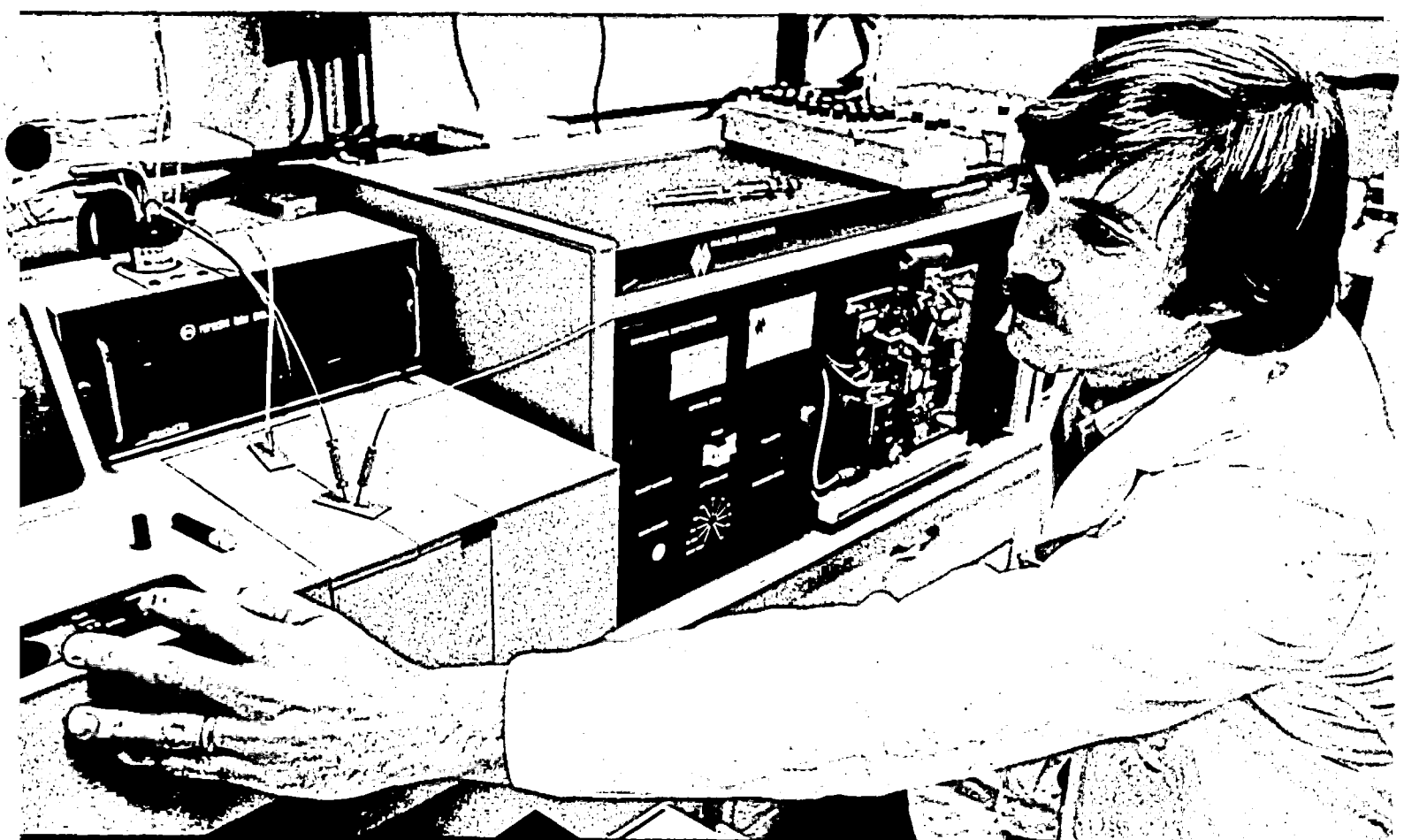


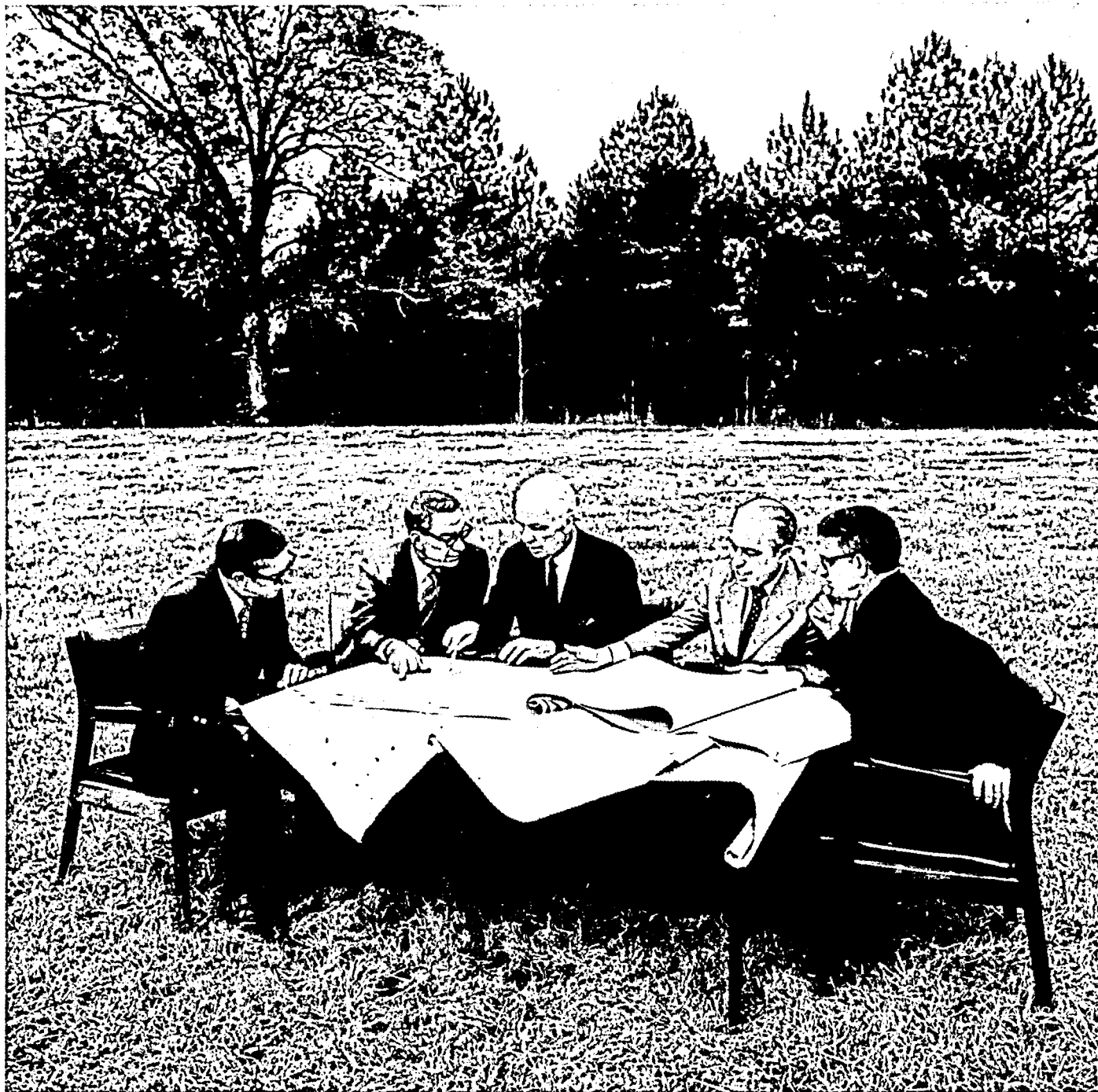
1975



**Research Triangle Institute**

Research Triangle Institute • Research Triangle Park, North Carolina 27709

**RTI**



Site of the tenth building on Research Triangle Institute's 180-acre campus in the Research Triangle Park. The six-story structure will be named for RTI Board of Governors chairman George Watts Hill, center. He is shown with, from left, Institute treasurer William H. Perkins, Jr., corporate vice president S. C. Ashton, president George R. Herbert, and Board executive committee chairman Dr. William F. Little, vice chancellor of the University of North Carolina at Chapel Hill.

# RTI In Brief

## Operation

Research Triangle Institute is a not-for-profit organization performing research under contract with departments of Federal and State government, corporations, industrial associations, public service agencies, and other clients.

## Formation

In December of 1958 RTI was incorporated as a separate research affiliate by joint action of the University of North Carolina at Chapel Hill, Duke University at Durham, and North Carolina State University at Raleigh. Research operations began in the spring of 1959.

## Location

RTI occupies nine office and laboratory buildings on a central campus in the 5,200-acre Research Triangle Park between Raleigh, Durham, and Chapel Hill. A 13,000-square foot annex for some energy and environmental research activities is located in Durham.

## Growth

	CONTRACT REVENUES	STAFF
1976 <i>Est.</i>	\$18,500,000	700
1975	16,200,000	650
1970	7,500,000	384
1965	3,600,000	263
1960	280,000	54

As contractual commitments require, staff members are temporarily assigned to locations throughout the United States and abroad. In 1976 staffing began at RTI's first permanent branch, established with the cooperation and encouragement of the University of North Carolina at Charlotte.

## Funding

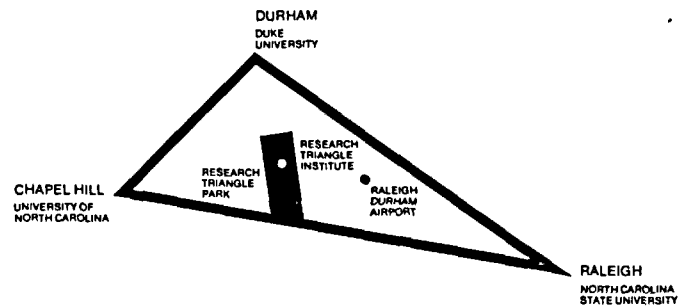
RTI contract revenues are generated by project charges to clients. After payrolls, purchases, and other charges, net revenues are reinvested in Institute facilities and development. Buildings and facilities are valued at more than \$6 million.

The Research Triangle Foundation provided a start-up grant of \$500,000 to finance initial operating deficits until RTI reached the break-even point in 1962, and donated 180 acres for the RTI campus. The Foundation is a trusteeship which promotes the resources and manages development of the Research Triangle Park.

The State of North Carolina has participated in Institute growth through grants totaling \$1,015,000 for the acquisition of scientific equipment. Contributions of \$1,915,000 have also been received from individuals, foundations, and business concerns.

## University Affiliations

Joint ownership by and close working ties with its founding universities are of the utmost importance to RTI. Cooperative research is conducted in many subject areas, and the availability of faculty members as project consultants greatly enhances RTI research capability.



## Board of Governors

RTI's Board of Governors consists of 13 representatives from the parent Triangle Universities, 13 members elected from the business and professional communities, and the Institute president.

Alertness to the concerns and needs that determine national goals and priorities has been a decisive influence in shaping Research Triangle Institute's character and stimulating its growth.

During the formative years that followed the beginning of RTI operations in 1959, the major concerns that engaged the nation's applied research community included defense and weapons, nuclear physics, electronic communications, information systems, industrial processes, materials, and the all-out space effort.

The young Institute lacked an established track record in these areas. However, the decision had been made that RTI, benefiting from its regional origin and clear regional identity, should strive to serve national purposes by building programs and staff that encompassed a broad spectrum of the sciences and by attracting a widely diversified sponsorship.

Under this policy, RTI research managers initially concentrated on building strength in statistical studies, systems reliability, natural products chemistry, solid state electronics, civil defense preparedness, and polymer physics and chemistry. Within three years these programs achieved operating break-even for RTI on a 1962 annual contract volume of \$1.3 million.

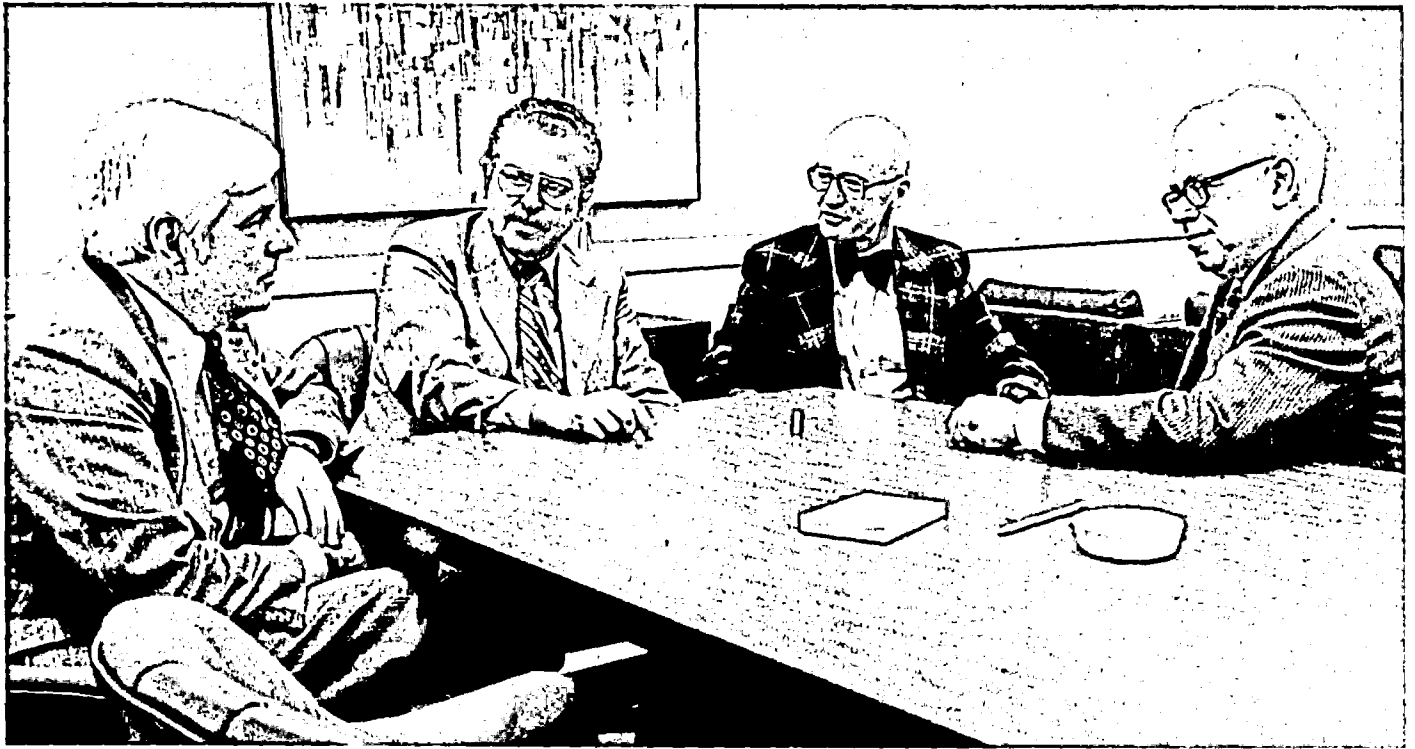
Meanwhile, perceptible changes were taking place both in the nation's societal goals and in the Institute's research interests.

Youth and flexibility enabled RTI to gear staffing and program development to emerging national challenges, and Institute research emphasis turned to meet them.

Moving into the young maturity of its eighteenth year, a distinguishing mark of Research Triangle Institute operations is its degree of involvement in programs aimed at improvements in the quality of life. Through the first half of the 1970s three-quarters of Institute research effort has been in areas directly concerned with education, health, environment, energy, transportation safety, economic growth and regional development, societal problems, and the structure of social organizations.

These areas, combined with a continuation of strong programs in the physical and engineering sciences, mark the course of future growth and service for RTI.





RTI research vice presidents William C. Eckerman, Daniel G. Horvitz, James J. B. Worth, and Monroe E. Wall.

RTI research activity is organized into multidisciplinary groups. The following pages contain a representative selection from their broad mix of research projects.

**Social Sciences**

William C. Eckerman  
VICE PRESIDENT

**Statistical Sciences**

Daniel G. Horvitz  
VICE PRESIDENT

**Chemistry and Life Sciences**

Monroe E. Wall  
VICE PRESIDENT

**Energy, Engineering and  
Environmental Sciences**

James J. B. Worth  
VICE PRESIDENT

# Social Sciences

William C. Eckerman, Vice President

Multidisciplinary research covers many subject and problem areas that involve social and economic systems and human resources.

## Center for Development and Resource Planning

James A. Street, DIRECTOR

Research on economic and social aspects of regional growth focuses on systematic data collection and analysis, evaluation, and planning. Studies are directed to significant national issues as well as to those of multistate regions, individual states, groups of counties, and communities. They include economic development strategies, manpower requirements, transportation systems, industrial growth, economic systems analysis, natural resource use, and social program evaluation.

## Center for Educational Research and Evaluation

Junius A. Davis, DIRECTOR

George H. Dunteman, ASSOCIATE DIRECTOR

Research involves educational program evaluations, assessments of educational progress, management information systems development, and design of educational research strategies, including psychometric applications. Recent emphasis includes data-based policy studies, educational system audits, institutional governance and planning, access to higher education, and design of normative and criterion-referenced testing programs.

## Center for Health Studies

Jay T. Wakeley, DIRECTOR

Research in health systems planning and services delivery emphasizes substance abuse, hazardous materials, medical registry design and operation, community health planning, emergency care, manpower needs forecasting, health professions education, assessment of treatment modality effectiveness, health care costs and evaluation of medical insurance benefits, assistance to health maintenance organizations, and dental care quality control methods.

## Center for Population and Urban-Rural Studies

Quentin W. Lindsey, ACTING DIRECTOR

Research concentrates on broad trends in population growth and distribution, and the problems of people living within urban and rural communities. Specific studies deal with population policy and program development, urban and rural organization and decision making systems, socioeconomic determinants of fertility, marital disruption and family size, and social, economic, and political aspects of change in the U. S. and less developed countries.

## Center for the Study of Social Behavior

Alvin M. Cruze, DIRECTOR

Research encompasses positive aspects of human behavior as well as priority areas of deviant behavior. Programs include the measurement of behavior, motivations, and attitudes through studies of drug abuse, use and abuse of alcohol, crime and delinquency, adolescent psychology, consumer behavior, dental service delivery, human resource program analysis, and problems of special concern to the young and the aging.



James A. Street, Junius A. Davis, Alvin M. Cruze, and Jay T. Wakeley.  
Insets: Quentin W. Lindsey, George H. Dunteman.

# Statistical Sciences

Daniel G. Horvitz, Vice President

B. V. Shah, CHIEF SCIENTIST

Paul G. Homeyer, SENIOR SCIENTIST

Research aims at the development and use of sound and cost effective methods for collecting and analyzing statistical information.

## Computer Applications Center

Robert H. Thornton, DIRECTOR

Programming, data base management, and data analysis capabilities support data collection activities throughout the Institute. Research in software design, systems analysis, and computer applications includes simulation modeling, large-scale data systems design and modification, linear and dynamic programming, and developing software for data editing, document receipt control, and report production.

## Sampling Research and Design Center

James R. Chromy, DIRECTOR

Research covers the design and selection of efficient samples of target populations for all Institute national and regional surveys. Sampling theory and statistical applications programs include

general unequal probability sampling methods, response error modeling, public health and educational statistics, cost-variance estimation, stochastic simulation, optimization procedures, data analysis, and randomized response techniques.

## Statistical Methodology and Analysis Center

J. Kenneth Poole, DIRECTOR

Innovative methods and modifications to known procedures are applied to statistical problems. Research extends to design and analysis of experiments, theory and application of multivariate analysis, mathematical and computer simulation modeling, evaluation of response errors in sample surveys, optimization of survey design, estimating variance components in multistage surveys, and the technical editing of statistical literature.

## Survey Operations Center

J. Donald Bates, DIRECTOR

Supervises and performs all phases of survey data collection and reporting. Develops field-testing and scheduling procedures for data collection, designs and pretests questionnaires and other survey instruments, conducts interviewer training, edits and codes survey data, and implements verification and quality control measures. Performs methodological studies for enhancing data collection techniques.

## National Assessment Administration Center

William K. Grogan, DIRECTOR

Designs field procedures and coordinates data collection activities for the administration of educational assessment packages to a national sample of students.



James R. Chromy, William K. Grogan, Robert H. Thornton, W. Kenneth Poole, and J. Donald Bates. Inset: B. V. Shah and Paul G. Homeyer.

## SURVEY RESEARCH

The resources of RTI's Social Sciences and Statistical Sciences groups give the Institute a distinctive capability among national survey research organizations.

The combined staff of the two groups totals over 250 and includes sociologists, economists, social psychologists, political scientists, demographers, health analysts, urban planners, transportation engineers, ecologists, and educational specialists, as well as statisticians expert in sample design, survey methods and operations, data processing, and data analysis.

Each RTI survey research project emphasizes total survey design. Appropriate measuring instruments consistent with project objectives are developed, and the most cost effective methods are used for collecting reliable and accurate data from the population group of interest. Sampling strategies, modeling, and multivariate analysis are often combined with data collection techniques in innovative ways to solve specific problems.

THE RTI NATIONAL GENERAL PURPOSE SAMPLE, consisting of 100 primary sampling units across the country, is staffed by 12 off-site district supervisors who hire, train, and direct field interviewers according to specifications developed by central office survey specialists.

A leading feature of RTI's survey research operations is the availability of central staff specialists for assignment to specific locations throughout the U.S. for on-site supervision of community and state surveys.

## Survey Research Capabilities

### Complete survey research services

- survey design
- questionnaire design
- sample design and selection
- data collection
- data reduction and tabulation
- analysis and reporting

### Sampling and statistical methodology

- sampling methods and theory
- experimental design
- data analysis
- statistical theory
- complex survey design evaluation
- modeling

### Sampling frames

- national area probability sample
- households and individuals
- hospitals, nursing homes, physicians
- schools and universities

### Data collection

- questionnaire design, development, and pretesting
- methodological studies of questionnaire formats, response options, alternate field procedures, and screening techniques
- field supervision of data collection
- mail, telephone, and personal interviews
- quality control of data and procedures

### Data processing

- data base design
- direct data entry terminals
- optical scan machine scoring
- real time control systems
- file maintenance and data retrieval
- report production

### Quality of life research experience

- population and demographic surveys
- socioeconomic surveys
- national educational surveys
- state educational assessments
- health surveys
- environmental studies
- program impact and evaluation surveys
- longitudinal surveys

Research Triangle Institute conducts national, regional, state and local sample surveys on a wide range of social, economic and health issues. Recent and ongoing survey research projects include:

Drug usage among an arrestee population  
Drug Enforcement Agency

Social contexts of alcohol consumption  
National Institute on Alcohol Abuse and Alcoholism

National survey of adolescent delinquent behavior  
National Institute on Alcohol Abuse and Alcoholism

National assessment of educational progress  
Education Commission of the States

State educational assessments in more than a dozen states

Health effects of nitrogen oxides in ambient air  
Environmental Protection Agency

Household surveys of births and deaths  
National Center for Health Statistics

Incidence of abortion in urban North Carolina  
School of Public Health, University of North Carolina

Organization of fire protection systems  
National Science Foundation

Incidence, prevalence and costs of head and spinal cord injuries  
National Institute of Neurological Disease and Stroke

National longitudinal survey of high school seniors  
National Center for Educational Statistics

Follow-up of patients treated with Iodine-131  
Environmental Protection Agency

Rural area development coordination  
Community Services Administration

Safe schools study  
National Institute of Education

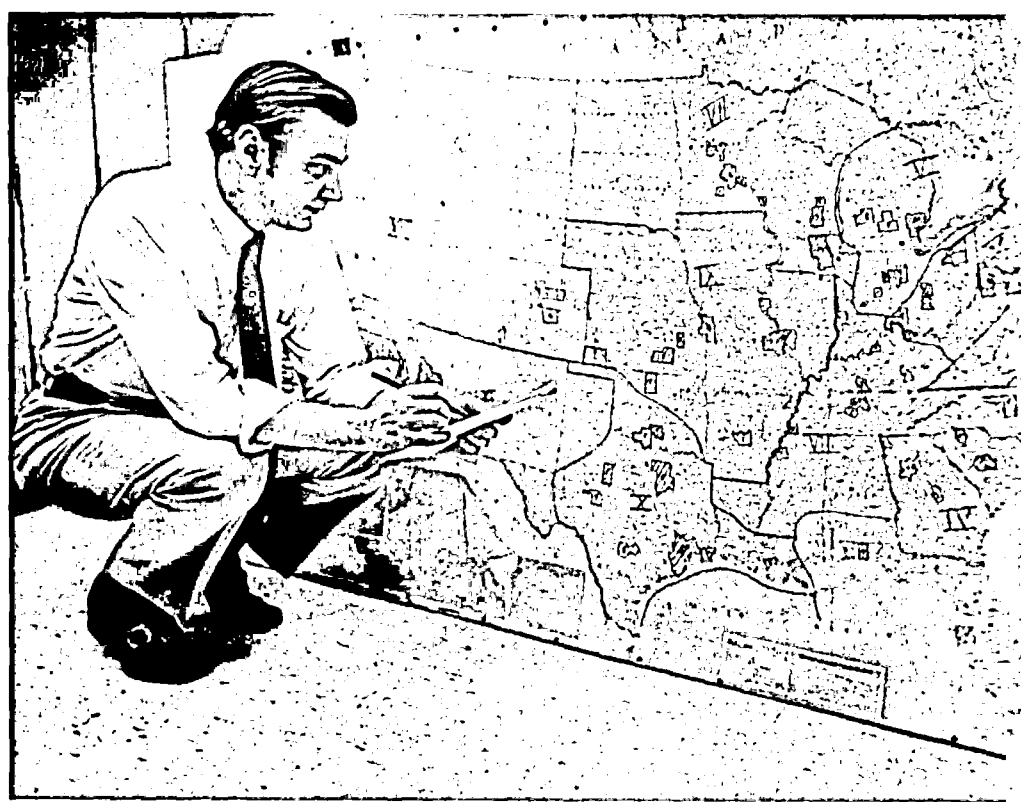
Social, economic, and environmental effects of water resource development projects  
Corps of Engineers, U.S. Army

Women, infants and children nutrition survey  
School of Public Health, University of North Carolina

Registry of patients on chronic dialysis  
National Institute of Arthritis, Metabolism and Digestive Diseases

National fertility study (birth cohort 1900-1910)  
Georgetown University

Evaluation of hospital discharge survey  
Health Resources Administration



RTI's national general purpose sample consists of 100 primary sampling units across the U. S. subdivided into 960 sample points.

The goals of the National Assessment of Educational Progress (NAEP) are to provide census-like information that describes the knowledge, skills, and attitudes of America's young people, and to measure changes in these attributes over time.

A project of the Education Commission of the States funded by the U. S. Office of Education, the assessment includes written, oral, and demonstration exercises administered to students in all sections of the country. It covers ages 9, 13, and 17.

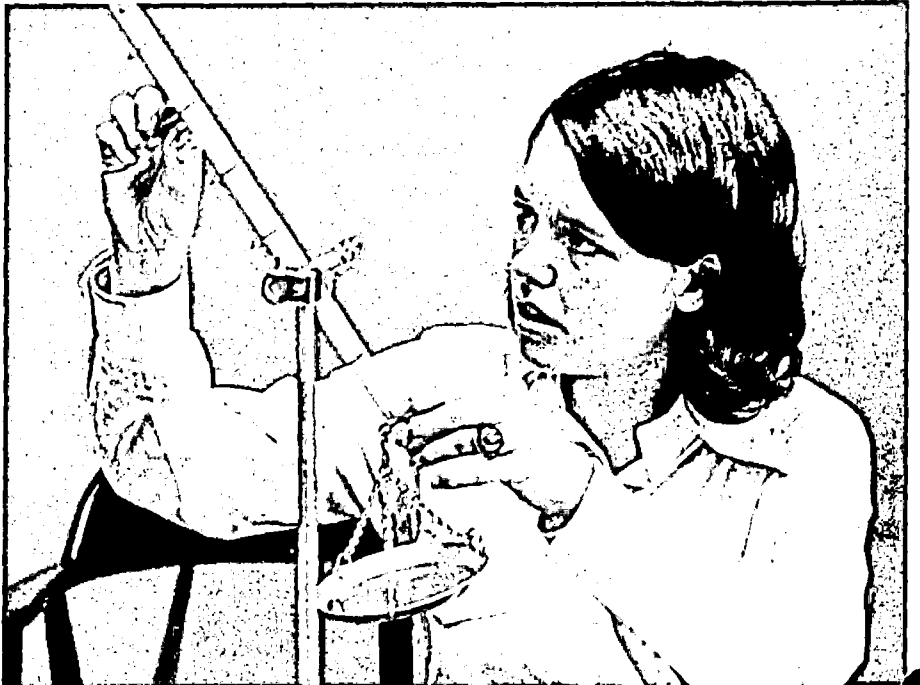
RTI statistical scientists and survey specialists have assisted with NAEP planning and implementation since 1966. They

## National assessment of educational progress

design the necessary sample surveys, specify procedures for identifying randomly selected individuals to be assessed, and are responsible for exercise administration and data collection.

About 100,000 young people in the three age groups are assessed each year in two of ten subjects. The same two subjects are repeated with the same age groups at five-year intervals. Results obtained in the successive cycles provide comparisons by which changes in educational attainment can be measured.

Assessment results are analyzed by the Education Commission's NAEP staff, and reported for the U.S. as a whole and for the nation's four major geographic regions.



Art and science are two of the ten NAEP assessment subjects. Others are career and occupational development, citizenship, literature, mathematics, music, reading, social studies, and writing.

In educational assessments for individual states, information similar to that obtained by NAEP can be used to compare the performance of a state's students with national and regional results.

## State assessments

Using NAEP methodologies as models, a state can tailor its assessments to special objectives, needs, circumstances, and resources.

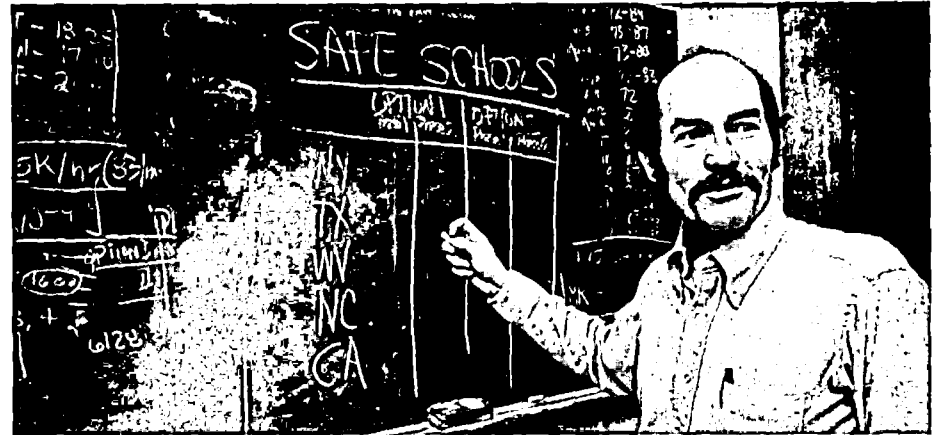
Particular features developed for state programs are assessing students by grade level rather than by age group, "piggybacking" (a method by which school districts can economically obtain local results), and "desired outcome" measures which may highlight areas of concern or commendation.

RTI assists more than a dozen states from coast to coast in their assessment programs. Institute participation may include management planning, instrument development, sampling, survey design and execution, staff training, field supervision, and data processing and analysis.

RTI provides data collection, processing, and analysis services for a University of North Carolina at Chapel Hill pilot study to evaluate the health effects of a U. S. Department of Agriculture supplemental food program for pregnant women, infants, and

## Food program health effects

children. Data for the medical evaluation include information about sociodemographic status, clinical and biochemical measurements, and dietary habits of 45,000 individuals from low income families in 20 geographic pilot areas.



RTI statistical scientists combine basic research in the classical fields of experimental design, sampling, and theory with new systematic approaches to clients' action and planning programs.

RTI keeps track of the progress and plans of more than 20,000 former high school students in a national

## High school follow-up

longitudinal survey of seniors from the class of 1972. The study's aim is to determine how individuals' high school experiences affect their later attitudes, levels of aspiration and

performance, occupational choices, and decisions to pursue technical training or other forms of higher education. Tracing techniques used in follow-up surveys have enabled RTI to maintain contact with more than 90 percent of the students who were included in a 1972 U. S. Office of Education national probability sample of high school seniors.

Alcoholism research at RTI includes analyses of drinking behavior and habits, assessment of alcoholic treatment center operations, and monitoring the effectiveness of rehabilitation programs for the public inebriate. Major studies cover the evaluation of drinking-driving countermeasures, the alcoholic experiences of adolescents and their attitudes towards drinking, the social situations in which drinking occurs

## Alcoholism

and the amounts consumed as a function of social context, recovery from alcoholism in the absence of formal treatment, multiple drug use among alcoholic persons, and differences in drinking behavior determined for such cultural variables as age, sex, ethnicity, religious affiliation, and other socioeconomic characteristics.

For several decades rural America has not shared fully in the physical, economic, and human resource development investments made in metropolitan areas. In a 2½ year study of Federal demonstration projects in multi-county regions of two states, RTI researchers are conducting an evaluation of Community Services Administration

## Rural rehabilitation

programs which seek solutions to some of the problems associated with rural poverty. The purposes of the demonstration projects are to articulate the needs of rural minorities, and to devise and provide services which will improve their incomes, educational opportunities, health care, social satisfactions, and general living conditions. RTI's objective is to gauge the effectiveness of the two projects by measuring the attitudes



Health manpower research includes computer modeling to estimate the future demand for registered nurses.

and degrees of satisfaction among the individuals, families, and communities that have received increased services in the demonstration areas.

Damage to the skull, brain tissue, and spinal column makes up a category of conditions that is

## Head and spinal cord injuries

variously estimated to affect anywhere from three-quarters of a million to eight million Americans at any given time. RTI is conducting a nationwide case survey to enable

the National Institutes of Health to make more reliable estimates of the incidence, prevalence, and costs of head and spinal cord injuries. An RTI advisory committee of leading neurologists, neurosurgeons, and other specialists specified the medical definitions for the injuries to be covered in the survey, and provided needed guidelines for collecting medical data from hospitals, clinics, nursing homes, rehabilitation centers, and physicians in private practice. Cost data include direct expenses of patients, public expenditures for care and facilities, and estimates of manpower productivity losses.





RTI social scientists analyzed U. S. teenagers' drinking habits and their alcohol-related beliefs and attitudes in a national survey of more than 13,000 students at a randomly selected sample of 60 junior and senior high schools.



The Navajo are included in RTI research to measure English language proficiency among bilingual ethnic groups.

■  
 Drug usage and drug abuse are subjects of special concern to society and to RTI. An Institute investigation into the relationship between the use of illegal drugs and the incidence of serious crimes against the person is the most comprehensive study yet undertaken in this area of human behavior. Related research includes a statistical analysis of pharmacy theft data, a study of

## Drug abuse

measures for reducing drug abuse in the Army, and a survey of persons arrested on federal drug charges and later implicated in or charged with post-arrest drug offenses. Major research programs on substances of abuse are carried out in RTI's Chemistry and Life Sciences Laboratory (see page 25).

■  
 English-speaking disability inflicts serious handicaps on many members of America's ethnic minorities and poses a major challenge to U. S. educational programs. To test the validity of proposed methods for accurately estimating the severity

## English language proficiency

and extent of the problem, RTI has carried out a field survey with instruments designed to measure English language proficiency among bilingual ethnic groups. Results of this study are used to aid in formulating interview questions incorporated in a very large national survey conducted by the Bureau of the Census. Households covered in the RTI field test include those of the Navajo, Asians, and Spanish-speaking Chicanos and Cubans.

Recreation, tourism, and travel have been the subjects of RTI research for several states. They include analyses of state park and state forest needs, outdoor recreation planning, and detailed inventories of the services, uses,

## Recreation, tourism, travel

and economic effect of public and private recreational facilities. An Institute survey for North Carolina's billion dollar travel industry contains comprehensive data about traveler and trip characteristics such as size of party, purpose and duration of trip, activity preferences and spending patterns, and about the impact of income and employment generated by travel expenditures.

Criminal incidents at the nation's public schools have been estimated to cause tens of thousands of injuries to students and teachers, while vandalism and theft may result in losses of some half-billion dollars annually. In addition, the effects that violence and the fear of violence have on impairment of the learning process and pupil achievement are extremely serious.

## School crime

RTI is obtaining and assembling information about the number and types of criminal incidents occurring on school property, crime prevention methods used at the schools, and the individual experiences of teachers and students. The data will be used as the basis for a National Institute of Education report suggesting policies that will be effective in reducing and controlling school crime.



Programming, data processing, and data analysis capability enables RTI to deal with very large quantities of information in support of research in all Institute groups.

Fire claims an estimated 12,000 lives and three billion dollars in property damage every year. RTI is compiling and analyzing census-ELE survey data from 200 moderately-sized (less than 1.5 million population) metropolitan areas to evaluate the organization of their fire protection delivery systems in regard to efficiency, effectiveness, equity, and responsiveness. The National Fire Protection Association and International City Management

Association are collaborating in the study for the National Science Foundation.

Cities' fire protection problems vary according to such

## Fire protection systems

characteristics as area, population density, location and climate, industrial and residential patterns, governmental system, equipment resources, and budgets. In order to

relate an area's fire service to its context within the local community, RTI researchers examine these and other characteristics in terms of fire protection supply and demand. Special emphasis is given to quantifying the potential tradeoffs between fire prevention activity and fire suppression activity in reducing losses, and to providing criteria by which cities can evaluate the performance of their entire fire protection systems.



To some health maintenance planning programs, an systems analysts created and maintain a national registry of chronic urmia patients who are receiving dialysis treatment. The eight year-old kidney disease registry now includes medical and demographic data on 30,000 dialysis patients, about 70 percent of the nation's total, and approx. 500 treatment centers.

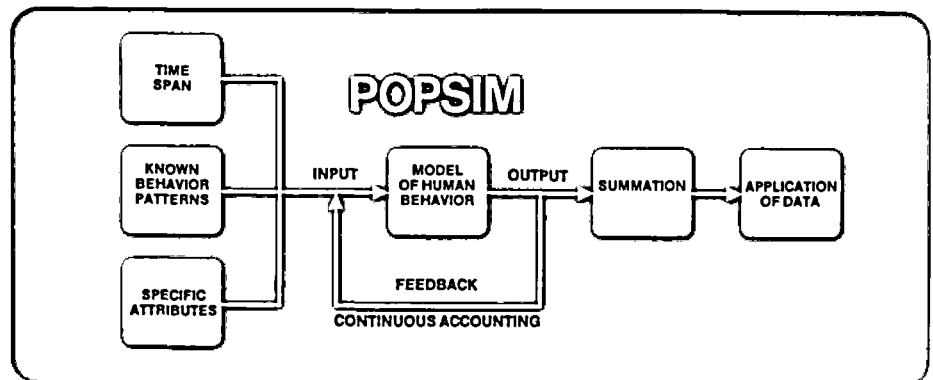
POPSIM is a dynamic demographic model designed for computer simulation of the real-life processes that occur among human societies and their subpopulations. After a population is identified by specific attributes such as age, sex, color,

## Population simulation

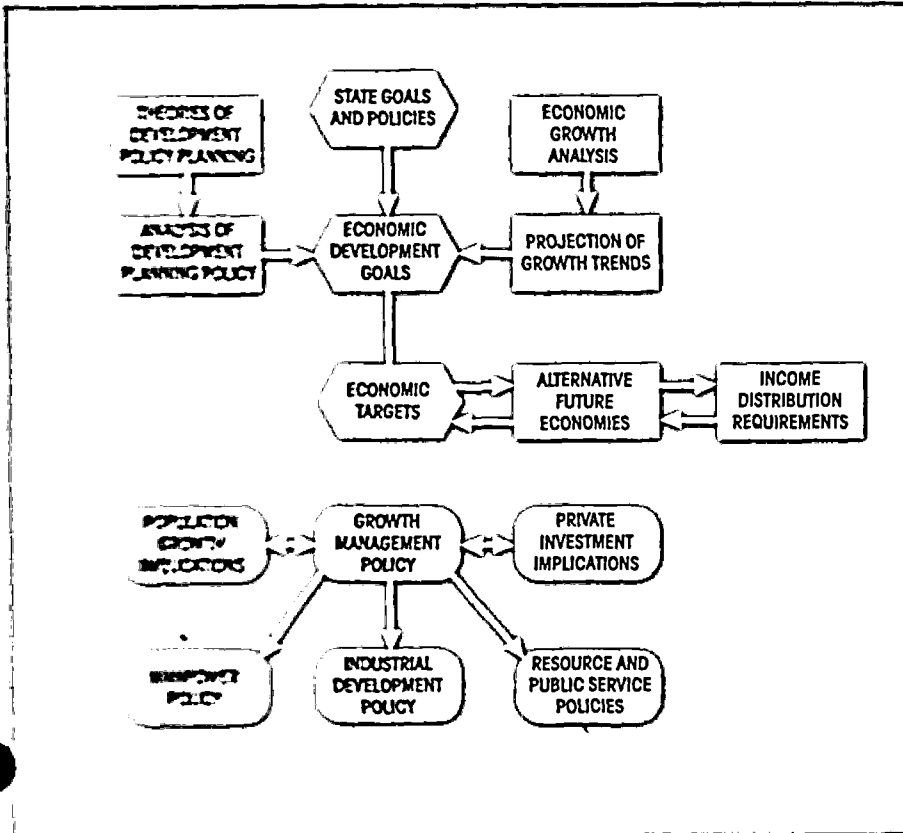
marital status, income, education or other items, POPSIM generates a vital history for each individual that includes birth, marriage, parenthood, divorce or widowhood, illness, death, and other events. Behavioral patterns for the entire population of individuals are observed through time, then summarized and reported in terms of numbers, rates, and other descriptive statistics.

A stochastic microsimulation

model, POPSIM can deal with complex population and other social phenomena using fewer restrictive assumptions than analytic models require. POPSIM was developed at RTI in cooperation with the University of North Carolina's School of Public Health and the National Center for Health Statistics, and has been adapted for a variety of applications in the U. S., Asia, and Africa. Uses include evaluating family planning practices, analyzing fertility trends, forecasting the morbidity and mortality effects of public health measures, examining the consequences that errors in survey data have on derived statistics, and preparing population projections for models of hospital utilization and hospital manpower requirements.







Planning for economic growth management.



A consultant advisor for the U. S. Bureau of Health Manpower, RTI research teams are working with students and health education officials to identify the barriers that members of rural minorities perceive as limiting their opportunities for pursuing careers in dental hygiene, occupational therapy, x-ray technology, and other medical support fields.

State governments are concerned with the dynamics of change and interaction among populations, natural and financial resources, and balanced economic growth. RTI economists and analysts assist in

## State growth policy

the development of guidelines for state growth policy planning and decision making. Research activity includes forecasting changes in economic, demographic, and employment structure, describing the impact of public service investments and industrial development, identifying public service needs, and defining alternative growth strategies.

RTI research in less developed countries has focused on population growth and economic development. Current activity centers in Africa, with an RTI senior population economist stationed in Ghana as advisor to the government and to the University of Ghana. In addition, the Institute

## Less developed countries

provides short-term assistance to several other countries through contracts with the U. S. Agency for International Development and the International Bank for Reconstruction and Development. The major sectors being addressed are health and nutrition, agriculture and rural development, and education and human resources.

The U. S. Bureau of the Mint is producing almost 14 billion coins per year, three-quarters of them pennies. The 1974 total manufacturing figure was 11.6 billion, and in 1973 the Mint produced 9.7 billion coins. In 1950 only about two billion new coins were issued. In a study to forecast the nation's coinage requirements through the year 1990, RTI is assessing options for possible changes in coin denomination, size,

## Coinage requirements

and shape, and in the raw materials used for coin composition. Particular attention is being given to a proposed 2-cent coin and to a

smaller, handier dollar. The research also includes surveys to determine public acceptance of proposed options, examination of production and distribution methods needed to meet future demand, and estimating the marketing and economic effects that would result from adoption of the various coinage system alternatives.

A U. S. Public Health Service dental care program began several years ago at grade schools in a 13-county area of Tennessee and Georgia. In addition to examination and treatment for participating students, the program also introduced dental health education

for parents, teachers, and administrators. An RTI survey to evaluate and document the sentiments associated with their acceptance or nonacceptance of

## Dental care

the program will provide a basis for assessing probable national response to proposals for national health insurance coverage of dental services to children. RTI is also analyzing the increases in productivity and efficiency that may be achieved through group dental practices as compared with solo practices, and is examining the quality evaluation methods used by third party carriers of prepaid dental insurance.



RTI has developed a pedestrian and bicycle safety program that is being put into effect for North Carolina school children beginning in kindergarten and continuing through grade nine.

The children of migratory agricultural workers and fishermen face severe educational disadvantages. Although provisions are made to support special programs for them, there are many problems in accurately assessing

## Migrant children

the effect that these programs have on educational progress. The children's mobility is their most serious handicap, and also hinders reliable measurement of educational attainment and experience. Their lack of competence in using the English language is another obstacle, both to achievement and to assessment. The U. S. Office of Education has outlined an approach for

evaluating the impact of government investments in behalf of migrant children. Working with national, state, and local agencies, RTI is developing the outline into a viable evaluation design.

Increased deliveries of crude oil to the Atlantic Coast may require expanded refinery capacity and port facilities. To aid state

## Petroleum industry

government in formulating policy related to future petroleum industry growth, RTI has investigated the economic, social, and environmental consequences

that can be expected from such developments in eastern North Carolina. Specific regional impacts were examined at three target locations. RTI conducted the economic and social components of the research. Their effects were measured in terms of direct and indirect employment, personal income, property tax base, housing, schools, and community attitudes and expectations. The State of North Carolina performed the environmental component, which covered water resource requirements and potential stresses on air, land, animal, and water systems. RTI designed the overall study and analyzed the interactions among economic, social, and environmental effects.



Programmable Sycor direct data entry terminals convert all types of survey data onto computer tape in machine readable form.

Remote terminals at RTI provide access to the IBM 370/165 at the Triangle Universities Computation Center.

# Chemistry and Life Sciences

Monroe E. Wall, Vice President

F. Ivy Carroll  
DIRECTOR FOR  
ORGANIC AND  
MEDICINAL CHEMISTRY

Clarence E. Cook  
DIRECTOR FOR  
LIFE SCIENCES AND  
BIOORGANIC CHEMISTRY

Colin G. Pitt  
DIRECTOR FOR  
PHYSICAL SCIENCES

Monroe E. Wall  
ACTING DIRECTOR FOR  
ANALYTICAL SCIENCES

The traditional separations between life sciences and chemistry have all but disappeared over the past decade. Basic medical science depends more and more upon the physical sciences, especially chemistry, and chemists have become increasingly aware of

their responsibilities in the life sciences. This merging of interests is evident at RTI, where chemists and life scientists work closely together on basic research programs in natural products chemistry, synthetic organic and medicinal chemistry, polymer chemistry and physics, bioanalytical and environmental chemistry, drug metabolism, genetics, teratology, reproduction, and pharmacology.

Program areas in organic and medicinal chemistry include the isolation and structure determination of biologically active compounds from natural sources, and the synthesis of isotopically labeled organic compounds, anticancer agents, oral contraceptives, narcotic antagonists, the active constituents of marijuana, antimalarials, and a variety of hormonal substances,

analgesics, barbiturates, and agricultural materials.

Analytical chemists study methods for detecting environmental pollutants, and are developing techniques such as radioimmunoassay, gas chromatography, and mass spectrometry for the detection of drugs and their metabolites in biological fluids.

Life scientists are studying the interaction of natural and synthetic hormones with receptor proteins, the pharmacokinetics of many different drugs, including contraceptive agents and drugs of abuse, and the teratogenic (birth defects) and mutagenic (hereditary) effects of industrial chemicals and pollutants.

Polymer chemistry and physics programs cover basic research on the structure and properties of polymers, with an increasing emphasis on industrial and health-related applications. Areas of interest include synthesis, characterization, and degradation of polymers, radiation effects, transport phenomena, rheology, fiber morphology, plastic deformation and fracture, flammability and flame retardation, and the development of desalination membranes, blood compatible polymers, and drug-delivery systems based on polymers.

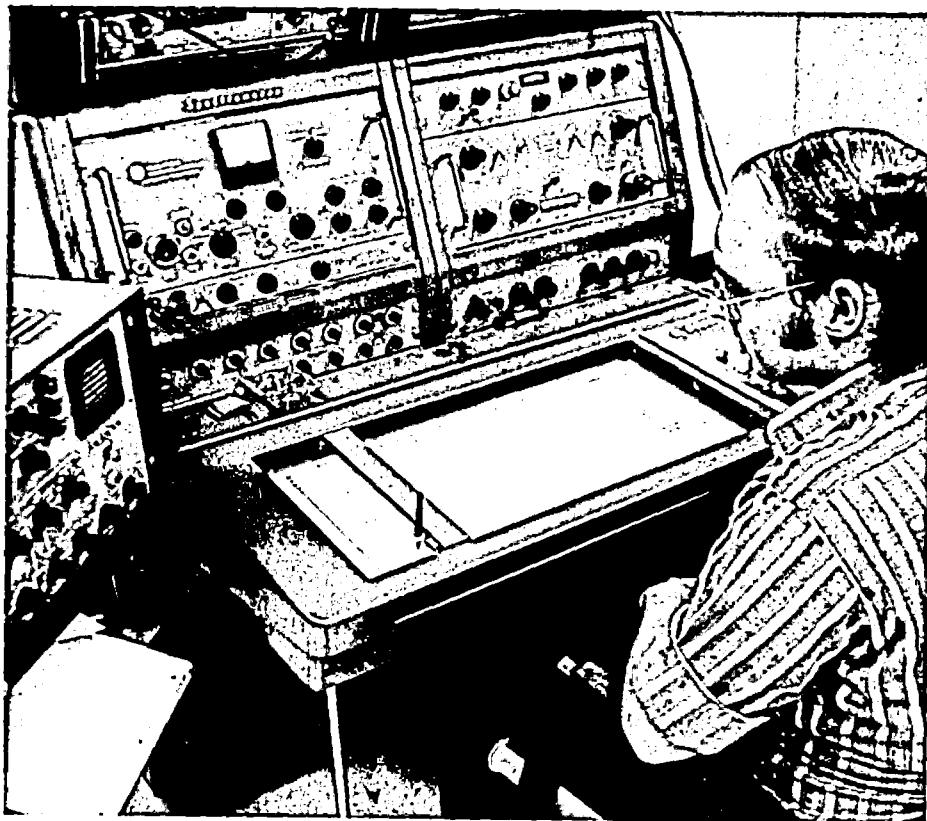
Extensive analytical instrumentation resources are available. Mass spectrometry, gas and high pressure liquid chromatography, nuclear magnetic resonance spectroscopy, atomic absorption, x-ray scattering, and scanning electron microscopy are among the many physical techniques used by RTI scientists.

Chemistry and Life Sciences members have published more than 600 papers in the scientific literature.

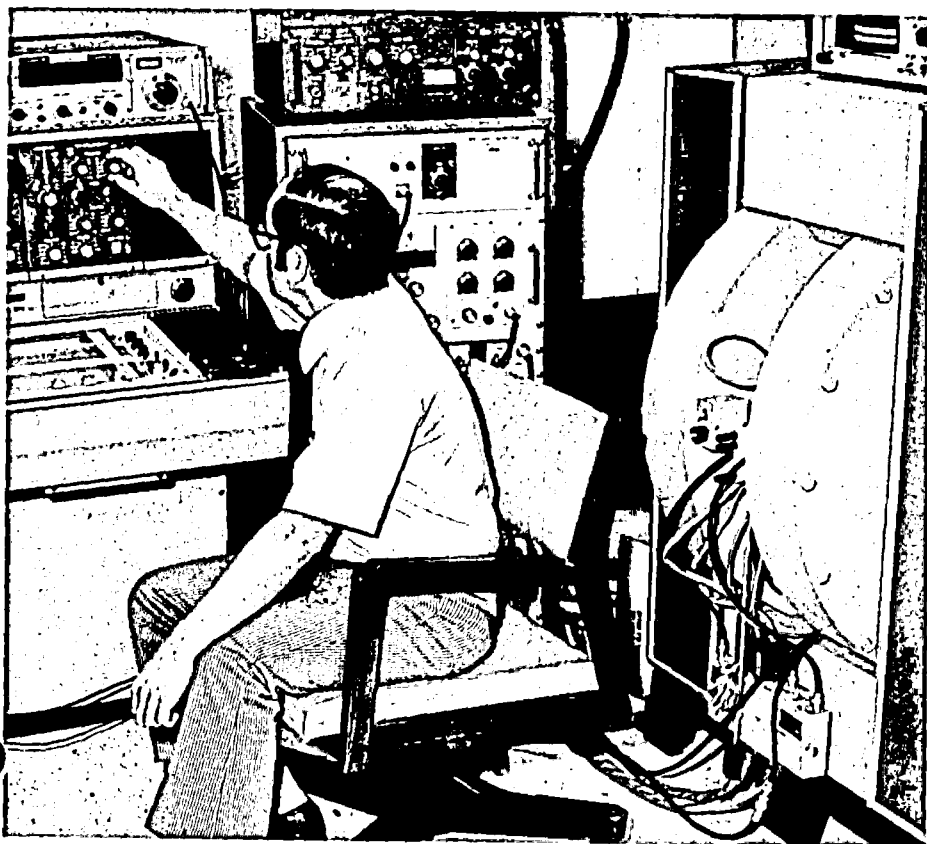


F. Ivy Carroll, Clarence E. Cook, and Colin G. Pitt.





RTI analytical equipment for examining natural products, drug metabolites, and other biomolecules includes both proton and pulsed transform carbon-13 NMR fourier spectrometers.



## Reproduction and Fertility

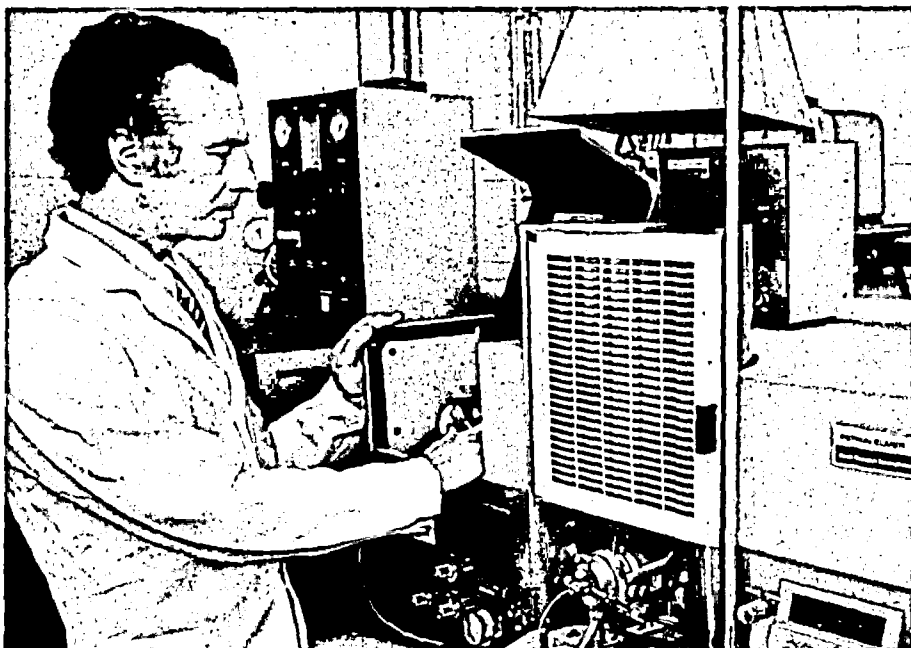
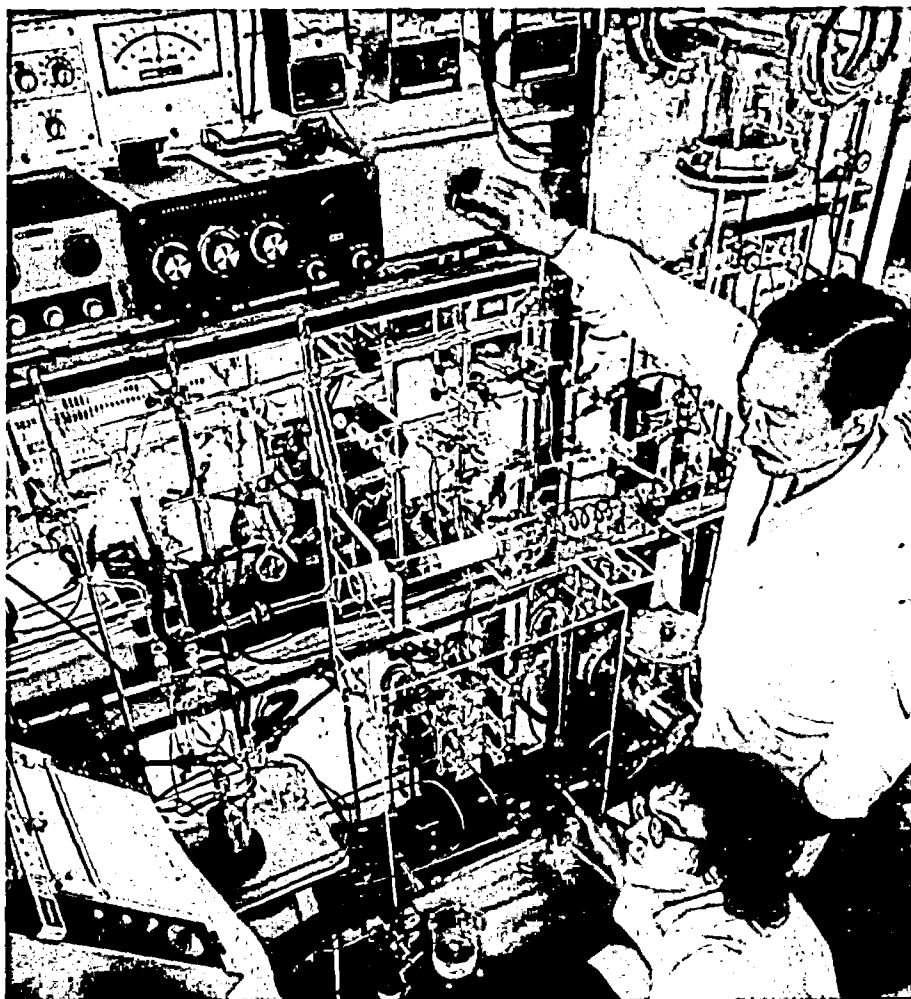
The development of oral contraceptives represented substantial progress towards the goal of bringing population growth into balance with the world's finite resources of land, food, materials, and energy. Unfortunately, the pill in its present form can cause serious side effects.

A better understanding of the biochemistry of reproduction is helping chemists develop new and safer contraceptive agents. For example, it is known that the fluctuating but synchronized levels of the steroid hormones estradiol and progesterone are critical to the proper regulation of the various phases of the ovarian cycle and, consequently, to human reproduction. RTI scientists are studying the possibility that estrogen or progestogen antagonists administered to females may act as contraceptive agents by blocking or displacing the natural hormones from their protein receptors.

In addition to synthesizing many different compounds which have potential antifertility properties in males and females, RTI scientists are testing their effectiveness with animals such as the rat and hamster. The action of these new compounds at the molecular level is also analyzed, and measurements of their interaction with receptor proteins in the body are providing information on how to design better agents.

Glow discharge polymerization improves the blood compatibility of materials used in building artificial organs for the human body.

Atomic absorption techniques enable RTI scientists to detect and analyze trace amounts of metals which occur in virtually all physical and biological environments.



## Drug Delivery Systems

While very significant progress has been made in the design of more effective and selective drugs for medicinal purposes, methods for improving their administration have received far less attention.

If a drug is to be utilized properly, it must be present in the body at the right place, for the right time, and in the right amount. The body can control the supply and distribution of its essential chemicals by very precise and sophisticated mechanisms. The clinician, administering a therapeutic drug in the form of a pill or intravenous injection, rarely achieves the same degree of control. Recognizing this, scientists are devising new methods of drug administration.

An especially promising approach being studied at RTI involves the use of polymers to maintain a continuous supply of the drug within the body. The drug is mixed with or placed inside a small cylinder of the polymer, and after injection it is released slowly and continuously at a predetermined rate. With this technique the drug supply can be maintained at therapeutic levels for very long periods, avoiding the undesirable fluctuations that occur with daily administration.

RTI scientists are developing polymer systems which will continuously release contraceptive agents for one year or more, and which are slowly biodegraded by the body during this time. The polymers are polyesters. Following their synthesis, the rates of diffusion of the drugs from the polymers are measured under *in vitro* conditions. The experiments are then repeated using laboratory animals, and information on the rate of biodegradation of the polyesters is also collected. By

evaluating a number of different types of polymers, RTI scientists can now design polymer devices with predictable drug delivery rates and lifetimes.

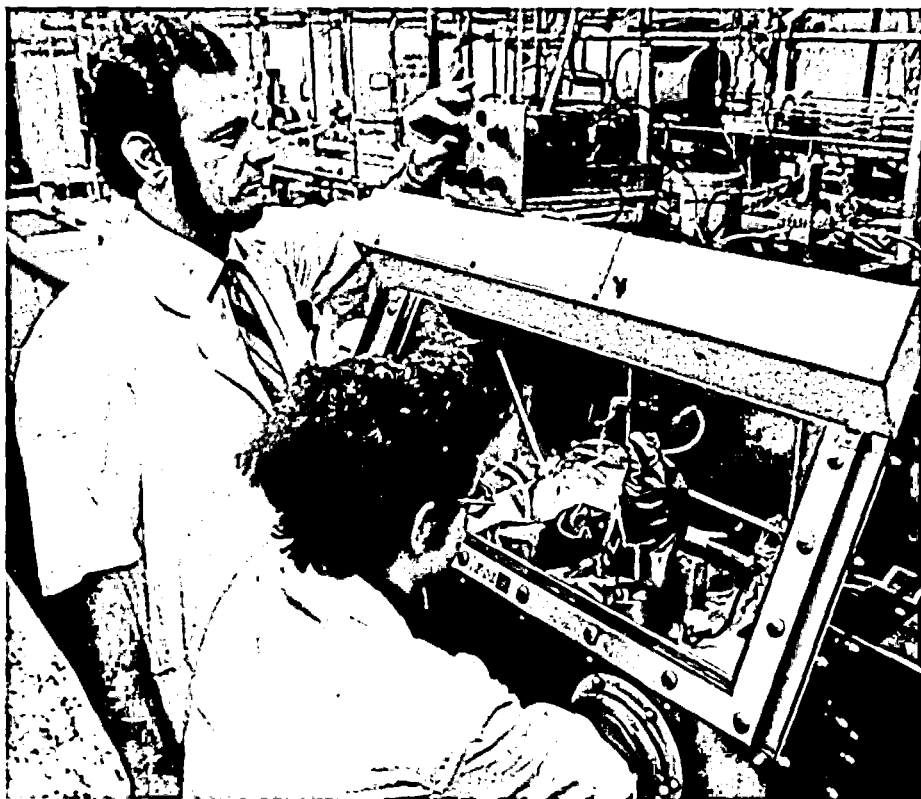
## Drug Abuse

As part of a national program sponsored and coordinated by the U. S. Department of Health, Education and Welfare, RTI is studying the chemistry and pharmacology of many commonly abused drugs. Prescription drugs such as amphetamines and barbiturates, marijuana, habit-forming narcotics of the morphine class, and narcotic antagonists such as methadone are among the classes of drugs being examined.

One facet of the research deals with the development of new and more sensitive methods of

detecting drugs through the use of chromatography, mass spectrometry, and radioimmunoassay. These analytical techniques are useful in biological studies, and also find application in forensic laboratories, and in hospitals, where they enable physicians to diagnose overdose cases and promptly initiate treatment.

RTI chemists are also looking at new ways to synthesize the drugs and the antagonists, and to label them with radioisotopes. These materials are sent by RTI to medical centers throughout the world for use in pharmacological and toxicological studies. Working with university hospitals, pharmacologists at RTI have made significant contributions to knowledge about the metabolism of marijuana in humans.



RTI chemists assist the Environmental Protection Agency by developing new materials for capturing and analyzing trace amounts of potentially hazardous carcinogenic or cancer-causing vapors.

## Antimalarial Agents

Malaria is one of the most widespread and lethal of all human diseases. It is a protozoan infection in which the causative agent undergoes cyclical development both in man and in the mosquito carrier. Four species of protozoan organisms cause malaria in humans: *Plasmodium falciparum*, *P. vivax*, *P. malariae*, and *P. ovale*.

Primaquine is a well known antimalarial drug which is highly active against the primary exoerythrocytic (red blood cell) forms of *P. vivax* and *P. falciparum*

malaria, and against the gametocytin of all four species of plasmodia that infect humans. The major drawbacks to the use of primaquine are its relative toxicity and rapid excretion. In contrast, however, other antimalarial drugs such as the 4-aminoquinolines, quinine, and quinacrine have proven to be inadequate for preventing relapses of *vivax* malaria.

An RTI program to study modifications of primaquine has included both the resolution of the drug into its optical isomers, and the synthesis of many 4-substituted

primaquine analogs. These compounds have been tested against *Plasmodia cynomolgi* in rhesus monkeys. Results have shown that one optical isomer of primaquine is only one-half as toxic as the other, while retaining the same antimalarial activity. In addition, test results have shown that 4-ethylprimaquine, one of the compounds prepared in RTI laboratories, is more active than primaquine against *P. cynomolgi*. RTI chemists are investigating the resolution of other primaquine analogs, as well as further modifications of this drug.



High pressure liquid chromatography is an analytical technique for separating and quantifying plant constituents, pesticides, medicinal drugs, and other biological materials.

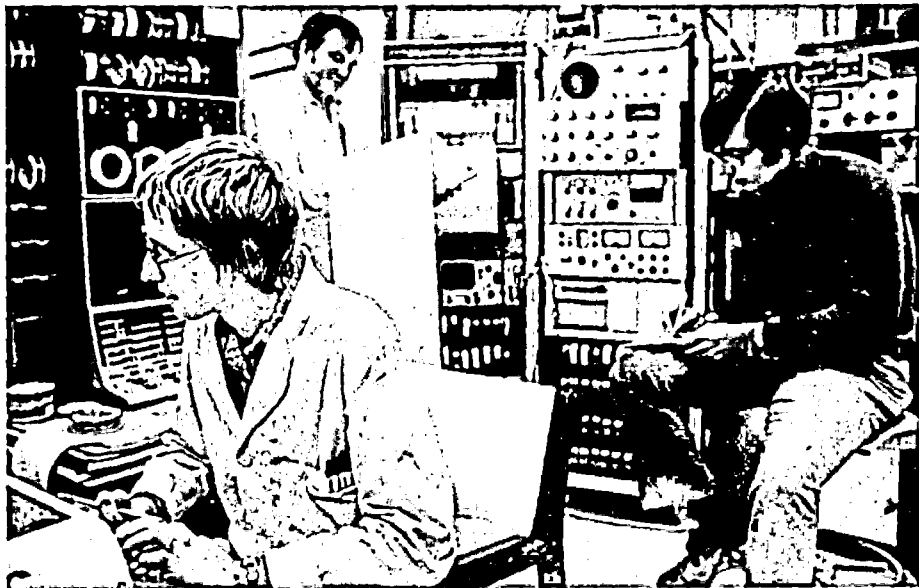
## Cancer Chemotherapy

The oldest sustained research effort at RTI involves the isolation and characterization of antitumor and antileukemic substances from plant materials and fermentation extracts. Some 6,000 plant samples have been examined in this continuing 15-year program with the National Cancer Institute (NCI), and a number of promising tumor-inhibiting agents have been identified.

Plant samples are procured from all parts of the world by U. S. Department of Agriculture botanists, who make special efforts to obtain additional genera and species of those plant families which show potential therapeutic activity. Fractionation guided by bioassay at every stage enables RTI scientists to isolate biologically active constituents which may be present in minute amounts. Classical methods of isolating active phytochemicals such as alkaloids and glycosides would not provide the range of totally novel and unique structures which has been revealed by this approach.

The first step in the fractionation process is preparation of a crude extract of the plant material. After testing for biological activity using a cell culture, extracts are forwarded to other NCI contractors for animal tests with a variety of experimental leukemia systems such as L-1210 and P-388. Purified extracts which show activity are also tested against slow-growing tumor systems such as B-16 melanoma and Lewis lung mouse carcinoma.

When the biological activity of a plant extract is confirmed by these animal studies, purification and identification of the active compounds is initiated. Purification may be accomplished by any of a number of separation techniques,



RTI's mass spectrometry center processes samples as small as a billionth of a gram for researchers in clinical medicine, biology, and environmental chemistry. Jointly established with the Triangle universities under grants from the National Institutes of Health, the center provides mass spectrometry services for institutions in the Triangle area and throughout the southeast.

including adsorption, partition, and thin layer and high pressure liquid chromatography. The structures of the purified compounds are established by various spectroscopic techniques, including infrared and ultraviolet spectrometry, high resolution mass spectrometry, and proton and carbon-13 nuclear magnetic resonance spectrometry. In many cases the exact structures of very complex, biologically active compounds have been established by x-crystallographic analysis.

### Fiber Morphology

Recent research at RTI has emphasized the role of microfibrillar structure in determining the strength and deformation properties of cotton fibers and the influence these properties have on transport phenomena. This work led RTI polymer physicists to the discovery that cotton in its never-dried botanical growth state possesses characteristics that differ significantly from those found in cotton's normal dried or wet state, and after treatment with various durable-press agents. The never-dried cotton is in a unique state, since it never reverts back after drying and re-wetting.

Methods were found for fixing cotton permanently in its never-dried condition, thus retaining these otherwise irrecoverable properties. Information emerged suggesting that some of these properties, such as high accessibility and the retention of high mobility between constituent microfibrils, might be potentially useful. As a result a "pioneer" patent on fixed never-dried cotton fiber assemblies has been assigned to RTI's client, Cotton Incorporated.

Related research on the structure of synthetic fibers and natural

polymers has resulted in the successful modification of cellulose to produce highly elastic fibers, yarns, and fabrics.

### Blood Compatibility

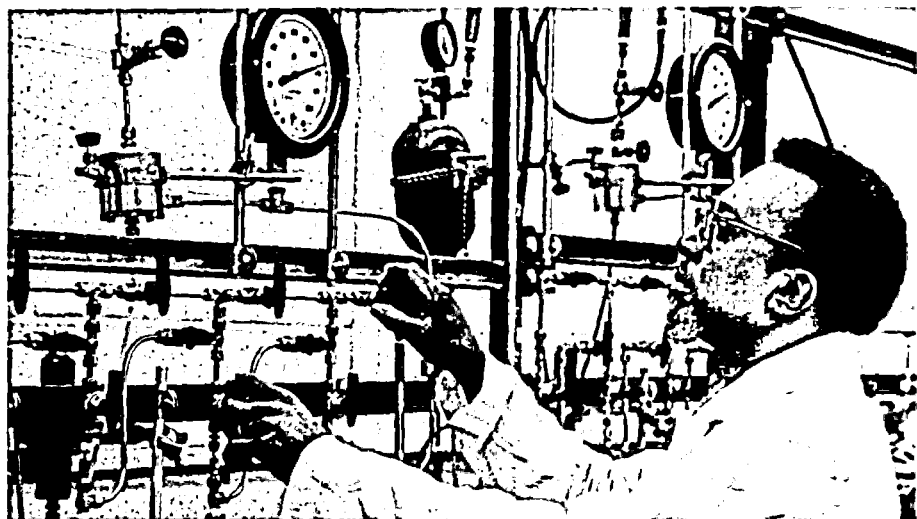
One of the most exciting fields of polymer chemistry is the development of new materials for the reconstruction of damaged or diseased human organs. A difficulty associated with the use of synthetic polymer materials in the body is their tendency to cause blood clotting. To help overcome this problem, RTI scientists are studying the application of glow discharge or plasma polymerization techniques to produce a very thin coating of blood compatible material on the polymer surface. This technique can be applied to nearly all types of polymers and, because the bulk physical properties of the polymer are unaltered, it is an ideal means of improving blood compatibility.

The development of nonthrombogenic, anticoagulant surfaces for various other medical uses is also being investigated. The objective is to produce a mobile, water-like pseudosurface which

resembles the surface of the blood conduit and will be innocuous to the blood, although not actively nonthrombogenic.

### Environmental Chemistry

Characterization and measurement of extremely minute amounts of hazardous compounds (carcinogens, mutagens, teratogens, etc.) in ambient air have been seriously hampered by the lack of reliable and sensitive instrumentation for direct analysis. RTI research for the Environmental Protection Agency includes special systems that concentrate organic pollutant vapors from the air for subsequent qualitative and quantitative analyses. Analytical techniques have been developed for evaluating collection efficiencies and breakthrough volumes of sorbent materials during the concentration of organic vapors from a flowing airstream. A thermal desorption inlet-manifold has also been designed for recovering and transferring hazardous substances from sorbents in cartridge samplers to a gas-liquid chromatograph or a gas-liquid chromatograph-mass



Hyperfiltration cells used in research on the development of new membranes for water desalination.

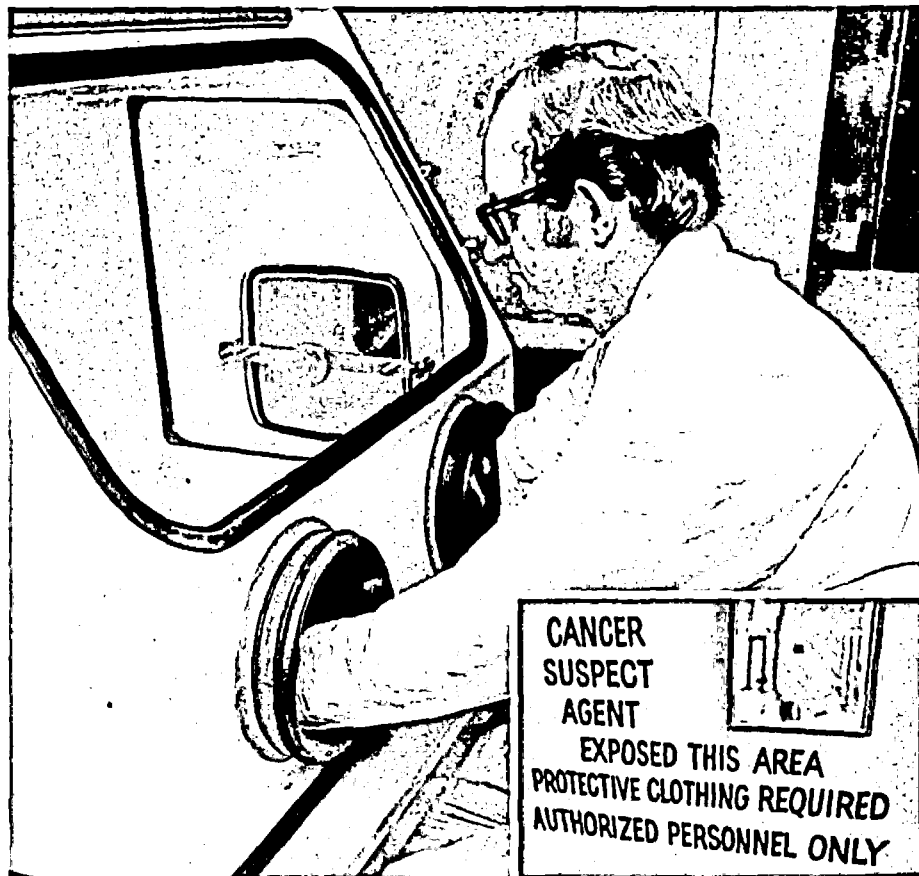
spectrometer, and design criteria were developed for a field sampling system to collect pollutants on a cartridge sampler.

Methodology and instrumentation developed at RTI have been applied to the analysis of ambient atmosphere in several geographic regions of the U.S., and have established the presence of carcinogens and mutagens in some areas. Through the use of RTI techniques, in-depth pattern recognition and statistical studies can be undertaken to correlate airborne pollutant concentrations with human health effects.

Other environmental research involves the identification of individual organic and elemental substances in liquid and solid wastes and effluents from energy-related processes. Results of these studies will provide a data base for researchers who are concerned with control technology and monitoring techniques, and with the health and ecological effects of energy-related pollution.

### Water Desalination

As part of a national desalination program sponsored by the U.S. Department of the Interior, RTI is developing new and improved membrane materials designed to produce fresh water from the sea and from brackish inland water. One approach employs reverse osmosis to develop a membrane which couples high water permeability with high salt rejection. RTI is evaluating the use of highly stable composite membranes which are prepared by plasma deposition of various polymers on an inert porous substrate in the form of sheets or hollow fibers. Another approach is based on the principle of pyrolysis. This principle produces that special composite



A hazardous materials facility protects researchers from exposure to cancer-causing and other toxic agents.

membranes, called charge mosaic membranes, can be prepared which, under hyperfiltration conditions, are more permeable to salt than to water. The prediction has been verified and RTI scientists are working on methods for improved production of charge mosaic membranes.

### Flammability

Many synthetic polymers are highly combustible and must be treated with fire retardants before they can be used safely in clothing and as construction materials. The effectiveness of flame retardants used for these purposes is often limited by laundering, weathering, and aging. RTI scientists are looking at methods of creating longer

lasting retardants by chemically grafting them to the synthetic polymers. RTI's cobalt-60 gamma radiation source is employed to initiate free radical combination of the fibers and retardants, and methods for grafting the retardant within the fiber as well as on its surface are being explored. The durability and effectiveness of the two types of grafting are compared with the aid of optical and scanning electron microscopy.

### Toxicology

The introduction of man-made chemicals and other substances into the environment has raised questions about their long term effects on human health. RTI programs aimed at helping to

answer these questions include studies on teratology and mutagenesis.

In the teratology program, RTI scientists look for abnormalities in animal fetuses which have been treated with chemicals such as food additives, pesticides, pollutants, and industrial products. The intent of these studies is to avoid such human tragedies as the thalidomide-induced deformities which occurred in the early 1960s.

Environmental factors may also exert long range toxicity by their ability to cause mutation. Programs at RTI are aimed at identifying potential hazards and at developing better techniques to evaluate their mutagenic and carcinogenic potential. The development of bacterial screens to provide rapid information is one area of research. In another, RTI scientists are measuring changes in the electrophoretic patterns of various enzymes to identify mutagenic effects. Since the sensitivity of these techniques makes it unnecessary to sacrifice the mutant animals, follow-up studies may be carried out.

### Drug Metabolism

Any drug which is administered to humans or animals is subject to attack and degradation by enzymes present in the body. Generally, the products of this enzymatic attack, termed metabolites, are more readily eliminated from the body than the drug itself. On occasion, however, they may cause toxic effects, or may even be responsible for the observed therapeutic effect. The rate at which metabolic conversion occurs has considerable bearing on the level of drug which can be achieved in the body with a given dose, and on the time during which the drug will remain effective. Therefore, the study of

drug metabolism is necessary both to determine the best mode of drug usage and to identify biologically active metabolites.

RTI involvement in drug metabolism studies covers all aspects of research from drug synthesis to assistance with clinical evaluation. Radioactively labeled drugs, with the labels serving as markers that trace the movement of the drug and its various metabolites through the body, are synthesized by radiochemists. Preliminary information on the nature of the metabolites is often obtained by incubating the radioactive drug with homogenized animal liver, which is a source of most of the enzymes that effect metabolic conversion. Small amounts of the radioactive metabolite products are isolated by thin layer chromatography or high pressure liquid chromatography, and their structures are established



RTI research on the isolation and characterization of antitumor and antileukemic substances from natural products has involved the examination of some 6,000 plant samples.

by such techniques as infrared and ultraviolet spectroscopy, high resolution mass spectrometry, and proton and carbon-13 NMR spectrometry. Both separation and identification can frequently be achieved by combined gas-liquid chromatography-mass spectrometry which, in effect, provides a fingerprint of each individual component.

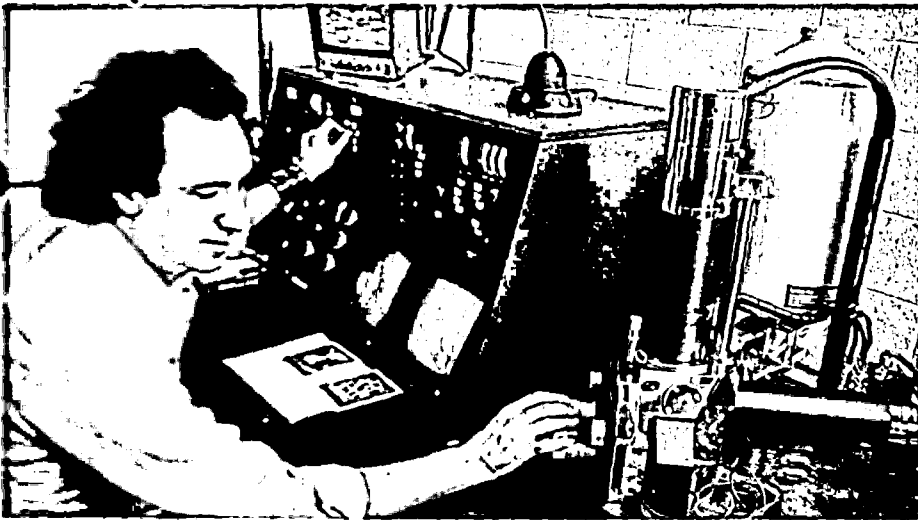
After identification, the metabolites are synthesized, and the synthetic materials are used to determine their biological properties and to establish analytical procedures for their detection and quantitation in human patients. Working in cooperation with clinicians, RTI scientists then examine how the drugs behave in the body. Once the human pattern of metabolism is known, analytical procedures are developed to quantitate the parent drug and its metabolites in body fluids such as urine and plasma. Sensitive and specific techniques such as liquid chromatography, gas-liquid chromatography, and radioimmunoassay are adaptable to clinical monitoring. Mass fragmentography, a highly specific technique, is used both to verify other methods and to overcome difficult analytical problems.

Drug metabolism programs at RTI have included a ten-year research effort on widely used oral contraceptives. In studies of various barbituates, RTI chemists were able to synthesize each of the two optical isomers which make up commercial products, and to study the metabolism of each form individually. More recent emphasis has been given to the metabolism of the active constituents of marijuana. Drug metabolism research at RTI also includes quinidine and certain proprietary compounds developed by pharmaceutical companies.





Analyzing the cannabinoid content of marihuana samples by gas liquid chromatography.



Scanning electron microscopy aids in analyzing the effects that durable-press and other chemical treatments have on the structure of textile fibers.



A cobalt-60 gamma radiation source is used in RTI research on flame retardant textile coatings and blood compatible polymers.

# Energy, Engineering and Environmental Sciences

James J. B. Worth, Vice President  
Robert M. Burger, CHIEF SCIENTIST

Engineers, scientists, economists, and analysts carry out RTI studies and perform laboratory and field analyses that provide insight on problems of national concern, aid in developing and applying new technologies, and meet the research, development, and programmatic needs of many organizations. Staff capabilities in a variety of engineering disciplines interact closely with those of related sciences in many subject areas. Strongly supported by information management and data processing resources, the combination produces a problem-oriented team approach that is flexible, versatile, and responsive to client needs.

## Energy and Environmental Research Division

Jimmie J. Wortman, DIRECTOR  
Harry L. Hamilton, Jr., ASSISTANT DIRECTOR

Engineering Sciences  
Process Engineering  
Economics  
Geosciences

## Operations Analysis Division

Edward L. Hill, DIRECTOR

Management Information Sciences  
Applied Ecology  
Applications Programming

## Systems and Measurements Division

James B. Tommerdahl, DIRECTOR  
Lyman A. Ripperton, SENIOR SCIENTIST  
Richard D. Alberts, SENIOR ENGINEER

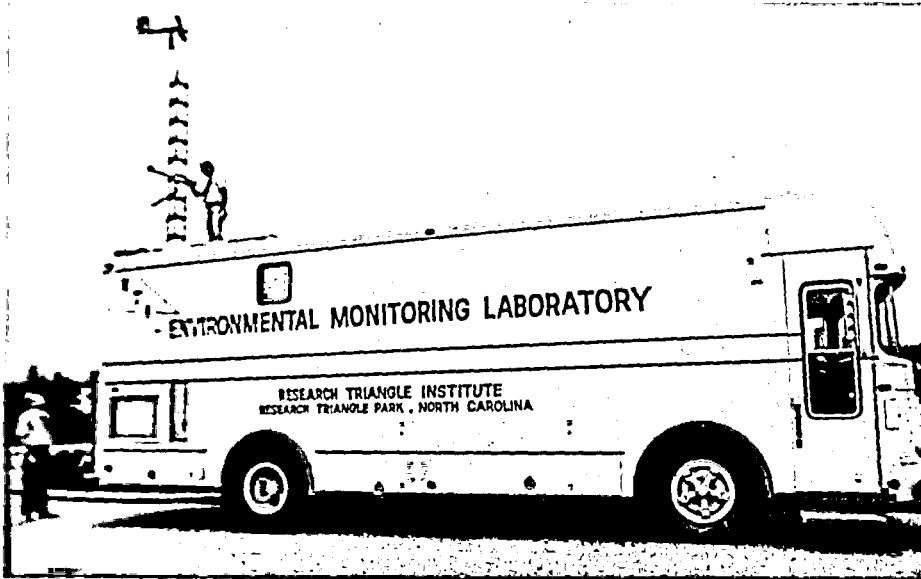
Systems Instrumentation  
Systems Engineering  
Environmental Measurements

## Center for Technology Applications

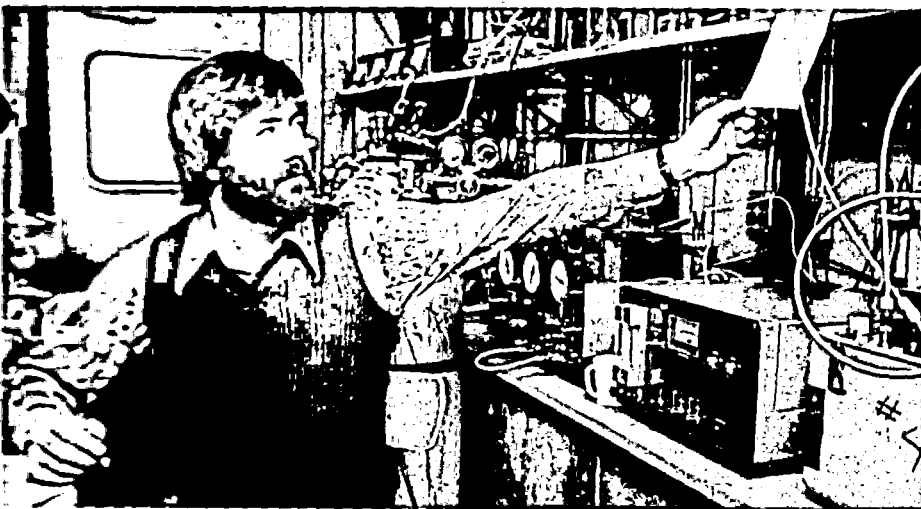
James N. Brown, Jr., DIRECTOR  
Biomedical Engineering  
Technology and Resource Management



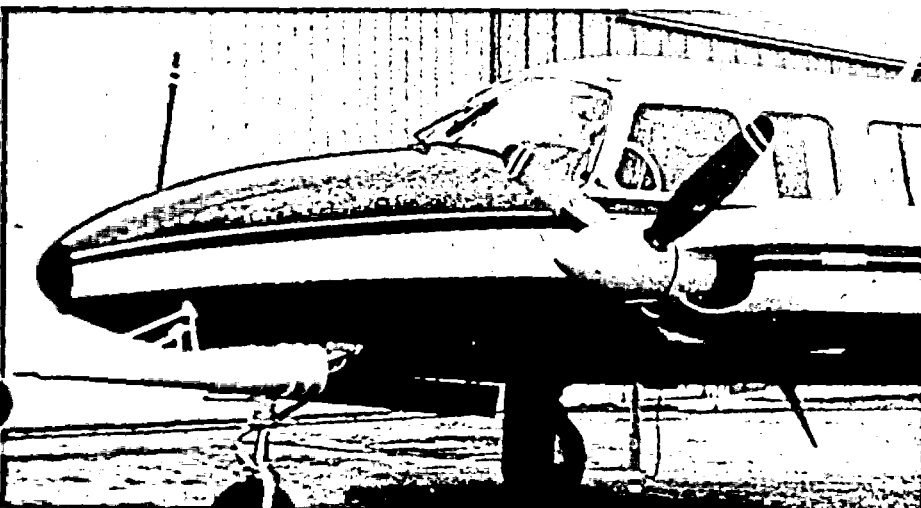
Harry L. Hamilton, James B. Tommerdahl, Robert M. Burger, Jimmie J. Wortman, Edward L. Hill, and James N. Brown.



RTI conducts on-site and in-transit ambient air surveys in cities and rural areas all over the U. S. The Institute's environmentally controlled mobile monitoring laboratory was purchased and equipped with the assistance of grants from the N. C. Science and Technology Committee.



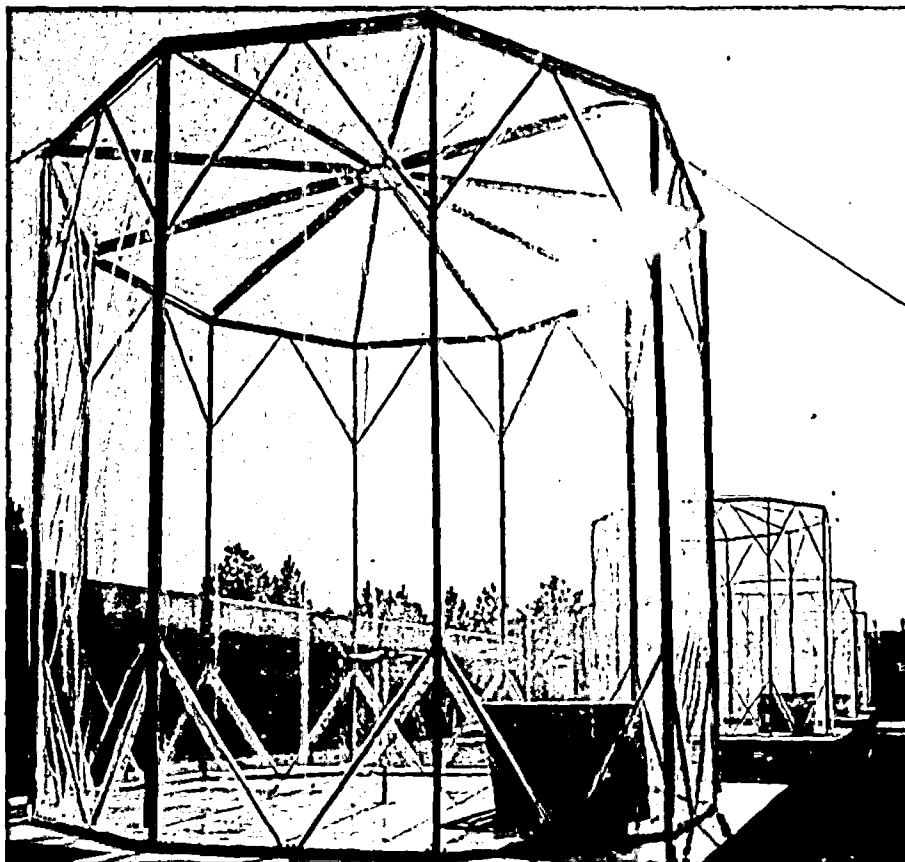
Up to 20 gaseous and meteorological parameters can be selected for continuous monitoring and display in RTI's motorized laboratory van. Instrumentation includes calibration systems for each analyzer, and a digital magnetic tape recording system coupled with a computer capable of on-line data processing. Ground level measurements can be supplemented by information from instrumented aircraft.



RTI capability for dealing with environmental problems encompasses the design and evaluation of instrumentation for pollutant detection and measurement systems, analyses of the economic impact of alternative pollution control strategies, air quality monitoring, source testing, development of water and air pollution control technology, emission abatement program evaluation, atmospheric chemistry, and environmental health.

A representative selection of projects suggests the extent of RTI activities. Many of them are carried out in support of EPA Research Laboratories and the Office of Air Quality Planning and Standards, both located in the Research Triangle area, as well as other divisions of the U.S. Environmental Protection Agency, industrial groups, and private companies.

- Analyze least cost air quality control strategies for reducing emissions of particulate matter, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide.
- Assess the health costs of air pollution.
- Design automated and manual techniques for monitoring atmospheric pollutants and for source testing methods.
- Estimate the expected 1985 levels of nationwide emissions from stationary sources in selected industries, and the potential emission reductions and economic impacts that would result from applying new source performance standards to emission control.
- Evaluate flue gas and industrial waste gas cleaning methods for controlling particulate and sulfur oxide emissions in copper, zinc, and lead smelting processes.
- Identify pollutants associated with coal gasification and liquefaction processes.



Teflon reaction chambers are used in RTI studies of the kinetics of potentially harmful photochemical oxidants and their precursor chemicals during transport from urban to rural areas.

- Investigate the relationships between urban hydrocarbon control strategies and high ozone concentrations observed in rural areas.
- Monitor community health surveillance systems to determine the effects of nitrogen oxides on human respiratory infections.
- Perform quick reaction episode monitoring and field instrument calibration services for air pollution sample acquisition and analysis systems.
- Prepare process and cost comparisons of alternative methods for removing sulfur from coal.
- Test and evaluate theoretical procedures for optimum

meteorological and air pollution sampling network selection.

- Estimate net social costs and gains of alternative fiscal policies for encouraging materials recycling.
- Conduct environmental, social, and economic impact assessments of water supply and flood control projects, mining operations, large scale farming and recreation area development, and wastewater collection and treatment facilities.
- Assist states in preparation of implementation plans for meeting and maintaining National Ambient Air Quality Standards, including computer simulation of various control strategies to reduce emissions.

Energy supply, conversion, conservation, distribution and utilization are areas of expanding activity in which RTI applies the techniques, technologies, and interdisciplinary capabilities that have been developed in its environmental research programs.

Concern over the rate of U.S. energy consumption has created a demand for accurate estimates of the total energy required for product manufacturing and distribution. RTI has taken the first

## Energy

steps for providing a broad set of such estimates that cover almost 500 industrial products and a similar number of consumer products.

Coal combustion adds large quantities of pollutant materials to air and water. RTI involvement in methods for providing cleaner coal includes various aspects of physical and chemical cleaning processes, and the conversion of coal to gas and liquid fuels.

Energy related research comprises a major proportion of the projects evaluated by RTI in an assessment of the degree of utilization resulting from studies supported by the National Science Foundation's program of Research Applied to National Needs. They include research efforts associated with water cells, energy conservation, solar heating and cooling, energy policy, coal gasification and refining, oil and gas operations in the outer continental shelf, and waste heat disposition.

The occurrence of ozone and its precursors in rural areas has been the subject of study by RTI chemists and meteorologists over a ten-year period. Field studies have been

made in the mountains of western North Carolina, on the summit of Pikes Peak, in Garrett County, Maryland, in the four-state area of Ohio, Maryland, West Virginia, and

## Rural ozone

Pennsylvania, over the northern tier of states extending from Montana to the Atlantic, and along the Gulf Coast from Texas to western Florida. Data obtained from fixed stations using automatic measurement and data recording techniques are supplemented by air samples returned to the RTI campus for precision analysis of hydrocarbon content, and are supported by aircraft measurement of ozone, nitrogen oxides, and hydrocarbons. Quality assurance audits of all data collection techniques and field procedures add significantly to the level of confidence assigned to the data.

Concentrations of atmospheric ozone in excess of the EPA's National Ambient Air Quality Standards have been found to occur and persist for extended periods of time (in excess of 26 hours, for example). Preliminary results suggest that these high concentrations in nonurban locations are caused by the transport of ozone and its precursors from urban-industrial areas, and that they will occur in association with meteorological situations characterized by high pressure systems and featuring low wind speed with variable directions, small amounts of cloudiness and, consequently, abundant sunshine.

RTI economists have projected the impacts of a broad range of economic incentives that have potential for promoting the conservation of energy and other

natural resources, for reducing air pollution, solid waste generation and littering, and for inducing the recycling of waste materials. The policy instruments that have been examined include emission charges, subsidies for emission reduction, taxes on packaging, taxes on virgin materials used to package consumer products, and subsidies for the use of recycled materials.

A subject of specific interest is the impact of legislation requiring minimum deposits on all the containers in which beer and soft drinks are sold—refillable bottles, nonrefillable bottles, and cans. Mandatory deposit laws have been

## Bottles and cans

enacted in several states and similar legislation is being considered by the U.S. government. A major objective is to conserve energy by inducing consumers to return cans for recycling or to shift consumption toward beverages in refillable bottles. Using an economic model of consumer and producer market behavior, and engineering process models of the energy needed to produce and distribute beer and soft drinks in the various types of containers, RTI has estimated the possible energy savings and other economic effects that might result from a national system of mandatory deposits.

In research to improve the safety and efficiency of air traffic flow in and near major airport terminal areas, RTI systems engineers and simulation specialists have developed a detailed and flexible terminal area simulation model to evaluate current and proposed air traffic management system concepts. Derived in a series of studies for NASA's Langley Research

Center that began in 1967, the model is based on data obtained from Atlanta's international airport. The model simulates a realistic multiple-aircraft environment that

## Air traffic

contains the major features of airborne and ground instrumentation and air traffic control (ATC) procedures. The model permits analysis of advanced ATC and flight techniques, new instrumentation such as cockpit displays, and environmental concerns such as energy use and noise levels.

One function of the terminal area simulation model is to interface with the Wallops Island flight center experimental research facility as part of NASA's terminal configured vehicle (rcv) program. The rcv program involves analyses, simulations, and flight studies with a specially equipped Boeing 737 aircraft. RTI is participating in the definition of rcv experiments, and is assisting in the development of the experimental research facility.

RTI engineers are also investigating the application of NAVSTAR/GPS (Global Positioning System) techniques to general aviation. This proposed satellite system offers unparalleled velocity and position-determination accuracies and ease of access for many potential users.

The vulnerability of components and systems to nuclear and space radiation is a problem of particular importance to the designers of military and satellite systems that must survive intense radiation environments. Under Department of Defense sponsorship, RTI has played a major role in radiation effects research designed to develop a better understanding of

the phenomena involved and to improve the radiation tolerance of contemporary semiconductor components. Research at RTI has focused primarily on the effects that ionizing radiation has on semiconductor materials, devices, and integrated circuits. Pulsed radiation effects studies, which previously led to the discovery of short-lived damage phenomena in semiconductor insulators, are continuing as part of a coordinated Defense Nuclear Agency program

## Radiation tolerance

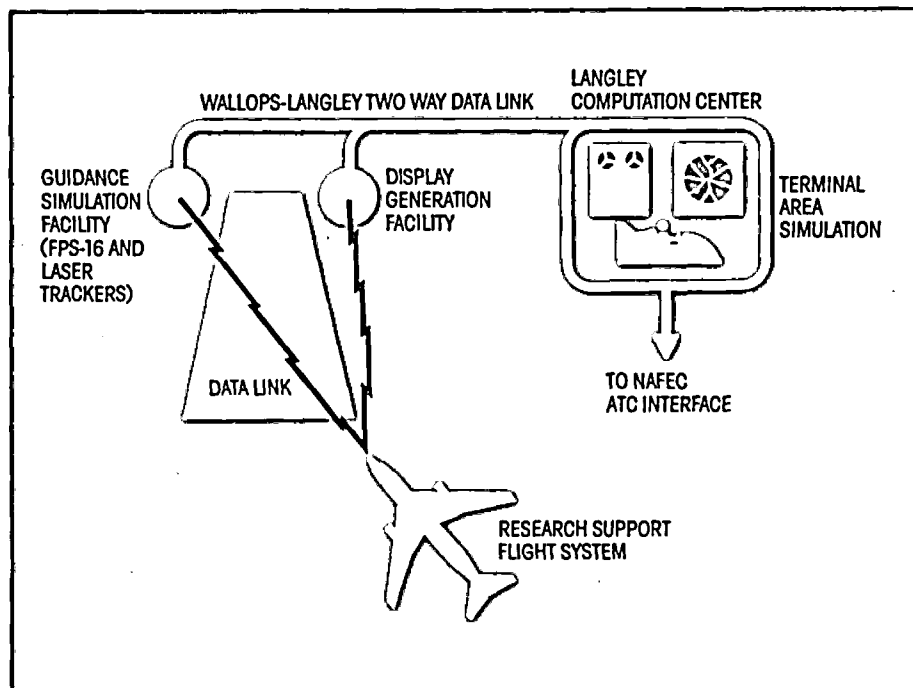
to develop a new line of low power, radiation-resistant devices. A concurrent study for the Air Force involves a comparative analysis of contemporary semiconductor technologies from the standpoint of radiation hardness, as well as overall performance characteristics. Attention is also being given to the radiation vulnerability of experiments and hardware designed by RTI for NASA satellite and space probe missions.

High gradient magnetic separation (HGMS) is a technique for trapping and removing submicron particles

## Particle removal

from industrial effluents that have been cleaned of larger particles. Its technical feasibility has been demonstrated in purifying mineral ores and coal in various slurries and solutions. HGMS methods have also been successful in removing bacteria and viruses from water by seeding the water with ferromagnetic filings that chemically bond with the contaminants and are easily removed by magnetic force.

RTI physicists and chemical engineers are investigating the economic feasibility of applying HGMS to the removal of particles in the 0.02 to 2 micron range from the emissions of air pollution sources. Candidate materials for HGMS include asbestos fibers, manganese dioxide, nickel, chromium, vanadium, tungsten, and other toxic substances. A primary concern of Institute scientists is to determine



Adapted from NASA.

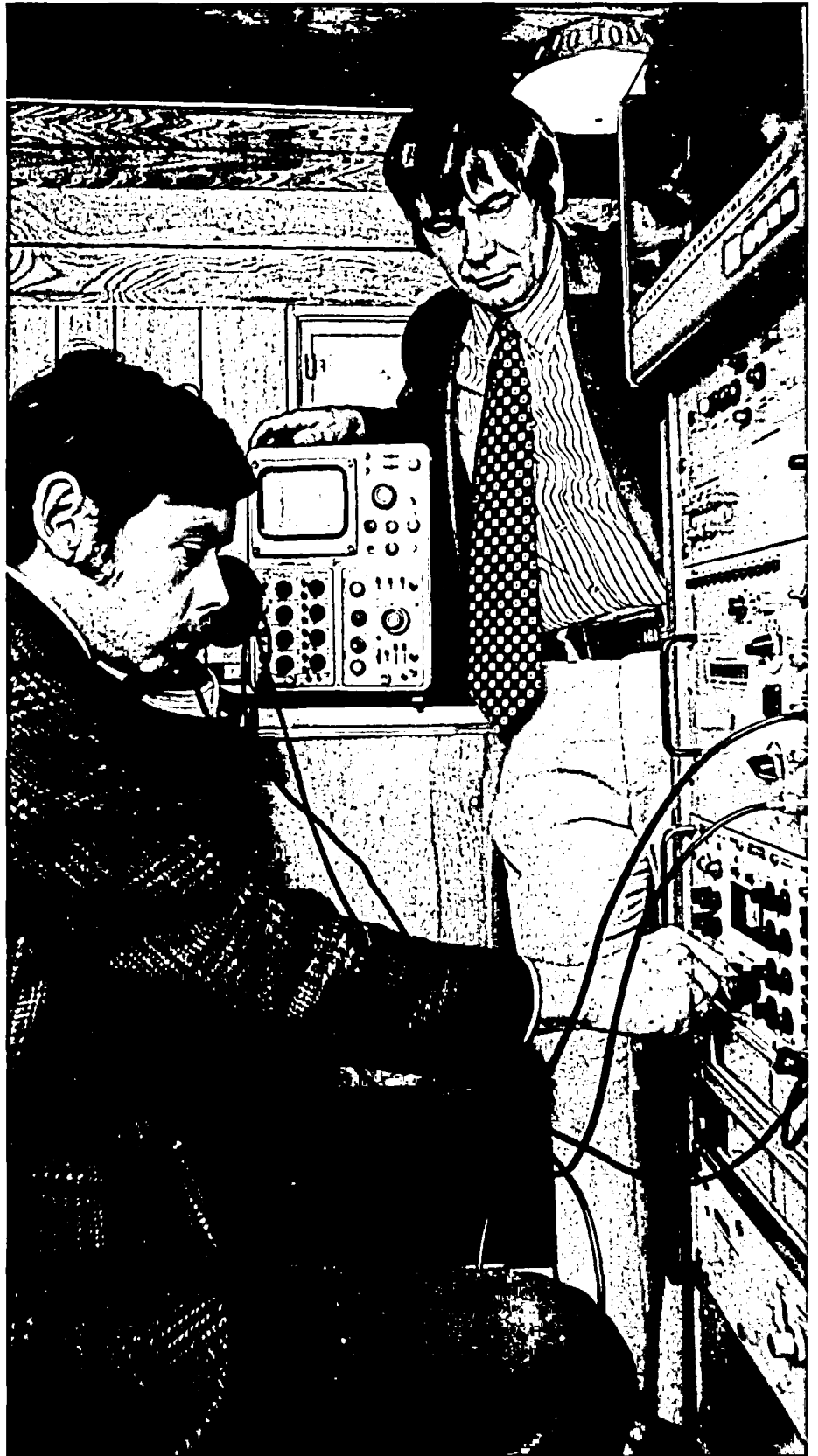
whether or not there are major pollutant sources whose total emissions of respirable particles can be reduced by HGMS to acceptable levels and at acceptable cost. Other objectives are to develop designs that optimize HGMS equipment and procedures, and to implement the designs for laboratory testing. Laboratory results will then be applied to the design of full scale equipment and processes.

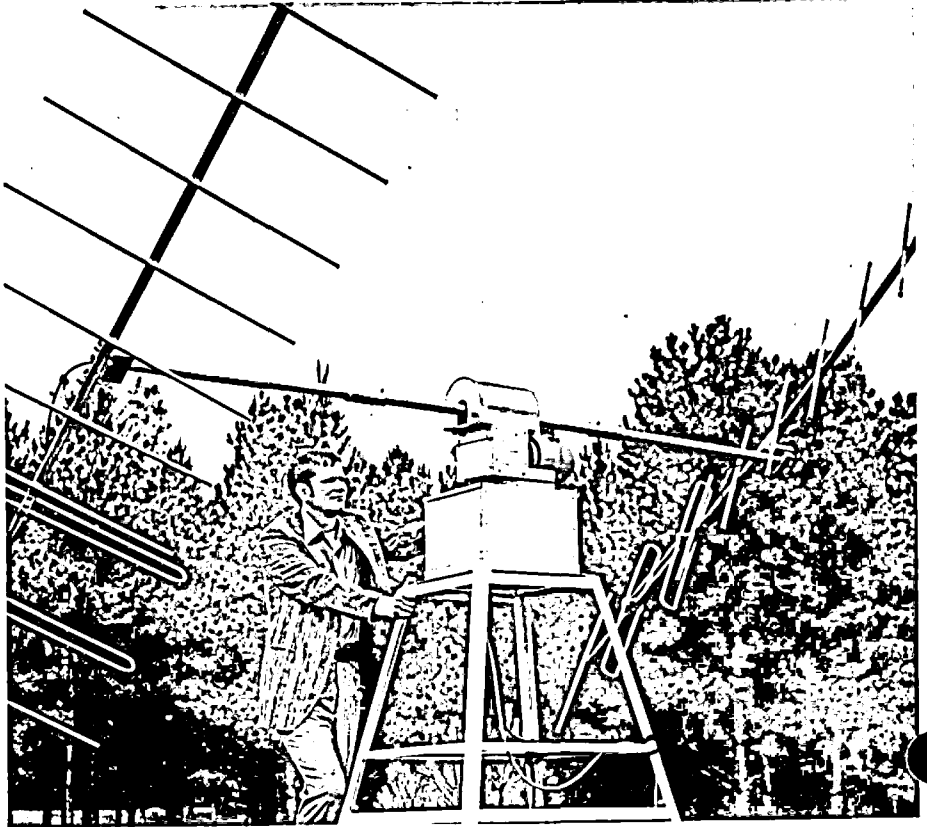
Software, solar cells, fault tolerant systems, piezoelectric polymers, integrated circuits, and gallium arsenide technology are among the areas in which RTI is making contributions to national defense. Current activities involve provision

## Defense technology

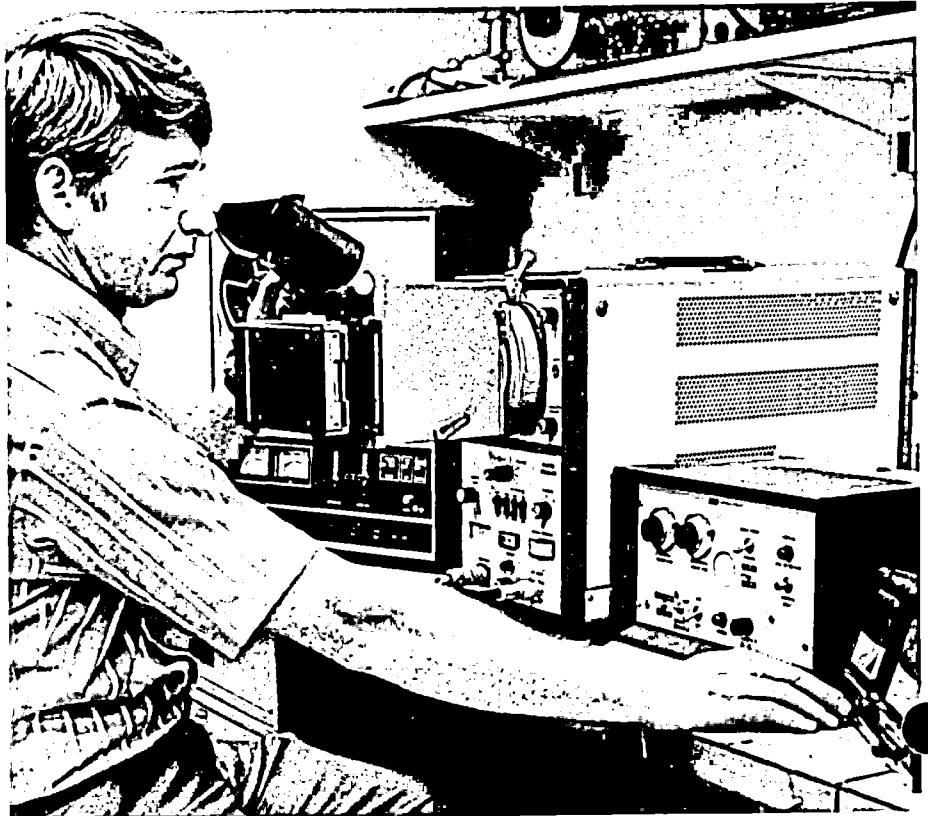
of planning support to the Navy in development of components and subsystems, developing plasma chromatography techniques to detect minute quantities of TNT vapors for the Army, and analyzing uses of advanced simulation facilities for the Air Force. RTI participation in national defense research also includes the analysis of planning and policy issues.

Data collection and analysis at RTI aid NASA in evaluating the Differential Omega navigational system. Related research involves an experimental radio frequency multilateration system for application in NASA's VTOL automatic landing techniques program.





NOAA weather satellite signals are picked up by an RTI antenna, top, and converted into oscilloscope displays, bottom, from which hard copy images of cloud cover are made.





RTI meteorologists receive visible and infrared images of cloud patterns and ocean surface phenomena from the NOAA series of satellites. Satellite-derived temperature patterns are used with shipboard and expendable buoy measurements of currents, temperature, and salinity to investigate the life histories and changing structural characteristics

## Satellite oceanography

of eddies developing along the Gulf Stream boundaries, and to examine the dispersion of effluent plumes from ocean outfalls.

Research for the National Environmental Satellite Service is also providing digital data quality assurance for systems flown on board the TIROS-series satellites. Computer algorithms to enhance sea surface temperature patterns

have been developed in the program, along with analysis and simulation of the digital data communications systems.

The electronic properties of many materials are sensitive to environmental parameters such as temperature, light, humidity, pressure, and the composition of gases in contact with their surfaces. RTI has investigated a variety of solid state sensor concepts ranging from thin film oxygen sensors to pressure transducers. In research for the U.S. Bureau of Mines on the effects of gas composition on electronic behavior in candidate

## Solid state sensors

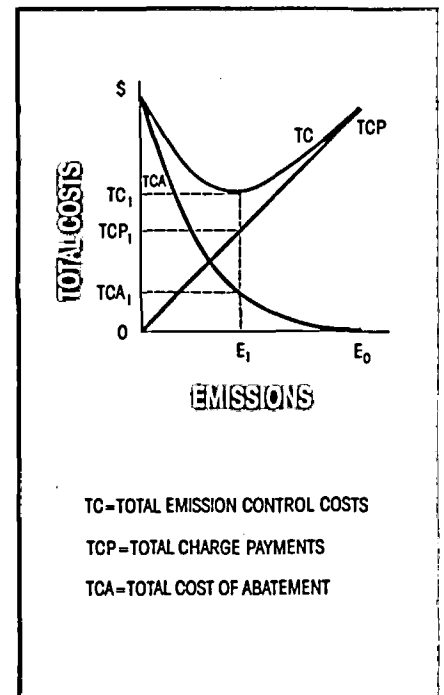
sensor materials, RTI solid state physicists and electrical engineers determined the sensitivity and selectivity of various metal oxides

in film and other physical forms. The objective is to develop sensors suitable for use in a prototype portable gas detection instrument that can monitor mine environments for the presence of carbon monoxide in a range of from a few parts per million to 250 ppm.

Other Institute research in solid state technology includes the stress-dependence of p-n junctions, methods for adapting the piezjunction phenomenon as the sensory element in various transducers, and partial and absolute thin film oxygen pressure sensors. A gas-pressure sensor system developed at RTI was used by NASA to measure the frequency and impact of meteoroid particles striking the Pioneer 10 and Pioneer 11 spacecraft during their flights across the 150-million-mile-wide asteroid belt between Mars and Jupiter.



Special isolation garments have been adapted by RTI's BATEAM to protect patients who are highly susceptible to infectious diseases such as aplastic anemia, and cancer patients receiving treatment with certain drugs. The original garments were worn by Apollo astronauts during the quarantine period after their return from the moon.



RTI analysts have examined the economic effects of a pollution tax on industrial emissions. The diagram illustrates a manufacturer's cost-minimizing behavior.

The National Institute of Occupational Safety and Health (NIOSH) has compiled occupational hazard information in a survey of more than 5,000 U.S. industrial plants. The results enumerate chemical, physical, and biological hazards to which workers are exposed. To assist NIOSH in assessing the location and prevalence of potential health risks, RTI is verifying, clarifying, statistically analyzing, and interpreting the enormous amounts of data accumulated in the survey.

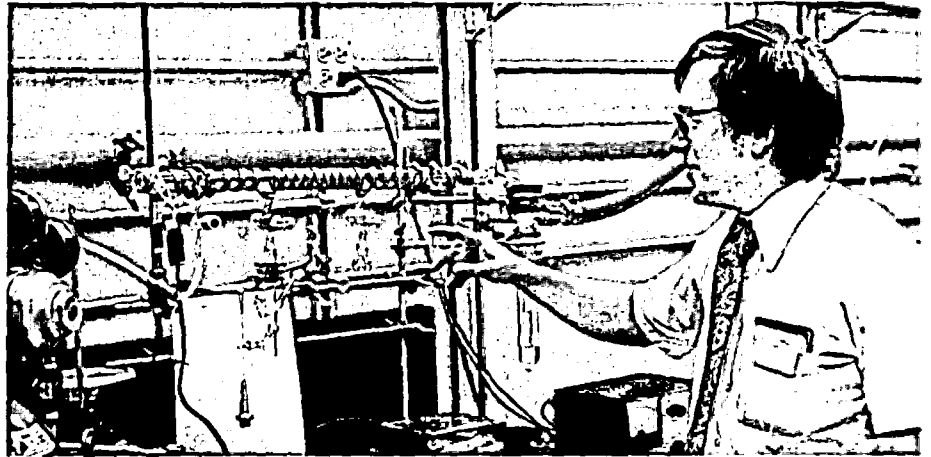
## Occupational hazards

The multidisciplinary group engaged in the study includes RTI specialists in operations and systems analysis, chemistry, chemical engineering, industrial and environmental hygiene, mathematics, statistics, and computer science. Supported by consultants from the University of North Carolina's School of Public Health, their analysis is leading to a comprehensive measure of potential occupational hazard exposures, and to the development of a computer accessible data base management system to respond to queries about exposure potential.

Civil defense preparedness and emergency planning have been subjects of extensive research at RTI for over 15 years. More than 60 projects have been undertaken on virtually all aspects of building

## Civil defense

construction, population movement, shelter protection and supply, medical care, decontamination, and postattack recovery. Finding solutions to the problems confronting civil



RTI experiments determine the wetting characteristics of surfaces in basic studies of heat pipe design.



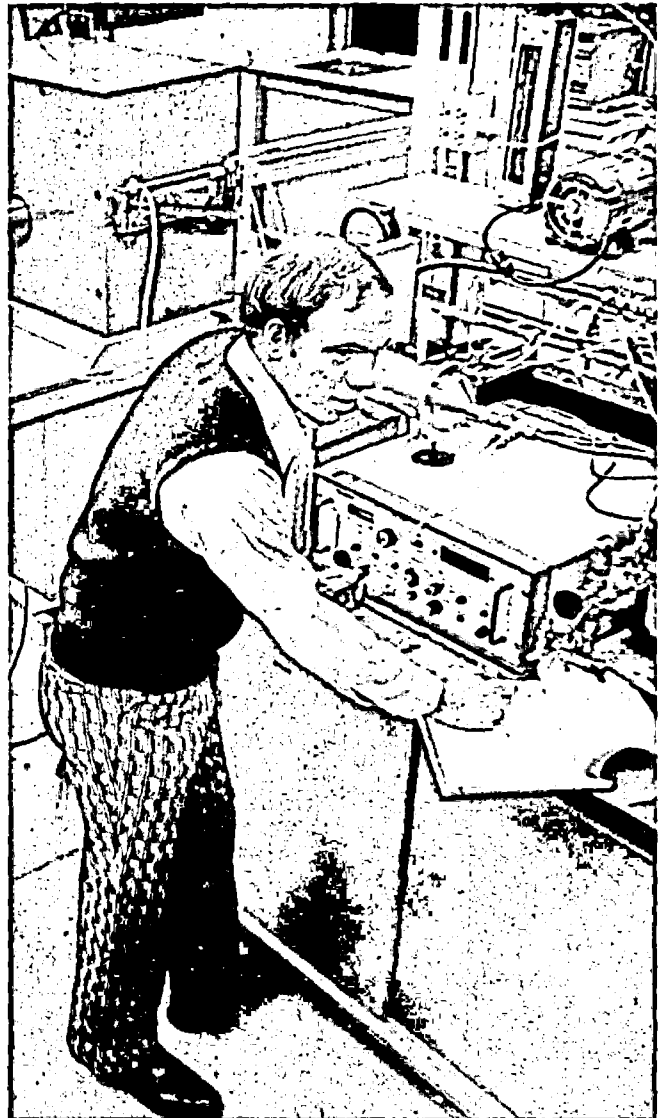
Photolithography processes are used for fabricating semiconductor components.



Computer science, statistics, chemistry and industrial hygiene are among the disciplines involved in RTI's comprehensive statistical analysis of occupational health hazards.



High gradient magnetic separation removes fine particulate matter from contaminated air streams.



preparedness planners has required the application and adaptation of statistical surveys and analyses, computer simulation, mathematical modeling, structural evaluations, and experimental procedures. Current studies include the management of medical problems resulting from population relocation, identification and survey of underground mines suitable for shelters, determination of the habitability of large shelter spaces, postattack health and medical care models, and a local emergency operating system model.

A NASA-sponsored Biomedical Applications Team at RTI seeks to identify space technology that can be applied to medical diagnostic

and treatment problems. The BATEam is part of NASA's technology utilization program that seeks to

## Biomedical engineering

find second applications for space-related innovations.

Acting as an interface between clinical medicine and space research, RTI engineers work with physicians to identify medical problems which appear amenable to solution through application of the devices, materials, and systems developed in the nation's space effort. Translating the medical problems into aerospace terms, they then search for possible solutions through NASA data banks and consultation with scientists at the space agency's technology utilization field offices.

The primary function of RTI and NASA technology utilization researchers has been to provide research physicians and clinical investigators with fresh insights from disciplines they might not otherwise encounter. Since its inception in 1966, RTI's BATEam has assisted in producing more than 80 successful transfers of space technology to medical purposes.

- A device for monitoring astronauts' respiration has been used for the observation and study of epileptic seizures.
- A radiographic image processing technique that improves the clarity of space photographs has been modified to aid in studies of blood circulation through the heart and speed the diagnosis of coronary disease.



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Such dissimilar statements as "He can go" and "Get a coat" are ambiguous to the lip reader. When lipreading is combined with simultaneously displayed cued speech signals, however, deaf persons can readily distinguish the difference.

— A control mechanism for pilots has been modified to evaluate the manual dexterity of patients suffering from Parkinson's disease and other crippling illnesses.

— A stretchable helmet with attached electrodes that recorded electroencephalogram readings of Skylab astronauts was adapted to provide greatly simplified methods for obtaining EEG information that determines dysfunctions in the human nervous system, especially among disturbed children.

NASA's Space Shuttle will open a new era of space research in the 1980s. Through its ability to place a variety of experimental objects in orbit, retrieve them at a later time, and return them to earth for analysis, redesign, and reuse, the Shuttle will greatly expand the scope of economically acceptable space activity. Space research applications have been demonstrated in communications, meteorology, medicine, and other fields. However, the extent to

## Space shuttle

which benefits are spread to a broader range of human concerns will largely depend on how users and potential users take advantage of the new opportunities that will be made available by the Shuttle. RTI is probing the nation's scientific community to ascertain the degree of interest in these opportunities, and to define concepts for using the Shuttle to bring value to man on earth. Working primarily with academic institutions, investigators are finding a high level of interest among potential users, and are identifying a number of specific concepts for possible experiments

from which Space Shuttle payloads will be assembled.

RTI has assembled a comprehensive capability for assessing the environmental impact of actions that affect air, water, land, and other natural resources. To assist the U.S. Army Corps of Engineers in

## Environmental impact

evaluating alternatives to a proposed water resource development project, RTI identified and analyzed the short and long term effects that the several alternatives would have on existing and projected economic, social and environmental conditions within a five-county area. The research included a household survey to measure attitudes of residents on a wide variety of existing social, economic and environmental factors that would be influenced by the proposed project, as well as a mail survey to elicit the opinions of



RTI plans and conducts many technical conferences that deal with a variety of environmental concerns including off-shore drilling, polychlorinated biphenyls, and x-ray fluorescence analysis.

special interest groups and planning organizations in the area.

RTI and Gallaudet College of Washington, D. C., are engaged in joint research on a wearable, automated speech analyzer for the deaf. The automated digital system is designed to perform speech analysis in real time, thus removing the high ambiguity of speech perceived through lipreading, and to present partially decoded speech to the deaf either through visual signals or through sense of touch.

The concept for a wearable speech analyzer is based on a method of communication called cued speech, which originated at Gallaudet College, the nation's only

## Speech signals for the deaf

institution of higher learning for the deaf. At present, cued speech is a system in which speaking is synchronized with hand shapes and positions to eliminate lipreading ambiguities. It is used in 21 languages.

The automated analyzer conceived by RTI is based on the principles of cued speech. These are (1) two-part speech, where the analyzer output signal is one part and lipreading is the other part, and (2) presentation of the analyzer signal as a combined consonant-vowel syllable cue (instead of a separate cue for each individual sound) so that a deaf person can integrate the two parts and perceive them simultaneously. Experiments with the automated cuer are demonstrating that deaf persons can accurately perceive speech in real time when lipreading is combined with analyzer output signals presented through visual display or tactile stimulus.

## Engineering Handbook Office

Richard R. Entwhistle, HEAD



Scientists and engineers from throughout the United States contribute to a series of technical research handbooks on subjects of concern to the Army Materiel Command. The handbooks contain basic information essential to the design, development, and maintenance of Army materiel and systems.

The major purposes of the handbooks are to outline the most promising approaches to selected problems, to provide a reference of fundamental design information, to generate, compile, and maintain up-to-date records of critical design data, and to keep pace with advancing technologies.

RTI is responsible for handbook administration, contents, format, and manuscript technical editing. After handbook topics are decided upon by an Army advisory group, detailed preparation is carried out by technically proficient consultants at industrial and government laboratories, universities, and other organizations.

RTI became primary contractor for the Engineering Design Handbook Series in 1973. Since then 14 handbooks totalling 6,600 pages have been furnished to the AMC for printing and distribution. Representative titles of recently completed handbooks are *Armor and Its Application*, *Explosive Trains*, *Helicopter Performance Testing*, *Military Vehicle Power Plant Cooling*, *Rotational Modeling of Plastic Powders*, and *Maintenance Engineering Techniques*.

## Research Services

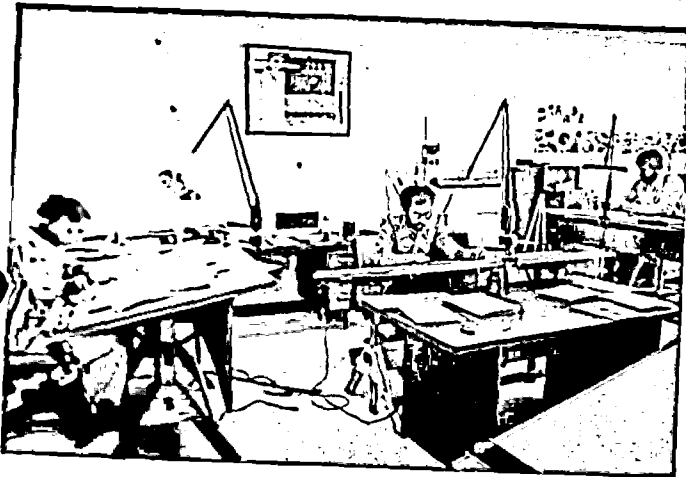
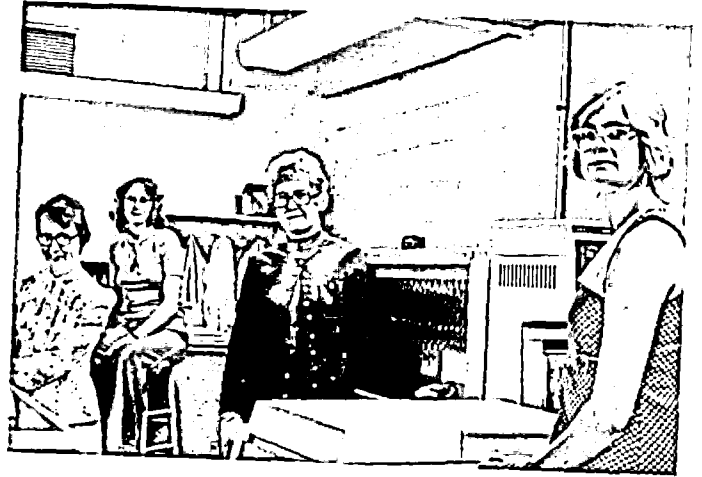
RTI research operations are supported by a full complement of service and administrative functions.

Executive assistant to the president and RTI assistant secretary F. Thomas Wooten is responsible for research services, with Charles W. Halloran as department manager. Support groups and their supervisors are: Data Services, Mildred Pennington; Duplicating, Anne Fuller; Library, Lois Melton; Report Editing and Word Processing, C. H. Burnett, Jr.; and Technical Illustrating, Charles Younger.

## Administration

Administrative offices and their heads are: Accounting, R. S. McLean, who is also corporate assistant treasurer; Personnel and Security, Robert M. Graper; Purchasing and Maintenance, W. J. Thomas; and Research Contracts, John C. Ragan.

Reporting to the Institute president are offices of Institute Information, headed by C. X. Larrabee, and University Relations, headed by Ralph L. Ely, Jr.



## RTI and The State of North Carolina

Research Triangle Institute recognizes that it has special resources and opportunities for serving State of North Carolina institutions, business, and citizens.

The scope of RTI services to North Carolina industry and government has steadily expanded over the years. It covers statistical analyses, sample surveys, agricultural and forensic chemistry, health care services delivery, and industrial research. Other subjects include environmental impact studies, air and water quality research for industry, energy management planning, and technical assistance to manufacturers.

State and regional planning, economic analysis and forecasting, and natural and human resource development have been the subjects of primary emphasis in research for state government. Projects include planning for the needs of the community college system, manpower and occupational training surveys, and a state land use information system.

In support of long-term goals and policies that will shape North Carolina's growth patterns through the end of the century, an RTI program now in its tenth year has been directed toward designing and implementing an information data base that can be periodically updated to assist in analyzing demographic, economic, and social trends and in estimating their effect on future state revenues and expenditures. Other research deals with devising an effective strategy for achieving desired balances in employment, industrial growth, and public service investment allocations.

The Institute has performed a variety of projects for all the states bordering North Carolina, as well as for multi-state regional agencies. The opening of a branch in Charlotte enhances RTI's opportunities to serve its state and region.

## RTI and Its Founding Triangle Universities

Close relationships with its three founding universities, all within a 20-minute drive of the Institute, are RTI's most distinctive feature.

Although the Institute's staff and programs are separate from the schools, its place in the university family is evident in a variety of corporate and research activities. They range from university membership on RTI's Board of Governors to cooperative contract research and many other formal and informal associations.

University-Institute ties are most productive in terms of mutual effort and support.

RTI and its clients benefit particularly from project participation by university scientists in many disciplines who act as consultants assisting with contract work.

In addition, some joint research contracts call for a portion of the work to be performed by a university group and a portion within the Institute.

A number of RTI senior staff members hold adjunct professorships and teaching appointments. Other Institute researchers continue in graduate programs for advanced degrees.



## Founding Contributors and RTI Associates

The libraries of the Triangle Universities are an invaluable resource for the Institute. Their combined collections are cross-catalogued and readily available to RTI staff members. Access is also provided to many of the special research facilities maintained by the schools. Direct access between Institute terminals and the IBM 370/165 at the Triangle Universities Computation Center is of special significance in meeting RTI's extensive data processing needs.

New mutual University-Institute activities include the search for a collaborative mechanism by which patentable disclosures can be identified and pursued, and establishment of an RTI branch in Charlotte in cooperation with the University of North Carolina campus there.

RTI academic ties also include a program of summer internships for students from North Carolina Central University in Durham, and work-study arrangements with engineering students from North Carolina State University at Raleigh.

The Founding Contributors and Associates of Research Triangle Institute are corporations, foundations, individuals and other contributors that have provided material resources to assist in the growth and development of RTI.

Major grants and contributions have been made by the State of North Carolina, the Research Triangle Foundation, the Camille and Henry Dreyfus Foundation, Celanese Corporation, Grover M. Hermann, and George Watts Hill. In recognition of gifts of \$100,000 or more, they are designated as *Founding Contributors* of the Institute.

Smaller amounts in the form of special gifts and annual contributions have been given by others designated as *RTI Associates*.

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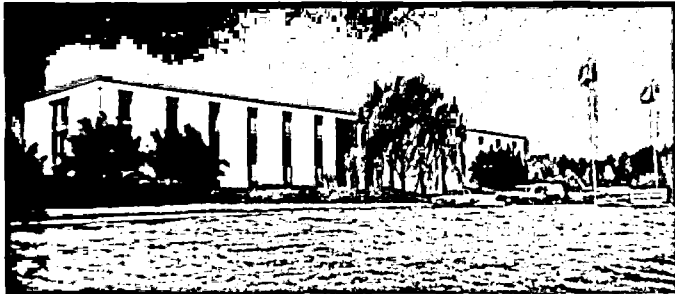
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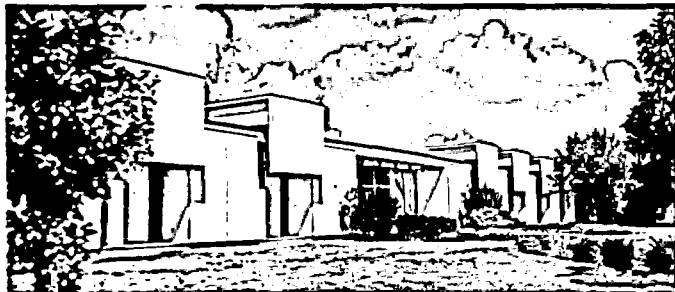
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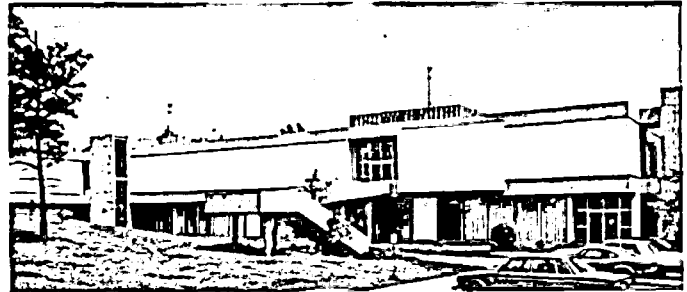
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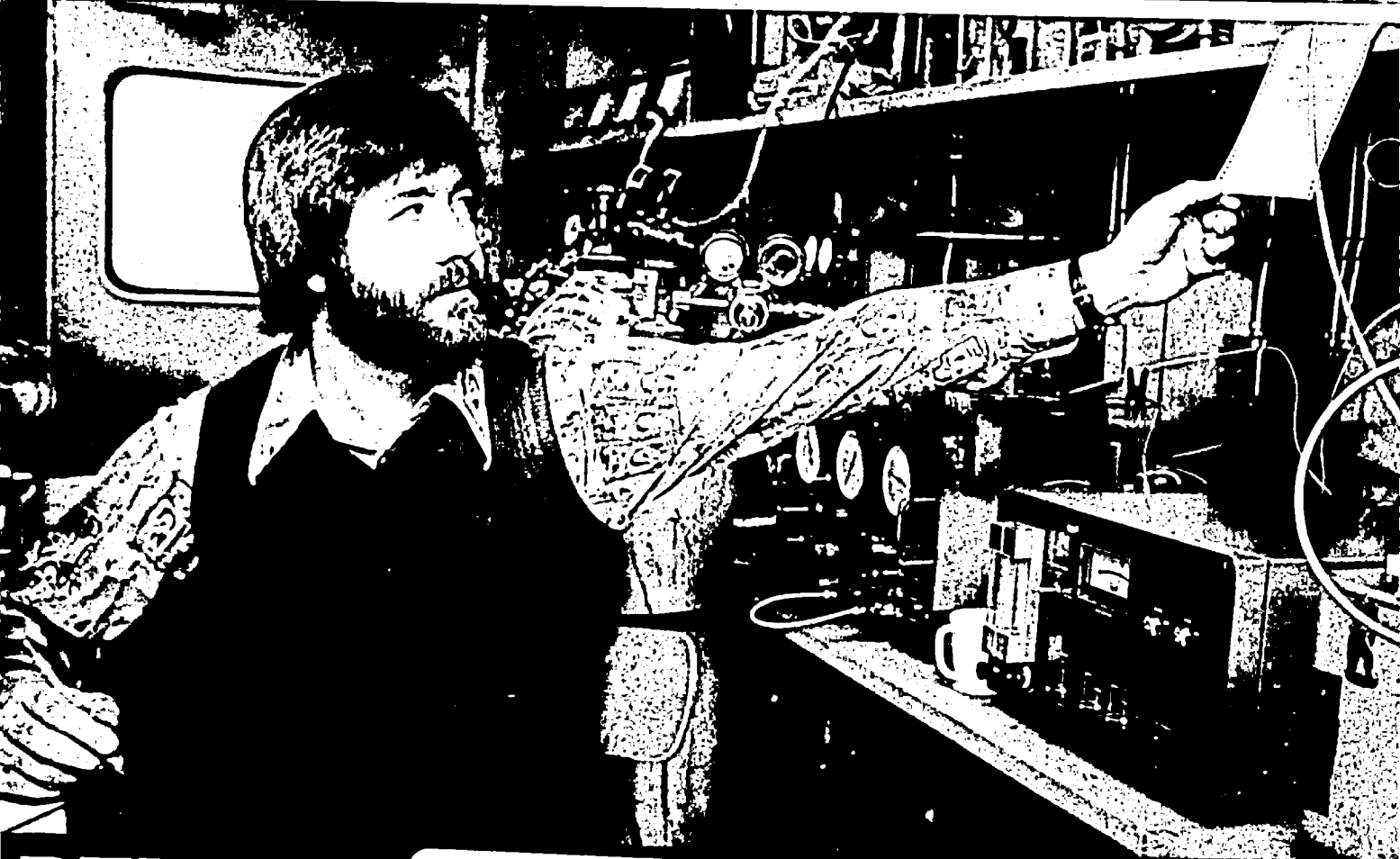
Energy and Environmental Research Annex

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