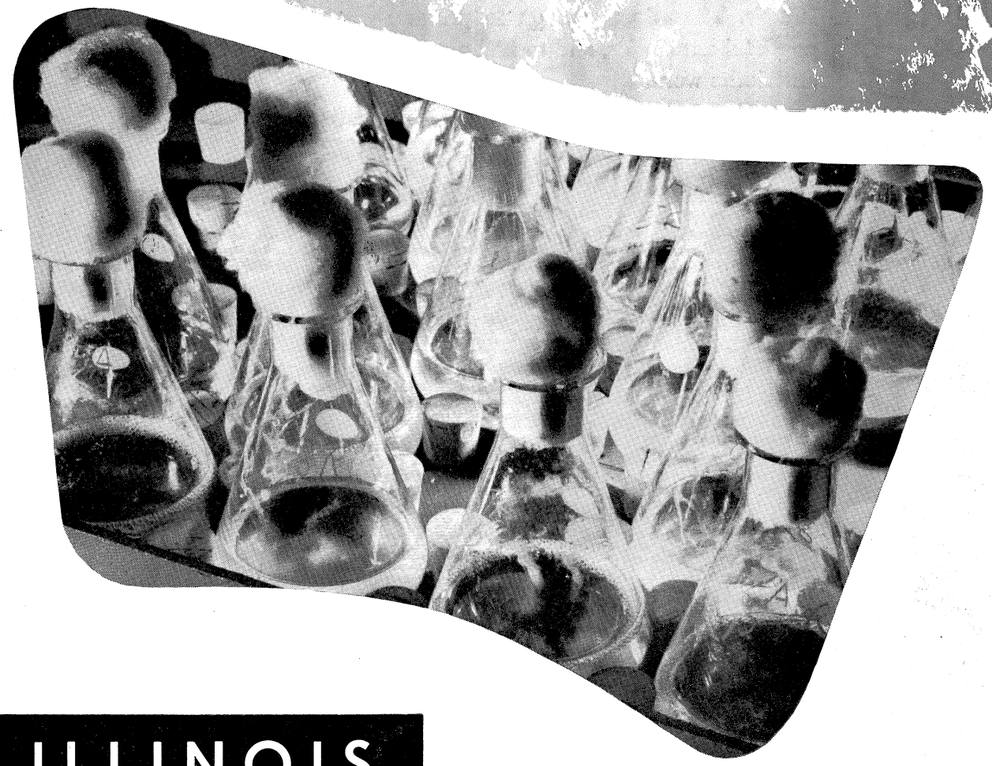
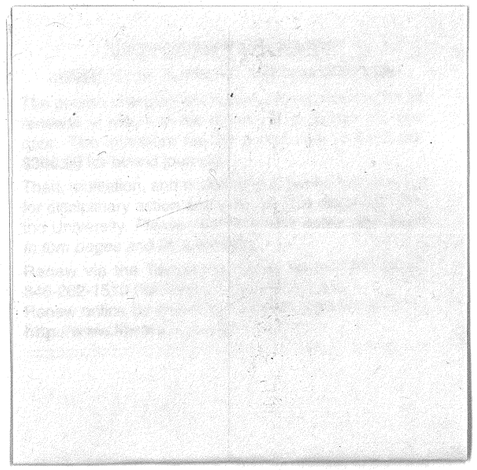
RESEARCH



AT ILLINOIS

UNIVERSITY OF ILLINOIS
BULLETIN

The picture on the cover shows some of the sterile bottles in which penicillin and other antibiotics are grown in the Illinois laboratories. Chloromycetin, one of the four powerful antibiotics (the others are penicillin, streptomycin, and aureomycin), was discovered independently at Illinois. The effort goes on to produce new and more powerful antibiotics, and to find out more about how the antibiotics work.



UNIVERSITY OF ILLINOIS BULLETIN

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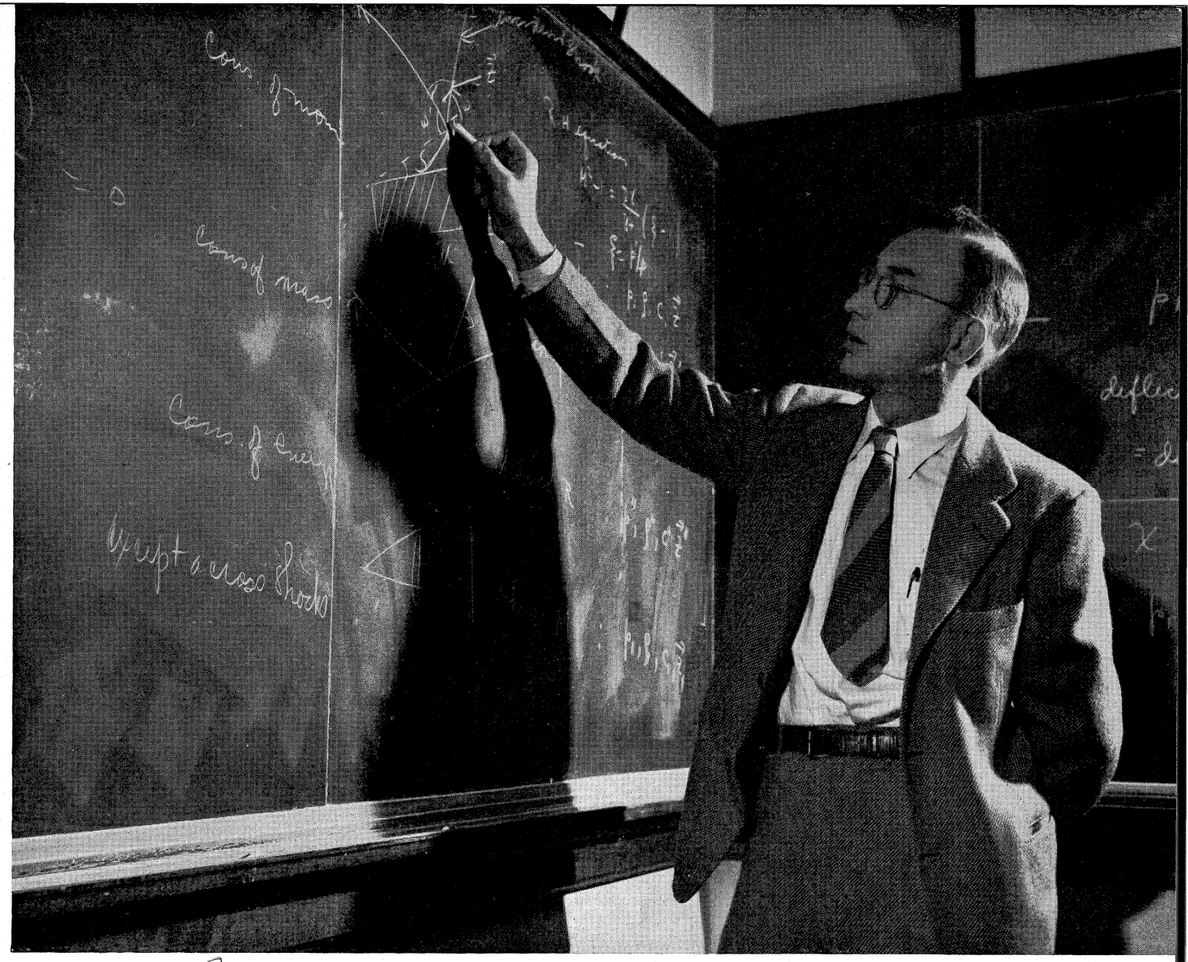


Research at Illinois

A UNIVERSITY is more than a teaching institution. It is a forward outpost in man's continuing attack upon the unknown. Research at the University of Illinois has led and is leading to important victories over ignorance, misunderstanding, and the brute forces of environment.

Because men use instruments of measurement and control, the pictures in this booklet are often filled with impressive apparatus. The reader should not be misled by this circumstance. *Men* do research; apparatus assists them. The most important requirement for a sound and successful research program is a staff capable of first-rate work. To emphasize this fact, our first picture shows the basic and irreducible resource required for any research: a man who is interested in it and competent to do it. The man shown is A. H. Taub, Research Professor of Applied Mathematics. His interests are largely in the theory of relativity and in the shock waves which accompany, for example, the detonation of an explosive or the flight of a supersonic airplane. He typifies all the Illinois staff members who are doing the research described below.

Teaching and research are intimately related in the University. Students are taught by men who have themselves helped to create the knowledge they are imparting. Advanced students can use the remarkable facilities offered by the University for creative science and for scholarship: laboratories, experimental farms, a great research library. An institution offering such facilities

can bring to its staff the most distinguished scientists and scholars of the age. Thus, even if research at Illinois offered no other benefits, its vital role in the educational work of the University would amply justify it.

But, as is well known, research brings magnificent returns beyond its influence on education. It is fundamental to our present technological civilization. It is largely responsible for our prosperous farms and bountiful harvests, for our productive industry and our victories over disease. Research in social science, as it yields an understanding of man's complicated relationships with man, may help us to defeat poverty, social disorder, and even war. All this is widely understood.

Less well appreciated is the paradox that the research work which has the most important consequences is often that which seems, at the time when it is done, entirely removed from any hope of practical application. The outstanding recent example of this is, of course, atomic energy, which only ten short years ago was a laboratory curiosity pursued by a few long-haired physicists. The research which molds tomorrow's society, tomorrow's industry, tomorrow's agriculture, is being done today. But it is being done by scientists without a "practical" goal in mind, men who are striving only to understand the nature of things a little better.

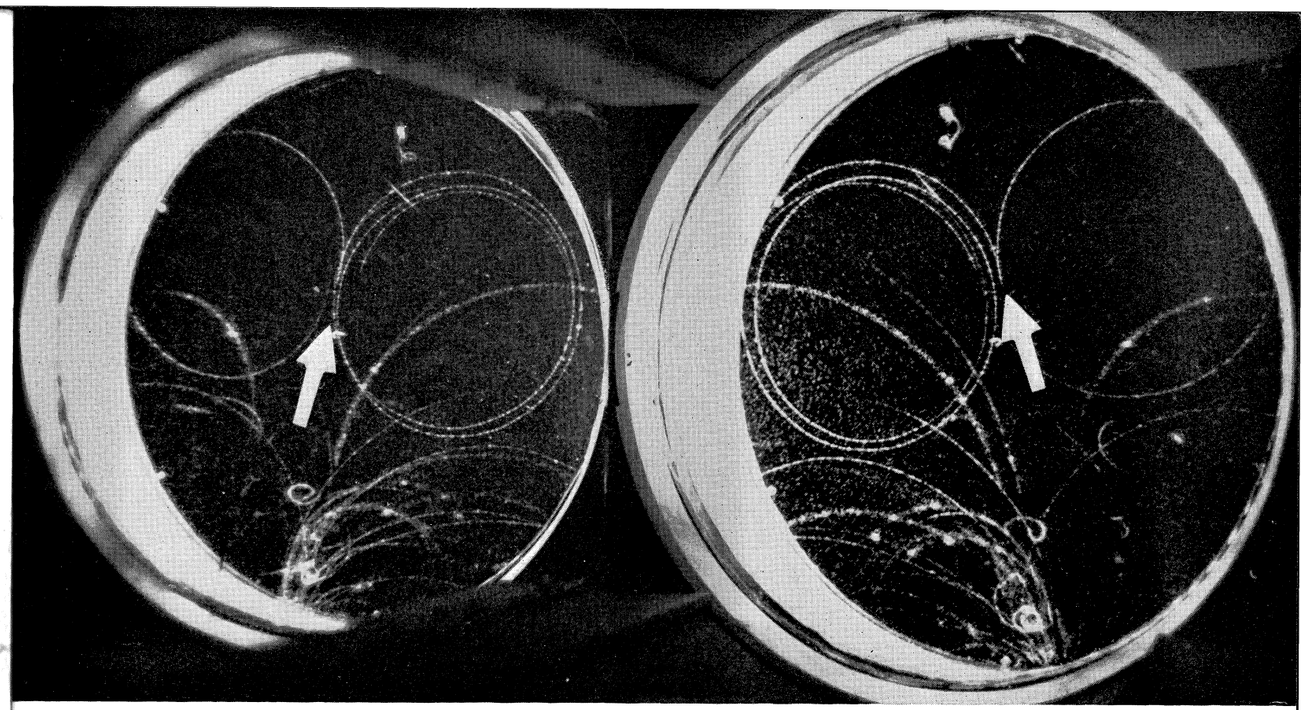
This paradox — that useful practical results are best secured by avoiding research problems which seem "practical" — can be understood with a little thought. A program of "practical" research is undertaken with a specific goal in mind. Since the goal can be visualized, the research program will yield, at best, a result which was already obvious at the beginning. But a research program undertaken to learn what can be learned, with no particular "practical" end in view, may yield unexpected results of the greatest significance to society.

The University tries to strike a proper balance between "practical" research and the basic research which actually produces most of the important practical results. Both types are needed, the first for short-range problems, the second for major advances.

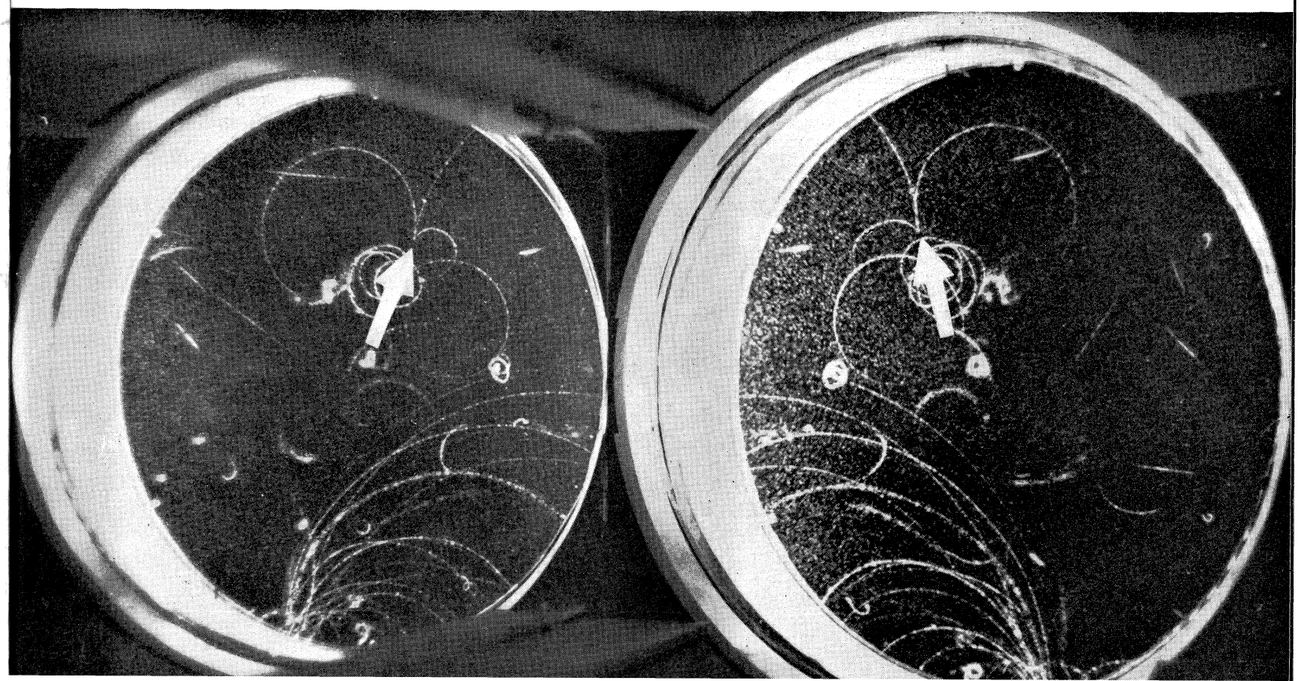
This brief report on a few of the research activities at the University of Illinois is presented in the hope of giving those interested in the University some indication of the scope and nature of that research. The pages that follow treat perhaps one out of every hundred research projects now under way on the Illinois campus. No project is fully or adequately treated, and the work of some entire units of the University is left out, because of the limitation of space. Despite these shortcomings, this bulletin presents some idea of what we are doing.

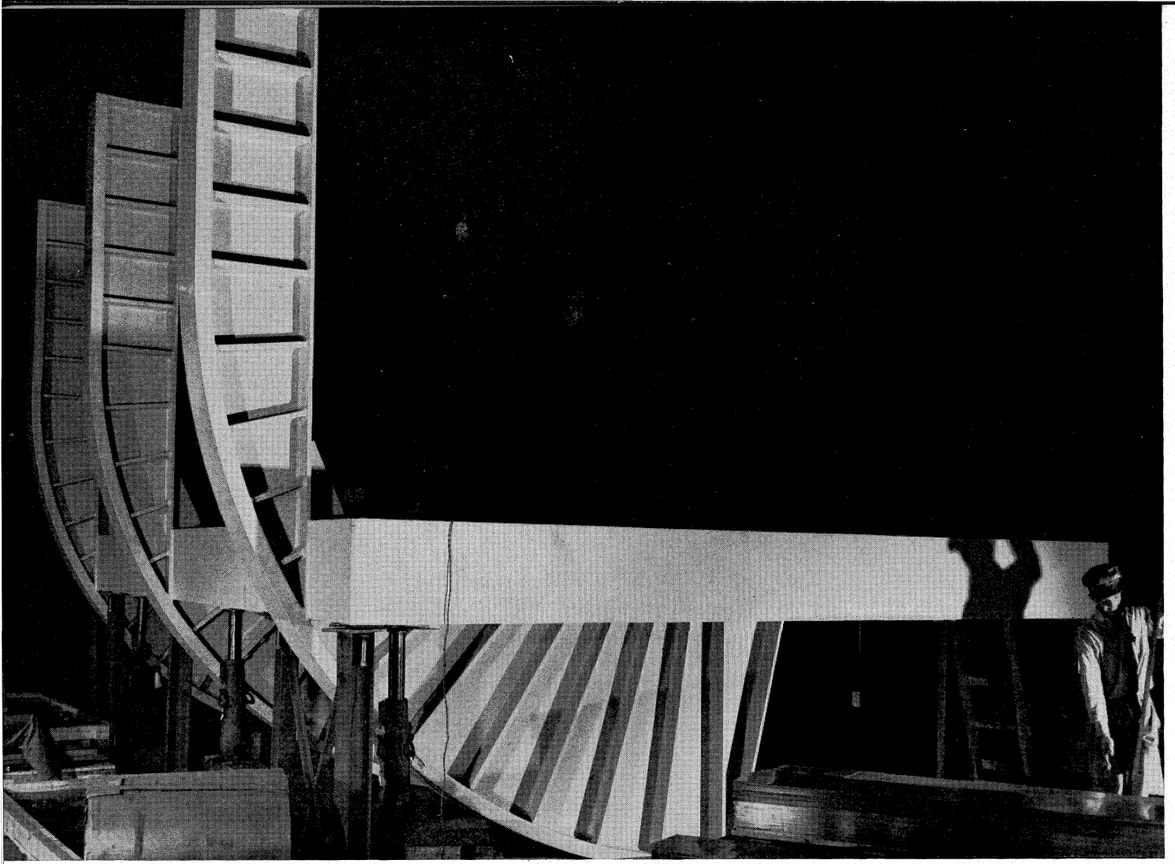
LOUIS N. RIDENOUR

Chairman, University Research Board



The Physical World





Illinois Physicists Study the

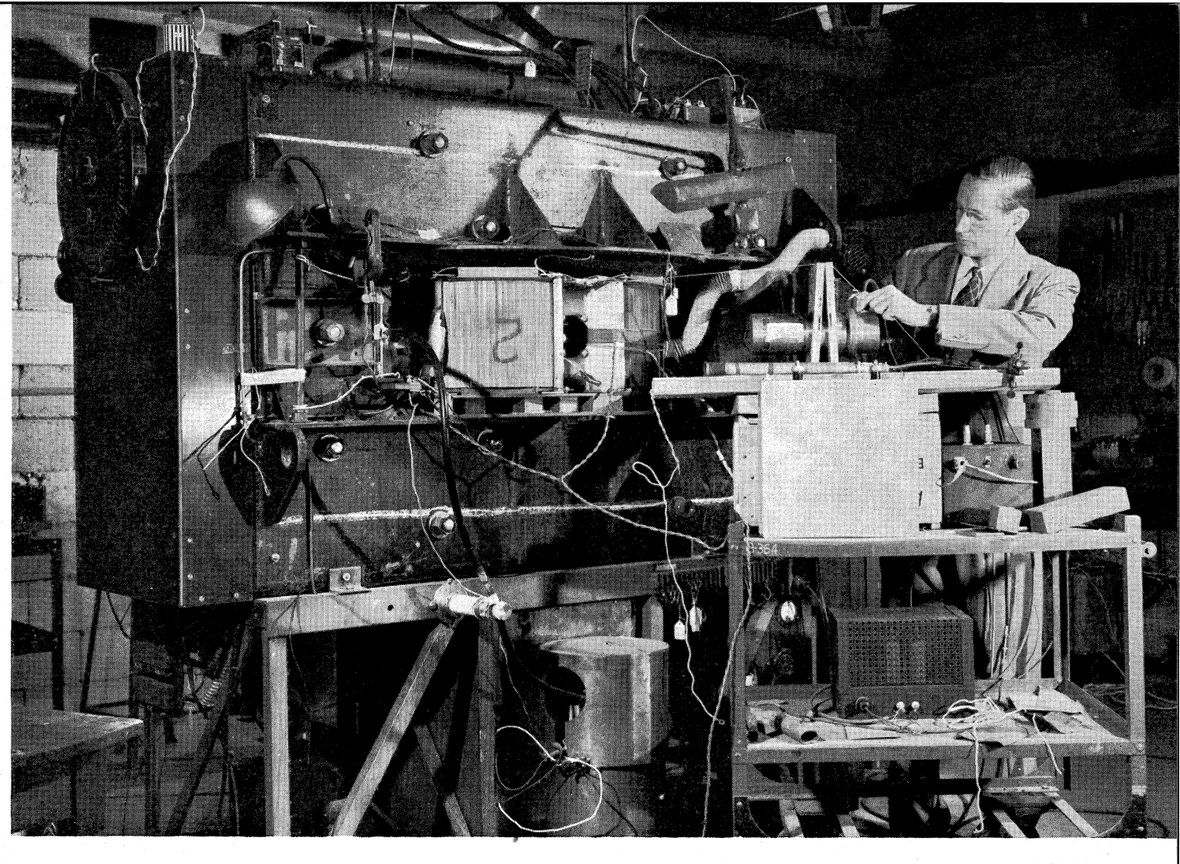
ONLY eleven generations have passed since Galileo initiated the orderly study of the laws of matter, energy, and the physical world. Yet we have today a fairly broad knowledge of this important field. The cloud-chamber photographs on the preceding page show two events (indicated by arrows) in which energy is turned into matter, something thought impossible only a few years ago.

Paths of electrons in the cloud chamber show up as bright trails of liquid droplets; the curvature of the paths is produced by deflecting the electrons in a strong magnetic field. In the top picture, a pair of electrons, one of negative electric charge, the other positive, as shown by their opposite deflection, has been created in the gas of the chamber by a penetrating gamma-ray produced by the Illinois cyclotron. The lower picture shows a similar event, this time one involving a third electron.

One of the most powerful tools for the study of the sub-atomic realm is the *betatron,* invented at Illinois in 1940 by Professor Donald W. Kerst, of the physics department. The betatron was the first instrument to produce x-rays and electrons whose energies were in the multi-million volt range. Penetrating x-rays from a betatron were used during the war to "look" through as much as 12 inches of solid metal, inspecting shells, guns, and other ordnance for hidden flaws.

Dr. Kerst is shown above right with the 75-million-volt scale model made to test the design of the 300-million-volt betatron now being built at Urbana. The model has been operating since the summer of 1948. Recent improvements in betatron design make this model actually smaller than its 22-million-volt predecessor.

On the gigantic steel frame shown above, the 300-million-volt betatron is being constructed. When it is completed, in late 1949 or early 1950, this great machine

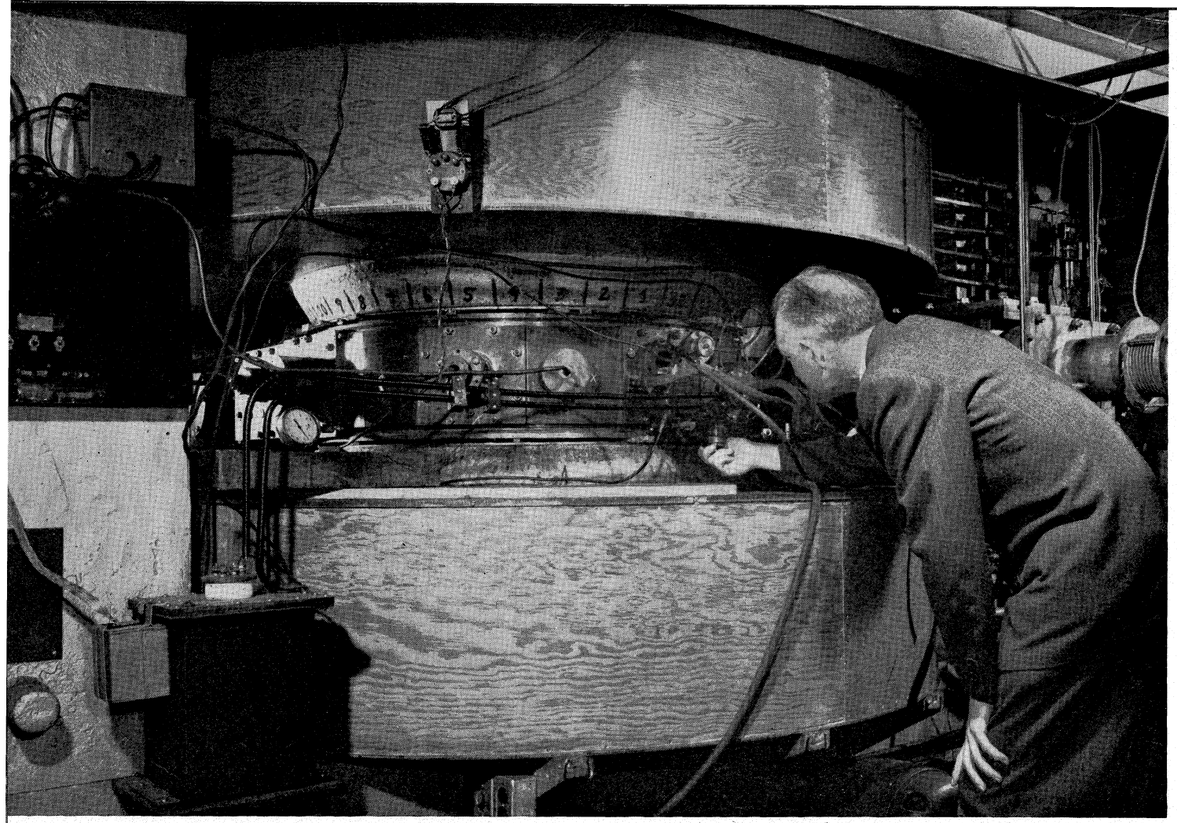


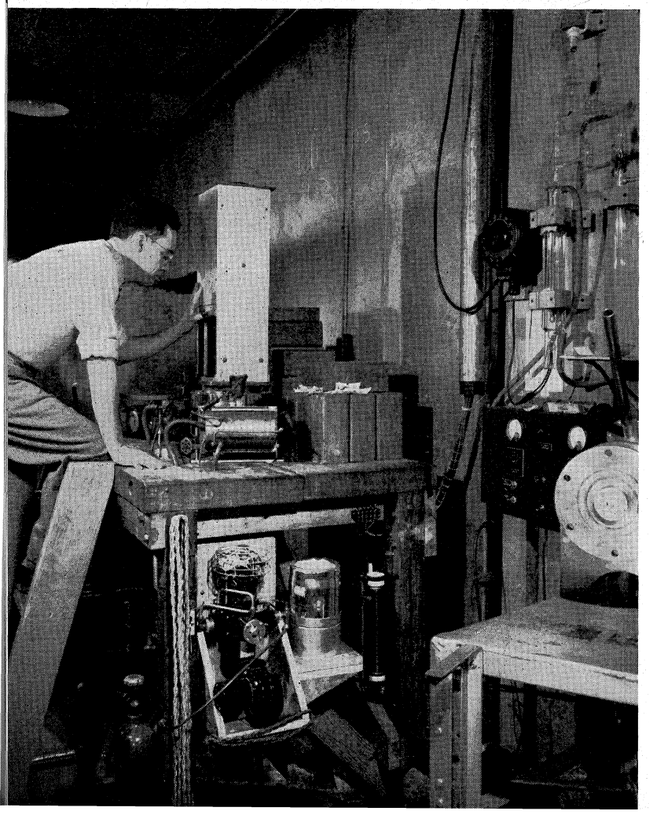
Fundamental Structure of Matter

should produce electrons of energy high enough to create in the laboratory the mysterious particles called *mesotrons,* which have been observed in cosmic rays. Mesotrons probably play an important role in connection with the little-understood forces which hold together the nucleus of the atom. Their controlled investigation in the laboratory should contribute much to our fast-growing knowledge of the ultimate structure of matter.

In addition to its uses as a scientific tool and as a super-x-ray for industry, the betatron promises to be an important weapon in the fight against cancer. Its high-energy rays can deliver a bigger dose of radiation to a deep-lying tumor, especially one that is shaded by bone, than can be done by ordinary x-ray equipment. Further, the beam of rays from the betatron remains sharp as it penetrates the body of the patient, instead of fanning out, as beams of lower energy do, to cause damage to healthy organs and tissues surrounding the region being treated.

Besides those studies with the betatron, other investigations into nuclear structure are being carried on at Illinois. Professor M. Goldhaber is studying the processes which result when nuclei capture neutrons, and learning more about the energy states in which atomic nuclei can exist. Professors C. W. Sherwin and James S. Allen are investigating the elusive *neutrino,* a particle which seems to be produced in the decay of radioactive substances. Since it apparently has no electric charge, no magnetic properties, and no mass when not in motion, the neutrino can pass through great thicknesses of matter without producing any effects. Thus, it can be studied only through the effects it causes at the moment it is emitted from an atomic nucleus. On the next page is found the work centering around the Illinois cyclotron.



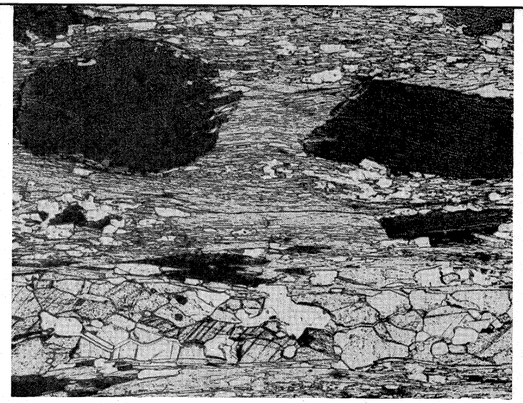


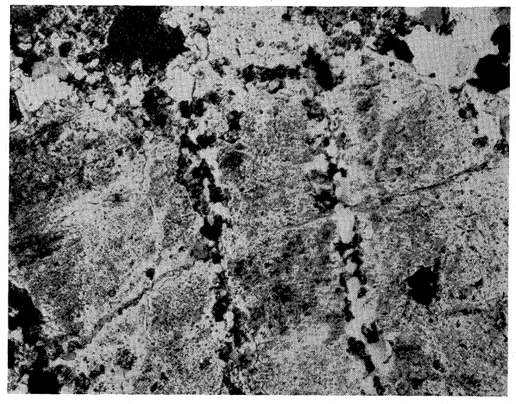
Cyclotron . . .

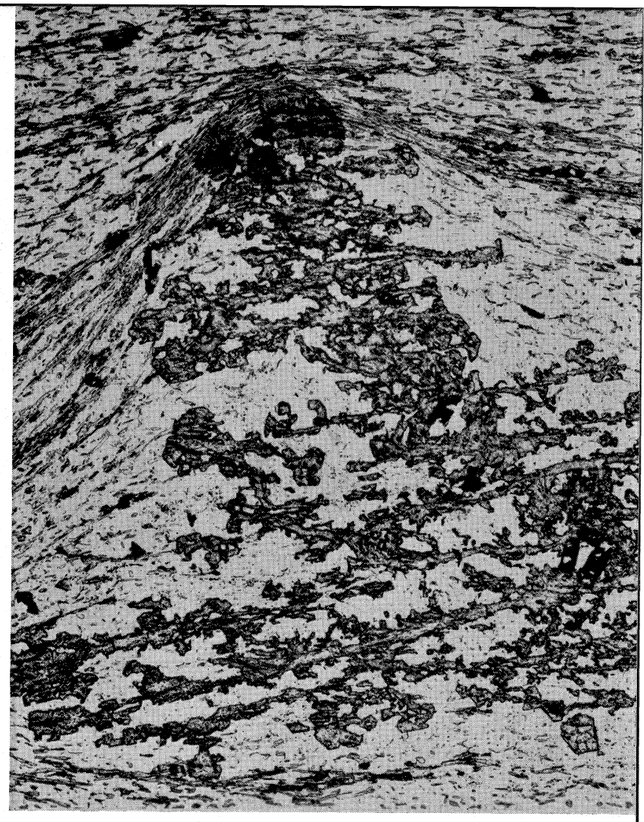
Tool for Research

ANOTHER of Illinois' tools for the study of the atomic nucleus is the *cyclotron,* here shown with Professor P. Gerald Kruger making adjustments. The betatron makes a beam of electrons or x-rays; the cyclotron accelerates the much heavier nuclei of atoms. It can produce streams of swift protons (hydrogen nuclei), deuterons (nuclei of heavy hydrogen), or alpha particles (nuclei of helium). By studying the scattering of these high-speed particles when they strike stationary atomic nuclei and bounce off, scientists are learning more about the laws of force between nuclear particles, and thus about the forces which hold atomic nuclei together.

Since the cyclotron produces radiation that will damage living tissue, observations are made outside a shield of heavy tanks filled with water. At left H. A. Leiter, a graduate student assistant, checks the operation of a cloud chamber similar to the one used to make the pictures on page 3.







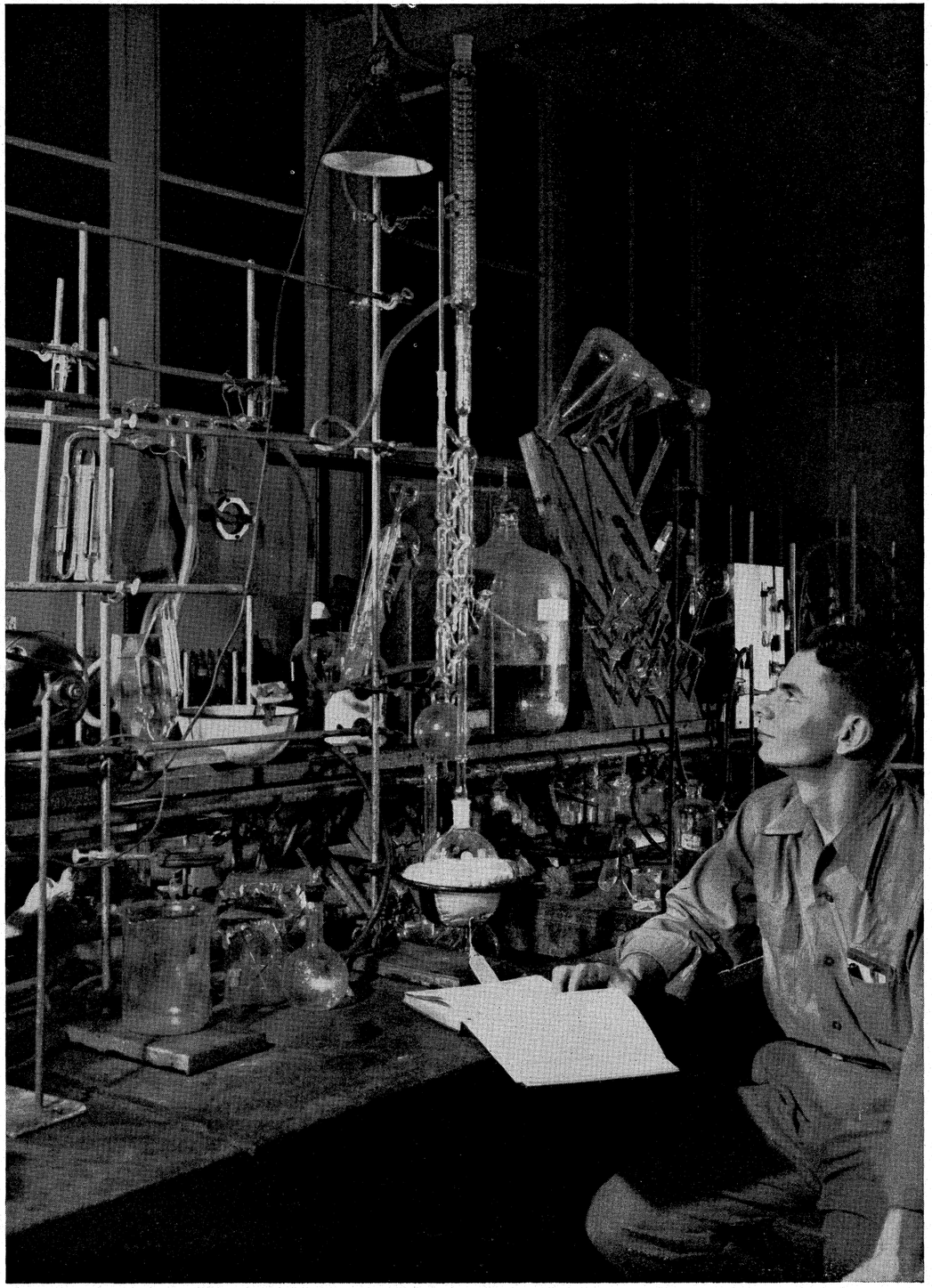
Geologists Read History in Rocks

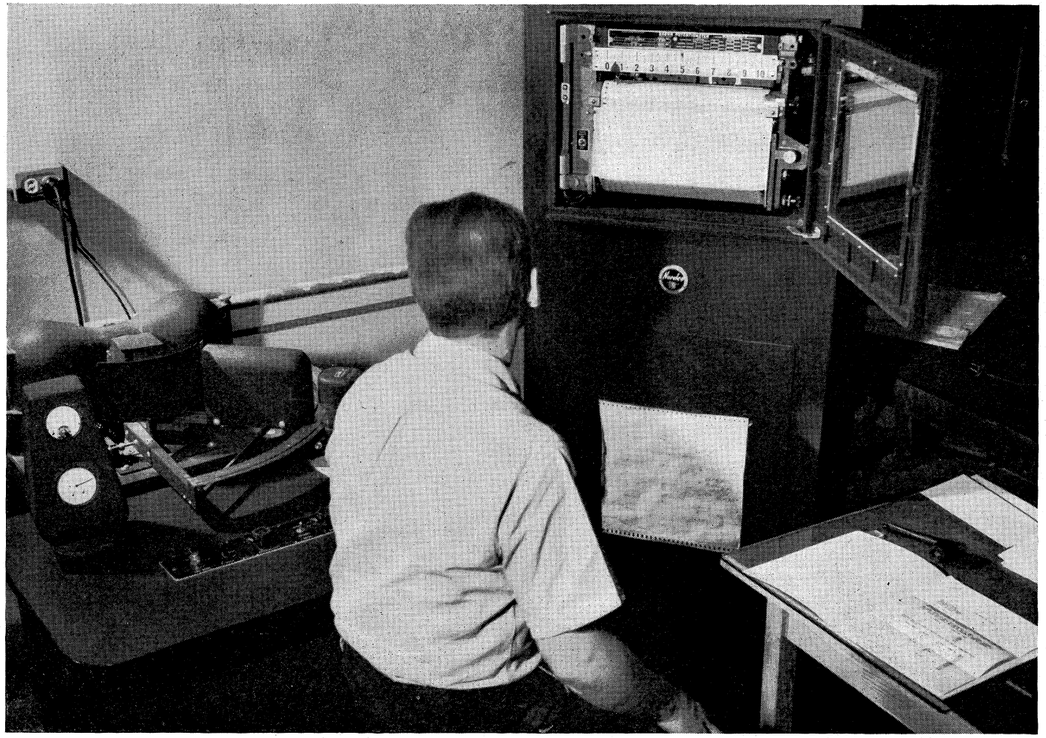
ILLINOIS geologists are studying the history of the earth as it is recorded in the rocks. One of their tools is the polarizing microscope, under which the detailed nature of thin sections of rock is revealed. The pictures on this page, for example, show rock sections 3/1000 inch thick, magnified 20 times, taken from western New Hampshire. With such specimens Dr. Carleton A. Chapman is studying the history of the Appalachian Mountains. The minerals present show that sedimentary rock like shale and sandstone were at some time subjected to tremendous temperatures and pressures. The rock recrystallized; larger crystals and new minerals formed. At top left is black biotite mica surrounded by chlorite. The large white crystals are calcite. At bottom left a large crystal of feldspar has cracked in two places when the temperature was high. As the rock cooled it resealed by crystallization. At right is large crystal of garnet.

When Professor Jack Hough returned from Admiral Byrd's last expedition, he brought back records of the antarctic climate for the last million years. By means of a pipe-like "core sampler", he secured from the ocean bed — both in the open sea and under pack ice — samples of the sediment forming the ocean floor. The deepest layers of his samples were laid down as long as a million years ago. Dr. Hough's studies of the nature of these samples enabled him to show that the cycles of glaciation in past epochs, already known from studies in this hemisphere, corresponded to times when the southern hemisphere was also largely covered with ice.

In most sedimentary rock whose age is less than about 500 million years, there are found fossils of plants or animals. Professor Harold W. Scott is specializing in the study of a class of two-shelled microfossil animals called *ostracodes.* Since these animals went through evolutionary changes in past eras, the type of ostracodes present in any particular rock sample tells the geological age of the rock. The study of such fossils is important not only to our understanding of the development of living creatures; it is also a highly useful tool to petroleum geologists and oil prospectors.

Professor Harold Wanless has studied and mapped most of the Pennsylvanian rocks in this country. The coal beds of Illinois belong to this geological period, as do the well known red-rock outcrops in the Garden of the Gods in Colorado.





Exploring Molecular Structure

UNDER the leadership of Roger Adams, the chemistry department at Illinois has awarded the Ph.D. to more research students than have been trained in any other department in any other university. Illinois' preeminence in chemical research is widely recognized. Only a hint can be given here of the many important investigations that are being carried on.

During the war, Illinois chemists helped develop synthetic rubber for the government. Today, their studies are being continued on a more basic level. At left, a graduate student studies the esterification of succinic acid, in connection with this program. Rubber and many other plastics are members of the class of substances called *polymers*. Each rubber molecule is a long chain of atoms strung together. Normally, this chain is so twisted and bent that its over-all length is small compared with its length when straightened out. When we stretch a strand of rubber, we straighten out the molecules; when we release it, each molecule snaps back into its shorter, twisted, shape. Chemists at Illinois are studying the relation between the structure of such molecules and their physical properties, such as elasticity. Once this is understood, it may be possible to make plastics "to order", designing molecules that will have any desired combination of physical properties.

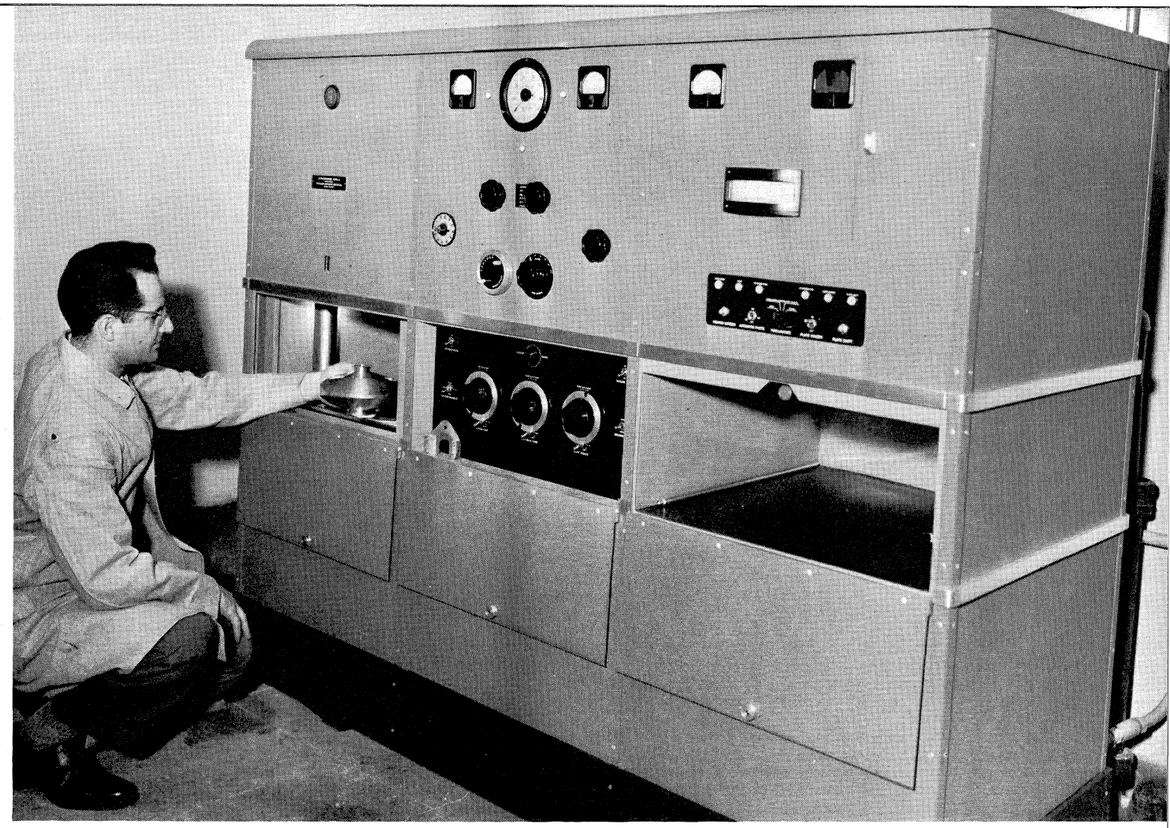
One tool for the study of the structure of molecules is the x-ray spectrometer shown above. When x-rays fall on a substance, they are scattered in certain directions which are determined by the number, nature, and geometrical arrangement of the atoms making up the molecule. The structure of an important class of waxes called branch-chain hydrocarbons has recently been worked out at Illinois in this way. Another important tool of Illinois chemists is the infra-red spectrograph. Chemical compounds can often be distinguished by the particular wavelengths of invisible infra-red light which they absorb. With such equipment, chemists at Illinois can bring to bear on their problems powerful modern techniques.

The Smallest "Living" Things

VIRUS particles are so extremely tiny, apparently being single large protein molecules, that they will not settle out of a liquid in which they are suspended. The force of gravity pulling them toward the bottom of the vessel is too small to overcome the effects of the random buffeting of the virus particles by the molecules of the suspending liquid.

If a liquid containing virus particles is whirled in a centrifuge, forces of many times gravity act on the particles, and they will settle out. A virus can be concentrated in this way, and measurements of the rate of settling of the particles will even give an idea of the size and shape of the virus or other particle being concentrated.

One of Illinois' newest research tools is the ultracentrifuge shown here. It can whirl a cell containing the liquid being investigated at a thousand revolutions per second, producing forces more than 260,000 times that of gravity. At this prodigious speed, each pound of the rotor being whirled "weighs" one hundred and thirty tons. The rotor is the piece of metal that Professor B. Roger Ray is holding. Biochemists and pathologists at Illinois are using the ultracentrifuge in their studies of proteins, enzymes, and virus diseases in plants and animals. Colloid and polymer chemists are using it in their studies. It is one of the modern instruments that makes Illinois a productive center of research.



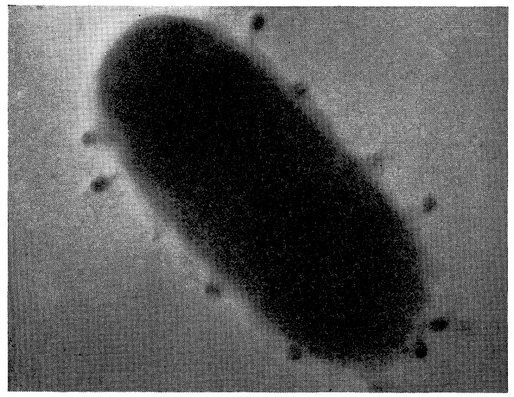
ILLINOIS chemists pioneered in studies using the electron microscope, which uses beams of electrons, rather than of ordinary light. Microscopes of the usual sort cannot form an image of any object smaller than a few times the wavelength of the light used, and are thus restricted to magnifications of one or two thousand diameters. Under good conditions, magnifications of a hundred thousand can be reached with an electron microscope. At this magnification, a cockroach would look more than three miles long; a gnat would appear bigger than a B-29 Superfortress.

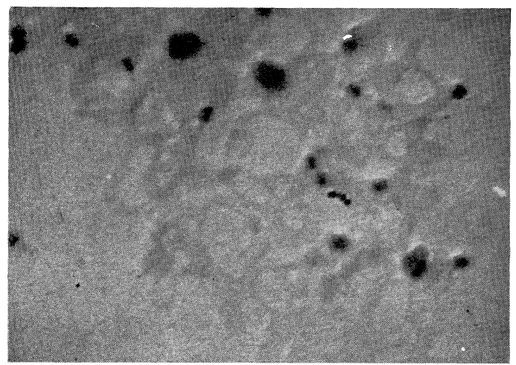
Professor George L. Clark is shown at right with one of the two electron microscopes at Urbana (a third is installed at the College of Medicine, in Chicago). The instrument shown is the first commercial electron microscope to be delivered to a user by an American manufacturer.

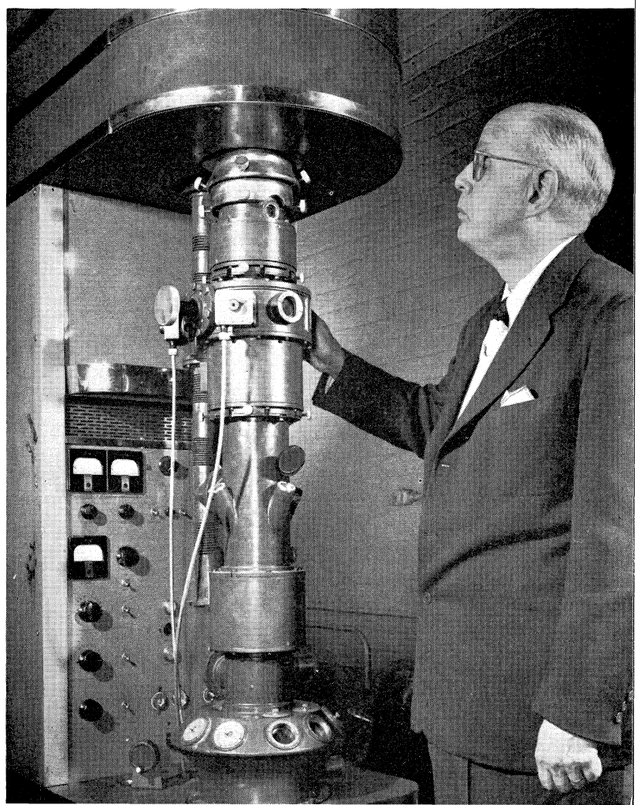
By using the electron microscope, scientists are bridging the gap which was formerly thought to exist between the simplest "living" things and the most complicated "non-living" chemical molecules. Many of the viruses which cause certain important diseases of man, animals, and plants can be seen with the electron miscroscope. Viruses have been found that are bigger than the smallest known "living" cells; other viruses are smaller than the largest known "non-living" molecules.

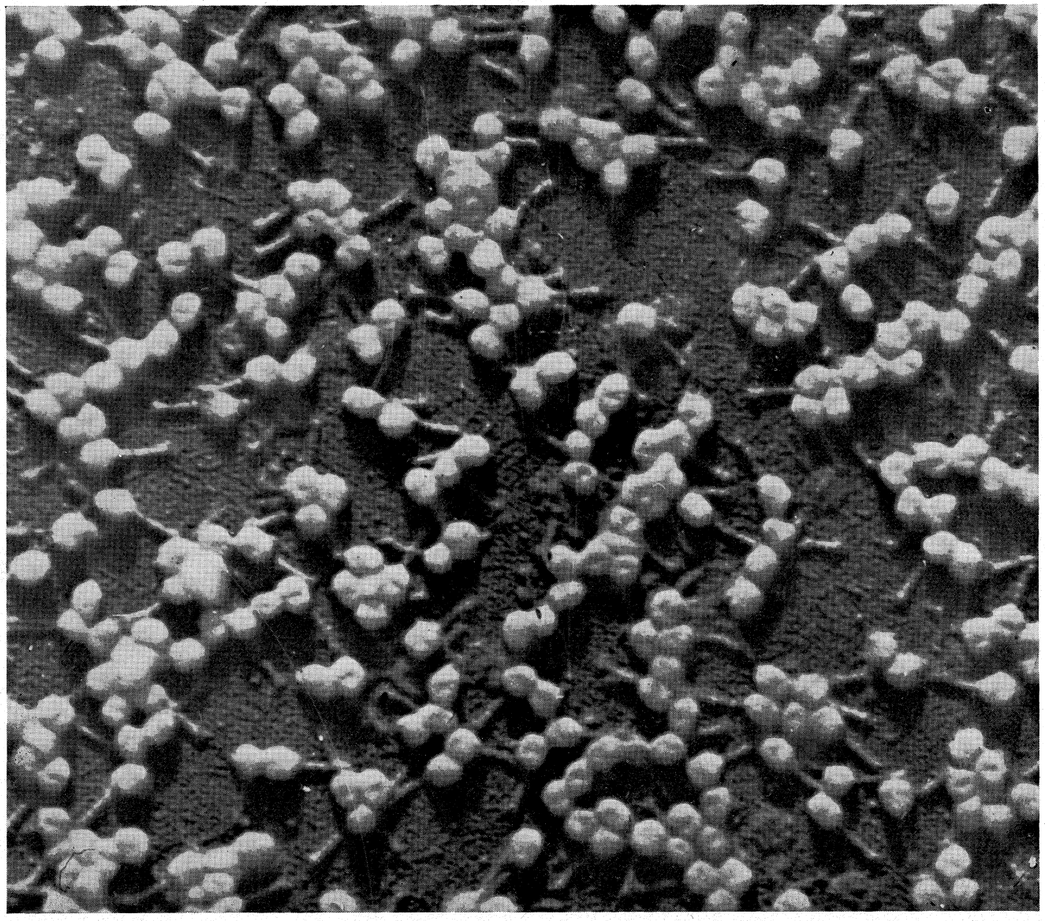
Are viruses "alive" or not? What we know today suggests that the question has no meaning. Outside the body of the host on which the virus is parasitic, a virus seems quite dead. It can even be crystallized into crystals like those formed by most chemical compounds. Inside its host, it acts alive. Most importantly, the virus multiplies itself at the expense of its host.

Some viruses are parasitic on bacteria. Shown at the right top are the tadpole-like T2 virus particles attacking the intestinal bacterium called *B. coli*. What happens is shown at right below. The virus has killed and destroyed its host, and has multiplied within the body of the bacterium. The virus particles drift off to find a new host. The T2 virus shown here is so small that it cannot be seen at all with an ordinary microscope.







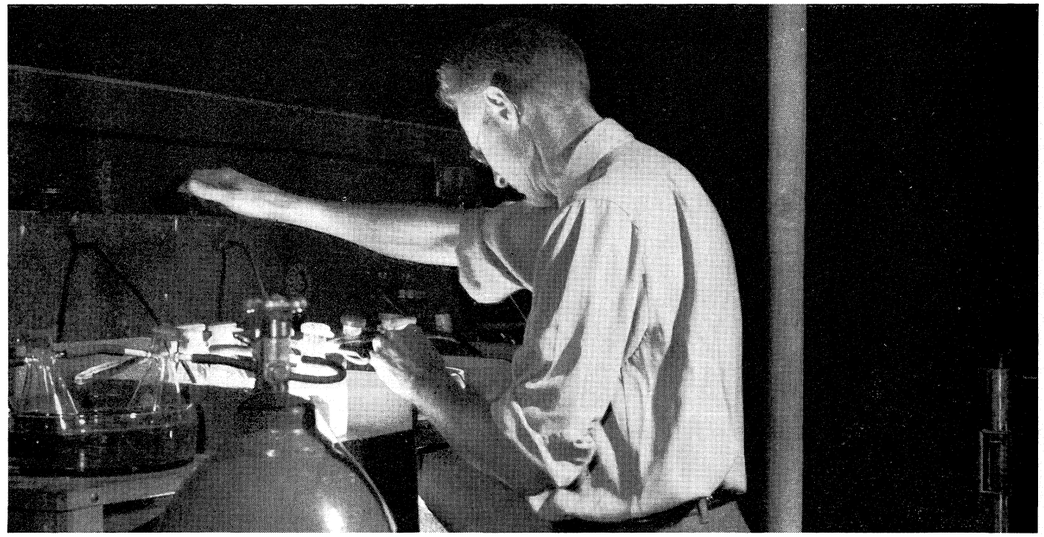


The Life Processes

SCIENTISTS in the University of Illinois research laboratories are constantly at war with the great killers — cancer, tuberculosis, and cardiovascular diseases — and with such sources of human misery as mental disorders, arthritis, allergies, and tooth decay. They are constantly searching for ways to make the soil more productive, and to produce hardier crops and farm animals. But behind every advance in these campaigns lies basic research in the life sciences.

Biology and chemistry are to medicine and agriculture what physics and chemistry are to engineering. Just as the development of the greatest recent importance to engineers took place in the laboratories of atomic physicists, so the developments of greatest ultimate importance to physicians and farmers are taking place in laboratories where scientists are trying to understand the basic processes of life.

One aspect of this research is illustrated by the picture shown above. The objects that look like mothballs are colon-bacillus bacteriophage, virus particles that

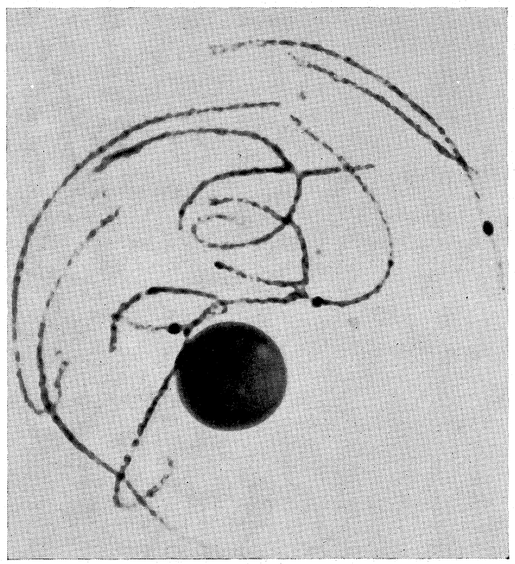


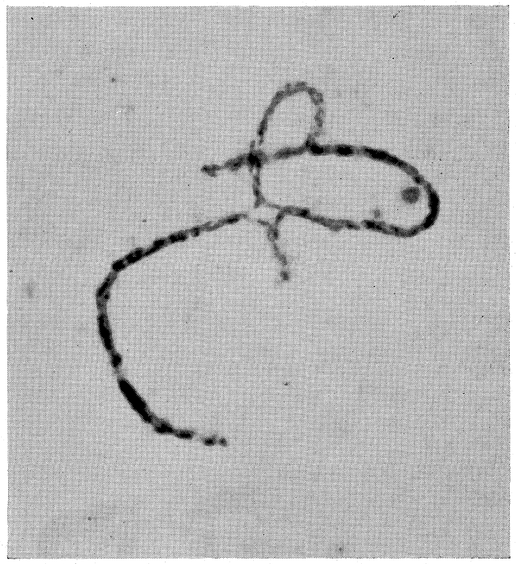
combat bacteria in the human digestive tract. The picture was taken with one of the Illinois electron microscopes, at a magnification of 100,000 times.

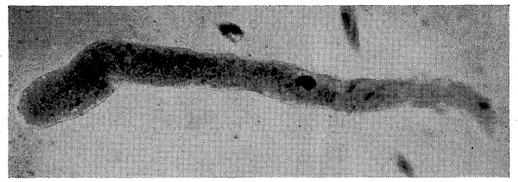
The pictures on this page are of research in photosynthesis — the process in which a plant converts energy from the sun into useful chemical energy. In the upper picture, Dr. Robert Emerson is growing organisms containing chlorophyll, the green substance in a plant which absorbs sunlight and stores it as potential energy. Dr. Emerson is using carefully measured artificial light. In the lower picture, he and Dr. Eugene Rabinowitch are reading an instrument which measures indirectly the amount of carbohydrates a plant produces when it receives a measured amount of light. In this basic life process we call photosynthesis a plant takes carbon dioxide and water from the air, combines them with the aid of the light absorbed, and makes carbohydrates like sugar and starch. This is the process by which the leaves of the corn produced the ear. All animal life is possible only because plants can build food in this way.

The Study of Heredity

THE MAN looking so intently at the ears of corn is Dr. M. M. Rhoades, who is studying heredity. The other pictures on this page show what he sees through the microscope in front of him. The microphotograph below left shows the 20 chromosomes which occur in every normal cell of corn. They occur in pairs which are very close together, so that one actually sees only 10 in the picture. These chromosomes hold the genes which determine the inherited characteristics of the corn. The large round spot is the nucleolus found in the nucleus of the cell. Dr. Rhoades is studying the genes that control the inheritance of color in grains of corn. He is observing the patterns of inheritance that result from different combinations of genes, and also is producing changes in the genes by experimental methods. The lower right picture shows two of the chromosomes which have been joined together by x-ray treatment in the laboratory. The effect of these artificially produced changes is being studied, and the results will contribute to our understanding of the principles of heredity and to the development of new species. Gene changes occur in nature besides being brought on by laboratory treatment. Dr. Rhoades is particularly interested in unstable genes which change easily.







How Cells Divide

LIVING things reproduce and grow by the process of cell division. In each act of division, twice as many cells are formed. This process goes on, as long as life goes on. Cell division has often been studied in the amoeba, a one-celled animal usually visible only through a microscope. On this page, however, are pictures magnified 48 times of a most unusual giant amoeba, so large that it can be seen by the naked eye. Dr. Richard Kudo, who discovered this amoeba in a near-by stream, has been studying it in the University laboratories. In the upper picture, the amoeba is photographed as it creeps along in search of food. Other organisms, which are prospective food, can be seen swimming away. In the lower picture, the amoeba has fed and is resting on the bottom of its container. The giant amoeba is a single cell with many nuclei, all of which divide simultaneously when the animal reproduces. This giant amoeba affords scientists an opportunity to study the process of cell division in unparalleled detail.

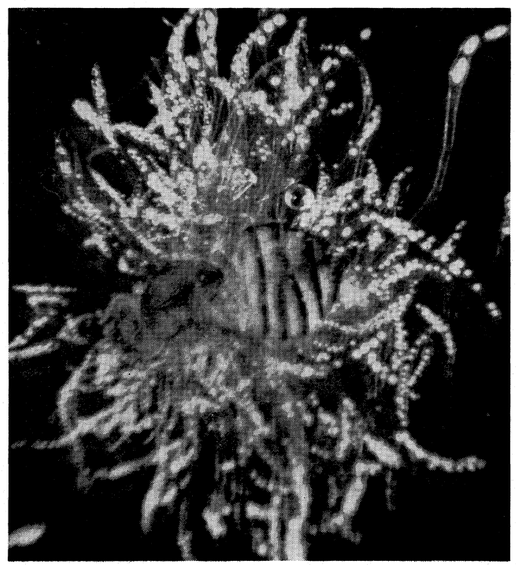
Classification of Plants and Animals

MORE useful to a botanist than any reference book is a herbarium where he can find specimens of plants he wishes to identify. Illinois has such a herbarium where, at last count, 302,500 plant specimens are preserved and classified. The herbarium, under the direction of Dr. G. Neville Jones, now ranks as the 5th largest university plant collection in the United States.

One of the world's outstanding collections of Mexican snakes and reptiles, 18,000 specimens in all, also is maintained at Illinois. Since snakes are among the oldest forms of animal life on earth, Dr. Hobart M. Smith is primarily interested in their evolutionary relationships.

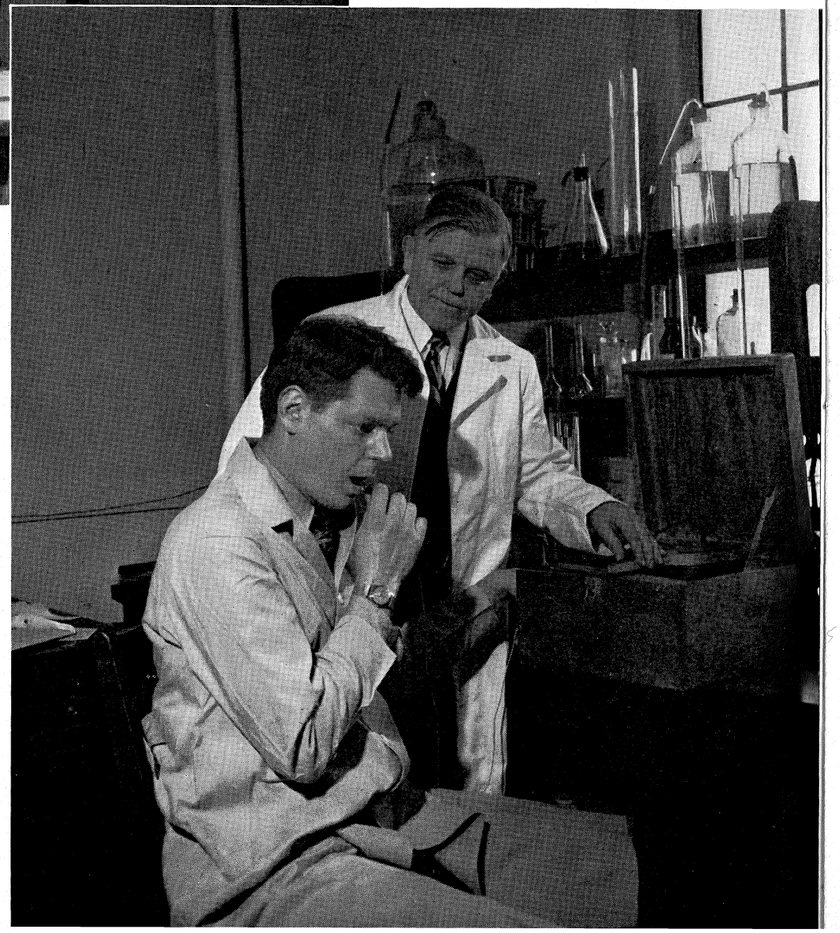
Illinois also boasts an outstanding collection of aquatic fungi assembled and studied by Dr. Leland Shanor. A microphotograph of one of these many fungi is shown below. It is a water mold growing on a fruit fly placed in the water. The mold in turn has parasites growing on it.

In connection with the work of its many other systematic botanists and zoologists, the University maintains a Natural History Museum, an aquarium, and many smaller collections of which the one of plant fossils is typical.



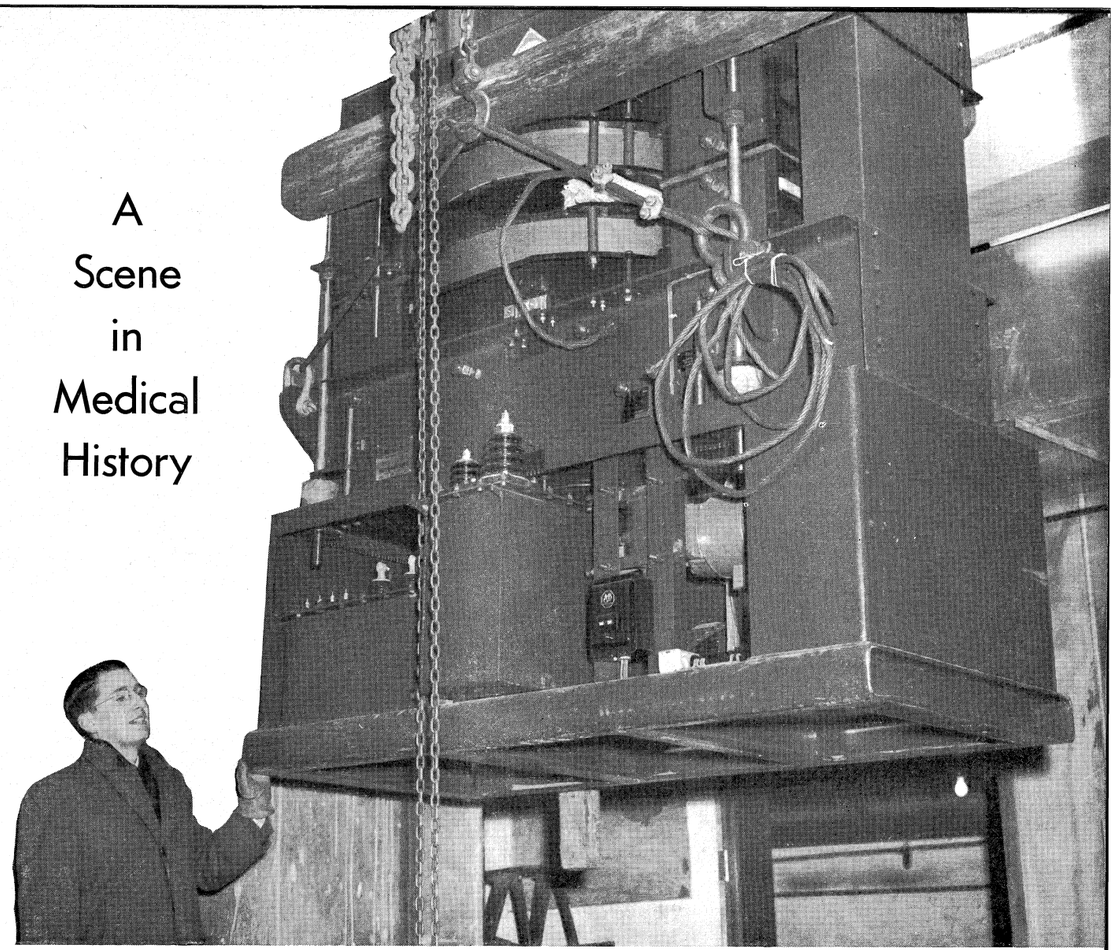
THE MEN on this page have done much to strip away the mystery from body chemistry and to pave the way for conquering the diseases of internal organs.

Dr. William C. Rose at the right of the top picture is the discoverer of one of the amino acids. Dr. Rose and his associates have established that eight of the 20 known amino acids are necessary components of the diet of man and that ten are required for the normal growth of animals. With Dr. Rose is Dr. Herbert Carter. Dr. Carter has made contributions to the knowledge of the chemistry of fatty materials in nervous tissue and is investigating new antibiotics.



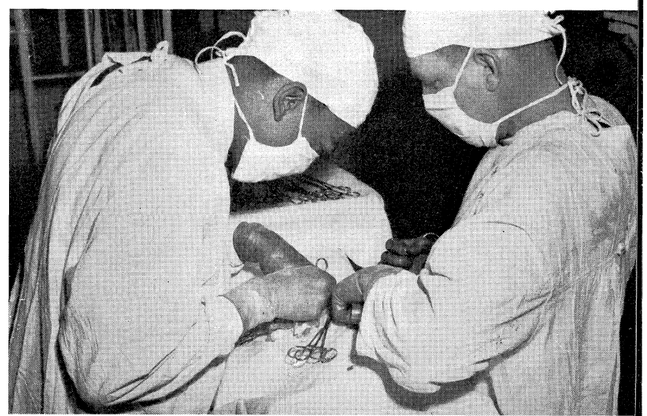
AT THE REAR of the right picture is Dr. Andrew C. Ivy, vice-president of the University, who is one of the world's greatest physiologists. Dr. Ivy is the discoverer of enterogastrone, a hormone which offers hope of successfully treating peptic ulcers, and also of another hormone which has the power of contracting the gall bladder. As head of the University's research program in clinical science, Dr. Ivy supervises research studies on cancer, diseases of old age, analgesia, aviation medicine, and diseases of the gastrointestinal tract. In this picture he and Dr. Robert Jamieson are testing a method for measuring the threshold of pain.

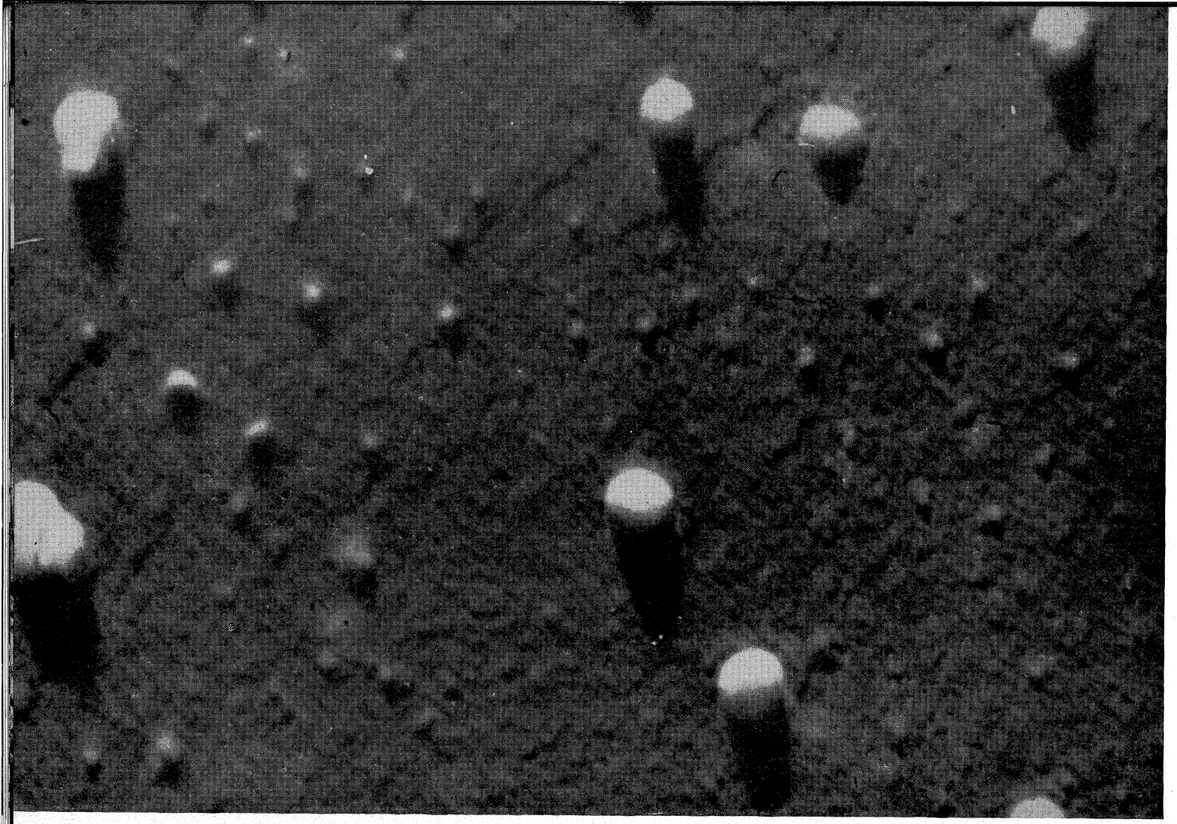
A Scene in Medical History

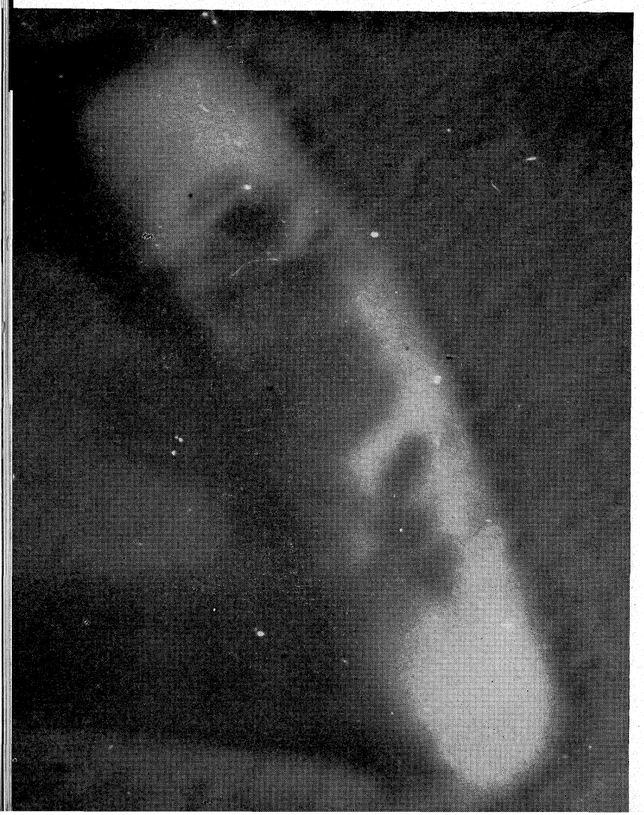


THIS is a historic scene in medical science. A 22-million volt betatron is being lowered into the radiation-proof chamber where it will be used for cancer research and treatment in the Illinois College of Medicine. The betatron, developed by Illinois physicists, is the most powerful source science has yet found to produce high-energy x-rays. It is especially important for cancer treatment because it can concentrate these rays on a small target deep inside the body and do little damage to the skin and surrounding tissue. This is the first medical betatron. The instrument is now being put into use cautiously while physicians, continuing preliminary experiments begun on the Urbana campus, determine the amount of radiation which may safely be applied to different tissues of the body.

MORE Americans die from diseases of the heart and blood vessels than from any other cause. Many of these diseases are still little understood. In this picture, an operation is being performed which may provide information concerning high blood pressure. Dr. G. E. Wakerlin and his associates in the College of Medicine have found an extract of animal kidney which helps to reduce blood pressure. This holds out the hope that further study of the kidney may reveal the actual cause of high blood pressure. Following this lead, Illinois doctors are studying animals in which they have experimentally produced high blood pressure.







Portraits of Killers

THESE are portraits of killers. The white balls are influenza virus, photographed with an electron microscope at a magnification of 110,000 times. The object that looks like a sausage is a tubercle bacillus, the organism that causes tuberculosis. This picture is also an electron micrograph at a magnification of 47,000. It was taken early in the development of the technique of shadowcasting which brings out the three-dimensional quality of minute organisms. The tubercle bacillus is surrounded by a fatty or waxy envelope which protects it against such drugs as the sulfas and penicillin, and therefore makes it extremely hard to kill. Illinois research men are now studying methods of piercing this envelope to get at the bacillus itself.

One of the great hopes for victory over tuberculosis is the new vaccine BCG. The University of Illinois has undertaken to manufacture this vaccine for study and experimental use throughout the country.

Electrical Currents Measured in Nerves

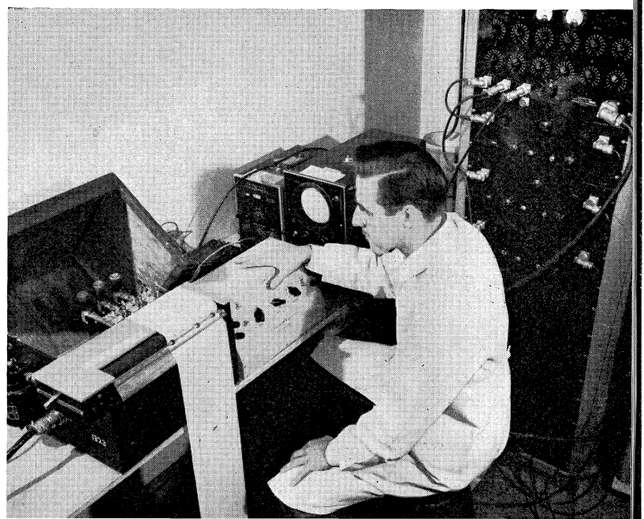
TINY electrical currents flow through our nerves, carrying to our higher nerve centers reports of what we see, hear, feel, smell, and taste, and carrying back to our muscles a series of orders concerning what movements they are to make. In the brain, similar currents have to do with our thought processes and the way we store information for later use.

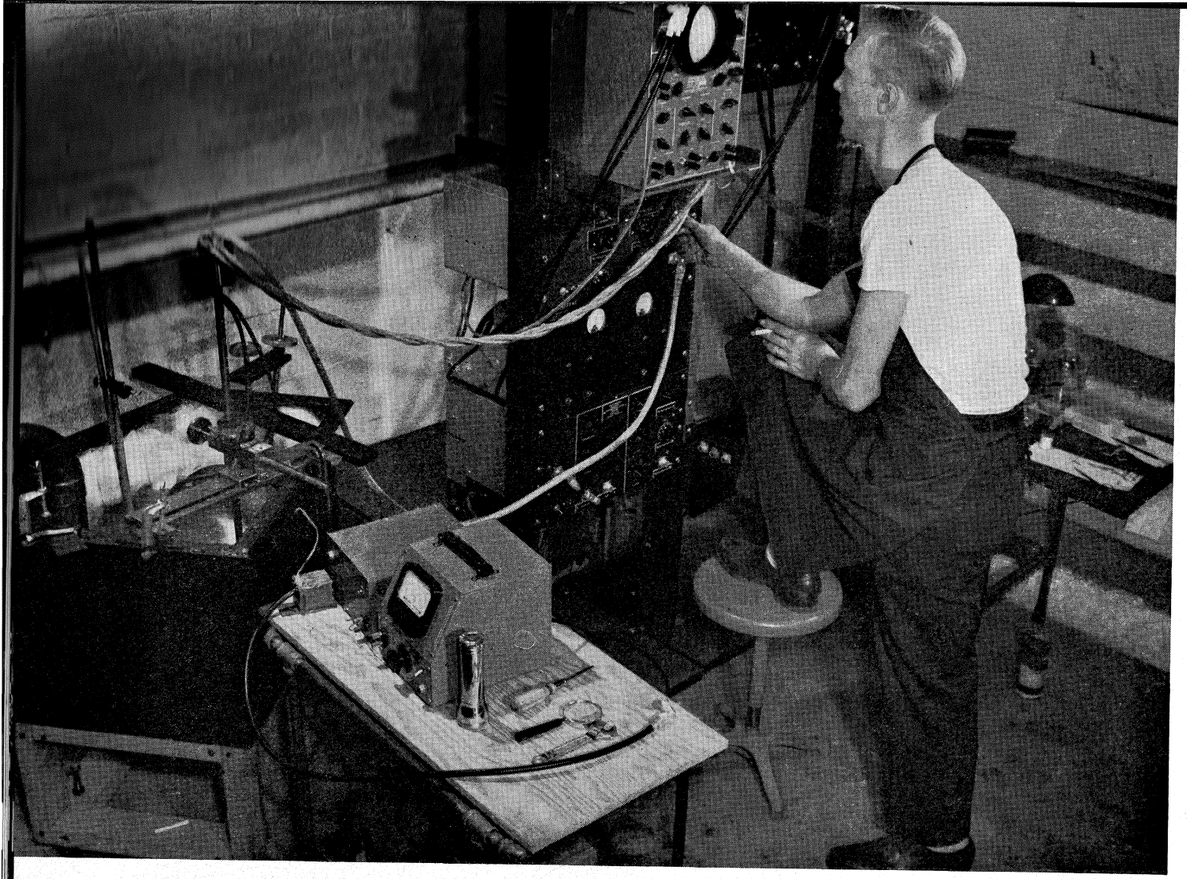
The apparatus in the picture above is a Warburg apparatus being used to study the metabolism of brain tissue. Dr. Otto Warburg, its designer, was on the Urbana campus last fall as a visiting professor from Berlin.

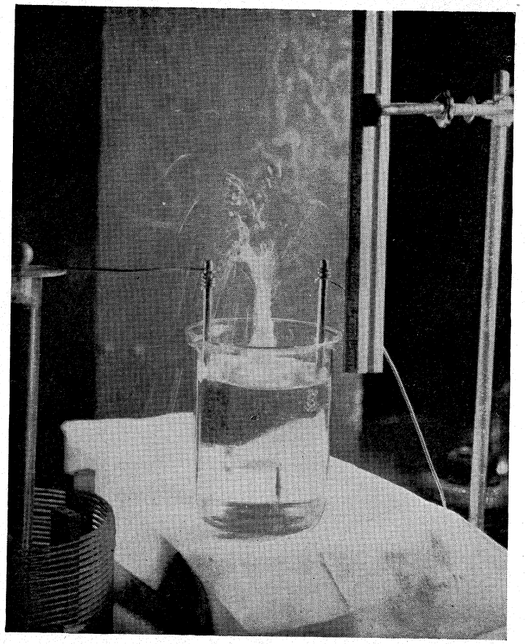
In the lower picture, an electroencephalograph is measuring the amount of current that flows through the optic nerve — the channel by which the eye reports to the brain. Light is focused on the eye of an animal by lenses and flashed by means of a rotating shutter between the light and the eye. Electrical connections are made from the optic nerve to this electroencephalograph, which records the changing currents in the nerve as the light is made brighter or less bright.

Professor C. Ladd Prosser is studying the phenomena accompanying nerve currents by investigating the way in which radioactive tracer elements are taken up by cells in their activity.

Dr. Warren S. McCulloch, of the College of Medicine, has pioneered in the mapping of nervous nets in the human brain.







Inaudible Sound

Ultrasonic vibrations are sound waves of such high frequency that they cannot be heard by the human ear. When produced at high intensity, such high-frequency sound waves have striking properties. In the picture at the left, a crystal immersed in a glass of liquid is vibrating at an ultrasonic frequency. The energy which its vibration transfers to the liquid is producing a miniature geyser at the surface of the liquid. It has been known for some time that passing such ultrasonic vibrations through a liquid will kill bacteria present in the liquid. Illinois scientists are seeking the explanation of this bactericidal effect. Other effects of ultrasonic waves on living tissue are under study at Illinois. The nerves of the living body carry their messages from one part of the body to another by means of tiny electrical disturbances which race along the nerves at speeds of about 400 feet per second. It has been found that when a nerve is subjected to ultrasonic waves, its response to stimulation is greatly modified. An experiment of this sort is shown above. Illinois scientists have found a way to generate high-intensity ultrasonic waves at a variable frequency.

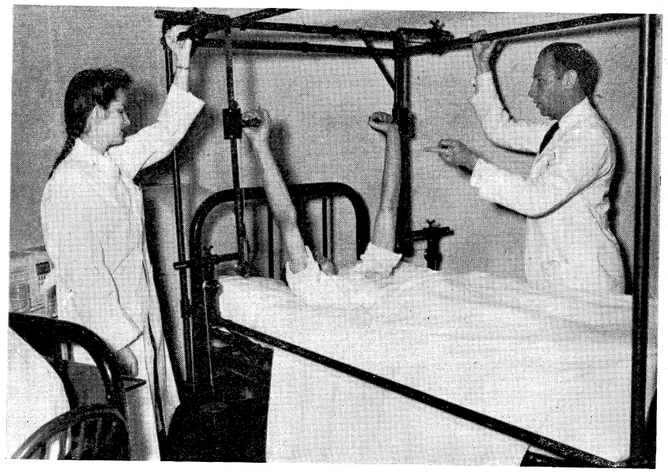
Physical Fitness

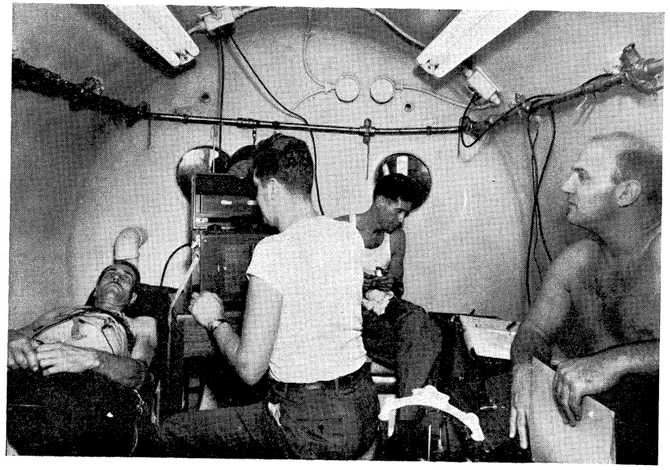
The pictures on this page are all concerned in one way or another with physical fitness. The athlete in the top picture is running on a treadmill while Dr. Thomas Cureton of the Department of Physical Education measures the amount of his oxygen intake. In the same picture is Herb McKenley, Illinois athlete who holds the world's record for the quarter mile. He has completed his run and is having his blood pressure checked. During 1948, a large part of the American Olympic team came to Urbana to participate in these tests. Purpose was to try to find out what physical fitness really means physiologically and what degree of fitness the average man needs to feel well and be effective.

The second picture shows research on post-operative recovery. The patient has recently been operated upon. Now he is being given exercises to keep up his muscle tone and speed his recovery. It has been found that patients can get out of bed much sooner and resume normal activity much more quickly if they are given a proper program of exercise during convalescence.

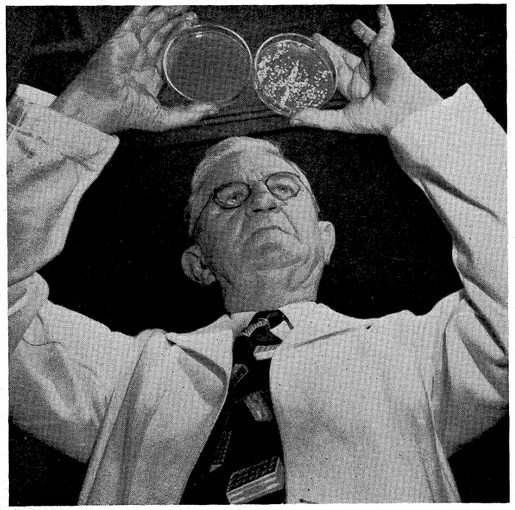
The third picture is taken in a low pressure chamber which is a part of the University's physical environment research unit. New high altitude airplanes and wartime experience in the tropics and the polar regions showed us that we know far too little about the effect of environment on man. In this low pressure chamber, men are being tested under the same atmospheric conditions they would face in high-altitude flight. Other chambers test the effect of great cold. Results of these controlled environment studies are valuable also in the study of allergies.

A new building to house the University's Aeromedical and Physical Environment Laboratory was dedicated this year on the Chicago campus. Research on problems of physical environment will be accelerated by the new facilities.





They brush their teeth for science



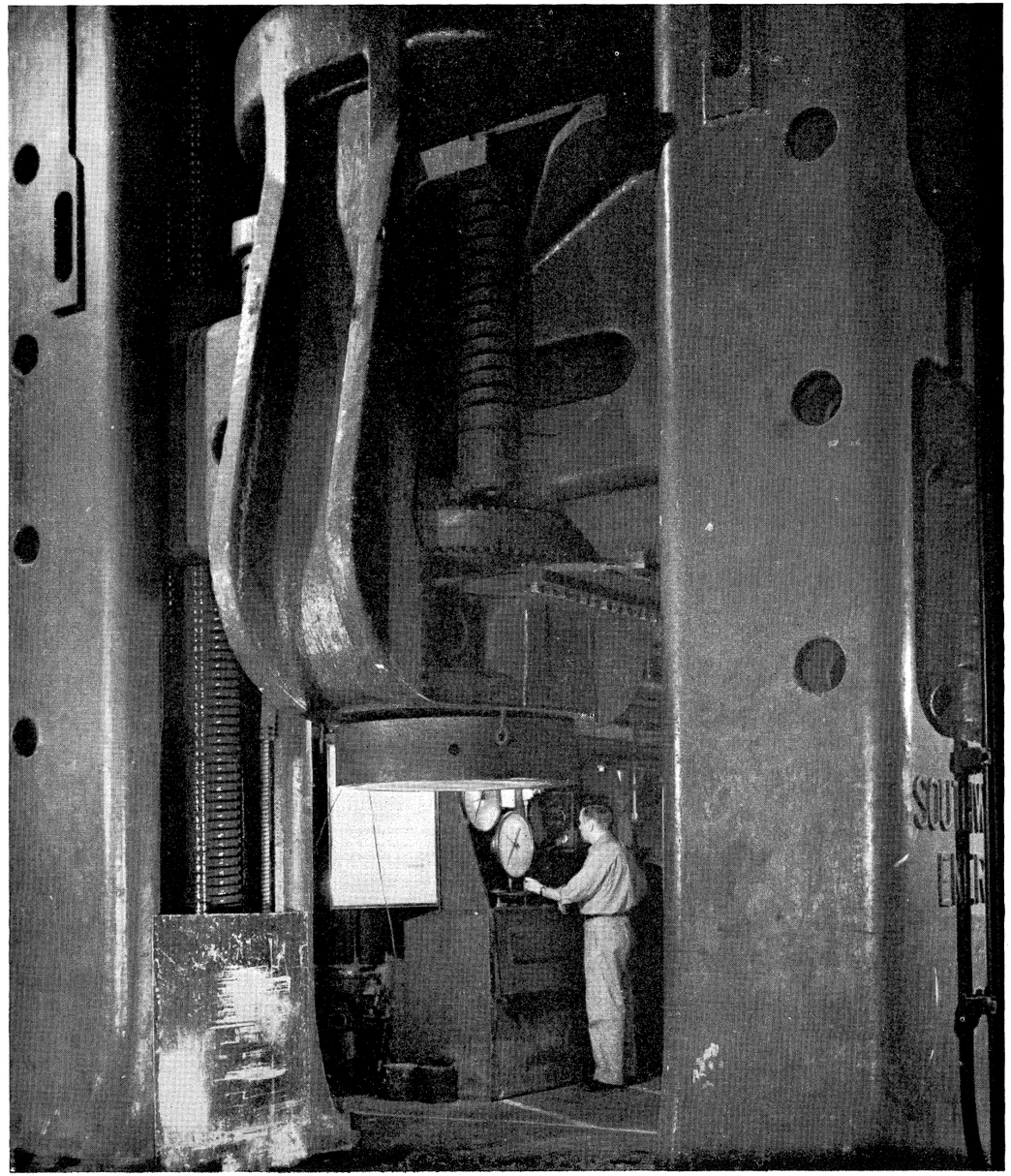
New dentifrice kills bacteria

THE SCHOOL children at left are brushing their teeth for science. They are using a new dentifrice developed by Dr. Robert G. Kesel and his associates, Edward C. Wach, Joseph O'Donnell and Ernst Kirch of the Colleges of Dentistry and Pharmacy. They studied some of the lucky people who have never had cavities in their teeth and found that all lack certain bacteria in their mouths, bacteria which are found in the mouths of all persons with tooth cavities. Experimenting further, they found that ammonia developed in the saliva of all these cavity-less people more rapidly than in the saliva of other people. Laboratory experiments showed that this chemical was deadly to the bacteria. A dentifrice was devised using salts of ammonia.

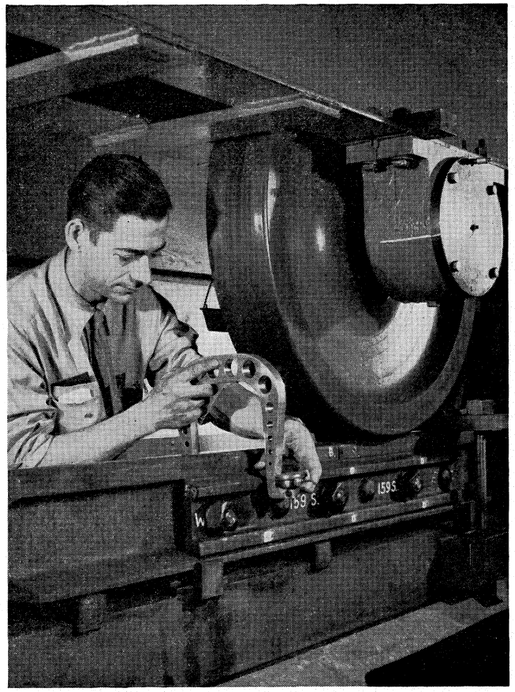
In the picture at the right, Dr. Joseph F. O'Donnell holds up two culture plates. Bacteria specimens from the mouths of patients were placed in each of them, but the plate at the left was treated with the chemicals present in the new dentifrice.

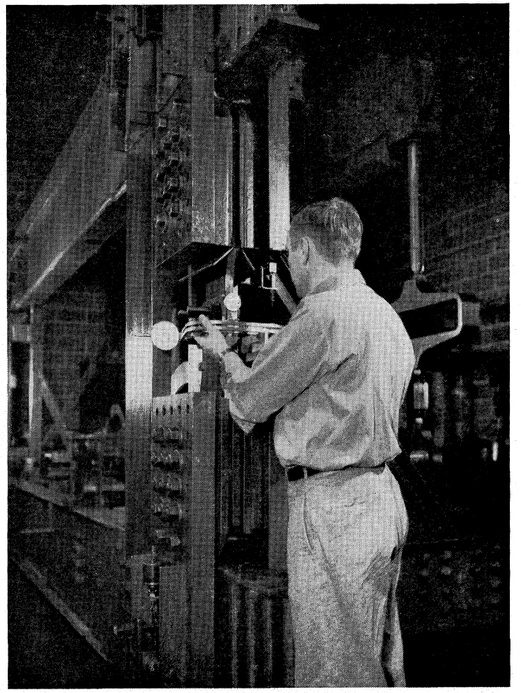
Last year fifth graders in the Aurora and Peoria schools were chosen as subjects on which to test the dentifrice. At that age most children have just got their second teeth and little decay has started. First, all their teeth were examined and cleaned. Then the children began a routine of brushing their teeth four times daily with the new dentifrice. Since the schools are cooperating, two of the brushings are done in the classrooms under the teachers' supervision.

Next year when the study ends (after the children have used nearly 25,000 pounds of tooth powder!), Dr. Kesel and his associates and the Illinois State Health Department who are also cooperating in the study will be able to compare four groups of children. One group is the control — its members kept on doing just what they've always done. A second group followed the brushing routine, but didn't use the ammoniated dentifrice. The third and fourth groups used two different types of ammoniated dentifrice.



Technology





Materials and Structures

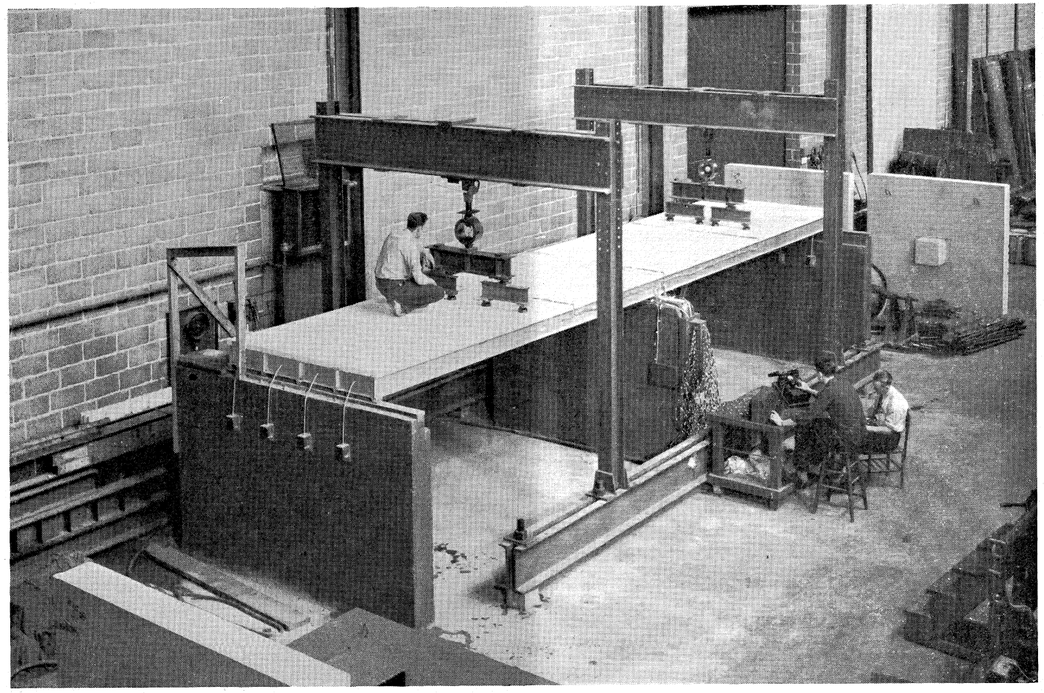
SHOWN on the preceding page is the giant compression-tension testing machine at the Talbot Laboratory of the University. Second largest in the world, and largest in this part of the country, it can apply a force of more than 3 million pounds to a test specimen clamped in its mighty jaws. It is one of a battery of machines that engineers at Illinois use in the testing of the metals on whose strength and reliability our industrial civilization rests.

One of the most annoying and mysterious types of metal failure is that due to *fatigue*. A metal part subjected to millions of on-and-off cycles of repeated stress will finally break, though it has never had to withstand any single force big enough to cause immediate failure. The machine shown above right is a fatigue-test machine used in engineering studies being carried on at Illinois. The bolted joint mounted between the machine's jaws will be carried through hundreds of thousands of carefully controlled stress cycles, until it fails. All types of riveted, bolted, welded, and brazed joints are undergoing study.

Not all of the research in structural engineering involves experiments with testing machines and instruments. Much important work is done with pencil, paper and calculating machines to develop the theories of behavior of buildings, bridges, airplanes and other structures. Many important problems are so complicated that they cannot be solved by formal mathematical techniques. For these problems, numerical methods of computation are being used and developed by engineers and mathematicians.

Metallurgists, civil engineers, and applied mathematicians work together to determine the best materials for a given purpose, the best design for a given structure, and the reliability of various structures in actual service use. In addition, the physicists are supplementing these extensive engineering studies by taking up fundamental work in the theory of the solid state. The empirical tests and measurements of engineers must ultimately rest upon a foundation in the basic theory of crystal structure and the properties of solid materials.

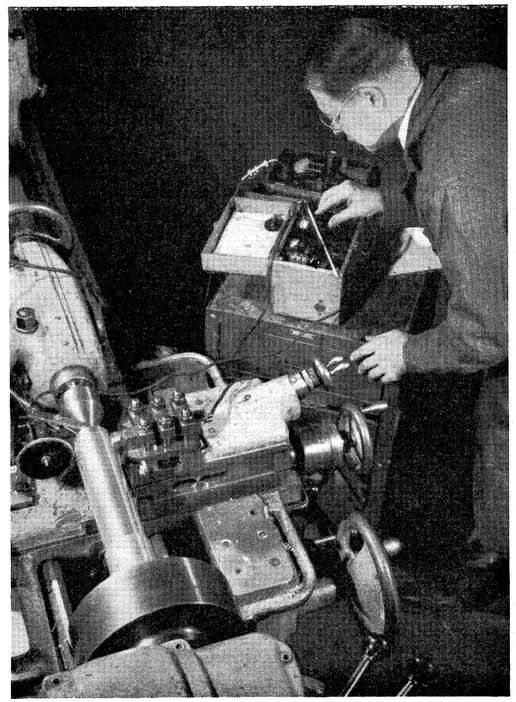
Today, however, extensive tests which reproduce the

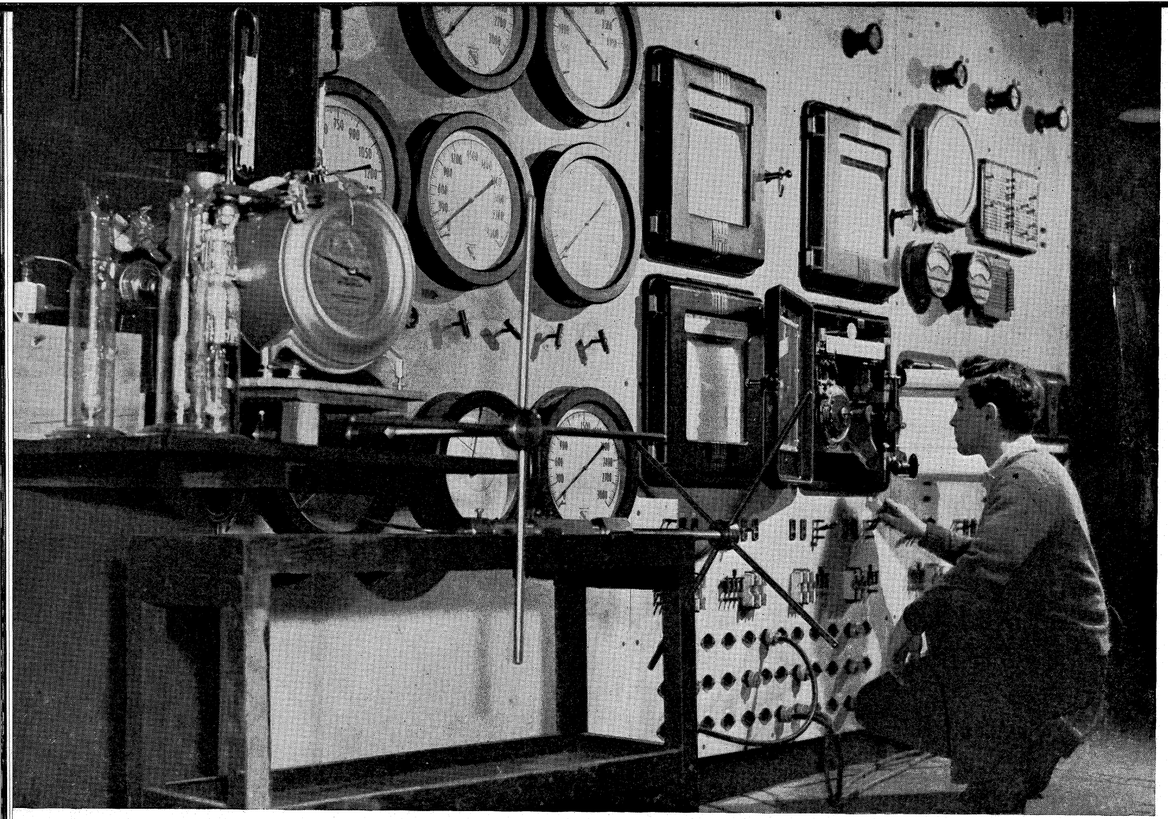


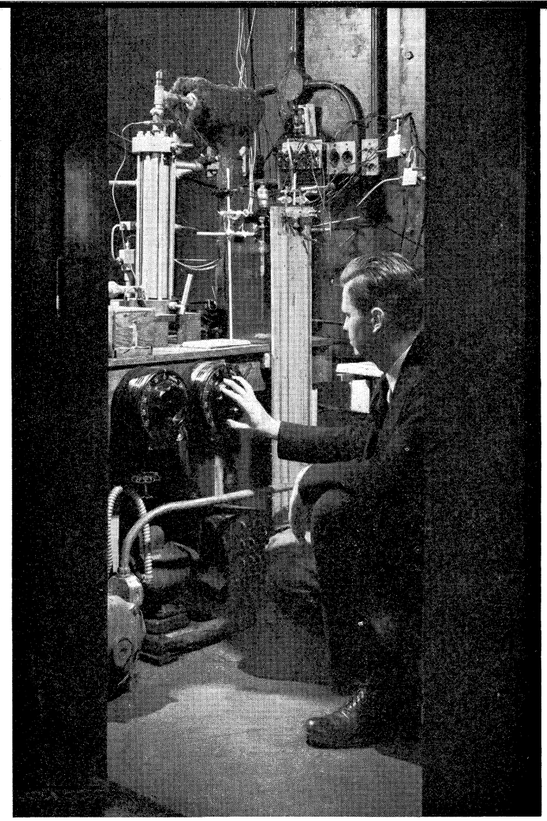
conditions of service use are essential to the design of practical devices. Shown at the far left is a special testing machine which rolls a railroad car wheel back and forth on a short section of track, applying loads up to 50,000 pounds: twice the load on each wheel of a fully loaded coal car. Sidewise forces like those which occur when a train goes around a curve can also be applied. From studies with this machine, Illinois engineers are designing better wheels and rails.

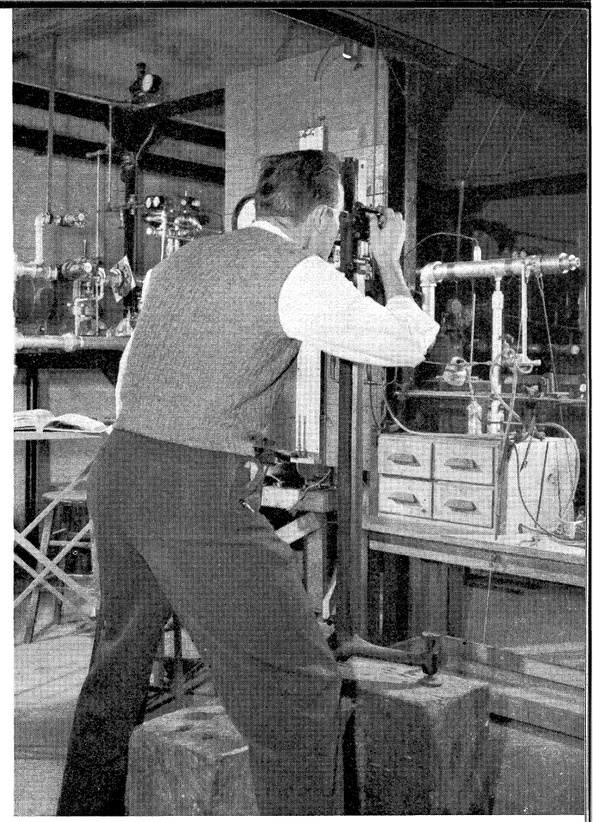
In the picture above a concrete bridge is being tested. Studies of bridge floor slabs have been going on since 1936 under the direction of Professors N. M. Newmark and F. E. Richart. These studies have resulted in notable contributions to highway bridge design. The picture shows one phase of this work — tests of a model of a two-span I-beam bridge. These studies, analytical and experimental, have recently been honored by selection as one of the three outstanding research developments in Civil Engineering during the past ten years.

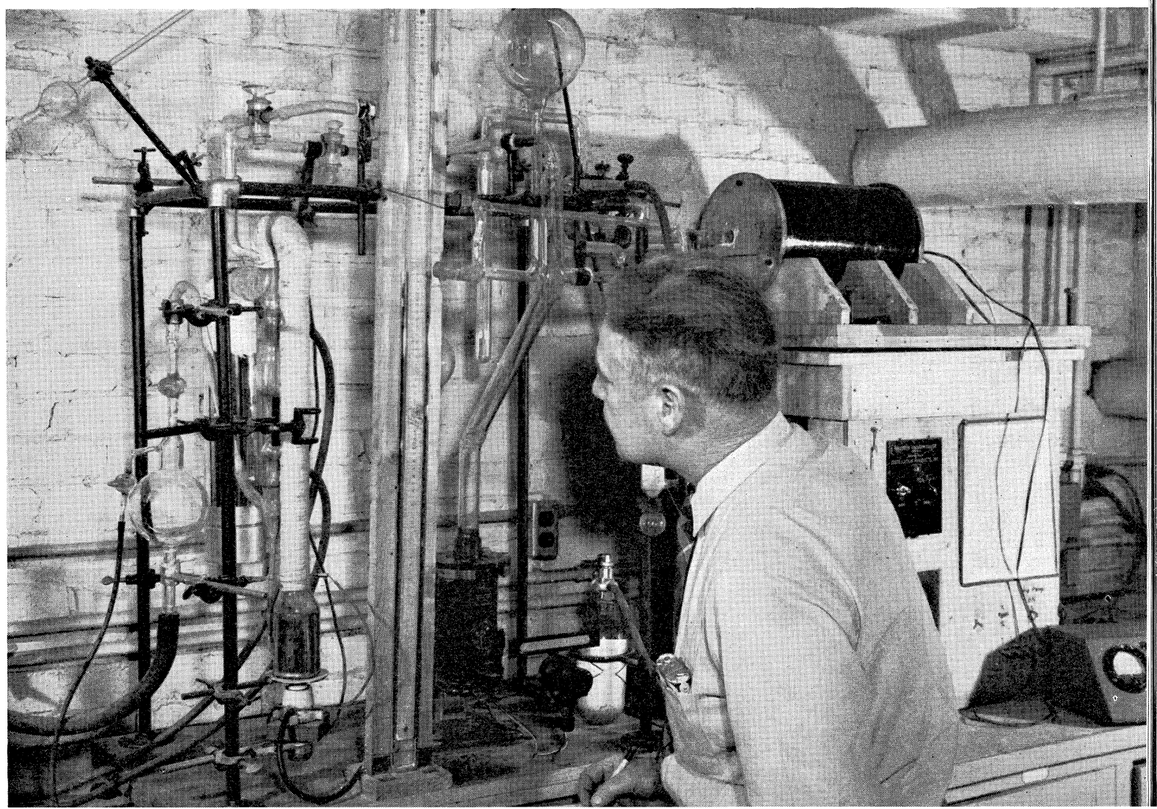
At right, Professor Kenneth J. Trigger is measuring the wear of metal-cutting tools at various speeds and depths of cut. Contrary to what might be supposed, the lightest cut does not produce least wear on the tool; as cuts are made heavier, the work warms up, is softer, and thus is cut more readily. Tool wear is least at intermediate feeds and speeds; when the rate of cutting is too great, the tool wears rapidly.











THE University's high-pressure research laboratory was one of the first in the country when it was built in 1926. Out of it have come many useful discoveries in chemical engineering, such as the process for making acetic acid by reacting carbon monoxide and methanol at high pressure. Studies can be made at gas pressures as high as a thousand atmospheres — 15,000 pounds per square inch.

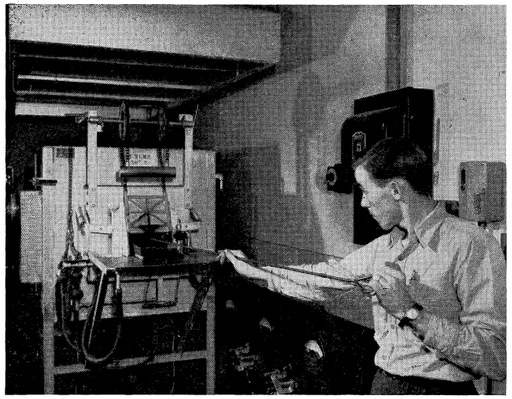
Shown above is the control and monitoring panel for the high pressure equipment. Facilities will be improved and expanded when chemical engineering moves into a new building now under construction.

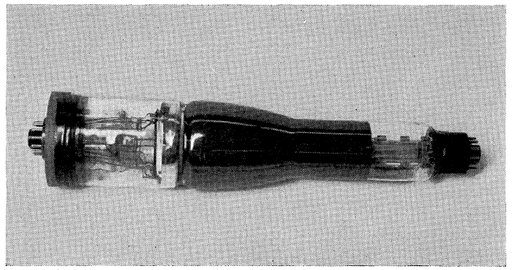
To the right of the control panel is shown one of the steel cubicles where the high pressure experiments are actually carried on. Dr. Edward W. Comings looks over the set-up to be used in an experiment on the behavior of gases in the critical region. When the experiment is being carried out, the temperature and pressure within the cubicle will be controlled from the outside panel.

IN COOPERATION with the Office of Naval Research, chemical engineers are making fundamental studies on the mixing of fluid streams. When a high-velocity jet of gas or liquid is squirted from a nozzle into a stationary gas or liquid, complicated patterns of turbulent flow result. An understanding of these patterns is essential to correct design of many important devices, such as jet engines, rockets, and even the cylinders of internal combustion engines. At right above a graduate assistant is sighting through a telescope to check the alignment of a tiny pressure-pickup tube used to explore the distribution of pressure near the opening of a nozzle from which a high-speed gas jet emerges.

HOUSEWIVES can thank ceramic engineers at the University of Illinois for the longer-lived enamel pots and pans which they now find in the stores. In a long series of tests, a greatly improved porcelain enamel was developed. The enamel specifications used by the Bureau of Standards, worked out at Illinois, have had to be revised upward twice in the last six years as Illinois research improved the durability and quality of porcelain enamel. Ceramic coatings are used for other purposes, too. Applied to the metal exhaust stacks of airplane engines, they lengthen the life of the stack and make it run cooler and therefore glow less. This was important during the war, when the red glow of aircraft exhaust stacks could disclose a plane's position to hostile night fighters.

At right, Professor Dwight G. Bennett is measuring the permeability of glass to various gases. Such information is important in the design of ceramic coatings which are to be exposed in service to hot gases which may penetrate the coating and attack the metal underbody.





Making Special Vacuum Tubes

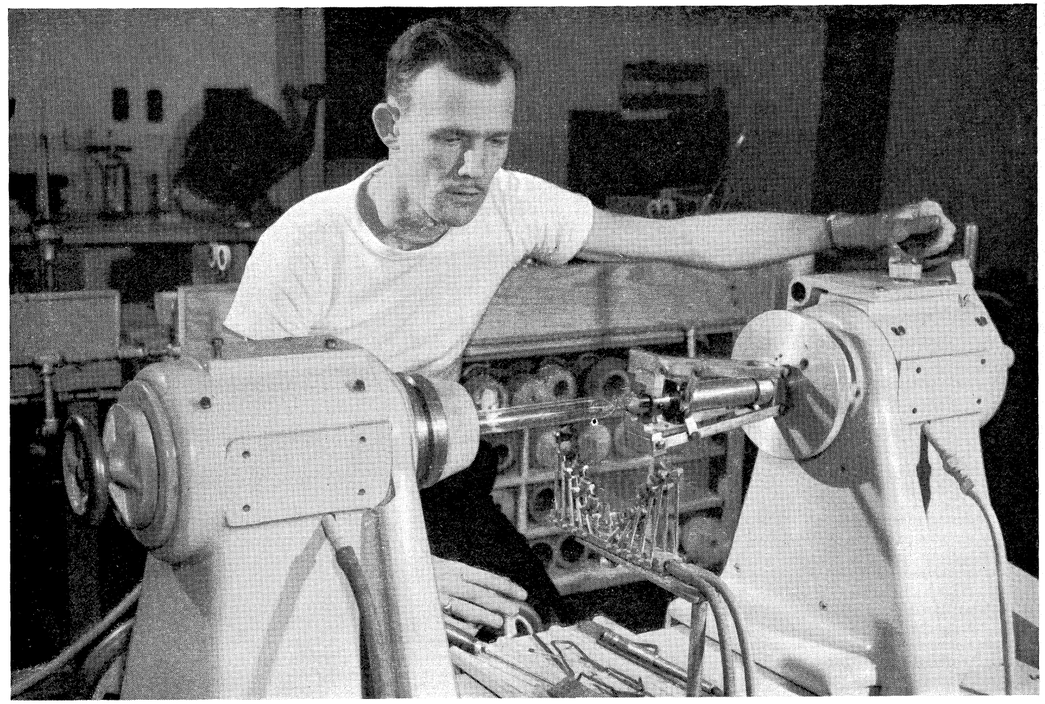
THE VACUUM TUBE is the heart of the increasingly complicated electronic devices which are becoming vital to all industry. The ordinary person is familiar with the tubes that are used in radio and in television, but may be unaware of the existence of the many special types of electron tubes that are used in radar, industrial control mechanisms, telephone and cable systems, welding machines, elevator and electric railway power plants, and many other unexpected places.

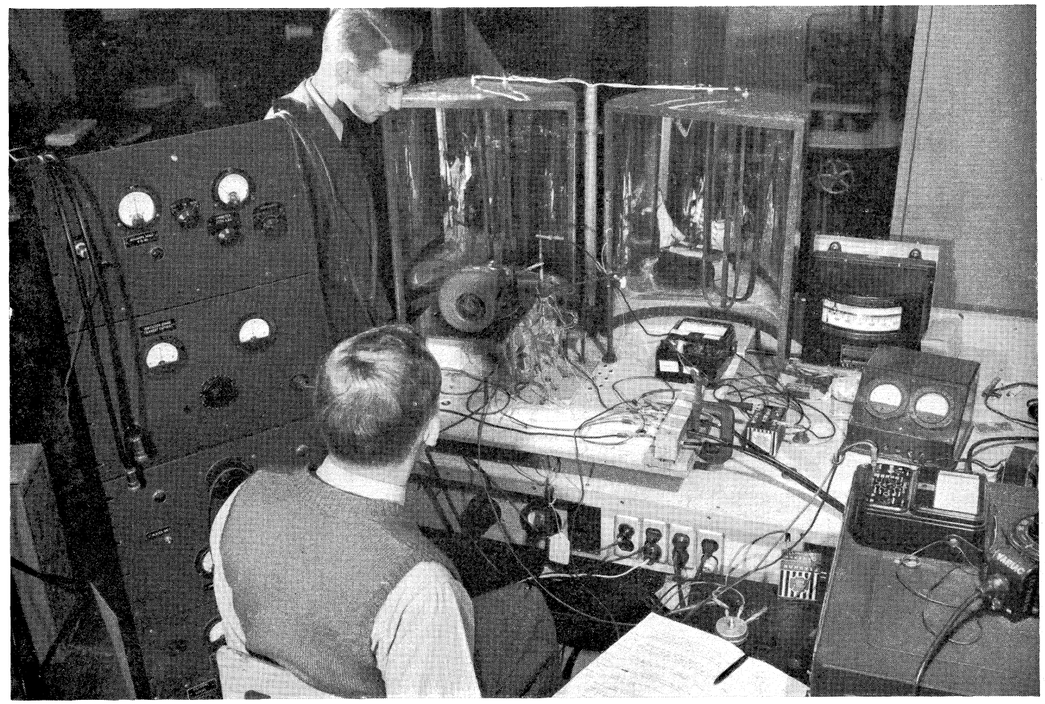
To do research in electronics, it is necessary to be able to build special types of experimental vacuum tubes. Illinois is one of the few universities having a full-scale model shop that can make vacuum tubes to any experimental design. Some of the important steps in making tubes in that shop are shown on these pages.

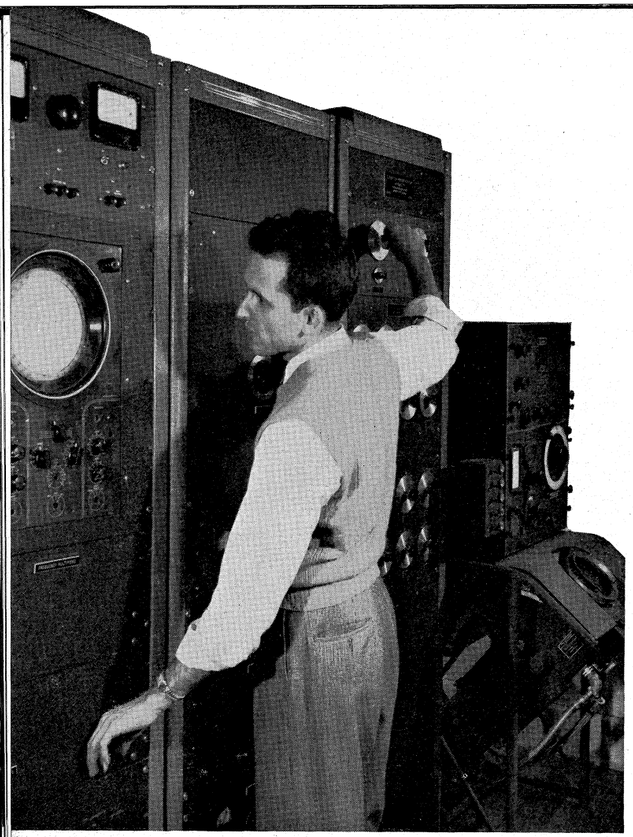
At left above is a hydrogen furnace in which the metal parts for the inside of the tube are cleaned and heat treated. The glass-to-metal airtight junctions which are often used in vacuum tubes are made by heating the joint by means of high-power radio waves generated by the machine shown above right. Glass parts are fabricated on glass lathes like that shown at the far right above.

When a tube is finished, it is given its final electrical tests while still connected to the vacuum pumps. Such a test is shown at the lower right. The vacuum tubes made in the shop take many forms. The complex example at the lower left, which has leads coming out each end, is a special tube built at Illinois for use in the "memory" mechanism of an electronic high-speed computer now under construction.

Other types of special tubes being developed by staff members include improved types of magnetrons, klystrons, and traveling-wave tubes. The first two types were used in wartime radar equipment, but were either built to operate at only a single fixed radio frequency, or else were tunable over only a narrow range. Emphasis in the work at Illinois is on the development of single tubes that can be tuned continuously over a very wide range of frequencies.







Radio Direction Finding

When you receive a radio program at home, you are not particularly concerned with the direction from which the radio waves reached the antenna of your set. For specialized uses of radio, however, it is often extremely important to have this information. In peacetime, the Federal Communications Commission uses radio direction finders — devices that measure the direction of arrival of radio waves reaching a receiver — to track down and silence unlicensed radio stations. In time of war, such direction finders are used to locate the source of enemy radio transmissions.

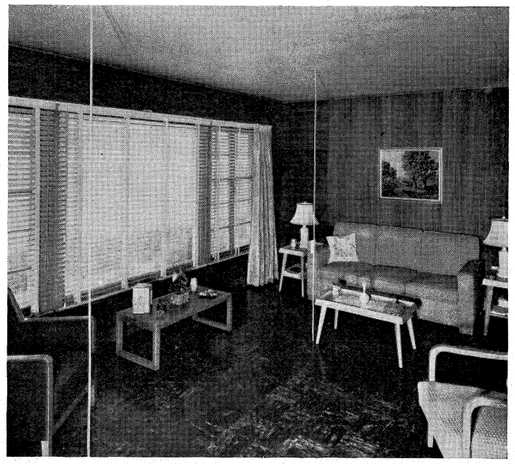
At the University of Illinois, the electrical engineering department is carrying on a major program aimed at the improvement of such radio direction finders. The goal is a direction finder which will receive a signal of any wavelength, coming from any direction, and promptly indicate its direction of arrival. The complicated analyzer shown above, designed at Illinois under the supervision of Professor Edward C. Jordan, is a device for making laboratory tests on the performance of various types of radio direction finders.

Heat for the Home, Air for the Subway

Mechanical engineers at Illinois have long been interested in problems of heating and ventilating. They have played a leading role in developing such home heating innovations as radiant baseboards and ceiling panels, as well as in designing such major ventilating systems as those in use in the Holland Tunnel and the Chicago subway. In addition, Prof. Julian R. Fellows has invented a smokeless furnace which burns any solid fuel and reduces smoke by 90%. Last year 1500 American homes were the first ones to be heated by this smokeless furnace.

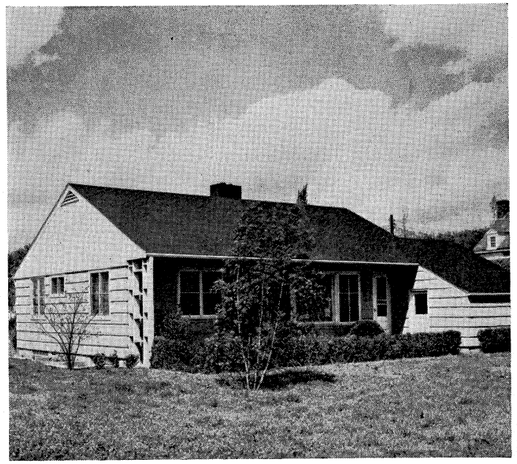
For many years, research in home heating has been carried on in two experimental residences which simulate home conditions. In one of these homes (whose living room and exterior are shown below), warm-air heating systems are tested. In the other home, steam heating systems are studied. Radiant baseboards were largely developed in this steam heated home; radiant ceiling panels are currently under test in the house pictured. The tiny pipes running from floor to ceiling of the living room carry thermocouple wires. Thermocouples measure the temperature at every height between floor and ceiling.

In the field of ventilating, engineers are currently working on an air distribution system which can distribute warm air in winter and cool air in summer, economically enough for home use. Different volumes of air are required in each season.



A Better House for Your Money

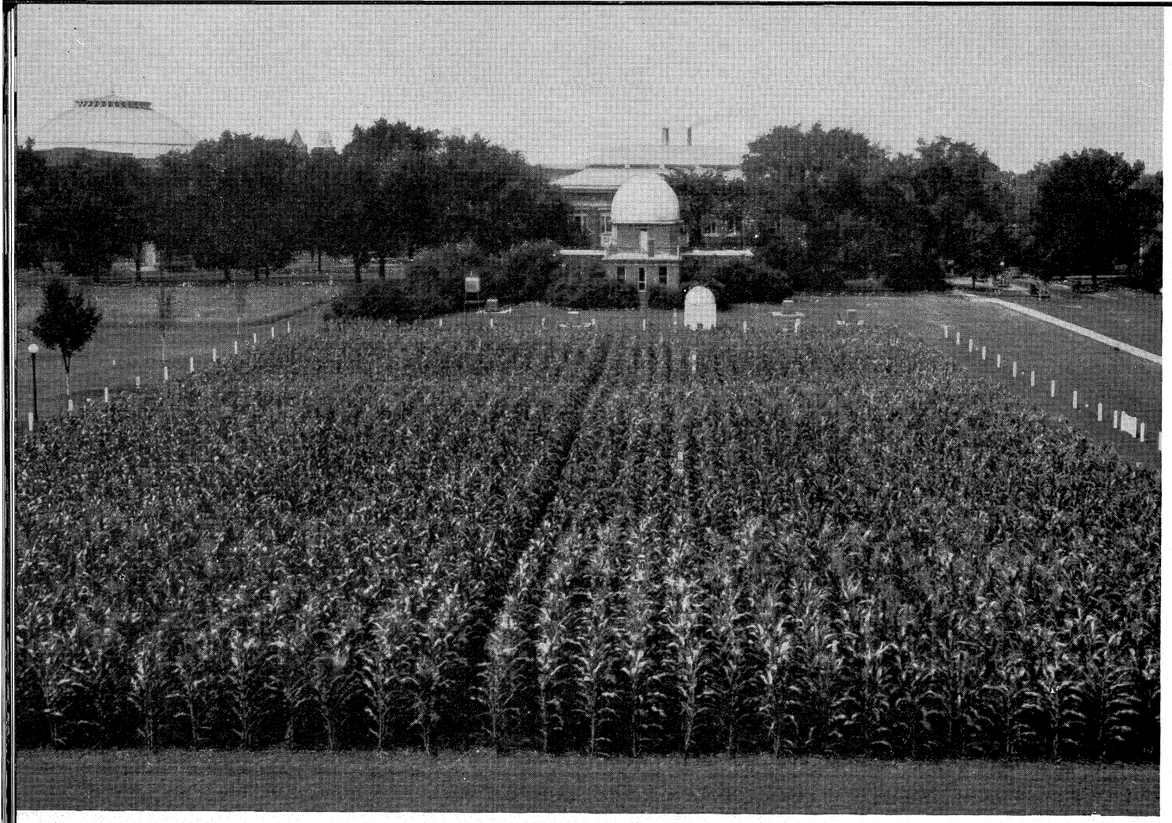
Many of the engineering research projects at Illinois have important applications to the design of homes. To test new designs and structures, experimental houses are built and studied. Research at Illinois has resulted in the development of radiant baseboards and ceiling panels (see opposite panels), new types of warm air, steam, and hot water systems and improved coal furnaces for home heating. Plans have been developed for improved farmhouses. Other studies involve basementless houses built on concrete slabs, modular methods of construction, and many other improvements.



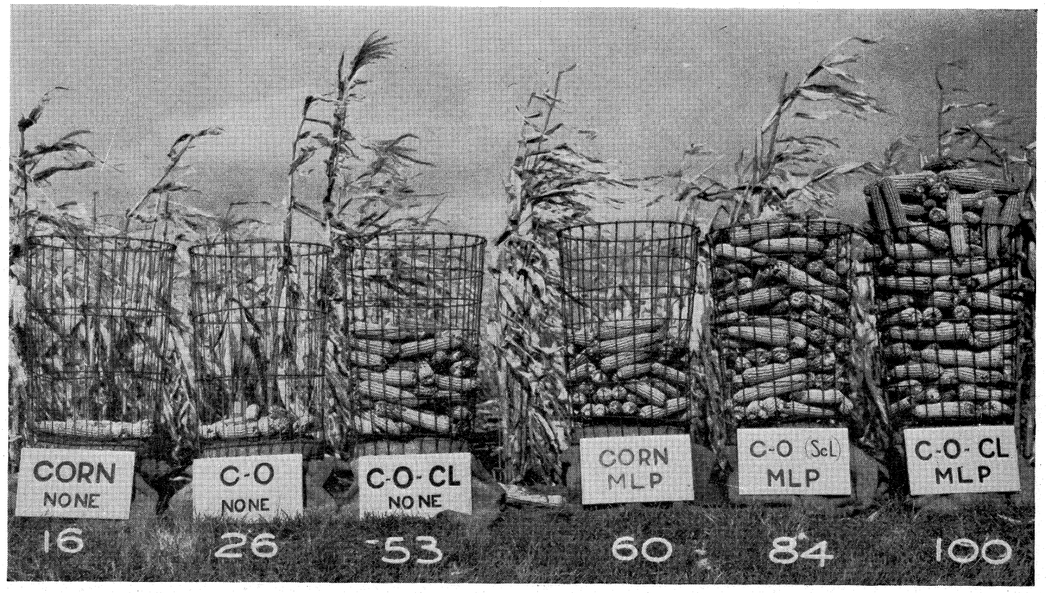
Studies made in a warm-air research home first showed how proper insulation and storm windows could cut heating losses. Nearly every home built in the past decade has been insulated, with a resultant saving of up to half of the heating bill.

At Illinois, the Small Homes Council coordinates studies affecting home planning and construction and publishes easy-to-understand bulletins covering the many phases of home design. Past bulletins have discussed plumbing, wiring and construction. They have included pamphlets on choosing a lot and on landscaping.

Shown above are some of the Small Homes Council publications which have been issued; several hundreds of thousands have been distributed to all parts of the United States.



Land—Our Basic Resource



THE BASIC resource of Illinois is its land. The best use of Illinois land and the conservation of its productive power have been continuing concerns of the University since its foundation.

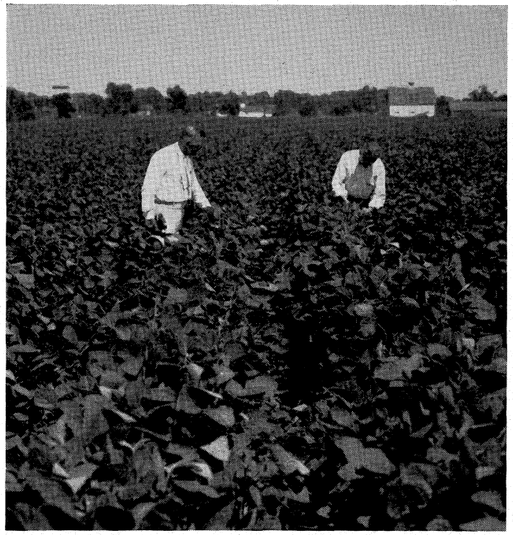
Shown above left are the famous Morrow Plots located on the campus at Urbana, the oldest continuously used soil experiment plots in the United States. The controlled use of these plots since 1876 by Illinois agronomists has dramatically demonstrated how land productivity depends on soil management.

Different systems of farming have been followed on different areas of the Morrow Plots. In one area, the land was planted in corn every year and no fertilizer was used. In other parts, the corn was rotated with oats, or in succession with oats and clover. In still other parts, these same rotational plans were combined with additions of manure, lime, and phosphate to the extent that soil tests indicated the need for these fertilizers. The lower picture illustrates the resulting differences, in one year, in terms of yield per acre: 16 bushels (in the case of land planted continuously in corn) to 100 bushels (from land rotated in corn, oats, and clover, and fertilized with manure, lime, and phosphate). At the present time it would take 345 acres of the land planted continuously in corn to produce the same income (above cost of production) as was realized from the original virgin soil. But the land on which the crops have been rotated, and to which fertilizer has been added, is actually more productive than the original rich soil of the prairie; 76 acres now produce as much net income as 100 produced originally.

In addition to the experimental fields at Urbana, the College of Agriculture has 29 experimental farms located on soils of different types throughout the State. On these farms, soil treatments and cropping systems best adapted to particular soil types are being worked out.

In order to take advantage of these studies, farmers in 70 counties of the State have established soil-testing laboratories for the purpose of keeping a continuous check on the fertility needs of their farms. These laboratories are supported entirely by the farmers, but the technical work and the interpretation of results are directed by soil scientists of the College of Agriculture.

Soil conservation goes hand in hand with proper crop rotation and soil enrichment. Above is a picture of land being farmed for the future. The farm is planted in strips corresponding to the contour of the ground, in order to hold the soil in place and prevent runoff. Methods for combating soil erosion are being studied at Urbana and on the experimental farms.



THE FIELD above is planted in soybeans. The University of Illinois College of Agriculture pioneered in developing the soybean industry in the United States. For many years, thanks to the work at Urbana, Illinois has produced more soybeans than all the rest of the country. During the war years, because of the great need for oil-producing crops, production was greatly increased in other states, but Illinois still leads the country in this crop. The Lincoln, the Chief, and the Illini are three of the famous strains of soybeans developed at the University of Illinois. Dr. C. M. Woodworth developed these three strains.

Many millions of dollars of additional wealth are now produced annually by the farm lands of the State as compared with their productivity 15 years ago. This new wealth results from increases in the yield of Illinois' three major farm crops during the period 1932-1947. Based on 3-year averages centered on the first and the last year of this period, corn yields have increased nearly 50% — from 36 bushels to 53 bushels per acre; oat yields have increased 36% — from 30 bushels to 41 bushels per acre; while the state-wide yield of soybeans has increased from 17.7 bushels to 21.8 bushels per acre, or 23%.

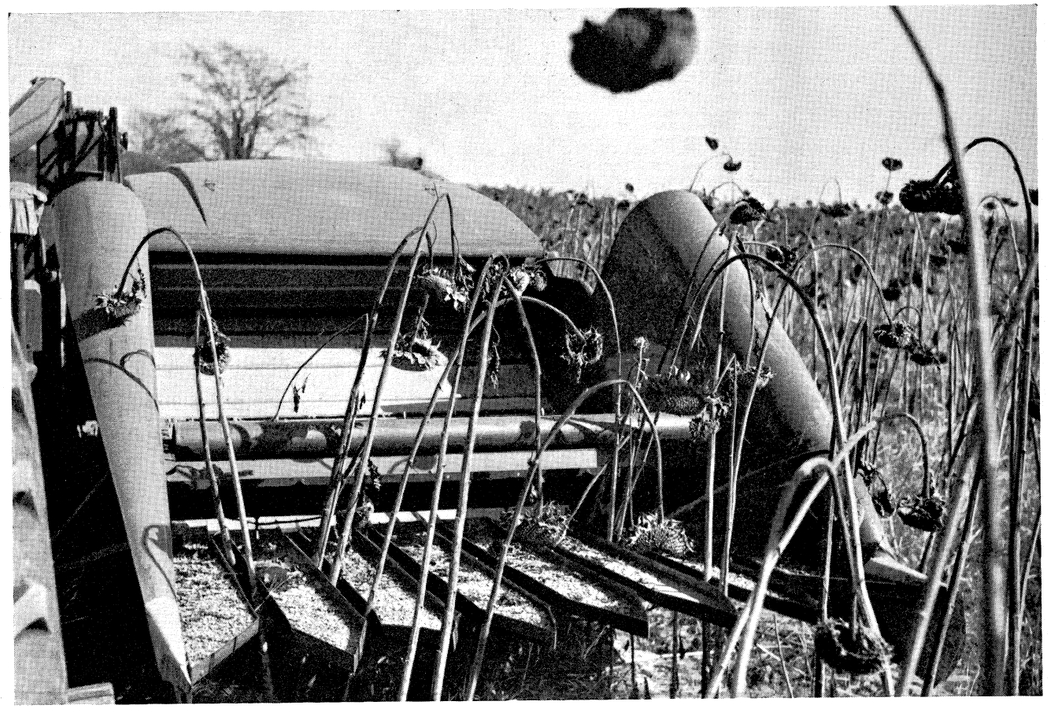
The College of Agriculture has played a leading part in creating this increased wealth. Its plant-breeding studies have produced new and higher yielding strains, and the improved soil and crop management practices developed in its research program have been carried to the farmers of the State by the Agricultural Extension staff. In addition the College of Agriculture is training students who, after graduation, will carry on scientific farming throughout Illinois.

WHEN a new crop is developed, producers are confronted with harvesting problems. For example, the harvesting of sunflower seed is radically different from harvesting other more familiar crops. In such a case, the Department of Agricultural Engineering undertakes the job of designing a machine, such as that shown in the picture, which can harvest the crop without excessive loss of the seeds which contain the oil for which the crop is chiefly valuable.

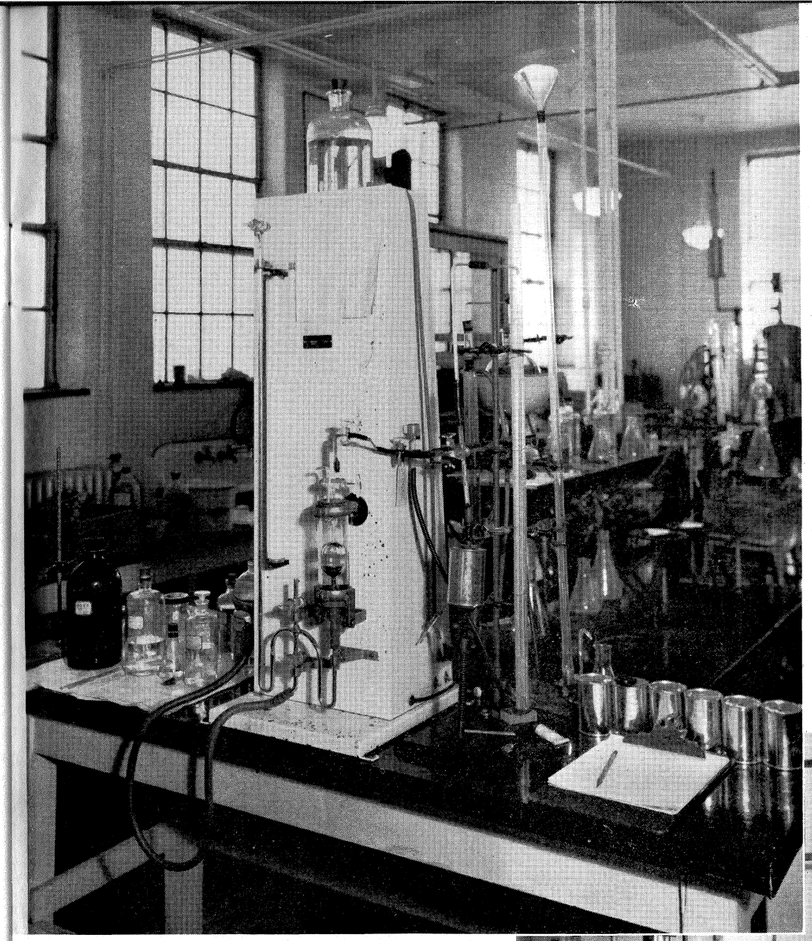
Progress in mechanization, rural electrification, soil and water engineering, and farm building design has greatly affected farm operation, and has created many problems which require research and the application of engineering principles.

MORE productive farm animals, combined with more efficient feeding and management, are also continuing goals for research at Illinois. The pig shown is living in a room kept at 42° F. Investigators in the Department of Animal Science are measuring his needs for riboflavin, to determine whether the pig's requirement for this vitamin depends on the temperature at which he lives. The riboflavin requirement of similar pigs at 85° F. have already been measured. In such experiments, Illinois scientists are finding the sorts of feed which will increase the size of animals, their rate of growth, and the nutritive quality of food products obtained from them, while keeping increased food costs proportional to the increased sale value of the animal.

Many other problems of livestock breeding, feeding, and disease control are under study. Such investigation helps to use millions of acres of land which is not well adapted to the growing of crops, and enables the use as feed of many by-products of crop production.



THESE chrysanthemums growing in the floriculture greenhouse of the Department of Horticulture are of varieties developed by crossbreeding experiments. Fruits and vegetables, too, are under constant study and improvement which has the aim of producing varieties that are hardier, easier to grow, higher in yield, higher in quality and more resistant to disease. This picture was taken at the time of the annual mum show in the fall.

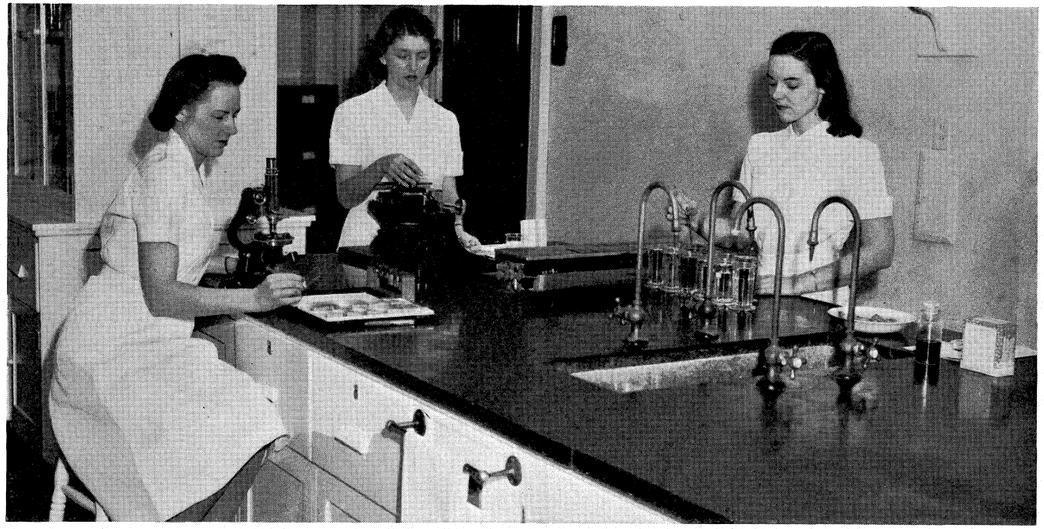


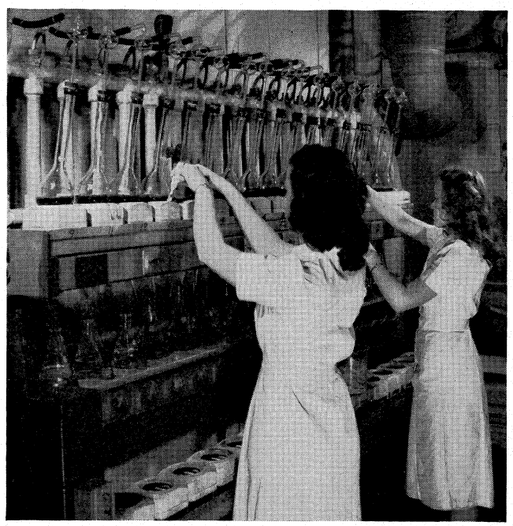
AS A PART of the fast-growing program in food technology at Illinois, a complete dairy and creamery are operated on the campus. Here studies are made of the best means for processing milk, butter, cheese, ice cream, and other dairy products.

Shown on this page are two pieces of apparatus used in studying how quality can best be maintained in dairy products.

ONE of the studies being conducted by the Department of Food Technology has to do with the keeping quality of dried milk, cream and ice cream. The picture above shows the apparatus used to analyze the gas content of the air space in sealed containers of dried milk.

A new approach to the destruction of bacteria in milk is the ultrasonic generator shown in the picture on the right. This machine destroys the bacterial cells with sound waves of such high frequency that they are not audible to the human ear.

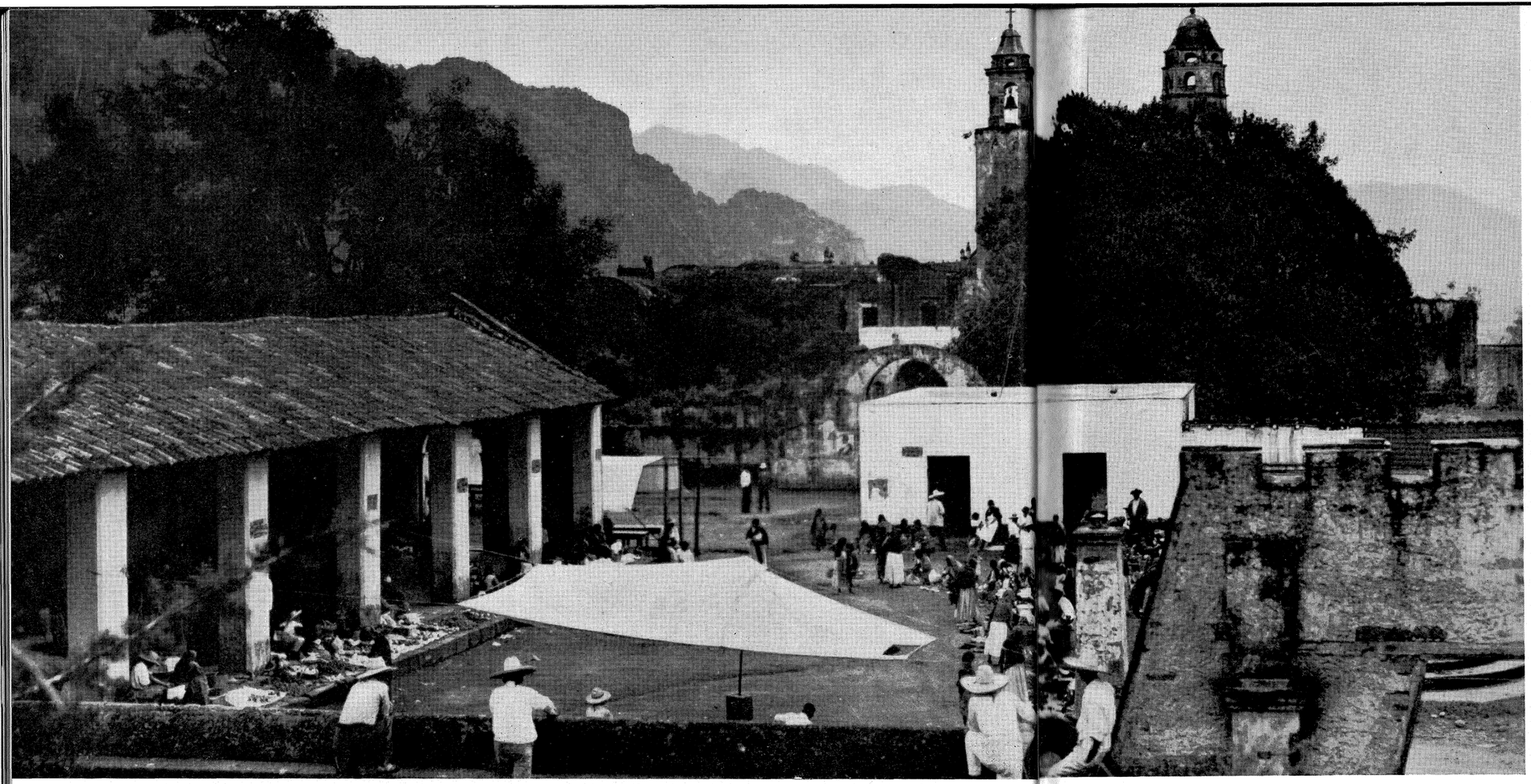




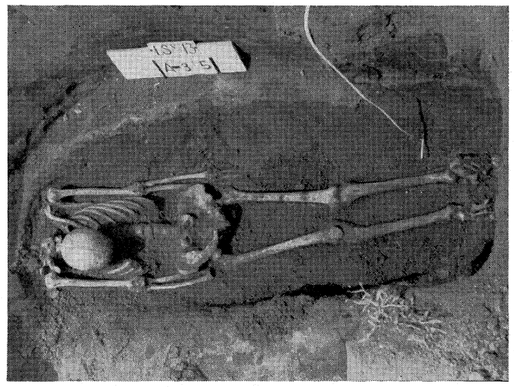
Better Nutrition Through Research

In the Department of Home Economics, nutritional needs of humans are being studied. Boys and girls 12 to 16 years of age, and college women, have served as subjects. Also under intensive investigation in this department is the effect of methods of food preparation and preservation, particularly home freezing, on the palatability and nutritive value of foods. At the top of the page is shown the kitchen of the house provided by the University as a home for the human subjects of dietary studies. Their food is all carefully weighed out. On the left laboratory assistants are making chemical analysis of the nitrogen content in foods fed the dietary subjects. In the right-hand picture, frozen peaches are being examined after several months of storage.

Human Behavior



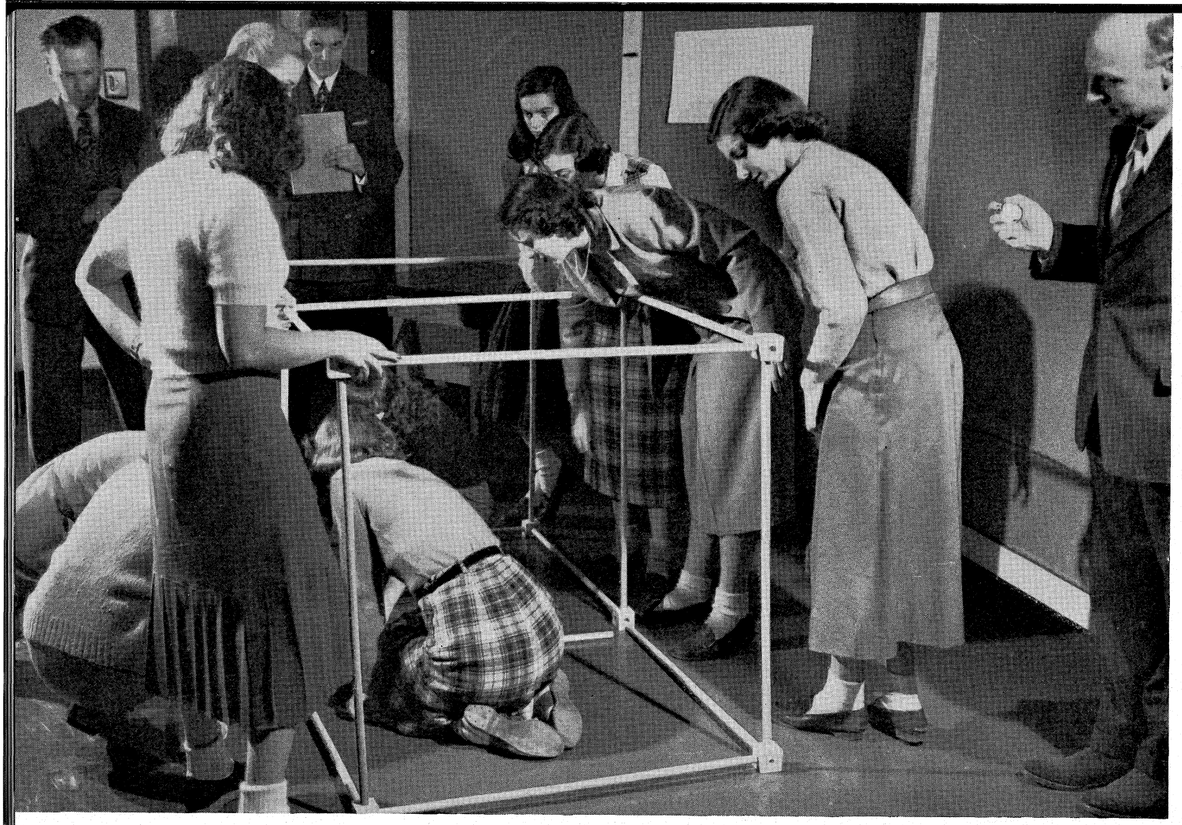
Human Problems Studied in Every Age and Culture



THE PEOPLE on the previous page — and millions of other people like them — are the real reason for all the other pages in this book. The University of Illinois' research laboratories and libraries, the great machines and precision instruments at Urbana and Chicago, exist only to push back the horizon of man's knowledge and to help make a better life for man on earth.

From the dim past of man as revealed by archaeology to present-day problems of business, government, labor, and home life, the records and problems of human behavior are being studied by University of Illinois research men. Archaeologists are delving into cultures that existed before the dawn of history. At the left is the excavated burial site of a man who may have known LaSalle or Father Marquette. His tribe was populous and powerful in Illinois long before the White Man came. By studying the records of these old civilizations, anthropologists can throw some light on the way civilizations rise and change and fall.

Dr. Oscar Lewis, of the Department of Sociology and Anthropology, has just taken advantage of a unique chance to study cultural change. For two years he has been studying what happened to a Mexican village (above) which, after having been almost isolated for hundreds of years, was suddenly put on a through road to Mexico City. He reports that this village, like rural Mexico as a whole, has probably changed more in the past twenty years than in the preceding three centuries. A native artist, Beltran, drew for him a series of pen sketches of the villagers, like the one at the right.



⇧ Working Together And Living in Groups

THE PICTURE ABOVE is a miniature of one of the most common problems in the world today — people trying to work together under difficult conditions.

In this particular case, too many cooks are spoiling the broth. The girls have been assigned a structure to build, but the pieces and holes are of different diameters and will only fit together in one way, which is difficult to find. Psychologists are observing the laboratory situation, noting how the girls organize to do the job, and how they select leaders.

This is part of a study of group behavior, which is important not only because it may help us to get better performance and happier relationships out of groups as different as a community, an office staff, and a football team, but also because national behavior is a form of group behavior, and a deeper knowledge of national behavior would help us toward world peace.

Illinois psychologists are constantly studying individual as well as group behavior. The process of learning, the basis of personality, the psychology of vision, and the nature of normal and abnormal speech are among the problems now being attacked.

Education for All ⇨ Of Illinois' Children

STAFF members in the College of Education are studying what the State of Illinois needs in the way of buildings, teachers, curricula, and money to give it an ideal school system. They are studying also the more individual but no less urgent problems of Illinois' handicapped children — how to avoid this human waste and how to help such children live as nearly a normal life as possible. A nursery school for mentally handicapped children was inaugurated this year. Work with the deaf has gone on for several years.

Above right is a deaf boy learning to speak. He is watching the movements of his teacher's mouth, feeling the sounds of speech on her throat and jaw, looking at the ball and trying to say the word "ball." Powerful acoustical amplification in his earphones is making use of what little hearing he has left.

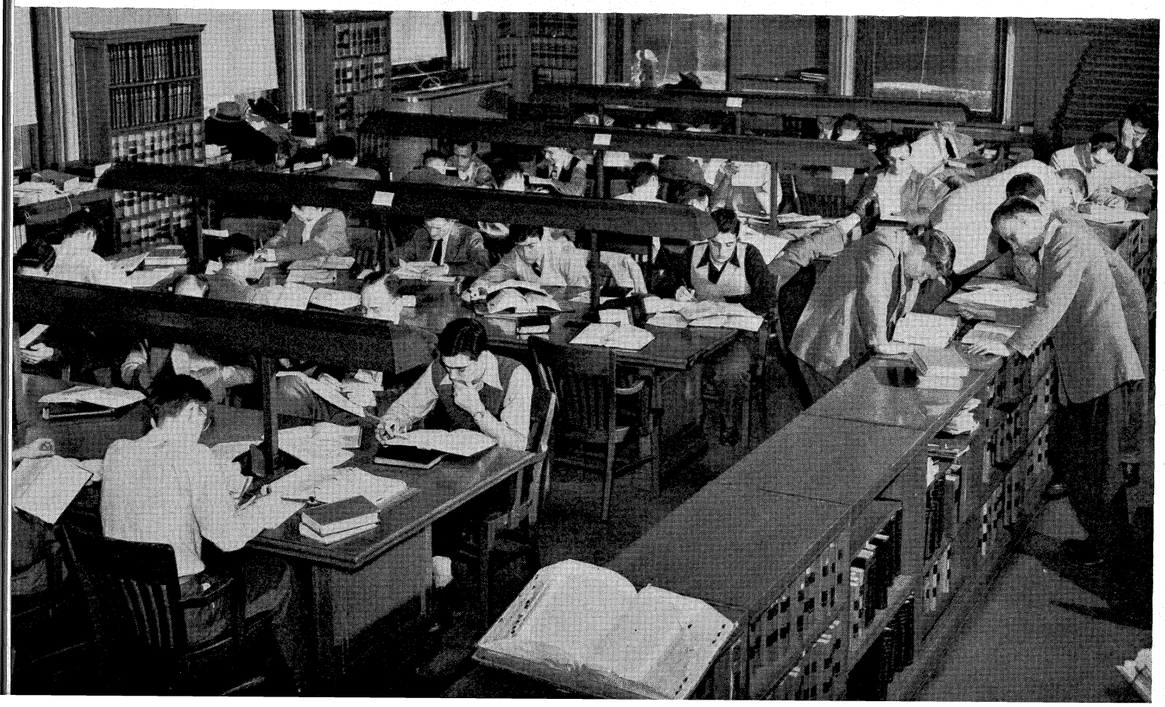
The children below have never heard before coming to school. Now, for the first time, through amplifiers and earphones, they are listening to the "Night Before Christmas." The teacher is stopping to point out words. These children eventually will be able to speak quite intelligibly, and to appreciate language.

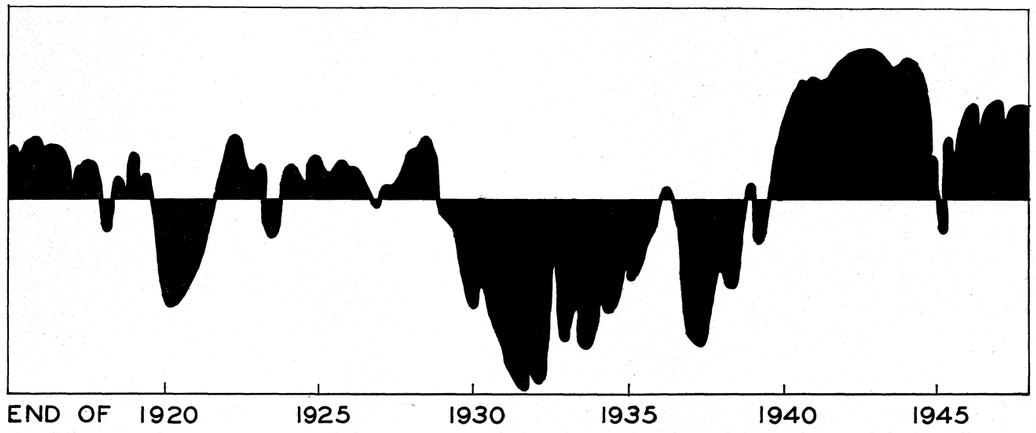
Law, History, Government

THE MAN who so strikingly resembles Lincoln in this picture is actually one of the greatest living authorities on Lincoln. He is Professor J. G. Randall, one of the distinguished research men of the Department of History. His latest book is *Lincoln the Liberal Statesman,* and he is now at work on a continuation of his *Lincoln the President: Springfield to Gettysburg.* On July 26, 1947, Professor Randall was one of the handful of scholars invited to be present at the opening of the long-restricted Lincoln papers in the Library of Congress.

IN THE busy law library shown below, and elsewhere on the Illinois campus, scores of legal and governmental problems are being studied. Professor Clyde Snider has just prepared a report on new sources of municipal revenue, and Professor J. N. Young a report on the State inheritance tax system, both for the State Revenue Laws Commission. Professor H. K. Allen has been borrowed by that Commission to be its research director. Professor R. N. Sullivan is studying the legal relations of church and state, and Professor Kenneth Carlston is reviewing this country's negotiations with Russia, trying to discover the common patterns in the Russian methods and how they may best be dealt with.

Professor Charles M. Kneier has just completed a study of state supervision over municipally owned utilities, and Professor Clarence Berdahl is finishing a study of political party organization. Professor F. G. Wilson has just published *The American Public Mind,* which is a survey of the conflicts of ideas in America from Colonial times to the present. Another important project is Dr. Walter Voskuil's on *Iron and Man.*

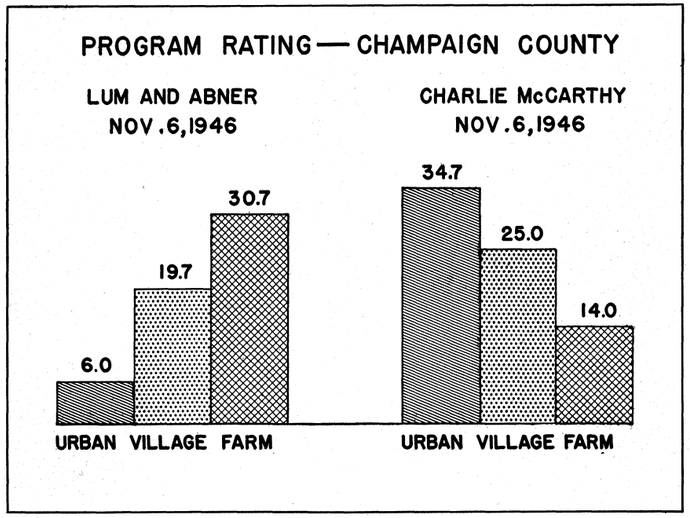




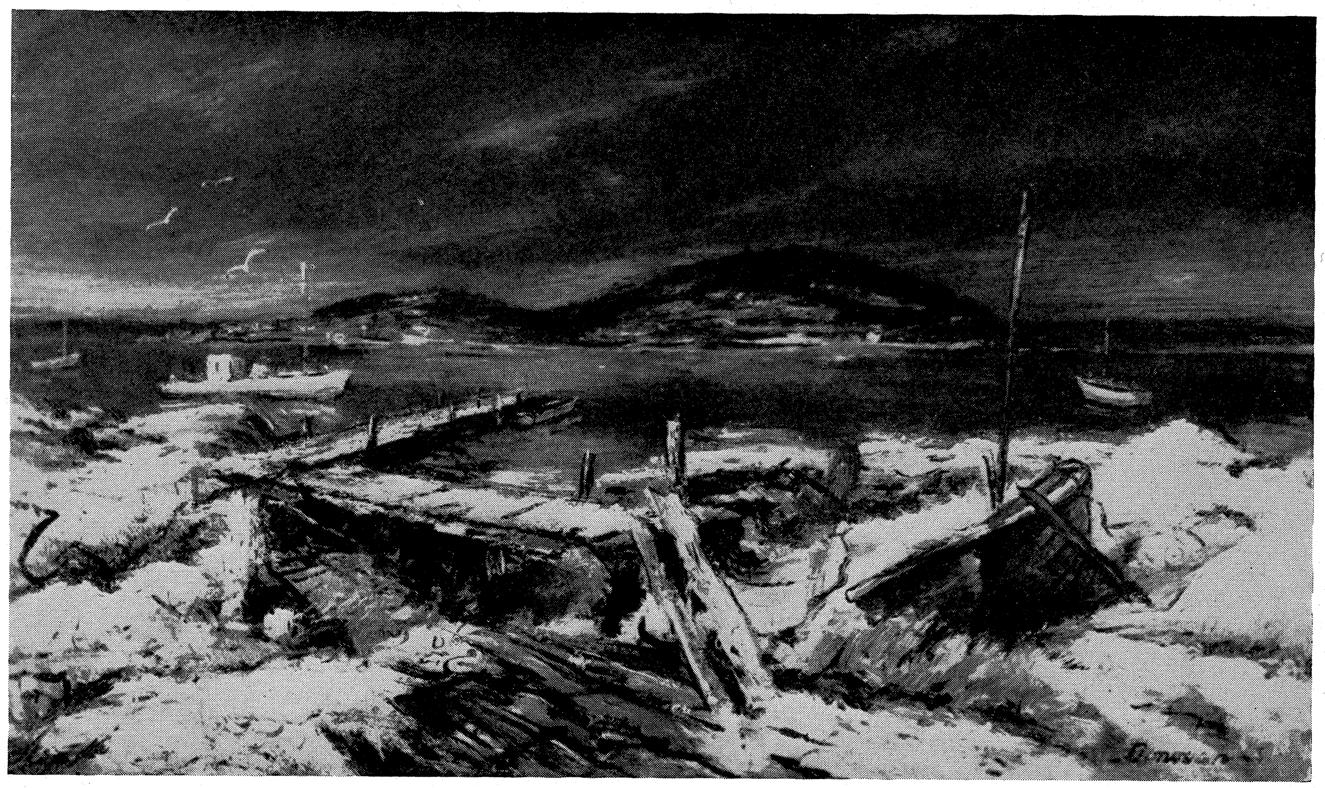
What Is Back of Booms and Busts?

THE JAGGED line represents the ups and downs of business during the last 50 years. No one wants depressions, yet no way has been found to prevent them. The College of Commerce, under the direction of Dean Howard R. Bowen, has begun a fundamental study of the psychological factors back of business fluctuations. The decisions of businessmen, consumers, and investors determine the amount of business activity. Their decisions are affected by how good they expect business to be. This study is intended to find out how the opinions men hold are related to their economic decisions, and how the pattern of business opinions is related to business cycles — and through this to throw new light on the question of why the line above is so uneven.

Communication of Ideas



THE chart at the left, based on some of the audience research of Professor Charles H. Sandage, illustrates the difference in radio listening tastes between city, village, and farm families. Professor Sandage is a member of the Institution of Communications Research. This Institute studies the problems of radio, press, and pictures with the intention of supplying verifiable information in that area where the hunch and the theory have so often ruled. In another Institute research project, Dr. Dallas Smythe is studying the effect of television on the lives and thinking of people. Dr. Wilbur Schramm is studying the reasons people select what they do from mass communications, and the mental processes that go on in the acts of reading and listening. Dr. Fred S. Siebert is studying the history and nature of freedom of the press. Dr. J. W. Albig is studying news, editorial and advertising content of radio and press.



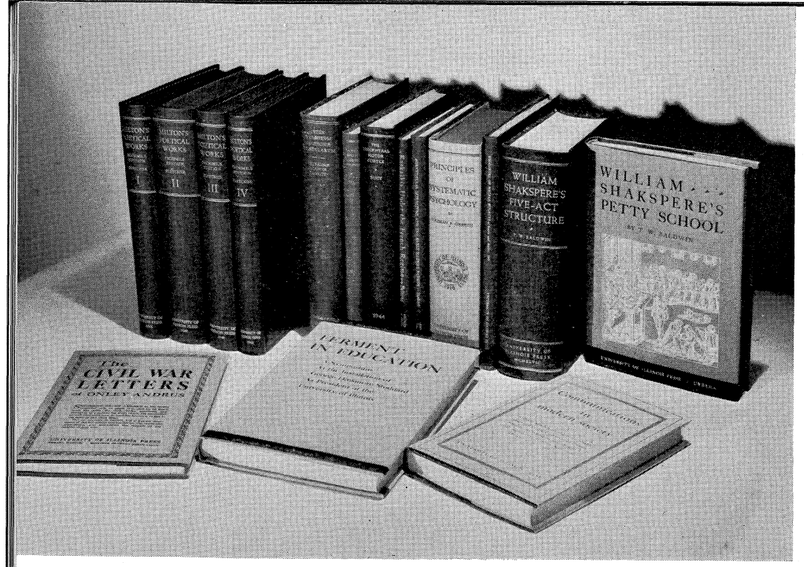
Other Creative Activities

THE pictures on this page are by faculty members of the College of Fine Arts. A number of Illinois faculty members exhibit their works in national shows, and their paintings hang in such places as the Metropolitan and Whitney Museums. The picture "Pacific Cove" shown above, by Prof. Cecil V. Donovan, won an award at the last "Paintings of the Year" exhibit. The silver chalice and plate below are by Arthur J. Pulos. The chalice has taken two awards in exhibitions.

On the opposite page above is Nicola Ziroli's "The Dead Soldier," which was recently exhibited at the Art Institute in Chicago. In fourteen years Mr. Ziroli's paintings have won 22 prizes and honorable mentions in national competitions.

The level of faculty creative work is also high in architecture, music, and drama. One of the great art shows of the country is the spring exhibition of painting at the University. This is combined with a festival of music, drama, and the other arts, to make a notable demonstration of creative activity on the campus.

One of the great string quartets, The Walden Quartet at right, is resident in the School of Music. The Quartet, the orchestra, the Sinfonietta, the choral groups, the famous Illinois band all program many works by new composers, many of them Illinois composers. The Illinois Theatre Guild presents many new plays as well as older ones, and one new member of the speech faculty, Arnold Sundgaard, has had a number of his plays produced on Broadway.



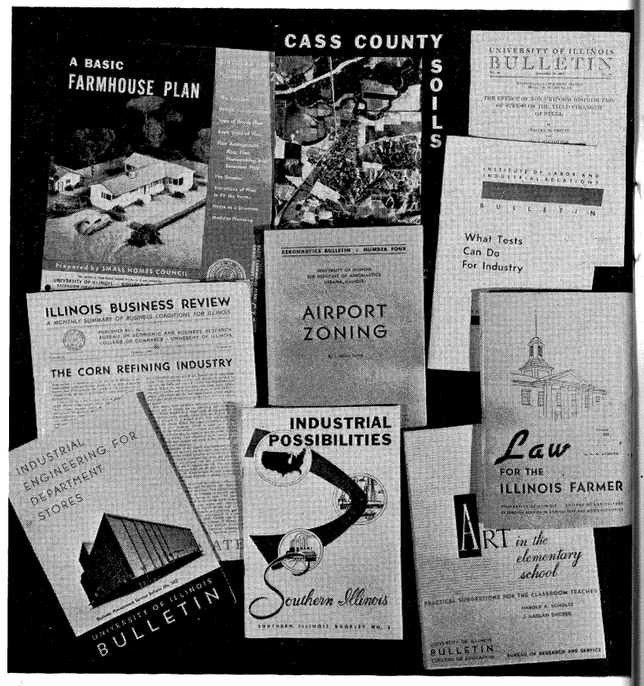
Some Products of Research Are Books

Books are laboratories for history, languages, and literature. The University of Illinois library, with two and one-half million books, is the seventh largest in the world, third largest among universities, largest among publically supported universities. From this great laboratory come each year a series of notable scholarly books. The volumes at the top of the page (all published by the University of Illinois Press) are some of these. They include two monuments of recent literary scholarship: Professor Harris Fletcher's facsimile edition of Milton, and Professor T. W. Baldwin's series of studies of Shakespeare's education and literary development.

Among the hundreds of research projects now under way in this area of the humanities are subjects as different as a monumental study of the Aesopic tradition and a series of studies in the history of Illinois and the Middle West; the first grammar of the Afghan language and a biography of Marcel Proust; a new American edition of Goethe and a linguistic atlas of Illinois.

Sometimes the end product of research is not a book at all. Sometimes it is a fact about matter or energy which does not seem to be of practical importance until it appears in such a tangible form as atomic energy. Sometimes it is a new understanding of the life process, or a chemical or drug or vaccine which saves human life. Sometimes it is an engineering development which makes life safer (like stronger metals and bridges), or more enjoyable (like sound motion pictures, which were developed at Illinois in 1922). Sometimes it is a new or improved crop (like the soybeans and hybrid corn now growing in Illinois). Sometimes it is a way to help a deaf child live like other children.

But very often research results go into booklets like those shown below. These are written so as to be usable in a common everyday way by farmers, businessmen, homemakers, laborers, professional men, teachers, school children — anyone to whom the gathering research knowledge of the University can be helpful. More than a million of these booklets are printed every year and distributed to the citizens of Illinois by way of sharing what the University discovers with the people whom the University represents.



Photographs on cover and pages 1, 4, 5, 6, 8, 9, 11 (top and lower right), 13, 14 (top), 16 (top), 17 (bottom), 19, 20 (top), 23, 24, 25 (bottom), 26, 27, 28 (top and right), 29, 30 (top), 31 (top), 35 (bottom), 42, and 43 by John F. Garfield; page 16 (lower right) by Fran Byrne; page 22 (right) by Wide World Photos; page 40 (bottom) by Illinois State Museum; others by University Photographic Service, University Illustration Studio, and staff members.