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UNIVERSITY OF ILLINOIS

— ONE
HUNDRED
MILLION
DOLLARS
PER YEAR

..... being a brief
résumé of the principal
research contributions of
the University of Illinois
to Agriculture and Industry

*The value of University of Illinois discoveries to the state and nation probably approximates a hundred million dollars a year *

The University of Illinois is a vast Laboratory of science and citizenship built by and for the people of Illinois and it has more world contacts growing out of solution of practical problems of existence than any other school in the country.

JAMES O'DONNELL BENNETT

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Foreword

There has been a good deal of discussion in recent years of the large amounts of money it costs to support colleges, universities and other institutions of higher education. This is especially so in the case of publicly supported institutions and particularly in times of economic depression when officialdom feels the necessity of curtailing, so far as possible, unnecessary expenses of government in order to reduce the burden of taxation. It is, therefore, appropriate at such a time as this for public bodies to give the people information about activities they are called upon to support.

Few people who have had the opportunity of a higher education question the social and economic value of universities and colleges; a great many, not so fortunate themselves, appreciate the importance to society as a whole of maintaining these institutions. But there is a vast number of people who have had no direct contact with colleges and universities either themselves, or through their children, and who naturally may not understand the indirect value to them of the work which these institutions are doing.

"What does the University of Illinois do for me that I should be called on to support it?", such a citizen of Illinois may ask himself. He may know that his State University is educating each year thousands of young men and women to prepare them for the various walks of life and who go back to their communities better and more useful citizens because of their training and experiences here. He may not question the importance and value of giving the young people of the State an opportunity to secure a college education because, after all, he realizes that the cost of educating them is simply a good investment on the part of the State and local community in their future citizenship. But what immediate benefits does he himself derive from the University of Illinois aside from the satisfaction of supporting an institution which gives his neighbor's children a higher education that they may live better and more useful lives?

The answer is simply this: through its scientific investigations it has discovered facts and principles which are worth millions of dollars annually to agriculture and the industries, to say nothing of their value to human welfare in general.

The purpose of this booklet, then, is to give the public some idea of the practical returns which their State University is giving them. It

is impossible to relate briefly all of the University's scientific activities. To read this booklet is to know something of the value of only the more important of the University's research in applied science. All of this is in addition to the work of its staff in pure science dealing with fundamental principles, the practical applications of which may be of great value when they are developed. It does not take into consideration the scholarly work of the faculty in other fields.

All of this should be borne in mind when one considers the cost of maintaining the University. Besides educating some fifteen thousand students annually, from one-fourth to one-third of the University's funds and a similar proportion of the time of its faculty are devoted to its various scientific and scholarly research activities. The annual cost of the University to the State, considered by itself, may seem large, but even the total State tax is only a small proportion, less than ten per cent in most cases, of the total tax paid in each community. Of this total only about two per cent goes to the University. Out of all taxes paid by citizens of Illinois for every purpose, including federal taxes, less than one per cent would represent the cost of the University. In other words, any comparison of the cost of maintaining the University of Illinois with other public expenditures will show that it is small, even negligible. And when one considers the social values it creates and the practical returns of its scientific work, any such comparisons make its cost utterly insignificant.

H. W. Chase

H. W. CHASE
President

The Value of Research at the University of Illinois

That the University of Illinois teaches some 15,000 students most everyone knows, but that it spends a large portion of its money and energy in research to bring forth new facts which enrich the life of the State and Nation is realized by only a small portion. Few really comprehend the tremendous value of these researches.

It is impossible in most instances to interpret in dollars and cents the value of the University's research contributions. However, very little figuring, and less imagination, is needed to demonstrate that many millions of dollars are annually given back to the State in the form of returns on its investment in this institution. Indeed one friend of the University said recently that the value of these discoveries "probably approximates a hundred million dollars a year—certainly many times the amount the State appropriates for *all* purposes—teaching, research, and building."

A prominent industrialist spoke of one research project in engineering which meant "ten millions of dollars annually in the Chicago area alone," and one agricultural project "is worth twenty-nine millions annually."

The University's research, which covers practically the whole field of human endeavor, has produced results which touch the lives of almost every person, although usually not realized by them. In engineering these achievements have been incorporated in building projects of many lines, in railroad operation and maintenance, in heating our homes, and in many other ways. In agriculture hundreds of projects have contributed soil and crop improvements, and have affected every phase of agricultural life in the interest of more profitable and better living conditions on the farm.

When thousands of pages of scientific data—proved facts—have been printed in official publications as a result of the University's investigational work, it is impossible to set down in a few pages any adequate statement of what the University has accomplished in years gone by, and what it is doing today. Several hundred pages of such material is printed each year and each publication relates a definite contribution to the general welfare of the State and Nation.

This publication mentions only the outstanding work in the two major fields of agriculture and industry. Apologies are offered to those on the faculty whose work is equally important in their respective fields. The discovery of Illinium, the only chemical element ever discovered in America; the production of Illium, a new metal which can be substituted for platinum in many instances; the very definite



THE "BROAD WALK" ON THE UNIVERSITY CAMPUS BETWEEN CLASSES

contribution to the treatment for leprosy; the low temperature process for coking Illinois coal which returns by-products worth more than the original cost of the fuel; the great series of investigations in the money market, and commercial fields in general; the development of the serum for combating ptomaine poisoning, and others, are stories perhaps already well known and will not be discussed here.

Our medical and dental staffs have added much to human welfare through their investigations. The chemists have added other contributions, as has the electrical engineering staff, the departments of architecture, entomology, geology, zoology, botany, and others. One might safely say that no one department of the University has failed to contribute its full quota to the world's knowledge.

Many of the research projects prosecuted by the University have been what are called "coöperative investigations," that is, part or all of the expense has been borne by outsiders who are interested in the solution of the problems involved, while the buildings, equipment, and

staff have been furnished by the University. The largest gift the University has ever received for purely research purposes has just been announced. It amounts to a quarter of a million dollars, \$50,000 each year for five years, and will be used for investigations in rail stresses.

And now for a brief discussion of some of these investigations—

Concrete and Reinforced Concrete

Throughout the world, wherever concrete is known, the University of Illinois is known, for in her laboratories the most outstanding and far-reaching contributions in this field of construction were evolved. What Illinois publications say has usually been the final word.

Beginning with the organization of the Engineering Experiment Station in 1903 there appeared a series of classical bulletins by Professor Arthur N. Talbot on concrete and reinforced concrete, which had a profound effect on the development of concrete construction. Some of these early bulletins are to this day the only authoritative sources of information on their subject.

The revised building codes now about to be adopted in Chicago, New York, Philadelphia and other cities, governing the safety and proper design of structures worth many millions of dollars, depend in a large number of details upon the work of the University research staff in this particular field.

Last year the Illinois Division of Highways adopted and put into effect a method of design and control of concrete mixtures which is based upon a University research bulletin published in 1923. By this method it is possible to utilize the sand, gravel and stone produced throughout the State, each on its own merit as a concrete-making material. As a result the State is enabled to secure greater uniformity of concrete in its pavements and has improved methods of determining the quantity for which it pays. Modifications of the method have also been adopted by the highway departments of Iowa and Michigan.

The development of light weight concrete for use in bridges and tall buildings is of particular interest to engineers and builders in Chicago, where several buildings and bridge floors have already been built. The material is being considered in the design of the proposed San Francisco Bay bridge, where the saving of dead weight will effect economies throughout the design of the structure.

The investigation of concrete masonry walls is intended to show the stability and bearing strength of walls made of various types of units and is expected to furnish the needed technical information on which to base specifications for concrete masonry in building codes.

The investigation of reinforced concrete columns now in progress has been given very considerable support by outsiders interested in this field. The value of the results may be expected to be greatest to the building industry in large cities like Chicago.

The broad applicability of fundamental research was well illustrated by the tests made for the Reclamation Bureau of the Department of Interior to determine the properties of the sandstone encountered in the foundation at the site of the proposed Madden Dam on the Chagres River in the Panama Canal Zone. The results of our investigations suggested to the engineers designing the dam that the methods developed in this investigation would give important information concerning the properties of the somewhat unsatisfactory rock which must be used as the foundation for the proposed dam.

Railway Engineering

This department of the University, through tests completed last summer, indicated that a possible saving of \$25,000,000 annually in the operation of 40,000 of the larger type of locomotives on American and Canadian railroads might be realized through the use of the thermic syphon, an appliance for the locomotive firebox.

The investigations proved conclusively that a gain of 8½ per cent in locomotive efficiency is possible. Extensive investigations were carried on in the University's locomotive laboratory on an eight-driver freight engine under conditions exactly the same as those encountered on the road. There has long been a difference of opinion as to the efficiency of this appliance and the University's test will settle the dispute. The syphon was invented about thirteen years ago and it was first used on a locomotive in 1918.

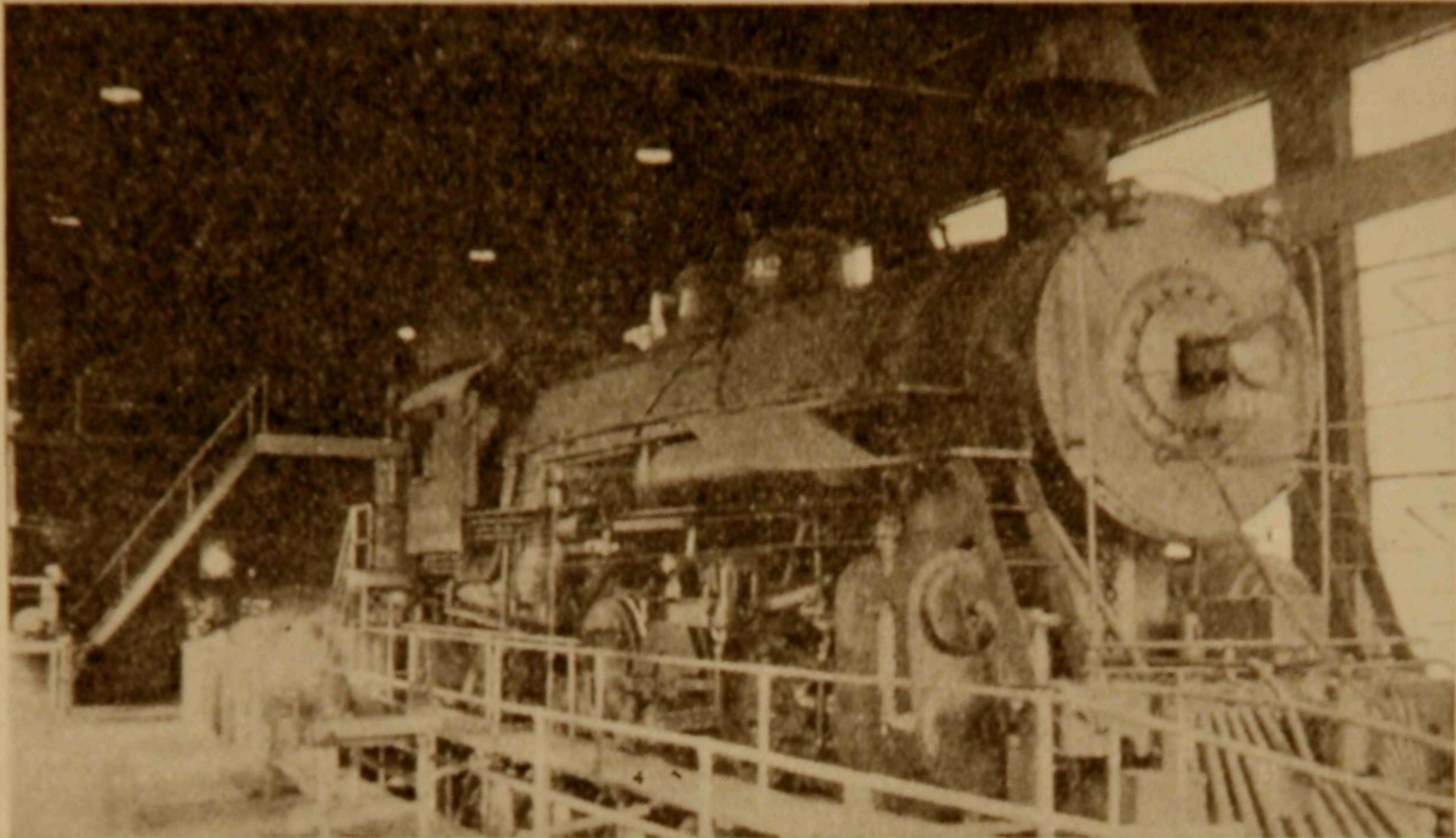
The department has carried on many investigations of technical problems arising on steam and electric railways. The following statements show the character and the results of the more important of these investigations.

(1) *New Design for Railway Car Wheels.* About thirty-five million chilled cast-iron wheels are used on American railroads, and about three million new wheels are required each year. The average price of one of these wheels is about eleven dollars. They are manufactured by 49 foundries throughout the United States and Canada, of which 5 are located within the State of Illinois.

Between 1917 and 1922 the department carried on an investigation of stresses arising in the wheels used under freight cars due to the action of the load and of the heat developed when brake shoes are applied to the wheel. Previous to this investigation there had been no

comprehensive information about such stresses and our tests developed for the first time data regarding the magnitude and distribution of stress adequate for the purpose of wheel design.

For about 60 years preceding these experiments there had been but little change in either the size or the design of freight car wheels, although during this interval the load carried on the wheel had greatly



FORTY-FIVE MILES AN HOUR BUT STANDING STILL

In the University of Illinois Locomotive Laboratory, railroad engines are run at top speed, when necessary, during experimental work. Rollers under the drive wheels make conditions the same as those occurring in railway transportation. Investigations conducted in this laboratory have aided the railway business and increased the margin of safety in railway traveling.

increased and the service required of it had steadily become more severe. Changes in the design and in the weight of the wheel were at that time necessary in order that this important part of railway equipment might satisfactorily and safely meet the severe requirements of modern service. Our investigation provided the basis for making these changes. The results of this research were so highly regarded by the Association of Manufacturers of Chilled Car Wheels that they were immediately used in redesigning the wheels.

(2) *Brake Shoes.* One of the smallest parts of a railway train, the brake shoe, has been the subject of much study, and the perfection to which it has been brought is evidenced by the fact that now-a-days a fast, through passenger train weighing about 1,100 tons and running 60 miles per hour can, in emergency, be brought to a stop within about 1,300 feet, which is but little more than its own length.

The properties of brake shoes have been the subject of painstaking and careful investigation for the last thirty-five years.

The necessity for so scientific an investigation of what appears to be so simple and rudimentary an element in car design, is indicated by the fact that there are in service on steam roads about 30,000,000 brake shoes and that the railroads spend annually for renewing these shoes about \$15,000,000.

The purpose of the investigation has been to find a shoe metal with good frictional qualities which has at the same time greater resistance to wear.

(3) *Tests of Locomotive Fuel.* An investigation concerning the relative value as locomotive fuel of various sizes of coal was made in 1917. The relative values of six sizes of Illinois coal were determined and set forth in the published material.

Information of this sort, if generally applied on all railroads throughout the State, would result in the use by the railroads of the fuel best suited to their needs and would effect also a considerable decrease in the coal consumed by locomotives. The decrease in consumption would, of course, release fuel for other purposes, and the more discriminating choice of fuel for locomotives would benefit many coal users of the State by releasing certain sizes of coal best adapted to their particular needs. The amount of coal used by the railroads is so great and the efficient selection of coal so important, that the application of the data developed by this investigation, in even a few cases, must have resulted in substantial gains.

(4) *Railway Fuel Conservation.* Immediately after the organization of the United States Fuel Administration in 1917, it inaugurated a campaign for the conservation of railway fuel. This work was later taken over by the railroad administration, and extended by them over the entire country. Even before this campaign was begun the Department of Railway Engineering began to accumulate information about railroad fuel practice and to prepare a set of directions and advice to railroad trainmen and others concerning the economical use of locomotive fuel. Circular No. 8 embodying these directions appeared early in 1918. Its appropriateness and value were at once recognized by the officers of the Conservation Section of the Railroad Administration and they advised all railroads to buy and distribute it to their men.

(5) *Electric Car Resistance.* At various times since 1907, the department has carried on tests to determine the resistance offered to the movement of electric cars on both straight and curved track. The results of these tests have shown the force required to move the car at various speeds. Such data are of use to the designer of electric rail-

way equipment, who must have definite information concerning car resistance before he can properly design or choose the car motors.

The results of these tests have been accepted as standards by many manufacturers for use in their design departments.

(6) *Locomotive Tractive Effort and Train Resistance on Steam Roads.* Through the operation of our dynamometer car and our locomotive laboratory, the department since 1908 has carried on various experiments to determine the tractive force of locomotives and the resistance of steam railroad trains at various speeds. This work still continues.

A knowledge of both locomotive tractive force and train resistance is required in what is known as the tonnage rating of locomotives; that is, in determining the proper train load for different classes of locomotives, taking into consideration the grade and curvature of the track, the speed, the weather, and other operating conditions. To this problem of tonnage rating the University has devoted a good deal of effort and has developed new processes of calculation which, supplemented by the results of the tests above referred to, enable our engineers to rate locomotives with more precision and uniformity than were attainable by the methods previously in vogue.

Our train resistance results have been rather widely adopted by leading railroads of the nation. In 1922 one great railway system of the State asked the University to revise its tonnage ratings. This work was done during the summer of that year and the new ratings made under our calculations were from 11 per cent to 26 per cent greater than those previously in force, the increase varying on the different divisions. The general average increase for the whole State was about 14 per cent, that is, under the revised ratings the average gross weight of trains on that road within the State of Illinois became about 14 per cent greater than it was previous to our revision. This increase in train load entailed a corresponding decrease in the number of trains and in the number of train-miles, and resulted in an annual saving in labor alone which for the year 1922-1923 was estimated to amount to a minimum of \$214,000 for this company.

Stresses in Railroad Track

Another field in which the University is a pioneer and a recognized world leader is that of stresses in railroad track. Our work in this field has involved the development of many measuring instruments and test methods, and has required the study of literally millions of test observations. The results of the investigation have been to furnish information to the railroads on practically all matters referring to the

design of the roadbed, as well as to give information to improve the design of locomotives. While no definite money value can be placed on work of this character, the return is certainly very large as is shown by the fact that the railroads have been glad to pay a large portion of the cost of these investigations during the last seventeen years.

The investigation of stresses in railroad track has been in progress since 1914, and five reports have been issued, giving information as follows:

(1) Analysis of the action of track as an elastic structure; development of methods of measuring stress and track depression; study of effect of size of rail; speed of locomotive; effect of wheel spacings; and effect of conditions of locomotive and track.

(2) The effect of speed and counterbalance of drive wheels on stresses in rail; studies of action of cross-ties; and transmission of pressure in ballast.

(3) Studies on four railroads with several types of locomotive, on curved and straight track; effect of speed, curvature, counterbalance and of design of locomotives; and the distribution of stresses in the rails.

(4) Tests on straight and curved track with several types of electric locomotives; study of various features of design of these locomotives; studies of action of tieplates and of canted rails.

(5) Study of the action of rail joints from analysis and from laboratory and field tests; study of the various types of rail joints; studies of bolt tensions and behavior of joints under load.

Not only greater safety, but untold savings to the railroad industry, have resulted from the University's contributions during these seventeen years of study.

Warm-Air Furnaces and Heating Systems

The more recently erected homes in American using warm-air heat may thank the University of Illinois for the improved plants and installations, and for the resulting comfort and economy.

The warm-air system of heating residences and other buildings is as old as the art of heating itself, but exact or definite data as to the performance of such systems, which could be used as a rational basis for the design or improvement, had been sadly lacking in the past. Difficulties encountered in measuring the correct volume and temperature of the air flow under the conditions existing in a gravity circulating furnace heating system had discouraged investigators in this field, and the industry had been held back in consequence of the lack of dependable information on the operating characteristics of its product.

The most outstanding results of the many years of investigation at the University having a direct value to the industry and home are:

(1) The determination of the performance characteristics of furnaces of various types, that is, the relation between combustion rate, draft, efficiency, heating capacity, and air temperatures throughout the system.

(2) The determination of the heat carrying capacity of first, second, and third floor leaders and stacks. This makes it possible to design a warm-air system in accordance with the heat loss from a building, thus placing the warm-air plant on the same basis as a steam or hot-water plant.

(3) The positive demonstration in the Research Residence equipped with a modern furnace heating plant that a properly designed warm-air system is a successful and satisfactory method of heating the better as well as the smaller class of American homes.

(4) The determination of the proper type of covering for basement pipes in order to reduce the heat loss from such pipes.

(5) The determination of the principal sources of heat loss from a furnace and the recommendation of means by which such losses may be minimized.

(6) The determination of the relative effectiveness of several types of water pans when used as humidifiers.

(7) The investigation has also made possible the formulation of a Standard Code for installation which has been accepted by the American Society of Heating and Ventilating Engineers and other national organizations. The adoption of the Code is of the greatest value to the home owner and the manufacturer and the installer.

Direct Steam and Hot-Water Heating Systems

The University of Illinois has, likewise, pioneered in direct steam and hot-water heating work.

The effectiveness of various types of direct steam and hot-water radiators in heating rooms has become a matter of great importance now that so many types of radiators and enclosures are available. Radiator manufacturers, heating contractors and engineers, as well as building owners, are seeking for definite information concerning this matter so that the most satisfactory and efficient types of room heating units may be selected, and properly placed or installed.

Three bulletins have already been published by the University and contain much information on the best and most economical method of heating rooms by direct radiators. The results have been widely circulated and quoted in the technical press, and have made it neces-

sary to modify certain long-standing conceptions regarding the selection and installation of radiators. The results show very definitely that the old idea of comparing radiators solely on the basis of steam condensed or heat given off, is basically unsound.

Sufficient data are now available from tests on modern commercial radiators under actual heating service conditions to show that the "heating effect" produced by a radiator varies greatly with the type of radiator, and moreover, the best "heating effect" is often obtained with radiators which condense the least amount of steam. Furthermore, it has been demonstrated in these tests that, contrary to our previous conceptions, the use of enclosures and shields over ordinary cast-iron radiators may materially improve the "heating effect" of such radiators and at the same time reduce the steam condensation *provided* the enclosures and shields are properly designed for this purpose.

In conducting this investigation the University has developed a unique testing plant in which full-sized rooms are subjected to zero weather conditions such as exist in heating service so that tests of all types of steam and hot-water radiators may be conducted at any time during the year under actual winter weather conditions.

Fatigue of Metals

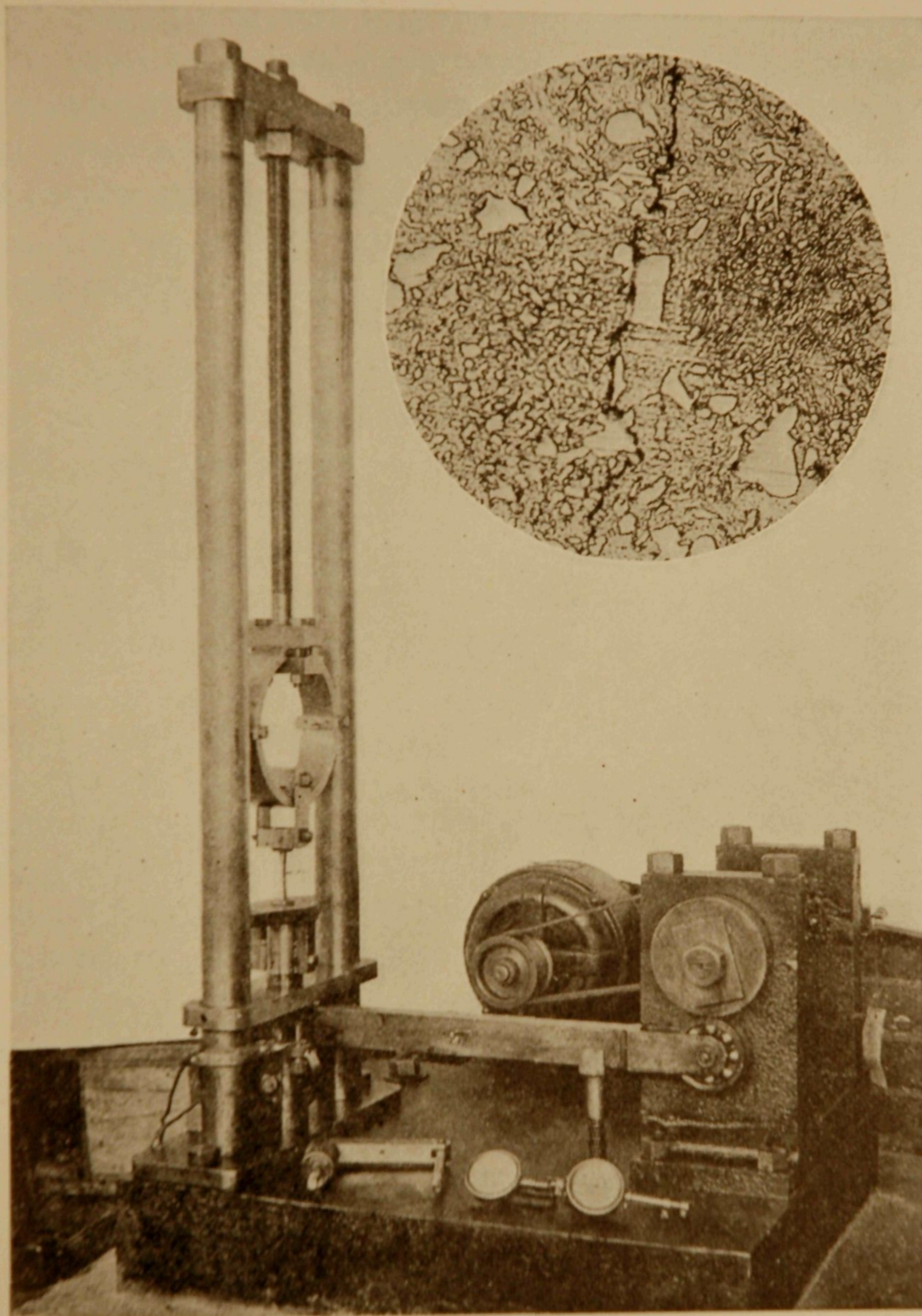
Hundreds of millions of tests carried on along one certain line by the University over a period of twelve years have been terminated. Railway wrecks, broken elevator cables, snapping of automobile steering knuckles and springs, and scores of other instances where metal is subjected to stress, are concerned in this work.

In the field of testing the strength of metals, the Materials Testing Laboratories have been the headquarters of an important investigation of the strength of metals under repeated stress, and so-called "fatigue" of metals. This work, which started in 1919, was an outgrowth of the recognition of the need of study in this field due to the advent of higher and stronger metals, of high speed machinery, and especially of the airplane. The investigation started at that time has continued ever since and has broadened its field through coöperative arrangements with many large firms.

The general investigation of the fatigue of metals established the fact that for nearly all the common metals there is a point of stress up to which these metals will safely stand. In other words, these metals may be stressed hundreds of millions, and probably an indefinitely larger number, of times without fracture. The first results of this investigation caused it to be characterized in a leading British

book on fatigue of metals as "One of the most valuable sets of experiments (of this kind) ever made."

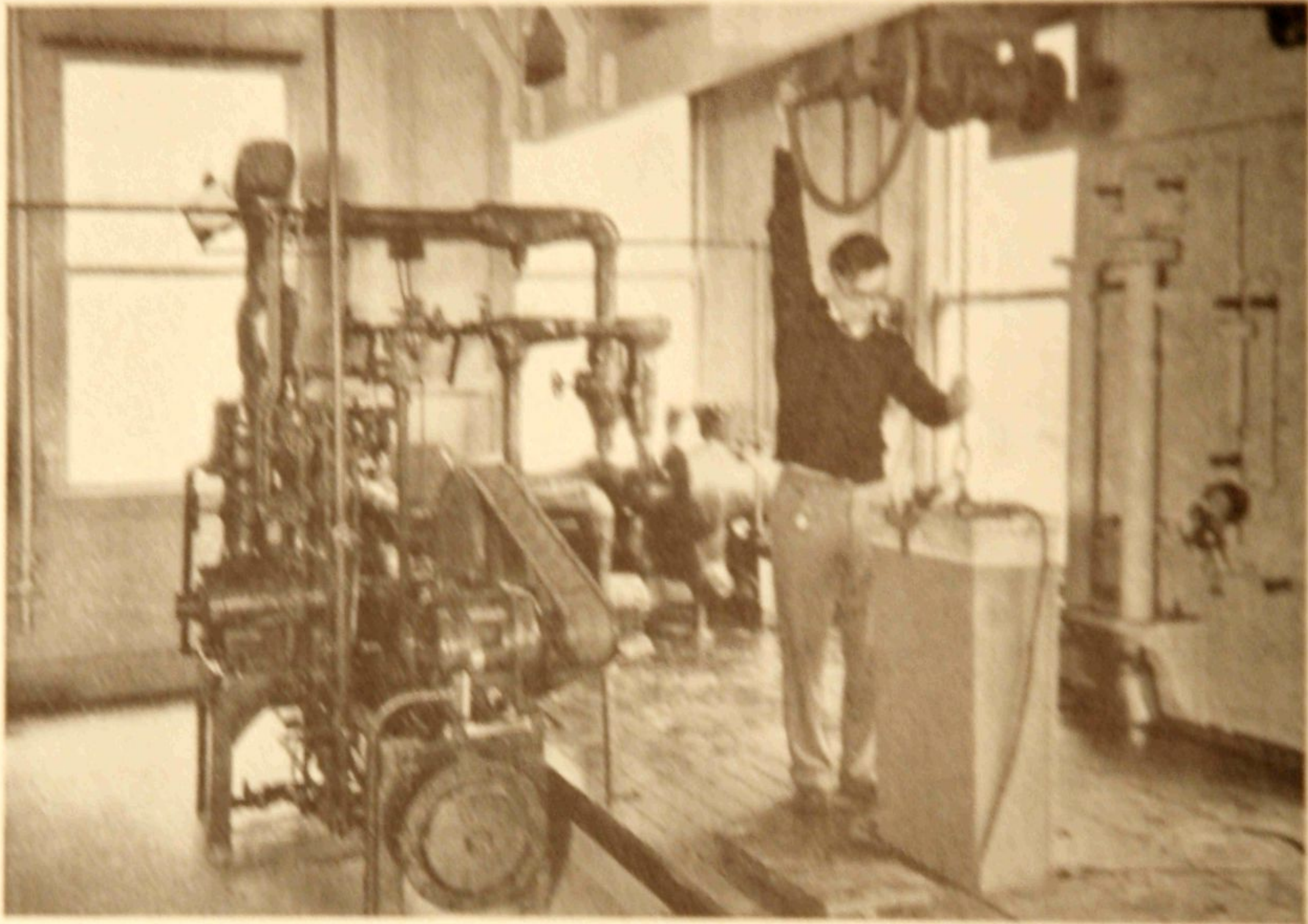
In addition to this outstanding result, investigations in these laboratories proved that the common practice of "gently" breaking-in a machine really strengthened the metal in it, and showed the extreme danger of notches, deep scratches, and sharp shoulders and holes in



WHEN WILL THE AXLE BREAK?

It has long been known that metals under repeated tension or stress would fail in a short time if the impacts or tension were repeated regularly. University of Illinois engineers have revealed heretofore unknown facts about the structural parts of metal. The application of these known facts to engineering and manufacturing methods has been an invaluable aid to mankind. Above is shown a machine for testing a piece of metal. The insert shows an actual breakdown in the metal, magnified 1000 times.

plants. Approximately one-third of the ice manufactured in the United States—53,000,000 tons in 1929—is now frozen in steam operated plants, which used the by-product, distilled water, to obtain clear ice. Electrification of these plants will result in the saving of from forty cents to one dollar per ton in the cost of production, it was ascertained. Work is now in progress on another project which involves



DO YOU INSIST ON CLEAR ICE?

University of Illinois industrial chemists, after thorough investigation, have secured results which indicate that clear ice may now be manufactured from industrial water supplies, eliminating the use of distilled water.

the possibility of utilizing lower freezing temperatures in the production of ice. It is estimated by the ice industries that if this problem is satisfactorily solved, it will mean an increase of 20 per cent with no major increase in cost of production except power. A large potential annual profit is involved.

Flue gas studies, especially in power plants, is the field of another piece of research now in progress. In these investigations an attempt is being made to remove the sulphur compounds from the flue gases, these compounds being the agent which causes terrific corrosion and damage.

Somewhat allied to the same field, but attacking the problem from a different angle, is the work of removing the sulphur from the coal. The object is the same as the one stated above.

In the same general direction is the study of the prevention of the deterioration of chimneys due to flue gases from gas-fired boilers.

The X-ray in Industry

Considered by many as more important than its use in medicine, the application of X-rays to industrial problems promises to extend the valuable assistance of this little known boon to humanity almost without limit.

As the doctor studies the muscle and bone structure of a human patient, so does the industrial X-ray expert look through iron and steel, wood and rubber, and a hundred and one other materials, seeking out defects and studying the internal structure.

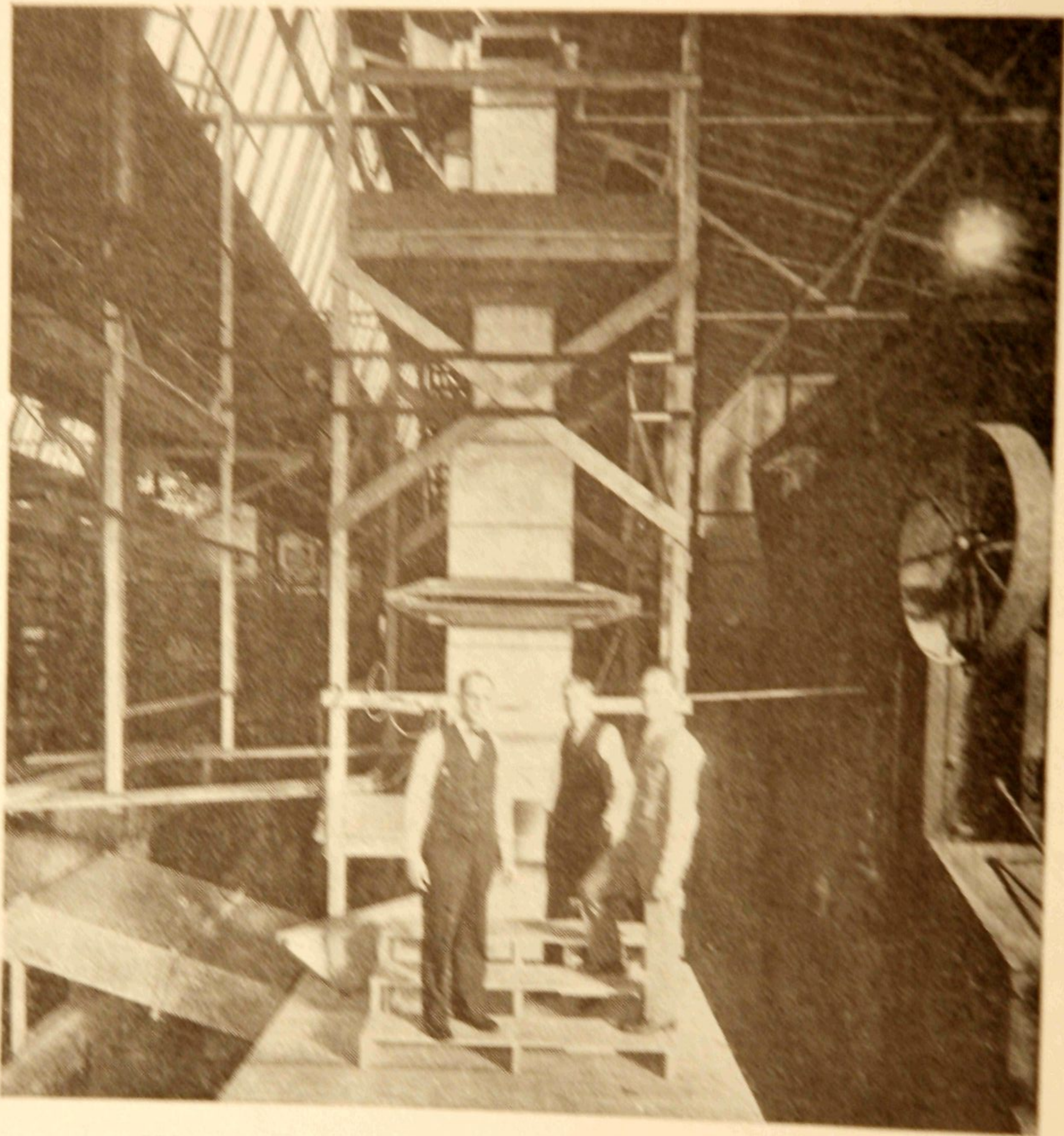
The University has found out many things of utmost importance in the application of the X-ray to the solution of industrial problems. The X-ray is discovering hitherto unknown qualities or properties of scores of industrial materials in order to utilize them more efficiently. Studies of commercial commodities like rubber, for example, have revealed valuable phenomena concerning its behavior during stretching and after composition changes. Metallic alloys, fabrics, electric transformer plates, asbestos, corrosion in iron, paper, petroleum products, and some organic chemical substances are among the materials studied. The use of the X-ray is opening a new field in industry by aiding the production of more standardized materials, the utilization of hitherto neglected substances, and improvements in the quality and efficiency of manufactured articles in everyday use. Great industrial concerns are realizing the value of the X-ray in solving their problems and now look to the University for the extension and development of the work.

Ventilation for the New Chicago Subway

The solution of problems concerning the proper ventilation of the proposed \$45,000,000 State Street Subway in Chicago, involving certain novel features intended to promote the health and comfort of the public, is a University of Illinois job.

The ventilation system will be capable of supplying 2,960,000 cubic feet of outside air per minute, which will provide, under maximum conditions, twelve complete air changes per hour. This air will be introduced both at the lower or train level, and also at the upper or mezzanine level through special ventilating towers supplied from main air ducts running just under the station platforms. These towers and air outlets will be designed as a result of tests now in progress on the University of Illinois campus.

There will be no poisonous gases produced in the operation of this new subway, such as are created by the automobile traffic in the Holland Tunnel at New York City (the ventilation system of which was designed as a result of tests made here at the University of Illinois), but there will be generated a large amount of heat coming from train motors, brakes, lights, and people. This heat will not prove



WORK ON THE CHICAGO SUBWAY VENTILATION

By experimenting with the model ventilation tower above, University of Illinois engineers are planning proper ventilation methods for Chicago's proposed State Street subway.

objectionable during the winter months, but during the summer months it will frequently produce uncomfortable atmospheric conditions such as are so commonly experienced in subways in other cities. Since it is economically impossible to cool the air artificially in the subway, the ventilating system will be so designed to introduce the air for ventilation or respiration as to maintain an appreciable air movement or "cooling effect" throughout the structure whenever the atmospheric conditions would otherwise become uncomfortable, as, for example,

during the afternoon rush hours on hot summer days. The air will not be discharged *directly* over the occupants in any part of the subway.

This "cooling effect" produced by the incoming ventilating air may be varied over a wide range, depending on the number of fans in operation at any time, which, in turn, depends on the number of people in the subway and the heat generated in consequence of their presence. Since air must be introduced for ventilation or respiration anyway, it is proposed to make it serve a double purpose and promote the comfort, as well as the health, of the public.

Internal Combustion Possibilities

What is scientifically termed "Thermodynamic Analysis of Internal Combustion Engines and of the Complete Expansion Engine Cycle" looks well to the future in this field and promises possible great economic results. While the immediate commercial value of an investigation of this nature is more remote than some of the others now being furthered, nevertheless, it furnishes invaluable information tending to broaden the field of knowledge. Such information may not have direct bearing on the design of engines at the present time, but as fuel becomes more expensive and more refinement in methods of design become imperative, the present more remote possibilities may become essential to the future improved methods of design.

The amount of work done per gallon of fuel used in a gasoline engine is dependent on how completely the exploded gas mixture is expanded on the stroke following the explosion, or in other words, how low a pressure is attained at the end of the stroke. If a low pressure is attained a much more efficient engine is obtained, but it necessitates a larger engine. It is estimated that if one mile more per gallon can be obtained, one large taxicab company of Chicago could save \$150,000 per year. The analysis of the complete expansion cycle was undertaken to determine:

(1) What saving might be effected by increasing the expansion beyond that used in the standard type of engine.

(2) How great an increase in the size and weight of the engine would be necessary. The analysis indicates that a gain of at least 18 per cent in efficiency may be obtained without increasing the size of the engine beyond a point that is commercially practical.

Contributions to Mining

Great have been the contributions of the University to one of its major industries—mining. Like so much of the University's work,

most of the results are indirect and intangible, but the contributions are certain and their value tremendous.

A study of coal mining practice in 100 selected mines of the State was begun in 1911. Eight bulletins embracing the results of these studies were published in 1914 and 1915, as well as a complete summary bulletin in 1915. Attention was called to dangerous conditions in certain districts, and in many cases improvements resulted in individual mines or in entire districts which contributed toward not only better operation but to the safety of human life.

Investigations in the subsidence, or lowering of the surface over mined areas, and in mining methods have had an influence in promoting a larger percentage of extraction of the coal, thus reducing the loss of coal left in the ground.

Studies of haulage, hoisting, power and ventilation have pointed the way to improvements in mining practice and a reduction in the cost of coal production.

Much work has been done on the utilization of Illinois coal in work for which outside coals are generally used. Such studies covered the manufacture of retort coal gas and water gas, the coking of Illinois coals, the purification of gas, and preparation and uses of tar and its derivatives.

For nearly 20 years special attention has been given by the University to the preparation of coal. These investigations have involved studies of coal washing methods, dry preparation methods, the occurrence and distribution of sulphur in the coal bed, and the friability (or crumbling characteristic) of Illinois coals. A study of the washability of Illinois coals just published will serve as a guide to coal companies who are interested in the results that may be obtained by coal washing. A letter from one in the industry states: "I find it to be the most comprehensive publication that it has been my pleasure to receive. It will, no doubt, be a great benefit to the coal industry generally."

The work that was perhaps of more extended public interest than any other was that on the storage of bituminous coal. All the world appears to be interested in the bulletins and papers that deal with this subject. There can be no doubt that many of the recommendations contained in these publications have been widely followed, resulting not only in safe storage of coal but in the avoidance of the hazards and monetary loss caused by fires in storage piles.

Boiler Use of Lesser Known Coals

An investigation of the combustion of Illinois coals to compare their performance characteristics, as determined by their ability to

maintain reasonable boiler loads and their influence on the overall efficiency when burned in the furnace of a typical steam boiler of moderately high capacity, has given noteworthy facts of industrial importance. The coals used were coals from two Northern Illinois mines not generally used for steaming purposes and a coal from a Southern Illinois mine but from a different vein from the coal usually mined in this district.

The results indicate that, when properly handled, these less known coals compare very favorably with better known varieties, and that mines in these districts may be used as available sources of coal for steaming purposes.

The Future of the Gasoline Motor

The tendency in commercial gasoline engine design is towards the use of higher compression, making possible the use of smaller engines. With the present day fuels the compression is limited by the fact that the higher compressions cause detonation resulting in permanent injury to the engine. From an investigation now in progress it is hoped to determine: (1) the fundamental laws of flame propagation for present-day motor fuels, (2) methods of predicting and controlling such propagation which can be used in the design of engines, and (3) methods of eliminating detonation and making possible the use of smaller and more efficient engines.

Industry Demands Better Gears

With the rapid developments in modern machinery have come urgent demands on the industry for quiet, efficient, and durable gearing. The exacting demands of users of gears have resulted in a high degree of refinement in manufacture, but no thorough investigation has yet been made of those important factors which enter into the satisfactory operation of gears—namely, efficiency, quietness, strength and durability. This situation is due in a very large measure to the time required and the expense involved in such an investigation.

The results obtained to date at the University of Illinois are based upon the most extended series of tests yet undertaken on efficiency and durability of spur gears. These results will also serve as a basis for further investigation which is necessary in order to obtain quantitative experimental data for establishing reliable formulas correlating the wearing qualities of gear teeth to their size, shape, and composition, under various conditions of load, speed and lubrication. A great many problems of this nature are awaiting solution and research work in

this field will be of immediate, practical value to the gear making industry.

Buildings, Bridges and Highways Made Safer

It is impossible to place an estimate on the value of research in the civil engineering department, for it is fundamental in character and has had or will have a considerable effect on engineering design and practice.

Fifteen years ago the results of a study of wind stresses in the steel frames of office buildings were published. This investigation has had a pronounced effect on the developments in this important field and is referred to in nearly every discussion of the subject which has appeared since that time.

The development of the slope-deflection method for the calculation of stresses in rigid frames has resulted largely from studies which were made here and formed the basis of a bulletin published in 1918. Numerous references have been made to the bulletin in the technical press and extensive use has been made of the slope-deflection method in engineering offices.

The rigidity of the joints of a riveted steel frame such as used in the steel skeleton of tall buildings is an important factor in design. The principal investigations which we have made in this field were reported in a bulletin issued in 1917.

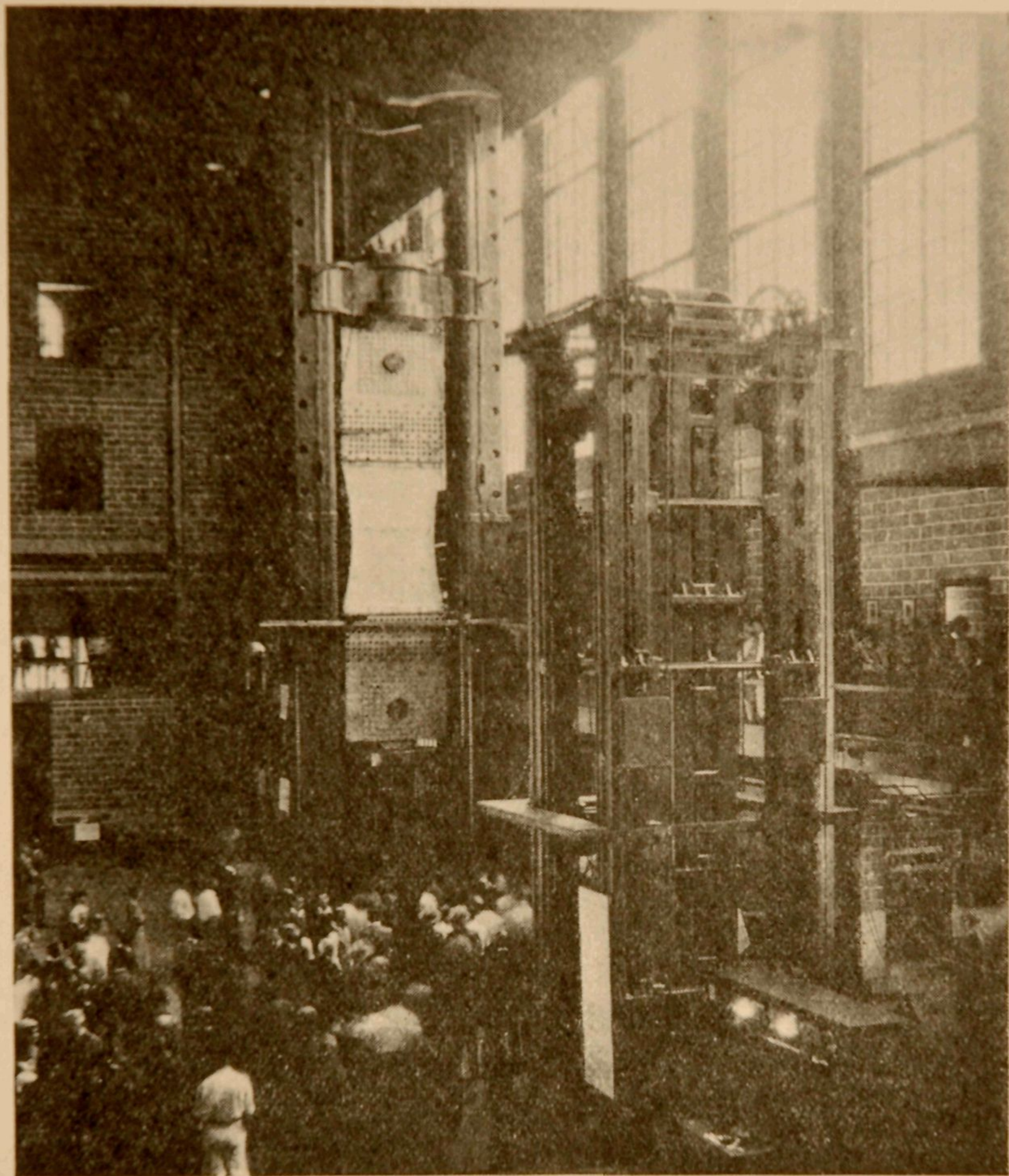
The use of rivets in tension has not been permitted by many engineers and has been avoided whenever possible by all others. The objections have not been based on experimental study but have resulted from an erroneous idea of the structural action of rivets in tension. An extensive investigation of this subject conclusively proved the fallacy of the objection and will have a far reaching effect on structural design.

The investigations on reinforced concrete arches which have been under way for several years and which are to continue for some time to come have been by far the most extensive and valuable experimental and analytical studies which have been made in this field. Their effect has been far reaching.

Of an entirely different nature have been the contributions on rolling bascule bridges. The savings in maintenance and repair costs on such bridges, due to the Illinois studies on the bearing value of large rollers, have already been large and in the future will reach a figure which it would be futile to estimate. Most of the river bridges in Chicago are of the bascule type.

Further, the analytical methods developed by the department for

the calculation of stresses in statically indeterminate frames have already been widely adopted by structural engineers because of their great simplification of such calculations. They are the most outstanding developments in methods for stress calculation which have been made in recent years.



HOW STRONG ARE YOU?

This giant 3,000,000 pound testing machine in the University of Illinois Testing Laboratory is here exerting 1,325,000 pounds of tension, trying to pull a sheet of bridge steel apart at the butt-weld.

The drainage investigations which have been under way for seven years have recently been completed and have yielded results which will be of great value in engineering enterprises involving rainfall and run-off data for this part of the country.

A valuable investigation on methods of sewage treatment and another on plumbing have contributed to the field of sanitary engineering.

Other investigations in structural and highway engineering might be mentioned but enough has been given to show what an important factor the investigations in the civil engineering department have been in the development of that branch of engineering.

In the Realm of Physics

While the main concern of the department of physics is, of course, with problems of pure science, applications which contribute directly to the industrial wealth of the State are nevertheless important. Of the latter, the work in the field of acoustics of buildings has been of wide importance. The department has done much in photoelectricity and particularly with the development of the photoelectric cell. This cell, as perfected at Illinois, is so sensitive that it reacts to the light of a star which cannot be seen by the naked eye. Furthermore, Illinois scientists have made the cell "fatigue-proof," whereas its predecessors required constant rejuvenation. The photoelectric cell was so improved in our laboratories that it became a useful physical instrument which is widely used in astronomy, physiology, chemistry, medicine, and for pure scientific purposes. The weak photoelectric current has been amplified up to a million times by an audion tube. The University has received a patent on certain forms of photoelectric cells as a result of its investigations. In the last few years photoelectric cells have been introduced in the industries; the manufacture of the cells has itself become a considerable industry. They are used for the reproduction of sound in talking pictures, for the reproduction of images in television, for the selection of minerals, papers, cigars, ball bearings, etc., for the automatic control of gases in tunnels, factories, smoke stacks, etc., for signaling purposes in railroads, and for many other applications. The physics department has a large share in the development of this branch of industry.

There has also been invented a type of alkali vapor detector tube for radio purposes which reduces the "B" battery necessary from 21.5 volts to about 7 volts by the introduction of a potassium-sodium alloy into the tube. These sensitive radio tubes are at present being manufactured by one of the nation's largest concerns.

Investigations in the acoustics of buildings have been in progress since 1909. These researches have resulted in four Engineering Experiment Station bulletins—"Acoustics of Auditoriums," "Correction of Echoes," "Sound-proof Partitions," and "The Absorption of Sound by Materials"—Which have been distributed freely throughout the State to architects, builders and other interested parties. Each bulletin contains information that may be put to practical use, with the

result that many buildings in the State are now adjusted so as to have satisfactory acoustic properties.

Strength of Structural Members, Machine Parts and Pipes

A large number of contributions have been made by the University in this field, such as: The effect of keyways on the strength of shafts, the strength of rolled zinc, strength of I-beams in flexure, the strength and stiffness of steel under bi-axial loading, the strength of joints, rigidity of riveted joints of steel structures, and many others. Engineering Bulletin No. 22, "Test of Cast-Iron and Reinforced Concrete Culvert Pipe," first published in 1908, was in such demand that it was reprinted in 1926.

An investigation to determine the strength of cast-iron pipe and fittings is now under way and a very large number of tests have been made on sizes from 6-inch to 36-inch pipe. The tests on fittings point the way to considerable savings to the cities of the State.

The work of one of the staff members with the Bureau of Reclamation, while on leave of absence last year, was used as one of the bases for the selection of the type of dam to be built in Boulder Canyon.

Hydraulics

As long ago as 1910 tests were made by staff members on every type of locomotive water column used on American railways. Because of the tests, the water columns were redesigned and made more efficient, due to less delay in filling locomotive tenders, and because heights of railway tanks could be made less. It is impossible to estimate the savings to railroads in time and in reduced pumping costs but it is probably considerable. Many other contributions in hydraulic investigations have been made.

Contributions in Ceramic Engineering

Investigations of raw materials of the State by the Department of Ceramic Engineering, in coöperation with the State Geological Survey, have resulted in the establishment of manufacturing plants utilizing these materials. Not less than three plants have been established as a result of preliminary studies of the properties of the clays which they now use. The annual production of these three plants is conservatively valued at \$600,000.

Possibly a much greater amount of money has been saved by discouraging the development of unsatisfactory clay deposits about which owners have been enthusiastic. Some contribution has been made in

development of the silica industry, as well as the clay production, in southern Illinois.

Statements from manufacturers who have attended the annual Ceramic Short Courses at the University indicate that improvements or savings in manufacturing costs that have directly resulted from that course have amounted to many thousands of dollars a year. One manufacturer volunteered the statement that he had saved 10 per cent on fuel and 20 per cent on time in firing his kilns as a result of short course instruction. The fuel saving alone would amount to about \$6,000 a year in the one plant. Other similar results have been reported.

The results of research work in this field, as applied in the industry, have meant definite contributions, while considerable savings in plants have resulted from studies on drying clay products.

Greater Use of State Molding Sand

Tests of Illinois molding sands from all the known producing pits and from 42 new deposits throughout the State have been completed. Until this investigation there had been no concerted attempt to study molding sand conditions in the State, and as a consequence the foundry industry had not been able to draw fully upon the extensive and excellent domestic sand deposits owing to lack of information about the qualities of the sand and extent of the deposits. It has been the practice of Illinois foundries to purchase from pits without regard to their location, in order to secure sands of certain specifications.

Illinois has nearly 500 active foundries, of which over 200 are located in Chicago. The latter have been importing over 50 per cent of the sand used from outside the State and downstate foundries about 10 per cent. There are over 6,000,000 tons of this type of sand, exclusive of large deposits three to five miles from railroads, within the borders of Illinois. Some of the deposits are of very high quality. The production of natural bonded molding sand in Illinois in 1923 was 150,720 tons.

The information developed, if utilized to the fullest extent, will result in foundry production economies and greater output from sand pits. There will be resultant savings from substituting some of the comparatively unknown but excellent molding sands for the commercially exploited but inferior sands from other states. Further, the use of Illinois sands is certain to be extended to other states as a result of the investigation.

Bond Strength of Clays in Molding Sand

Another investigation was to determine the properties of clays being used by foundrymen to rebond old molding sands. Progressive foundrymen have found that rebonding clays could be added to their old molding sand to strengthen them instead of adding more new molding sand, this method proving less expensive in renewing the strength of the bond. Very little work, however, had been done to demonstrate the properties of rebonding clays.

Clays from various parts of the United States were selected for use in this investigation, three of which were Illinois clays. These Illinois clays all proved suitable for rebonding of molding sands. The bond strength of clays under a wide range of conditions has been determined and a formula developed for calculating the bond strength. The use of this information is enabling foundries to select clays adapted to their particular requirements.

Greater Efficiency for Twist Drills

The object of this investigation is to determine the proper design of the twist drill, one of the most widely used metal working tools. Almost no scientific work has been done in this field, except at the University of Illinois.

Tests already completed here show possible savings of 20 per cent in power consumption by drills of improved design at the higher drilling rates. Manufacturers of drills both in the United States and Europe have made application of this information by increasing the helix angle on the drills now being made, thereby increasing the life of the drill and reducing the power consumption. Aggregate savings in the cost of power by using more efficient metal working tools may be very large.

Projected tests include other factors related to drills and the drilling machine, such as the efficiency of cooling fluids, proper drilling rates, and drilling machine efficiency. All of these topics are of practical value to the metal using industry. They are now being consistently investigated by other agencies.

Heat Transmission through Boiler Tubes

Valuable factors for use in the design of steam boilers, besides the results affecting boiler designs, have resulted from the University's work with regard to heat transmission through boiler tubes.

The objects of this investigation were: (1) To determine the relations existing between the rate of heat transmission from the hot

gases to the water in a water-tube boiler, the velocity of the gases, and the rate at which the water in the boiler is circulated, (2) the effect of scale formations in reducing the rate of heat transmission, and (3) the effect of soot deposits in reducing the rate of heat transmission.

The information in regard to the effect of scale and soot is valuable both in determining the economic loss arising from such deposits and in making allowances in the design of boilers to provide for the normal loss in the efficiency of the heating surfaces incident to conditions arising from actual operation.

Value of Research to Agriculture

Less than 20 cents a year from each of the 30,731,947 acres of improved farm land in the State would pay all the appropriations for the University of Illinois. In considering that fact, also consider this: Returns at the rate of more than 24 cents an acre are being paid by a single one of the 379 research and extension service projects which the University is conducting through its College of Agriculture.

This is the limestone-legume project. That limestone and legumes must be used for efficient crop production was one of the earliest findings of the College and is now one of its most popular teachings. During the last year for which complete figures are available (1929) Illinois farmers spread a total of 925,000 tons of limestone in carrying out that teaching.

On the basis of results from the College's soil experiment fields operated under all soil conditions, limestone has been worth about \$8 a ton net. Assuming that farmers will maintain the 1929 rate of limestone use, it will add \$7,400,000 annually to the wealth of the State, or \$1,510,000 more than the annual appropriation for the entire University. Prorated over the 30,731,947 acres of improved farm land in the State, the \$7,400,000 represents a return of more than 24 cents an acre, or 5 cents more than needed to pay the appropriation.

More than 375 similar projects of the College are returning inestimable millions to Illinois, a State with 214,871 farms and 1,534,077 homes. Its agriculture alone represents a total capital investment of \$4,094,000,000.

To the wealth of these homes and this industry, the University of Illinois, through the College of Agriculture, is making contributions in three principal ways:

1. Instruction of students, the majority of whom later use their training in agriculture and home economics or in industries closely allied to these.

2. Investigation of and research in the major problems of agriculture and of home economics.

3. Extension service to take the new-found facts and teachings to farmers and homemakers out over the State.

Research and Extension

(Only the briefest mention can be made of the major benefits accruing from the research and extension work of the College of Agri-

culture. Those interested may secure more information from the 250 or more free publications of the College, from the annual reports of the Experiment Station, or direct from the departments concerned.)

Agronomy

County soil reports are now available for 47 counties of Illinois, unbound soil maps are available for eight others and information by



THE ILLINI STRAIN OF SOYBEANS DEVELOPED BY PLANT BREEDERS OF THE UNIVERSITY

Illinois is now the leading soybean producing State of the Nation and an important factor in the growth of the industry has been this improved and higher-yielding variety.

Information that has had a far-reaching effect upon the agriculture of the State and that is being woven into soil management practices far and wide has been supplied by soil experiment fields. More than 50 of them, located upon important representative types of soil, have been established in all sections of the State. They have been in operation for periods ranging from 17 to 54 years. Thirty of them are still in operation. It has been demonstrated on the fields that the productivity level of the better soils of Illinois is 10 times greater than that of the poor soils. The experiment fields have clearly defined the various systems of soil treatment that may be used with profit on the different soils of the State.

correspondence is available regarding all other counties of the State as a result of the progress made in the State Soil Survey. It deals with the classification and correlation of soils and was needed not only as a basis for working out practical systems of soil management and treatment for the various soils of the State but also as a basis for adopting cropping systems best suited to the various kinds of soils. It also has exposed the seriousness of the erosion problem in Illinois by revealing that there are only 16,000 square miles in the State on which erosion is not sufficiently rapid to be at least somewhat harmful. Interest in land utilization is increasing rapidly. Through the Soil Survey, much data are ready for immediate application to the problems of utilization.

Sweet clover, once regarded as little more than a weed, is now an almost universal fertilizer worth many millions following the success of what were, so far as is known, the first experiments with it for soil improvement purposes. These were established by the University on the Odin Soil Experiment Field in 1903. The growing of sweet clover for soil building purposes has been an important part of the College's extension service program for soil improvement with the result that more than three-quarters of a million acres of it were grown on Illinois farms in 1929 whereas in 1920 only 70,000 acres were grown. The increased acreage of sweet clover has brought benefits of many millions to farmers in the form of decreased costs of production of all crops in the rotation and better distribution of farm labor. Sweet clover in the rotation is credited with increasing the productivity of the average soil approximately 15 bushels of corn. This would make a total of 11,220,000 bushels as the potential gain in the 1930 corn crop, provided all the 748,000 acres which produced sweet clover in 1929 were put into corn.

There was a time when little or no limestone was used by Illinois farmers, but tests on the soil experiment fields established the fact that it is essential on many soils which would not otherwise grow sweet clover or other legumes. In the experiments, the returns from limestone costing \$2 to \$3 a ton have been as much as \$35 to \$40 a ton and have averaged \$8 a ton net. More than six million tons of limestone have been applied to Illinois farm lands during the past 12 years largely as the result of the College's limestone-legume extension project. In 1929 alone, farmers of the State used 925,000 tons whereas in 1906 only 2,000 tons were used. One-third to one-fourth of the limestone used in the entire United States is now spread on Illinois farms. The six million tons spread during the past 12 years have increased the net efficiency of Illinois crop yields to the extent of 48 million dollars, even if the net worth of limestone for improving yields is figured at no more than \$8 a ton.

The College has developed a practical field test for available phosphorus which enables farmers of the State to use phosphatic fertilizer more intelligently. Its use has extended into at least 34 states, Hawaii, Alaska and the District of Columbia, as well as into six foreign regions, including France, Australia, South Africa and the Argentine.

The idea generally accepted 15 years ago that the cost of plowing deeper than about seven inches would be returned in increased yields was shown by the College to be in error. Information obtained from these experiments is of inestimable value to farmers because it costs nearly twice as much to plow 14 inches deep as it does to plow 7 inches deep, while dynamiting the subsoil costs from \$20 to \$40 an acre.

Efficiency of corn production in Illinois has been increased an estimated 26,330,850 bushels a year as a result of revolutionary corn cultivation experiments showing the superiority of shallow cultivation.

Benefits of more than 16 million dollars annually now come to Illinois farmers as a result of the college's discovering the cause for the general failure of alfalfa previous to 1902. At that time, it was found that the absence of suitable nodule bacteria was responsible for the unsatisfactory results with this crop. Since the introduction of the proper organisms, the acreage of alfalfa has gradually increased until 221,000 acres were grown in 1929. In addition, 748,000 acres of sweet clover grown in 1929 were dependent upon the same kind of bacteria for their growth and development. A conservative estimate indicates that 80 million pounds of nitrogen are fixed annually out of the air by bacteria on these crops, which, if bought on the open market, would cost Illinois farmers 16 million dollars.

Alfalfa has since come to be recognized as the most valuable legume hay crop in Illinois and by rebuilding the reduced acreage of 1928 the College extension service put the crop back in its rightful place with a consequent benefit of \$1,087,500 to farmers in 1930.

Illinois is now the leading soybean State of the Nation and an important factor in the growth of the industry has been the Illini variety which plant breeders of the College originated in 1920 as a single plant selection from the A. K. variety. In tests it outyielded all others with an average of 42.1 bushels an acre for five years.

The "more-legumes" project of the extension service has expanded the acreage tremendously with consequent benefits worth millions to farmers of the State. In the case of soybeans, for instance, the acreage mounted from a total of 15,000 in 1919 to 689,000 in 1930.

Variety demonstrations in 40 counties have influenced the standardization of soybeans in the State with a resulting reward of more than a half million dollars a year to farmers. It seems conservative to estimate that the Illini soybean is adding at least three bushels of beans an acre to more than 160,000 acres of soybeans in Illinois, or a total of 480,000 bushels worth \$500,000.

A federal seed act to protect American farmers against heavy loss from unadapted foreign red clover seed was passed as a result of facts disclosed in tests made in Illinois and other states. It was found that some southern European seed was not at all adapted to Illinois conditions. Yields of hay grown from the seed from various foreign countries varied from a complete failure to about 75 per cent of the yield of native-grown Illinois seed.

Thousands of dollars are being saved annually for Illinois farmers through the testing of inoculants which are continually being put on the market for the improvement in crop yields. Some of these are valuable whereas others are worthless. New types of legume inoculants which appear on the market periodically show great differences in their efficiency. Such information is of value in the choice of cultures for farm use.

Efficiency of corn production on much of the 9,002,000 acres devoted to this crop in Illinois could be increased five bushels an acre by following the College's corn improvement program. The institution leads the world in corn breeding. The improvement program is partly the result of an experiment started 34 years ago to determine the effect of selection for protein and oil in corn.

One of the most complete changes in farm practice noted in any state in recent years has been brought about in Illinois through the College's extension service project on corn improvement. The accepted type of seed corn now used on fully 60 per cent of the corn acreage of Illinois is distinctly different from that used at the time of the promulgation of score card for Utility corn which was based upon research work of the College and the United States Department of Agriculture.

That the efficiency of corn yields on the estimated 5,400,000 acres growing Utility type is improved two and a half bushels an acre has been demonstrated by project leaders coöperating in the College's corn improvement work. This means that the use of this type of seed instead of the old type has actually benefited Illinois agriculture to the extent of 13,100,000 bushels of corn a year.

This, however, is not the only significant benefit. Project leaders have reported that use of Utility standards in the selection of their seed corn so improves the quality of the crop that it will usually grade at least one grade higher than corn produced from seed of the old type. The normal spread in price between "sample" and No. 6 corn is 4½ cents. Allowing a gain of only half a grade, the spread would be 2½ cents a bushel. This 2½ cents on the 157 million bushels of corn produced on that 60 per cent of the acreage growing Utility type would bring a total of \$4,672,500.

Another important contribution of inestimable value to the State's most important grain crop was the joint discovery by the state entomologist and representatives of the College that certain varieties of corn carry distinct resistance to chinch bugs. These varieties, four in number, made it possible for farmers to grow a fairly satisfactory crop of corn, despite chinch bug infestation, where other less-resistant corns

were practically failures. Under such conditions of heavy infestation, these varieties yield 25 bushels an acre more than the commonly grown ones.

Information whereby half of the 71 million bushels of corn now destroyed annually in Illinois by diseases could be saved for added profits of many millions has been worked out in corn disease studies.



IMPROVED SEED THAT HAS MEANT MILLIONS TO ILLINOIS CORN GROWERS

A section of the Annual Illinois Seed Grain and Utility Corn Show at the University. The type of seed now used on fully 60 per cent of the corn acreage of Illinois is distinctly different from that used at the time of the promulgation of the score card for Utility corn which was based upon research work of the University and the U. S. Department of Agriculture. It has been demonstrated that the efficiency of yields is improved two and a half bushels an acre through the use of Utility type seed.

On the basis of these studies made during the past ten years, it is estimated that losses in dent corn from the ravages of diseases have been more than 20 per cent.

Anticipating the eventual need for information on European corn-borer control, the College has gone to the pest instead of waiting until it comes to Illinois, thereby saving what undoubtedly would have been a heavy loss in time and money to the agriculture of the State. The institution is coöperating with the Illinois Natural History Survey and the United States Department of Agriculture in experimental work in the heavily-infested areas near Toledo, O., as well as in Illinois, which is still uninfested.

Ilred, an improved and higher-yielding strain of wheat originated by plant breeders of the College in 1910, now makes up 25 per cent of the hard red winter wheat grown in the State, with inestimable benefits coming to farmers as a result. In the plant breeding plot tests,

it outyielded Turkey Red, the variety from which it was selected, by 14.6 per cent as an average of five years. Farmers growing the improved strain may reasonably expect more efficient production to the extent of one to two bushels an acre over Turkey Red and similar unimproved types.

A new soft red winter wheat, which has been one of the highest yielders in four years of test, is believed to fill the need for a soft, winter-hardy productive wheat that can be grown in central Illinois. Other soft wheats are not hardy enough for this section.

The superiority of a dry wheat-seed disinfectant over liquid treatments has been well established in tests by the College with the result that in Illinois this latter method has been pretty well supplanted by the newer plan. Wheat-seed disinfectants against stinking smut and other diseases have been used to some extent for about 200 years. Up until a decade ago, however, all disinfectants in general use were of a liquid nature. The dry treatment, a copper carbonate combination, which the College established as being superior, was first used in Australia some years ago. The material is inexpensive and improves the efficiency of wheat yields 3 to 4½ bushels an acre.

The effect of a new and superior seed treatment on the yield of oats has been worked out principally at the University of Illinois College of Agriculture. Up until about five years ago the formaldehyde seed treatment had been considered as standard for treating oats against smut. Then a dry dust treatment, an ethyl-mercury-chloride, was found. Whereas formaldehyde controls primarily only smut, the ethyl-mercury-chloride also controls some other important diseases. In experiments conducted during the past three years, formaldehyde improved the efficiency of oats yields only 4.8 bushels an acre, while the ethyl-mercury-chloride dust bettered the yield 12.1 bushels an acre.

Animal Husbandry

Years are required to bring about general adoption of improved methods of livestock production and often those most benefited lose sight of the real origin of the movement before it is completed. A case in point is the gradual shift from aged steers to younger ones, which culminated in the popularity of baby beef with consequent savings and profits to farmers running into inestimable amounts. It is not surprising that many students of the industry assign the origin of this movement to packer demand, which unquestionably did much to hasten the change. However, it also had the support not only of agricultural college and extension men but also of the agricultural press, and marketing agencies. Sanders in his, "The Story of the Herefords," recalls,

"Signs were not wanting, however, as early as 1878, of impending changes in the best feedlot practice Pioneer mid-west scientists, like the late Professor George E. Morrow, of the University of Illinois, were persistently calling the attention of farmers to the great expense at which added pounds were gained as the steer advanced in age."

The accurate reports of livestock markets which are now published daily almost in every general newspaper in the country and broadcast several times daily by various agencies were made possible by pioneer work on classes and grades of livestock done nearly 30 years ago by the University of Illinois College of Agriculture.

Shortly after the publication of a series of bulletins defining market classes and grades, the College concluded the first comprehensive study ever made of the capacity of steers of different grades to convert grains and farm roughages into beef. In this study, Illinois introduced the carlot unit into experimental methods, thus making an important contribution to increased reliability of results from experiments with feedlot practices.

The Experiment Station of the University of Illinois College of Agriculture is rather generally recognized as a national leader in making the beef cattle feeding business a success. Studies resulted in new and valuable information on methods of preparing feed for fattening cattle, maintenance rations for beef breeding cows, hand vs. self-feeding, short-fed cattle, feedlot shelter, influence of cattle rations on the gains made by hogs following cattle, relative efficiency of different amounts of feeds for fattening steers and on many other phases of cattle feeding operations.

Results of studies on the production and use of ear-corn silage for cattle offer a solution of the soft corn problem, often a serious one. In fact, ear-corn silage has proved so satisfactory that some cattle feeders regularly harvest a portion of the corn crop in this manner. The College made the first studies dealing with the effect of ear-corn silage on the quality of beef produced. Calves full-fed on a ration of ear-corn silage, cottonseed meal and alfalfa hay produced choice beef, but required from 30 to 60 days longer to do it than similar calves fed on shelled corn, cottonseed meal, corn silage and alfalfa hay.

Great possibilities for the use of soybeans and soybean oil meal as a home-grown protein concentrate for the beef cattle farmer have been disclosed as a result of experiments on the utilization of these products.

Contributing a finding of far-reaching effect in the control of tuberculosis, the College was one of the first to prove that calves and hogs are susceptible to fowl tuberculosis following contact with infected

fowls, thus incriminating infected chickens as well as infected wild birds as a source of danger to cattle and swine. It also was observed in connection with these studies that chickens, following artificial exposure, may temporarily harbor the bovine type of the disease and thus become a potential agent in propagating the bovine infection on the premises.



THE BEEF CATTLE FEEDING PLANT OF THE UNIVERSITY WHERE SUCCESS-PROMOTING PRACTICES ARE WORKED OUT

The Agricultural Experiment Station of the University is generally recognized as a national leader in making the beef cattle feeding business a success. Studies resulted in new and valuable information on methods of preparing feed for fattening cattle, maintenance rations for beef breeding cows, hand vs. self-feeding, short-fed cattle, feedlot shelter, relative efficiency of different amounts of feeds for fattening steers and many other phases of cattle feeding operations.

Investigators of the College were the first in the United States to confirm the finding of the Danish investigators, Bang and Stribolt, on the causative agent of contagious abortion of cows. The institution followed this finding in 1910 with the first experiment station study of the disease in this country. A practical form of management involving testing and proper disposition of reacting animals has been valuable in suppressing abortion disease in Illinois herds. The disease is estimated to be causing cattle owners of the State a minimum loss of five million dollars annually; hence the benefits of any plan which is successful in suppressing the malady are obvious.

It is estimated that a quarter of a million lambs annually are fed wholly or partially in Illinois corn fields without being given supplementary feeds. This has been shown to be a very slow and uneconomical method, for by the use of a small amount of legume hay or concentrated protein supplement the rate of gain may be doubled, the

degree of "finish" of the lambs improved and the cost of the gains reduced. If a saving only of 10 cents a head were assumed, the improved practice worked out and recommended by the College would result in a yearly saving of \$25,000.

The swine industry brings an income to Illinois farmers of \$80,000,000 to \$100,000,000 annually. An understanding of the market demands is essential to an intelligent production program in an industry



WHERE MILLIONS OF DOLLARS HAVE BEEN MADE FOR ILLINOIS FARMERS

These are sanitation pigs alongside "wormy way" pigs on a Warren County farm. The former weighed 225 pounds each when pigs of the same age which were raised under common methods weighed but 125 pounds. More than an estimated one million dollars a year is being added to the net income of Illinois swine raisers as a result of the swine sanitation extension service project being furthered throughout the State.

such as this. The College made the first study dealing with the size, type, quality and finish of hogs demanded by the markets. The results published in 1904 gave swine producers of the State a clear idea of the kind of hogs most in demand in those days.

Feed represents about 85 per cent of the total expense of producing pork and the cost of the ration fed, therefore, is a matter of constant importance to livestock producers. A long study of the feed requirements of growing, fattening and breeding swine resulted in the development of one of the early feeding standards for swine which has been followed in later years with other facts of benefit and value to the State's farmers.

More than one million dollars a year is being added to the net income of Illinois swine raisers as a result of the swine sanitation extension service project being furthered throughout the State. This

project has been promoted since 1925 and careful estimates by counties indicate that more than 20,000 farmers, or one-tenth of the number in the State, use this system in raising their hogs. These include the larger hog raisers, but even if this one-tenth of the farmers raised only one-tenth of the hogs, their annual production would be about 400,000 hogs. Records kept by farmers using this system indicate that sanitation saves feed to the value of \$2.50 a hog.

Illinois farmers might now be spending thousands of dollars needlessly for expensive mineral supplements to their swine rations had not the College established the fact that the mineral needs of pigs can be rather simply met.

Studies over a period of eight years clearly indicated for the first time that a specific infectious type of abortion occurs in swine. As in cattle, the serum agglutination test has proved valuable in the diagnosis of the disease in swine, thus enabling many owners with infected herds to detect the trouble.

In connection with extensive studies on the nutritive requirements of farm animals, the College has completed, for the first time, a study which gives the basis for scientific estimates of the nutritive requirements of pregnancy in swine. Taken as a whole, the series of studies offers a firm scientific basis for estimates of the nutrient requirements for growth and, less completely, for maintenance and reproduction, of the more common species of farm animals.

Results secured by the College on the chemical nature of proteins from the important sources of this nutrient in common farm rations are the most accurate available and have been widely quoted. The extent to which these feed proteins may be used in covering the protein requirements of growing animals has been measured by a method adapted to this purpose, the measurement being called the "biological value" of the protein. The application of this method in feeding experiments with rats, pigs and chickens has furnished information hitherto not available with reference to a considerable number of feeds and still represents one of the most productive experimental projects being pursued at the present time. The method has made possible for the first time the accurate measurement of the supplementing effect of one source of protein upon another.

Until five or six years ago, the science of poultry nutrition was a sadly neglected field of study and the College was among the first to initiate active investigations of the nutritive requirements of poultry. Its investigations of the basal heat production of chickens as influenced by age, sex, castration and environmental temperature are the most complete ones available at the present time.

It has been shown for the first time that chickens do need vitamin E for successful reproduction. The results are peculiarly clear cut and represent the first demonstration that this vitamin is needed by any other species than the rat, with which the discovery of this vitamin was made.

As a result of its studies on the growth requirements of chickens, the College probably was the first to recommend the use of high-protein mash mixtures for young chicks during the first eight weeks of life with a view to securing maximum as well as economical growth.

Studies on the inheritance of resistance to disease have opened the way for the application of genetics in helping control disease among animals, one of the most serious problems confronting the animal breeder and feeder. Working with pullorum disease, one of the most fatal diseases affecting young chicks, the College has produced a strain of fowls which is much more resistant to this disease than are ordinary commercial varieties. While this stock has not been disseminated among farmers, its future possibilities are great.

A far-reaching contribution toward solving one of the most serious poultry disease problems in Illinois has been made by the College through the isolation of the organism which is associated with at least one type of fowl bronchitis, more properly called laryngo-tracheitis. Subsequent study of the organism and of the disease have revealed many facts of benefit. The disease occurs both in farm flocks and at poultry concentration plants and is recognized as the worst obstacle to profits in the commercial poultry-fattening business.

The Agricultural Experiment Station of the University of Illinois College of Agriculture was the first in the country to do experimental work in meats. "Market Classes and Grades of Meat," published in 1910, was the first attempt to classify and standardize the various market classes and grades of meats and the market terms which were in general use in the wholesale meat trade at that time. The information reported is the basis of the present market classes and grades of meat which are nationally used in the meat trade, in the market reports and in the beef grading service of the United States Department of Agriculture.

Another investigation revealed that the relative food values of the various cuts of meat do not correspond to their market prices, the cheaper cuts being far more economical sources both of lean and of total edible meat. It was evident, therefore, that market prices of the various cuts of beef are determined chiefly by considerations other than their relative food values. These facts were used as a basis of a successful campaign by the meat industry to popularize the cheaper

cuts. These results have also been of untold value to the producers of beef cattle by stimulating the demand for their product, inasmuch as one of the big problems of the meat industry has been to dispose of the so-called cheap cuts, such as chucks, briskets and plates.

Recently attention from many sources has been directed to a study of the factors responsible for the well-known differences in the quality of meat from different carcasses. In this new phase of investigational work, the College has first devised and adapted chemical methods to the estimation of some of the constituents of meat known to be, or suspected of being, related to its quality and palatability. It has been shown that some of the characters of a beef carcass or of a cut of beef upon which its quality is judged in the butcher shop are not related to its content of those ingredients determining, in part at least, its quality and palatability. On the other hand, differences in the composition of the different cuts of beef from the same carcass with respect to the main constituents of connective tissue, collagen and elastin have been clearly revealed for the first time.

In connection with studies of an acute toxemic condition in animals, principally horses and poultry, it was established by the College that at least three distinct types of botulism toxin, or poison, known as A, B and C, may be associated with losses in farm animals. Antitoxin prepared against the three types of serum have proven meritorious in the prevention of the disease in animals. The antitoxin prepared from strains isolated from animal sources at the College also have been used repeatedly with encouraging results in the treatment of the disease in man.

As a further contribution along these lines, the College has shown that botulinum toxins A, B and C may be detoxified, or rendered inert, with formalin and heat. The immunity induced in animals by the inoculation of such toxids is of longer duration than the immunity following antitoxin, although its use incurs a greater degree of risk.

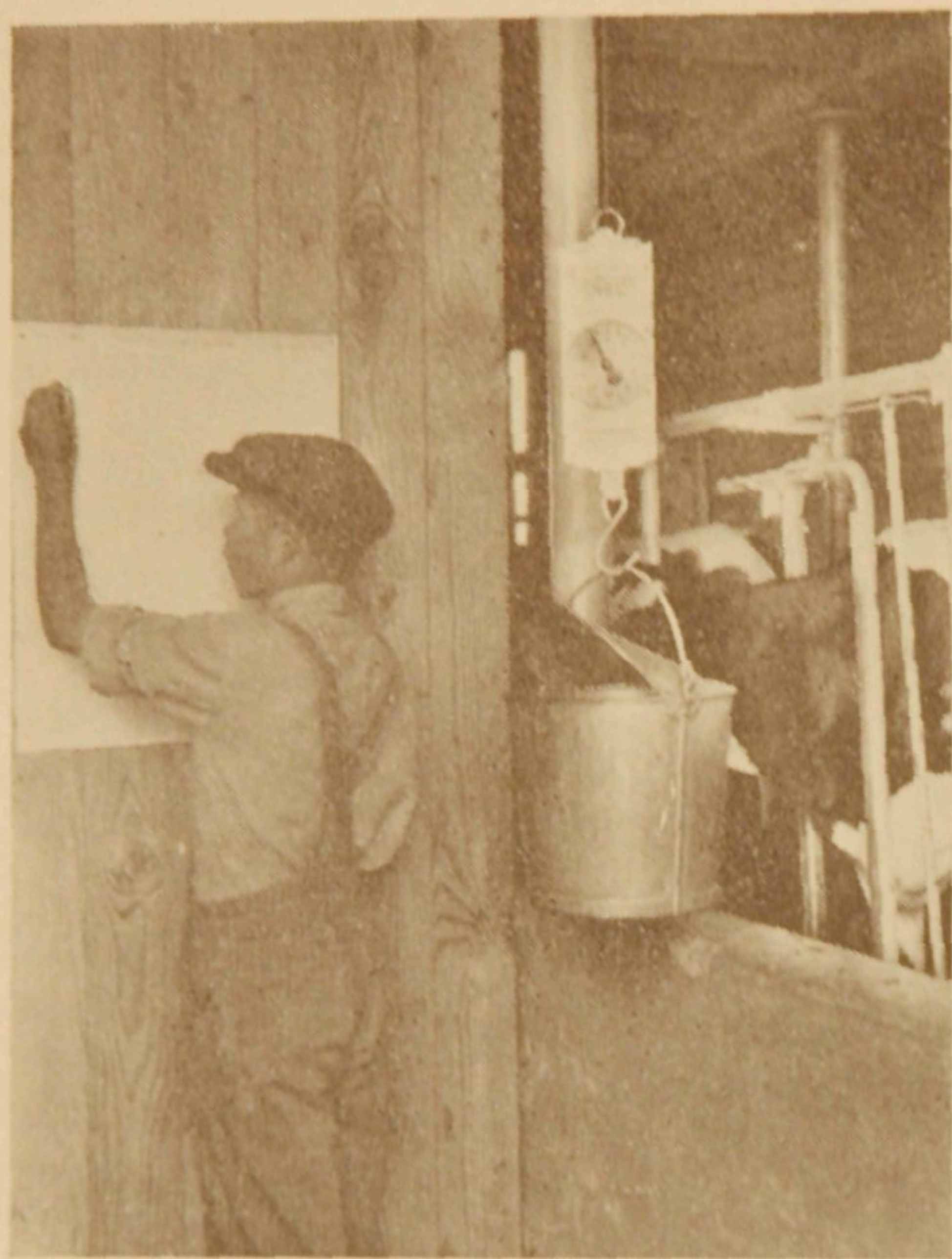
Coöperative livestock marketing has been promoted by the College as an extension service project for more than 12 years. In the early part of this period, more than 500 coöperative livestock shipping associations were organized and these formed the basis for the later organization of coöperative livestock commission associations at Chicago, East St. Louis and Peoria which now handle from 10 to 20 per cent of the total livestock receipts at these markets.

In the first comprehensive analysis of comparative marketing expense by truck and rail, the College found that in 1927 stockmen shipping to the three Illinois terminal markets paid out for truck transportation on a million head of livestock about \$400,000 more than rail

transportation in carload lots would have cost. The study also set forth all the essential factors involved in such a way that any stockman can make a similar analysis for his local situation and pointed out the great need of sound balance between or combination of rail and truck transportation.

Dairy

The College was the first in the country to prove and make known to farmers the extent of the difference in the production of cows and



MAKING A SUCCESS OF THE
DAIRY BUSINESS

the accompanying difference in economy of production. The principle involved is now extensively used in dairy herd improvement associations and in other systems of herd improvement.

Careful experiments showed the superiority of alfalfa hay over timothy hay for milk production at a time when dairymen were growing timothy extensively and alfalfa only rarely. Alfalfa and other legumes have now largely displaced non-legume hay in the dairy ration.

Four-year tests with dairy cattle showed that good rations require no mineral supplements, except common salt, and that except in special cases there is no need for the farmer to spend money for the various proprietary mineral mixtures offered for sale.

Thousands of dollars which might otherwise have been spent by Illinois dairymen for advertised

More careful and improved methods which are being established by means of dairy herd improvement associations made the 21,000 cows in those associations in 1929 an average of 65 per cent more efficient as milk and butterfat producers than the average cow in the State.

mills have been saved as a result of experiments which disclosed that the feeding value of such roughages as alfalfa and soybean hay can be increased only very slightly by grinding them.

Dairy extension projects are being carried out in all parts of the State for the purpose of teaching and demonstrating to farmers improved practices in dairying to the end that the farm income will be increased. It was estimated on January 1, 1930, that the average dairy cow in Illinois produced 4,690 pounds of milk a year. This production

exceeded the production of the average cow in Illinois in 1910 by 1,448 pounds. It was estimated January 1, 1930, that there were 1,006,000 dairy cows two years old or older in the State. Figuring milk at \$2 a hundred, the 1,006,000 dairy cows with the present average production would return in a year's time \$29,133,760 more than the same number of cows with the average production of 1910. While all of this very significant improvement was not brought about by extension teachings, undoubtedly much of it was.

There are more than 21,000 cows in the dairy herd improvement association project which is one of the main ones of dairy extension work. These 21,000 cows in 1929 were, on the average, 65 per cent more efficient as milk and butterfat producers than the average cow in the State.

A five-year study has provided the basis for recommendations on milk grading systems established throughout the State.

A method of manufacturing sweet curd cheese has been developed that has met with approval wherever tried. This has assisted plants in disposing of surplus skim milk profitably and this in turn has reflected better prices to milk producers.

Acquisition of a better understanding of the principles involved in the operation of ice cream freezers has led to the establishment of better methods of freezing which have saved the industry thousands of dollars and resulted in a higher quality ice cream for the consuming public.

The cause for the shrinkage of ice cream has been determined and methods of control devised, thereby solving one of the perplexing problems of the industry.

The "feathering" of cream in coffee has been a problem to milk plant operators, but recent studies by the College have shown the causes of the defect and preventive measures have been recommended.

The College has developed a decantation method for the determination of fat in butter which is rapid, convenient, inexpensive and accurate and which is being used in creameries to control the composition of butter manufactured.

A modified Babcock test for fat in buttermilk has been developed which is useful in discovering undue losses of fat during the manufacture of butter.

A study on the relation existing between the fat, specific gravity and solids of milk resulted in the modification of formulas for the computation of total solids and of solids-not-fat.

A non-acid method for the determination of fat in ice cream affords a simple, accurate means of assisting in the plant control of the composition of the product.

Dairy farmers and operators of dairy plants have been given a simple, effective and inexpensive method for sterilizing their utensils as a result of an investigation of the use of chemical sterilizers.

For the past several years, studies have been conducted on the manufacture, medicinal value and nutritional value of fermented milk. It has been established that certain nutritional disturbances common to infants can be eliminated by introducing small amounts of acidophilus milk into the regular milk fed to the baby.

Pasteurization studies have revealed that with but few exceptions all non-spore-forming organisms can be eliminated from milk by pasteurization but that spore-forming organisms are not eliminated by this means. The latter are, however, reduced in number. Pasteurizing milk at 130 degrees for 30 minutes did not render it less valuable for feeding purposes.

Farm Organization and Management

As an aid in helping the 214,871 farmers of the State organize and operate their farms with a high degree of economic efficiency, a state farm accounting project has been carried on since 1916. More than 2,500 accounts were kept in 98 counties of the State during 1930. Studies of the effect of such accounts on the net earnings of the individual farm are reported in Illinois Bulletin 252 which points out, "Farm accounts kept by 19 Woodford county farmers led them to improve the organization and operation of their farms in many ways that added approximately \$650 to their average net incomes the seventh consecutive year in which they kept accounts." Other studies have shown this to be a conservative valuation of the results.

This work led to the farm bureau-farm management service which is now recognized as the outstanding development in farm management research and extension work in this and other countries.

Detailed cost investigations which reveal a 100 per cent or greater variation in costs of producing the same products in the same community have greatly stimulated the farmer's interest in making careful studies of his own operations to find out how he may reduce his operating costs and select those enterprises which will add most to his farm income. Other cost studies have revealed invaluable information on the relative costs of harvesting corn by machine and hand, costs of harvesting small grains with combines, costs of producing soybeans, costs of fruit and vegetable production and costs of milk.

Two standard forms of farm leases have been prepared and furnished at the cost of printing. The demand for about 1,000 of these leases a year and the fact that many men who first used these leases

are continuing to use the same form indicates that they are meeting a specific need.

Agricultural Economics

Two bulletins, one dealing with the geographical distribution of grain from Illinois and the second dealing with the seasonal variation in the marketing and prices of Illinois grain have been published as a result of a survey of the various aspects of grain marketing economics.

Trends of prices of Illinois farm products and factors influencing them have been analyzed and a number of long-time series of Illinois farm prices have been collected.

In the field of coöperative milk marketing, research work has been centered upon the different types of price plans used in the various cities in the United States in an attempt to make better seasonal adjustments between milk production and consumption. A method for buying and selling milk by means of which individual production is adjusted to market consumption has been developed and put into operation in several Illinois milk markets.

Farm Mechanics

Approximately 44,000 Illinois farmers now have electricity on their farms. About 21,000 of these have service from high-voltage lines; the remainder have their own plants. At least a part of the rapid increase during the past five years in the number of farmers who have high-line service has been the result of studies made by the College. Farmers previously had been slow to accept electricity as the most dependable power to use in farm production because of the scarcity of definite facts about its use on the farm. Investigational work was started by the College in 1923 and in 1924 a coöperative project was begun with the Illinois State Electric Association.

Despite the fact that water under pressure and plumbing with sanitary fixtures and sewer connections are the first requirements demanded by the city buyer or renter, less than 12 per cent of the farm homes in Illinois have these conveniences. Since less than half of the farm homes in the State are equipped with as much as a sink and drain, the College is conducting a successful project to show the practicability and ease of building up a plumbing system step by step when funds are not available for installing a complete system all at one time. Only one out of ten farm homes has a septic tank to care for sewage wastes. After a series of studies, the College designed a simple rectangular septic tank, a description of which has been supplied to nearly 10,000 farmers and others in the State. Collapsible forms for building such tanks have been provided in more than 20 counties.

About five and one-half million acres of land in Illinois are subject to serious erosion, while more than fourteen million acres of high-value land is subject to serious sheet washing and is gradually reaching a condition where gullies are forming. The College has carried on an active campaign to extend the use of terraces to prevent destructive losses on such land.

More than 18 per cent of the Illinois farm land and building value is in farm buildings. The College started a farm building plan service in 1922 to meet the demand for better farm buildings. There are now more than 275 separate plans in the service which involves all types of farm buildings. A special farm house plan service is rendered to a select few through county home advisers.

Home Economics

One of the earliest pieces of research work on pectin and its relation to the making of fruit jellies was done by the College with consequent benefits both to homemakers and to industrial concerns.

That good breads can be made from Illinois soft wheat flours, thereby broadening the outlet for this important crop has been demonstrated. Earlier studies of wheat and bread and bread-making attempted to set standards and resulted in the score card for bread.

Warned of the several dangers of obesity, the public is showing widespread interest in weight reduction. Many dietary fads which are dangerous to health and others which are impractical for persons who cannot get special diets have appeared. Preliminary results of a study made by the College suggest that weight can be safely reduced by simple, well-balanced diets readily available at ordinary eating places and that it is not necessary to resort to extremes in food selection in order to get a steady and reasonably fast loss in weight.

Home economics extension work for women and girls of the State is carried on through the medium of county home advisers of whom there are now 30 in Illinois. In 1930 the Home Economics Extension Service directed girls' 4-H club work in 99 counties of the State. There were approximately 14,000 girls enrolled in 1,100 clubs with 1,835 local leaders assisting and giving definite training.

Adult projects are offered in child development and parent education, foods and nutrition, health education, home management, clothing, home furnishings and home accounts and budgets. During 1930, 10,500 meetings were held in connection with projects with an attendance of more than 310,000.

Horticulture

In keeping with the importance of Illinois as a horticultural state, extensive investigations have been conducted by the College with reference to the production, protection and marketing of fruits, vegetables and flowers. Outstanding among the results of the early investigations in this field were the discovery of the organism causing pear



NEW-TYPE, WILT-RESISTANT TOMATO
(RIGHT) IN COMPARISON WITH
A COMMON VARIETY

The most serious problem hampering the growing of greenhouse tomatoes, an important Illinois industry, was solved by horticulturists of the University through the breeding and development of two new varieties which are resistant to the disease, *Fusarium* wilt, and which at the same time yield far more than other varieties.

factors affecting the yield of onions, including a demonstration of the feasibility of growing ripe onions from sets.

More recent publications have reported the results of studies regarding the production of lima beans as a market garden crop, factors affecting the yield of peppers, the winter forcing of rhubarb and Wit-

blight; the discovery of the cause of bitter rot of the apple together with the development of an effective method of controlling this disease which in one year destroyed one and one-half million dollars worth of apples in four Illinois counties; demonstration of the value of orchard cultivation in promoting tree growth; the tracing of the life history of the curculio and the working out of a practical means for its control in commercial apple orchards; the discovery of the effectiveness of spraying with arsenate of lead for the control of late broods of the codling moth, and demonstration of the profitableness of the long-row farm garden.

Somewhat later, publications were issued giving the results of experiments in different methods of fertilizing muskmelons, studies of factors affecting the profitable culture of tomatoes for early market, the use of sodium nitrate as a top dressing in the production of early vegetables, methods of fertilizing sweet potatoes and fac-

loof chicory, the fertilizing of truck crops in southern Illinois, the fertilizing of twenty-five kinds of vegetables in the corn belt, the inheritance of kernel arrangement in sweet corn, the development of two new wilt-resistant varieties of greenhouse tomatoes and various phases of the production of roses, carnations and other floricultural crops under glass.

In the field of marketing, horticultural publications of the College include bulletins or circulars dealing with marketing the muskmelon, grading and packing Illinois peaches, an exhaustive study of marketing Calhoun county apples, studies of factors affecting the keeping quality of fruit during shipment and observations on the refrigeration of fruit in transit.

The circulars on grading and packing peaches were issued shortly before the harvest of the two largest crops of peaches Illinois has ever produced and were of distinct help to the growers in preparing their fruit for market. Following the publication of the bulletin on marketing Calhoun county apples, much improvement was made in the handling of the apple crop in that county along the lines suggested as a result of the study.

Research work which has progressed far enough to give definite results but which has not yet been published in bulletin form includes the development of 34 potential new varieties of apples and 15 of peaches, an exhaustive study of methods of fertilizing sweet corn grown for the cannery and methods of fertilizing various vegetable crops in the Chicago area.

Other lines of work in progress include the breeding of raspberries and gooseberries with a view to developing high-yielding varieties resistant to disease; studies of root distribution of fruit trees under different soil conditions in relation to cultural practices and fertilizer applications, and methods of pruning apple and peach trees of various ages to promote the most desirable form of growth and proper balance between wood production and fruitfulness.

Studies on thinning of peaches have gone far toward defining the limits of this operation for the industry as a whole and have shown that it is possible to thin effectively over a much longer period than has heretofore been the practice.

No important crop can any longer be grown commercially in the United States without some measure of protection against diseases and insects. The research in plant diseases and the science of plant protection by the College and the Illinois State Natural History Survey has contributed much in the development of effective measures for insect and disease control.

The use of chemical sprays for the protection of fruits and vegetables has become routine practice on the part of growers, yet 40 years ago there was only one spray outfit in the State of Illinois. These spray materials so essential to the production of crops have been developed or adapted to our conditions by investigators at the College.

Some of the outstanding recent contributions to plant protection as a result of the research of the College are:

1. The substitution of efficient oil sprays for lime sulfur in the control of San Jose scale when this insect became resistant to lime sulfur.

2. The efficient development of apple blotch control through a study of the life history of the causative organism.

3. The elimination of wasteful spraying by a study of the relative resistance of varieties of fruit crops to disease. Certain varieties known to be highly resistant to a given disease need not be sprayed even when this disease is prevalent on other varieties.

4. The perfection of a spray schedule for commercial fruit growers which, while giving maximum protection, assures against excessive injury to the fruit and foliage.

5. The dissemination of timely information to growers predicting the behavior of diseases and insects based on the scientific study of these organisms. This service would not be possible but for the painstaking and prolonged research in past years.

In 1928 Illinois produced 7,150,000 bushels of apples. Data secured in connection with spraying experiments show that 70 per cent of the apples are unmarketable when not sprayed. The loss, therefore, on apples would have been 5,000,000 bushels, or a loss of \$5,000,000.

Peach production in 1928 was 1,638,000 bushels. The loss on unsprayed plots in 1928 was 75 per cent. If the peaches had not been sprayed, there would have been a loss of 1,228,500 bushels, which at \$1 a bushel would represent a loss of \$1,228,500.

The floricultural industry in Illinois, which has expanded very rapidly in the past decade, still holds first place among the states in the Union, both in glass area and in total production of flowers. Important practical contributions to this progress have been made by the College through studies in breeding, nomenclature, propagation, culture and methods of protecting flower crops from diseases and insects.

Agricultural Extension Service

An important factor in encouraging farmers to work together has been the policy of the Agricultural Extension Service in asking farmers of a county to build an organization if they wish to have a county farm

adviser. Ninety-eight of the 102 counties have a Farm Bureau organization coöperating with the Extension Service in the employment of a farm adviser. Many farmers in the four unorganized counties are supporting farm bureaus in adjoining counties. Thus it can be said that farmers in practically every county of the State are coöperating with the College in carrying out a program for more efficient and more profitable agriculture.

During 1930, 1,831 boys' and girls' 4-H clubs were organized in 100 counties with a total enrollment of 23,361, including the 14,000 girls reported under Home Economics. Out of this total enrollment, 82 per cent of the members completed their projects in better farming or homemaking practices. Serving as local leaders were 2,731 farm men and women.

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Illinois university

One hundred
million dollars.