Solid State Implants

Speech Analysis

Tactile Vocoder

Cell Potential Study

For further information concerning either the bio-electrical engineering research program, support grants available, or program possibilities, contact Prof. Herman R. Weed or Prof. Martin O. Thurston, 2024 Neil Ave., Columbus, Ohio, 43210.

Bio-Engineering Program

ANNOUNCING AN INTERDISCIPLINARY PROGRAM OF STUDY FOR ELECTRICAL ENGINEERS IN THE LIFE-SCIENCES

Department of Electrical Engineering
The Ohio State University
Columbus
ELECTRICAL ENGINEERING DEPARTMENT

The E.E. department is developing a series of courses in the instrumentation, modeling and control areas with applications in the biological field. Other courses and research topics are being developed as rapidly as possible. Several research problems and support grants already exist.

Present courses that appear to have direct application are:

E.E. 751—Open Cycle Control and Instrumentation
E.E. 701—Communication Theory
E.E. 720—Circuit Theory of Solid State Devices
E.E. 721—Advanced Electronic Circuits
E.E. 752—Feedback Control Systems
E.E. 754—Advanced Control Systems
E.E. 660—Logic Circuit Theory
E.E. 760—Theory and Design of Digital Computers
E.E. 713—Elements of Radio Wave Propagation
E.E. 753—Magnetic Amplifiers
E.E. 770—Biological Control Systems
E.E. 771—Bio-Electrical Instrumentation
E.E. 840—Electromechanical Systems
E.E. 850—Theory and Design of Feedback Control Systems
E.E. 853—Analysis of Nonlinear Systems
E.E. 851—Synthesis of Linear Feedback Control Systems
E.E. 830—Solid State Electron Devices I
E.E. 831—Solid State Electron Devices II
E.E. 832—Solid State Electron Devices III
E.E. 811—Waveguides and Resonators
E.E. 813—Radiation and Radiating Systems
E.E. 880—Bio-Electrical Modeling

RESEARCH IN PROGRESS

Research in the area of bio-electrical engineering is available either in the bio-electrical laboratory in the Electrical Engineering Department or in one of the associated interdisciplinary research areas.

The bio-electrical laboratory is carrying on work in the areas of system and receptor modeling utilizing the new digital and analog equipment in the department, speech analysis and filtering both for aids to the deaf and for bandwidth-intelligence relationships using extensive filtering capability, remote sensing and telemetry of in-vivo data from implanted sensors utilizing in turn the solid-state laboratory facilities and data reduction and correlation from patient monitoring. The program is expanding into several new areas such as heart pacers and lasers.

Interdisciplinary research is being carried on in many areas of the campus including:

Electrical behavior of cells under various effects of drugs. This work is under general sponsorship of the National Institutes of Health and is located in Hamilton Hall in cooperation with Dr. Hollander, Department of Pharmacology.

Solid-state transducer and telemetry development for remote measurement and data reduction in living animals. This work is shared between the E.E. Department Solid-State Laboratories and the Agricultural Experiment Station at Wooster, Ohio in cooperation with Dr. Teague.

Measurement and correlation of data from learned psychological responses under controlled conditions. This work is in the Psychiatric Hospital at O.S.U. with the cooperation of Dr. Corson.

A cardio-vascular research center is in the planning stage with provision for extensive engineering in instrumentation, modeling and continuous data monitoring. This is with the cooperation of Dr. Warren, Department of Medicine.

Specific work is already in progress in heart surgery and patient diagnosis with Dr. Vasko and Dr. Weissler of the Department of Surgery and Medicine and EKG analysis with Dr. Hamilton of Veterinary Medicine.
Bio-Engineering Program

Department of Electrical Engineering
Herman R. Weed, Coordinator

The Department of Electrical Engineering of The Ohio State University has initiated an interdisciplinary program of study in the Bio-Engineering area at both graduate and undergraduate levels and has 25 to 30 students active at this time.

The object of the program is to provide the opportunity for capable electrical engineers to broaden the scope of their efforts to include electrical aspects of such life-science areas as Physiology, Medicine, Biophysics, Pharmacology, Veterinary Medicine, Agriculture, Optometry, Speech, Hearing and Psychology. The intent is that the engineer will prepare himself to carry on his engineering in these life-science areas rather than become an authority in one of these fields. However, the engineer is expected to become sufficiently trained in the adjacent field to make possible his active participation in development and research and not serve only in a technician capacity. This last point is very important and has been the cause of much misunderstanding in previous attempts to bring these two scientific areas together.

GRADUATE PROGRAMS

The engineer is generally lacking in the areas of organic chemistry, biochemistry, physiology and psychology, the areas that represent the fundamentals of the life-science and provide the language of the field. The extent to which the student needs to make up this material depends upon the particular area in which he proposes to work and whether he is pursuing a Master of Science or Ph.D. or both.

Master of Science

A typical program leading to a M.Sc. in E.E. with emphasis on some field of life-science would include approximately one course per quarter in the life-science area for the 3 or 4 quarters of the program. Depending upon the student, these courses might be substituted for the Physics and part of the E.E. elective (600-700) courses, with the student still satisfying the requirement of 5-15 hrs. of Math, a minimum of 12 hrs. of E.E. 800 courses and a thesis of 6-9 hours.

The thesis will generally be a topic related to the bio-electrical field either totally advised by a professor in Electrical Engineering with research interest in this special area, or a thesis jointly advised by a member of the E.E. staff and a member of some allied life-science field. In all cases, the thesis must have engineering significance as well as a contribution to the life-science area.

Typical courses often elected are:

- Organic Chemistry 241 A, Sp 3 U
- Biochemistry 511 A, W, Sp 4 UG
- Physiology 516 A 5 UG
- Physiology 517 W 5 UG

Doctor of Philosophy

The increased length and opportunity to study in depth of the Ph.D. program suggests that the student might best include a particular area of the life-sciences as one of his minor fields and have this area represented on his general examining committee and his reading committee for the dissertation. Whether this is an added area, or serves to replace Mathematics or Physics or one of the three normal E.E. areas, will be determined by the student and his advisor.
In general, he will need the same background as the M.Sc. program to which he can add the depth of a specific life-sciences field.

The dissertation would normally be carried out under the advice of an E.E. staff member interested in a particular bio-electrical research field, or under the joint advisement of an E.E. staff member and a member of the particular life-science area chosen. In either case, the dissertation must make a definite contribution to electrical engineering as well as to the life-science discipline.

A list of possible courses to provide this depth study would be very large and changing continually with the development of the field. A more realistic listing would be the departments and individuals within these departments who have shown an interest in such a cooperative effort. A partial list is given:

**Pharmacology**
- Dr. P. B. Hollander

**Physiology**
- Dr. R. C. Little

**Medicine**
- Dr. J. V. Warren
- Dr. A. Weissler
- Dr. Wiseman

**Agricultural Engineering**
- Dr. R. Stewart
- Dr. W. L. Roller

**Biophysics**
- Dr. Leo Lipetz

**Biochemistry**
- Dr. R. O. Moore

**Zoology and Entomology**
- Dr. G. F. Shambaugh

**Veterinary Physiology**
- Dr. R. L. Hamlin

**Animal Science**
- Dr. H. S. Teague

**Psychology**
- Dr. S. A. Corson

**Radiology**
- Dr. William Myers

A few courses of present interest are:

- Physiology 516—Advanced Mammalian Physiology
- Physiology 517—Advanced Mammalian Physiology
- Physiology 807—Advanced Studies in Physiology
- Physiology 623—Cellular and Comparative Physiology
- Physiology 645—Principles of Biophysics
- Physiology 646—Radiation Biophysics
- Physiology 648—Physical Instrumentation for Biologists
- Biochemistry 511—Introduction to Biological Chemistry
- Biochemistry 521—Introduction to Biological Chemistry Lab.
- Biophysics 800—Advanced Topics in Biophysics
- Physiological Optics 512—Eye Movements
- Pharmacology 745—Bio-Electric Potentials
- Electrical Engineering 728—Open Cycle Control and Instrumentation
- Electrical Engineering 770—Biological Control Systems
- Electrical Engineering 771—Biological Instrumentation
- Electrical Engineering 880—Bio-Electrical Modeling
- Zoology 620—Advanced Zoology of Vertebrates

**UNDERGRADUATE PROGRAM**

The technical elective content in the last year of the B of E.E. may include up to 7 hours from outside the department and on special request may be increased beyond this limit. The undergraduate student wishing to include particular areas of the life-sciences can elect a reasonable amount of work through this medium, thus effectively choosing an option in the life-sciences field. This is particularly helpful if graduate work is anticipated, providing for better preparation and greater life-science content in the Master's program.
University Gets Guggenheim Grant For Radio Altimeter Development

The Guggenheim Fund for the Promotion of Aeronautics has made a grant to the University of $3750 for the development of a radio altimeter, invented by Professor W. L. Everitt, of the Department of Electrical Engineering.

The principle of this altimeter is that a radio wave is generated in the plane which travels to the earth, is there reflected, and when it arrives at the plane again, the time consumed in its journey is measured. As this time is very short, being one millionth of a second if the height of the plane is five hundred feet, it is of course necessary to use means other than a stop watch to record such an interval. Actually the time can be measured by the reaction of the returned wave upon the wave which is then being emitted, the action being continuous.

There are several important advantages for such an altimeter over the barometric devices now in use. The present altimeters depend on atmospheric pressure. This pressure drops as the altitude is increased, but unfortunately it also drops when a storm is approaching, so that an aviator flying into bad weather is apt to think he is higher than he is. Furthermore, such an altimeter measures the height above the starting point, so that the pilot must know accurately where he is if he is to know his height above the ground below. With the radio altimeter, if he is flying over terrain invisible because of fog, his instrument would indicate to him the contour of the earth beneath and he could locate valleys and be warned of mountains.

The device has other uses, such as the location of irregularities in the ground in oil fields, which would increase the probability of bringing in a well, and the sounding of the sea by a ship which is sailing in unknown waters.

The following quotation is made from the discussion on altimeters in a booklet published by the Guggenheim Fund and most interesting of all the proposals is that entitled "Solving the Problem of Fog Flying."

"From a theoretical point of view, the most interesting of all the proposals is that made by Mr. W. L. Everitt, of the Ohio State University. In Mr. Everitt's altimeter the frequency of the carrier wave is varied by the rotation of an air condenser. For a certain rate of frequency change, the beat note set up by the transmitted and reflected wave. As compared with other radio altimeters, Mr. Everitt's instrument is simpler and has the advantage of indicating altitude directly instead of altitudes within a nodal distance."

The grant provides the University with a Fellowship which is held by R. C. Newhouse, B.E., '29. Mr. Newhouse has been working with Professor Everitt for the past year on the preliminary development. In addition to expenses for materials, provision is also made for the rental of a plane and securing of the services of a pilot for flights of the instrument.

The major problem before the aeronautical industry is the increasing of safety in flight. The Guggenheim Fund has chosen this as its field of activity, and its grants are all considered from this angle. The development of a proper altimeter is listed as one of the five main problems in fog flying, at present the greatest foe of airmen.
Newest Radio Telescope Records Galactic Survey

Dr. John D. Kraus Reports On Initial Survey Of New Telescope Located At University Farms

The nation's newest radio telescope, located on campus, has completed its first systematic survey of the heavens, revealing "in a striking manner" the shape of the Milky Way, the vast galaxy to which the earth and solar system belong.

Dr. John D. Kraus, director of the radio observatory, reports that the initial study recorded not only the flat, disc-like form of the galaxy, but also structures interpreted as its spiral arms, similar to the streamers thrown out by a July Fourth pinwheel.

The radio telescope consists of a giant antenna array for picking up radio waves from the stars and an ultra-sensitive receiver for detecting and recording them.

World's Largest

Located on the University Farms, the "Telescope of the Future," is the world's largest rotatable array type. It is made up of 24 "cork-screw" antennas, each 10 feet long, mounted on an 80-foot steel framework.

It is now half as large as it will be when completed. Addition soon of 24 more antenna units—enlarging the array to a length of 160 feet—will make it possible to pick up stars at least twice as faint as those the device currently can record.

The study just completed was the first survey of radio waves from space at a frequency of 250 megacycles, although a few similar surveys at other frequencies have been made elsewhere.

"Radio Stars"

The work so far has included observation of several "radio stars," bodies which produce radio waves but so little light as to be invisible to optical telescopes. Another phase of the work has involved measurements of radio waves from the sun. These revealed that the temperature in the sun's corona, or upper atmosphere, where the radio waves originate, is 1,800,000 degrees Fahrenheit.

The studies here began Aug. 1, when 12 of the spiral antenna units were connected. An additional 12 units were added later. In recent weeks, Dr. Kraus, a member of the electrical engineering faculty, and Sol Matt, Grad, have been engaged in interpreting the data obtained.

Since the radio telescope does not depend on light, it can operate around the clock. Its observations are recorded automatically by a pen on a moving paper tape. The receiver and recording apparatus are housed in a trailer at the antenna site.

New Science

At present the radio telescope is being employed in making measurements at various frequencies. Later it will be concentrated on studies of radio stars, one of the most interesting phenomena in the new science of radio astronomy.

In using the radio telescope, the researchers are dealing with extremely small amounts of electrical energy. For example, the radio waves traveling at a speed of 185,000 miles per second from one of the nearest radio stars outside our own galaxy require a million years to reach the earth. This makes it obviously impossible for the scientists to use the radar technique employed recently in bouncing signals off the moon.

When the star's "signals" do reach the earth, they have an average power of a millionth of a millionth of a millionth of a watt per square yard of antenna surface. To handle such small amounts of power, the large antenna system and highly sensitive receiver are required.

The radio telescope project is supported by some $20,000 in grants from the Caroline Drew Lovejoy Memorial Fund, the University Development Fund and the Ohio State Research Foundation.

Cowan Supervisor

Much of the construction work has been done by the electrical engineering shops, supervised by John D. Cowan, with the assistance of Andrew Bowns, Charles Cave, Lester Lewis, Marvin Phieister and Jess Wolfe.

The largest radio telescope antenna in existence at present is a parabolic type, 218 feet in diameter, at the University of Manchester, England. This antenna is fixed in position, however, while Ohio State's can change its declination.
RESEARCH

OPPORTUNITIES

in

ELECTRICAL

ENGINEERING

at

The Ohio State University

1957-1958

Typical

Research Activities


Servo-Mechanisms: Linear and Non-Linear Servos and Controls

Medical Electronics and Rotating Machinery

Grants-in-Aid

Research Associates work full-time and may carry one-third of a normal graduate program— $4560 and up annually.

Research Assistants may carry about four-fifths of a normal graduate program and work half-time— $2280— $2676 annually.

Fellows and Scholars carry a full-time program of graduate study. No service to the University is required.

Sperry Gyroscope Fellowship— $2900 annually (Physics Dept., 1957-58)

Westinghouse Fellowship— $1700 for nine months

Stillman W. Robinson Fellowship— $1100 for nine months

University Scholarships and Fellowships— $700 to $1200 per academic year

Non-Resident tuition scholarships— Tuition only

Assistants paid at same rate as Research Assistants for 20 hours work per week.

Incidental fees are $75 a quarter for Ohio residents. All grants-in-aid include remission of the non-resident tuition.

Prospectus

The grants-in-aid available in Electrical Engineering at The Ohio State University afford the opportunity for study toward the M.Sc. and Ph.D. degrees, and will be of interest to students in Electrical Engineering, Physics, Astronomy, and Mathematics. Research conducted under these grants can be entirely or partly applied toward a thesis or dissertation. The research is directed by a permanent staff of recognized scientists in the various fields, with supporting technicians, machinists, draftsmen, and typists.

Since many of the research staff members teach in the Electrical Engineering Department, personnel relationships of a most desirable kind are generated. Participants in the program obtain professional experience in an atmosphere of modern electrical research, closely paralleling their academic interests, and broad flexibility permits making arrangements best suited to the individual. Extensive facilities for research include the Antenna Laboratory (new Field Station shown above), the Electron Device Laboratory, and the Radio Astronomy Observatory.

Applications for Fellows, Scholars, and Assistants for 1957-58 will be accepted until February 15, 1957. Appointments for Research Assistant or Associate are considered currently. For further information address: Professor E. E. Dreese, Chairman, Department of Electrical Engineering, The Ohio State University, Columbus 10, Ohio.
COLUMBUS, O., March 16.-- Ohio State University is one of six institutions in the nation selected by the National Academy of Engineering to find improved ways of putting modern technology to work in the enhancement of biomedical research and health care.

The study will be conducted jointly by the university's departments of electrical engineering and medicine in cooperation with Battelle Memorial Institute under a contract of $21,282 from the academy.

Results of the work will assist the academy's Committee on Interplay of Engineering with Biology and Medicine in fulfilling a contract with the National Institutes of Health for recommendations on the development of biomedical engineering.

Other universities joining in the study include Carnegie-Mellon University, Johns Hopkins University, Massachusetts Institute of Technology, the University of Virginia and the University of Washington.

Work at Ohio State will be directed by Dr. Herman R. Weed, professor of electrical engineering.

All of the universities will base their studies on the particular needs and resources of the communities in which they are located.

In general, they will develop concepts for relating university (MORE)
bioengineering - 2

activities in engineering to the physical, biological, medical, social and management sciences.

They also will identify and assess particular industrial and civic resources that can contribute to solution of the problem of medical care and study the operations of health and medical care institutions, focusing on issues that can be resolved through cooperation of medicine and engineering.

Finally, each university will develop prototype operational plans to secure cooperation between industry, the community and education that will stimulate research and obtain the best combination of resources for dealing with medical care needs.

Study results are expected to accelerate the development of new instruments, artificial organs, devices for therapy and diagnosis and other medical tools.

Other ideas developed may lead to improvement of health care management, as in the design of automated clinical laboratories or the installation of quality control and information processing systems.

-mog-
NEW YORK, March 19. -- -- Widespread use of sonic power systems could rival industrial use of electric power in the not too distant future, two Ohio State University engineers have predicted.

In a paper presented here Tuesday (3/19) to the international convention of the Institute of Electrical and Electronics Engineers, Dr. Robert C. McMaster, Regents' Professor of Electrical and Welding Engineering, and Charles C. Libby, research associate in welding engineering, told of new developments in sonic power research at Ohio State.

These developments, the engineers reported, will permit large-scale economical use of high levels of sonic power in industrial applications.

"Recent experience has demonstrated that sonic power offers many unique advantages in industrial application, typically offering gains of the order of 100 to one over conventional processes," McMaster said.

The work at Ohio State's Sonic Power Research Laboratory has been conducted for the past five years under primary sponsorship from the Ohio Department of Highways and U.S. Bureau of Public Roads. The studies were directed toward application of sonic power systems in construction and maintenance of interstate highways.

(MORE)
This basic research led to new forms of high-power sonic motors and of methods of coupling and utilizing sonic power, the engineers noted.

"These generic principles now permit many additional applications of sonic power in basic industries such as primary production of metallic and nonmetallic materials, forming, cutting, shaping and welding of materials in manufacturing industries, materials handling and transportation."

The engineers explained that for a given industrial application, the sonic motors they have developed reduce power requirements 10 to 100 times below the power requirements for the same process effects by conventional rotary drive motors.

And, they said, there is no present evidence that the basic design principles cannot be readily extended to sonic motors with power ratings from 100 to 10,000 horsepower or higher.

As described, the sonic motor design has many advantages over rotary motors and drive systems. The sonic motor has no "moving parts." There are no elements subject to wear or that require lubrication.

"In terms of common figures of merit, such as horsepower per pound, overall size of units for given output ratings, efficiency, versatility and reliability in service, the sonic motors, after only three years of development, compare quite favorably with rotating electric motors developed during the past 75 years," McMaster said.

"Because of the simplicity of design, components and assembly, and the minimal requirements with respect to materials, it is evident that costs per horsepower of capacity of sonic motors can be reduced in mass production well below those of conventional motors."

As an example, the researchers pointed out that all metallic component parts for the motors can be machined on a conventional
sonic power- 3
lathe, and assembly can be done manually in a short time. Repair of motors or replacement parts could be done with simple equipment in a few minutes.

The engineers also provided examples of specific functions which sonic power systems could do better than conventional systems.

They included replacement of static force, alleviation of friction, deformation of metallic materials, cutting and drilling of hard materials, local generation of heat from remote sources, and acceleration of many naturally-occurring reactions.

And in many cases, they noted that productivity of processes and quality of products can be improved by sonic systems.
COLUMBUS, O., Oct. 26.-- --Research -- into everything from birth control pills for deer to cars which drive themselves -- forms an important part of the role of the Ohio State University.

But research is similar to the iceberg -- only the top part shows. The seldom-seen bottom of the research iceberg is a group of skillful, adaptable artisans who build the tools which make much of the research practical.

There are 24 workshops on the Ohio State campus in Columbus, serving both undergraduates and graduates, repairing equipment, building equipment for students to use, and building the specialized tools for research.

Typical of them is the electrical engineering machine shop in the basement of Caldwell Laboratory, 2024 Neil Ave., serving the electrical engineering department, communication and control systems laboratory, electro-science laboratory, the electronic materials and devices laboratory and the Ohio State radio observatory, 23 miles from Columbus, near Delaware.

Supervisor of the shop is Jesse R. Wolfe, RFD 1, Pickerington. His staff consists of Ernest Beery, 1413 Francisco Rd.; Robert Bielec, 38 W. Duncan St.; Charles Gardner, 3383 Fisher Rd.; Harold Hayman, 182 W. Main St., Westerville; Warren Hensley, 307 Loveman Ave., Worthington; Raymond Knapp, 1102 Kennington Ave.; Robert Law, 9132 Sawmill Rd., Dublin; Thomas McCann, 1855 Lehner Rd., and Willie Truss, 2214 Ontario St. (MORE)
workshops - 2

When a tool -- a machine or fabrication -- is needed for research by any of the electrical engineering research groups, the shop provides it.

Usually, Wolfe and his staff are not provided with blueprints. "The best we get is usually a rough drawing on the back of an envelope," Wolfe says.

"Usually, we work with just an idea -- they tell us what they want and we come up with it.

"The men are not tied down to any specific design. They use their imagination and try to achieve what the engineer is trying for.

"There isn't a man in the shop who hasn't been here 15 years, and they have acquired a lot of specialized experience.

"This way they are able to help the engineers and advise or suggest mechanical designs."

Basic equipment for the shop is six South Bend precision lathes which can take work up to 10 inches in diameter. Beds vary from 3 to 8 feet long. There are also several small jewelers' lathes for very small parts, and shaper and milling machines.

Much of the work done on the big lathes is kept to a tolerance of plus or minus one-half of one-thousandth of an inch.

Some of the work is exceptional -- like the electron guns turned on one of the big lathes. The work was so fine that some of it was done under a 100-power microscope fixed to the lathe.

"When the project contract expired, Ohio State sent all the things we had fabricated to a leading electronics firm," Charlie Gardner recalls.

"The firm sent some men down to our shop and they said it wasn't possible to make some of those parts on a lathe.

(MORE)
workshops - 3

"So Ray Knapp stopped the work he was doing and made three more for them while they watched."

Almost every project in the shop is different from anything that has gone before. And some of them are different from anything that is done in a regular machine shop.

Like grinding stones into perfect spheres.

Like drilling and machining lavite, a volcanic rock.

Like making highly-polished heads for lasers -- precise teardrop shaped tubes through solid brass, gold plated on the inside.

Like a 12-foot diameter "lens" made from blocks of Styrofoam, locked together with dovetail keys because glue could not be used.

Like lapping machines to grind silicon blanks to paper thickness.

Like the machine to attach pure gold wires one-half of one-thousandth of an inch thick to microcircuits -- a microscope must be used to position the wire in place and bond it down.

Not all the parts used in building research tools are made in the shop. A driving simulator for research into automated cars and highways, for instance, uses two tuning key assemblies originally made for a guitar, a gearbox salvaged from a Link flight trainer and a commercially-made clothes fastening material (Velcro) for the road bed. The car which runs on the material is a metal toy.

"This is where the creativity comes in," Wolfe says. "All the men are at liberty to use anything that will do the job.

"These men take pride in their work and this is reflected in the end result."

The men follow their projects through and install them in place, wherever it might be. At times they have dug ditches, poured concrete, erected huge steel frameworks and painted walls.

And on one occasion, to help with a research project on terrain profiles...they built a small railroad.

-ecs-
Release on Receipt

COLUMBUS, 0., Dec. 5.-- --Dr. Marlin O. Thurston, professor at Ohio State University for 13 years and chairman of the department of electrical engineering since 1965, has been elected a Fellow by the board of directors of the Institute of Electrical and Electronics Engineers.

According to Seymour W. Herwald, president of IEEE, the honor is being given to Thurston "for contributions to electron devices, and for ability as both a teacher and an administrator."

Each year IEEE elects some 125 of its 160,000 members to the grade of Fellow, highest status achievable in the organization. Known to IEEE members as "the hallmark of unusual distinction," the award is "conferred only upon persons of extraordinary qualifications in their particular fields."

The distinction of Fellow status carries with it a certificate and recognition at a special ceremony held in the Columbus section of IEEE as well as a banquet in honor of Fellows during the 1969 IEEE International Convention.

The department of electrical engineering at Ohio State University is the largest of the academic engineering departments in the College of Engineering. Presently, the department enrolls more than 500 undergraduate students and nearly 350 graduate students. The (MORE)
department each year awards about 75 bachelor, 60 master's, and 25 doctoral degrees.

The Institute of Electrical and Electronics Engineers, with headquarters in New York City, is an association of practicing engineers and is said to be the largest professional organization in the world.

Dr. Thurston, an Upper Arlington resident, lives at 3751 Kioka Ave.

-cep-
COLUMBUS, O., Feb. 25.----The world of sound may soon be opened to millions of deaf people through a new machine developed at the Ohio State University.

It provides the deaf with a mechanism of learning to speak with precision.

In the future, simplified, miniaturized versions may be carried by all deaf people to give them a vital awareness of the world around them -- of people, out of their sight, speaking to them; music, singing, the sounds and noises that people with normal hearing take for granted, and to complement lip reading.

The machine is called a tactile vocoder. It converts sounds into distinct patterns which can be felt and recognized easily by the deaf.

It uses eight keys which vibrate. The deaf person puts eight fingers on the keys.

A sound, perhaps the vowel sound of "eye," is electronically converted into mechanical vibration. This sound might vibrate three keys -- perhaps the first, fifth and sixth.

(MORE)
vocoder - 2

Other sounds might vibrate the same three keys, but the rate of vibration of the keys would be different.

The idea of "touch-speech" is not new -- it goes back to the 1920's. But the Ohio State researchers have developed the basic idea into a practical working model and have given it initial clinical evaluation.

In teaching a deaf child to speak, the instructor would first repeat a sound into the machine's microphone several times to impress the vibratory pattern into the child's memory.

Then the child would take over the microphone, making sounds until he achieved the same pattern.

It would be slow, but still faster than methods commonly used. And it would be more precise -- the machine gives a distinct pattern for each sound.

A simplified, miniaturized, pocket-sized model of the vocoder -- perhaps using only four keys -- could be built right now with the state of the art of integrated circuits, where a dozen transistors can be built into a space one-sixteenth of an inch square. A microphone, worn like many hearing aids are now worn, would complete the portable "ear."

Development of the tactile vocoder was achieved under the bio-medical engineering program of the department of electrical engineering, College of Engineering at Ohio State.

The objective of the program is to provide an opportunity for meaningful education between the

(MORE)
vocoder - 3
various branches of engineering and life sciences such as medicine, physiology, biophysics, pharmacology and psychology.

The tactile vocoder -- at present a large, not-very-portable instrument -- was developed by Prof. Herman R. Weed of the department of electrical engineering and Richard Aston, a graduate student.

Clinical experimentation has been carried out at the Ohio School for the Deaf.

Development of the successful machine has allowed the researchers to probe into the problem of similar sounds -- for instance, the vowel sounds in "pat" and "pet."

With a minimum of three states for each of the eight keys -- off (motionless), low vibration and high vibration -- there are 6,561 possible combinations.

But the combinations for similar sounds are also similar, and subjects are not always able to differentiate among them.

Research is at present being concentrated on overcoming this problem -- increasing the distinctiveness of the machine's response to similar sounds.

-ecs-
Research Funds Cut

By CAROL ANN LEASE

Recent cutbacks in federal funds for research could lead to reduced enrollment in the Department of Electrical Engineering (EE), Marlin O. Thurston, chairman of the department, said Tuesday.

"We haven't had much reduction in enrollment yet but we undoubtedly will have," Thurston said. "It's hard to predict because there are so many factors involved."

Thurston said federal funds for research in the EE department, reduced $200,000 from last year, have been dropping since the federal government started cutting expenditures three years ago.

The department's solution is to let enrollment drop by not replacing graduating Ph.D. and masters students, Thurston said.

Future enrollment may depend on students' ability and willingness to further their education without assistantships and research grants, he added.

Reduced research funds have not produced serious hardships on individuals yet, but they will have serious long range effects, Thurston said.

Calling research the "best kind of learning experience for students," Thurston said, "The fall-off in sponsorship will also reduce the quality of students graduated."

James A. Robinson, vice president and provost responsible for University research funding, said federal research money has decreased in all University departments.

Ohio State's federal funds for research dropped from $16.75 million in 1968 to $16 million in 1969, Robinson said.
OSU teaches 3-ton ‘baby’ to walk

By David Lore
Dispatch Science Reporter 5-20-85

Higher education at Ohio State University this fall will include teaching a six-legged, three-ton machine how to walk.

"By the end of summer, it should be wiggling its legs," said Robert B. McGhee, professor of electrical engineering.

"In the autumn, it will be walking supported by a cable from an overhead crane.

"We're protecting it, just as you'd hold a young child's hand so it doesn't hurt itself, but by spring, it should be walking independently."

"It" is ASV or Adaptive Suspension Vehicle, a 17-foot experimental vehicle with massive, 8-foot insect-like legs for crawling over difficult terrain.

ASV is being developed by the Pentagon for battlefield uses, but it could be the prototype of a new breed of industrial walking machines in the 21st century.

"Japan already has a commercial viable walking machine," said McGhee. "It's got eight legs and weighs 72 tons, and is used under water for the construction of sea wall foundations."

OSU's walker is now legs and brains and infrared eyes scattered across various engineering labs. After years of work, McGhee and his partner, Professor Kenneth J. Waldron, are preparing to put it all together and introduce ASV to the world on June 27 at a campus "roll out" ceremony.

McGhee has been working on walking machines for two decades for both the Pentagon and non-military sponsors. McGhee and Waldron have a three-year, $5 million development contract with the Defense Advanced Research Projects Agency.

ASV is not a robot, McGhee stressed, because it carries a human operator who controls the machine's speed and general course. But robotic systems determine where each foot is placed during travel and how the legs should be coordinated to span particularly difficult obstacles, such as a ditch or a small cliff.

A boulder in the path of the machine, for example, is spotted up to 32 feet away by the infrared optical radar, which is the "eyes" of the machine. Rock elevation and dimensions are analyzed by a computer, which automatically directs ASV's steps to bypass or climb over it.

Waldron said ASV should be capable of stepping across a 9-foot-wide ditch or mounting a 7-foot-high vertical cliff.

It should be able to move at about 3 mph on rough terrain, and 5 to 8 mph on smooth ground. Normal cargo load would be about 500 pounds, although it should be capable of carrying up to 12,000 pounds at an extremely slow gait, Waldron said.

Walking machines could move on slopes or rugged ground impassable for wheeled or track vehicles, said McGhee. In lumbering, he said, walkers could dig in their legs to pull heavy objects, and yet be delicate enough to carry legs over soft ground without tearing up the forest floor.

McGhee and Waldron are already talking about ASV's offspring at OSU, a four-legged machine capable of speeds up to 20 mph.
Kenneth J. Waldron, left, and Robert D. McGhee examine one leg of their six-legged Adaptive Suspension Vehicle.
Programs vie for funding in Regents' competition

By Jay Cooper
Lantern staff writer

Three OSU academic programs have been selected as finalists in the Board of Regents' Program Excellence competition.

The aeronautical and astronautical engineering, journalism, and electrical engineering programs were among 41 programs picked as finalists from 139 proposals submitted statewide.

Program Excellence was established in 1983 to recognize the best programs within state universities, according to Kate Carey, communications administrator for the Board of Regents.

The Program Excellence competition is part of a five-part, $62 million dollar program administered by the Board of Regents to improve state educational institutions, Carey said.

She said $3 million will be awarded to between 20 and 25 programs this year. The final selection will be made following site visits to each of the finalists' programs.

Stuart L. Petrie, chairman for the Department of Aeronautical and Astronautical Engineering, said the department submitted a proposal that would strengthen aeronautics and get more modern instrumentation into the program.

Petrie said the idea behind the Program Excellence is good, because it attempts to make the best even better. He said this type of effort will help make the funded programs leaders in education on the national and international levels.

Henry H. Schulte Jr., associate professor of journalism, said if the School of Journalism received funding, it would use the money to complete the broadcast recording studio. Schulte said it is an honor to be selected as one of the 41 finalists in the program.

Hsien C. Ko, chairman for the Department of Electrical Engineering, said if it wins, the department would use the funding to modernize and upgrade curriculum by introducing computer- graphic-based instruction facilities into the undergraduate program.

"I am certainly very happy we are one of the semifinalists and I hope we win, but at least I hope it's someone from Ohio State," Ko said.

The site visits for the three programs will take place:

* April 1 for the School of Journalism.
* April 30 for the Department of Aeronautical and Astronautical Engineering.
* May 1 for the Department of Electrical Engineering.
Gift from power

By Joan Slattery
Lantern staff writer

Plans are currently underway to refurbish the Caldwell undergraduate electric machines laboratory after American Electric Power Service Corporation gave a gift of $200,000 to the College of Engineering.

American Electric gave the money to Ohio State because of their growing concern about declining enrollment in power engineering programs.

“Now there are less people enrolled in power engineering programs across the country, and there are less programs. But some of the schools are making a new commitment and are refurbishing their programs,” said Howard K. Amchin, director of engineering education programs at American Electric.

Amchin explained that enrollment declines when the industry loses its appeal to students.

Accidents such as the nuclear accident at Chernobyl is one example of why students have a bad perception of utilities. They see fewer jobs, and other fields, such as computers or robotics, are more attractive.

Stephen Sebo, professor of electrical engineering, said Ohio State has always offered courses in the electrical power systems area.

“Because of the importance of the power field, these courses are essential to everyday life,” Sebo said.

During the economic recession of the '70s, demand for electricity was down. Because of this, Sebo said, power companies had no growth period and hired fewer people.

He said students who see a decline in employment in power engineering fields chose other fields. Now that the economy of the country is picking up, student interest will be higher.

“The American Electric Power gift was one lump sum of $200,000 for the updating of the undergraduate electric machinery laboratory,” Sebo said. “That lab is old.”

He said the College of Engineering will now completely modernize the lab with computers and new experiments, making the lab more interesting, exciting and competitive.

The lab's renovation should be completed in three to four years. Sebo said weekly meetings are currently being held to plan the new experiments and decide what the department needs to buy.

American Electric also made an extension for a second five-year period supporting the establishment of a designated professorship in power systems engineering in the Electrical Engineering Department, Sebo said.

Though Sebo said faculty shortages are not a problem in engineering at Ohio State, Amchin
company will refurbish lab

said this is a concern among other schools across the nation.

"Industry isn't funding research on campus," Amchin said. Since there are less students enrolled, faculty members want to teach something else.

"People take electricity for granted. All electric power systems from the Atlantic coast to the Rockies are interconnected. If there is a problem at one system, it is felt everywhere. Producing electricity is very complicated," Amchin said.

American Electric makes two kinds of gifts to promote engineering, Amchin said. Annual contributions maintain continuous programs of long durations.

Five years ago American Electric started a $15,000 annual gift to Ohio State to support research and teaching in power engineering programs. This year, the company increased the gift to $20,000 a year.

American Electric also contributes to special drives. The university contacted the company as a community member and employer of OSU students. The company has an obvious interest to promote power engineering, so it responded to the campaign with the gift for the laboratory refurbishment, Amchin explained.

James L. Nichols, university treasurer, said gifts such as these play an important role in the university. "Endowments touch all of the colleges. They touch all of the disciplines within the university and involve students, faculty and research," he said.

Endowments given to the university are established in an account and the interest from that investment pool is used on a continuous basis.

The university receives approximately 12 endowed gifts a month and money is always being added to existing accounts, Nichols said.

This year Ohio State will raise more $40 million in the form of gifts. From July 1986 to December 1986, the first six months of this fiscal year, $28 million was raised, Nichols said.
COLUMBUS, Ohio -- Students of power systems engineering will benefit from a new endowed fund created by the American Electric Power Service Corp. at Ohio State University.

The university's Board of Trustees established the AEP Fund in Electric Power Systems Engineering at its meeting Friday (3/6) with a gift of $200,000 from the corporation.

Annual income from investment of the gift will support the refurbishing of the undergraduate electric machines and power systems laboratory in the university's Caldwell Laboratory.

Donald G. Glower, dean of the College of Engineering, said:

"The university is most grateful to the AEP Service Corp. for the splendid response AEP has made to the university's campaign. This generous commitment will strengthen the university's power systems engineering program by allowing faculty to revitalize the laboratory with much-needed equipment."

"The Ohio State University Campaign was a primary reason for this gift," said Howard K. Amchin, director of engineering education programs for AEP. "We wanted to be a good neighbor and at the same time help counteract the nationwide decline in enrollment in power systems engineering. We felt that this gift would help Ohio State to meet the competition for students from

- more -
such fields as robotics and semiconductors, which appear glamorous to students today."

Stephen A. Sebo, American Electric Power Professor of Power Systems Engineering, explained that most of the electric machines laboratory equipment is in working condition but is 30 to 40 years old.

"The new fund will enable the department to modernize by applying state-of-the-art high technology to a traditional area," he said. "The department is planning to design new experiments, design and install computer hardware and software and update lecture and laboratory classes. Some of the lab's equipment can be kept as is, some will be overhauled and some may be removed."

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Contact: Anne Kochman, University Communications, 292-2711. (0084a)
Robotic vision not yet in sight

By DARRYL J. FELDMEYER
Lantern staff writer

An OSU researcher is trying to develop computer vision that would allow a robot arm to respond to directions from a pair of video cameras, so the robot can operate without supervision.

Kim Boyer, assistant professor of electrical engineering, is developing cameras that can recognize objects for a robot arm to manipulate. The research project is one of several funded by a gift of $50,000 from the AT&T Foundation to Ohio State.

"A robot would be a great deal more useful if we could merely dump a pile of parts on the table," Boyer said. "It would look out there on the table, find the parts it needs, sort through, and put things together much like a person would."

Haile Ko, chairman of electrical engineering, said the $26,000 his department received will buy new equipment to research computer vision, speech recognition and computer networks. The rest of the money will go to the Department of Computer and Information Science.

"AT&T has been a supporter of the electrical engineering department for many, many years," Ko said. There are now 161 graduates from the department working for AT&T in research.

Boyer said, "Computer vision is the study of techniques related to trying to endow machines literally with the ability to see."

"Robots in industry today are by and large without sensory capability at all," he said. "They are deaf, dumb, blind and have numb fingers. Therefore, they have to operate in a very rigidly structured environment."

For a robot to work, everything must be supplied in a particular order or location, Boyer said.

To recognize physical objects, a computer processes their images to recognize elemental features such as the edges of the objects, he said. Boyer said he also is trying to teach computers to read maps.

"There's an incredible amount of information on a map," he said. "To get that information off the map and into a computer ... is a very tedious process."

Boyer said a computer could use information from a map and from other sources to determine the best location for a new factory.

Boyer said he is also working to get a computer to recognize the use of an instrument it hasn't seen before.

People have some ability to infer an object's usefulness from its shape, Boyer said. But people do it so effortlessly that it's hard to know how to start teaching a computer to do the same, he said.

As a start, the computer has compiled a library of 10,000 images. Boyer said he wants a method to categorize the images so the computer can compare what it sees with those in a particular category, rather than with all 10,000 images in the library.

"Unfortunately, it's not like a library where I can alphabetize by author's last name. There's no apparent order in the models of objects," he said.
Departments receive grants to fund special projects, expand programs

By Yolanda L. Gonzalez
Lantern staff writer

"Ohio State University received $45,000 in grants, Wednesday to use for special projects in the departments of Computer Information Science and Electrical Engineering.

The two AT&T Foundation Special Purpose Grants were presented by Jack Degan, campus executive director of AT&T, to Dr. Heo C. Ko, chairman of the Department of Electrical Engineering and to Professor Merwin E. Muller, chairman of the Department of Computer and Information Science.

Computer and Information Science received $20,000, which is to be used to buy a large-scale color projector. This machine will display computer output of an instructional engineering workstation, a computer more powerful than the personal computers and smaller than the powerful computers.

"The projector will allow the instructor to show a whole class the output of the workstation," Muller said.

He said this tool, which will be used in the department's courses, will be a demonstration for other departments about how this new technology can be used to improve teaching.

Muller said he hopes this grant will help the department to catch up with AT&T's instructional program.

AT&T has a training program inside the company where they are using their own technology to teach employees.

The $25,000 received by the Department of Electrical Engineering will allow them to get more engineering workstations to promote research and teaching in the areas of Device Modeling, Circuit Design, and Electronical and Optical Computer Architecture.

"These computers will be more productive. It will help students to do research in a more efficient and productive way," said Ko.

Both departments presented a proposal to the campus management of the AT&T program, which were then submitted to the AT&T Foundation in order to compete for the grants.
Engineering students heading to Japanese firm for research

By Stephanie Bryant
Lantern staff writer

Two OSU students will be among 14 Americans working overseas in research and development for major Japanese businesses.

Michael Taylor and Tom Borgstrom, graduate students in electrical engineering, will be working for Matsushita, a large electronics firm.

WHILE JAPAN sends thousands of its researchers to work and study in American labs, few Americans are permitted to work for Japanese firms. Last year, the Japanese government made 100 positions available for foreign researchers. Only 14 Americans applied for these jobs.

"The Japanese company hired us because they want to have Japanese-trained American researchers to form the initial management team of an American-based research center."

— Michael Taylor

The Japanese company hired us because they want to have Japanese-trained American researchers to form the initial management team of an American-based research center.

"I THINK the class will give us a good language base to work from," Borgstrom said. "But the course is teaching us the Tokyo dialect and we're going to Osaka, so who knows?"

Phil Moore, an OSU graduate who has been living in Japan for one year, said he thinks there are four stages one goes through when moving to Japan.

"The first stage is the 'oh boy, I'm in Japan stage,'" he said. "The second stage is 'oh God, what am I doing in Japan stage.' The third stage is the 'this isn't so bad, I've got these people figured out stage' and the fourth stage is the 'uh-oh... I really don't have these people figured out stage.'"

Both students will be leaving for Japan in early Autumn and will remain in Japan for an undetermined amount of time.
OSU engineers developing wheelchair for airplane use

By Jeff Shafer
Lantern staff writer

Engineers at Ohio State are designing a chair that will help people who are confined to wheelchairs have more mobility when they are flying in an airplane.

They are building a light-weight, moveable chair, called the “air chair,” that people can be transferred into at the airport and taken right onto the plane, said Herman Weed, coordinator of the project and an OSU professor of electrical engineering and preventive medicine.

The project started in January 1989 with a $40,000 grant from the Ohio Rehabilitation Services Commission and a targeted completion date of December 1990, Weed said.

Currently, people confined to wheelchairs are put on chairs, wheeled onto the plane and lifted into their seats. They must be carried if they need to be moved once they are in the plane, Weed said.

“The chairs now being used are top-heavy and can be tipped over sometimes, causing injury to the passenger,” Weed said.

The goal of the “air chair” is to provide a mechanical framework to support the passenger and provide easy movement throughout the flight, Weed said.

The idea for the chair was created by Cuyahoga County Juvenile Court Judge Peter Sikora, who is confined to a wheelchair.

“It is difficult for people in wheelchairs on airplanes, so I wanted to find some means of solving the problem,” Sikora said.

The chair, now in its third version, is made of aluminum and steel, with a hydraulic jack to move the chair up and down, said Alan Mortensen, a graduate research assistant working on the project.
Grant may help OSU, company make better artificial limbs

By Alan Johnson
Dispatch Statehouse Reporter

A Mount Sterling, Ohio, company that began manufacturing wooden legs 85 years ago will team up with The Ohio State University to make it easier for amputees to walk.

Ohio Willow Wood and OSU are in line for a $49,677 grant from the Ohio Department of Development’s Thomas Edison Program. The program uses state dollars to unite Ohio companies and state universities in the research and development of products and inventions. The program has distributed more than $14 million since 1983.

The State Controlling Board is to act on the grant proposal Monday.

Researchers would use the money and a matching sum from the company to develop “an active prosthetic foot for rehabilitation of lower limb amputation.” Simply put, that means an artificial foot and ankle that act more like the real things.

Ohio Willow Wood engineers will work with Yuan Zheng, an OSU professor of electrical engineering.

Jim Colvin, chief engineer for Ohio Willow Wood, said he wants to develop an artificial foot with electronic sensors that send messages telling the ankle to adjust to different pressure as a person walks.

That, he said, would allow users to simulate a more normal gait in walking, especially on uneven surfaces. It also would reduce stress on the hip joints.

“If all goes well after one year, we hope we can produce it,” Colvin said.

Ohio Willow Wood, founded in 1907 by W.E. Arbogast, an amputee, produces prosthetic components.
Electrical Engineering Faculty and Areas of Specialization 1994-95

Bio-Engineering

BOYER, KIM L., Assoc. Professor
Computer Vision, Image Processing, Artificial Intelligence

CLYMER, BRADLEY D., Assoc. Professor
Holography, Optical Computing

HEMAMI, HOOSHANG, Professor
Control, Digital Systems, Robotics

WEED, HERMAN R., Professor
Bio-Medical Engr.

Communications and Signal Processing

BOYER, KIM L., Assoc. Professor
Computer Vision, Image Processing, Artificial Intelligence

KRISHNAMURTHY, ASHOK, Assoc. Professor
Digital Signal Processing, Computer Speech Systems, Digital Systems

LEVIS, CURT A., Professor Emeritus
Propagation, Remote Sensing, Satellite Communications

MITRA, URBASHI, Asst. Professor
Adaptive Multiuser Communications, Mobile & Personal Communications,

MOSES, RANDOLPH L., Assoc. Professor
Digital Signal Processing, System Identification

POTTER, LEE C., Asst. Professor
Signal and Image Reconstruction, Neural Networks

Computer Engineering

AHALT, STANLEY C., Assoc. Professor
Neural Networks, Computer Architectures

BOYER, KIM L., Assoc. Professor
Computer Vision, Image Processing, Artificial Intelligence

BREEDING, KENNETH J., Professor
Microprocessors, Computer Vision

DEGROOT, JOANNE E., Asst. Professor
Computer Architectures, VLSI, CAD

JAGADEESH, JOGILAS M., Assoc. Professor
Image Processing, Computer Architectures, Vision Systems

KLEIN, CHARLES A., Professor
Robotics, Computer Graphics

ORIN, DAVID E., Professor
Robotics, Parallel Architectures

OZGUNER, FUSUN, Professor
Fault-Tolerant Computing, Advanced Computer Architectures, Parallel Processing

ZHENG, YUAN F., Professor and Chairman
Robotic Control, Integrated Manufacturing, Real-Time Computer Systems

Control Systems

FENTON, ROBERT E., Professor
Digital Control, Transportation Systems

HEMAMI, HOOSHANG, Professor
Control, Digital Systems, Robotics

MAYHAN, ROBERT J., Professor
Control Systems

MOSES, RANDOLPH L., Assoc. Professor
Digital Signal Processing, System Identification

OZBAY, HITAY, Assoc. Professor
Linear Systems, Robust Control, H Optimal Control, Distributed Parameter Systems

OZGUNER, UMIT, Professor
Decentralized Control, Robotics, Flexible Structures

PASSINO, KEVIN M., Asst. Professor
Discrete Event Systems, Intelligent Control

UTKIN, VADIM, Ford Chair in Electromechanical Electromechanical Systems Control, Variable Structures Systems, Nonlinear Control

YURKOVICh, STEPHEN, Assoc. Professor
System Identification, Robotics, Flexible Structures

ZHENG, YUAN F., Professor and Chairman
Robotic Control, Integrated Manufacturing, Real-Time Computer Systems

Electric Power Systems

KASTEN, DONALD G., Assoc. Professor
Power Systems

KEYHANI, ALI, Professor
Power Systems, Electric Machines, Motor Control Systems

SEBO, STEPHEN A., Professor
Power Systems, High Voltage Systems

XU, LONGYA, Asst. Professor
Power Electronics, Electric Drives

Department of Electrical Engineering
Electromagnetics and Optics

BURNSIDE, WALTER D., Professor
Electromagnetics, Antennas
CL YMER, BRADLEY D., Assoc. Professor
Holography, Optical Computing
GARBACZ, ROBERT J., Professor
Electromagnetics, Scattering
HODGE, DANIEL B., Professor
Wave Propagation, Scattering
LEE, ROBERT, Asst. Professor
Electromagnetics, Scattering, Numerical Methods
MIUK, BENEDIKT A., Professor
Electromagnetics, Antennas, Radomes
NEWMAN, EDWARD H., Professor
Electromagnetics, Numerical Methods
PATHAK, PRA BHAKAR H., Professor
Electromagnetics
PETERS, LEON, JR., Professor Emeritus
Electromagnetics, Antennas, Scattering
RUDDUCK, ROGER C., Professor Emeritus
Electromagnetics, Antennas

Solid State Microelectronics

ANDERSON, BETTY LISE, Asst. Professor
Opto-Electronics, Semiconductor Devices
BIBYK, STEVEN B., Assoc. Professor
Microelectronics
CL YMER, BRADLEY D., Assoc. Professor
VLSI, Opto-Electronics
DEGROAT, JOANNE E., Asst. Professor
Computer Architectures, VLSI, CAD
GOTTLING, JAMES G., Professor
Electronics, Computer Aided Design
ISMAIL, MOHAMMED, Professor
Analog/Digital VLSI Design
KHAN, FURRUKH, Assoc. Professor
Solid State Physics and Devices
RINGEL, STEVEN A., Asst. Professor
Electronic Materials, Device Physics, Photovoltaics
ROBLIN, PATRICK, Assoc. Professor
Microwave Semiconductor Devices, Device Physics
VALCO, GEORGE J., Assoc. Professor
Microelectronics, Compound Semiconductor Devices, High $T_c$ Superconductors

Robotics

BOVER, KIM L., Assoc. Professor
Computer Vision, Image Processing, Artificial Intelligence
HEMAMI, HOOSHANG, Professor
Control, Digital Systems, Robotics
KLEIN, CHARLES A., Professor
Robotics, Computer Graphics
ORIN, DAVID E., Professor
Robotics, Parallel Architectures
OZGÜNER, UMIT, Professor
Decentralized Control, Robotics, Flexible Structures
YURKOVICH, STEPHEN, Assoc. Professor
System Identification, Robotics, Flexible Structures
ZHENG, YUAN F., Professor and Chairman
Robotic Control, Integrated Manufacturing, Real-Time Computer Systems

Manufacturing Engineering

HEMAMI, HOOSHANG, Professor
Control, Digital Systems, Robotics
KLEIN, CHARLES A., Professor
Robotics, Computer Graphics
ORIN, DAVID E., Professor
Robotics, Parallel Architectures
OZGÜNER, UMIT, Professor
Decentralized Control, Robotics, Flexible Structures
PASSINO, KEVIN M., Asst. Professor
Discrete Event Systems, Intelligent Control
ZHENG, YUAN F., Professor and Chairman
Robotic Control, Integrated Manufacturing, Real-Time Computer Systems
Fiber-optic sensors could improve product quality

By Susan R. Little
Latern staff writer

Researchers working in the School of Electrical Engineering could help auto manufacturers build better car parts with higher productivity and fewer mistakes.

The researchers have developed a technique using light-emitting sensors to detect wrinkles that form in sheet metal during the manufacturing process, said Yuan Zheng, professor of electrical engineering.

The sensing technique was successfully tested by Zheng and graduate student Pratap Pereira, using fiber-optic and laser sensors.

Wrinkling is a common problem in a variety of processes where sheet metal is used, Zheng said.

When pushed into a die, the pressure on the sheet metal has to be exactly correct, he said. If it is too strong, the sheet metal will tear. If the pressure is too weak, it causes the sheet metal to wrinkle.

Currently, manufacturers have to rely on trial and error to determine the correct pressure. With the OSU process, mistakes are eliminated, Zheng said.

"Our sensing process can monitor the status of sheet metal while it is actually being pushed into the die," Zheng said. "The sensors can detect wrinkles being formed before they can be seen, and then the pressure can be adjusted accordingly."

In one of the two setups the researchers used to test their technique, two fiber optic sensors were used. Each sensor emitted a beam of light which struck the metal as it is pushed through the die and reflected back to the sensor.

If the length of one beam of light became shorter or longer than the other, it indicated a wrinkle was starting to form, Zheng said.

This information can then be fed into a computer that adjusts pressure on the metal. The system can detect wrinkles being formed while they are still only a few microns high. A micron is 1,000th of a millimeter.

The second setup used only a single laser sensor which measured changes on the metal's surface by emitting a beam to the surface which is reflected back onto a third surface.

This triangulation method is more precise than the fiber optic system, Zheng said. However, it is bulkier and not practical for use during the manufacturing process, he said.

"We think this laser process could be used off-line for quality control inspection of finished products," Zheng said.

He said both types of sensors are already commercially available. However, these sensors have never been used before in the manufacturing process to detect wrinkles.

Zheng said the sensing strategy has only been tested in the laboratory, and the results need to be replicated in a manufacturing environment.

"The auto industry is very interested in this process," he said.

Auto manufacturers are more frequently introducing new models, and new dies are constantly being designed. This method will help to get the new dies working properly more quickly, Zheng said.

While the auto industry is the most obvious beneficiary of the new process, Zheng said companies using sheet metal to make products ranging from house gutters to pans could use these sensors to their advantage. "We think the sensing strategy will have a wide variety of uses in industry," he said.

The study which was funded by the U.S. Office of Naval Research and OSU's Engineering Research Center for Net Shape Manufacturing was published in a recent issue of the journal IEEE Transactions on Instrumentation and Measurement.
Engineering students build self-driven cart

By Anissa Clement
Lantern staff writer

OSU engineering students think it's a golf cart you'll probably never see at Muirfield Village Golf Club due to their new project.

OSU engineering students are using knowledge they've learned in the classroom to develop a self-driven golf cart they plan to enter in the International Ground Robotics Competition. The competition will be held at Oakland University in Rochester, Mich., May 20-22.

Although this is the third year for the event, this is the first time Ohio State has entered.

The golf cart is one of the projects offered by the College of Engineering through the Automated Robotic Transporter Program.

Students can become part of this project and several others through the ART program. ART is comprised of two projects. The first is an undergraduate design course. The senior-level course, called ART Jr., lets students design and develop a small, autonomous robot with wheels that can be used in a factory or warehouse type environment, Orguner said.

New ART is a group effort by undergraduate and graduate students to develop an autonomous wheeled vehicle — a golf cart — that will navigate around a marked track using vision and other sensory inputs, Orguner said.

The circular, one-lane track is about 1000 feet long, said Keith Redmill, the student team leader. The course includes hills, curves, obstacles and a sandtrap that the vehicle must navigate around, he said.

The maximum speed allowed is 5 miles per hour and there is a time limit of 10 minutes. Penalties are given if the cart runs into an obstacle or crosses the boundary lines, Orguner said.

About 20 colleges entered last year's competition. Only two vehicles completed the course, Redmill said.

Four undergraduate and four graduate students, all electrical engineering majors, are working on the golf cart, Redmill said.

The students have been working on the project since November. The project is considered part of the graduate students' research. Undergraduates earn credit toward graduation, Redmill said.

The project consists of three parts. The first is the vision system that involves programming the golf cart's computer to identify lines, lane markers, and obstacles, Redmill said.

Muralo Kunapathipillai, a graduate

student in electrical engineering from Sri Lanka, has been working on the vision system.

"It's very interesting to work on a project which is actually being developed in industry and other universities," he said.

The self-propelled system involves modifying the golf cart, by developing a new steering system and modifying speed control, Redmill said.

Steve Manette, a graduating senior in electrical engineering from Lima, Ohio, spends five to 10 hours a week working on the steering mechanism.

"Instead of number crunching all the time, you can actually get something to work out," Manette said.

The third area is the control task which involves taking the data from the vision system, commanding the vehicle to move at certain speeds and making steering corrections, Redmill said.

Konur Unyelidou, an electrical engineering research scientist from Turkey, designed the theoretical controller model. The controller commands the steering, which he described as the "driver" — the eyes provide information about the road and the brain determines the position and orientation of the vehicle.

"It (the competition) allows them to integrate and apply all the material they've learned to build a complete product," Redmill said.

Although the students working on the golf cart are electrical engineering majors, the project is open to all engineering students, Orguner said.

Ohio State has never entered the competition before because of lack of funding, time and student interest, Orguner said.
Electrical Engineering Faculty and Areas of Specialization 1996-97

Bio-Medical

KIM L. BOYER, Professor
Computer Vision, Image Processing, Artificial Intelligence

BRADLEY D. CLYMER, Associate Professor
Holography, Optical Computing

HOOSHANG HEMAMI, Professor
Control, Digital Systems, Robotics

HERMAN R. WEED, Professor
Bio-Medical Engineering

Communications and Signal Processing

KIM L. BOYER, Professor
Computer Vision, Image Processing, Artificial Intelligence

STEVEN B. BIBYK, Associate Professor
Signal Processing in VLSI, Signal Coding for Computation, Analog/Digital VLSI

MICHAEL P. FITZ, Associate Professor
Communicator Theory, Wireless Communications, Satellite Communications

ASHOK KRISCHNAMURTHY, Associate Professor
Digital Signal Processing, Computer Speech Systems, Digital Systems

CURT A. LEVIS, Professor Emeritus
Propagation, Remote Sensing, Satellite Communications

URBASHI MITRA, Assistant Professor
Adaptive Multiuser Communications, Mobile and Personal Communications

RANDOLPH L. MOSES, Professor
Digital Signal Processing, System Identification

LEE C. POTTER, Associate Professor
Signal and Image Reconstruction, Neural Networks

Computer Engineering

STANLEY C. AHALT, Associate Professor
Neural Networks, Image Processing

KIM L. BOYER, Professor
Computer Vision, Image Processing, Artificial Intelligence

KENNETH J. BREEDING, Professor
Microprocessors, Computer Vision

JOANNE E. DEGROAT, Associate Professor
Computer Architectures, VLSI, CAD

CHING-CHIH JASON HAN, Assistant Professor
High-Speed Networking, Real-Time Computing, Wireless Communications, Multimedia Applications

CHAO-JU JENNIFER HOU, Assistant Professor
Real-Time Computing, Real-Time Communications, Distributed Systems, Resource Management in ATM Networks

JOHNNAL M. JAGADEESH, Associate Professor
Image Processing, Computer Architectures, Vision Systems

CHARLES A. KLEIN, Professor
Robotics, Computer Graphics

DAVID E. ORIN, Professor
Robotics, Parallel Architectures

FUSUN OZGUNER, Professor
Fault-Tolerant Computing, Advanced Computer Architectures, Parallel Processing

YUAN F. ZHENG, Professor and Chairman
Robotic Control, Integrated Manufacturing, Real-Time Computer Systems

Control Systems

JOSE B. CRUZ, Professor and Dean of Engineering
Game Theory, Manufacturing

ROBERT E. FENTON, Professor Emeritus
Digital Control, Transportation Systems

HOOSHANG HEMAMI, Professor
Control, Digital Systems, Robotics

ROBERT J. MAYHAN, Professor Emeritus
Control Systems

RANDOLPH L. MOSES, Professor
Digital Signal Processing, System Identification

HITAY OZBAY, Associate Professor
Linear Systems, Robust Control, Optimal Control, Distributed Parameter Systems

UMIT OZGUNER, Professor
Decentralized Control, Robotics, Flexible Structures

KEVIN M. PASSINO, Associate Professor
Discrete Event Systems, Intelligent Control

VADIM UTKIN, Ford Chair in Electromechanical Systems Engineering and Professor
Variable Structures Systems, Nonlinear Control

STEPHEN YURKOVICH, Professor
System Identification, Robotics, Flexible Structures

YUAN F. ZHENG, Professor and Chairman
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Department of Electrical Engineering
Electric Power Systems
DONALD G. KASTEN, Associate Professor
Power Systems
ALI KEYHANI, Professor
Power Systems, Electric Machines, Motor Control Systems
STEPHEN A. SEBO, Neil Smith Chair in Electrical Engineering and Professor
Power Systems, High Voltage Systems
LONGYA XU, Associate Professor
Power Electronics, Electric Drives

Electromagnetics and Optics
BETTY LISE ANDERSON, Associate Professor
Optoelectronics, Semiconductor Devices
WALTER D. BURNSIDE, Professor
Electromagnetics, Antennas
BRADLEY D. CLYMER, Associate Professor
Holography, Optical Computing
ROBERT J. GARBACZ, Professor Emeritus
Electromagnetics, Scattering
JOEL T. JOHNSON, Assistant Professor
Electromagnetics, Remote Sensing, Numerical Methods
ROBERT LEE, Associate Professor
Electromagnetics, Scattering, Numerical Methods
BENEDIKT A. MUNK, Professor
Electromagnetics, Antennas, Radomes
EDWARD H. NEWMAN, Professor
Electromagnetics, Numerical Methods
PRABHAKAR H. PATHAK, Professor
Electromagnetics
LEON PETERS, JR., Professor Emeritus
Electromagnetics, Antennas, Scattering
ROBERTO G. ROJAS, Associate Professor
Electromagnetics, Antennas, Scattering
ROGER C. RUDDUCK, Professor Emeritus
Electromagnetics, Antennas

Robotics
KIM L. BOYER, Professor
Computer Vision, Image Processing, Artificial Intelligence
HOOSHANG HEMAMI, Professor
Control, Digital Systems, Robotics
CHARLES A. KLEIN, Professor
Robotics, Computer Graphics
DAVID E. ORIN, Professor
Robotics, Parallel Architectures
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Solid State Microelectronics
BETTY LISE ANDERSON, Associate Professor
Optoelectronics, Semiconductor Devices
STEVEN B. BIBYK, Associate Professor
Signal Processing in VLSI, Signal Coding for Computation, Analog/Digital VLSI
LEONARD J. BRILLSON, Center for Materials Research Scholar and Professor
Electronic Materials, Semiconductor Interface Control
BRADLEY D. CLYMER, Associate Professor
VLSI, Optoelectronics
JOANNE E. D'GROAT, Associate Professor
Computer Architectures, VLSI, CAD
MOHAMMED ISMAIL, Professor
Analog/Digital VLSI Design
FURRUKH KHAN, Associate Professor
Solid State Physics and Devices
STEVEN A. RINGEL, Assistant Professor
Electronic Materials, Device Physics, Photovoltaics
PATRICK ROBLIN, Associate Professor
Microwave Semiconductor Devices, Device Physics
GEORGE J. VALCO, Associate Professor
Microelectronics, Compound Semiconductor Devices, High T_c Superconductors

Manufacturing Engineering
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YUAN F. ZHENG, Professor and Chairman
Robot Control, Integrated Manufacturing, Real-Time Computer Systems
Electrical Engineering Faculty and Areas of Specialization 1997–98

Bio-Medical

KIM L. BOYER, Professor
Computer Vision, Image Processing, Artificial Intelligence

BRADLEY D. CLYMER, Associate Professor
Holography, Optical Computing

HOOSHANG HEMAMI, Professor
Control, Digital Systems, Robotics

HERMAN R. WEED, Professor Emeritus
Bio-Medical Engineering

Communications and Signal Processing

STANLEY C. AHALT, Associate Professor
Neural Networks, Image Processing

KIM L. BOYER, Professor
Computer Vision, Image Processing, Artificial Intelligence

STEVEN B. BIBYK, Associate Professor
Microelectronics, Communications

MICHAEL P. FITZ, Associate Professor
Communication Theory, Wireless Communications, Satellite Communications

ASHOK KRISHNAMURTHY, Associate Professor
Digital Signal Processing, Computer Speech Systems, Digital Systems

CURT A. LEVIS, Professor Emeritus
Propagation, Remote Sensing, Satellite Communications

URBASHI MITRA, Assistant Professor
Adaptive Multuser Communications, Mobile and Personal Communications

RANDOLPH L. MOSES, Professor
Digital Signal Processing, System Identification

LEE C. POTTER, Associate Professor
Signal and Image Reconstruction, Neural Networks

Computer Engineering

STANLEY C. AHALT, Associate Professor
Neural Networks, Image Processing

KIM L. BOYER, Professor
Computer Vision, Image Processing, Artificial Intelligence

KENNETH J. BREEDING, Professor
Microprocessors, Computer Vision

JOANNE E. DEGROOT, Associate Professor
Computer Architectures, VLSI, CAD

CHING-CHIH JASON HAN, Assistant Professor
High-Speed Networking, Real-Time Computing, Wireless Communications, Multimedia Applications

CHAO-JU JENNIFER HOU, Assistant Professor
Real-Time Computing, Real-Time Communications, Distributed Systems, Resource Management in ATM Networks

JOGIKAL M. JAGADEESH, Associate Professor
Image Processing, Computer Architectures, Vision Systems

CHARLES A. KLEIN, Professor
Robotics, Computer Graphics

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Advent of 'SmartChip' changes OSU's reputation

By Kevin Zapiecki
Lantern staff writer

Ohio State may not be known for developing high-tech businesses, but three electrical engineering faculty members have developed a microchip for a small company that could change OSU's reputation.

Steven Bibyk, Mohammed Ismail and Joanne DeGroat invented a programmable analog microchip called SmartChip. It can make electronic systems more cost effective and easier to design.

"Using analog chips has been similar to writing reports with a typewriter, instead of a word processor," Bibyk said. "Every time you made a mistake, it was slow and tedious to correct."

The microchip is about 2 years old and still has a year before it will be distributed, Bibyk said. Ismail has been at OSU for nine years and is a co-founder of Micrys, a company that is attempting to merge technology with big business and wants to sell microchip technology by OSU.

Micrys has a development and license agreement with OSU, Bibyk said.

"Part of the agreement is that OSU was given 126,000 shares of Micrys stock, which at the time was about five percent," he added.

Micrys has to make minimum payments of $1.5 million to OSU in terms of royalties and research development over five years, he said.

"The payments give Micrys the rights to sell the chip and other technology that Micrys pays to develop and give OSU a better chance to see our ideas get to the marketplace," he said.

It's not easy to start a small business in Columbus, because it is hard to work with institutions like Ohio State, Bibyk said.

"Micrys is putting a lot of effort in working with Ohio State at the same time Ohio State is trying to work with small companies," he said.

There are about seven people who are running the 2-year-old company and about 15 OSU electrical engineering graduate students who are being paid to do research.

"Ohio State is viewed as a sleeping giant in the sense of being aggressive and taking research results and commercially applying them," Ismail said. "This will create new jobs and perhaps stop the brain drain of our brightest students to other states such as California," he said.
Ohio State Molecular Beam Epitaxy Facility

The Ohio State University Molecular Beam Epitaxy (MBE) Facility was founded in 1994 via a grant from the OSU Center for Materials Research (CMR). The MBE Facility has world-class capabilities for growing advanced electronic and optoelectronic semiconductor materials, multilayers and quantum structures based on GaAs, AlGaAs, InGaAs and related materials with atomic precision. This capability is a central component and focal point for major interdisciplinary electronic materials and devices research activities involving students, post-doctoral researchers, research scientists and faculty members throughout various departments in the Colleges of Engineering and Mathematical and Physical Sciences, the CMR, in conjunction with outside industry and federal laboratories.

A graduate student adjusts the MBE system during growth of an AlGaAs/GaAs superlattice.

**Highlights:**

- First MBE system at an institution within Ohio
- Housed in multi-purpose class 100/1000 semiconductor fabrication cleanroom built in 1994
- Capable of growing ultra-thin (as small as 10 billionths of an inch!) crystalline layers of compound semiconductor materials with precise uniformity across a 3 inch wafer
- Multiple, interconnected chambers for the deposition of III-V compound semiconductors, metals and *in-situ* chemical and structural characterization
- Enables leading edge research in advanced semiconductor materials, quantum structures, artificially-engineered materials, interfaces, surfaces and materials physics
- Enables leading edge research of next-generation optoelectronic and electronic devices used in communications, computers, sensors, displays and alternative energy technologies
- Focal point for inter-department and inter-college electronic materials research programs
- Focal point for industrial involvement in electronic materials and devices research at OSU

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MBE Research at Ohio State

The OSU MBE Facility is housed in the Department of Electrical Engineering's semiconductor fabrication cleanroom and is a central facility for interdisciplinary research activities in electronic materials and devices throughout the Colleges of Engineering and Math and Physical Sciences. Graduate students, post-doctoral researchers, research scientists and faculty members interact closely through fundamental and applied research programs ranging from basic studies of the physics and chemistry of interfaces in the quantum regime to growth techniques that inhibit defect formation in lattice-mismatched semiconductors to the design and development of superlattices for state-of-the-art devices such as lasers, high speed transistors, photodetectors, optical modulators and solar cells. Industrial involvement and support is a strong component of our MBE-related programs, which provides excellent exposure for our students as they complete their graduate education.

Transmission electron micrograph of an AlGaAs/GaAs superlattice grown by MBE.

Selected Areas of MBE-Related Research:
- Advanced III-V photonic devices including high-speed photodetectors, photorefractive devices, and vertical cavity surface emitting lasers
- Alternative energy devices such as thermophotovoltaics and solar cells
- Properties and applications of low temperature III-V materials
- Inter-band and inter-subband quantum structures: their properties and device applications
- Heteroepitaxy, lattice-mismatched heterostructures and III-V/Si materials integration
- Defect engineering and control in epitaxial growth
- Structure and properties of semiconductor surfaces and interfaces
Microelectronics encompasses a broad interdisciplinary background, involving device physics, materials science, manufacturing, analog and digital circuits, computer-aided VLSI design, optoelectronics and photonics, superconducting devices and technology, electronic neural circuits, and the future development of new technologies for information processing and power handling.

Microelectronics continues to experience and lead a technological revolution having a major impact on the quality of life. The future is leading to technologies involving a billion transistors on a chip, from megahertz to gigahertz logic, from gigahertz to terahertz analog, even toward computational systems with billions of processors, comparable to the number of neurons in the human brain. Advances in microelectronic materials have lead to arrays of quantum dot devices one hundred billionths of an inch in dimension, and are pushing toward integration of lasers, optical waveguides, photodetectors and electronic drive and logic devices on a single chip. Superconductors have been used in digital logic circuits operating in excess of 100 GHz and high temperature superconductors are being developed for use in microwave wireless communications systems.

The solid state microelectronics area in the Department of Electrical Engineering consists of nine faculty, two research scientists, a technician and extensive laboratory facilities. It encompasses a wide scope of research topics including both experiment and theory of electronic materials and devices, VLSI circuit design, analysis and measurement, optoelectronics, fiber optics, and more.
Graduate Course Offerings In Electrical Engineering

EE 637 Solid State Microelectronics Laboratory I
Introduction to fabrication techniques for Si and III-V compound semiconductors including oxidation, diffusion, epitaxy, photolithography and metalization; fabrication and measurements of bipolar and field effect devices.

EE 638 Solid State Microelectronics Laboratory II
Design and fabrication of integrated circuit projects such as amplifiers, NMOS, CMOS, and bipolar digital circuits.

EE 720 Modern Active Filter Design
The fundamental design concepts, tradeoffs, and design techniques of modern active filters. Second and higher order structures, monolithic sensitivity analysis; non-ideal effects.

EE 721 Advanced Electronic Circuits
VLSI circuit design on CAD systems; integrating and differentiating circuits; timing circuits; pulse circuits; wave-forming and wave-shaping circuits.

EE 722 Active Network and Logic Circuit Design by Digital Computer
Study of computer aided network design programs, topological matrices, active device modeling, linear and non-linear solutions; logic circuit analysis and design by digital computer.

EE 723 Microwave Transistor Amplifiers and Oscillators and Laboratory
Design principles of microwave transistor amplifiers and oscillators. Low-noise power, and broadband amplifiers. Computer-aided design, microstrip realization and testing in the laboratory.

EE 731 Fiber Optics
Waveguiding in dielectric slab waveguides, waveguiding in optical fibers, fiber losses, physical operation of optical sources (LEDs and lasers), coupling, detectors and receivers, noise sources, optical link analysis, coding schemes. Included brief introduction to fiber sensors.

EE 732 Quantum Electron Devices: Lasers
Atomic interaction of radiation, cavities with gain, pumping techniques, amplifier and oscillator configurations.

EE 734 Solid State Electronics Design and Technology
Discrete and integrated circuit device design and silicon technologies; VLSI processing procedures; device measurements for process development.

EE 735 Compound Semiconductor Electronics Design and Technology
III-V compound semiconductor device fabrication technology; epitaxy, doping, bandgap engineering; GaAs and InP high speed devices and IC design approaches; testing and failure mechanisms.

EE 737 Photonics Laboratory
Experiments in state-of-the-art photonics, from among: fiber optics, liquid crystals, quantum devices, optical sensing, acousto-optics, lasers, and solar cells.

EE 820 Analog VLSI Design
Hardware implementation of analog MOS VLSI circuits and systems with applications in important areas such as telecommunications; analog interface systems for mixed analog/digital VLSI; analog VLSI neural networks.

EE 830 Semiconductor Theory

EE 831 Semiconductor Device Theory
Basic semiconductor device current equations including generation and recombination mechanisms and charge trapping. Measurements and analysis of interface states. Advanced p-n junction theory, avalanche breakdown, metal-semiconductor contacts, MIS capacitors and short channel devices.

EE 832 High Speed Semiconductor Devices
Principles underlying the operation and application of high speed solid-state active devices, electron transport in high fields, Gunn effect, superlattices, heterostructures, and modulation doped devices.

EE 833 Optical Effects in Materials and Devices
Static and quasi-static piezoelectric, electro-optic, photorefractive, acousto-optic and magnetooptic effects, and devices based on these effects.

EE 834 Parametric Electronics and Nonlinear Optics
Coupled mode theory of wave interactions; acousto-optical devices; nonlinear optical phenomena; optical parametric processes; tunable optical oscillator; high power laser interactions.

EE 881 Seminars in Electrical Engineering
Classroom presentations made by doctoral students based on their own literature and research investigations.
Facilities and Programs

There are extensive facilities for carrying out experimental and theoretical research in solid state electronics. A new 4000 sq. ft. cleanroom houses facilities for processing of electronic materials, devices and circuits, including a Molecular Beam Epitaxy (MBE) system with multiple chambers, allowing growth of several different materials systems.

The processing capabilities are supplemented by comprehensive and state-of-the-art facilities for characterization of the processed materials and devices. A few of the materials characterization capabilities are deep level transient spectroscopy, photoluminescence, Hall effect and double crystal x-ray diffraction. There are electronic testing facilities for measurements of analog circuits, digital circuits, and currents and capacitances of devices at various temperatures and frequencies. Specific test stations are: low temperature measurement systems for CMOS devices and superconductors, digital VLSI testing, RF and microwave measurement equipment, and analog circuit performance measurement capabilities. Almost all measurement instruments are under computer control for rapid data acquisition and analysis.

The photonics laboratories include several vibration isolated optical tables plus a variety of low and high power lasers including HeNe, ruby, CO2 argon, Nd:YAG and semiconductor. Equipped for varied experiments in holography, optical sensing and fiber optics, the lab has a full array of optical components and measurement instruments.

The CAD facilities involve a network of workstations which are used for analog, digital, and microwave circuit design. These computers are also used for modeling and simulation of high frequency semiconductor devices, semiconductor power devices, and the structure and properties of electronic materials.

The laboratory capabilities provide a wide range of research for student projects, theses, and dissertations. Opportunities for interactions with other areas of electrical engineering and other fields of science and engineering, such as physics, materials science and engineering, mechanical engineering, and computer science, exist and are frequently exercised.
Current Research Interests

The following is a summary of some of the current research activities in the Solid State Microelectronics and Photonics areas.

Microelectronic and Optoelectronic Materials

- Experimental research on a variety of materials and semiconductor heterostructures, including Si, Ge, GaAs and InP, wide bandgap materials, and various alloys, which have applications for optoelectronic, electronic and photovoltaic devices, is being performed. Materials growth by molecular beam epitaxy, electrical, optical and microstructural characterization of defects and interfaces, monolithic integration of dissimilar semiconductors, optical properties and electronic transport properties are some of the areas currently under study. Particular device applications include solar cells, high speed FETs and optical emitters and detectors. (Prof. Ringel)

- The dynamical properties of covalent semiconductors are being investigated via numerical simulations using the method of Molecular Dynamics, while retaining the quantum nature of the electrons at the level of the Local Density Approximation. The aim is to understand the formation of surfaces and study crystal growth. A method of performing Quantum Molecular Dynamics by using the Tight-Binding formulation has been developed. Relaxation of surfaces, steps, and kinks, sticking and diffusion of an atom on surfaces, dynamics of atoms near a relaxed kink, and growth of kinks into steps will be studied. The local CRAY Y/MP at the Ohio State University campus, as well as massively parallel machines located at the Oak Ridge National Laboratory, are used to perform the simulations. (Prof. Khan)

- Experimental research on electronic applications of a variety of materials in being performed. Pulsed laser deposition is used to form thin films of materials such as high temperature superconductors, piezoelectrics and ferroelectrics, which are characterized and processed into microelectronic devices or circuits such as microwave resonators, filters or oscillators. (Prof. Valco)

Device Modeling

- Modeling of semiconductor devices at microwave frequencies and under transient operation is being undertaken. In particular, novel large-signal models for FETs and BJTs which are both charge-conserving and non-quasi-static are being developed. A quantum simulator using realistic band structures for the calculation of 3D scattering-assisted tunneling in layered semiconductor heterostructures is also being developed. (Prof. Robin)

VLSI Circuits and Systems

- Development of VLSI architecture for signal processing systems is in progress. At present, this involves the design of an associative memory chip set for use in image processing and pattern recognition. Other projects are the development of mixed analog and digital microelectronics for biomedical pacemaker applications, analog computations in control systems, and digital communication systems. (Prof. Bityk)

- Research in design and testing of mixed analog/digital VLSI circuits for signal and information processing applications is being carried out. This involves chip designs in CMOS and BiCMOS technologies for applications in areas such as consumer electronics, telecommunications and analog VLSI artificial neuro-computation. (Prof. Ismail)

Optoelectronic Devices and Photonics

- The spatial coherence of semiconductor laser diodes is being studied for use for a variety of new applications, including a communication channel to increase the capacity of all-optical networks, and characterization of optical interconnections in optoelectronic integrated circuits. Research on fiber optic sensing and investigations of the radiation hardness of optical devices are also being performed. (Prof. Anderson)

- Research is being performed on optical interconnection and networking for multiprocessor systems, medical imaging, adaptive filtering, tomographic reconstruction of images, Fourier and diffraction optics, holography, acousto-optics, electro-optics, and acoustics. (Prof. Clymer)

Experiments on fiber optic Interferometry being performed in the Photonics Research Lab.
The Ohio State University

Graduate Program in Electrical Engineering
The City of Columbus
The state’s capital and largest city, Columbus is one of the fastest growing metropolitan areas in the United States and currently has a population of just over one million. Its growth has been spurred in part by its moderately priced housing and broad-based economy. Columbus has dozens of service and information-related businesses, many research- and insurance-based companies, and several regional and national retail distribution centers.

The city has a thriving downtown with excellent restaurants, a symphony, a ballet company, theaters, museums, and art galleries. A fine zoo, dozens of shopping malls, specialty shops, and housing styles ranging from turn-of-the-century brownstones to ultramodern condominiums, as well as many fine public and private schools have made Columbus, together with its surrounding suburbs, an attractive place to work, get an education, start a business, begin a career, or raise a family.

The Ohio State University
Founded in 1870, The Ohio State University is a comprehensive institution that emphasizes graduate and professional education and research. Of the 51,000 students enrolled, almost 11,000 are graduate students who come from every state in the nation and over 100 different countries. These students are instructed by more than 4,000 faculty members who teach a wide range of disciplines in 19 colleges, 7 schools, 4 centers as well as the Graduate School. With its fine library system and research facilities and equipment, these faculty have made The Ohio State University one of the premier institutions of higher education in the United States. As a Land-Grant university it has long been dedicated to the principle of equal opportunity for students from all economic backgrounds and social levels, without distinction as to race, color, creed, national origin, sex, sexual orientation, age, or handicap.

The Department of Electrical Engineering

The Department of Electrical Engineering occupies three buildings on campus specifically designed for instruction and research: Dreese Laboratory, Caldwell Laboratory, and the ElectroScience Laboratory. Well equipped experimental facilities and computational capabilities help students and faculty in both classroom and research tasks in such specialties as communications and signal processing, control, computer engineering, electric power systems, electromagnetics, electronic materials and devices, robotics, and biomechanics. In most of these areas interdisciplinary projects allow and encourage graduate students to draw the coursework and research from other departments on campus such as mathematics, mechanical engineering, physics, geodetic science, medicine, etc.

Because of its strong faculty, curricula, and research activity, this department’s graduate program ranks favorably in published comparisons among leading departments in the United States, usually securing a place among the top 15-20 of 200 or so electrical engineering departments nationwide.

Departmental philosophy seeks a close coordination of practical research with course work. This goal is realized by faculty participation, either individually or in organized laboratories, in a large volume of sponsored research and development. These laboratories vary considerably in size and mode of operation while depending to a significant degree on graduate students for the staffing of individual research programs. They provide excellent opportunities to conduct research leading to master’s theses and doctoral
dissertations and possess excellent staffs and facilities to support such research. Research groups and organized laboratories within the Department of Electrical Engineering and their major areas of research include:

- **Control Research Laboratory**
  - Large Scale Systems
  - Digital Control & Microprocessor Applications
  - Robust Control
  - Nonlinear Control
  - System Identification & Adaptive Control
  - Flexible Structure Control
  - Robotics and Locomotion
  - Intelligent Control
  - Intelligent Vehicle Highway Systems (IVHS)

- **Parallel Computing Laboratory**
  - High Performance Architectures
  - Parallel Algorithms
  - Communication and Routing in Distributed Memory Multiprocessor
  - Fault-Tolerance
  - Computer Aided Design of VLSI Circuits

- **ElectroScience Laboratory**
  - Electromagnetics
  - Antennas and Radomes
  - Numerical Techniques
  - Electromagnetic Field Measurement
  - Remote Sensing
  - Target Identification
  - Communications and Signal Processing
  - Radar Systems

- **Lamme Power Systems Laboratory**
  - Electric Power Systems
  - Electric Machines
  - High Voltage Engineering
  - Power System Economics

- **Electronic Materials and Devices Laboratory**
  - Materials Growth and Characterization
  - Device Fabrication and Measurements
  - Computer Modeling of Materials and Devices
  - Computer Aided VLSI Design
  - Microwave Devices and Circuits
  - High Temperature Superconductors
  - Fiber Optics

- **Signal Analysis & Machine Perception Laboratory**
  - Aerial and satellite image understanding
  - Stereo autonomous camera calibration
  - Large structural modelbase organization
  - Motion analysis for collision avoidance

- **Optimal methods in feature extraction**
- **Perceptual organization and Bayesian networks**
- **Robust estimators, surfaces in range data**

- **Robotics Laboratory**
  - Manipulators
  - Walking machines
  - Dexterous hands
  - Computer graphics
  - Computer Vision
  - Neural networks
  - Manufacturing

- **Signal Processing & Neural Network Laboratory**
  - Automatic Target Recognition
  - Speech analysis, synthesis, and recognition
  - Signal recovery and inverse problems
  - Neural Network algorithms and hardware
  - Auditory models
  - Robust parameter estimation
  - Image compression

### The Library
The Ohio State University Libraries system houses the 16th largest research and academic collection in North America. The system comprises the main library, two undergraduate libraries, and 24 subject-oriented or departmental libraries. The aggregate collection includes over 4.5 million volumes, 3.5 million microfilms, 32,381 journal subscriptions, and a host of non-print media. Students and faculty can use computer terminals to locate and determine availability of any holding in the collection. In addition, through interlibrary loan researchers can borrow materials from libraries throughout the world.

Of particular importance to engineering students is a new Science and Engineering Library located in the science/engineering areas of campus. This library has holdings of...
363,000 volumes and 24,000 journal subscriptions, and is
CD ROM networked. It seats 710 persons in a pleasant and
quiet environment.

Graduate Student Housing
You can choose from several housing options at Ohio State. For unmar-
nied students the University maintains three gradu-
ate residence halls which provide attractively fur-
nished single and double rooms and are designed to
provide a mature atmos-
phere for advanced study.

For families the University
has one and two bedroom apartments at Buckeye Village,
an apartment complex on the campus that is close to
shopping and other facilities. Each apartment is provided
with major kitchen appliances, air-conditioning, heat, wa-
ter, trash collection, storage space, and parking space, as is
free bus service to other campus locations. Two bedroom
apartments are available only to families with children.
There is a long waiting list, and students are urged to apply
as soon as possible. For information and applications for
residence hall rooms or Buckeye Village apartments write
to: Residence and Dining Halls, Office of Contracts and
Assignments, 640 Lincoln Tower, 1800 Cannon Drive,
Columbus, OH 43210-1230 or call (614) 292-8266.

Ample off-campus housing of all types is available near and
far from the campus. Columbus housing costs are very
reasonable compared to many major metropolitan areas,
especially those along the East and West coasts. For
additional information about off-campus housing, write or
visit the Office of Off Campus Student Services, 211 Ohio
Union, 1739 North High Street, Columbus, OH 43210-1392
or call (614) 292-0100.

How to Apply
To apply to the graduate program in electrical engineering
or if you have specific questions, please write:

Graduate Studies Chairperson
Department of Electrical Engineering
2015 Neil Avenue
Columbus, OH 43210-1272

Phone (614) 292-1752
Fax (614) 292-7596
The Future of WOSU, a History in Engineering

Posted: April 8, 2019

In 1900, when Morse code still ruled the airwaves, a rogue electrical engineering student holed himself up in a room at The Ohio State University to follow his research muse. His experimental work became the quiet beginnings of what we know as WOSU Public Media today.

That student, Robert Marriott, born in Richwood, Ohio, would go on to become one of the most celebrated wireless innovators in the United States. He was among the first to work in the field of radio communications.

Tom Rieland, general manager of WOSU, said it’s this shared history with Ohio State he wants to tap back into. In October 2018, he announced a $29 million plan to build a new WOSU headquarters at the corner of 14th and Pearl streets as part of the 15th + HIGH project – a proposed hub of activity on campus Ohio State dubs “University Square.” Ground breaking for the new facility starts in April.

With the expansion, Rieland said, comes a need for the next generation of Ohio State electrical engineers to help lead the way.

“We’re taking on a huge technical project over the next two years, moving into these new facilities,” Rieland said. “It’s going to be all hands on deck. We want and need to expand the electrical engineering talent around us.”

Rieland said WOSU is offering new summer internships and fellowships, showing students the pathway toward rewarding careers in broadcast
engineering. WOSU set-up a one million dollar endowment to support student educational opportunities within the stations.

"We are beginning to re-forgé the historic links WOSU has had to many Ohio State academic areas and this new relationship with electrical engineers takes us back to our roots as a broadcast station," he said.

WOSU was operated under Ohio State electrical engineering faculty until 1927. The post-World War I boom in radio broadcasting marked a new high in scientific achievement for the university, bringing this new thing called radio to life.

Hesham El Gamal, Chair Ohio State’s Electrical and Computer Engineering (ECE) Department, said he wants to help, not only by showing how ECE integrates into all forms of modern technology, but by guiding graduates toward different industries and opportunities they might not have thought of before.

"We would like to be a department that helps the city," Gamal said.

It’s become serious, Rieland said. Experienced broadcast engineers are retiring and they aren’t being replaced with new faces. He said the entire media and communications industry stands to take a hit if this trend isn’t reversed. They depend upon novel ideas and technological advancements.

"There is a growing demand for broadcast engineers," Michael Meadows said, WOSU Chief of Technology. "It’s all about the mentorship experience. I would have benefited from that when I was in school. That specific engineering knowledge is going away."

He said Ohio State engineers can find welcoming careers in radio frequencies, signal propagation, antenna design, digital equipment, transmitters and consultation at radio and television stations across the country.

International students are especially being courted, Meadows said, as they often have more difficulty finding summer internships or careers that don’t require security clearance.

WOSU provides a variety of broadcast services to Central Ohio: the 89.7 NPR News FM station that started in 1949; the only classical music station in Columbus, and the community PBS station. The
WOSU facilities are currently in the basement of the Fawcett Center located on Olentangy River Road.

Not only will the new location at 14th and Pearl offer WOSU room to grow, Rieland said, it provides a better platform for engaging and collaborating with the Ohio State community and Columbus.

Ohio State engineering students interested in joining WOSU internship and fellowship opportunities can apply via the Student Job Board and Engineering Career Services.

*Story by Ryan Horns, ECE/IMR Communications Specialist (Horns.1@osu.edu)*

Tags: Administration, Alumni, Awards, In the News, Faculty, Research, Students, Graduating Students, Jobs & Internships, Announcements

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OSU students a part of Arctic ice expedition

By Josephine Birdsell For The Columbus Dispatch

Oguz Demir and Brandi Downs have stood in Barrow, Alaska, at the northernmost tip of the United States.

The graduate students at Ohio State University’s Department of Electrical and Computer Engineering, worked alongside scientists from across the globe and learned how to properly sample snow and ice. It’s precise work that sometimes takes many tries. They learned to drive snowmobiles. They learned to shoot rifles to ward off polar bears.

But it was the smallest lessons that were the most important: Stand with your back facing the wind; it’s not quite as cold that way. Layers upon layers of thick, fuzzy socks and the nicest of North Face boots won’t match up to Alaska’s snow and ice; you’ll have to invest in thick, military-grade bunny boots instead.

It was a week worth of preparation for the months they’ll spend in the Arctic this winter.

Demir and Downs are two of some 600 researchers and scientists from 19 different countries traveling to the Arctic as part of the Multidisciplinary Drifting Observatory for the Study of Arctic Climate, also known as MOSAiC. The first-ever, yearlong expedition into the central Arctic is billed as the largest polar expedition in history. The Ohio State students will travel aboard the German research icebreaker Polarstern, which set sail from Tromsø, Norway, last month.

Their research, along with their peers’, will serve to fill in gaps in the worlds’ knowledge about changes in Arctic ecosystems and their contribution to climate change across the globe. As of now, the Arctic isn’t
well represented in climate models because it’s not well understood, Downs said.

“There’s a lot of unknowns about the Arctic and the ice and why it’s melting so fast, or why Antarctica isn’t melting on the same level,” she said.

But scientists do know that changes to the Arctic, such as melting sea ice, are affecting ecosystems worldwide. That means more accurate models of Arctic ecosystems may lead to better weather forecasts, allowing people to better prepare for extreme weather like Hurricane Dorian, which devastated the Bahamas early September.

“So hopefully (our data) will be used in climate change models,” Downs said.

The expedition will consist of six legs, each two months long, in which scientists will live on the Polarstern. The Polarstern will lodge itself in Arctic ice, and drift with the ice toward the North Pole for a full year. Instruments will surround the Polarstern up to 30 miles out, but most instruments will lie within a half-mile of the ship.

Demir and Downs will work with the MOSAiC’s remote sensing sea ice team to study how sea ice changes throughout the year. Other teams will study the Arctic Ocean and atmosphere.

Once the scientists complete their research, their findings will be available to anyone. That will allow scientists to build a more comprehensive view of Arctic climate.

“The great thing about this project is that there are so many different researchers and so many different groups going (to the Arctic). And so our data is adjacent to everyone else’s data and can overlap,” Downs said. “So that we … can get this much bigger picture of what’s going on.”

Demir and Downs will use a wide-band radiometer to measure electromagnetic waves in sea ice, which helps determine the structure of the ice terrain, including its thickness, salinity and temperature, without boring holes in the ice. The goal is to better understand how sea ice changes through the seasons.

A research team at OSU’s electrical engineering department first developed the ultrawide band microwave radiometer three years ago. It was used to measure the temperature of glaciers in Greenland from an airplane.

But the Arctic environment may present unique challenges for the instrument, Demir said.

Most manufacturers don’t test their products under 40 degrees Fahrenheit, meaning devices on the instrument are subject to break or fail in the Arctic’s cold, which reaches temperatures as low as minus-58 degrees Fahrenheit in the winter.

“Everything can break in the Arctic,” Demir said.

Demir and Downs will each only be on the Polarstern for one two-month leg of the expedition. Demir left Columbus on Sept. 11 and will return in early January, including travel time. Downs will leave in late January and return in April.

If the radiometer technology proves successful, it may someday be developed for use as a wide-range satellite, Demir said.
"I feel like (the expedition) is going to be a huge ... in terms of data, in terms of what we can learn about climate change and ice. It's just a really big project," Downs said.

"It's the expedition of a lifetime," Demir said.

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