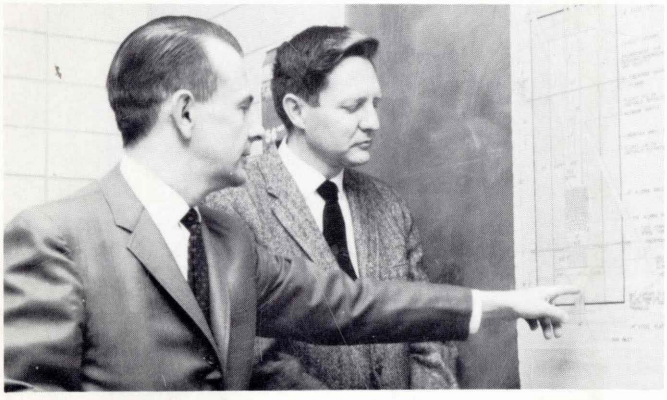
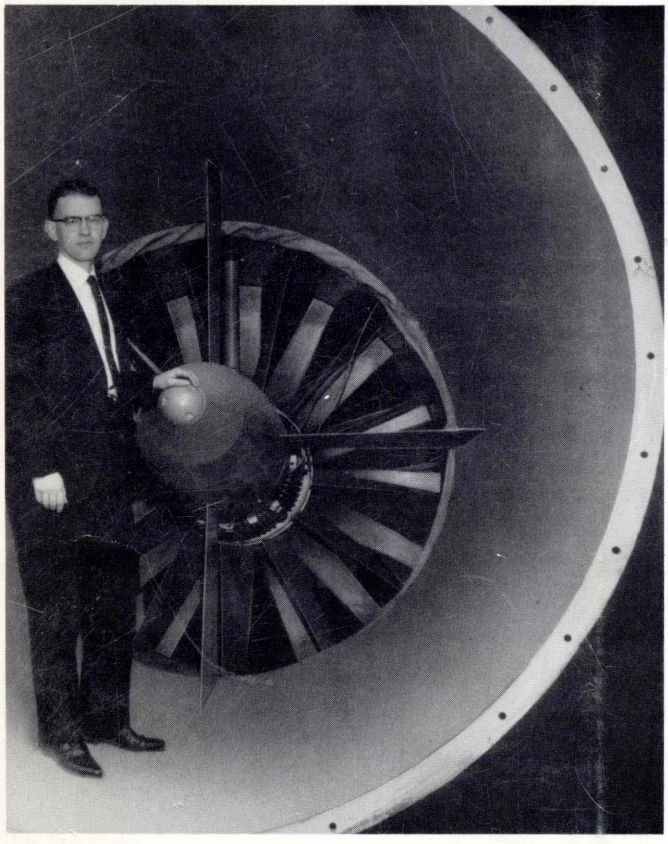
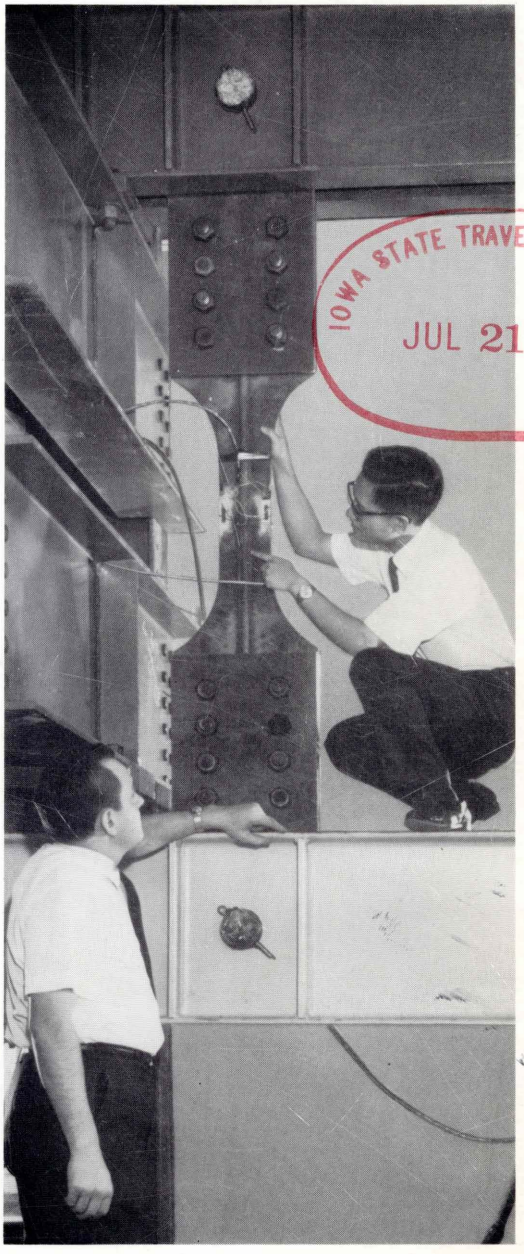
IOWA STATE ENGINEERING RESEARCH

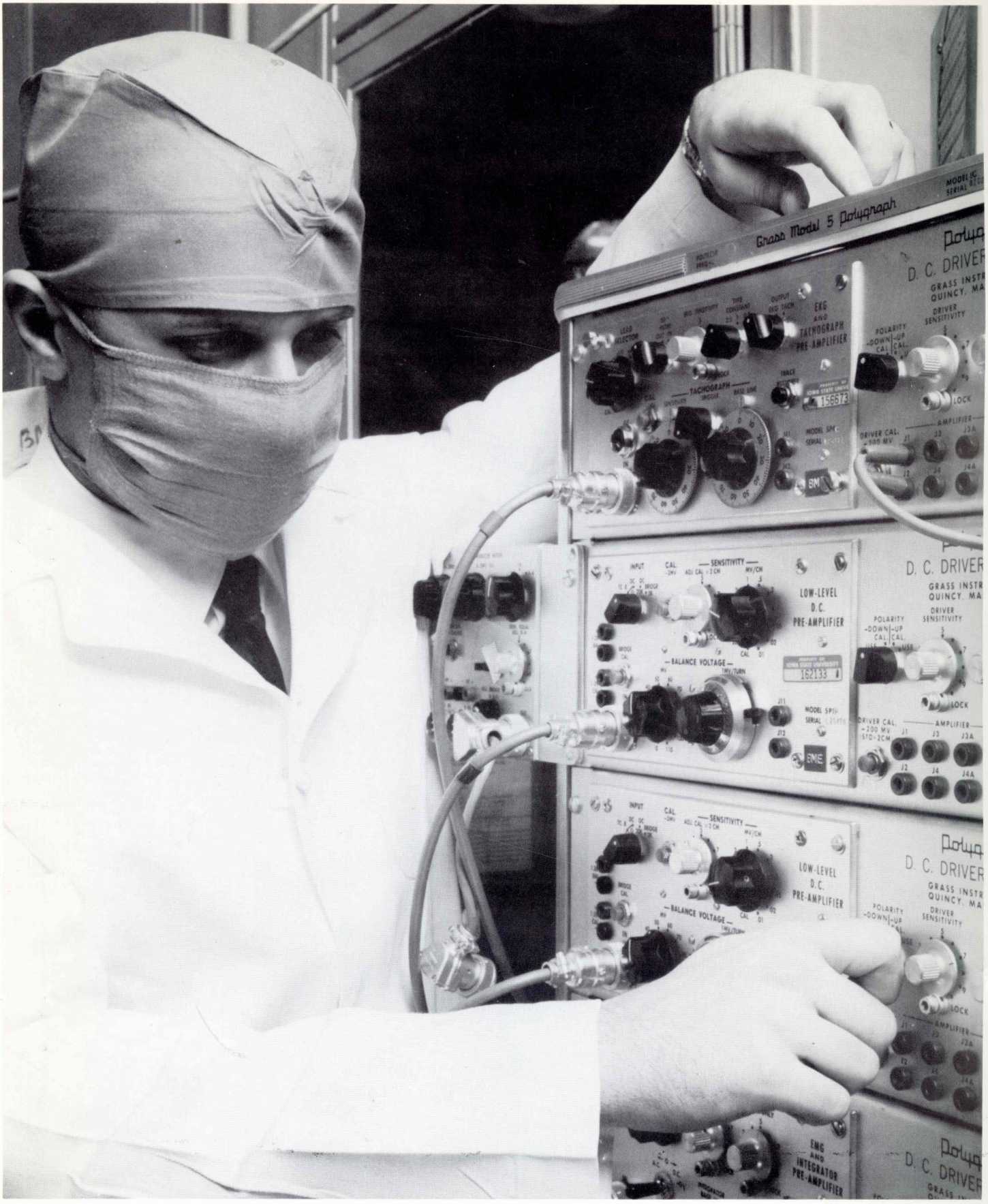






SPRING 1966

ENGINEERING RESEARCH INSTITUTE
IOWA STATE UNIVERSITY of Science and Technology AMES, IOWA



BIOMEDICAL ENGINEERING

The use of electronics in biomedical research will be the subject of an article appearing in the next issue of IOWA STATE ENGINEERING RESEARCH. Curren Swift, Graduate Assistant, is shown with some of the electronic monitoring equipment used in research to develop an artificial implantable heart.

about

this

issue

of

IOWA STATE ENGINEERING RESEARCH

This issue of

IOWA STATE ENGINEERING RESEARCH

is the first issue reporting on engineering research activities of the Engineering Research Institute at Iowa State University. The objectives of this new publications are to acquaint readers with the activities and capabilities of the Engineering Research Institute and to promote engineering research and education at Iowa State University.

IOWA STATE ENGINEERING RESEARCH

is published by the Engineering Publications Office, 104 Marston Hall, Iowa State University, Ames, Iowa 50010.

The objectives of IOWA STATE ENGINEERING RESEARCH are to acquaint readers with engineering research activities and capabilities of the Research Institute and to promote engineering research and education at Iowa State University.

IOWA STATE ENGINEERING RESEARCH is published by the Engineering Publications Office in cooperation with the University Information Service.

IOWA STATE ENGINEERING RESEARCH

VOL. 1 SPRING, 1966 NO. 1

IN THIS ISSUE

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ENGINEERING RESEARCH INSTITUTE

This issue of IOWA STATE ENGINEERING RESEARCH introduces a new medium for reporting the research related activities of the College of Engineering at Iowa State University. This first issue also coincides with the change in name of the *Engineering Experiment Station* to *Engineering Research Institute*, which is a more appropriate description of our activities. The new name emphasizes Research, particularly ENGINEERING RESEARCH, which suggests also the close relationship of the research activities to the academic programs of the College of Engineering.

Since 1904

The change in name does not reflect a change in the research program or philosophy, and the Institute will continue to be the research arm of the College of Engineering. The Director will report to the Dean of Engineering who maintains final responsibility for research as well as academic programs.

The Engineering Research Institute is one of the oldest engineering research organizations of its kind in the United States. It was established in 1904 as the Iowa Engineering Experiment Station by forward looking administrators who saw the need for intensive study on engineering problems. In scope, the early activities included:

1. engineering and scientific investigation;
2. dissemination of educational information on technical subjects;
3. tests and analysis of engineering materials.

All three types of work were pursued actively until 1913 when the State Legislature established the Engineering Extension Service to disseminate educational information. Later, as testing laboratories were established in the State, the work of the Station on tests and analyses of materials was curtailed, and the first activity, namely engineering and scientific investigations, has become the major pursuit of the Institute.

Service to the College

In carrying out these activities, the Institute encourages, promotes

David R. Boylan
Director

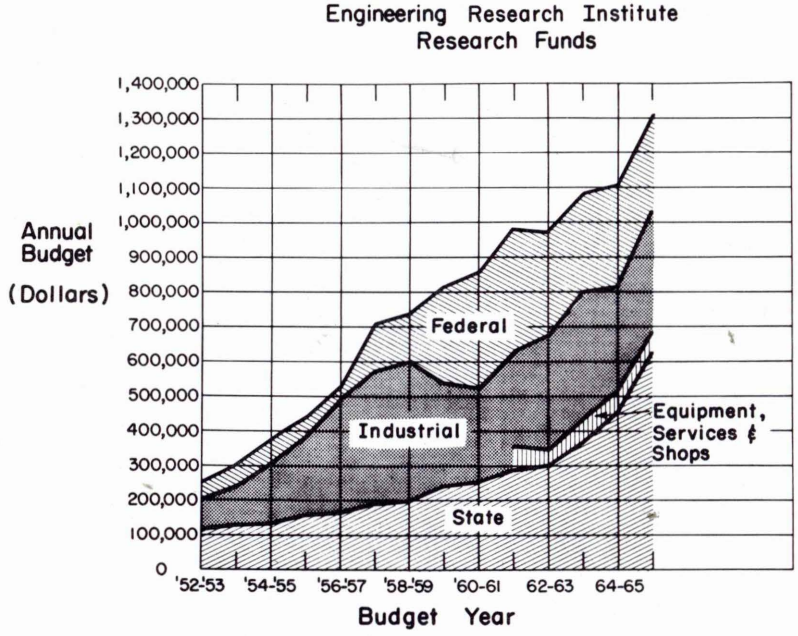
and supports research in each of the various disciplines of the College. In addition, the Institute provides services for the research programs, through the administration of contracts, grants and appropriations, and through the establishment of shops, laboratories and publication facilities.

An important philosophy of the Institute is that research efforts be directed toward the support of our academic programs. Therefore, in general, the research staff of the Institute are integrated with the academic program; the staff engaged in research are also engaged in teaching. Thus, the Institute research is an outgrowth of the specific interests, abilities and specializations of the academic personnel. Usually the research is of long-range nature and directed toward fundamental or basic problems in specific areas.

Present Program

The change in name also affords an opportunity to evaluate the present program. In any such evaluation, the contributions of the total program are far greater than those of an individual project. Among the significant continued objectives are:

1. The initiation and establishment of active research in all departments of the College of Engineering, including interdisciplinary research programs such as Biomedical Engineering, Water Resources and Soils Stabilization. Over one hundred active research projects are underway, some of which are abstracted in this issue of ENGINEERING RESEARCH.
2. Provision of valuable opportunities for staff development through research programs. Staff members are helped to keep up-to-date in their field, come in direct contact with real problems and programs, and obtain a fresh viewpoint to feed back into the classroom. The Institute is devoted to support of major staff interest. Some 60 staff members with the rank of Assistant Professor and above are actively conducting or supervising research.
3. Support for the graduate program in the various departments through research funds. All graduate students in the College of Engineering, except those pursuing the Master of Engineering degree, are required to undertake original research for a thesis. In general, these students are supervised by the research staff of the Institute, and the graduate students' projects are usually a part of the Institute's research program. During the past year, at least 100 graduate students have been employed by the Institute and approximately 81 M.S. and 37 Ph.D. theses have resulted.
4. Dissemination of information on new technologies, processes, devices and engineering principles resulting from the conduct of research conducted by the Institute. Our contribution in this area is evidenced by at least 80 technical papers published and many others presented to technical societies during the past year.
5. Greater service to industry and government agencies by the contract research program. We have had opportunity to work closely with many outside organizations, and the sponsors have been aided in solution of problems and development of specific information. In all, some 30 companies, 15 government agencies and 3 state agencies have sponsored recent Institute research.
6. Provision of the best possible support facilities for the conduct of research. These now include a Machine Shop, Electronic Shop, Precision Equipment Laboratory, Electron Microscope Laboratory, Analytical Laboratory, Bituminous Laboratory, Soils Laboratory, Structures Laboratory, Sanitary Laboratory, Shock Tube Facility, Low Turbulence Facility, Aero-Dynamic Smoke Tunnel Facility, and Engineering Publications Office.



The growth of the research program over the past decade is shown in this graph, which indicates the funds available for Institute activities by budget year. For the fiscal year 1966-67 the Institute research program will approximate one and one-half million dollars.

THE RESEARCH FOUNDATION

Protecting ISU's Inventors

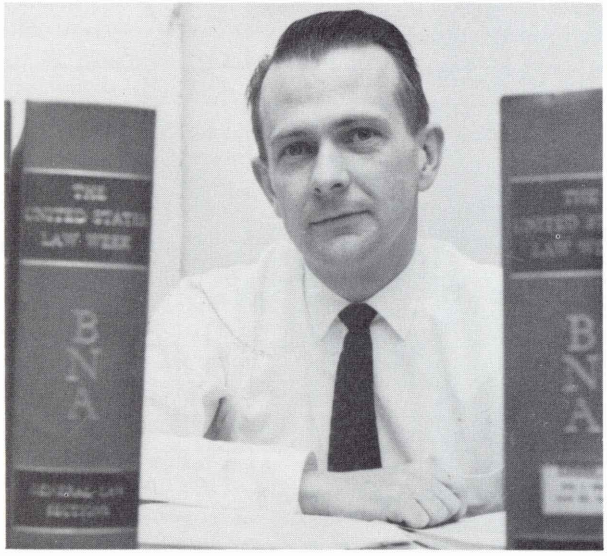
by Daniel L. Griffen, Jr.
Manager, Iowa State University
Research Foundation, Inc.

A suitable outlet for patentable discoveries is an essential factor in maintaining a strong university research program. Iowa State University has long recognized this need as a means to protect the discoveries of its staff.

Today, the research staff at I.S.U. is served by the Iowa State University Research Foundation, Inc., with a full-time, experienced staff ready to procure patents, copyrights or trademarks to protect the inventor (or author).

Patent protection for I.S.U. research had its beginning in 1924 when patent applications were filed by the University through state channels. This procedure continued until 1934 when the first formal statement of policy of the University was adopted. During the first ten years, 36 patents were assigned directly to the University, all of which, of course, have now expired. At that time, as is true today, the primary purpose was to provide control in the interest of the inventor, the University and the public.

In 1938, the Iowa State University Research Foundation, Inc. was established for the purposes of administering patents, which were an outgrowth of the research at I.S.U. This nonprofit corporation consists of eleven members: the President of the University, a member of the State Board of Regents, six members of the faculty, and three alumni members. The corporation is a separate legal entity and requires that the net income of the corporation be used for education and research at I.S.U.



DANIEL L. GRIFFEN, JR., holds his B.S. and M.S. degrees from Iowa State University. In 1953 he received his degree in law from Drake University.

At the start, the Foundation was financed by a small loan from the Alumni Association and had a part-time patent manager to administer the affairs of the College-owned patents, not then expired. The first goal of the Foundation was to become self-supporting as quickly as possible, as well as to serve as a functional organization for handling patents, copyrights, and trademarks. The organization became self-supporting in about 1943, mainly due to the proceeds of licenses of a blue cheese and a whirlwind terracing machine. Since that time, the Research Foundation has maintained itself as a self-supporting corporation for service to the University. Over the years, the Research Foundation has, by virtue of its royalties income, been able to grant to the University over $1,000,000. In addition, the Research Foundation has retained, to perpetuate the organization, approximately $750,000.

125 Patents

The Research Foundation has, in this period of time, held a total of about 125 patents. Currently it holds 65 patents, has on file 41 applications, and is working on 37 different disclosures.

The Research Foundation was incorporated in 1938 under the nonprofit section of the Iowa Code, and has set as its purpose the procurement of patents, copyrights, or trademarks to protect the inventor (or author), the University, and the public from inappropriate exploitation by others and to encourage the development of inventions or discoveries for the benefit of the public.

It has long been recognized that the University function is one of basic or applied research. It is not the University's purpose to develop ideas or inventions for commercial purposes. It is also not the intention of the University or the Research Foundation to engage in developmental work when others have the facilities and know-how to develop and market the results of inventions. It should also be added that the Research Foundation does not patent just for the purpose of development, but will also patent for the purpose

of recognition of the ingenuity and creativity of the inventor.

It has been the policy of the Research Foundation to license in a manner which reasonably provides assurance that the patent will be developed in the interest of the public. On certain occasions this has required that the patents be dedicated to the public. On other occasions it has required a nonexclusive licensing policy, and on occasion has required an exclusive licensing policy because the developmental work and Federal clearance have required a reasonable period for the developer in which to recover the cost of the above. The Research Foundation has adopted the policy of informing interested parties as to the developments of a patentable nature but has not engaged in an active promotion program. It is our hope in licensing to provide encouragement to the developer and to participate in the success of the invention in a reasonable manner, again, to protect the inventor's interests, the University, and the public.

Assigning Patents

The Research Foundation usually does not enter into an assignment of its inventions or licenses which are effectively an assignment. It believes, in the best interest of the licensee and licensor, that periodic review and negotiation of licensing arrangements is desirable.

The announced policy of the State of Iowa is that patents, copyrights, and trademarks may only be procured by the University with the consent of the inventor and at the discretion of the Board of Regents. This policy statement, as of necessity, guided the Research Foundation and provided the impetus for the establishment of it. The Research Foundation, in addition, has provided a reasonable service to the faculty to encourage the individual faculty members to assign patentable inventions. The Research Foundation assumes all costs of patenting. The inventor is not required to invest any of his own funds to procure patent protection, although he is called upon to aid in the prosecution of the patent. The Research Foundation employs counsel from various private law firms in Iowa and other states on the basis of their competency to draw and prosecute specific patent applications. It is intended that with competent counsel and the services of the Research Foundation the time and energy required by the inventor in the preparation and prosecution shall be held at a minimum since the Research Foundation recognizes that his energies should primarily be directed toward research and education. In addition, the Research Foundation will, after filing the application, attempt to find an appropriate industrial firm or firms to develop the invention. Iowa firms are given an opportunity to participate in development based upon their ability and know-how, necessary for the proper implementation of the inventions.

The Research Foundation operates in the following manner: When an invention is brought to the attention of the Research Foundation, the Research Foundation will review the disclosure and if it feels it is appropriate will initiate a search. When the search has been completed and evaluated, the decision is then made whether to proceed with the application. At this time, the inventor is asked to assign the invention to the Research Foundation in consideration for the contractual guarantee of 15% of the net royalties. Upon execution of such an agreement, the appropriate counsel is asked to prepare the application. Upon successful completion of the drawing of the application, it is filed and first action is awaited. In this waiting period, the Research Foundation generally commences its information program to prospective licensees. Assuming a licensee is found, the inventor, the Research Foundation, and the licensee cooperate fully in the prosecution of the patent application to its usually successful completion. The Research Foundation has been fortunate in the past in that it has had very few rejections of patent applications.

In the development of the invention, the University and the inventor must cooperate with the licensee in every way possible. The Research Foundation is not in the position of making a contract for the transfer of know-how; however, the license is usually accompanied by a complete disclosure of the information then available at I.S.U. The licensee also has the opportunity to make a consulting agreement with the inventor or inventors, under University policy. The University has allowed for consultation of its faculty members but has, as a rule of thumb, limited such activities to approximately one day out of five.

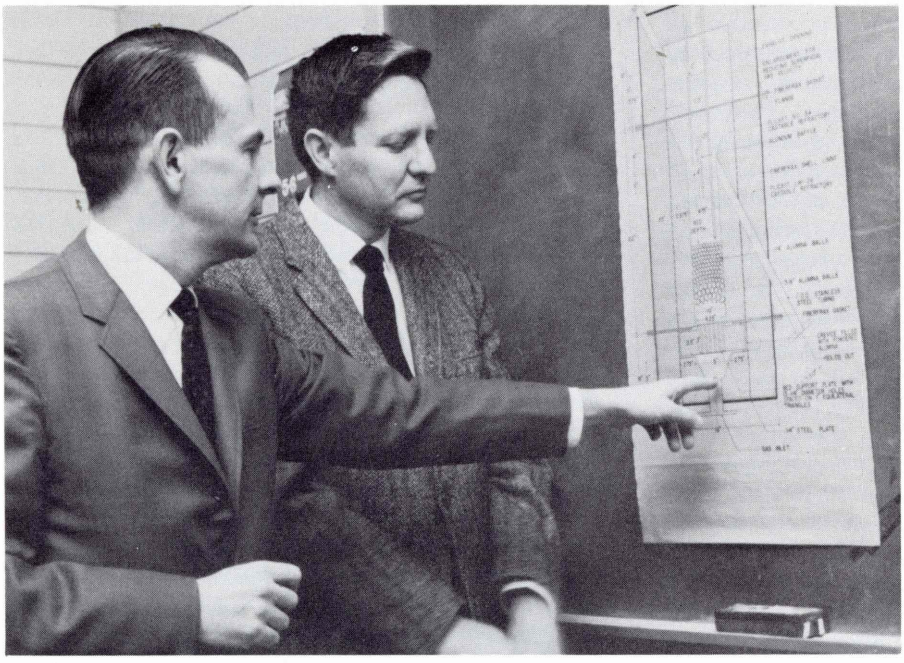
The Research Foundation has been successful in its relationships with the Federal Government and usually is in the position of prosecuting the patent applications where Federal Government interests appear.

43 Patents for Engineers

In the Engineering College, there have been 43 patents granted and 27 patent applications applied for over the past years. For a complete list of these, please see the list following this article. In addition, the Foundation is working on several disclosures from the Engineering College. It has been successful in licensing several of the patents and patent applications for development by licensees. For example, it presently holds license agreements on the Csanyi foamed asphalt method and apparatus, the Arp and Carlson life systems devices, and the Chu-Davidson soil dispersion apparatus.

Any earnings which follow from the licensing of patents is returned to the University for research and education. Funds have been primarily granted in areas where so-called "seed money" is needed for the development of new research and educational opportunities. The Research Foundation has supported such activities as the analog computer facilities, the com-

puter facilities, the smoke tunnel, graduate fellowships, research leaves for faculty members, artificial seawater systems, instron testing equipment, small research projects, fatigue testing apparatus, engineering measurements laboratory, the biomedical engineering program, simulation facilities, to name a few.



DISCUSSIONS with Engineering Research Institute staff members concerning patent requirements is an important part of Professor Griffen's responsibilities. Here he confers with Dr. T. D. Wheelock, professor of Chemical Engineering.

In conclusion, the Research Foundation provides a service to the University and its faculty. It provides patent counsel and patent protection for University developments and attempts to develop, for the use of the public, outgrowths of research at I.S.U. Through grants to the University, it endeavors to encourage research and education at the University.

ENGINEERING COLLEGE PATENTS

Inventor	Title	Patent Number Issue Date
ARNOLD, LIONEL K.	Drying Equipment	2,554,769 5-29-51
ARP, LEON J. and GREEN, JOHN M.	Variable Differential Gear Drive Automatic Control Apparatus for Machines	3,202,893 8-24-65
ARP, LEON J. and GREEN, JOHN M.	Automatic Taped Program Control Apparatus for a Machine Tool	3,202,895 8-24-65
BERESFORD, HOBART	Feed Bunk	3,015,308 1-2-62
BERESFORD, HOBART and CALDERWOOD, DAVID L.	Control Mechanism	2,913,188 11-17-59
BOAST, WARREN B. and ISKE, JAMES E.	Phase-Shifting Transformer	2,737,626 3-6-56
BOAST, WARREN B. and RYDER, JOHN D.	Generator	2,588,797 3-11-52
BOAST, WARREN B. and RYDER, JOHN D.	Wattmeter-Varimeter	2,661,457 12-1-53
BOLIE, VICTOR W.	Device for Teaching Morse Code	2,967,619 3-28-61
BOLIE, VICTOR W.	Blood Pressure Detector	3,149,628 9-22-64
BOLIE, VICTOR W.	Dual-Chamber Artificial Heart	3,182,335 5-11-65
BOYLAN, DAVID R. and ROUNSLEY, ROBERT R.	Quick-Curing Process for Producing Superphosphate	3,041,158 6-26-62
BRIDGER, GROVER L.	Method of Producing Dicalcium Phosphate Containing Fertilizers	3,011,888 12-5-61

(Continued on page 58)

Clearing House for Engineering Publications

The services of the newly reorganized Engineering Publications Office to the ISU Engineering staff and research sponsors are continually being expanded. Originally known as the Engineering Experiment Station Editorial Office, the publications office staff has extended its services to the academic, research, and other service departments within the College of Engineering.

Burton J. Gleason, Administrative Assistant to the Dean, heads the Engineering Publications Office. Tom C. Cooper is Editor and in charge of much of the Research Institute activity. John R. Lawrence, Miss Dawn Henry and David Hansen provide engineering graphics service. EPO secretaries are Miss Rose Herington and Mrs. Letha Osmundson.

EPO HEAD: Burton J. Gleason

The EPO office handles editing, typing, proofreading, drafting, art, layout, reproduction, and distribution services for written communications originating in the College of Engineering. The Engineering Publications Office provides liaison with other campus service groups when specific services are not provided by EPO. An example is liaison with the ISU Printing Service; all multilith, Ozalid, and Address-o-graph work is done by Printing Service for EPO.

More than 250 research proposals and reports on sponsored research (progress, annual, special, and final reports) were edited, reproduced and distributed by EPO last year. Twenty-four-hundred drawings were inked by the EPO drafting service during the past 12 months; and more than 8,500 pages of copy were edited, typed, and proofed.

A variety of public relations activities have been engaged in by EPO staff, including preparation of news information for release through the Iowa State University Information Service, and preparation of brochures, booklets, and displays. Spot announcements for television through WOI-TV and the Telecommunicative Arts Department have also been initiated.

EDITOR: Tom C. Cooper

Often an Engineering College staff member will desire to have copies of an article which he plans to submit to a technical journal available prior to the journal's publication date. Pre-prints of the journal article are then prepared by the EPO to satisfy requests received before the journal's publication date.

Slide making services are also made available to Engineering College staff members who are presenting oral papers at professional meetings. A new method used by EPO is the diazo-chrome process which provides Engineering staff with a variety of top quality colored slides for oral presentations.

The EPO publishes a series of bulletins and reports on research projects of special interest but which are too extensive to be published in the average technical journal.

A series of staff seminars is being prepared which will be made available to College of Engineering staff as well as others who are interested. These seminars will treat technical writing and editing, reproduction processes, and proposal preparation.

DRAFTSMAN: Jack Lawrence

Tearing Things Apart

While most engineers spend their time trying to put things together, there are several at the Engineering Research Institute who are trying to tear things apart.

These men are putting to use a recently installed device which tests the fatigue life of construction materials. According to Dr. Raymond Untrauer, professor in charge of the Structural Research Laboratory of the Research Institute, the new device is one of the first of its kind to be used by a university.

Study Welds

When the fatigue testing equipment was put into operation recently, Dr. Ti-Ta Lee, assistant professor of Civil Engineering, began investigating the effect on fatigue life of residual stress and discontinuities of shape caused by welding.

It is suspected that welding during bridge construction causes residual, or internal, stress due to the effect of temperature. Also, the rough surfaces and notches formed when two steel plates are welded together are suspected of being points of stress concentration.

Dr. Lee is conducting his research under a grant from the Iowa State Highway Commission, which is interested in learning more about this subject as it applies to bridge building.

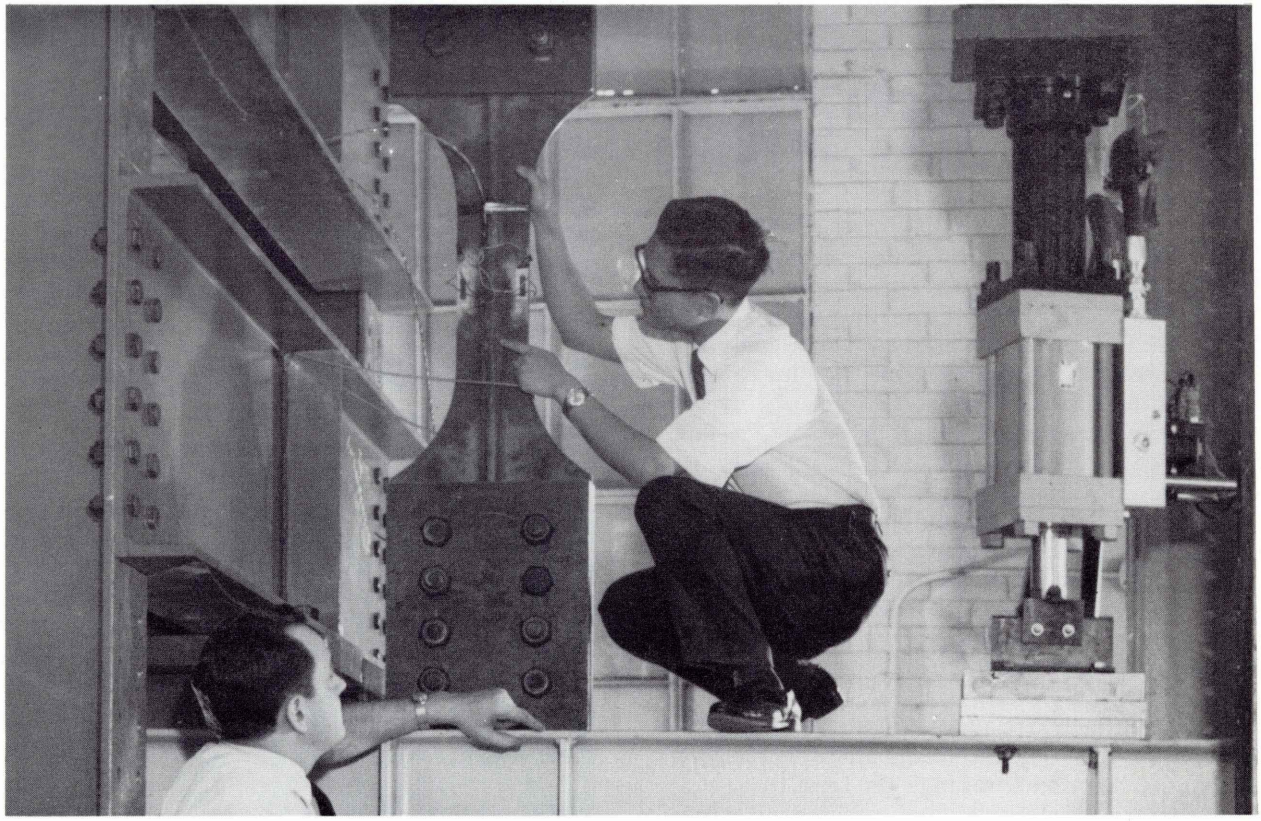
Fatigue life is determined by tests and used to estimate how long a structure, in this case a bridge, will hold up under certain amounts of stress. This information helps establish the maximum design stress of a bridge.

Fatigue itself can be seen when one takes a piece of wire and bends it back and forth until it breaks. The stress of bending causes the material to weaken and break. Similar stress, along with the other forms of stress—shearing, tension, torsion and compression, are constantly working on bridges.

The fatigue testing system at Iowa State looks at first sight like a giant "Erector Set," and that's essentially what its self-contained frame amounts to. Constructed of steel beams and columns and measuring 24 feet in length and 17 in height, the frame can be reassembled to accommodate test beam as long as 22 feet and as deep as 5 feet.

Electronically Controlled

The heart of the device is an electronic console



DR. TI-TA LEE discusses a weld under test with Dr. Raymond Untrauer, lower left. Dr. Lee is project director; Dr. Untrauer is director of the Structural Research Laboratory.

which controls everything else. The console maintains a constant two-way communication with the components of the fatigue tester in what Dr. Untrauer calls a "foolproof" closed-loop system.

The "loop" consists of the console, an oil pump and a hydraulic jack which does the actual work of applying stress to the material under test. Once the console is set for a certain test condition, it operates the testing system accordingly until either the desired testing is completed or some malfunctioning of the system develops. In either case, the console will automatically shut down the whole operation.

However, such a large and complicated testing system requires constant attention. Dr. W. W. Sanders Jr., associate professor of Civil Engineering, has been the supervisor of the testing system since its installation.

Dr. Sanders sees to it that every part in the system functions properly and that everyone who will be operating the machine receives adequate instruction.

In Dr. Lee's investigation the test material, a piece of steel with welds applied longitudinally, is fixed at one end near the top of the "Erector Set." The other end is connected to a moving beam at the bottom of the frame.

The hydraulic jack can be operated at any rate up to 1,000 cycles per second and actually stretches the test piece in an effort to weaken it to the breaking point.

The machine is left running day and night. An automatic counter on the console records the number of stress applications while an oscilloscope shows what is happening to the steel as it is subjected to tension.

Dr. Lee is applying 3.2 cycles of tension to the steel every second. The tension as the piece is stretched goes from near zero to 34,000 pounds per square inch on each cycle.

System is Versatile

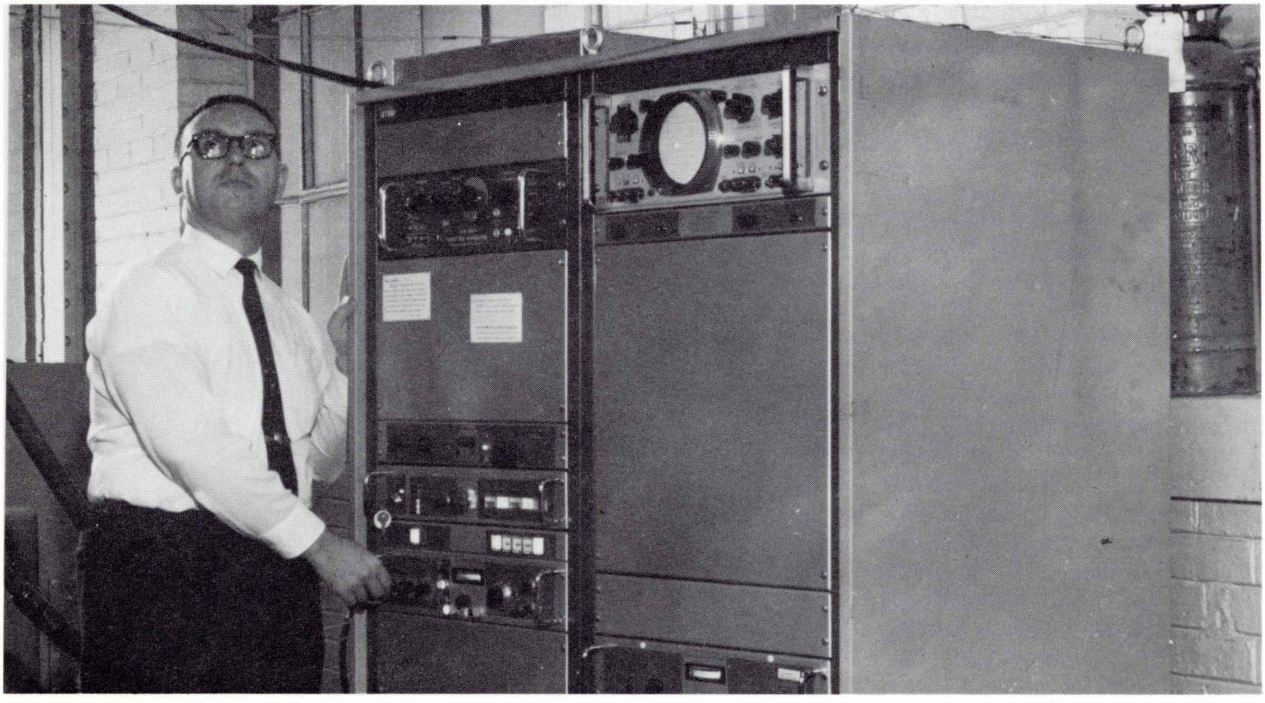
However, the test set-up is capable of producing as much as 150,000 pounds of tension and compression, and up to 100,000 pounds of bending force. Any type of material can be tested—even soils.

The main tests being conducted involve 41 specimens to be used for 28 fatigue tests, 6 residual stress measurement tests and 7 static tests. The specimens measure 60 x 14 x 1/2 inches. The test section itself is 5 x 1/2 inches. Half of the specimens have longitudinal center welds and half have longitudinal side welds.

The variables of the tests are weld area, residual stress distribution, maximum stress and stress range.

Dr. Lee will continue with tension tests until about June 30 and then initiate study on another factor influencing fatigue life of structures. He believes that his work will result in beneficial information about fatigue life and that the fatigue testing system will prove to be very valuable in the long run.

Dr. Untrauer agrees, saying that the fatigue testing field is a fast-moving one. So fast, in fact, that he thinks Iowa State's new equipment will require additional units in a couple of years in order to keep the system up to date.



DR. W. W. SANDERS operates the control console that maintains a constant two-way communication with the components of the fatigue testing system.

New Wind Tunnel Facility Readied

A new, three dimensional smoke tunnel believed to be the fastest subsonic smoke tunnel in existence, is now entering the operational stage in the Engineering Research Institute and the Department of Aerospace Engineering.

The open circuit tunnel was constructed with a $15,000 grant from the ISU Research Foundation. It is located in the northeast corner of Exhibit Hall.

According to assistant professor William D. James, the tunnel will have an air speed range of from 10-15 ft/sec up to 310 ft/sec (over 210 mph) in a test section measuring 30 x 36 in. With a smaller test section, even higher speeds can be expected.

Helicopters First

James and others specializing in aerodynamics research have high hopes for the tunnel. For example, the group expects to research helicopter aerodynamics and already foresees several opportunities. One area of study involves the high noise level caused by the downwash of air over the copter fuselage and its interaction with the free stream air around the fuselage. Little is known about this interaction according to James, and particularly as to why a helicopter creates a characteristic "popping sound". This "pop, pop, pop" frustrates copter crews in places like Viet Nam where the enemy is alerted to approaching choppers from considerable distances. Thus, the ISU staff hopes to obtain visual information on this air flow upon which to base mathematical theories needed for redesign of helicopters.

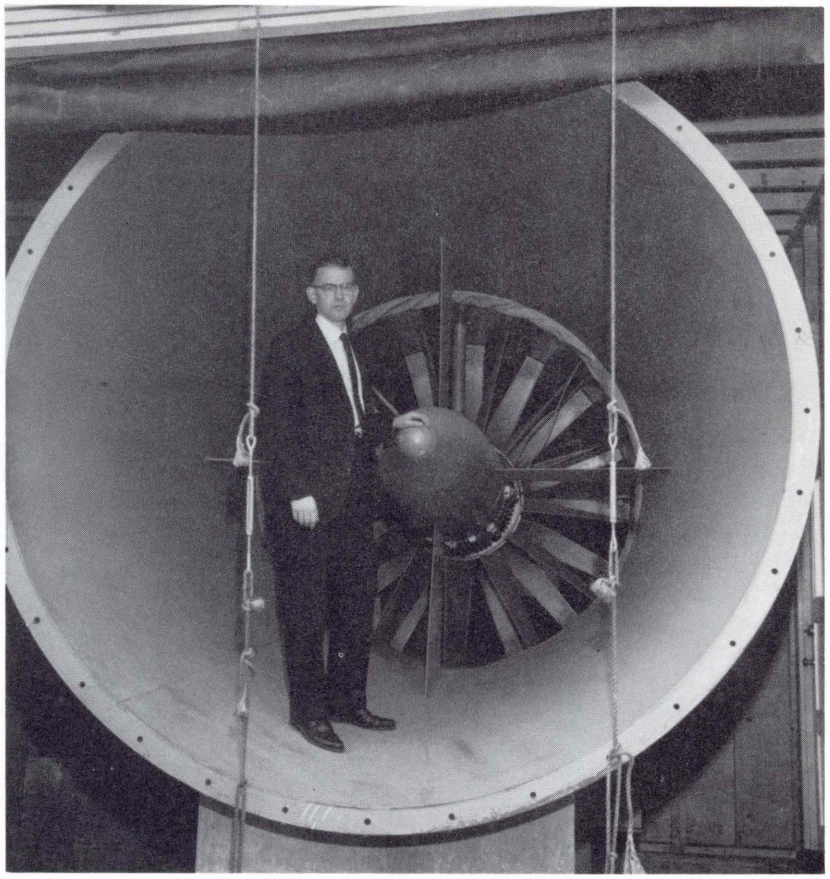
James summarizes the expectations of using the new tunnel facility by explaining that "slow" speed air dynamics research has been over-shadowed in the rush to study supersonic and hypersonic aerodynamics and the massive problems of space research. "The aircraft industry now realizes it doesn't know everything about slow speed aerodynamics and it's in this area where we can make some real contributions to aerodynamics theory," James explains.

Many Uses

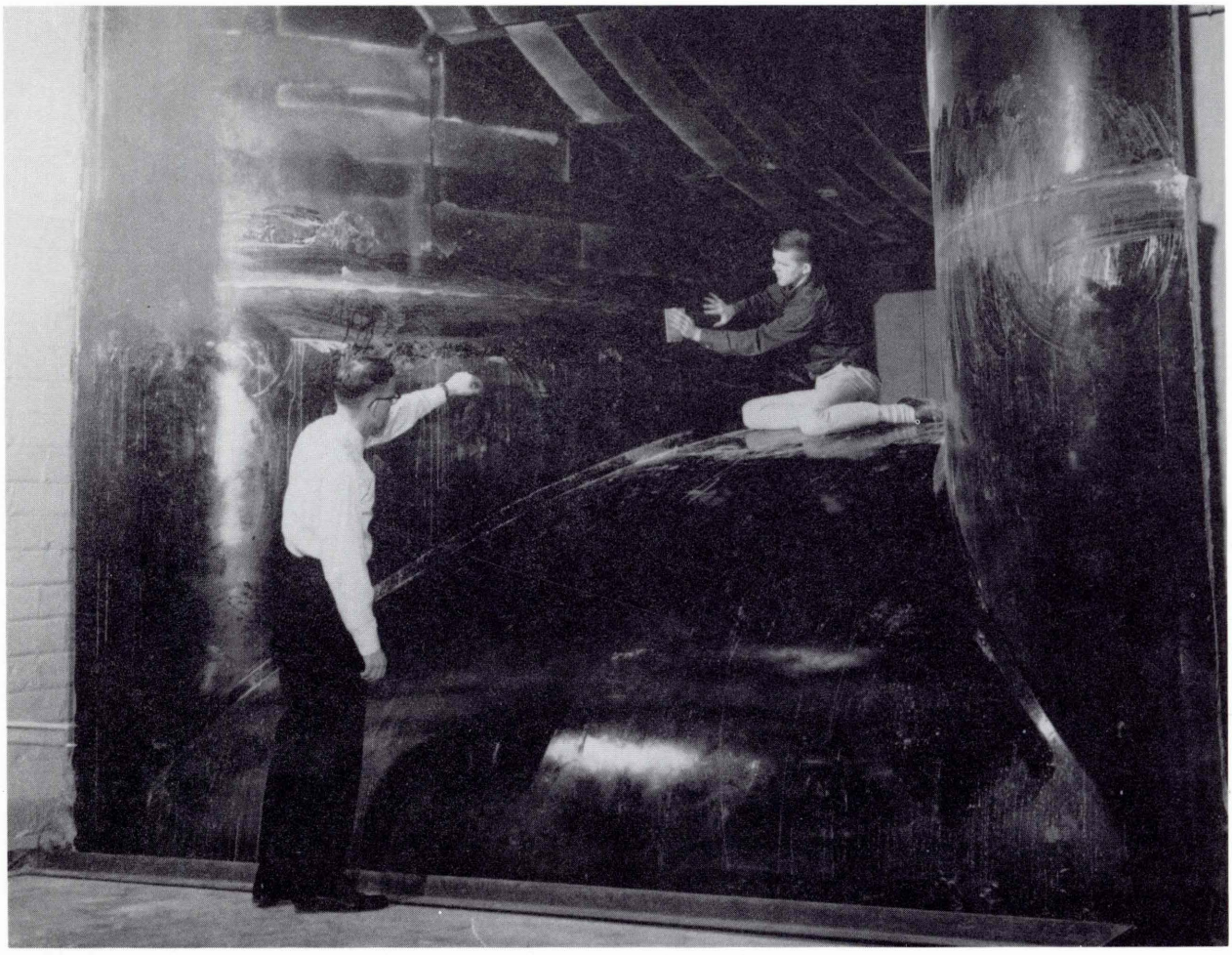
Other areas of probable research involve air cushion vehicles, and air flow through ducted fans. James also foresees the possibility of using the facility to study air flow on architectural models, and possibly extensively in teaching, for such subjects as introductory aerodynamics, and for courses in viscous flow. Using a smaller test section, courses in compressibility can also be taught.

Further, the tunnel will be used even to study boundary layer air flow over crops and terrain.

The tunnel section itself starts with an inlet section measuring 13 by 13 feet which contracts to the test section area. The entrance to the inlet section will be covered by 14 anti-turbulence screens in an effort to obtain a low turbulence within the flow and to prevent extraneous matter from entering the airstream. Eight of these are 15 by 15 mesh nylon screens with the remaining six 22 by 28 mesh nylon screens.



POWER FOR THE OPEN CIRCUIT TUNNEL is supplied by a two-speed 100 horsepower AC motor and an axial flow fan seen behind Professor James.



WILLIAM D. JAMES DIRECTS THE FINISHING TOUCHES on the inlet section on the University's new subsonic smoke tunnel. Made of fiberglass, the 13 x 13 foot section funnels down to a three dimensional convergence section measuring 30 x 36 inches. The entrance to this section will be covered by nylon mesh screens to lessen air turbulence and to prevent extraneous matter from entering the air stream. Smoke will be introduced into the air stream at this point by dripping parafin base oil on a hot calrod unit.

The funnel section is made of fiberglass sprayed on a form.

Smoke is introduced into the airstream by dripping parafin base oil on a hot calrod unit. The smoke is forced out of the smoke chamber and into the airstream.

The power supply for the unit is a two-speed 100 horsepower AC electric motor. The pitch of blades of the axial flow fan can be varied. This variable pitch facility coupled with the two speeds of the motor will give researchers a range of air speeds.

Complete Visability

The test section has glass on all four sides to allow complete visibility of models which are placed on a sting type mount. The models will be illuminated on all sides to permit the taking of both still and motion pictures of the existing flow patterns. In addition, the sting type mount will be instrumented with strain gages to permit the measuring of the lift, drag, and ride forces and the rolling, pitching and yawing moments. This ability to be able to measure the forces while visually observing the flow patterns causing them will be the outstanding feature of the tunnel.

The overall facility is patterned after smoke tunnels in use at Notre Dame, but the ISU facility will be larger and will produce higher air speeds. Its addition to the already existing wind tunnels at Iowa State and the recently acquired smoke tunnel donated by Collins Radio bring to 7 the number of wind tunnels operated by the Department of Aerospace Engineering. In addition to the new research facility these are two small, slow speed tunnels used in undergraduate laboratories, one low speed tunnel having a maximum speed of 180 ft/sec in a 2 by 3 1/2 ft test section, one small supersonic wind tunnel used to demonstrate shock and expansion patterns at Mach Numbers up to 3.59, one two-dimensional smoke tunnel and another three-dimensional smoke tunnel, both having maximum velocities of 25 ft/sec and both built by Collins Radio.

Simple Device Developed for Soil Load-Bearing Tests

Iowa State University engineers have developed a simple field device for determining the load-bearing capacity of soil.

Born of a long-time need in foundation design for large structures, the device is also expected to prove a boon to home-builders.

The load-bearing capacity of soil is expressed in terms of its shearing strength, which derives from soil cohesion and internal friction.

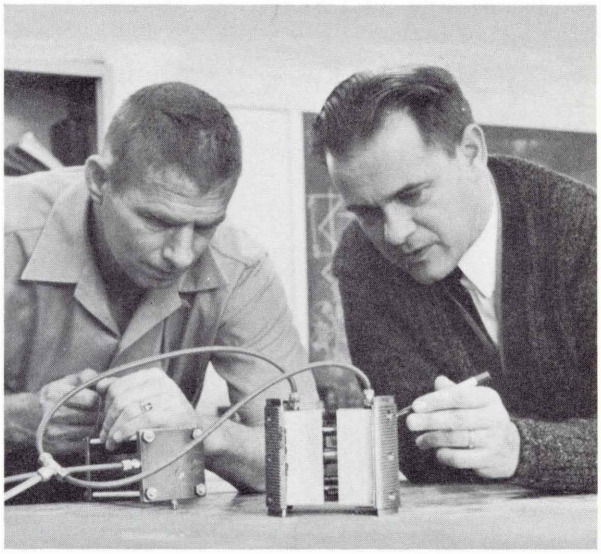
With present procedures, the necessary separation of cohesion and friction values involves power drilling and a series of elaborate laboratory tests.

This "handy" device was conceived by Dr. R. L. Handy professor-in-charge of the Soil Research Laboratory, and built in the Research Institute machine shop by C. N. "Spike" Spicer, and tested and modified by Nat Fox, an army captain working toward a masters degree in soil engineering. Fox is now preparing a master's thesis on the soil-strength test device, which will be patented through the ISU Research Foundation.

The working members of the experimental model are two curves, laterally-corrigated steel "shoes" actuated by two hydraulic cylinders—in the prototype these were automobile brake cylinders. The device is lowered to any desired depth in a test hole obtained by machine boring or hand augering. The device is then expanded to contact the soil, and it is pulled. Since both the expansion force and the pulling force are measured separately, soil cohesion and angle of internal friction may be evaluated. These two soil shear strength parameters are basic in virtually all soil mechanics calculations for shear failure, whether for foundations, landslides, retaining walls, etc. Present methods for evaluating them require extensive laboratory tests. Accuracy with the new device has been excellent.

Tests are generally made on the weakest soil stratum encountered in the drilling of the test hole. An advantage over present tube sampling, vane shear or blow count testing methods is that the soil layers are identified prior to testing. Present methods, since they are run "blind" in the bottom of the hole, may miss important layers.

Recent preparations for construction of the Iowa State Center gave Fox a convenient site for comparative tests of the new device. Four soils were tested in four hours, and results were identical and more comprehensive than data previously collected on the Center site with conventional methods. Handy estimates that triaxial or direct shear laboratory testing for the same data would have taken four days.



DR. R. L. HANDY, right, and Carmi Spicer work with the newly developed device to test the load-bearing capacity of a soil. Dr. Handy conceived the idea of the device and Mr. Spicer superivsed its construction.

Fox also used the device on a Des Moines site where, in an earlier project, Dr. Handy used chemical treatments to stop a landslide which threatened destruction of several houses. The slide occurred because the houses were built on an unstable landfill. The tests showed the factor of safety is now about 1.8, and sliding has stopped.

Citing the Des Moines situation as an extreme example, Dr. Handy points out that foundation design for small buildings is now "largely guesswork." With present methods it isn't feasible to make thorough site studies for small buildings. So foundations are built to standard specifications. If they're inadequate for soil conditions on a particular site, failures occur. In other cases, foundations are over-designed, which means unnecessary expense.

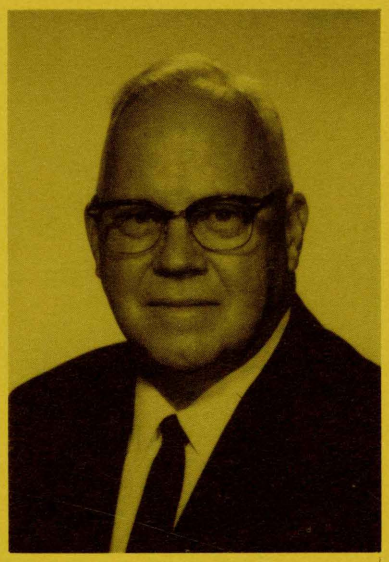
"We believe this new device will not only streamline procedures in foundation design for larger structures, but will make thorough site study feasible for the average home-builder."

research highlights
research highlights
research highlights
research highlights

Presented on the following pages are abstracts of research projects supported or administered by the Engineering Research Institute. The list does not include research projects conducted by individual departments.

research highlights
research highlights
research highlights
research highlights

aerospace engineering



Dr. Ernest W. Anderson
Department Head and
Distinguished Professor

RESEARCH SMOKE TUNNEL FACILITY, Project 535-S

SPONSOR: ISU Research Foundation

PRINCIPAL INVESTIGATOR: William D. James

The object of this project is to design and construct a low speed wind tunnel which will permit the simultaneous study of both the forces acting upon a body, and the flow field that exerts these forces upon the body. The forces will be obtained using a sting mount that has been instrumented with strain gages for the models, while flow field visualization will be accomplished by the introduction of smoke streams into the flow ahead of the models.

Calibration tests on the tunnel are underway. The staff anticipates starting research work on May 1. Helicopter research is the first planned project.

MODIFICATION OF OPTIC SYSTEM, Project 566-S

SPONSOR: ISU President's Permanent Objectives Committee

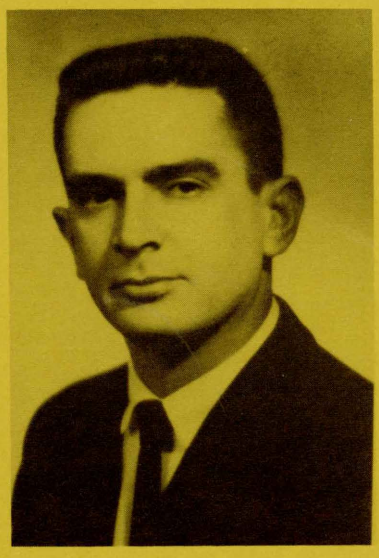
PRINCIPAL INVESTIGATOR: William D. James

The object of this project was to improve the usefulness of the Aerospace Engineering Department's Nozzle Thrust Stand by modifying and improving the optic system of the facility. This was done in the following ways:

The pedestals upon which the light source and mirror of the optic system are mounted have been redesigned so both the light source and mirror may be raised or lowered. This now permits a visual study of flow through both two-dimensional nozzles and their much shorter three-dimensional counterparts.

A camera mount that is attached directly to the structural frame of the nozzle test stand has been designed. This mount can be moved in both the horizontal and vertical directions, permitting photography of both two- and three-dimensional nozzles.

architecture



Mr. Raymond D. Reed
Department Head
and Professor

ARCHITECTURE RESEARCH, Project 373
SPONSOR: Engineering Experiment Station
PRINCIPAL INVESTIGATOR: Arthur E. Burton

The amount of moisture build-up within a small contemporary residence is being measured and its nature studied. The flat roof structure being studied is a modular house built on a slab on grade. Walls are sheathed with plywood, part of which is plastic-coated and exposed to weather. The roof is of a fibrous decking material which serves as finished ceiling, structural deck, and insulation.

No trouble has been encountered. The owner has carefully ventilated the house, and if this care continues, it is expected that no moisture problem will occur.

ESTIMATING PROCEDURES IN THE MILITARY CONSTRUCTION PROGRAM, Project 582-S
SPONSOR: Institute for Applied Technology, for Department of Defense
PRINCIPAL INVESTIGATOR: Thomas C. Jellinger

The objective is to evaluate present cost estimating procedures in the military construction program. It is expected that results will lead to facilitating systems innovations into military construction projects.

The project study has been completed and a final report presented to the Department of Defense. While the complete DOD study is classified information, a summary brochure was prepared by the Bureau of Standards and made available to various governmental agencies to encourage the use of the new concepts of construction planning and design.

biomedical engineering

Dr. Neal R. Cholvin, D.V.M.
Head of the Program
and Professor

INFANT RESPIRATOR, Project 510-S

SPONSOR: ISU Research Foundation

PRINCIPAL INVESTIGATOR: Dr. William McCormack, M.D.

MAJOR STAFF: Dr. David Carlson, Leon Arp, J. Ben Buck and James Varnum

More than 25,000 newborn infants die annually from the respiratory distress syndrome, an acute disease occurring at birth which affects breathing efficiency. The sick infant often dies of respiratory exhaustion in trying to overcome his temporary disability. If the infant's respiration can be mechanically assisted for a few days, he is likely to survive if there are no other complications.

During the past four years this staff, associated with the Biomedical Engineering Program, has developed what appears to be the first successful respiratory assistor for newborn infants. Ancillary equipment which makes possible clinical application of respiratory assistance for newborns has also been developed. The equipment is undergoing continued clinical trial in Ames and New York City. Manufacturing rights for the equipment have been licensed by the University.

The devices, which include three respirators, a single breath spirometer for measuring exhaled breath volume, a unique infant nasal mask, and environmental control equipment, have been tested by use in the treatment of a number of distressed infants. The units have been found useful not only for the treatment of respiratory distress, but also for post-operative support and resuscitation of asphyxiated newborn infants.

Work is being continued along these lines toward the development of more sophisticated devices for the care of sick infants.

INFANT RESPIRATOR, Project 539-S

SPONSOR: State University of Iowa, Anesthesiology Department

PRINCIPAL INVESTIGATOR: Dr. D. L. Carlson

The objective is to develop a volume-limited IPPP respirator primarily for infants of 6 months to 4 years of age. This respirator is a scaled up version of the

infant respirator developed by an ISU Biomedical Engineering group.

Clinical evaluation of the respirator will be carried out by Anesthesiology Department at the University of Iowa.

Device was delivered October 7, 1965, and clinical evaluation began shortly thereafter.

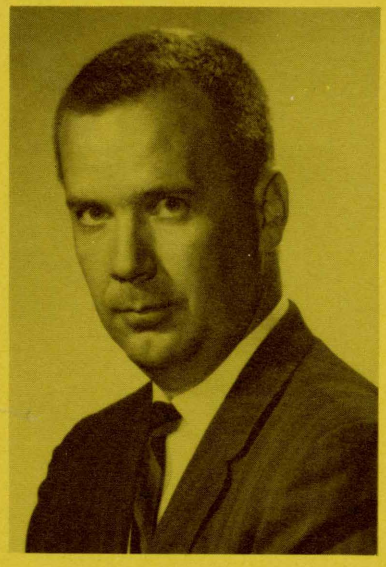
SIMILARITY CONCEPTS AND THE THEORY OF MODELS IN BIOMEDICAL FLUID MECHANICS, Project 606-S

SPONSORS: Engineering Experiment Station, ISU President's Permanent Objectives Committee

PRINCIPAL INVESTIGATORS: Dr. Donald F. Young and Dr. Neal R. Cholvin, D.V.M.

The objective of this project is to determine the feasibility of applying the concept of similitude to biological systems, with particular emphasis on problems related to the fluid mechanics of living systems. Current work is directed toward: (1) the development of similarity parameters, based on classical model theory that are applicable to the study of arterial blood flow, and (2) the establishment of the validity of these parameters experimentally.

ceramic engineering



Dr. David R. Wilder
Department Head and Professor

DEFORMATION PROPERTIES OF CERAMIC SYSTEMS, Project 345

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. Thomas D. McGee

This project has been concerned with making better alumina silica refractory materials through an understanding of their constitution at elevated temperatures. The research has included X-ray diffraction and electron microscopic investigation of the constitution of fireclay refractories at elevated temperatures, the measurement of the viscosity of synthetic glasses as a function of temperature, and the correlation of the hot load strength and hot pressing properties with constitution and viscosity data. The research in hot pressing covered a range from 1200° C to 1600° C and ranged in composition from

20 to 60% aluminum oxide. (Current research includes the study of the kinetics and morphology of mullite formation and the effect of impurities on the phase equilibria of the alumina-silica system.)
Three papers accepted for *Journal of American Ceramics Society* cover the results of the research up to 1961 that resulted in a practical process for the manufacture of high density fireclay refractories. There has been some commercial interest the past year. More should develop when the papers are published. The staff is currently looking at deformation under load, kinetics of mullitization, etc.

Also included in this project is a program to develop high-capacity, high-voltage condensors through a study of the solid state principles of barrier layer dielectrics. This includes a study of doped single crystals of $BaTiO_3$. Important variables are stoichiometry, reduction, oxidation and electrodes. It includes making practical polycrystalline ceramic condensors and measuring dielectric loss and capacitance as a function of biasing voltage.

Single crystals have been grown, and electronic test sets have been calibrated. The staff is now working on doping.

UNDERGRADUATE SCIENCE EDUCATION PROGRAM, Projects 506-S and 579-S

SPONSOR: National Science Foundation

PRINCIPAL INVESTIGATOR: Dr. Thomas D. McGee

This is a part of a continuing program to interest outstanding undergraduate students in graduate education. A wide variety of projects have been pursued. These have all been in conjunction with existing graduate-level research. Each student has studied an independent problem closely related to one of the current graduate research problems.

Present subjects are: Ronald Finch—Precipitation of Crystallites in NaCl grain boundary melt zones. Charles Foy—Analysis of the Deformation of Hot Pressed Fireclay Specimens at 1300°C.

Some previous project titles were: Particle Size of Mullite by X-Ray Line Broadening. Stabilization of Lime with a Protective Glass Coating. X-Ray Fluorescent Analysis of Impurities in Mullite Epitoxial Growth of LiF on MgO.

CERAMICS FOR STRUCTURAL USE, Project 596-S

SPONSOR: U. S. Army Research Office (Durham)

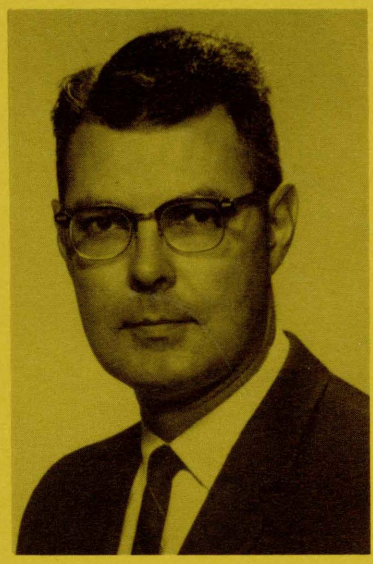
PRINCIPAL INVESTIGATOR: Dr. Thomas D. McGee

ASSISTANTS: David M. Martin, Gerald K. Fehr

The mechanical properties of ceramic materials are affected by their crystalline and glassy makeup and by their structure. Refractory oxides of special interest are often the cubic ionic solids. These are very high-melting compounds, e. g., magnesium oxide has a melting point of 2800° C. High purity single crystals of these compounds are ductile. Polycrystalline ceramic refractories are not. This research is using electron microscopy, internal friction, and optical birefringence methods to measure the effect of crystal defects on the ductility of cubic ionic compounds. Sodium chloride is being used as a model crystal to study the interactions of dislocations with grain boundaries because this is experimentally more convenient.

Several technical papers have resulted. The staff has a better understanding of the effect of grain boundaries on the ductility of ceramic materials. Research is still in process.

chemical engineering



Dr. George Burnet, Jr.
Department Head
and Professor

EXTRACTION OF SOYBEAN OIL, Project 203
SPONSOR: Engineering Experiment Station
PRINCIPAL INVESTIGATOR: Dr. L. K. Arnold
MAJOR STAFF: Ronald T. Johnson
GRADUATE ASSISTANT: B. J. Baliga

Studies have been made on the solvent extraction of soybean and other oils. A new continuous extractor of our own design, built in the Engineering Shop, has been installed.

Work has recently started on the extraction of soybeans with hexane. Extraction efficiency will be determined for various solvent and miscella circulation patterns such as counter current and co-current, with combinations of these. Other materials will be extracted later.

MANUFACTURE OF FERTILIZER MATERIALS, Project 263
SPONSOR: Engineering Experiment Station
PRINCIPAL INVESTIGATOR: Dr. David R. Boylan
MAJOR STAFF: Dr. George Burnet, Dr. M. A. Larson, and Dr. T. D. Wheelock

The objective is to develop new and improved processes and to expand technology for the manufacture of fertilizer materials. This program of research encompasses nitrogen, phosphorous and potash nutrient materials and their combination fertilizer processes.

The fertilizer research program has resulted in new fusion processes, new quick curing processes, new nitrogen processes, improvements in granulation techniques, improvement in acidulation procedures, improvement in analytical methods, and notable contributions to fertilizer technology.

FLUID FLOW THROUGH POROUS MEDIA, Project 331
SPONSOR: Engineering Experiment Station
PRINCIPAL INVESTIGATOR: Dr. David R. Boylan

The objective is to develop fundamental relationships for the flow of fluid through

porous media. It is hoped that these relationships will allow prediction of fluid flow from fluid characteristics which can be simply measured in the laboratory.

Mathematical models for filtrations have been developed and correlation with practice has been demonstrated. A simple laboratory compression-permeability test cell has been designed and successfully used to correlate filtration theory with industrial equipment operation.

Considerable evidence of the concept of partical shape has been made of the fluid flow field and some success has been realized in developing a general correlation to predict fluid flow characteristics in partial shape measurements.

PRODUCTION OF SULPHUR DIOXIDE AND LIME FROM GYPSUM, Project 371

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. Thomas D. Wheelock

GRADUATE ASSISTANT: L. A. Robbins

The kinetics and reaction mechanism for the high temperature reductive decomposition of calcium sulfate are being investigated by measuring reaction rates, yields, adsorption isotherms, and heat effects, and by determining crystal lattice structures. The results may lead ultimately to the design of an industrial process for the production of sulfuric acid from the naturally occurring minerals, gypsum and anhydrite.

The reaction of calcium sulfate (gypsum or anhydrite) with a reducing gas such as carbon monoxide or hydrogen at temperatures in the range of 2,150 to 2,250°F has been investigated. If a relatively high concentration of carbon dioxide or water vapor and a low concentration of reducing gas are maintained in the system, nearly all of the sulfur can be recovered as sulfur dioxide while calcium oxide is left behind. On the other hand, with a low concentration of carbon dioxide or water vapor and a high concentration of reducing gas, there is a tendency to leave some sulfur behind as calcium sulfide. This may also happen if the temperature falls below the optimum range. The desulfurization rate appears to be the first order with respect to the carbon monoxide concentration and it also depends upon the temperature, particle size, and mass velocity.

Since the reaction mechanism may involve the chemisorption of the gaseous components of the reaction on the solid components, adsorption in this system has been investigated with a very sensitive chromatographic method which would detect any adsorption down to 10-11 moles/gm. of adsorbent at a pressure of 0.1 mm. of mercury. The adsorption isotherms for carbon dioxide and sulfur dioxide on calcium oxide have been determined for temperatures up to about 2,150°F. At low pressures the adsorption of these gases follows a monolayer type of adsorption isotherm, while at higher pressures the gases seem to saturate the solid surface and penetrate the crystal lattice forming the corresponding carbonate and sulfite compounds. Adsorption isotherms for carbon dioxide and sulfur dioxide on calcium sulfate and calcium sulfide have also been determined. Adsorption of carbon monoxide, hydrogen, and oxygen on the solid surfaces was too small to be detected in most cases. In a few cases the gases reacted with the solids so adsorption measurements could not be made.

The reaction mechanism may also be affected by a polymorphic transformation which takes place in calcium sulfate at a temperature falling within the optimum temperature range. This has been partially studied by using X-ray diffraction and other techniques.

HORIZONTAL DISTILLATION COLUMN, Project 372

SPONSORS: American Oil Co. and Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. M. A. Larson

Separation of chemicals by distillation under conditions of high vacuum is important to many chemical engineering operations. A distillation apparatus without any packing or trays would have a very low pressure drop and, therefore, would be able to operate at high vacuum conditions. A device to operate at low pressure drop has been constructed and successfully tested. It consists of a horizontal hollow tube heated along the bottom side and cooled along the top.

Preliminary results have shown that a horizontal distillation column is feasible and that equipment to carry out this type of distillation can be constructed simply. The investigation is continuing.

CRYSTALLIZATION, Project 384

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. M. A. Larson

This research is an experimental study in continuous salting-out crystallizers to demonstrate a theory that correlates the dynamic changes in numbers and size of crystals to station changes in production rates.

A crystallizer is operated to duplicate the constraints of theory, including perfect mixing of a mixed crystal suspension with a mixed product removal. The experimental study results have been shown to be in agreement with the theoretical model. The transients resulting from step changes in production rates are being compared with the theoretical model by the use of digital and analog computers.

KNO_3 GRANULATION CHARACTERISTICS, Project 461-S

SPONSOR: Southwest Potash Corp.

PRINCIPAL INVESTIGATOR: Dr. David R. Boylan

The objective is to demonstrate the granulation characteristics of potassium nitrate (KNO_3). This study involves the development of fundamental principles of granulation and includes studies in equilibria phase separation, crystallization, metathetical reactions, gas-solid reactions and crystal solubility.

The role of potassium nitrate as an aid to granulation has been conclusively demonstrated. The nitrate aids in forming appropriate solution phase, resulting in a lower initial moisture content and greater on-size granules. The work on granulation fundamentals is continuing.

DECOMPOSITION OF PHOSPHATE ROCK, Project 466

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. David R. Boylan

The purpose is to develop new and more efficient methods for recovering phosphorous from phosphate rock. A special objective is to use high temperature (30,000° F) plasma arcs to decompose phosphate rock. This problem involves the investigations of equilibria, gas-solid reaction, and complex phosphate chemistry.

Preliminary investigation has shown that phosphate rock can be decomposed in plasma arc. The product from this investigation was found to be metaphos-

phate which suggests that the phosphorous vaporized recombined with phosphate rock. The investigation is continuing.

SUGAR BEETS, Project 475-S

SPONSOR: Iowa Development Commission

PRINCIPAL INVESTIGATOR: Dr. L. K. Arnold

The overall objective is to develop an integrated soybean oil-beet sugar extraction plant. Work has been conducted in the following areas: (a) extraction of sugar from beets in an extractor previously developed for soybean oil extraction, (b) evaporation of dilute sugar solutions, (c) drying the extracted pulp, and (d) designing the integrated plant.

The experimental work has been completed and the results are being evaluated and written up in an overall project report.

Results in brief: (a) Sugar was extracted with good results; (b) Dilute sugar solutions were evaporated in a single tube climbing film evaporator similar to the one previously used experimentally on soybean oil miscella. Promising data were secured; (c) Extracted pulp was dried in an experimental tunnel type dryer and in the dryer on the new soybean extraction unit. The new unit has good capacity, and (d) A preliminary design has been made. While the economics of the integrated system do not look highly attractive, the data are being critically evaluated and a final decision will have to be made later.

FLUIDIZED BED STUDIES, Project 491-S

SPONSOR: U.S. Department of Agriculture

PRINCIPAL INVESTIGATOR: Dr. Thomas D. Wheelock

GRADUATE ASSISTANTS: R. W. Goetz, A. H. Kranz, K.-j. Li and A. C.-y. Teng

A potential industrial process for producing a tub size for paper by acid modification of wheat flour in a gas fluidized bed is being investigated. The project includes determining the fluidization characteristics, sorption rates, reaction rates, and thermochemical properties of flour. A preliminary pilot plant evaluation and process design will be made.

The dense-phase fluidized bed characteristics of wheat flour containing small concentrations of submicron size silica powder were determined using air for fluidization. The effects of column diameter, bed height to diameter ratio, and gas velocity on the bed pressure drop, bed expansion, and entrainment rate were measured. The addition of small amounts of certain types of finely divided solids such as the precipitated and pyrogenic silicas was found to be essential for successful fluidization.

A pilot plant for acid modifying wheat flour continuously in a fluidized-bed reactor was operated successfully at feed rates up to 20 lb./hr. under a variety of conditions. The effects of temperature, acid to flour ratio, and reactor hold-up time on the degree of conversion were studied. It appears that a product suitable for use as a tub size for paper can be produced by this process.

The adsorption of hydrogen chloride gas by wheat flour was investigated using a McBain adsorption balance. It was found that the total amount adsorbed depends not only on the temperature and partial pressure but on the moisture content of the flour as well. Thus, dry flour will adsorb only a small amount of hydrogen chloride while flour containing moderate amounts of moisture will adsorb a considerable quantity of hydrogen chloride. Adsorption rates were also measured and these were found to depend upon the same variables already mentioned.

The heat capacity and heat of hydration of flour were measured calorimetrically at various temperatures and flour moisture contents. An empirical correlation was found which relates the heat capacity to the temperature and moisture content of the flour. The heat capacity and heat of hydration were used to prepare an enthalpy diagram for flour.

NUCLEATION AND GROWTH IN A MIXED CRYSTAL SUSPENSION, Project 508-S

***SPONSORS:** National Science Foundation and Engineering Experiment Station*

***PRINCIPAL INVESTIGATOR:** Dr. M. A. Larson*

The objective is to develop an experimental and mathematical analysis of the kinetics of crystal growth and nucleation in a mixed suspension continuous crystallizer. The control of size distribution in crystallizers depends on a thorough knowledge of these kinetics. Growth and nucleation parameters are being determined for a number of crystallizing systems.

This investigation has resulted in a national contribution to the understanding of crystal growth. The mathematical model provides for the first time sufficient information to measure and control crystallization processes. This results from inclusion in the model of terms for nucleation rate.

ADHESIVES FROM CORN GLUTEN AND DIALDEHYDE STARCH, Project 532-S

***SPONSOR:** Iowa Development Commission*

***PRINCIPAL INVESTIGATOR:** Dr. L. K. Arnold*

***GRADUATE ASSISTANT:** William W. Swift*

Corn gluten is reacted with dialdehyde starch to produce a high polymer which is being tested for adhesive applications. Other possible applications are as a plastic film or molding material.

Commercial gluten feed and the gluten taken from the factory stream did not produce a satisfactory product as compared with previous products using wheat gluten.

Zein, a refined commercial protein product, produced a good adhesive. Variables in the reaction and in the application of the reaction product are being studied to determine optimum conditions.

ECONOMICS OF SOYBEAN OIL REFINING IN IOWA, Project 534

***SPONSOR:** Engineering Experiment Station*

***PRINCIPAL INVESTIGATOR:** Dr. L. K. Arnold*

***GRADUATE ASSISTANT:** Roger Brekken*

Technical and economic data are being assembled and preliminary plant designs and cost data worked out for the production of such consumer products as vegetable shortenings, salad oil and margarine.

Cost data based on preliminary studies indicate that a plant producing the various consumer products could be operated at a satisfactory profit. Calculations were made for several different capacity plants, including batch plants from 10,000 to 80,000 gallons soybean oil per day and continuous plants for 47,000 and 94,000 gallons per day.

ADSORPTION DYNAMICS OF NONISOTHERMAL SYSTEMS WITH NONLINEAR ISOTHERMS, Project 544

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. L. E. Burkhart

GRADUATE ASSISTANT: Youngok Ahn

The purpose is to develop a mathematical model for a fixed bed adsorption system which fits observed experimental data and which includes initial and boundary conditions comparable with these actually encountered in practice.

Unsteady state adsorption in a fixed bed using the CO_2-air-molecular sieve 5A system was simulated on a digital computer and the results compared with experimental pilot plant data supplied by Linde Division of Union Carbide Corporation. The study was carried out with a nonisothermal system and a nonlinear equilibrium isotherm. The temperature and adsorbate distribution with respect to bed length at the beginning of the adsorption process was not restricted to uniform conditions. Concentration, temperature and flow rate of the incoming gas at the inlet of the fixed bed could also vary as a function of time.

The study is particularly useful in simulating a fixed bed operation where adsorbate concentration is high, although trace removal problems can also be handled. The programs can be applied to a temperature swing process as well as the constant pressure steps of a pressure swing process.

Although the direct use of the j-factor correlation was found to be invalid, a design procedure which makes use of the j-factor correlation has been developed.

NITRATION OF BUTANE, Project 550-S

SPONSOR: Commercial Solvents Corp.

PRINCIPAL INVESTIGATOR: Dr. George Burnet, Jr.

MAJOR STAFF: R. W. Hankinson

GRADUATE ASSISTANT: D. H. Johnnie

The nitration of butane produces a family of nitrated hydrocarbons which are important solvents and building blocks in chemical synthesis. To obtain maximum yield of the most desirable of these products, an understanding of the basic reactions involved is required. The feasibility of obtaining kinetic (reaction rate) data by gas-liquid chromatography is being investigated.

Work at Iowa State since 1959 has resulted in the development of gas chromatographic techniques which provide quantitative analysis of the many significant products and by-products produced from the vapor phase nitration of butane. A molten salt reactor has been operated in the temperature range of 370°C to 480°C and a mole ratio of butane to nitric acid in the feed of 3.4 to 7.8. Yields and conversions were not appreciably affected by changes in mole ratio. Temperature, however, had a significant effect. Yields based on both acid and butane decreased as the temperature was increased. Conversions on both bases increased with increases in temperature to a miximum and then decreased as the temperature was further increased.

Nitroparaffin distributions were not affected by changes in mole ratio but again varied greatly with temperature. The amount of lower molecular weight NP's formed increased with temperature. Future work will be directed toward obtaining more complete and precise data for equilibrium and reaction rate analysis.

LIQUID CYCLONE OR ROTOCLONE, Project 556-S

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. L. K. Arnold

Mixtures of soybean fines in solutions of hexane and soybean oil such as commonly obtained from an oil extractor are being pumped through a liquid cyclone separated under varied conditions to determine effectiveness of fines removal.

A liquid cyclone was constructed and set up. Preliminary studies separating paper pulp suspensions in water gave promising results.

ELECTROFLUIDIC PROCESSING OF COAL, Project 577-S

SPONSOR: Office of Coal Research, U.S. Department of Interior

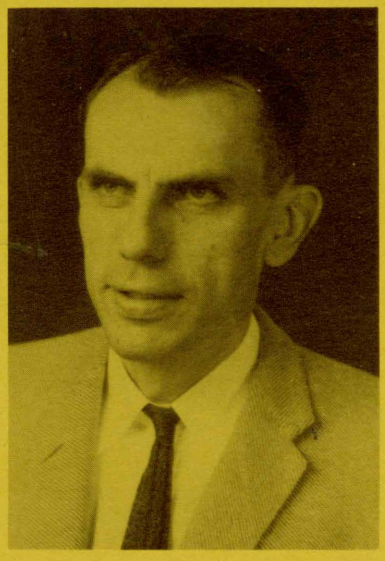
PRINCIPAL INVESTIGATOR: Dr. Thomas D. Wheelock

MAJOR STAFF: Dr. A. H. Pulsifer

GRADUATE ASSISTANT: T. M. Knowlton

Potential process applications of the electrothermal fluidized-bed reactor for producing various chemicals from coal are being investigated. The first process to be tested is one for making hydrogen by reacting steam and coal char.

civil engineering



Dr. Carl E. Ekberg, Jr.
Department Head and Professor

FARM WATER SUPPLIES, Project 353-S

SPONSOR: Everpure, Inc.

PRINCIPAL INVESTIGATOR: Dr. E. Robert Baumann

GRADUATE ASSISTANT: Amir Al-Khafaji

This project is designed to provide basic information required for the design of small water supply systems for individual farms and installation in order

to increase their economy, effectiveness, and dependability.

A new method of disinfection of small water supplies (super chlorination-dechlorination) has been developed. This method of chlorination depends on the use of a higher than normal chlorine residual of several parts per million for a contact period of about five minutes. In order to remove the residual chlorine, the water is passed through a pre-coat carbon filter which may be used to dechlorinate the water and also to remove suspended solids, such as iron and pond water turbidity. Currently, studies are being made which permit prediction of the life of the pre-coat carbon filter in normal operation with a given water.

Laboratory tests are being made using the filters for the removal of iron and various clay materials from suspension in an attempt to correlate the filtrability characteristics of the water and the life of the filter in normal service.

WATER POLLUTION CONTROL STUDIES, Project 387-S

SPONSOR: Lakeside Engineering Corp.

PRINCIPAL INVESTIGATOR: Dr. John L. Cleasby

OTHER STAFF: Dr. T. L. Willrich and Dr. E. R. Baumann

The oxidation ditch is a simple aerobic biological treatment method for waste water containing organic materials. Its simplicity makes it an attractive method for small cities and large confined animal feeding operations. Aeration is accomplished with a mechanical bladed rotor. Studies include oxygen transfer efficiency of the rotor, water velocity patterns induced by a rotor in the ditch, and the amenability of the method to hog waste treatment.

Results indicate that the oxygen transfer of the bladed rotor in an oxidation ditch in slightly lower than in a conventionally-shaped activated sludge tank and varies with rotor immersion and speed. Velocity patterns in the ditch also are dependent on rotor immersion and speed. Conditions that favor maximum induced velocity reduce oxygen transfer efficiency and vice-versa.

SOIL CONSISTENCY LIMITS WITH SOIL MOISTURE TENSIONS, Project 490-S

SPONSOR: Iowa Highway Research Board

PRINCIPAL INVESTIGATOR: Dr. Jack L. Mickle

GRADUATE ASSISTANT: Eugene R. Russell

The purpose of this research was to develop a new method of determining the liquid and plastic limits of soils based upon moisture tension values. The objective was to save time and effort and to arrive at a procedure yielding more consistent results by reducing operator variability.

The project was recently completed. The results were:

1. Moisture tension desorption curves follow a predictable pattern for each soil textural group studied. Although forces other than capillarity play an important role, especially in the clays, the composition mainly controls the parameters that affect curve shape.

2. The desorption curve can be divided into three distinct regions. By assuming popularly accepted moisture tension and plasticity theory as being correct, the three regions, "lower flex", "upper flex" and the "unloading region" between the flexes, are analogous to the liquid limit, plastic limit and plasticity index, respectively. The moisture tension method of liquid limit determination is based on theoretical principles and offers a less empirical, less arbitrary and more clearly defined point than the standard ASTM method.

3. There is essentially no operator variability connected with the moisture tension method. A test indicated that wide variances in initial condition of the soil had little effect on the resulting value; therefore, differences in operator technique should not affect the results, the equipment itself offers no source for variation, and that caused by sampling, or splitting a sample into portions, is minimal.

4. The moisture tension method can be used to approximate liquid limits of Iowa soils with less variance than that of the ASTM standard method at the following pressures:

Clay	40 inches of water pressure
Silty clay	40 inches of water pressure
Silty clay loam	60 inches of water pressure
Clay loam	60 inches of water pressure
Loam	70 inches of water pressure
Sandy loam	70 inches of water pressure
Gravelly sandy loam	70 inches of water pressure
Silt	70 inches of water pressure

5. The effect of textural groups on liquid limit determination is not especially critical; the total pressure difference used being only 30 inches of water or 1.09 psi. Obtaining acceptable results, then, at one pressure cannot be ruled out, although a time factor may be required.

6. The plastic limit value of clay can be approximated at 162 psi. The rest of the plastic limit groups run were questionable.

7. The limit values obtained by moisture tension can be reproduced at the same tension with little variation; they are reproducible to a high degree.

8. The quality of the results and the speed of making determinations make the moisture tension method a valuable substitute for liquid limit devices. The method shows such promise that it should be valuable to any organization running values in great number.

9. The plastic limit determination by moisture tension shows enough promise that it should be studied further.

RESIDUAL STRESSES AND FATIGUE BEHAVIOR OF WELDED STRUCTURAL MEMBERS, Project 501-S

SPONSOR: Iowa State Highway Commission

PRINCIPAL INVESTIGATOR: Dr. Ti-Ta Lee

The objective is to investigate experimentally the fatigue strength under axial loading of flange plates in welded beam sections as influenced by different residual stress distributions which are caused by different sizes of weld.

Testings are currently in progress. Limited test results seem to indicate that the presence of high tensile residual stresses due to welding may make the fatigue strength of the specimens more sensitive to geometrical discontinuities and that discontinuities introduced by welding are probably more detrimental to fatigue strength than the residual stresses.

SOIL STABILIZATION AND PHYSIOCHEMICAL PROPERTIES OF CLAY MINERALS, Project 505-S

SPONSORS: Iowa State Highway Commission and U. S. Bureau of Public Roads

PRINCIPAL INVESTIGATOR: Dr. Turgut Demirel

MAJOR STAFF: Dr. R. L. Handy, coordinator; Dr. Gilbert Roderick and Lin Lu.

Project 505-S was recently completed after a two-year investigation. The study was divided into three phases:

In the first phase an investigation was undertaken to determine the effect of a quaternary ammonium salt on the stability of a granular base course material after wetting with water. The effect of the quaternary ammonium salt on the stability of the base course material treated with varying percentages of the salt and exposed to the action of water was determined by investigating its shearing strength.

The conclusions showed that Arquad 2HT is an effective additive for improving the shear strength of a water susceptible granular material under adverse moisture conditions. Without treatment the shear strength of the material varies greatly. The average shear strength of the untreated material is significantly lower than that of treated material. There is little variation in the shear strength of treated material under these extreme moisture conditions.

In the second phase, epoxy resins were found to be satisfactory for soil stabilization. They were subjected to a detailed investigation in this phase using four soils. The results showed:

(1) After the soils were stabilized with various percentages of epoxies, all were found suitable as base course materials. Traffic Simulator tests showed that the resistance of epoxy or epoxy-lime stabilized soils may be tried as a road surface material.

(2) The effectiveness of epoxy treatment depends on the clay content. High clay content gives the least satisfactory results.

(3) All soils used in this investigation were improved in immersed strengths by the addition of lime to the soils to be stabilized by epoxy.

In the third phase, water vapor with sodium montmorillonite was investigated with X-ray diffraction and sorption isotherm (gravimetric method) experiments. Expansion of the montmorillonite occurs in three increments. The data suggest interlayer water builds up in a laminar fashion. The hysteresis of sorption isotherms is apparently due to the formation of a thixotropic structure and to attractive interlayer forces. BET parameters from adsorption isotherm data reflect adsorption only on external surfaces.

Free energy data, computed from adsorption isotherm data, and X-ray data allow separation of the free energy change on adsorption into two components: one for adsorption on external surfaces, and one for adsorption on and separation of internal surfaces. The data also permits the estimation of swelling pressures exerted by sodium montmorilonite due to the uptake of interlayer water from the vapor phase.

THE EFFECT OF WIRE AND FIBERGLASS ON THE STRENGTH OF CONCRETE, Project 513

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. R. E. Untrauer

MAJOR STAFF: R. E. Montag

ASSISTANT: Dan Aksoy

The object is to determine the effect that the addition of short lengths of steel wire to the concrete mix will have upon the strength and deformation of concrete in tension and compression and to utilize these strength-deformation

relationships in structural members manufactured with this type concrete.

Test results have indicated that a ductile type of concrete can be produced for both tension and compression. The stress-strain curve for a standard cylinder has a flat top as exhibited by many structural steels. This type concrete is now being used in experimental tests of beams.

LONGITUDINAL STRESS DISTRIBUTION IN SPACE FRAME STRUCTURES, Project 515

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. Ti-Ta Lee

The objective is to investigate experimentally the behavior of a highly redundant arcuate space frame structure.

Tests results on uniformly loaded models with three different width/span ratios indicate that within the range of the tests, chord members, forming the shape of an arch (in the direction of span) are subjected to highest stresses while longitudinal members (in the direction of width) and web members show low magnitudes of stresses. The results also indicate that the analysis of the structure assuming infinitely long width will give reasonably good approximate solution for most parts of the structure.

GRANULAR BASE COURSE MIXES, Project 516-S

SPONSOR: Iowa State Highway Commission

PRINCIPAL INVESTIGATOR: J. M. Hoover

PROJECT COORDINATOR: Dr. R. L. Handy

MAJOR STAFF: Dr. Clara Ho and D. Merrill

OTHER STAFF: Fernando Tinoco, Glen Ferguson, Al Wassenaar, Capt. Thomas Best and Capt. Jack Whisler

This is a three-phase project involving compacted crushed stone as the base course for flexible highways. Determination is being made of (1) a suitable and realistic laboratory method of compaction for uniform control of density and minimization of degradation and segregation of the stone particles; (2) the effect of gradation and mineralogy of the particles on the cohesive and frictional stabilities of the compacted crushed stone; and (3) the effect of organic and inorganic chemical additives on the cohesive and frictional stabilities of the compacted crushed stone.

Contractual arrangements between the Iowa State Highway Commission and I.S.U. do not permit formal reporting of results until approved by the Commission and Bureau of Public Roads.

TRAFFIC SIMULATOR, Project 526-S

SPONSOR: Iowa State Highway Commission

PRINCIPAL INVESTIGATOR: Ladis H. Csanyi

MAJOR STAFF: Dr. Dah-yinn Lee

A test device, known as a Traffic Simulator has been developed. The resistance of asphalt mix to displacement under a moving wheel load may be evaluated with this device.

The test results of the Traffic Simulator are being correlated with the effects of traffic on a road through a series of comparative tests performed on laboratory design specimens, plant mix specimens, and specimens cored from roads

containing the plant mixes after a year of service under traffic.

Through such correlation a valuable new tool would be made available to assure longer service life of asphalt pavements.

The study disclosed that stability alone does not provide an adequate means of assuring resistance of mix to traffic in service, and that the Traffic Simulator test provides an auxiliary method by which the behavior of a mix under traffic may be evaluated more rapidly. It was also found that mixes containing softer coarse aggregates, that tend to degrade and absorb asphalt slightly, and mixes that had 8 to 9 percent voids possessed better trafficability.

New criteria for the Simulator test were established. Field checks of this criteria on mixes in service for 9 months confirmed the reliability of the new criteria.

FATIGUE FAILURE OF PRESTRESSED CONCRETE, Project 529

SPONSORS: Engineering Experiment Station, and U.S. Army Research Office

PRINCIPAL INVESTIGATOR: Dr. C. E. Ekberg

MAJOR STAFF: J. B. Hilmes

The purpose of this work was to develop an approach to the solution of fatigue problems in prestressed concrete flexural members due to repeated live loads. The experimental portion involved the fatigue testing of approximately 50 samples of prestressing strand using the facilities of the Rex Chain-Belt Co. of Milwaukee, Wis.

The remainder of the project involved a statistical evaluation of the strand test data in conjunction with a flexural analysis of numerous test beams.

The project was completed in 1965 and a report entitled "Statistical Analysis of the Fatigue Characteristics of Underreinforced Prestressed Concrete Flexural Members" was distributed to the sponsors.

ASPHALTIC CONCRETE, Project 540-S

SPONSOR: Iowa State Highway Commission

PRINCIPAL INVESTIGATOR: Ladis H. Csanyi

MAJOR STAFF: Dr. D. Y. Lee

The objective of this research is to determine which of the various asphalt tests is most critical with regard to the changes that occur in asphalt cements from the time they are delivered to a plant to the time the asphaltic mix is laid in the pavement. Having been determined develop a procedure by which unsuitable asphalts may be defined.

Results to date show:

1. Although all ten asphalts studied were 85-100 pen grade, their physical as well as chemical properties differed widely.

2. The thin film oven test appears to be the most critical in denoting material difference between the asphalts studied.

3. Hardening of asphalts during mixing approaches in degree to that of the thin film oven test.

4. Hardening of asphalts during mixing is a function of original viscosity and film thickness.

5. Hardening of asphalts during the first year road service is a function of air voids in the pavement and initial hardening during mixing.

CORNCRETE, Project 543

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. Turgut Demirel

GRADUATE ASSISTANT: Joseph LaRose

Mixtures of phosphoric acid digested corncobs, furfural alcohol, and spent sulfite liquor pressed at various pressures and temperatures as construction material are being investigated. Chemical, physical, and mechanical properties of the material (named corncrete) produced under various conditions are determined to evaluate it as a material of construction.

Formulations producing fireproof, waterproof and high structural strengths have been developed. Economical analysis has indicated that this material compares favorably with plywood.

DESIGN OF MUNICIPAL DIATOMITE FILTERS, Project 549-S

SPONSORS: National Institute of Health; U.S. Public Health Service, Water Supply and Pollution Control Research Grant

PRINCIPAL INVESTIGATORS: Dr. E. R. Baumann and Paul E. Morgan

OTHER STAFF: Dr. John L. Cleasby and Dr. Charles S. Oulman

GRADUATE ASSISTANTS: Perialwar Regunathan and Tom Besett

This study was undertaken to determine the characteristics of municipal applications in which diatomite filters may be used successfully, to study the effect of various variables on filtration economy and effectiveness, and to outline a procedure for designing a plant to operate with maximum economy.

Diatomite filtration equations have been developed to predict the head loss-time relationship during a filter run by use of empirical filter cake resistance measurements. An equation has been developed to predict filter cake resistance from measurable filtration variables. Empirical constants in the prediction equations are collected in pilot filter runs. A digital computer program has been prepared to use the equations and cost information to optimize plant design.

Filter cake resistance information has been collected in laboratory and plant-scale filtration work on iron bearing, clay bearing, and lime-softened waters. Additional laboratory and field work is necessary to collect additional filter cake resistance data on coagulated and uncoagulated surface waters. These data will be used to evaluate the characteristics of municipal installations where diatomite filters may be used economically.

Laboratory studies are being conducted to determine the effect of inorganic metal coagulant coatings and organic polyelectrolyte coatings on the zeta potential of diatomite particles and on the changes in filter cake resistance that result from the coatings. Depending on conditions, the zeta potential may be changed from electronegative to electropositive, and cake resistance may be increased or decreased. The changes in filtration effectiveness are now under study.

SIZE AND SPACING OF STIRRUPS FOR BOND STRENGTH, Project 553-S

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. R. E. Untrauer

ASSISTANT: Conrad McWilliams

The object is to determine the effect of size and spacing of transverse reinforcement (stirrups) on the bond strength of the longitudinal reinforcement in reinforced concrete. The present specifications used in the United States in building design bases the bond strength only on the strength of concrete and the diameter of the longitudinal reinforcement.

An M. S. Thesis, "Influence of Stirrup Confinement on Bond Strength of Concrete" by Conrad Allen McWilliams has been written. The results indicate that for top bars the bond strength can be expressed as a function of the diameter of longitudinal reinforcement, strength of concrete, depth of beams, and spacing of stirrups.

STRESS DISTRIBUTION IN NON-PRISMATIC FOLDED PLATES, Project 559-S

SPONSOR: I.S.U. President's Permanent Objectives Committee

PRINCIPAL INVESTIGATOR: Claude D. Johnson

The object of this investigation is to determine the stress distribution in the plate elements of certain types of non-prismatic folded plate structures.

A model study of two non-prismatic folded plates has been conducted. Presently, methods of analysis for these types of structures are being formulated which will be programmed for the digital computer. The results of the analytical study and the model study will be compared.

DEGRADABILITY OF AMINES, Project 568-S

SPONSOR: ISU President's Permanent Objectives Committee

PRINCIPAL INVESTIGATOR: Dr. Owen Sletten

The specific objective of this project was to determine whether certain selected amines would be broken down by exposure to sewage microorganisms. Nitrogen is an important element in almost every phase of our existence. It is also an important component of our waste products, both of human and industrial origin. Amines play a significant role in the nitrogen cycle, but literature reveals little about their susceptibility to biological degradation. Because of their importance and the need for a better understanding of their degradation, an exploratory study was made of their break-down by microorganisms.

There is ample evidence that the salts of amines are biodegradable. This study was limited to pure compounds, but it can be reported that even certain pure compounds of amines are biodegradable. Warburg respirometer runs indicated that amine concentrations as low as 100 mg/l were toxic for some compounds tested. On the other hand, selected amines ranging in concentration between 2 and 25 mg/l underwent degradation in the Warburg respirometer, when exposed to sewage microorganisms.

Experiments conducted in this study indicate that certain amines are easily oxidized by exposure to the air.

A sensitive test for certain amines was developed in this investigation.

SOIL PIPE AND FITTINGS RESEARCH, Project 571-S

SPONSOR: Cast Iron Soil Pipe Institute

PRINCIPAL INVESTIGATOR: Dr. R. E. Untrauer

MAJOR STAFF: Dr. W. W. Sanders and Dr. Ti-ta Lee

ASSISTANTS: Maan Jawad, Michael Goodkind, and George Papamichalopoulos

The object is to determine the structural requirements for the various sizes of cast iron soil pipe and fittings. In particular, it is desired to determine a single weight of pipe (one thickness for each diameter) that will perform satisfactorily under all conditions. During this research project, stresses that the pipe must safely withstand must be determined for all phases of its life. To accomplish this, the life of the pipe has been divided into the following four periods:

(1) Manufacturing,
(2) Transporting,
(3) Construction, and
(4) Service.

Stresses will be determined for each of these four areas. Many of the stresses are such that they are accumulative and proper combination will result in the maximum stress requirement of the pipe.

The literature survey has been completed and experimental tests are now underway to determine the stresses caused by constructing lead-oakum and elastomeric joints. Tests are also underway to determine the residual stresses locked in the pipe and fittings that are caused by differential cooling at time of manufacture. Experimental tests will be started to determine the stresses in the pipe systems due to building movements.

CONCRETE POPOUTS, 573-S

SPONSOR: Iowa Producers of Aggregate and Concrete

PRINCIPAL INVESTIGATOR: Dr. R. L. Handy

MAJOR STAFF: Derwin C. Merrill

The objective is to determine the cause and cures for concrete popouts, a surface blemish of concrete.

Early research shows that the cause appears to be an alkali-aggregate reaction.

COOPERATIVE STUDY-DISPOSAL OF PESTICIDES AT PUBLIC STOCKYARDS, Project 575-S

SPONSOR: National Animal Disease Laboratory, U.S. Department of Agriculture

PRINCIPAL INVESTIGATOR: Dr. John L. Cleasby

OTHER STAFF: Dr. Owen Sletten

In stock yards throughout the country, animals are frequently dipped in dip tanks containing from 1,000 to 10,000 gallons of pesticide solutions. After use, these pesticide solutions must be disposed of without adding to the problem of water pollution. It has been proposed that these dip tanks be discharged to sanitary sewers in the municipal system. This study was undertaken to determine whether the pesticide dip tank contents are toxic to the biological life in water pollution control plants and to determine whether the pesticides are bio-degraded in their passage through the water pollution control treatment plant.

In the laboratory, samples of pesticides were added to activated sludge in an extended aeration process. Samples of the activated sludge containing the pesticides were studied in a large volume manometric apparatus to determine the effect of the pesticide on the oxygen up-take of the microorganisms.

Preliminary studies indicate that lindane and toxaphene pesticides in the concentrations normally encountered are not seriously toxic to the micro-biological activity observed in the laboratory manometric apparatus. The pesticides appear to concentrate in the activated sludges. Tests will be made using a laboratory continuous-flow extended aeration pilot plant prior to making tests using a full-scale activated sludge treatment unit.

X-RAY DIFFRACTION OF HIGHWAY MATERIALS, Project 576-S

SPONSOR: Iowa State Highway Commission

PRINCIPAL INVESTIGATOR: Dr. R. L. Handy

MAJOR STAFF: Dr. Clara Ho

This is a continuation of work in progress on chemical reactions between clay minerals and lime or portland cement. Evaluation of waste carbide lime for soil stabilization is conducted.

The most important strength-giving product from clay-lime pozzolanic reaction is "tobermorite", a hydrated calcium silicate that also sticks concrete together. Other reaction products, including hydrated aluminates, hydrogarnets, and asbestos, also have been identified.

Lime slowly dissolves and diffuses into clay lumps, stabilizing the clay. Therefore, the soil need not be finely pulverized. Practical applications include successful stabilization of soil for an airport runway at Mt. Pleasant, Iowa, and chemical stabilization of a landslide in Des Moines.

SEISMIC DENSITY VS. IN-PLACE DENSITY OF SOILS, Project 581-S

SPONSOR: Iowa State Highway Commission

PRINCIPAL INVESTIGATOR: J. M. Hoover

PROJECT COORDINATOR: Dr. R. L. Handy

GRADUATE ASSISTANT: J. M. Hogan

This investigation is aimed at developing a field method of determining in-place density of highway components utilizing seismi wave velocities.

Contractual arrangements between the Iowa State Highway Commission and I.S.U. do not permit formal reporting of results until approved by the commission and the Bureau of Public Roads.

RAPID BEARING TESTS USING A SPHERICAL PENETRATION DEVICE, Project 597-S

SPONSOR: Iowa State Highway Commission

PRINCIPAL INVESTIGATOR: Dr. Turgut Demirel

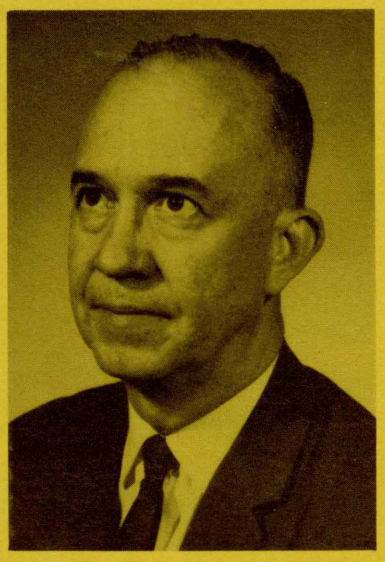
MAJOR STAFF: Dr. R. L. Handy, coordinator; Lin Lu, research assistant; G. S. Butt, graduate assistant.

The objective of this research is to study the load bearing capacity of soils.

A survey of literature has been completed and necessary test equipment fabricated.

Preliminary tests on silty clay soils have been completed. Results obtained verified the expected empirical relationship. The staff is currently developing a method for detecting deformation within the soil. The effect of density and moisture content of the soil on its spherical bearing capacity are being investigated.

electrical engineering



Dr. Warren B. Boast
Department Head and
Distinguished Professor

AN AFFILIATE RESEARCH PROGRAM IN SOLID STATE ELECTRONICS, Project 424-S

SPONSORS: Ampex Corp., Control Data Corp., Fabri Tek Corp., Fairchild Semiconductors, Inc., General Electric Co., Honeywell, Inc., IBM, National Cash Register Co.

PRINCIPAL INVESTIGATOR: Dr. A. V. Pohm

MAJOR STAFF: Dr. A. A. Fouad, R. J. Zingg

GRADUATE ASSISTANTS: Ronald Haglund, Richard Schultz, Bo Loony Ho, Curran Swift

The broad objective of this program is to investigate new solid state devices and phenomena. There are four major research areas:

(1) Materials—research on the properties of thin magnetic and insulating films. The work includes research on switching, dispersion, creep and other properties of magnetic films, and on the negative resistance characteristics in insulating films. Efforts are directed toward the properties of semiconductors, ferroelectrics, and other bulk materials.

(2) Devices, Circuits, and Components—as a result of the thin film material research, a number of devices, such as magnetic film parametric amplifiers, balanced moderators, parametrons, and memory elements, are being studied. In addition, memory systems and related circuits are being examined from both a device and systems point of view. Work has also been carried out on semiconductor radiation particle detectors, strain transducers, and tunnel diode transistor logic and sensing circuits. The work on devices, circuits, and components is a major segment of the Affiliate Program.

(3) Energy Conversion—research is being undertaken in the performance of thermoelectric converters under transient loading conditions. The effects of junction resistance on such devices are also being examined. The study and evaluation of thermionic converters is considered to be a part of the examination of energy conversion devices and their performance as part of a power system.

(4) Devices and Tranducers for Bio-Medical Instrumentation—applications of solid state research are extensive in the biomedical electronic field. Circuits and transducers are presently being built using solid state devices. Additional areas of research are anticipated, using the magnetostrictive properties of thin ferromagnetic films to create transducers, using implanted solid state circuits to measure and telemeter physiological information, using solid state materials to investigate the feasibility of electronically activated limbs, using solid state devices for instrumentation, and using new materials to create artificial organs.

Approximately 30% of the research activities are basic and fundamental, and approximately 70% are applications of the fundamentals developed.

AFFILIATE RESEARCH PROGRAM IN ELECTRIC POWER, Project 460-S

SPONSORS: Iowa-Illinois Gas and Electric Co.; Iowa Power and Light Co.; Iowa Public Service Co.; Iowa Southern Utilities Co.; Detroit-Edison Co., and Commonwealth Edison Co.

PRINCIPAL INVESTIGATOR: Dr. Paul M. Anderson

MAJOR STAFF: Dr. Essam Nasser, Charles F. Haberly, N. H. Woodley, Dr. Hui-Ying Chung, Frank L. Chen and John R. Pavlat.

There are six project areas within the program. Three of them are continuation of earlier investigations and the other three were added during the 1964-65 research year.

John Pavlat continued his study of the dynamic behavior of a machine by applying state space techniques.

Frank Chen investigated the problem of peak load forecasting and presented partial results to sponsors.

Dr. Chung continued his work in constructing a thermionic energy conversion device.

Neil Woodley completed a study of the methods of analyzing faulted networks and has written a computer program for the IBM 7074.

Charles Haberly investigated the use of digital communications for power systems.

Dr. Nasser studied a new area of power system research in high voltage phenomena.

DIGITAL MAGNETIC RECORDING, Project 468

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. Roger C. Camp

ASSISTANT: Donald E. Chapman

The principal objective is to investigate a completely new form of Digital Magnetic recording. This new system has several unique features and is potentially very inexpensive.

The secondary objective is the further development of some of the component parts.

A crude working model is now in operation. Further development is underway on a good engineering model. Two papers relative to the project have been published and a third is being reviewed for publication. A patent has been issued by the U. S. Government patent office on this new system.

WAVE PROPAGATION STUDIES, Project 470

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. R. E. Post

OTHER STAFF: J. D. McMechan and C. D. Cowan

This research is designed to investigate radio-wave propagation phenomena.

This project is currently supporting work in the following areas:

(1) Transhorizon radio-wave propagation modeling using a laser.
(2) Characteristics of VLF radio-wave propagation.
(3) Characteristics of spaced-ring resonators.
(4) Study of edge currents in ground planes.

PROCESS IDENTIFICATION TECHNIQUES FOR USE IN ADAPTIVE CONTROL SYSTEMS, Project 477

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: R. M. Willet

ASSISTANT: D. J. Duven

The problems associated with controlling the flight of missiles and aircraft are becoming more and more complex as the speed and altitude capabilities of the vehicles are improved. The X-15 aircraft for example flew at such extreme altitudes and speeds that its performance characteristics could not be completely predicted. To adequately control such vehicles, the automatic control system must be capable of changing its own characteristics as the characteristics of the vehicle being controlled change.

The adaptive control technique being investigated makes use of a computer program which will identify the pulse transfer function of the system being controlled. The results have been very encouraging for simple second order systems, and currently work is being done on fifth and sixth order systems. Mr. Duven is preparing a paper on one of the programs he has written for this project.

AFFILIATE RESEARCH PROGRAM IN ELECTRONIC CONTROL AND COMMUNICATIONS SYSTEMS, Project 514-S

PROJECT COORDINATOR: Dr. M. H. Mericle

MAJOR STAFF: R. G. Brown, C. J. Triska, R. E. Post, R. M. Willett, A. G. Potter, H. M. Hale, D. W. Gade, R. M. Stewart, R. A. Sharpe and J. D. McMechan.

The project is intended to serve as an affiliation between the University and the industrial affiliates in the areas covered by the general term "electronic control and communications."

It is intended to be a financially attractive research investment for the participating companies, to provide graduate student support, and to provide a vehicle for exchange of ideas between the University and the industrial participants.

LORAN C MONITORING, Project 517-S

SPONSOR: National Bureau of Standards and Engineering Experiment Station

PRINCIPAL INVESTIGATOR: J. D. McMechan

ASSISTANT: David Morton

This project covered the design and construction of some auxiliary detectors to be used with a LORAN C receiver on loan from the National Bureau of Standards. These new detectors allow a sample to be made of the received sky wave signal.

The detectors have been built and operated to confirm their operation. As a result of the changes in the original contract, no data have been collected. However, currently the staff is attempting to get the equipment in operation. When the system is returned to operation the staff will collect data and analyze it using computer programs which Mr. Morton has already written.

ELECTROMAGNETIC WAVE PROPAGATION, Project 530-S

SPONSOR: National Science Foundation

PRINCIPAL INVESTIGATOR: Dr. R. E. Post

OTHER STAFF: J. A. Hootman

The objective of this research is to study the effects of the interaction of acoustic waves and electromagnetic waves in the lower atmosphere.

The results were reported at the National Electronics Conference in October 1965.

The study was undertaken to find a mathematical model and a method of solution of this model for a known one-dimensional variation of the refractive index. The formulation of this electromagnetic acoustic interaction is easily solved by numerical techniques.

In particular the reflection coefficient from sinusoidal wave forms was studied in detail. The reflection coefficient was found to vary in a linear manner with the magnitude of pressure as well as with the interaction length.

The reflection coefficient varies with the frequency of the acoustic wave as well as with the angle of incidence that the electromagnetic wave makes with the acoustic wave. The frequency variations of the acoustic signal and the angle of incidence have the same apparent effect on the reflection coefficient for small angles. Variations of the reflection coefficient with frequency and angle of incidence were calculated for a sinusoidal pressure distribution. It was found that the angle of incidence must be on the order of 10 to 12 degrees before the reflection coefficient varied appreciably. This is equivalent to a frequency deviation of the acoustic wave of two percent or less from the frequency of maximum reflection.

Reflection of electromagnetic energy from modulated waves was lower than the equivalent acoustic wave when unmodulated. In general the formulation lends itself well to the modulated acoustic wave problem.

From the fundamental information obtained about the interaction of electromagnetic waves with acoustic waves it is hoped that by an extension of the procedure a remote method of measuring the acoustic wave and thus the associated atmospheric parameters can be found.

NOISE PROPERTIES OF A LOW FREQUENCY THIN MAGNETIC FILM PARAMET, Project 538-S
SPONSOR: National Science Foundation
PRINCIPAL INVESTIGATOR: Dr. Glenn E. Fanslow

A previous investigation of the application of a thin magnetic film in a low frequency parametric amplifier found that the device could not be used for low level amplification because of "noises" due to "Barkhausen Jumps", extraneous fields, etc. The work being done under this project is the fabrication of thin magnetic films that exist in a single magnetic domain state.

The major portion of the study was devoted to the vacuum deposition of thin magnetic films on cylindrical substrates. The results of these efforts were negative in that the easy direction of magnetization was axial instead of circumferential as was desired. As a consequence these films were not suitable for use in the amplifier.

Different methods of amplifier design were attempted using "flat" films and electroplated wire. No improvements over the earlier investigation were obtained.

MULTI-STEP CAPACITOR BANKS, Project 552-S
SPONSOR: Commonwealth Edison Co.
PRINCIPAL INVESTIGATOR: Dr. P. M. Anderson
MAJOR STAFF: Dr. A. A. Fouad

The principle objective was to determine the instantaneous values of currents in the switching of large, high voltage capacitor banks.

Currents were solved for a specific set of conditions as suggested by Commonwealth Edison Company.

KALMAN FILTER, Project 557-S
SPONSOR: Engineering Experiment Station
PRINCIPAL INVESTIGATOR: Dr. R. G. Brown
ASSISTANT: Richard Horton

The Kalman filter applied to a stochastic process results in an optimum least squares estimate of the state variables of the process at discrete time points. A posterori estimate of the state variables is obtained by using a single measurement to improve the a priori estimate at these time points.

The objective of this project is to investigate schemes which would use a combination of measurements to improve the a priori estimate without decreasing the length of the interval between time points. The principal questions are: how close to optimum are these suboptimum schemes, and can computing time be shortened.

Although several schemes have been tried, to date none of the valid ones has proved to be satisfactory. Others are being examined at the present time.

RADIO PROPAGATION, Project 562-S
SPONSOR: ISU President's Permanent Objectives Committee
PRINCIPAL INVESTIGATOR: J. D. McMechan

The Engineering Experiment Station Electronics Shop is constructing a receiver to allow measurements to be made of the Very Low Frequency (VLF) Station NBA, Canal Zone, Operated by the U. S. Navy. This work will be used to

provide VLF data for comparison with the LORAN-C data, as well as measurements of VLF phenomena.

The receiver has been completed and used for several months. Its operation is very satisfactory. Currently a second similar receiver for 60 Kc. and the frequency of the existing receiver has been changed to 20 Kc. The staff will use the two receivers to monitor WWLL (20 Kc) and WWVB (60 Kc) operated by the National Bureau of Standards at Fort Collins, Colorado upon completion of the second receiver.

VIDEO TAPE FOR LABORATORY INSTRUCTION, Project 563-S

SPONSOR: ISU President's Permanent Objectives Committee

PRINCIPAL INVESTIGATOR: Dr. James W. Nilsson

The project is devoted to the development of audio-visual aids to be used to acquaint undergraduate students with laboratory equipment. Thus far four video tapes, an audio-slide program, and an audio-manual program have been developed. The four video tapes are:

I. The Cathode Ray Oscilloscope
II. The Transistor Curve Tracer
III. The Digiac Logic Trainer
IV. The Bitran Six Digital Computer

The audio-slide program introduces the student to the cathode-ray-oscilloscope, and the audio-manual program introduces the student to the analog computer.

Student response to these audio-visual programs has been very favorable and all four video-tapes have been integrated into the teaching program.

PHASE SWITCHING INTERFEROMETER, Project 564-S

SPONSOR: ISU President's Permanent Objectives Committee

PRINCIPAL INVESTIGATOR: Dr. R. E. Post

OTHER STAFF: J. P. Basart and G. D. Bergland

The objective of this project is to construct a 220 mc/s phase switching interferometer to use in cosmic noise studies.

The receiver is almost completed. The antennas have been completed and moved to a site at Mather Observatory. The staff expects to begin taking data in April or May.

ELECTRICAL IONIZATION OF GASES, Project 567-S

SPONSORS: Engineering Experiment Station, ISU President's Permanent Objectives Committee, Power Affiliate Program

PRINCIPAL INVESTIGATOR: Dr. Essam Nasser

Transition phases of gases from the insulation to the conductor stage are being studied. This transition or breakdown occurs when the electric field in the gas exceeds certain values depending on gas density. The ionization processes are to be investigated and then their complexity revealed. Applications vary from the gas discharge tube, spark plugs, and X-ray technology to particle accelerators, corona, circuit-breakers, insulation in space and in high-voltage systems and in possible thermonuclear fusion using plasmas.

A thorough study of the cathode's role on the breakdown of a positive point-to-plane arrangement was conducted. It was found that when the first ionizing process reaches the cathode from the anode high concentrated fields cause intensive electron emission from the cathode. These electrons form electron avalanches by collision and can build some negative streamers which propagate in opposite directions. (Paper F-6 of Gaseous Electronics Conference, 1965)

ENERGY CONVERSION, Project 584-S

SPONSOR: ISU Research Foundation

PRINCIPAL INVESTIGATOR: Dr. A. A. Fouad

ASSISTANT: Jish-Min Wang

The purpose of this project was to construct an auxiliary discharge-type thermionic energy converter and to investigate its properties and as well as optimize its parameters. The staff later hopes to investigate different schemes for possible generation of alternating current by magnetohydrodynamics.

Presently the equipment is operational and studies are underway.

engineering mechanics

Dr. Harry J. Weiss
Department Head
and Professor

FLUID MECHANICS, Project 425

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. D. F. Young

ASSISTANT: X. J. R. Avula

This project is concerned with the behavior of fluids under time-dependent flow conditions. Unsteady flow problems are commonly encountered in practice, but in general are difficult to solve because of the additional variable time. The broad, long range objective of this project is to investigate various types of unsteady flow problems so that suitable experimental and analytical techniques can be developed for the analysis of these problems. Through specific studies of this type a better understanding of the fundamental characteristics of unsteady flow can be achieved.

Specific fluid mechanics problems that have been, or are currently being inves-

tigated include:

(1) analog methods for solving unsteady flow problems,
(2) flow characteristics under random pressure gradients,
(3) unsteady flow of compressible fluids through orifices and screens, and
(4) unsteady, non-uniform flow in the entrance region of a tube.

USE OF MODELS TO SIMULATE DYNAMICALLY LOADED UNDERGROUND STRUCTURES, Project 574-S

SPONSOR: U.S. Air Force Special Weapons Center, Kirtland Air Force Base

PRINCIPAL INVESTIGATORS: Dr. Glenn Murphy and Dr. D. F. Young

MAJOR STAFF: Dr. K. G. McConnell
ASSISTANTS: Ervin T. Boulette, John L. Ridihalgh, Larry D. Schleuker

The objective is to apply the principles of similitude to permit the use of small scale laboratory models in predicting the structural response of large underground structures to blast loading.

TRANSIENT WAVES IN LINEAR VISCOELASTIC MEDIA, Project 601-S

SPONSOR: National Science Foundation

PRINCIPAL INVESTIGATOR: Dr. K. C. Valanis

The project will involve the analytical investigation of wave propagation in linear viscoelastic materials. The analysis is based on a new method, developed by the principal investigator which will open avenues of investigation into a number of problems, which thus far have remained intractable.

It has been proposed that the following problems will be solved in the course of the investigation:

(a) Transient stresses in "long" viscoelastic cylinder under internal and/or external pressure which may be symmetric.

(b) Stresses and displacements in a viscoelastic sphere due to impulsive radial loads.

(c) Stress fields in a finite cylinder encased in a thin elastic shell due to various types of impulsive internal pressure.

The investigation will be of particular interest to space technology (solid fuel rocketry), and seismology.

SIMILARITY CONCEPTS AND THE THEORY OF MODELS IN BIOMEDICAL FLUID MECHANICS, Project 606-S

SPONSORS: Engineering Experiment Stations, I SU President's Permanent Objective Committee

PRINCIPAL INVESTIGATORS: Dr. D. F. Young and Dr. Neal R. Colvin, D. V. M.

The objective of this project is to determine the feasibility of applying the concept of similitude to biological systems, with particular emphasis on problems related to the fluid mechanics of living systems. Current work is directed toward: (1) the development of similarity parameters, based on classical model theory that are applicable to the study of arterial blood flow, and (2) the establishment of the validity of these parameters experimentally.

engineering graphics

Mr. James S. Rising
Department Head
and Professor

ELECTROMECHANICAL PLOTTER AND DATA STORAGE, Project 433
SPONSOR: Engineering Experiment Station
PRINCIPAL INVESTIGATOR: L. J. Arp

The objective is to develop a simplified digital data plotting system which is low in cost, easy to program and accurate in the presentation of graphical data.

Patent applications have been filed based on working model.

CO_2 ANALYZER, Project 499
SPONSOR: Engineering Experiment Station
PRINCIPAL INVESTIGATOR: L. J. Arp

The objective is to develop a CO_2 and oxygen utilization analyzer which will make determinations on a breath-by-breath basis.

A patent application has been filed based on laboratory model.

AUTOMATED MICROSCAN UNIT, Project 569-S
SPONSOR: I.S.U. President's Permanent Objectives Committee
PRINCIPAL INVESTIGATOR: Carl J. Sayre

The purpose of the project is to develop a method of recording 100 pages of information on an 8 x 10 photographic negative by means of microdots and then using this film negative in a projector for display on a screen. The wanted pages are selected electronically in a matter of micro-seconds.

DEVELOPMENT OF A PLASTIC NEEDLE WITH RETAINING MEANS, Project 500
SPONSOR: Engineering Experiment Station
PRINCIPAL INVESTIGATOR: L. J. Arp

The objective of this project is to develop a plastic needle which may be left in place for prolonged periods of time for administering anesthetic agents.

A patent application has been filed, which is based on the working model.

industrial engineering

Mr. Joseph K. Walkup
Department Head and Professor

REGULATION OF PUBLIC UTILITIES, Project 541
SPONSOR: Engineering Experiment Station
PRINCIPAL INVESTIGATOR: Dr. Gerald W. Smith

This is research into factors pertaining to the analysis of capital expenditures of utility companies. The project involves treatment of special problems and needs such as capital budgeting practices, group property analysis (using Iowa-type survivor dispersions), impact of tax law changes, regulation, etc.

Results to date have been reported and published via the annual Iowa State University Conference on "Public Utility Valuation and the Rate-Making Process".

mechanical engineering

Mr. Henry M. Black
Department Head
and Professor

SHOCK TUBE, Project 351

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Robert Fellinger

MAJOR STAFF: Dr. William J. Cook

ASSISTANTS: E. J. Felderman and J. L. Hall

The Shock Tube Laboratory is concerned with experimental studies of short duration (approximately 500 micro seconds), high speed, high stagnation temperature gas flow. The existing shock tube is approximately 40 ft. long, of the single diaphragm type, and has a constant area channel 3 in. wide and 6 in. deep. It is equipped with a Schlieren system for flow visualization, thin film gages and one micro-second time base counter for wave velocity measurements. Major work is in the areas of high speed heat transfer, boundary layers and wave interactions. Experimental techniques using thin film platinum gages for heat transfer study have been developed in the laboratory as well as data reduction methods. Currently, the tube is being redesigned to extend the range of capabilities using multiple diaphragms and a nozzle.

DEVELOPMENT OF IMPROVED METHODS FOR DESIGN AND PREDICTION OF PERFORMANCE OF AXIAL-FLOW TURBOMACHINERY, Project 407-S

SPONSOR: National Aeronautical and Space Administration

PRINCIPAL INVESTIGATOR: Dr. George K. Serovy

MAJOR STAFF: Dr. Patrick Kavanagh

ASSISTANTS: F. Byron Hamm, Marvin D. Smith

To permit closer control by the designer of the performance characteristics of axial-flow pumps, compressors and turbines, it is necessary that improved mathematical models of the flow in these turbomachines be available. Refinement of these flow models is possible through the experimental investigation of the flow patterns in typical flow passages and components, as well as by the development of calculation procedures which may use a more realistic flow model while remaining economical in terms of computation time required.

In this program a series of digital computer programs have been developed and tested which deal with both the design and analysis problems for axial-flow turbomachinery. Programs have also been developed for the design and analysis of unbladed axisymmetric annular passages. Concurrent experimental studies have been concerned with a number of internal flow problems in cascades, diffusers and annular passages.

ELECTROMAGNETIC SHOCK TUBE, Project 527

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: W. W. Bathie

The project consists of constructing and using an electromagnetic shock tube. This is a device which produces a short duration, high Mach number shock wave at low pressures. The maximum steady state duration of the shock wave is 75 microseconds. The pressure range for this type of device is between 10 and 1000 microns. The Mach numbers obtainable range up to 150.

This device can be useful in experimental work where useful data can be obtained in the steady state test time available. This includes the area of determining the heat transferred to a blunt body under conditions similar to those experienced by a vehicle re-entering the earth's atmosphere.

The original objective of this project was to determine the effect a magnetic field has on the heat transfer rate to a blunt body. Since defining the original problem it was discovered that it was necessary first to determine the total heat transfer rate to a blunt body when there is no magnetic field present. It was originally thought this problem had been solved but later determined that it had not. This, therefore, is the first objective of this project.

The next objective is to determine what fraction of this total heat transfer rate is convective heat transfer and what fraction is heat transferred by radiation. Once this has been done, the problem of determining the effect a magnetic field has on the heat transfer rate will be determined.

The shock tube was recently put into operation.

STUDY OF FLUID FLOW BETWEEN AN ANGULARLY ACCELERATED FINITE RIGID DISK AND A WALL, Project 561-S

SPONSOR: ISU President's Permanent Objectives Committee

PRINCIPAL INVESTIGATOR: Leo C. Peters

MAJOR STAFF: Dr. G. K. Serovy and Dr. D. F. Young

The objective of this project is to determine the variation of axial force and drive torque on a finite rigid disk, which is separated from a wall by a fluid, from a time when disk rotation starts to a time when steady state conditions are attained in the fluid after the disk has reached some arbitrary constant angular velocity.

The variations will be found by continuously recording the drive torque, the disk angular velocity and the radial pressure gradient across the disk during the time period mentioned above.

Information obtained from this work could be used to better understand "start up" operation of hydrodynamic thrust bearings or disengagement of fluid lubricated disk clutches since both conditions are approximated by the proposed test work.

At the present time the test fixture is being constructed. No results have been obtained.

STABILITY OF A HYDRAULIC POPPET VALVE, Project 565-S

SPONSOR: ISU President's Permanent Objectives Committee

PRINCIPAL INVESTIGATOR: Dr. B. L. Johnson

OTHER STAFF: Donald Wandling

A valve model has been built, which exhibited the planned instability at about 1,000 cps. As yet, no qualitative data are available because of a delay in receiving instrumentation necessary for the experimental portion of the project.

However, certain methods to eliminate the instability were conceived and tried; the most promising of these being a method to eliminate the resonance of the supply line.

Other work on this project includes an investigation into the feasibility of stabilizing the valve by deresonating the supply line.

nuclear engineering

Dr. Glenn Murphy
Department Head and
Distinguished Professor

INVESTIGATION OF DYNAMIC SIMILITUDE FOR SMALL SCALE STRUCTURES, Project 502-S

SPONSOR: U. S. Air Force Special Weapons Center, Kirtland Air Force Base

PRINCIPAL INVESTIGATOR: Dr. Glenn Murphy

MAJOR STAFF: Richard Turley

ASSISTANT: Jerry J. Swift

A series of models of a reinforced concrete underground structure was designed in accordance with the principles of similitude to demonstrate how models may be used to predict the performance of full-scale structures. The project was recently completed.

SIMILITUDE, Project 528

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. Glenn Murphy

MAJOR STAFF: Richard Turley

The purpose is to investigate general methods of similitude approach to the design of models of engineering structures, and to develop methods of using similitude to identify the significant characteristics of materials and systems.

Similitude analysis is being developed, and the preliminary results are highly encouraging.

SPATIALLY-DEPENDENT REACTOR TRANSFER FUNCTION, Project 554-S

SPONSOR: Engineering Experiment Station

PRINCIPAL INVESTIGATOR: Dr. R. A. Danofsky

ASSISTANT: Richard A. Hendrickson

The objective of the project is to design, construct, and operate a system capable of measuring the reactor transfer function by the cross power spectral density technique and to verify the spatial dependence of a theoretical transfer function.

The counting rate circuits have been fabricated and the two channels of instrumentation have been developed for the cross-power spectral density measurements. Preliminary measurements have been made in the nuclear reactor. The results from these measurements serve to indicate that the sensitivity of the system should be increased if accurate measurements are to be obtained. This can be done with the addition of higher efficiency neutron detectors and improved pulse preamplification and discrimination.

USE OF MODELS TO SIMULATE DYNAMICALLY LOADED UNDERGROUND STRUCTURES, Project 574-S

SPONSOR: U. S. Air Force Special Weapons Center, Kirtland Air Force Base

PRINCIPAL INVESTIGATORS: Dr. Glenn Murphy, Dr. D. F. Young

MAJOR STAFF: Dr. K. G. McConnell

ASSISTANTS: Ervin T. Boulette, John L. Ridihalgh, Larry D. Schleuker

The objective is to apply the principles of similitude to permit the use of small scale laboratory models in predicting the response of large underground structures to blast loading.

The behavior of large structures may be predicted from small-scale models.

SMALL SCALE MODELS FOR EVALUATION OF RADIATION SHIELDING, Project 588-S

SPONSOR: Office of Civil Defense

PRINCIPAL INVESTIGATOR: Dr. Glenn Murphy

MAJOR STAFF: Dr. B. M. Ma

ASSISTANTS: Joaquin Batancourt, Donald Remington

The objective is to study various types of shelter designs, configurations, placement of shielding masses, combination of masses and materials to produce the most economical shelters meeting shelter protection requirements.

Advanced Engineering Degrees Awarded to 145 in 1965

A total of 145 advanced degrees were awarded engineers by Iowa State University in 1965.

Ninety-two Master of Science degrees were granted, as well as six Master of Engineering degrees and 47 doctorates by the Graduate College.

In the past 20-year span, 1,128 masters and 338 Ph.D. degrees have been granted by Iowa State's College of Engineering. This is an average of 56 masters and 17 doctorates annually.

WINTER QUARTER 1965

MASTER OF ENGINEERING

ROZENDAAL, HARVEY LEO
Major: Aerospace Engineering

MASTER OF SCIENCE

AL-KHAFAJI, ABDUL AMIR ABDUL REZAK
Major: Civil Engineering
Thesis: Effect of Inlet Design on Efficiency of Center-feed Sedimentation Tank Models

BENGTSON, HARLAN HOLGER
Major: Chemical Engineering
Thesis: Purification of Monoglycerides by Liquid-Liquid Extraction

BURANAKARN, VIRA
Major: Architectural Engineering
Thesis: A Central Library Facility for Chulalongkorn University

CORNISH, GEORGE KENT
Major: Agricultural Engineering
Thesis: Predicting Elbow Losses in Pneumatic Conveyors

FORRESTER, JOHN HAROLD
Major: Theoretical and Applied Mechanics
Thesis: Impact Characteristics of a Gas Expanding Through an Orifice

FRIED, EDGAR M.
Major: Chemical Engineering
Thesis: Performance Characteristics of a Fluidized Bed of Wheat Flour

GARTNER, GERALD JAMES
Major: Metallurgy
Thesis: Applications of an Adiabatic Calorimeter to the Determination of the Heats of Fusion and Heats of Formation of Several Metalic Compounds

HENCH, DAVID LEROY
Major: Electrical Engineering
Thesis: Feasibility Study of a Biologically Implantable PAM/FM Telemetry System

HIRVELA, ROBERT JACOB
Major: Electrical Engineering
Thesis: Serial to Parallel Computer Input Conversion

HOFFMAN, LARRY DEAN
Major: Electrical Engineering
Thesis: A Method of Reliability Apportionment of Electronic Equipment

KRUPP, WILLIAM EDWARD
Major: Metallurgy
Thesis: The Preparation of Vanadium Metal by the Aluminum Reduction of Vanadium Pentoxide

LIEU, FRED YET
Major: Metallurgy
Thesis: The Resistivity of Molton Bi-Sn Alloys

LOVE, ROBERT DALE
Major: Industrial Engineering
Thesis: Forecasting Vocational Training Needs: 1. A General Method 2. Application to the Building Construction Industry in Iowa

MOURLAM, LOUIS JR.
Major: Electrical Engineering
Thesis: Low Noise Narrow-band Amplification with Field Effect Transistors

REGUNATHAN, PERIALWAR
Major: Sanitary Engineering
Thesis: Permeability of Diatomite Filter Cakes Containing Various Clay Minerals

SAN GIOVANNI, JOHN PAUL
Major: Chemical Engineering
Thesis: Calculation of Profiles and Surface Area for an Expanding Interface

SEBENIK, ROGER FRANK
Major: Chemical Engineering
Thesis: Computer Solution of Solvent Extraction Cascade Calculations for the Rare-Earth Nitrate-TBP-Nitric Acid System

STEWART, EDWIN EUGENE
Major: Mechanical Engineering
Thesis: The Transfer Function of a Helical Compression Spring

TIMM, DELMAR CLARENCE
Major: Chemical Engineering
Thesis: Crystal Size Distribution Dynamics

VAN FOSSEN, RALPH HARLEY
Major: Metallurgy
Thesis: The Effects of Strain Rate and Temperature on the Ductility of Pure and Hydrogenated Vanadium

WOODLEY, NEIL HOWARD
Major: Electrical Engineering
Thesis: Digital Calculation of Unsymmetrical Faults

YOUNG, TOMMY LEE
Major: Metallurgy
Thesis: Concentration of Cesium from Pollucite

DOCTOR OF PHILOSOPHY

DOCK, CHARLES HARVEY
Major: Metallurgy
Thesis: Oxidation States of Thorium in Fused LiCl-KCl Eutectic

EDGINGTON, GLENN EMMETT
Major: Electrical Engineering
Thesis: Reflection Characteristics of Hemodynamic Systems Under Coherent Optical Radiation

EDMONDS, CLINTON JAMES
Major: Sanitary Engineering
Thesis: Effect of Solids Concentration on the Anaerobic Digestion of Domestic Sewage Sludge

GOBEN, CHARLES ALVIN
Major: Electrical Engineering
Thesis: Neutron Bombardment Reduction of Transistor Current Gain

GUIDRY, MARK ROMAN
Major: Electrical Engineering
Thesis: A Model of Terrestrial Radio Wave Propagation Using a Laser

MULLINS, JAMES ALBERT
Major: Agricultural Engineering
Thesis: Herbicide Distribution From a Granule Into Soil

OGREN, JOHN ROGER
Major: Metallurgy
Thesis: Thermodynamic Measurements on CsCl-Type Structures in Rare-Earth-Magnesium Systems

RUFF, CLARENCE GERALD
Major: Soil Engineering
Thesis: Time-Temperature-Strength-Reaction Product Relationships in Lime-Bentonite-Water Mixtures

SCHAFER, ROBERT LOUIS
Major: Agricultural Engineering-Engineering Mechanics
Thesis: Model-Prototype Studies of Tillage Implements

SPRING QUARTER 1965

MASTER OF ENGINEERING

SCHULTZ, ELMER LAVERN
Major: Electrical Engineering
Thesis: An Improvement in Flight Simulation of the Longitudinal Aircraft Axis

MASTER OF SCIENCE

BAKKER, MARVIN LEE
Major: Electrical Engineering
Thesis: Determination of the State Variable A-Matrix by Direct Measurement

BERENYI, STEVEN GEZA
Major: Mechanical Engineering
Thesis: Experimental Velocity Distributions in an Axisymmetric Annular Diffuser

BLANK, DAVID
Major: Agricultural Engineering
Thesis: Quantitative Relationship of Factors Affecting Water Yield from Small Watersheds in Iowa

DEVRIES, ROBERT KENNETH
Major: Transportation Engineering
Thesis: Effect of Aggregates on Physical Properties of Asphalt Concrete Mixes

FISHER, THOMAS PAUL
Major: Soil Engineering
Thesis: Skin Friction and the Coulomb Equation for Cast-In-Place Piles

HARRIS, JOHN RUSHEE
Major: Sanitary Engineering
Thesis: Tertiary Treatment of Domestic Wastes by Chemical Oxidation and/or Diatomite Filtration

JAWHARI, MUHYIDDIN KHAIRI
Major: Chemical Engineering
Thesis: Decomposition of Phosphate Rock in a Plasma Flame

JOSEPH, ROBERT RODERICK
Major: Metallurgy
Thesis: Solid Solubility of Magnesium in the Close-Packed Modifications of Some Rare Earth Metals

KALIA, KANWAL KRISHAN
Major: Chemical Engineering
Thesis: Production of an Adhesive Polymer from Zein and Dialdehyde Starch

DURANA, MARTIN LUTZ
Major: Chemical Engineering
Thesis: Controlled Release of Nutrients from Granular Fertilizers

MERKEL, JAMES ANTHONY
Major: Agricultural Engineering
Thesid: Zone Cooling of Lactating Sows

MERRITT, IRA WILSON JR.
Major: Nuclear Engineering
Thesis: Application of the Learning Curve Technique to the Economics of Nuclear Power

MERRY, KENNETH JAKE
Major: Civil Engineering
Thesis: Tertiary Treatment of Domestic Waste Water by Rapid Sand Filtration

RYAN, JOHN THOMAS
Major: Architectural Engineering
Thesis: An Investigation of Design Methods for Steel Rigid Frames

SCOTT, FRANCIS GORDON
Major: Transportation Engineering
Thesis: A Traffic Accident Study for the City of Ames, Iowa, 1959-1963

SMALLEY, STANLEY PAUL
Major: Transportation Engineering
Thesis: Future Development of the Des Moines Municipal Airport

SWIFT, JERRY JOHNSON
Major: Nuclear Engineering
Thesis: Effects of Radiation on Fretting Corrosion of Zirconium and Zirconium Alloys

TAYLOR, MARVIN KEITH
Major: Aerospace Engineering
Thesis: Noncoplanar Intercept Procedures for Vehicles Launched from Different Sites

ZYLSTRA, HENRY JOHN
Major: Electrical Engineering
Thesis: Magnetoresistance in Silicon

DOCTOR OF PHILOSOPHY

BAILIE, RICHARD C.
Major: Chemical Engineering
Thesis: Behavior of Individual Particles in a Fluidized Bed

BASYE, CHARLES BENJAMIN
Major: Engineering Mechanics
Thesis: Oscillations of a Sphere in a Cylindrical Tube Containing a Viscous Liquid

BOLON, ALBERT EUGENE
Major: Nuclear Engineering
Thesis: Surface Temperature Distribution of Thermocouple Alloys by Infrared Photography

CAVINS, ROBERT EUGENE
Major: Electrical Engineering
Thesis: The Fabrication and Emission of Gallium-Aresnide Lasing Diodes

CHANG, JUANG-CHI
Major: Electrical Engineering
Thesis: A Parametric Traveling-Wave Amplifier Using Oriented Thin Magnetic Film

CUNNING, JOE DAVID
Major: Chemical Engineering
Thesis: Horizontal Distillation

ELLIOT, WILLIAM STEVENS
Major: Electrical Engineering
Thesis: Investigations of Yttrium-Iron-Garnet Materials in Coaxial Coupling Structures for Preselector Applications

QUENTIN, GEORGE HEINZ
Major: Chemical Engineering
Thesis: Dynamic Behavior of a Distillation Tray

SCHILMOELLER, NEIL HERMAN
Major: Nuclear Engineering-Mechanical Engineering
Thesis: The Effect of Selected Impurities on Some Optical Properties of Silicon

SHEPARD, MARION LAVERNE
Major: Metallurgy
Thesis: Single Crystal Elastic Constants of Lead-Thallium Alloys

SUMMER SESSION I, 1965

MASTER OF ENGINEERING

LEE, SUNG MOO
Major: Chemical Engineering

MASTER OF SCIENCE

BLUMENBERG, WAYNE EDWARD
Major: Chemical Engineering
Thesis: Fortran Simulation of a Digital Differential Analyzer

CARLSON, MICHAEL CLAUDEWELL JON
Major: Nuclear Engineering
Thesis: Gamma Dose Measurements in the Rabbit Tube of the UTR-10

CHITTENDEN, JIMMIE ALAN
Major: Chemical Engineering
Thesis: Equilibrium Data for the TBP-D2EHPA-Nd $(NO_3)_3$-HNO_3 System

HALLIGAN, JAMES EDMUND
Major: Chemical Engineering
Thesis: Prediction of the Approach to Steady-State of a Mixer-Settler Extractor

IVES, BRIAN FREDERIC
Major: Chemical Engineering
Thesis: Single Sample Analysis by Gas-Liquid Chromatography of Products from a Tubular Flow Bitane Nitrator

MERMELSTEIN, NEIL HOWARD
Major: Chemical Engineering
Thesis: Climbing-Film Evaporation of Sugar Solutions

SCIGLIANO, J. MICHAEL
Major: Engineering Valuation
Thesis: An Evaluation of the Weibull Function as an Estimator of Industrial Property Mortality

SHUCK, DAVID LEROY
Major: Chemical Engineering
Thesis: Comparison of Axial Dispersion and Radial Diffusion Models for Fixed Bed Catalytic Reactor Design

SILVA, WALDOMIRO GOMES da
Major: Transportation Engineering
Thesis: A Suggested Sufficiency Rating System Applicable by Brazilian Highway Departments

TRULIN, DARRYL JON
Major: Aerospace Engineering
Thesis: An Expansion-Deflection Nozzle Design Theory

YARGER, NORMAN LEROY
Major: Mechanical Engineering
Thesis: The Thermal Conductivity of Liquid Lead-Bismuth Eutectic

DOCTOR OF PHILOSOPHY

ENGLESSON, GEORGE ANTHONY
Major: Nuclear Engineering
Thesis: Superconducting Coils for Shielding in Space

EVANS, DENNIS REX
Major: Chemical Engineering
Thesis: Dynamic Testing in the Control of a Pulse Column

HILMES, JEROME BERNARD
Major: Structural Engineering
Thesis: Statistical Analysis of the Fatigue Characteristics of Underreinforced Prestressed Concrete Flexural Members

OKIISHI, THEODORE HISAO
Major: Mechanical Engineering-Engineering Mechanics
Thesis: Fluid Velocity Profile Development for Turbulent Flow in Smooth Annuli

SUMMER SESSION II, 1965

MASTER OF ENGINEERING

ANDERSON, GERALD D.
Major: Mechanical Engineering

DEJONG, PAUL STEPHEN
Major: Mechanical Engineering

MASTER OF SCIENCE

ABDULRAHIM, MOHAMMED
Major: Electrical Engineering
Thesis: Inrush Current for Switched Capacitor Bank

BUELL, CHARLES HENRY JR.
Major: Chemical Engineering
Thesis: Determination of Liquid Metal Diffusion Coefficients by Molecular Distillation

CARTER, NEAL EDWARD
Major: Nuclear Engineering
Thesis: Gamma Ray Shilding Using Cylindrical Geometry and Laminated Media

DEVENS, JOHN WELLINGTON
Major: Soil Engineering
Thesis: Development of a Vibratory Soil Drill

FOX, DAVID MARTIN
Major: Civil Engineering
Thesis: Experimental Evaluation of Sand Filtration Theory

JENISON, ROLAND DUANE
Major: Aerospace Engineering
Thesis: Foreplane-Wing Interference Effects in Supersonic Flow

KOEHRSEN, LAWRENCE GILBERT
Major: Sanitary Engineering
Thesis: Sludge Thickening Studies at the Ames, Iowa Water Pollution Control Plant

McWILLIAMS, CONRAD ALLEN
Major: Structural Engineering
Thesis: Influence of Stirrup Confinement on Bond Strength of Concrete

OWENS, THOMAS CHARLES
Major: Chemical Engineering
Thesis: Simultaneous Equilibria of D2EHPA and TBP with Pr (NO3)3 and Nd (NO3)3 Solutions

RUSSELL, EUGENE ROBERT
Major: Civil Engineering
Thesis: A Study to Correlate Soil Consistency Limits with Soil Moisture Tensions

VAN DIERENDONCK, ALBERT JOHN
Major: Electrical Engineering
Thesis: Convergence of the Integral of the Periodogram Function and Other Related Problems in Random Process Theory

VOGEL, JERALD MILO
Major: Aerospace Engineering
Thesis: Optimization of Satellite Inteceptor Trajectories

WOLFF, PHILIP RUSSELL
Major: Chemical Engineering
Thesis: Suspension Density Transients in a Mixed Suspension Crystallizer

DOCTOR OF PHILOSOPHY

BRUCE, ROBERT ALLAN
Major: Electrical Engineering
Thesis: An Investigation of a Multiple Iteration Rate Incremental Data Processor

DILLMAN, NORMAN GREGG
Major: Electrical Engineering
Thesis: Photodielectric Effect in Semiconductors

FURRY, RONALD BAY
Major: Agricultural Engineering
Thesis: Similitude Study of the Change in CO2 Concentration in a Ventilated Enclosure

HOOTMAN, JOALLAN
Major: Electrical Engineering
Thesis: Scattering of Electromagnetic Waves from a Known One-Dimensional Pressure Field

MARLEY, STEPHEN JOSEPH
Major: Agricultural Engineering-Theroetical and Applied Mechanics
Thesis: Field Work Completion Probabilities for Row Crop Production

RODERICK, GILBERT LEROY
Major: Soil Engineering
Thesis: Water Vapor-Sodium Montmorillonite Interaction

VAIGNEUR, HUGH OSWELL
Major: Agricultural Engineering
Thesis: Water Table Frequencies of Tile-Drained Land Based on Moisture Balance

FALL QUARTER 1965

MASTER OF ENGINEERING

JOHNSON, JAMES THOMAS
Major: Aerospace Engineering

MASTER OF SCIENCE

ARNBAL, CARL ANTON
Major: Soil Engineering
Thesis: Effects of Delay of Compaction on Soil-Cement and Soil-Lime-Cement Mixtures

BARBERREE, DANIEL ALBERT
Major: Chemical Engineering
Thesis: Preliminary Design of an Intergrated Soybean Oil-Beet Sugar Extraction Plant

BRAVO, JUAN MANUEL
Major: Ceramic Engineering
Thesis: Slag Resistance of Some Selected Refractories

BREKKEN, ROGER ALLEN
Major: Chemical Engineering
Thesis: Feasibility of Soybean Oil Refining in Iowa

BUTT, GHULAM SAFDAR
Major: Transportation Engineering
Thesis: Feasibility Study of Lyallpur-Rawalpindi Highway

CHEN, FRANK T. L.
Major: Electrical Engineering
Thesis: Computer Studies on Daily Peak Loads Forecasting

CHILDS, WILLIAM HENRY
Major: Electrical Engineering
Thesis: The Feasibility of Traveling Wave Parametric Amplification in Ferroelectric Ceramics

CLEARY, DAVID JOHN
Major: Chemical Engineering
Thesis: Wetting Characteristics of Liquid Lead-Bismuth Eutectic on Stainless Steels

FAY, THOMAS EDWIN
Major: Electrical Engineering
Thesis: Computer Programming of Games

GASKILL, ROBERT ALLEN
Major: Electrical Engineering
Thesis: Improved Method for Solving the Best Path Problem

HAMMERBERG, CHARLES CLIFFORD
Major: Metallurgy
Thesis: Diffusion of Hydrogen in Barium Metal

HELD, PETER CHRISTIAN
Major: Ceramic Engineering
Thesis: Vaporization of Solid UO_2

HENDERSON, ALLEN JAMES
Major: Engineering Valuation
Thesis: The Weibull Distribution and Industrial Property Mortality Experience

HENTZEL, HENRY CHARLES
Major: Mechanical Engineering
Thesis: Prediction of Velocity Distributions in Annular Diffusers for Axisymmetric, Steady, Isentropic Flow

HUANG, ROBERT TING-PO
Major: Chemical Engineering
Thesis: Laminar Flow Heat Transfer in Circular Tube—Numerical Solution Including the Effect of Axial Conduction

HUTCHISON, JOHN FRANCIS
Major: Metallurgy
Thesis: Vapor Pressures of Alkaline Earth Bromides and Iodides

JAWORSKI, RICHARD LEE
Major: Nuclear Engineering
Thesis: Control Rod Calibrations of a Coupled Core Reactor

JELINEK, FRANK JOSEPH
Major: Metallurgy
Thesis: Thermal Hysteresis and Initial Susceptibility Investigation of Magnetic Transitions in Several Rare Earth Metals

KNIGHT, ROGER SCOTT
Major: Civil Engineering
Thesis: Performance of a Cage Rotor in an Oxidation Ditch

MURDOCH, LAWRENCE BRYSON
Major: Chemical Engineering
Thesis: Separation of Cadmium from the Lead-Bismuth Eutectic by High Vacuum Single Stage Distillation: Chamber Design and Distillate Purity

PETTIT, DONALD ETHAN
Major: Metallurgy
Thesis: The Combined Effect of Mean Stress and Stress Concentrations on the Fatigue Properties of 2011-T3 Aluminum Alloy

POORE, BERNARD BRANDT
Major: Agricultural Engineering
Thesis: The Factors Affecting the Field Operation of a Hay Waferer

SMITH, DONALD PHILIP
Major: Engineering Mechanics
Thesis: Effect of Screens on Shock Tube Impact Characteristics

SODERQUIST, SVEN D.
Major: Metallurgy
Thesis: The Calcium-Ytterbium System

TUAZON, JESUS OCAMPO
Major: Electrical Engineering
Thesis: On the Influence of Magnetic Field on the Current Gain of Junction Transistor

WEAR, FREDERICK COLEMAN
Major: Mechanical Engineering
Thesis: An Experimental Investigation of the Air Flow Characteristics of Capillary Tubes

YIEH, HEH-NIEN
Major: Chemical Engineering
Thesis: Drying Extracted Sugar Beet Pulp

DOCTOR OF PHILOSOPHY

ALLEN, GALE RICHARD
Major: Electrical Engineering
Thesis: Magnetic Thin Films for an Adaptive Weighting Element

ANDERSON, JOHN ERNEST
Major: Aerospace Engineering-Mathematics
Thesis: Vibrational Relaxation and Nonequilibrium Dissociation in Gasdynamic Flows

ASSAF, WALID CONSTANTINE
Major: Nuclear Engineering
Thesis: Application of Dimensional Analysis to Radiation Shielding

COADY, LARRY BERNARD
Major: Electrical Engineering
Thesis: On a Cut-Set to Mesh Transformation

DILLINGHAM, JAMES HUGH
Major: Sanitary Engineering
Thesis: Use of Digital Computer in Design of Diatomite Filtration

EMANUEL, JACK HOWARD
Major: Structural Engineering
Thesis: Problems of Bridge Supporting and Expansion Devices and an Experimental Comparison of the Dynamic Behavior of Rigid and Elastomeric Bearings

FRISBY, JAMES CURTIS
Major: Agricultural Engineering
Thesis: Influence of Weather and Economics on Corn Harvesting Machinery Systems

GOERING, CARROLL EUGENE
Major: Agricultural Engineering-Engineering Mechanics
Thesis: The Mechanics of Unsprung Wheel Tractors

GRAY, JAMES ARTHUR
Major: Chemical Engineering
Thesis: An Equilibrium Study of the Chloride and Nitrate Systems of Praseodymium and Neodymium with Tributyl Phosphate and Acid

HABERLY, CHARLES FREDERICK
Major: Electrical Engineering
Thesis: Using a Power Transmission Line as a Digital Communication Channel in the 70 to 100 cps Range

HENG, OWEN ALBERT
Major: Chemical Engineering
Thesis: Dynamics of a Nonisothermal Imperfectly Mixed Tank Reactor

HOFT, RICHARD GIBSON

Major: Electrical Engineering
Thesis: Liapunov Stability Analysis of an SCR Brushless Motor Drive

LORETAN, PHILIP A.
Major: Nuclear Engineering
Thesis: Laplace-variational Method for Transient Multidimensional Temperature Distributions

MCDONALD, ROSS MERLE
Major: Theoretical and Applied Mechanics
Thesis: Minimization of Similitude Parameters in Physical Phenomena

MANGOLD, DUANE WILBUR
Major: Agricultural Engineering
Thesis: Effect of Air Temperature on Energy Utilization of Growing-Finishing Swine

MARLOWE, MICKEY ORVILLE
Major: Ceramic Engineering
Thesis: Resonant Frequency Determinations Applied to Sintering Phenomena

SMITH, MELVIN RAY
Major: Agricultural Engineering
Thesis: Ventilating Characteristics of Slotted Inlets for Livestock Buildings.

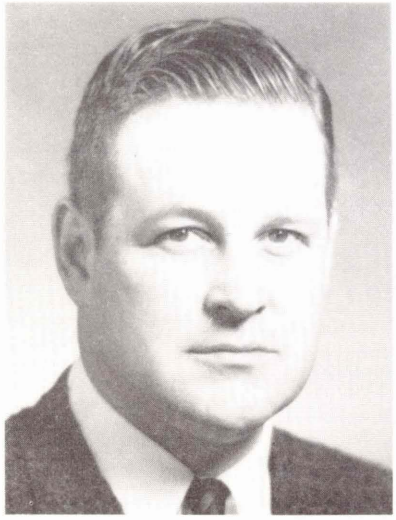
(Continued from page 8)

BRIDGER, GROVER L. and BOYLAN, DAVID R.	Fertilizer Compositions and Method of Preparation Thereof	2,782,113 2-19-57
BRIDGER, GROVER L. and CHANG, HSON M.	Separation of Menthol from Mint Oils by a Fractional Distillation Process	2,662,052 12-8-53
BRIDGER, GROVER L. and SPECHT, GORDON DEAN	Feed Chute Structure and Method of Feeding Particulate Material	2,799,377 7-16-57
CHANG, HSON M.	Separation of Menthol from Mint Oils by Chromatographic Adsorption	2,760,993 8-28-56
CHU, TING YE and DAVIDSON, DONALD T.	Soil Dispersion Apparatus	2,746,731 5-22-56
COLLINS, EDGAR V.	Earth Terracer with Variable-Speed Transmission	2,578,127 12-11-51
COLLINS, EDGAR V.	Earth Moving Apparatus	2,578,128 12-11-51
CSANYI, LADIS H.	Apparatus for Mixing Finely Divided Soilds with Liquids	2,861,787 11-25-58
CSANYI, LADIS H.	Method of Combining a Bituminous Binder with an Aggregate Material	2,917,395 12-15-59
DAVIDSON, DONALD T. and NICHOLLS, ROBERT L.	Soil Stabilization with an Organic Derivative of Ammonia and an Acrylate Polymer	2,981,162 4-25-61
FITTS, JAMES WALTER	Soil Crushing or Treating Apparatus	2,636,689 4-28-53
HANDY, RICHARD L. and DAVIDSON, DONALD T.	Soil Testing Apparatus	2,877,647 3-17-59
HUGHES, WILLIAM L.	Frequency Dividing Circuit	2,739,240 3-20-56
HUGHES, WILLIAM L.	Method for Recording and Reproducing Color Television Information	2,953,633 9-20-60
HUGHES, WILLIAM L.	Color Television Recordal	2,969,425 1-24-61
HUGHES, WILLIAM L.	Field Sequential Color Signal Combined with Continuous Brightness Signal	3,048,653 8-7-62
MATTSON, ROY H.	Switching System	2,981,832 4-25-61
READ, ALVIN A.	Counting Circuit	2,927,246 3-1-60
SPANGLER, MERLIN G. and CHU, TING YE	Method of and Apparatus for Testing Asphaltic Concrete	2,637,198 5-5-53
SWEENEY, ORLAND R. and ARNOLD, LIONEL K.	Countercurrent Extraction Apparatus	2,497,700 2-14-50
SWEENEY, ORLAND R. and ARNOLD, LIONEL K.	Solvent Extraction Apparatus and Process	2,501,880 3-28-50
SWEENEY, ORLAND R., ARNOLD, LIONEL K. and HOLLOWELL, EUGENE G.	Solvent Recovery by Distillation	2,504,053 4-11-50
SWEENEY, ORLAND R., ARNOLD, LIONEL K. and LONG, JUSTIN T.	Plastic from Furfural and Lignin or Lignin Sulfonic Acid	2,671,061 3-2-54
SWEENEY, ORLAND R., ARNOLD, LIONEL K. and LONG, JUSTIN T.	Process of Polymerizing a Mixture of Furfural, a Secondary Aromatic Amine and a Lignin Compound and Product Obtained Thereby	2,871,207 1-27-59
SWEENEY, ORLAND R., BROWN, MELVIN H. and ARNOLD, LIONEL K.	Production of Lignin, Cellulose, and Pentosans	2,615,883 10-28-52
WALKER, RICHARD E., BRIDGER, GROVER L. and ARNOLD, LIONEL K.	Method of Impregnating Wood with Wood-Preserving Oil	2,799,597 7-16-57
WHEELOCK, THOMAS D. and BOYLAN, DAVID R.	Reductive Decomposition of Calcium Sulfate	3,087,790 4-30-63
WILLETT, RICHARD M.	Sweep Circuit	2,923,837 2-2-60
YOERGER, ROGER R.	Method of Segmenting Corncobs	2,766,795 10-16-56
YOERGER, ROGER R.	Apparatus for Segmenting Corncobs	3,019,829 2-6-62

ENGINEERING COLLEGE PATENT APPLICATIONS

Inventor	Title	Serial Number Filing Date
ARP, LEON J.	Temperature Indicating and Controlling Apparatus	322,850 11-23-63

ARP, LEON J.	Anesthetic Device	328,999 12-9-63
ARP, LEON J.	Infant Supporting Apparatus	335,159 1-2-64
ARP, LEON J.	Oxygen Utilization Analyzer	347,785 3-12-64
ARP, LEON J.	X-Ray Trigger System Responsive to Cyclic Phenonmenon	472,792 7-19-65
ARP, LEON J. and GRIFFITH, RONALD J.	Apparatus for Measuring Breath Volume	337,778 1-15-64
BOLIE, VICTOR W.	Automatic Heart Massage Device	203,967 6-20-62
BOLIE, VICTOR W.	Erythrocyte Counter	227,796 10-2-62
BOLIE, VICTOR W.	Pneumatic Sawtooth Oscillator	261,314 2-27-63
BOLIE, VICTOR W.	Artificial Heart Cycling System	404,028 10-15-64
BOLIE, VICTOR W.	Whole Body Perfusion Time Monitor and Method	408,952 11-4-64
BOYLAN, DAVID R. and FENG, KUO KANG	Method of Producing Dicalcium Phosphate	478,000 6-18-65
BROWN, ROBERT G.	Terrestrial Navigation System	403,522 10-13-64
CAMP, ROGER C.	Magnetic Recording Device	192,419 5-4-62
CARLSON, DAVID L.	Respiratory Augmentor	332,369 12-23-63
CURRENCE, H. DAVID	Leaf-Strip Harvesting System	464,776 6-17-65
DEMIREL, TURGUT	Construction Material and Method of Producing Same	382,400 7-13-64
JOHNSON, HOWARD P.	Flow Meter for Measuring Pipe Discharge	238,150 11-16-62
KLINE, JACOB	Myocardial Prosthetic Device and Method	334,451 1-20-64
LARSON, MAURICE A. and HONG, KI CHOONG	Method of Supplying Phosphorus to the Soil	277,010 4-30-63
MORFORD, VILAS J. and EGGENBERGER, LEWIS	Bleacher	218,644 8-22-62
MUIR, ROBERT M.	Magnetic Memory for Display of Transients	376,313 7-8-64
POHM, ARTHUR V. and READ, ALVIN A.	Inductor and Method	50,691 8-19-60
READ, ALVIN A.	Magnetic Film Device Useful as a Modulator and Method	84,218 1-23-61
SCHLEUSENER, STUART A.	Laser Small-Particle Detector and Method	507,194 11-10-65
SPICER, CARMI N. and DEMIREL, TURGUT	Undercoating	390,711 8-19-64
WHEELOCK, THOMAS D. and BOYLAN, DAVID R.	Reductive Decomposition of Calcium Sulfate	276,559 4-29-63



Dr. A. V. Pohm Receives Western Electric Award

Dr. Arthur V. Pohm, Professor of Electrical Engineering, received the 1965-66 Western Electric Fund Award of the North Midwest Section of the American Society for Engineering Education this past winter.

The award, which is in recognition of outstanding teaching achievement, and a $500 check were presented at a ceremony in the Iowa State Electrical Engineering Auditorium. The presentation was made by R. F. Byron, chief engineer of Western Electric's Hawthorne Works located in Chicago, Illinois.

Pohm came to Iowa State in 1958, and most of his formal teaching is at the graduate level where he has developed courses in electrical properties of materials and in the design of computers.

Under his direction, a successful graduate program and research facility in solid state electronics have been developed. He was a leader of an Engineering Research Institute group which first investigated and reported on the feasibility of using thin magnetic films and parametrons for computing.

engineering Collage*

*A collection of diverse elements.

Researchers Study Shock Waves Under NSF Grant

The National Science Foundation recently awarded a $36,800 grant to a team of Engineering Research Institute researchers for theoretical investigation in shock waves as they pertain to such things as atomic bomb explosions and solid rocket propellants under exceedingly high stress.

Although the results of the two-year research program will have application to any area of study involving impact or shock waves, the Iowa State researchers are concerned chiefly with problems of impacts on spheres and waves within solid rocket fuels.

Dr. K. C. Valanis, associate professor of Engineering Mechanics, heads the investigation. He is being aided by T. C. Sun, assistant professor of Engineering Mechanics, and Moche Ziv, a graduate student.

Dr. K. C. Valanis

They will spend the two years allowed by the grant in the mathematical analysis of wave propagation in non-elastic materials, which are those which diminish impact waves as they spread from the point of impact.

The title of the project is "Transient Waves in Linear Viscoelastic Media."

Professor M. G. Spangler Featured in Magazine

Professor M. G. Spangler, 42 years on the research staff of the Engineering Research Institute, is the subject of a profile in the January-February issue of *Cast Iron Pipe News.*

The profile notes Professor Spangler's standing as an international authority on soil and structural engineering, and cites honors he has received for distinguished service to the engineering profession.

"At 71," the writer says, "Merlin Spangler has the uncompromising precision of an engineer; the clarity of a good teacher; the friendly informality of a born-and-bred Midwesterner; and a capacity for living that takes no account of the years."

Cast Iron Pipe News, published by the Cast Iron Pipe Research Association, is circulated among engineers, utilities executives, and civic officials throughout the United States.

$75,100 Grant Received By Electrical Engineers

A $75,100 National Science Foundation grant has been received by three Engineering Research Institute staff members to continue basic research into "Thin Magnetic Films".

The grant is for a two-year program.

Heading the Electrical Engineering research team is Dr. A. A. Read. Dr. A. V. Pohm and Dr. R. L. Samuels are associate investigators.

Under previous National Science Foundation grants, dating back to 1959 the team conducted research into magnetic film materials and devices. The new grant will allow the staff to further their research into four main areas: Non-uniform rotational switching; the effect of magnetostatic interaction on quasi-static and dynamic loss; demagnetization effects on anisotrophy and disperson; and optimized sandwiched films.

New Book Released On Combustion Gases

The Iowa State University Press recently released "Thermodynamic Properties of Combustion Gases," a 213-page book by Jerry D. Pearson, NASA Fellow in Mechanical Engineering and Computer Science, and Robert C. Fellinger, professor of Mechanical Engineering.

The authors have developed a set of tables for quickly deriving the various properties of combustion gases without the use of a computer. The book's 20 tables are expected to have practical applications in industry and in the classroom. According to the publisher, the book "can aid engineers in overcoming problems of design by enabling them to anticipate pressures and temperatures of combustion gases more easily. The tables serve as a substitute for the lengthy equation systems and computer techniques now necessary in even preliminary calculations of thermodynamic properties. When a computer is used for final accuracy, the

tables will aid in reaching correct solutions quickly."

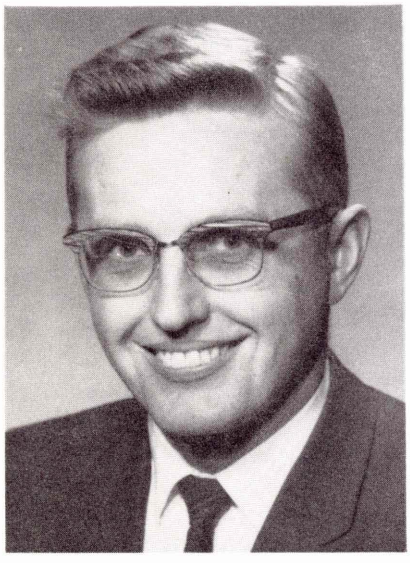
Dr. J. L. Cleasby to Study Sand Filter Performance

A $21,500 grant was recently received by Dr. John L. Cleasby, professor of Civil Engineering for research entitled "Empirical Prediction of Sand Filter Performance."

The Department of Health, Education and Welfare of the U. S. Public Health Service awarded the grant to Dr. Cleasby for the first year's work of a three-year study.

According to Dr. Cleasby, "There has been a trend in recent years to higher filtration rates for sand filters used in municipal water treatment. However, no acceptable rational method has been developed to predict quantitatively the filtering characteristics of a given suspension of solid using a granular filter media."

Dr. Cleasby explains further that previous attempts at developing a filtrability index were done with thin filters which measure only surface



Dr. J. L. Cleasby

removal effect and thus were not indicative of the depth removal obtained in a sand filter. Equations currently under study for prediction of the filter behavior have limitations that seriously restrict their usefulness.

"Data collected in this study should permit proper evaluation of such equations," according to Dr. Cleasby.

Two Research Initiation Grants Received

Two National Science Foundation Research Initiation Grants totaling $38,400 have been awarded recently to two Engineering Research Institute staff members.

The two staff members receiving the grants are Dr. Richard Danofsky, assistant professor of Nuclear Engineering, and Dr. Joseph M. Brown, assistant professor of Electrical Engineering.

Dr. Danofsky's research, entitled "Space Dependent Kinetics of Coupled Core Nuclear Reactors" is directed toward a theoretical and experimental study of the space time kinetics of coupled core reactors. Theoretical transfer functions for couple core reactors will be derived. The resulting expressions will relate the time variation of the neutron density in the reactor to an external input and will be a function of the observation point, input location and frequency of the input. Experimental transfer function measurements will be carried out in the Nuclear Engineering Department's UTR-10 reactor and results will be compared with theory.

Dr. Brown's research is entitled "Surface Properties of Silicon Structure." He will investigate certain surface properties of silicon at very low temperatures. Included will be a study of characteristics of Metal-Oxide-Semi-conductor (MOS) structures by utilizing diffused contacts of similar conductivity type to that of the substrate, opposite conductivity type and one of each.

It is hoped that the study will allow quantitative examination of possible space-charge-limited surface phenomena which have been qualitatively suggested by other investigators.

The investigation will also include examination of the effects on the surface of the metal "gate" region, the overlying oxide and contact with liquid helium under each condition.

Graduate College Enrollment Holds Steady

Enrollment of graduate students in the College of Engineering for Fall 1965 numbered 350, as compared to 353 for Fall 1964. Electrical Engineering continues to hold the lead in enrollment, with 84 students.

A departmental tabulation of graduate student enrollment for the fall quarters of 1965, 1964 and 1962 follows:

	1965	1964	1962
Aerospace Engineering	29	19	19
Architectural Engineering	5	5	7
Ceramic Engineering	14	12	7
Chemical Engineering	69	74	57
Civil Engineering	57	49	44
Electrical Engineering	84	85	90
Engineering Mechanics	11	7	--
Industrial Engineering	14	40	5
Mechanical Engineering	19	27	42
Nuclear Engineering	44	30	37
Theoretical and Applied Mechanics	4	5	13
TOTALS	350	353	321

NASA Provides 15 More Graduate Traineeships

With 15 new traineeships awarded by the National Aeronautics and Space Administration, Iowa State University will have 53 NASA trainees next fall.

The traineeships provide support for three years for students working toward Ph.D. degrees in space-related sciences, engineering and other fields of interest to NASA.

While NASA has not announced the amount of funds to be provided for the 15 new traineeships, Dr. J. B. Page, dean of the ISU Graduate College and vice president for research, said indications are that it will be at least $265,000. A year ago NASA awarded that amount. A similar award this time will bring the four-year total to more than $900,000 from NASA in support of the graduate training program at Iowa State.

Graduate students selected for traineeships receive a stipend of $2,400 for 12 months of training plus dependency allowances.

Baumann Presents Award Winning Committee Paper

A paper presented by Dr. E. Robert Baumann, professor of Civil Engineering, has been selected as the outstanding contribution to water purification in 1965 by the American Waterworks Association.

Dr. Baumann is professor in charge of the sanitary engineering section of Department of Civil Engineering.

The paper, entitled "Diatomite Filters for Municipal Use", was a committee report of a task group from the association composed mostly of industrial researchers and chairmanned by Dr. Baumann. The paper incorporated many concepts resulting from a five-year Engineering Research Institute study headed by Dr. Baumann.

The American Association of Professors in Sanitary Engineering recently elected Dr. Baumann its secretary-treasurer for 1966-67.

Dr. E. R. Baumann

Record Job Prospects For Engineering Grads

ISU Engineering graduates found job opportunities in practically every area at an all-time high in 1966, with salaries pushing above 1965's top marks and more positions available than ever before.

The College of Engineering had a record-breaking year in terms of employer visits to the campus, and reported average annual starting salaries for bachelor of science degree-holders $300 above 1965.

Lawrence R. Hillyard, placement director for the College, said 660 employer visits were made to the ISU campus during the 1965-66 academic year. Nearly 8900 interviews were scheduled.

He reported that as of the week prior to spring graduation all of the ISU engineering graduates who had been looking for jobs had been placed, were going to graduate school, or had offers of employment. Approximately four jobs were available for each graduate.

A record for starting salaries was also set. For the B. S. degree holder the average starting salary was $674 per month.

Hillyard said that Iowa State's two-year Technical Institute graduates averaged about $526 per month, up $32 from the previous year.

Dr. L. K. Arnold Honored For 40 Years Service

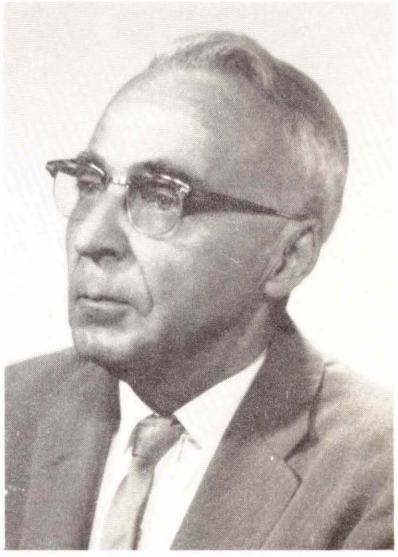
Dr. Lionel K. Arnold, retiring professor of Chemical Engineering, was honored in April for his more than 40 years of service to Iowa State University.

Dr. Arnold, a well-known authority on explosions, retired from the ISU faculty May 31. He is continuing his work as a private consultant on explosion and fire cases.

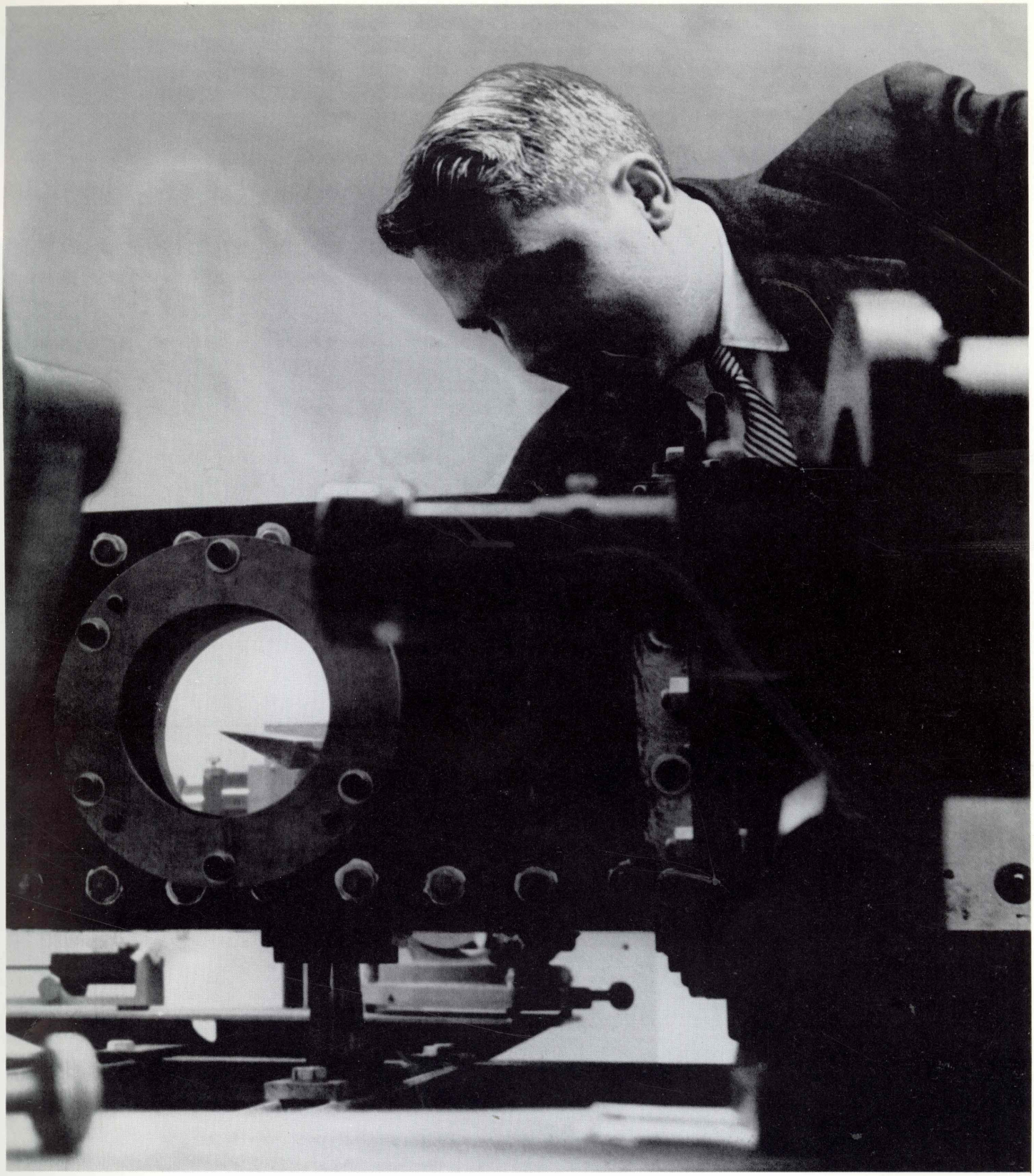
In addition to his consultation work and expert witness services in numerous fire, explosion and poisoning cases, Dr. Arnold is noted for his work at the Engineering Research Institute with plastics research and the utilization of agricultural products. He has contributed more than 150 publications to the technical and popular press.

Dr. Arnold first joined the ISU staff in 1925.

Dr. Arnold received his A.B. degree from Ellsworth College in 1920. He took his B.S., M.S. and Ph.D. degrees at Iowa State between 1921 and 1930.



Dr. L. K. Arnold



SHOCK TUBE LABORATORY The Shock Tube Laboratory, operated by the Department of Mechanical Engineering through funds made available by the Engineering Research Institute, is the subject of a feature article appearing in the next issue of IOWA STATE ENGINEERING RESEARCH. Dr. Bruce L. Johnson, Associate Professor of Mechanical Engineering, is shown with the test section of the 40-foot long, single diaphragm type shock tube.