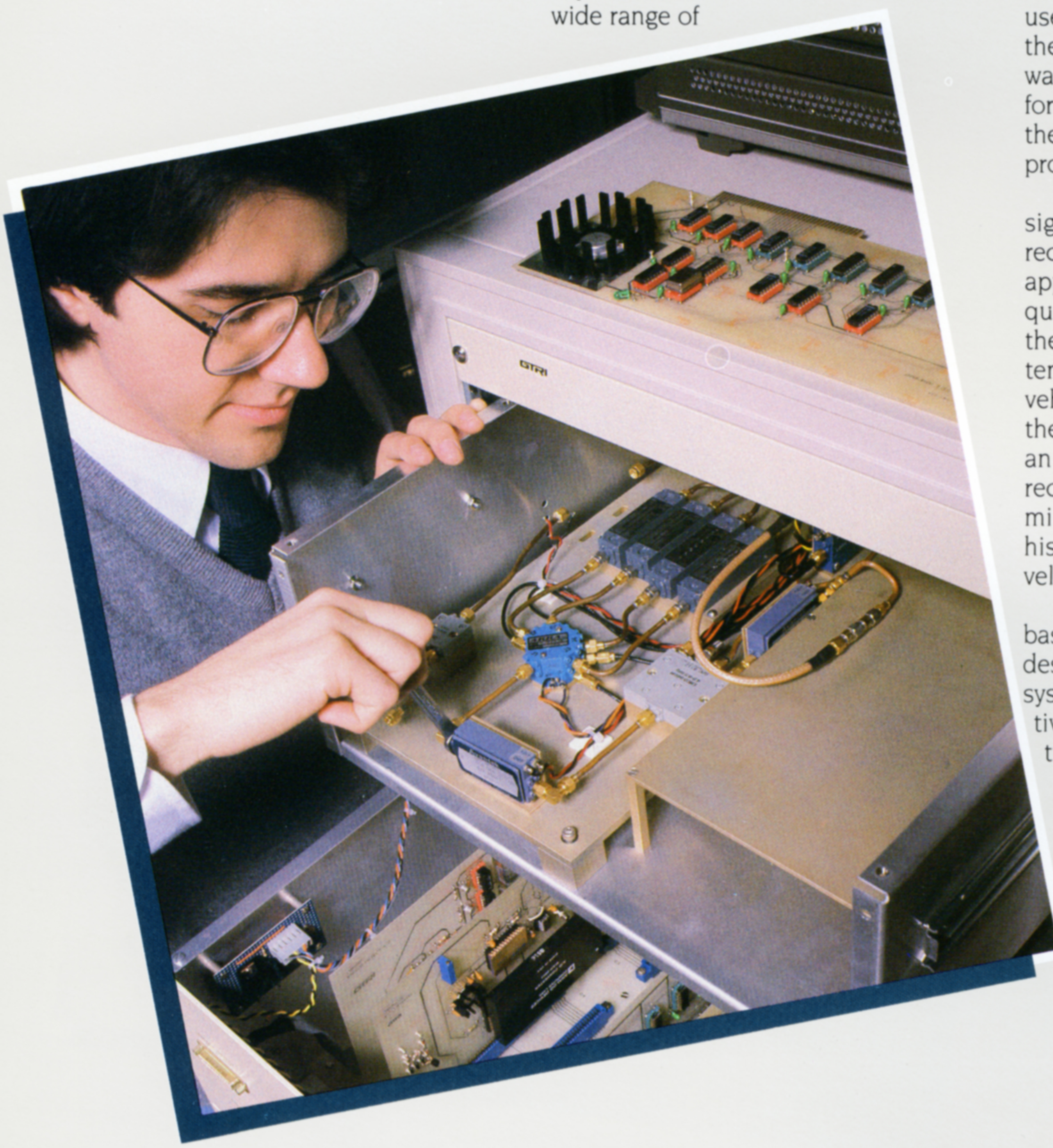
GTRI has more than 20 years of experience in command, control, and communications.

Our nation's security depends in part on our leaders' ability to know what is happening in the event of a crisis, to provide for decisions by legitimate authorities, and to have orders carried out precisely and faithfully. These capabilities form the system of what is called command, control, and communications, or C^3. GTRI has more than 20 years of experience in this area. It conducts a wide range of research and development projects in defense-related and other areas of application.

One major area of focus is communications surveillance and disruption. Modern military tactical communications systems employ sophisticated methods for avoiding detection of the signals they use. Tech researchers are investigating advanced technologies that might be used to make signals non-detectable. On the one hand, they deal with U.S. hardware that jams, disrupts, or intercepts foreign C^3 systems. On the other hand, they study and develop techniques for protecting our own systems.

Engineers have evaluated and designed computer controlled surveillance receivers for both military and civilian applications. Examples are a high frequency, multiple-intercept receiver for the Air Force and a data acquisition system for spectrum surveillance. A GTRI vehicle designed and constructed for on-the-air radio frequency signals includes an array of bussed instruments that link receivers, analyzers, tape recorders, and minicomputers. GTRI also has a long history of working with industry to develop communications technologies.

Another area of focus is computer-based simulation models for interactive design and analysis of communications systems. Applications include alternative military communications architectures, satellite communications systems to assess message routing strategies, and communications techniques for emergency signaling. □



Prototype software and hardware are developed by GTRI engineers to support defense communications and signal processing systems.

COMMAND AND CONTROL

The Research Institute is a pioneer in exploring and developing the uses of laserdisc technology. MICROFIX, an information management and display system based on commercially available hardware, was developed for the U.S. Army and is currently fielded at over 400 sites worldwide. Maps covering strategic areas of the world are stored on videodisc, with each disc containing up to 54,000 different map frames. The user simply enters a geographic reference to any point of interest, and the system instantly displays the map frame corresponding to that location on the color monitor.

Another major program in the area of Command and Control is the aircraft penetration analysis aiding (Pen-Aids) system, a mission planning tool that is being developed for the U.S. Tactical Air Forces. Digitized geographic terrain data, background map features, and enemy (anti-aircraft) threat intelligence information are stored as database files within a 68000-based microcomputer. Calculations are performed to determine which geographic areas are shielded or masked from the enemy threat radars. These areas can then be used as corridors of penetration for friendly aircraft.

Maps covering strategic areas of the world are stored on videodisc, with each disc containing up to 54,000 different map frames.

During FY 86, engineers also worked on a project for the Georgia Department of Transportation (DOT). DOT recently began to videotape all 18,000 miles of the State highway system in order to obtain a continuous record of the condition of the roads and their immediate surrounding environment. Georgia Tech engineers have developed both the hardware and the software to selectively enlarge each frame of the videotape image. This will enable DOT to identify and examine more closely any object on the video screen. □

The aircraft penetration analysis aiding system is a mission planning tool used to determine which geographic areas are shielded from enemy threat radars.

ELECTROMAGNETIC COMPATIBILITY

GTRI has conducted extensive research in electromagnetic compatibility for nearly three decades. Two major projects during FY 86 focused on the shielding of electrical equipment from external sources of inteference. In the first, engineers evaluated new techniques of shielding ribbon cables. Ribbon cables are a thin, wide type of cable commonly used in the computer industry. Left unshielded, they are especially susceptible to interference from other electrical devices.

The second project involved the aluminum panels found on the outer skin of aircraft. These panels are fastened together with a sealant that leaves a gap between the panels. This gap permits interference between the electrical equipment inside the aircraft and external sources and must therefore be closed off. Unfortunately, when aluminum panels are brought in contact, corrosion can result if moisture is present. To help solve this problem, GTRI researchers are developing techniques for bonding aluminum joints and panels so that they maintain shielding effectiveness when exposed to corrosive environments.

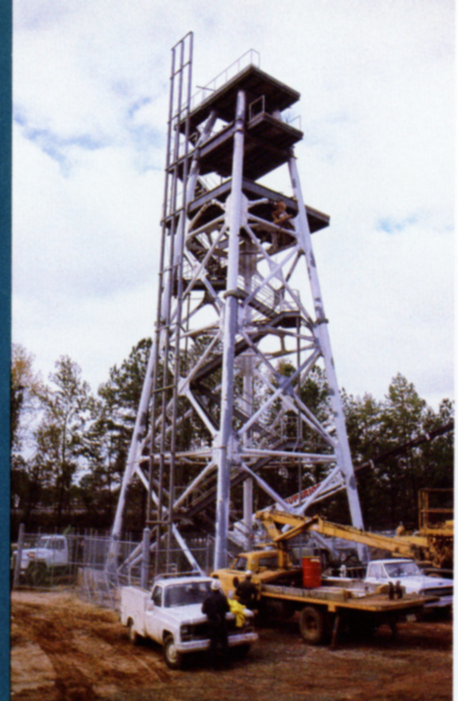
Another project concerned communications facilities where large quantities of electrical equipment are used. Tech engineers developed a generic approach to building design and equipment layout that will minimize the interference problems encountered in such facilities. Also performed was a study evaluating the interference characteristics of spread-spectrum communications. This is a largely new area about which little is known. Tech's study estimated potential undesired electromagnetic interactions and developed techniques and procedures for characterizing emitting sources and receivers.

Engineers are evaluating the interference characteristics of spread-spectrum communications, a new area about which little is known.

Finally, GTRI developed a methodology for measuring the electromagnetic susceptibility of high-speed, high-density (HSHD) integrated circuits (ICs). Engineers are modifying an existing state-of-the-art VLSI tester to demonstrate that electromagnetic susceptibility measurements, as well as normal functional testing, can be made. Additional hardware is being developed for integration into the automatic tester in order to combine RF and logic/power signals at specified pins of the IC during functional evaluation of the device. □

Engineers are studying how well high-speed, high-density integrated circuits perform in their intended electromagnetic environments.

ANTENNA DEVELOPMENT



The Research Institute's new Electromagnetic Test Facility became partially operational in January of 1986. The facility is a state-of-the-art complex for precision antenna measurements, radar cross section (RCS) measurements, electronic system measurements, and propagation studies.

The unique feature of the facility is that it combines at one site a heavyweight target turntable, multiple test ranges, stable towers, and extensive technical and strong analytical engineering support. When completed, the facility will include a far-field antenna range, a scale model RCS range, a turntable RCS range, and a roof-top laboratory. Plans also include a full-scale ground plane range.

The facility uses two towers. The first, which is 91 feet high, provides a source location for antenna and radar measurements of vehicles on the turntable and a receive location for propagation measurements between the tower and the roof-top laboratory. The second tower, which is 64 feet high, is used to provide a receive location for antenna measurements. The massiveness of the structural components gives the towers exceptional stability and rigidity.

Also developed was a 2-18 GHz compact range for broadband RCS measurements. This range, which is located in an anechoic chamber, can operate in both continuous and pulsed modes and employs Fourier Transform signal processing to obtain very high range resolution.

During FY 86, GTRI engineers began work on a telemetry (TM) phased array antenna that will be among the largest ever mounted on an airplane. The work is part of a larger project to develop an airborne platform that will operate in the Eglin AFB area. The 30 foot long, two and one-half foot wide antenna will contain 1,728 elements and will be capable of tracking five targets simultaneously with two data channels assigned to each target. When deployed, the phased-array will be mounted along one side of the fuselage of a DeHavilland-8 (known commonly as the Dash-8) aircraft.

GTRI won a $7.3 million research contract to build one of the largest phased array antennas ever to fly on an aircraft.

The antenna will weigh only 2,700 pounds, light enough for mounting on an economical aircraft like the DeHavilland. Engineers are using sophisticated computer simulations to reduce structural weight. The system is designed throughout to minimize spare parts inventory.

The antenna is one part of a $34 million airborne electronics platform being developed for the Air Force Systems Command. The platform will accommodate a variety of military testing programs.

In a separate but related project, GTRI researchers developed a Modulated Scattering Technique (MST) for rapid near-field measurements. The program was a collaborative one between GTRI and the Ecole Superieure d'Electricite (SUPELEC) in Gif-Sur-Yvette, France. The MST employs hundreds of tiny probes modulated at audio frequencies to rapidly measure the electric field distribution in a period of time ranging from seconds to minutes. Conventional measurement techniques require several hours of measuring time. The MST is particularly attractive for such applications as phased-array antennas and spacecraft or spaceborne antennas. The technique can be used for microwave imaging in biomedicine and in civil engineering.

Also developed was a new method of radio direction finding for pulsed signals. The method provides accurate signal source direction information for an octave frequency band over a large elevation angle, independent of source polarization.

Finally, several types of antennas were evaluated for use in a communications system linking rural areas with the M-Sat (X) satellite. The goal of this project is to furnish land mobile telephone and computer links to and from vehicles anywhere in the U.S. □

Above left, **part of the new Electromagnetic Test Facility, this tower is used as a source location for antenna and radar measurements.** *Above*, **GTRI's phased array antenna will allow the Air Force to collect telemetry data on up to five missiles and drones at once.**

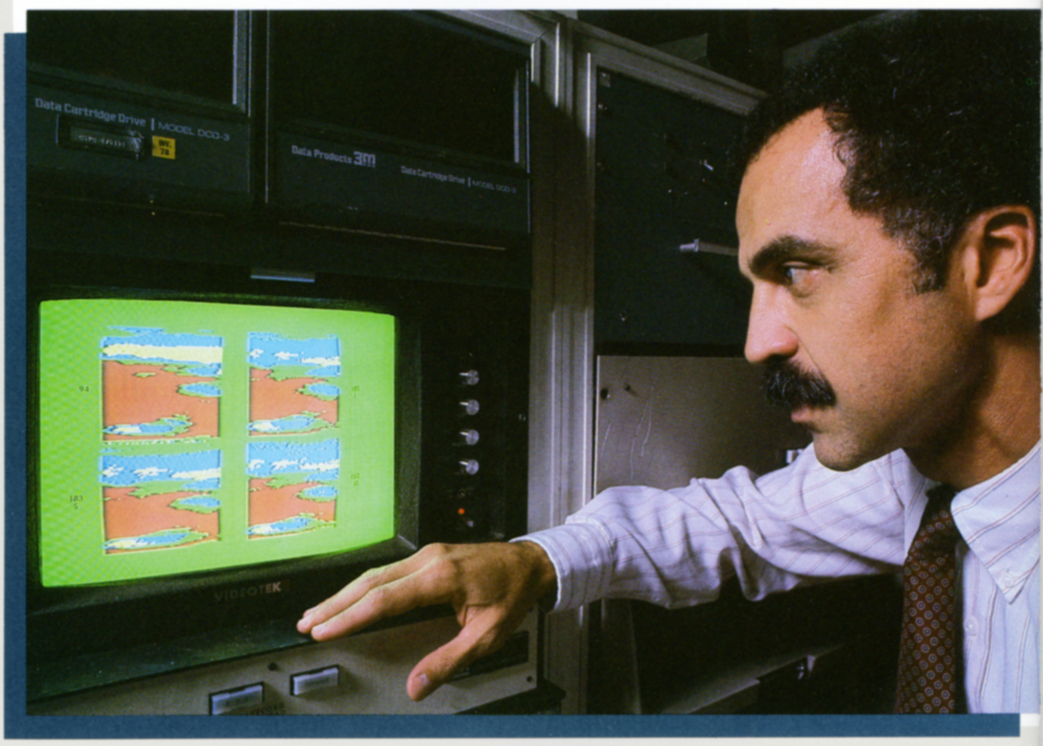
RADIOMETRY

FY 86 saw the completion and delivery to NASA's Goddard Space Flight Center of a 90/180 GHz window-mount radiometer. Developed as a prototype of satellite-based systems, the instrument collects data on tornadoes, hurricanes, and other storms. It is a fixed-beam radiometer that is mounted on the window of the aircraft and takes measurements as the plane ascends spirally into a storm. Its high signal-to-noise ratio gives it the ability to take very accurate readings of brightness temperatures, which are measures of the concentration of water vapor in the atmosphere.

Together, the window-mount and AMMS radiometers provide scientists with a detailed profile of the interior of storms.

GTRI engineers also continued work on their Advanced Microwave Moisture Sounder (AMMS). This instrument operates at the same frequencies as the window-mounted radiometer but is a scanning instrument that collects meteorological data below the aircraft as the plane flies over storms. Among the many advantages of AMMS are that it is easy to calibrate and that it contains its own built-in microprocessor data collection system. Originally developed as a test-bed for satellite sensors, AMMS has proven to be so reliable and accurate that it is used on a continuing basis by NASA to collect meteorological data in virtually all parts of the world. Last February, it took winter storm measurements along the eastern U.S. coastline while flying on the ER-2, a new version of the U-2 aircraft.

Together, the AMMS and window-mount radiometers provide scientists with a detailed profile of the interior of storms. The 90 GHz channel is used to collect such data as the size of rain drops, the rate at which drops fall, and other components of storm intensity. The 180 GHz channel gives information on the humidity in the atmosphere by measuring the concentration of water vapor at different altitudes. Georgia Tech's systems have long been regarded as frontrunners in MMW radiometry. □



This Advanced Microwave Moisture Sounder (AMMS) is a scanning radiometer that collects meteorological data below the aircraft as it flies over tornadoes, hurricanes, and other storms.

MILLIMETER WAVE TECHNOLOGY

Many of the capabilities built up at GTRI in the past quarter century contributed to a major research milestone in FY 86: the completion of a tactical millimeter wave direction finding (DF) system. This system called upon the talents of researchers from several laboratories. GTRI was able to develop the system because of its lengthy experience with direction-finding at lower frequencies and its capability for custom millimeter wave component design and fabrication.

The program yielded two direction-finder models. The first, called a payload unit, underwent successful test and evaluation by the sponsor on a GTRI research aircraft. The second, known as the stand-alone system, is an experimental test bed which will remain at Georgia Tech for study and upgrading. The stand-alone system has been tested successfully in an aircraft. The success of this program has attracted interest from defense agencies and has led to similar contracts with several sponsors. In particular, a similar system covering the 30-40 GHz range has been developed for the U.S. Army at the White Sands Missile Range, New Mexico.

Crucial to the performance of the DF systems are GTRI's broadband, low noise superheterodyne receivers. They comprise a broadband mixer, several switched local oscillators (LOs), an intermediate frequency (IF) amplifier, and backend electronics. The receivers developed for the DF systems cover three frequency ranges: 30-40 GHz, 80-100 GHz, and 130-150 GHz.

In developing the direction finders, GTRI engineers were faced with the problem of building a system that would scan a broad range of frequencies efficiently. They solved the problem by developing a special LO combining network and a set of three broadband mixers covering the three frequency ranges. The receivers use both fundamental and subharmonic mixers. These are designed to be broadband so that they can accept all of the LO and signal frequencies.

The antenna is a horn-fed lens system with a spinning reflector that is spoiled in one plane to provide a fan-beam for greater spatial coverage. An RF diplexer has been developed to allow the sharing of the lens between the 30-40 and 80-100 GHz receivers.

In another project, researchers developed a 340 GHz superheterodyne receiver. It is an active imaging system that will be used to locate targets in a field. The receiver includes a 340 GHz subharmonic mixer that uses an LO at one-fourth the signal frequency and will be driven by a solid-state 85.5 GHz phase locked local oscillator.

Tech researchers have also developed miniaturized, highly efficient broadband millimeter wave receivers. □

Above far left, **MMW integrated circuits for a mixer are mounted on a test fixture. They are about 4 thousandths of an inch thick.** *Above left,* **one of GTRI's tactical millimeter wave direction finders is shown mounted on a test aircraft.**

BIOMEDICAL ELECTRONICS

Today's world has increasingly become an electromagnetic sea made up of airport radars, CB radios, microwave ovens, power lines, and hundreds of other electronic devices. Does such constant, low-level exposure to electromagnetic radiation carry with it health risks?

GTRI researchers are helping to answer this question through their long-term studies of the effects of radio-frequency radiation on biological systems. They will soon begin a new two-year study to determine whether exposure to microwave radiation increases the incidence of cancer in rodents.

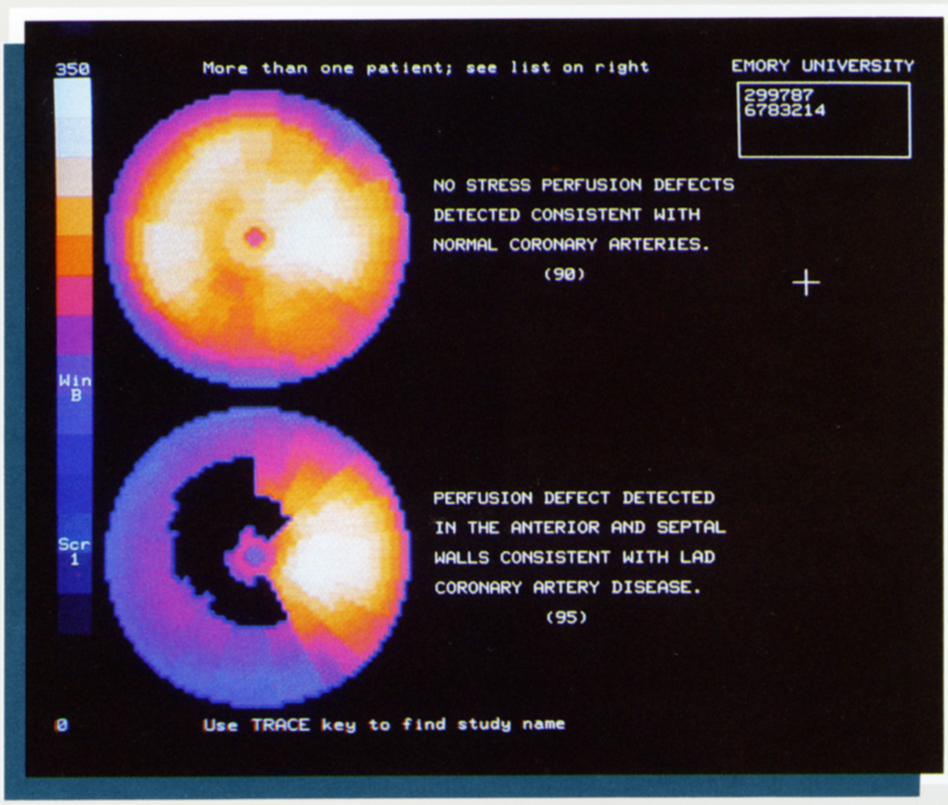
In another project, researchers developed state-of-the-art instrumentation for measuring the electrical properties of different types of biological tissue such as muscle and fat. The work focuses on computer-based network analyzers that measure electrical properties of tissue in the millimeter wave portion of the spectrum, a region for which data have not been available before. By measuring these electrical properties, researchers will be able to determine the amount of heat generated by propagating electromagnetic waves. Such measurements will make it possible to assess the problem of hazardous exposure more easily and accurately. The project is sponsored by the Office of Naval Research.

GTRI is also exploring the uses of electronics as a diagnostic tool in medicine. In one project, researchers are developing artificial intelligence techniques to assist in diagnosing cardio-

Scientists are developing a technique of monitoring human vital signs for use in emergency situations.

vascular disease. The system interprets images representing the distribution of blood flow to the heart muscle, analyzes the images, and recommends diagnostic strategies. The work is being conducted jointly with a team of physicians and medical physicists at Emory University.

During FY 86, scientists continued to develop instrumentation that monitors vital signs in humans without electrode contact. The technique developed at Tech is used to record waveforms (which reflect minute chest movements) that can be compared with conventional electrocardiograms (which record voltage patterns). The technique may find use in the battlefield, at the scene of automobile accidents, or in other emergency situations where conventional monitoring techniques are impractical. □



This system uses artificial intelligence techniques to help diagnose cardiovascular disease.

CHEMICAL SCIENCES

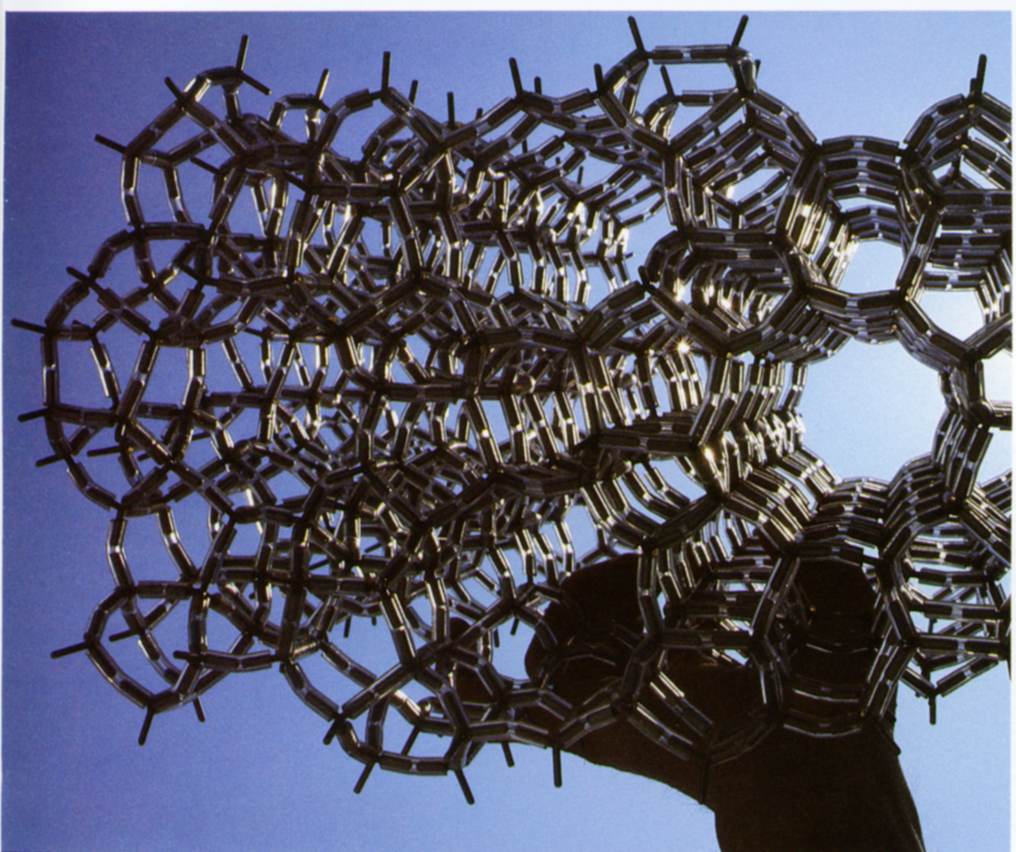
GTRI researchers pioneered the measurement and mass identification of ions at ground level. During FY 86, they made another major leap forward by adding to their existing Mass Identified Tropospheric Ion Sampling (MITIS) apparatus a new high throughput triple mass spectrometer. This new spectrometer makes possible for the first time the chemical identification of many previously undetected ion and neutral tropospheric species. The ions being studied make up less than 1 part in 10^{17} of the atmospheric gas. The neutral species exist in the low to sub-parts per trillion range. Researchers seek to determine the types and quantities of ions present in the troposphere and to understand their interaction with the neutral atmosphere, including their relation to aerosol formation and acid rain.

During FY 86, scientists measured a limited number of free radical reaction rates in the aqueous phase. This will contribute to knowledge of the complicated chemistry of sulfate and nitrate production in cloud water. Researchers also used lasers to create and detect transient species, adapting an innovative technique previously developed for studies in the gaseous state.

GTRI scientists continued to study chemical reactions that affect the rate of ozone depletion in the stratosphere. The ozone layer protects life on earth from excessive solar ultraviolet radiation. It is believed that solar photolysis of certain stable compounds such as halocarbon propellants initiates reactions which deplete the ozone layer. However, the data are still insufficient to predict these effects with certainty.

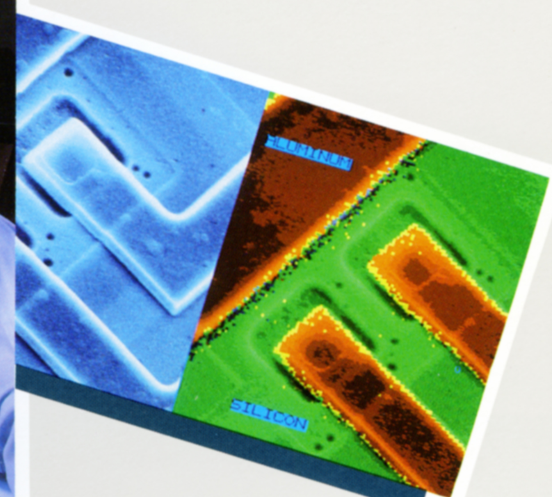
Researchers in atmospheric chemistry are amassing a data base that is useful not only for the immediate problems under study, but also will be applicable to studies of new types of emissions.

In GTRI's comprehensive research program on molecular sieves and zeolites, researchers continued to synthesize and characterize new molecular sieves for use as catalysts and adsorbents in the petroleum and chemical industries. Some nine compounds have been synthesized to date. Ongoing research focuses on modifying molecular sieves and zeolites by thermal and/or chemical treatments to improve performance, as well as tailoring them for special applications. Researchers are also investigating the effect of shape selectivity on catalytic reactions. The group established a broad multi-sponsor program of industrial research during the year. □



Scientists synthesized and characterized nine new molecular sieves for use as catalysts and adsorbents in the petroleum and chemical industries.

MATERIALS SCIENCES



GTRI researchers are developing harder, stronger materials that will endure the harsh environmental conditions imposed by today's space-age technology. One such material investigated during FY 86 was a silicon nitride composite. A pre-form is made out of ceramic fibers and powders, then fired in a reaction sintering process. The result is a dense composite that is strong and will withstand high temperatures. A silica process developed at GTRI for making advanced radome materials was further developed and refined. Radomes are used to protect aircraft radar.

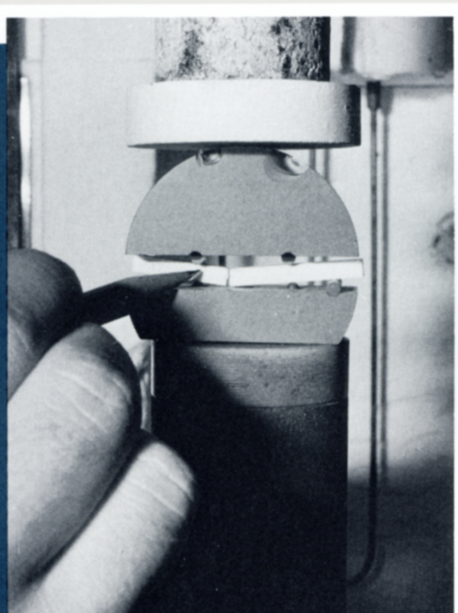
Another subject of investigation was structural changes taking place in carbon fiber composites subjected to the extremely high temperatures of the sun's radiation. Researchers seek to learn whether new forms of carbon are produced and how such processes will affect the long-term stability of these materials in space. Preliminary results indicate that solar thermal conversion imparts properties to carbon fiber composites quite different from those seen in conventional commercial processes.

Initiatives during FY 86 included evaluating integral heat shield materials to protect interceptor missiles in their hypersonic flight through the atmosphere; investigating methods to prevent corrosion of the outer shield that protects aircraft from the electromagnetic effects of nuclear blasts; and testing materials that will be used to build solar concentrators for the space station.

GTRI's trail-blazing research in thermite synthesis of ceramics concentrated in FY 86 on refining its new process for producing high-purity submicron titanium diboride. The titanium diboride is extremely reactive and can be used in such materials as abrasives, aluminum smelting electrodes, and computer chip substrates.

A new project focused on chemical vapor deposition of ceramic coatings for high-temperature, high-wear applications. Materials characterization received strong emphasis as scientists used electron microscopes to qualify memory elements for spacecraft. State-of-the-art equipment was acquired in FY 86 for X-ray diffractometry, scanning Auger microscopy, electron spectroscopy for chemical analysis, and secondary ion mass spectroscopy.

Researchers continued to develop ways of improving the anti-fouling characteristics and selectivity of separatory membranes. The GTRI process involves tailoring membrane surfaces by depositing molecular layers of selected materials. These monolayers can also be used to lubricate moving parts in space vehicles. □



Flexure testing involves applying a uniform stress on materials in order to measure their tensile strength. GTRI scientists use flexure testing *(left)*, **as well as advanced materials characterization techniques** *(above)* **to evaluate ceramic materials used in such high temperature applications as aerospace vehicles and gas turbine engines.**

MANUFACTURING TECHNOLOGY

To be competitive, American industry must manufacture high-quality products at a low cost. This requires developing new manufacturing processes, implementing the latest technologies, and networking these processes into an integrated system.

An example of this approach is GTRI's intelligent systems research, performed in cooperation with Georgia Tech's Material Handling Research Center (MHRC). During FY 86, the MHRC shifted emphasis to "off-wire" guidance of automated guided vehicles (AGV). Engineers used encoders to measure wheel rotations, cameras to look for landmarks, and a new optical system to measure the vehicle's progress more accurately. They also developed adaptive algorithms that can be used, in conjunction with information from tactile and visual sensors, to help guide the vehicle. In another program focusing on automated truck loading and unloading technology, researchers experimented with ultrasonic ranging for guidance within semi-trailers. Vision systems were used to recognize key environmental features.

Several new commercial AGV systems were acquired for use as testbeds. Gifts from IBM for GTRI laboratories included two Litton Series 800 vehicles and two Prontow vehicles. A Litton 400 Series vehicle is also used in the MHRC.

Engineers developed plans for large-scale automated storage facilities and began to study possibilities for automated palletizing of unequal size containers.

Researchers are developing new manufacturing processes using artificial intelligence techniques.

For the U.S. Postal Service, engineers designed and built a prototype machine for automated handling of packages. Working on a vibration principle, the machine separates a pile of packages and advances them in single file. The machine is being tested with real mail in a post office.

In the area of flexible manufacturing systems, engineers incorporated artificial intelligence techniques in the design of multi-level flexible planning and scheduling tools. Others worked on dynamic planning for intelligent robotic systems to enable the stand-alone operation of automated fabrication/assembly work cells. The dynamic planner can make process modifications and resolve contingencies automatically. Still other work focused on measuring and suppressing electromagnetic interference in automated factories. □

This prototype machine for automated handling of packages works on a vibration principle.

ASSISTANCE TO INDUSTRY AND GOVERNMENT

Increased legislative funding during FY 86 enabled five of GTRI's 12 industrial extension offices across the state — Albany, Augusta, Gainesville, Macon and Savannah — to each add a field engineer and a co-op student as a first step toward becoming Georgia Technology Centers. An extension office also was established for the Atlanta area. The expanded network provided short-term assistance to more than 1,500 industries.

The state also funded a new economic development research program to identify new technologies and uses for Georgia's resources and to stimulate economic development in specific regions. One study determined that there was great potential for Georgia's hardwoods in the manufacture of oriented strand board. Other research focused on diversification of the state's fishing industry, enhanced use of the Tri-Rivers Barge Canal, and the feasibility of more appliance manufacture in northwest Georgia. Researchers expected to complete about 15 studies by the end of the year.

The state legislature has approved a quarter-million dollar request to continue GTRI's highly successful small-quantity waste generator on-site consultation program.

The Southeastern Trade Adjustment Assistance Center helped industries hurt by imports competition and provided managerial and technical assistance to some 50 firms. A new program — the Southeastern Procurement Technical Assistance Center — was funded by the Defense Logistics Agency to help businesses in seven states sell their products and services to the U.S. Defense Department. Engineers also performed more than 65 energy conservation analyses of Georgia industrial plants and military installations.

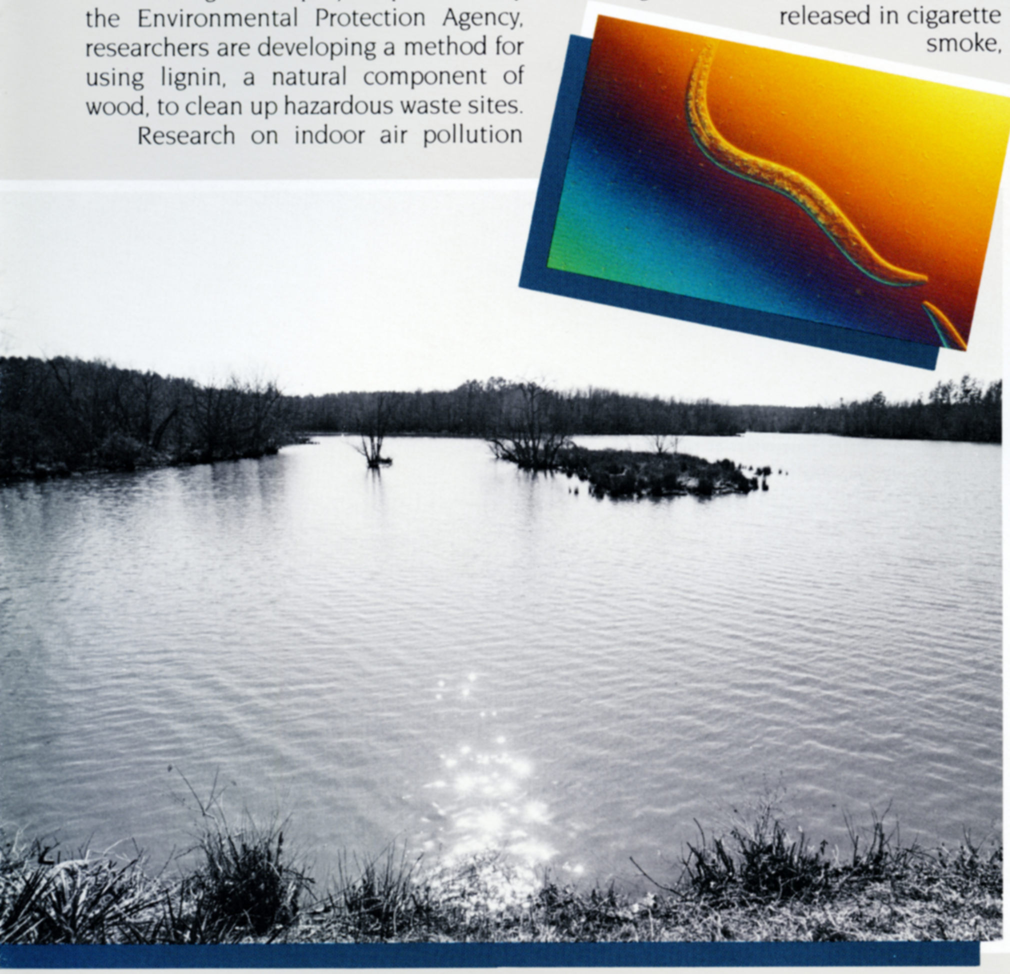
On the international scene, work continued on two large, multi-year projects in Africa. One involved training Egyptian engineers to carry on an industrial extension service to strengthen Egyptian industry. The other focused on adapting and disseminating renewable energy technologies in Sudan to alleviate deforestation contributing to famine and drought. Engineers also completed a two-year project during which they helped Central American industries learn how to conserve energy in the face of expensive petroleum imports and trained regional engineers to run the project themselves.

Following successful field-testing of a new GTRI hand-operated water pump in the Dominican Republic last year, four local manufacturers produced 750 pumps for installation in rural areas in FY 86. Tech trained the manufacturers in mass production and quality control techniques. A similar project is being launched in Ecuador. □

GTRI's industrial extension service was established in 1960 and today provides technical and management assistance to more than 1,500 industries annually.

ENVIRONMENTAL SCIENCES AND ENGINEERING

The Research Institute's programs in environmental sciences and engineering encompass research and development, technical assistance, and outreach and training. In one project sponsored by the Environmental Protection Agency, researchers are developing a method for using lignin, a natural component of wood, to clean up hazardous waste sites.



The nematode worm is used to develop improved bioassay techniques for studying the impact of environmental contaminants.

Research on indoor air pollution expanded during FY 86. The work involved large and small-scale environmental chamber testing. Studies focused on chemical emissions ranging from formaldehyde in building materials to volatile organics released in cigarette smoke, construction materials, and cleansers. Industrial hygienists conducted a study of possible nitrous oxide hazards in dentists' offices. Research for the National Institute of Occupational Safety and Health involved updating the criteria for exposure to certain chemicals in the workplace.

To better assess the contribution of natural ecosystems to the acid rain problem, researchers conducted studies on the production of sulfides in coastal marshes. They are also using a species of the nematode worm to develop improved bioassay techniques for determining the environmental impact of a broad spectrum of environmental contaminants.

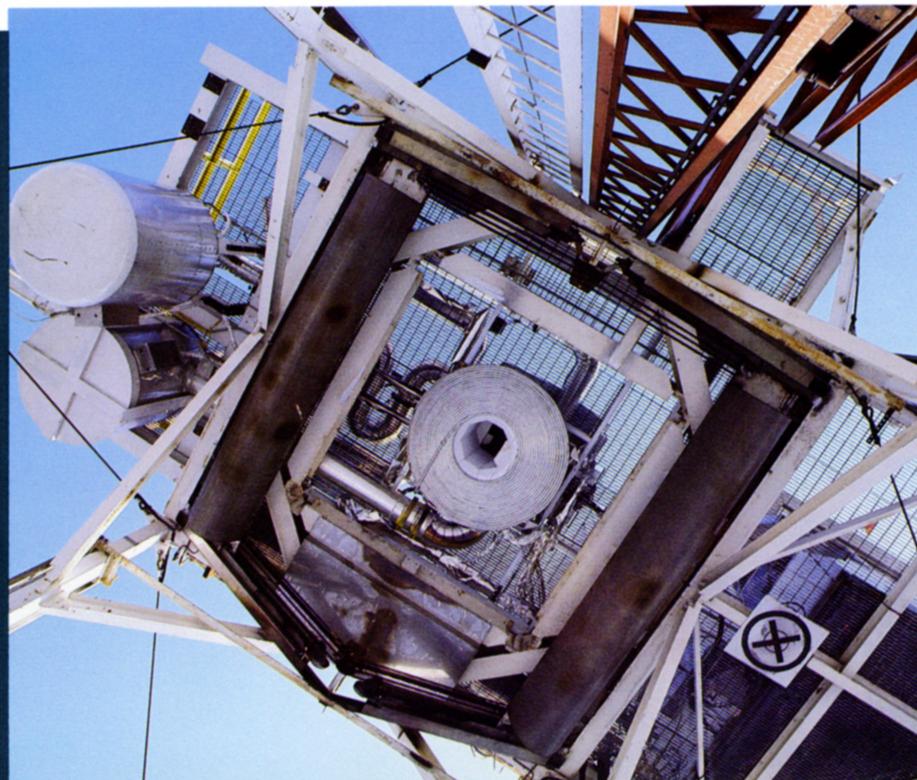
A team of hazardous waste specialists and environmental engineers are developing an innovative way to identify and separate groundwater contaminants, to determine when and where leaks occur, and to evaluate different cleanup strategies.

The Southeastern Asbestos Information Center, a part of the GTRI Asbestos Program, has for years provided national leadership in asbestos abatement technology. It has developed improved methodologies and trained hundreds of contractors and government officials to lessen the hazards of asbestos. Scientists will soon embark on a three-year asbestos abatement program for the Environmental Protection Agency.

Consultants and researchers in industrial safety and health and in hazardous waste management helped hundreds of firms to comply voluntarily with government regulations through on-site visits and educational programs.

Training activities totaled more than 60 programs in FY 86, encompassing short courses, workshops, symposia, and conferences in such fields as ergonomics, asbestos abatement, industrial toxicology, hazardous waste management and emergency response, audimetrics, indoor air quality, and trenching safety. □

ENERGY ALTERNATIVES



The Research Institute continued to play a leading role in solar thermal power research in FY 86. Engineers helped to develop innovative methods of powering the NASA space station and of generating cheaper electric power for domestic use on earth. GTRI researchers assisted industrial firms in the preliminary design of two types of solar dish collectors to generate electric power for the space station. Tasks included analyzing the optical properties of various concentrator designs, defining test methods, and evaluating construction materials.

GTRI's entrained pyrolysis process produces oil yields of up to 55 percent.

The solar thermal test facility staff, in cooperation with the Solar Energy Research Institute, successfully completed testing a solar receiver for heating molten salt by direct absorption of sunlight. The experimental technique has great promise as a cost-competitive source of energy for electric power generation. GTRI engineers also were responsible for the design of the hardware.

Engineers completed design concepts for instrumentation that will measure at the ground level the temperature of solar receivers as a function of their spatial position. Their work involved devising a way to measure only the heat radiated by the receiver. In order to eliminate false readings caused by energy reflected from the sun, the instrumentation will operate in wavelengths that are not in the solar spectrum.

Research in alternate fuels continued to be a major priority. An obstacle to widespread commercialization of biomass combustion and conversion systems is the lack of a suitable method for removing environmental pollutants from off-gases. GTRI engineers built and tested a self-cleaning, rotary, recycling off-gas separator for emissions from combustion units fired by agricultural or forestry wastes. Compared with traditional methods, the rotary separator, for which Georgia Tech holds a patent, boasts higher collection efficiency, lower capital cost, lower energy consumption, and very low maintenance requirements.

An independent evaluation of GTRI's entrained pyrolysis process, which produces oil yields of up to 55 percent, concluded that the high-quality oil produced now appears to be economically competitive with current liquid fuels. GTRI researchers also began exploring a new coal liquefaction process, using a series of new catalysts as depolymerizing agents.

Investigators identified and characterized several novel, highly energy absorptive materials for storage of thermal energy in buildings at low and moderate temperatures. Some of these materials will be used for passive heating and cooling of buildings.

The prototype industrial-scale thermoelectric generator designed and built by GTRI engineers for Omnimax Energy Corporation was installed on campus at the beginning of FY 86 and operated successfully throughout the year. □

Above, **a variety of high temperature solar thermal experiments is conducted at the Advanced Components Test Facility on the Georgia Tech campus.**

AGRICULTURAL RESEARCH

In FY 86, GTRI engineers continued to develop high technology systems for the poultry industry, the largest agribusiness in Georgia. Their goals are to help the farmer and integrator lower costs, improve productivity, and achieve higher product quality.

To help farmers monitor environmental conditions in poultry growout houses, researchers installed an experimental prototype of a low-cost microprocessor system, with home computer tie-in, on an actual farm. The system, designed at Tech, is used currently for data collection. The ability to automatically control environmental conditions will be added in the future.

Engineers also tested a new method for solar heating of poultry growout houses. The method uses a "solar attic" to preheat incoming air. Studies show that the new system, which is economical to install, can lower heating costs. This has not been achieved to date with conventional active solar collector designs.

Other research focused on the problem of how to economically and effectively dewater poultry processing sludge so that it can be handled by rendering plants. Engineers investigated both long-term solutions such as electro-osmosis and short-term ones such as thermally enhanced sludge dewatering. The latter is a low-cost, easily applied technique. Plans are to install a pilot facility at a poultry plant for evaluation. Researchers also studied techniques of anaerobic filtration for the treatment of wastewaters from poultry processing plants. Such filtration generates a useful gas by-product while effectively treating the wastewater to levels acceptable for discharge.

The Computerized Inspection Monitoring System developed at GTRI for poultry processors, was installed at a Virginia plant in the latter part of 1985 and has been operating almost flawlessly ever since. The system is being used to collect information on the performance of U.S. Department of Agriculture inspectors. Such information will aid in developing standards of expected levels of performance which can be used to allow plant personnel to assist in preinspecting (or sorting) birds. GTRI also recently acquired an automated vision system. The system will be used to develop improved methods of inspecting poultry products. □

Left, **this solar attic developed at Tech can reduce the heating expenses of poultry farmers.** *Top*, **researchers are developing methods of anaerobic filtration to treat wastewater from poultry processing plants.**

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Standing in front of the Centennial Research Building are (from left to right) **Donald J. Grace, James C. Wiltse, Robert G. Shackelford, Howard Dean, Patrick O'Hare, and Gerald Carey.**

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On top of the Georgia Tech solar tower, researchers test a solar receiver for heating molten salt by direct absorption of sunlight. The technique holds promise as a means of generating electric power.

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