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The Engineering Experiment Station and Its Relation to Illinois Industries

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THE ENGINEERING EXPERIMENT STATION AND ITS RELATION TO ILLINOIS INDUSTRIES.

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The State of Illinois is most advantageously situated in relation to the continually increasing industrial activities of the Middle West. The wonderful fertility of its soil has made it for many years foremost in the wealth of agricultural products. The climate and rainfall have favored the production of immense crops of corn, wheat and oats, and fully 75 per cent of its great area (56,650 sq. mi.) has been prepared for cultivation.

Its fuel supplies are enormous, its yearly product is next to Pennsylvania in amount and it probably has within its borders today more bituminous coal of usable grades than has any other state. It is not strange that to these fertile fields came many settlers. It is not strange that on the edge of its Great Lake was planted its now great city. After people come, transportation is provided, then manufacturers follow to supply the needs of the people. Then more people come to distribute the products of farm and factory, wealth accumulates, and still more factories are built to supply luxuries as well as needs. State and municipal institutions spring up and multiply. Provision is made for the penal, charitable and educational needs of state and city. What seemed large provision soon becomes inadequate and the work of a few years ago must be torn down and in its place must be put up again a new and larger and more modern structure. The stores and bank and the library are all soon too small and must be built anew. So it has been with Illinois, so it is now with Illinois. A great agricultural, a great mining, a great manufacturing, a great commercial, and a great transportation State, teeming with a vigorous, wide awake, progressive population surpassed in numbers only by New York and Pennsylvania and surpassed in opportunities and energy by none.

The story of the growth and development of the industries of Illinois is most interesting. The growth has been rapid and natural. It has not been held back by any natural barriers and progress has been easy compared with that of some of the states earlier settled. There are a few significant facts which should be continually before the citizens of Illinois. These facts should make them feel the possibility of accomplishing great undertakings, and should impress upon them the responsibilities which their wealth, their position and their opportunities impose. To some of these interesting facts your attention is directed under the heading of

Illinois—A Great Industrial State.

(a) The population of Illinois is about 5,500,000, which is approximately 1-14 of the population of the United States. Exceeded in population only by New York and Pennsylvania.

(b) Illinois stands second in the value of its agricultural products, for 1908 the value being about.....$550,000,000

(c) Illinois stands third in the value of its manufactured products, for 1908 the value being.....$1,600,000,000

(d) Illinois stands second in tons of coal produced, the value of product for 1908 being about (51,000,000 tons).....$54,000,000

(e) Illinois stands second in barrels of oil produced, the value of this product for 1908 being about (40,000,000 Bbls.).$24,800,000

(f) Illinois stands second in miles of steam railroad, the number of miles in 1906 being about.....12,000

(g) The value of the mineral products of Illinois has increased 65% since 1905. For 1908, which included coal and oil, the value was about $150,000,000

(h) The capital invested in the thirteen leading industries in Illinois is (1906) $600,000,000
In the remaining industries..... 375,000,000

Making a grand total of.....$975,000,000

This amount is now (1909) estimated at about....$1,200,000,000

The Development of Illinois Industries—By the charts and diagrams which accompany this article it is intended to point out the possibility of the great industrial growth of the United States and to show how rapid has been the development of Illinois as a manufacturing state. The population of the world, Fig. 1, gives promise of a market for the products of our farms and factories if only we are prepared to send them where needed. The citizens of Illinois gave evidence that they were awake to the future possibilities of a foreign market for Illinois products when they voted in favor of the next step in water transportation which must finally end in a waterway from the Lakes to the Gulf.

Illinois, now third in population (Fig. 2), is advancing rapidly and it will only be by taking thought for tomorrow that the future of her interests will be conserved. What will be the population of Illinois in 1950? Perhaps ten millions; the chart, Fig. 3, makes promise of that figure. And Chicago at that date,—will it still be 40% of the State's total, and reach four millions? If so there are many things to be done in the State and city in the next forty years and it is none too soon to start on many of them.

When we see what is the distribution of wage earners, Figs. 4 and 5, among the leading pursuits, it is not surprising that so much attention has been and will be given to those things that pertain to agriculture and to engineering. In Illinois, one quarter of the wage earners are engaged in agriculture while nearly one half are engaged

in pursuits directly related to engineering, such as manufacturing, transportation and mining. This nation has made such great progress because, above all things, it has found near at hand, forests, food and fuel. It has been extravagant in the use of all. Its forests

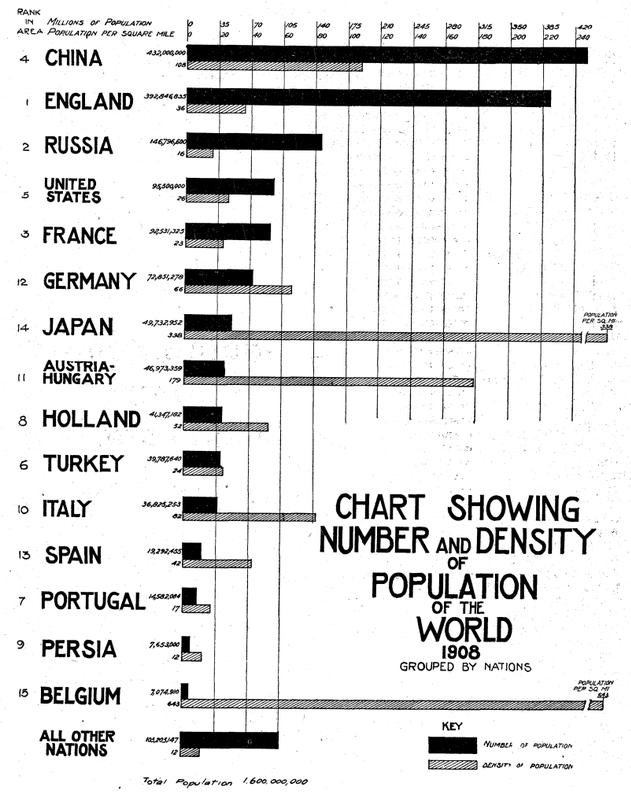

FIG. 1.—POPULATION OF THE WORLD

have rapidly disappeared; its land which once raised food is now unproductive; its fuel will last perhaps 600 years; it has apparently begun to think about these things; it will save and renew some forests; it can preserve the fertility of its soil and fortunately here in Illinois that problem is well in hand and the methods for doing it

are available in the investigations of the Agricultural Experiment Station. It can economize in the use of its fuels, it is doing so in all the great plants that manufacture light and power. Not more than one half as much coal is used to produce one horse-power today as

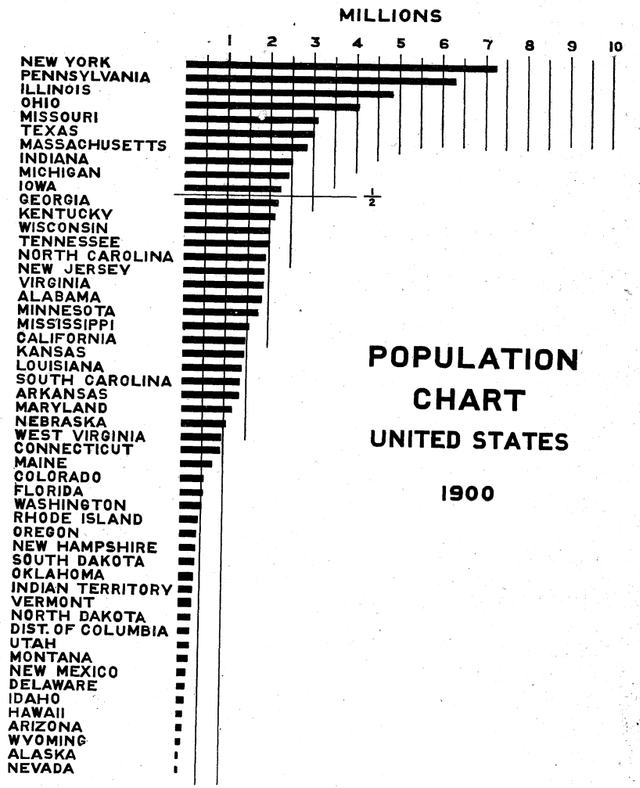

FIG. 2.—POPULATION OF THE UNITED STATES

was used thirty years ago. But fuel must be burned to produce most of our power (Fig. 6) for many years to come. Harness the water whenever you can, but three quarters of the power produced in the United States at the end of the next forty years will be produced by burning coal. Fortunately Illinois has much coal. It is cheaply

mined, and in large plants, located near plenty of condensing water, power can be produced as cheaply in Illinois as it is now produced at the brink of Niagara Falls. But industries prosper, because in

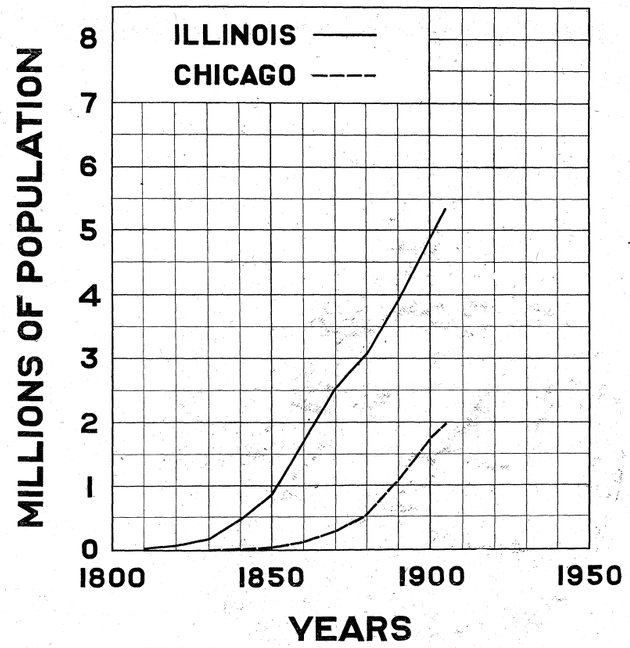

FIG. 3.—POPULATION OF ILLINOIS AND CHICAGO

America we use power for our labor and we make steam and electricity do a rapidly increasing part of the work. In some states it

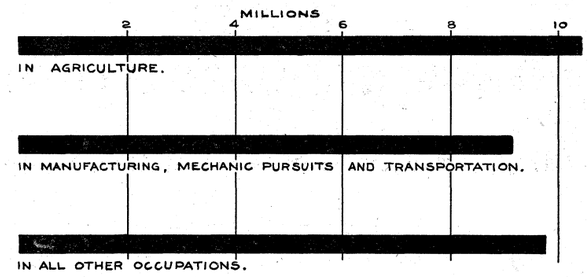

FIG. 4.—DISTRIBUTION OF WAGE-EARNERS IN UNITED STATES

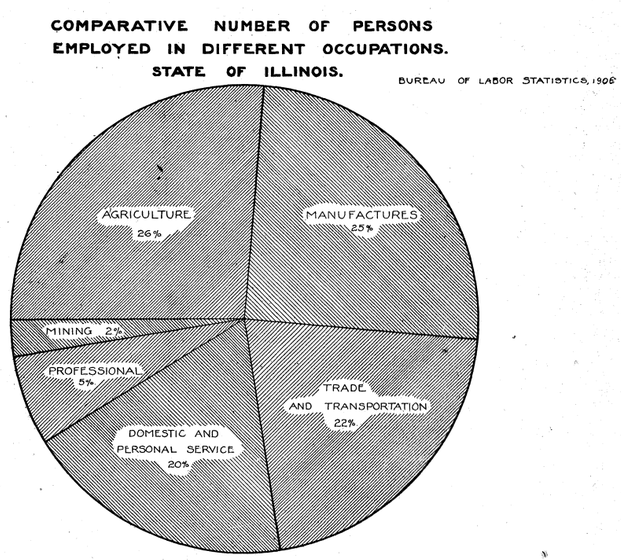

FIG. 5.—DISTRIBUTION OF WAGE EARNERS IN ILLINOIS

would seem as though all the wage earners, using all the possible power, were engaged in manufacturing. In these states the value of the manufactured product per capita of population is naturally large. It will be seen, Fig. 7, that in this list of states Illinois stands well

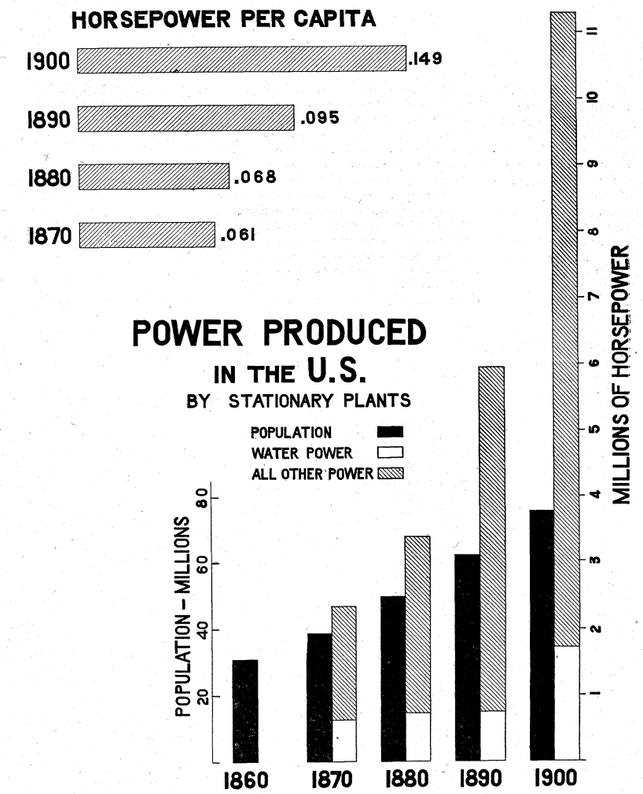

FIG. 6.—GROWTH OF MANUFACTURED POWER

up (eighth), notwithstanding the fact that so many of the wage earners are engaged in agricultural pursuits. The mineral output of Illinois, Table I, is restricted largely to its coal, pig iron, oil, clay, zinc, and other natural stones. Even in this classification the iron

ore is brought into the state, but this method of grouping is usually followed. The subject of its coal production has been so often and so well presented to this Society, that there is no need of treating it at length in this paper. The importance of the generous supply of coal, Fig. 8, furnished from our mines will, however, be of continually increasing importance as time goes on.

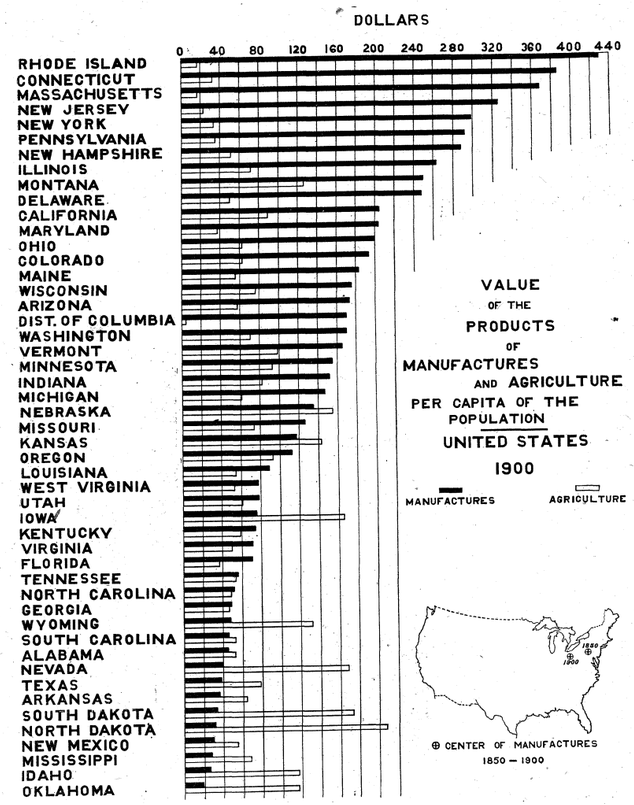

FIG. 7.—PER CAPITA PRODUCTION OF WEALTH

TABLE I.

Total Values of Mineral Output of Illinois in 1906-1907.

	1906	1907
Coal	$44,763,062	$54,687,382
Pig iron (estimated)	47,128,000	52,228,000
Oil	3,275,802	16,432,947
Clay	12,783,813	13,351,362
Zinc (estimated)	5,499,508	6,614,608
Limestone	3,476,449	4,333,651
Portland cement	2,461,494	2,632,576
Sand and gravel	1,043,041	1,367,653
Natural and slag cement	188,262	174,282
Fluorspar	160,623	141,971
Mineral water	77,287	91,760
Lead ore (estimated)	45,760	45,760
Sandstone	19,125	14,996
Pyrite		5,700
Total	$120,922,226	$152,122,648

The development of Illinois as a manufacturing state is so clearly shown (Fig. 9 and 10) by the table and chart, that nothing need be added in this connection. Since 1850 Illinois has passed twelve states ranking then above it. Whether it can ever hope to reach a higher rank is hard to tell, but it will be many years before it will pass its present leaders, New York and Pennsylvania. The capital invested and the product produced by its thirteen leading industries are matters of some interest (Fig. 11 and 12). Illinois needs next a larger number of smaller factories and it needs to attract a larger variety of industries. It has within itself all the elements which are needed for diversified industries, namely cheap facilities for production—a large population, extensive transportation facilities by lake and rail, and of no less importance it has in Chicago many most extensive and efficient organizations for the distribution of the finished products.

A summary of Illinois manufactures for the two years 1900 and 1905 presents some interesting figures, Table II. It shows the effect of the growth of corporations, the increase in the number of establishments being only 3.8 per cent. In all other items the growth is substantial and rapid.

TABLE II.

Summary of the Manufactures of Illinois.

	1905	1900	Per cent of increase.
Number of establishments....	14,921	14,374	3.8
Capital	$975,844,799	$732,829,771	33.2
Salaried officials, clerks, etc., number	54,521	40,964	33.1
Salaries	$60,559,678	$40,549,245	49.3
Wage-earners, average number	379,436	332,871	14.0
Total wages	$208,405,468	$159,104,179	31.0
Men 16 years and over.....	314,091	275,006	14.2
Wages	$187,568,896	$143,714,217	30.5
Women 16 years and over..	60,399	47,922	26.0
Wages	$19,893,360	$13,580,271	46.5
Children under 16 years....	4,946	9,943	*50.3
Wages	$943,212	$1,809,691	*47.9
Miscellaneous expenses.....	$172,185,567	$118,047,771	45.9
Cost of materials used.....	$840,057,316	$681,450,122	23.3
Value of products, including custom work and repairing.	$1,410,342,129	$1,120,868,308	25.8

**Decrease.*

The path of the center of population is still advancing westward; a little north of this path, is that of the center of manufacturing which apparently keeps the same few hundred miles behind it, Fig. 13. Recent changes in manufacturing locations for several vast industries will extend those paths still on toward the west. Will these centers reach Illinois? We believe they will and it looks now as though they would finally locate on the campus of the University of Illinois.

The Engineering Experiment Station of the University of Illinois was established by action of the Board of Trustees, December 8, 1903, in connection with the College of Engineering.

There were two influences which led to its establishment; first, a demand from the industrial interests of the State for scientific experimentation relating to manufacturing processes, fuel economies and transportation problems; secondly, the very great success attending the work of the Agricultural Experiment Station at the University which made it evident that a similarly successful career ought to be possible for an engineering experiment station. It is very evident from the work which has now been accomplished by our Station and the many helpful things it has done for the industries of the State, that no mistake was made in establishing such a station.

Organization—The control of the Engineering Experiment Station is vested in the heads (9) of the several departments of the College of Engineering. These constitute the Station Staff, and with

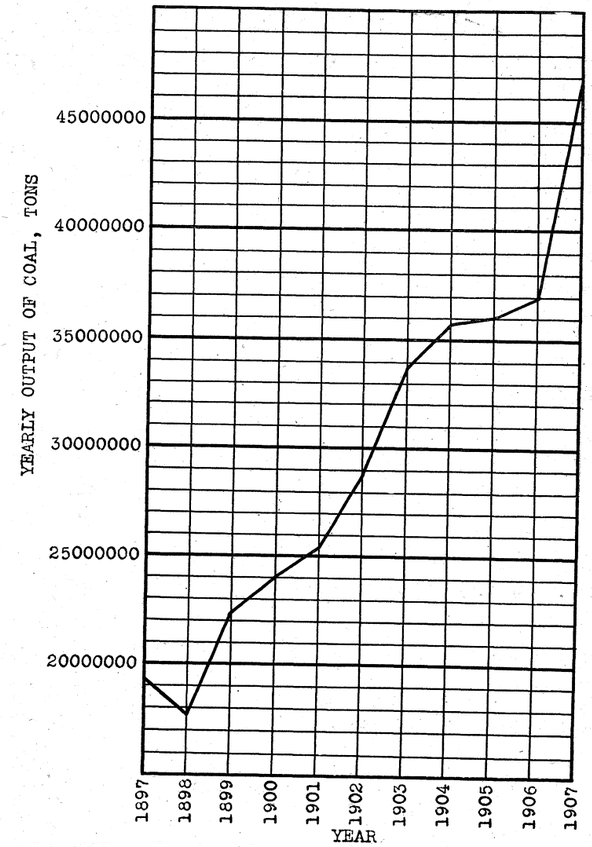

FIG. 8.—YEARLY OUTPUT OF COAL IN ILLINOIS

the Director, determine the character of the investigations to be undertaken. The investigations are carried on by the members of the Staff directly, by fellows as graduate work, by members of the instructional force of the College, and by special investigators belonging to the Station corps.

Plan and Scope—It is the purpose of the Station to carry on investigations along the various lines of engineering, and to make

RANK OF MANUFACTURING STATES.

	1850	1860	1870	1880	1890	1900
NEW YORK	1	1	1	1	1	1
MASSACHUSETTS	2	3	3	3	4	4
PENNSYLVANIA	3	2	2	2	2	2
OHIO	4	4	4	5	5	5
CONNECTICUT	5	5	8	7	10	10
NEW JERSEY	6	6	7	6	6	6
MARYLAND	7	12	14	13	14	13
VIRGINIA	8	9				
MAINE	9	14	12	15		
MISSOURI	10	11	5	8	7	7
NEW HAMPSHIRE	11	15	15			
RHODE ISLAND	12	13	10	14	15	14
KENTUCKY	13				16	
INDIANA	14	10	11	10	11	8
ILLINOIS	**15**	**8**	**6**	**4**	**3**	**3**
CALIFORNIA	16	7	16	12	12	11
MICHIGAN		16	9	9	8	9
WISCONSIN			13	11	9	
MINNESOTA				16	13	12
KANSAS						15
IOWA						16

FIG. 9.—RANK OF STATES IN MANUFACTURING

studies of problems of importance to professional engineers, and to the manufacturing, mining, railway, constructional and industrial interests of the State. It is believed that this experimental work will result in contributions of value to engineering science and to the industries of the State and that the pursuit of such investigations will give inspiration to students and add to the value of the instructional work in the College of Engineering.

Equipment and Facilities—In carrying on the activities of the Engineering Experiment Station, there is necessary a large amount of equipment of various kinds suitable for investigational purposes.

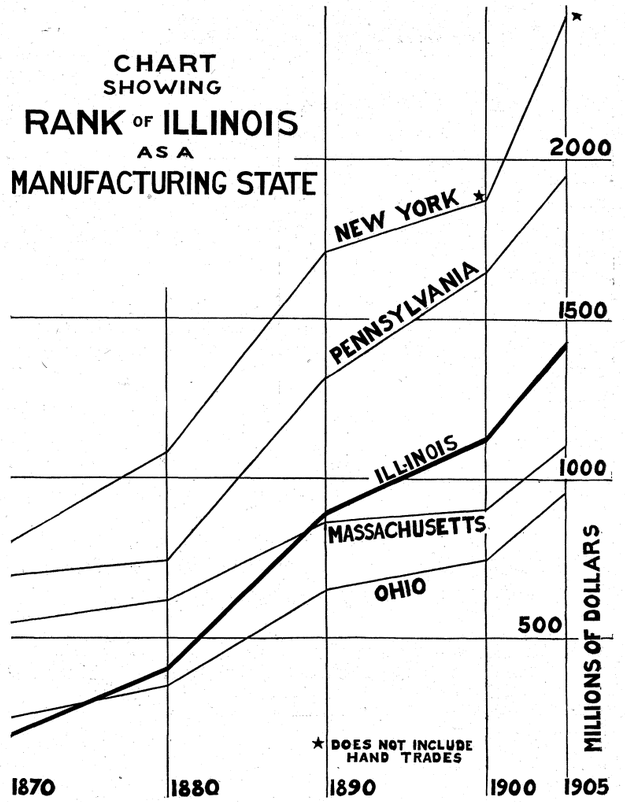

FIG. 10.—RANK OF ILLINOIS AS A MANUFACTURING STATE

The regular equipment provided for instruction in the College of Engineering has largely been used for these investigations, supplemented by the purchase of additional apparatus necessary for special researches in the Engineering Experiment Station. After an investigation has been concluded, the apparatus used becomes a part of the equipment of the department to which it most naturally belongs. The item of expense for equipment, therefore, does not enter into the general expenses of the Engineering Experiment Station. (The value of this total equipment in the College of Engineering is now [April 1909] about $225,000.)

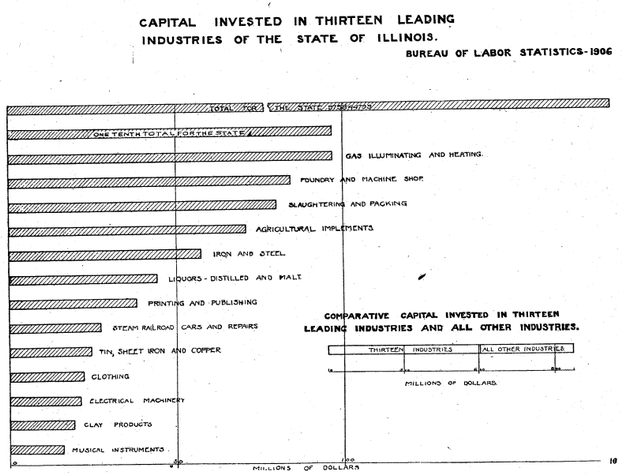

FIG. 11.—CAPITAL INVESTED IN THIRTEEN LEADING ILLINOIS INDUSTRIES

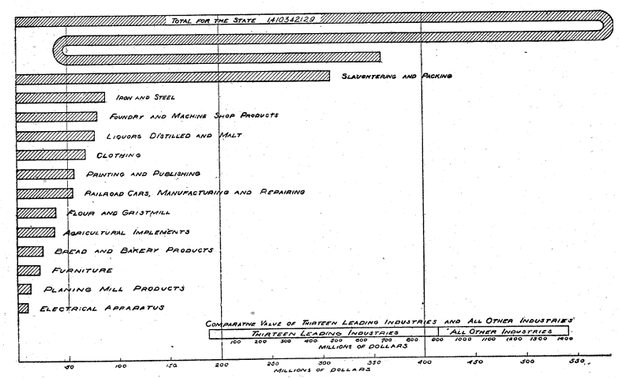

FIG. 12.—ANNUAL VALUE OF MANUFACTURED PRODUCTS IN ILLINOIS

The funds expended in carrying on the investigations, already completed and now in progress, have been during the last five years a little over $150,000, making an annual expenditure of about $30,000.

The existence of the Engineering Experiment Station at the University makes it possible to utilize to great advantage—

(1) The library facilities of the University.

(2) The continual extension of the equipment of the various departments of the College of Engineering.

(3) The helpful suggestions and direct co-operation of other scientific departments at the University outside of the College of Engineering.

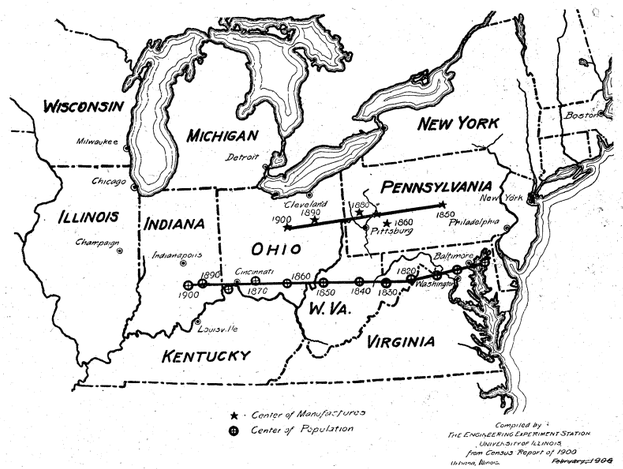

FIG. 13.—PATH OF CENTER OF POPULATION AND OF MANUFACTURES

With these three aids the expenditure of our funds is bound to result in much larger returns than would be possible otherwise.

The work of the Station is going on in all of the technical and scientific laboratories of the University. As an indication of the character of the investigations which are now possible a list of several important pieces of apparatus and installations is given. In connection with this article there are also given several reproductions showing the laboratories in which the investigations are in progress and also the most important apparatus.

List of Equipment in the Different Laboratories.

In the Laboratories of Applied Mechanics and Hydraulics.

(1) A Riehle vertical screw power testing machine of 600,000 pounds capacity fitted to take large and bulky test specimens. This machine will take compression pieces 25 ft. long and tension pieces

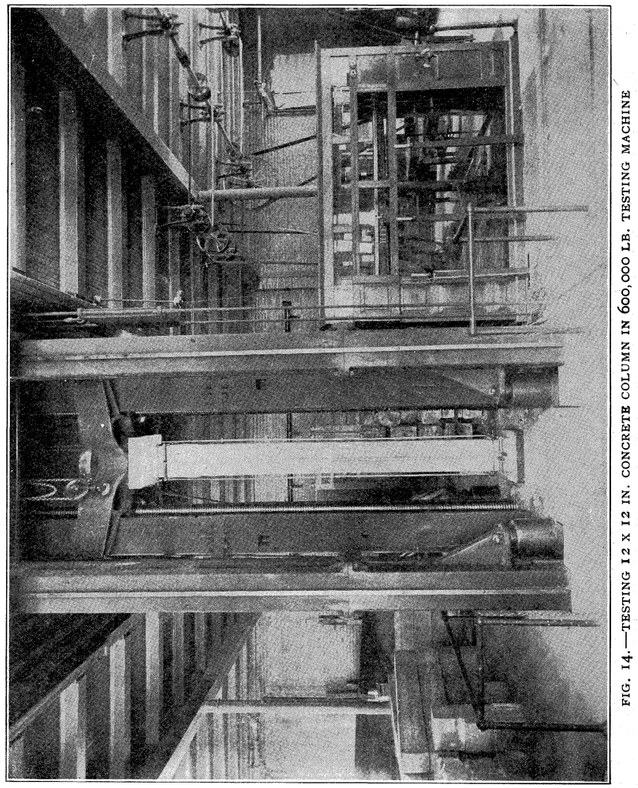

FIG. 14.—TESTING 12 X 12 IN. CONCRETE COLUMN IN 600,000 LB. TESTING MACHINE

of the same net length except as allowance must be made for stretch. The clear distance between screws is 36 in., which gives room for bulky and built-up pieces. The machine is provided with a stiffened vertical frame to allow eccentric and oblique forces to be applied

to test pieces, an unusual feature in testing machines. Short beams may be tested on the machine, and provision may easily be made for testing longer beams. Auxiliary appliances are used for holding the various forms of test pieces in order to secure an application or distribution of the load in the manner desired. Especial attention was given in the design and construction of the machine to making

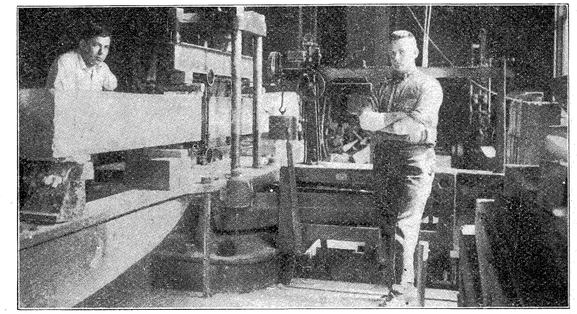

FIG. 15.—TESTING A REINFORCED CONCRETE BEAM

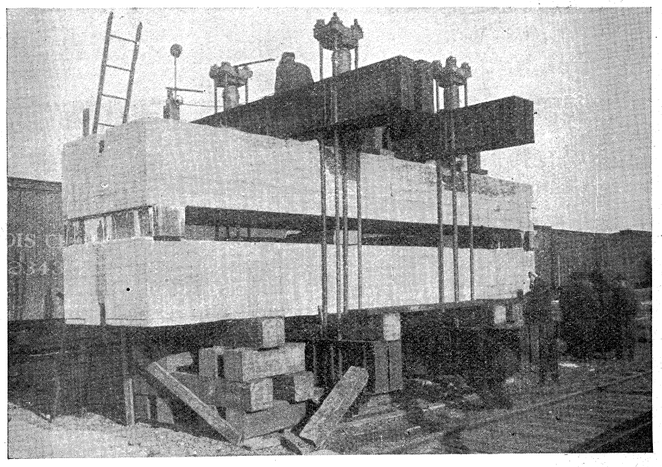

FIG. 16.—TESTING LARGE REINFORCED CONCRETE FLOOR SLABS FOR TRACK ELEVATION, I. C. R. R.

it applicable to a large range of tests. The calibration of the machine shows that it is very accurate and very sensitive. For the smaller loads a second poise weighing up to 60,000 lb. is used. Fig. 14.

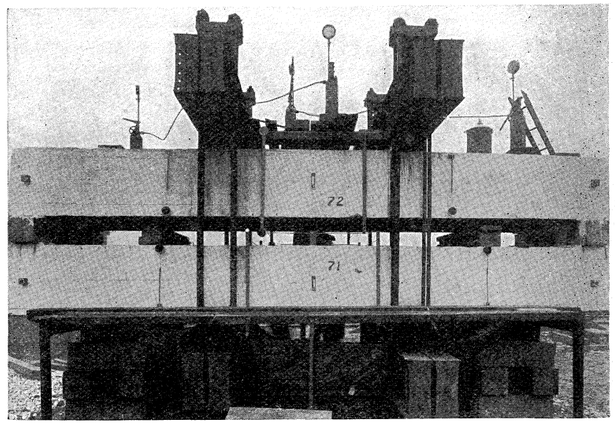

FIG. 17.—TESTING LARGE REINFORCED CONCRETE FLOOR SLABS
I. C. R. R. TRACK ELEVATION

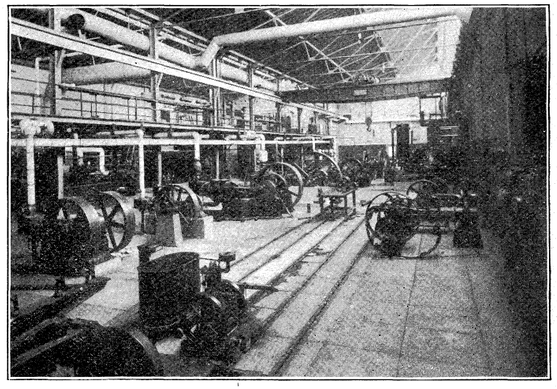

FIG. 18.—GENERAL VIEW OF MECHANICAL ENGINEERING LABORATORY

(2) An Olsen four-screw testing machine of 200,000 lb. for tests in tension, compression and flexure. This machine will take beams up to a length of 20 ft. Fig. 15.

(3) Four 100,000-lb testing machines of different makes, fitted up in the usual way.

(4) An Olsen torsion machine of 220,000 inch-pound capacity.

(5) An Olsen vibratory testing machine for testing stay bolts.

(6) An impact testing machine with a capacity of 3,000 foot pounds, fitted with autographic apparatus for recording the velocity of the falling weight and the deformation of the specimen.

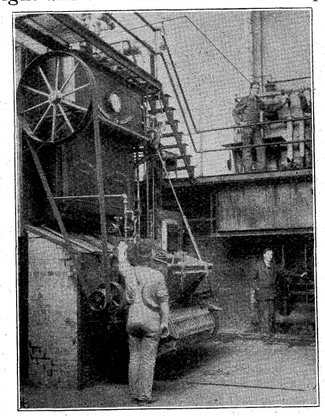

FIG. 19.—EXPERIMENTAL BOILER PLANT, 210 H. P. HEINE WATER TUBE BOILER GREEN CHAIN GRATE, STURTEVANT ECONOMIZER AND FOSTER SUPERHEATER

(7) Four hydraulic jacks with pumps having a total capacity of 800,000 lb., with auxiliary rigging, available for testing large culvert pipe, large reinforced concrete beams, reinforced concrete pier footings and other bulky pieces. Fig. 16 and 17.

(8) A variety of smaller machines for testing cast iron, timber, etc.

(9) A large equipment in measuring devices such as extensometers for various uses, autographic recording devices, gauges, etc. Many of these pieces of apparatus were designed and built by the department and are especially adapted to the work of the laboratory.

(10) A commodious hydraulic laboratory, well equipped with steam engine, steam pumps, centrifugal pumps, standpipe and pressure tanks, lines of piping, measuring pits, tanks, weirs, gauges, meters, motors, etc., giving excellent facilities for testing hydraulic apparatus and for making investigations in hydraulics. The equipment includes apparatus for the study of problems of sedimentation and filtration of public water supplies and the softening and removal of iron from water.

In the Mechanical Laboratory.—(Fig. 18 and 19.)

1. A 210 H.P. Heine water-tube boiler especially arranged for testing Illinois coals. This boiler is a duplicate of the boilers used by the United States government in testing coals from various parts of the country. A Green chain grate stoker is installed under this

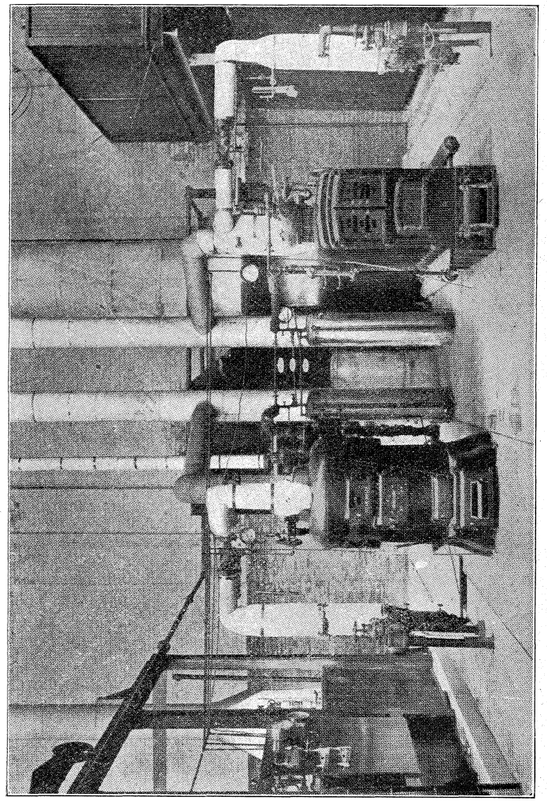

FIG. 20.—HOUSE HEATING BOILERS, TESTING FLOOR

boiler, and draft is furnished by a Sturtevant induced draft fan, drawing the gases through an economizer. The chain grate under the boiler may easily be removed and a plain furnace for hand-firing substituted. A complete equipment of auxiliary apparatus

necessary for boiler tests is available, including recording and optical pyrometers, and standard and recording apparatus for continuous gas analysis. Facilities are now available in the department of physics for calibrating all thermometers and pyrometers used in work of this character.

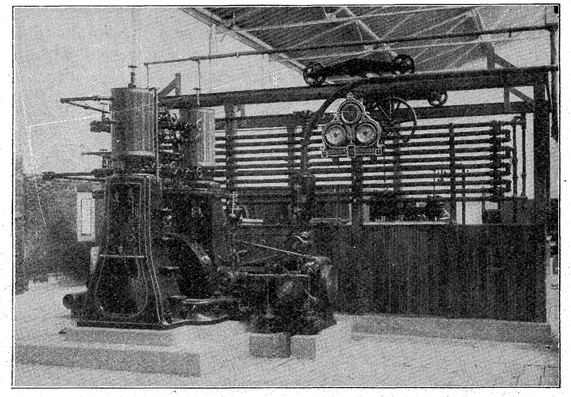

FIG. 21.—YORK ICE AND REFRIGERATING MACHINE

2. An independently-fired Foster superheater capable of superheating the steam from a 150 H.P. boiler to 300 deg. F. above its temperature, at 120 pounds gauge.

3. Several residence heating boilers, for hot-air, steam and hot water service. These boilers will serve to compare the values of such various coals as are offered in the Illinois market for domestic purposes. Fig. 20.

4. A 10-ton York refrigerating plant for the production of cold or for specific tests. With this plant there are 17 cans for ice making, each holding 100 pounds. The possibility of subjecting various building stones or other material to alternate freezing and thawing is worthy of consideration. The effect of fifty winters might thus be known in a single month. The heat conductivity of all kinds of walls used in buildings could be tested. Fig. 21.

5. A liquid air plant with a capacity of about three quarts an hour. It consists of a Norwalk four-stage compressor, compressing up to 3,000 pounds, together with a Hampson liquefier with facilities for temperature determinations.

6. An Ingersoll-Sergeant two-stage air compressor driven by compound steam cylinders. The steam cylinders are 12 in. and 22 in. in diameter with a 12 in. stroke, and air cylinders are 12¼ in.

and 18¼ in. in diameter with a 12 in. stroke. A vertical receiver 42 in. by 8 ft. high is provided for use with the compressor.

7. A 50 H.P. suction gas producer built by the Otto Gas Engine Works. This producer is adapted to burning anthracite pea coal, coke or charcoal. Special apparatus is available for extensive investigations of gas producer problems.

8. An Otto gas engine of 23 H.P. capacity for use in connection with the gas producer. The engine cylinder is 10 in. in diameter, with a 19-in. stroke. It is provided with a compressed air starting device, sparking generator, speed indicators and all other instruments necessary for testing gas engines. Fig. 22.

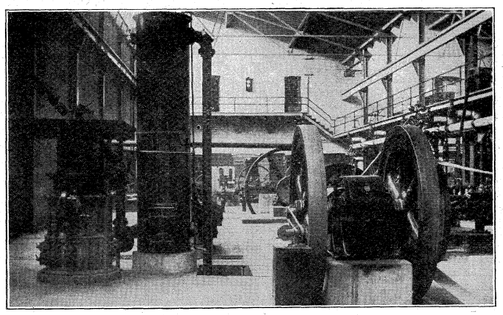

FIG. 22.—A 50 H. P. GAS PRODUCER AND OTTO GAS ENGINE IN MECHANICAL ENGINEERING LABORATORY

9. A 15 H.P. De Laval steam turbine direct-connected to a compound centrifugal pump. This apparatus will deliver 140 gallons of water per minute when pumping against a head of 500 feet. The turbine wheel and small pump runner make 23,500 revolutions per minute; the large pump runner makes 2,350 revolutions per minute. The turbine is provided with condensing and non-condensing nozzles.

10. A hot blast heating system installed to heat the Mechanical Engineering Laboratory. This consists of a series of coils amounting to 2,800 feet of 1-in. pipe and a 72-in. fan draws the air through the coils and forces it into the galvanized iron pipe, 36 in. in diameter, which distributes it to different parts of the building. The fan is driven by a small vertical steam engine.

11. A 100 H.P. Allis-Chalmers Corliss engine, equipped with a suitable brake and other apparatus for making tests.

12. Several high-speed steam engines for testing and for driving other apparatus.

13. Several types of gasoline engines, ranging from 1 to 10 H.P., for experimental purposes.

14. Automobile motor, 4 cylinder, independently cast, of 30 H.P., specially equipped for extensive investigation of high-speed internal combustion motors.

15. An automobile testing platform for testing automobiles.

16. A six-stage, 60 H.P. Kerr steam turbine, equipped with absorption dynamometer, and installed with 60 H.P. Wheeler surface condenser and supplied with saturated or superheated steam.

17. A Worthington surface condenser, 362 sq. ft. of cooling surface with independent steam driven vacuum and circulating pumps, equipped for special investigations of condenser performance.

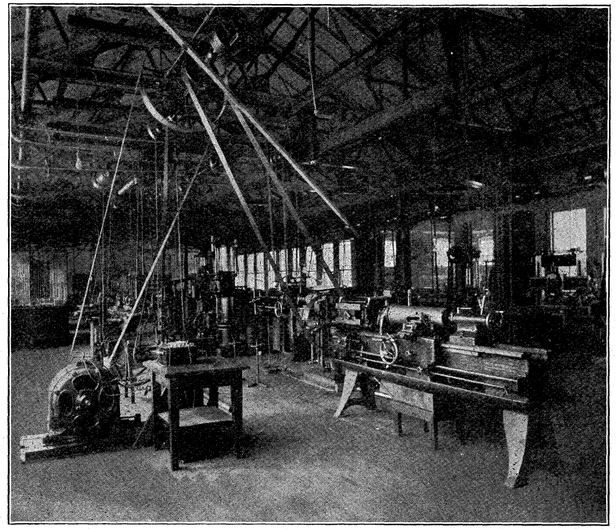

FIG. 23.—U. OF I. MACHINE SHOP, LATHE AND MOTOR DRIVE FOR TESTS OF HIGH SPEED TOOL STEELS

18. A Meitz & Weiss, 2-cycle, 10 H.P. kerosene engine equipped for comparative tests of oil and alcohol.

19. Gas Analysis Laboratory for complete analyses of flue gases from Heine boiler and house heating-boilers and furnaces, exhaust gases from gas engines, and power gas from the producer.

20. A 10-ton electric crane, having three alternating current motors, for experimental work.

21. A Golden oil testing machine for testing lubricating oils and bearing metals.

22. A lathe and motor for tests with high speed tool steels. Fig. 23.

In the Electrical Laboratory—(Fig. 24).

1. Three rotary converters furnishing current based on 110 and 550 volts D. C.

2. A 15 H.P. variable speed Westinghouse D. C. interpole motor giving a speed range of 300 to 1,200 rev. per min.

3. A 7½ kw. inductor alternator which can be run at frequencies up to 150 cycles.

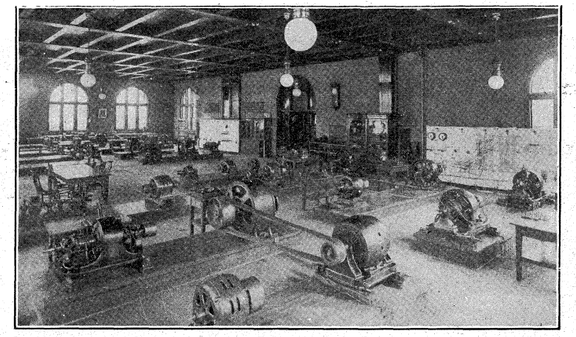

FIG 24.—MAIN TESTING FLOOR OF THE ELECTRICAL LABORATORY

4. Two General Electric stationary armature alternators designed to operate as either two or three phase generators or motors and at a variety of voltages.

5. A 45 kw. motor generator set, used to furnish a constant voltage either A. C. or D. C. for experimental purposes.

6. Several induction motors ranging from 2 to 5 H.P., of one, two, and three phases and various voltages.

7. A number of 110 and 220 volt D. C. motors of from 10-15 H.P. and a variety of D. C. generators of various makes and ranging up to 10 kw. in capacity.

8. A single phase, variable speed, 220 volt, 10 H.P., A. C. motor.

9. A 60 cell Gould storage battery of 240 ampere-hours capacity with a switch board so arranged that all voltages between 2 and 120 can be obtained; also current up to 100 amperes at full voltage with greatly increased current at lower voltage.

10. A large number of transformers of various capacities, voltages and transformation ratios, including a small 10,000 volt and a 10 kw. 100,000 volt testing transformer.

11. A photometry and illumination laboratory, provided with a

3 meter and a 5 meter photometer bar, photometers of various kinds, standard lamps, a Sharp Millar illuminometer and a room equipped for the study of problems in illumination.

12. Two experimental telephone switchboards and a supply of both manual and automatic telephone apparatus.

13. A large equipment in electrical measuring instruments of various types, both A. C. and D. C., among which is a series of electrostatic voltmeters measuring up to 1,800 volts.

14. A fine set of standard electrical measuring instruments including a Weston D. C. laboratory standard voltmeter and a millivoltmeter, Westinghouse precision voltmeter, ammeter and wattmeter and a Leeds Northrup potentiometer.

There are also switchboards for rapid handling of apparatus, numerous lamp banks for resistance, oscillographs, inductances, condensers, a mercury arc rectifier, arc lamps of many types, racks for life tests of incandescent lamps and much other smaller apparatus of value in research work. The department maintains a well equipped machine shop with an expert mechanic in charge so that special apparatus can be made under the direction of the experimenter on short notice.

The Cement Laboratory.

This laboratory is equipped with briquette molds, molding machines, testing machines, etc., necessary in testing hydraulic cement, and in making investigations as to the effect of different materials and methods of manipulation upon the strength of mortars and concrete.

The Road-Materials Laboratory—(Fig. 25).

The Civil Engineering department in its Road-Materials Laboratory is equipped with apparatus for testing materials for road and pavement construction as follows:

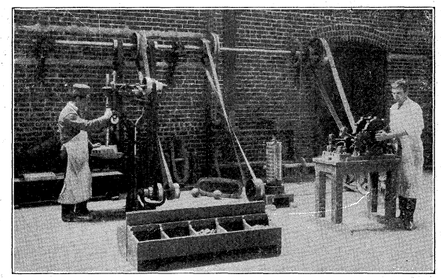

FIG. 25.—ROAD MATERIALS TESTING LABORATORY

(1) Two types of rattlers for testing brick: National Brick Manufacturers' Association and Talbot-Jones, machines.

(2) A Dorrey, a Deval and a Page machine with the necessary accessories for testing the road-building qualities of gravel and macadam.

(3) A stone crusher, ball mill, briquette machine and impact machine for testing the cementation of stone and gravel for road construction.

(4) Testing sieves and agitator for grading stone and gravel, also balances for accurate weighing.

In the Physics Laboratory.

The department of Physics has already done much valuable work for the Engineering Experiment Station. Upon the completion next September (1909) of its new Physics Laboratory, costing a quarter of a million dollars, it will then have such equipment and facilities as will enable it to do extensive fundamental research work which will be of great value to the Station. It is already well equipped for such work as—

(1) The checking and calibration of instruments for measuring temperatures.

(2) The checking and calibration of electrical standards and instruments.

Miscellaneous Testing.—Besides the equipment for the work in the lines indicated above, the department of Physics is supplied for research work with standard apparatus of a variety of kinds, all of which is available for testing purposes. Such facilities are standard barometers, standards of length, photometric standards with photometers, standards of weight with sensitive physical balances, a dividing engine and comparator, vacuum and compression pumps with gauges, and various optical apparatus for the determination of optical constants and accurate appliances for the measurement of volume or pressure of liquids and gases.

In the Railway Laboratory.

(1) *Electric Test Car.*—The Railway Engineering Department owns a two hundred horse power electric test car. This car, of the interurban type, was designed especially for experimental work and was built in 1905. It is equipped with four-50 H.P. D. C. motors and with the Westinghouse multiple control system. The car is supplied with recording voltmeters, ammeters, and wattmeters and with auxiliary measuring and recording devices by means of which there is automatically made a graphical record of voltage, current, power, speed, acceleration, time, and curvature.

By the courtesy of the Illinois Traction System, whose lines are at present operated between the cities of Danville, Urbana, Champaign, Decatur, Bloomington, Springfield and St. Louis, the department is enabled to operate this car on their lines.

(2) *Dynamometer Car.*—There was designed and built in 1900 a dynamometer car which is owned jointly by the University and the Illinois Central Railroad. This car is equipped with all the appliances necessary for carrying on train resistance experiments, as well as with auxiliary apparatus used during locomotive tests. During the seven years in which it has been in service this car has been operated over the entire Illinois Central System, in the establishment of tonnage ratings, as well as on the lines of the New Jersey Central, the Baltimore and Ohio, the Cleveland, Cincinnati, Chicago and St. Louis, and the New York Central Railways. Fig. 26 is a view of the interior of this car.

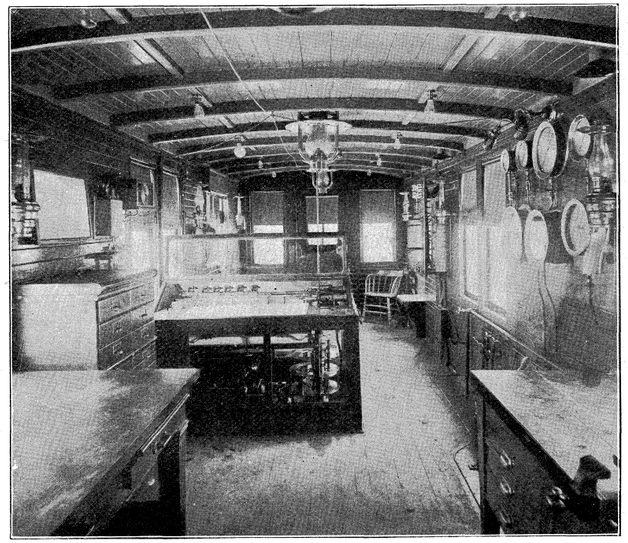

FIG. 26.—INTERIOR OF DYNAMOMETER CAR

(3) *Drop Testing Machine.*—There has recently been added to the equipment of the Railway Engineering Department a standard drop testing machine which in its design conforms to the specifications of the Master Car Builders' Association. This apparatus is used in making impact tests of car couplers, wheels, axles and other material. It consists essentially of a hammer weighing 1640 pounds which runs in vertical guides fifty feet in height. The material to be tested is placed upon the massive foundation at the base of the machine and the hammer is allowed to fall upon it from any desired height.

(4) *Brake Shoe Testing Machine.*—For the testing of brake shoes the department has constructed a brake shoe testing machine similar in design and identical in operation with the standard machine owned by the Master Car Builders' Association. By means of this apparatus it is possible to determine the coefficients of friction and the wearing qualities of various makes of brake shoes, as well as the wear of the wheel under the action of the shoes.

The above list will serve to show what facilities are now available for investigations in certain lines of work; but after all it is *men* and not facilities that determine what of value will finally be done. The men who have been giving thought, direction, energy and work to the Station during the last year are in a general way indicated by the following groups:—

(a) The heads of the different departments of the College of Engineering..... 9 persons
(b) The special investigators of the Station. Experts devoting all their time to this work, doing work, directing work and planning work..... 9 persons
(c) Research Fellows of the Station appointed for two years, devoting one half their time to the investigations of the Station and one half to Graduate Work, receiving the Master's degree at the end of the period..... 9 persons
(d) Various members of the corps of instruction of the College of Engineering who are able to devote a small part of their time to some investigation or who are able to direct some work in progress by assistants, fellows or scholars..10 persons
(e) Some Fellows and Scholars doing research work in the Graduate School..... 4 persons
(f) Heads of other departments of the University. Experts of the Federal Government, chiefs of state department bureaus, all cooperating with the Station for the mutual advance of special investigations ..... 8 persons
(g) Advisory Committees representing various engineering societies and commercial and civic organizations giving counsel, advice, suggestions and criticisms .....10 persons
(h) Draftsmen, computers, clerks, mechanics, assistants and laborers .....12 persons

It will thus be seen that more than seventy persons are now more or less directly interested in the work of the Station; of this number about fifty are actively engaged in the work of the Station for a part of their time and approximately twenty persons are devoting all their time to the interests of the Station.

The Work Already Accomplished.

The work which has thus far been undertaken may be divided into three parts:—

(a) Work completed and results published.
(b) Work in progress.
(c) Work of preliminary investigations.

(a) There have now been published (a few now in press) thirty-six (36) bulletins of the Station. As these bulletins are sent to all members of this Society it will not be necessary to refer in detail to their titles or to the character of the investigations to which they refer. When an investigation has been completed and the manuscript and drawings are ready for the press, a publication committee of three is appointed who are asked to read the material prepared, to look out for errors, and to criticise the work as they desire. The number of each edition published varies from six to twelve thousand copies, depending upon the character of the work and the estimated demand for the number. In several instances a second edition has been found necessary. At present about one-half of the bulletins printed are sent to residents of Illinois, the other half are sent to residents of other states and foreign countries. That the work of the Station is fully appreciated by engineers, manufacturers and others is shown by the hundreds of congratulatory letters received by the Station as well as by the very considerable space given in the best technical papers at home and abroad, to the reproduction of its papers and to favorable editorial comment. It is particularly desired that the bulletins of the Station should be received by all persons in Illinois interested in the numerous problems which connect its many industrial activities with the researches of engineering and applied science, such as manufacturing, mining and railway transportation; the chemical and heat values of Illinois fuels; coal consumption in boiler furnaces, in gas producers, or in residence heating furnaces; the strength of materials used in building engineering structures; the strength of concrete both plain and reinforced; the durability of road material; the flow of water in pipes, conduits and channels; the sanitary problems of industrial corporations and municipalities; the generation, transmission and use of electricity; the problems of architectural construction, roof trusses, columns, base plates, piers and foundations; the cost of power and the problems of heating and ventilation; the problems of heat transmission, radiation and absorption; the problems of speech and signal transmission and many other problems which the above enumeration will suggest.

In the wise distribution of the publications of the Station, the members of this Society may be most helpful and they should request that bulletins be sent to such persons, particularly those living in Illinois, as they believe would use and appreciate them. There are in Illinois about one hundred and fifty public libraries, all of

which receive our bulletins. They should be urged to preserve their copies, as many of the earlier numbers are now out of print and are not easily procured.

The mailing list for the Experiment Station bulletins is made up about as follows:—

1. *Receiving All Bulletins.* (a) List comprising all members of the W. S. E.; (b) All members of several Illinois societies, clubs and commercial organizations; (c) The residents of Illinois who are members of the National Engineering Societies; (d) The Technical Press, domestic and foreign; (e) The leading libraries of the U. S. and all libraries in Illinois; (f) Instructional Staff and all graduates of the College of Engineering..... 4500
2. *Receiving only Classified Bulletins.* (a) Manufacturers interested only in special subjects; (b) Fuel Engineers; (c) Refrigeration engineers; (d) Heating and Ventilating Engineers; (e) Railway Clubs; Boards of health; (f) City Smoke Departments; (g) Schools and Colleges; (h) Miners and operators of Coal Mines.....1000 to 4000
3. *Receiving Bulletins on Request.* (Application for Bulletins reach the Station from all parts of the world following reviews by the technical press).....1000 to 1500
4. Unclassified List—General 500

(b) There are now over fifty lines of investigation in progress in the Station; some are nearing completion, some are but just started. Many preliminary researches reveal the absence of any necessity for further work. Some investigations lead only to negative results. The following list will give an indication as to the character of work now (May 1, 1909) in progress, distributed among the various departments.

Investigations in Progress.

1. A study of plain base plates and ribbed base plates for columns.
2. Economical design of steel and of wooden roof trusses.
3. Description of specialties and conveniences adapted for isolated country dwellings.
4. Tests on the action of rolling loads on ordinary highway bridges.
5. Standardization of the rattler test for paving brick.
6. Use of concrete on the farm.
7. Tests on tungsten lamps.
8. Interference between high potential and telephone lines.
9. Tests of household electric appliances.

10. Electric drives for machine tools.
11. The flow of steam through nozzles.
12. Transmission of heat through tubes under varying velocities of water flow.
13. Gas producer tests at varying capacities.
14. Problems in steam heating by a central station system.
15. The cost of power.
16. Fuel tests with house-heating boilers.
17. Experiments on a smokeless furnace.
18. Fuel tests with hot air furnaces.
19. Fuel tests with Illinois coal in power plant boilers.
20. The weathering of coal.
21. Causes which promote the spontaneous combustion of coal.
22. Report of tests of Illinois Coals by U. S. Geol. Survey.
23. Occluded gases in coal.
24. The low temperature distillation of coal.
25. On the rate of formation of carbon monoxide in gas producers.
26. Thermal-conductivities at high temperatures.
27. Boiler waters.
28. Electric car resistance.
29. Boiler plate temperatures.
30. Wheel flange pressures.
31. Tests of rock ballast road-beds.
32. Resistance of interurban cars on curves.
33. Train resistance tests on steam roads.
34. Relation of economic conditions of territory to types of electric roads.
35. The properties of reinforced concrete columns with special reference to the use of large amounts of steel.
36. The properties of reinforced concrete beams; web resistance and modulus of elasticity.
37. Reinforced concrete wall footings and pier footings.
38. An investigation of continuous beams made with reinforced concrete.
39. Bond between concrete and steel.
40. The distribution of stress in structural steel columns.
41. A study of tests of timber stringers.
42. The distribution of stresses in structural steel compression pieces.
43. The action of metals under torsional and under combined flexure and torsion.
44. Resilience of metals beyond the elastic limit.
45. Strength and cost of acetylene-oxygen welds in steel and other metals.
46. Flow of water through sand and well screens.
47. The discharge of water from orifices and short tubes.
48. An investigation of water hammer in pipes.

49. Measurement of water by means of vertical tubes.

Doubtless some of the above work will lead to no results, some of it will not be completed for several years to come, but much of it is progressing rapidly and the prospect is good for future valuable bulletins covering a wide field.

The Influence of the Station on Our Educational Work.

It was our thought at the outset that the pursuit of definite experimental work would give inspiration to our students and add to the value of the instructional work of the College of Engineering. We have found this to be true. The work of the Station has had a marked effect in strengthening our instructional work. The contact with scientific experimentation and the methods of presenting the results in carefully prepared bulletins is a most helpful factor in the training of the young engineer. It is impossible for our experimental work to go on without attracting the attention of our students. The work must be carefully and accurately done; the preparation of charts and diagrams and the checking and rechecking of results and computations involve extreme care and accuracy. The fact that students see how problems are taken up, how they are solved, and the whole work satisfactorily presented, is perhaps the greatest single educational gain to them. They live in an atmosphere of research which they unconsciously absorb. They are attracted toward research work themselves. They realize that failure to contribute each particular assignment with accuracy may result in the failure of the entire experiment. While the investigations are carried on by the experts of the Station, still there is abundant opportunity to make real use of student help in many tests and computations. The chance to participate in many of the tests is appreciated and eagerly sought by the students. They are interested in the direct application of theoretical principles to the solution of practical, every day engineering problems. This illustrates the old pedagogical principle that when students are permitted to take part in real activities, they are more alert, interested and accurate than when merely carrying on exercise tests.

Some institutions have recently dropped the thesis requirement. This appears to be an unfortunate move. It has probably been caused by large classes and insufficient help and facilities. In the work of this Station many subjects relating to researches in progress are capable of preliminary investigations as thesis work, and students pursue this work with unusual care and attention. Students are also greatly benefited by conferences with and lectures by our special investigators who are always in readiness to advise students along the line of their particular problems.

Encouragement and aid are freely given to members of the instructional force who desire to take up some line of research. In this way much excellent work is done which necessarily reacts on

the quality of class instruction, and at the same time proves a source of development and broadening. This work serves to keep us all in close touch with outside engineering interests and practical every day problems in the industrial world. While our bulletins record mostly the results of the Station's own staff of investigators, there is also the publication of circulars, giving compilations of the results of important experiments by engineers, industrial works, technical institutions and governmental testing departments. This opens up opportunities for our instructors who can not undertake purely experimental work.

Each head of a department in the College of Engineering, being an active member of the Station Staff, is constantly on the alert to detect the possibilities of important lines of work and also to study the adaptation of certain men to certain lines of work and to the possibility of developing investigators from our present body of students and instructional force. While it may be true that the genuine investigator and experimenter, like the poet, is born and not made, still much may be done to develop the spirit of investigation. This in itself is always an element of true teaching and the awakening of a more general spirit of investigation would undoubtedly be an element of strength in all our educational work.

Research Fellowships.

The facilities of the Station for research have made it possible to do real graduate work, and the action of the trustees in providing for ten research fellowships in the College of Engineering of an annual value of $500 will be a distinct gain to advanced engineering education. The rapid growth of the Graduate School of the University is also proving most helpful to the interests of the Engineering Experiment Station and an increasing number of scholarships and fellowships in this department is to be expected.

Future Work of the Station.

In determining the character of the work which the Station shall undertake, the most careful consideration must be given first to the needs and the interests of the state of Illinois. Fortunately Illinois is singularly favored in all the conditions requisite for a rapid and permanent industrial development, and its interests cover very wide fields of engineering activity. In view of its cheap and abundant fuel, its great agricultural wealth and its unexcelled facilities for the transportation of raw material and finished products, it is not surprising that Illinois is the second state in the union in agriculture and third in manufactures. With these great resources devolves upon us great responsibility in developing and husbanding them. The testing of its materials of construction will always be a matter of importance for any state. The prevention of the waste of ma-

terial growing more and more expensive, as wood, and the correct factors of strength of new materials, as concrete, are always subjects for the most careful investigation. To this work we are giving considerable attention, and the demand for the results of our tests on reinforced concrete which are being carried on under the supervision of Professor A. N. Talbot indicates the interest which is taken in this work and the necessity felt by architects, constructors and builders for the most exact information along these lines.

The work of the Station will also extend into some fresh fields, seeking to discover new ways and means for economizing energy and materials, for the prevention of waste, for the protection of labor-saving machinery, for safer methods of travel, and for surer sanitary methods of water supply and sewage disposal.

Fuel supply is of such prime importance in our industrial development that no effort should be spared in the introduction and promulgation of improved methods and processes in the mining, preparation and consumption of coal. From broad economical considerations wasteful methods of using coal, or the rejection of any combustile part as waste, are to be discountenanced. Exhaustive and careful experiments will be required before the best conditions can be attained. These experiments must include analyses of coals from all parts of the state, a determination of the best kinds of coal for specific purposes, best methods of burning Illinois coals, effects of various methods of preparation, experiments on various kinds of furnace construction, etc.

Along the line of power production there is opportunity for much investigation. New problems are confronting both the builders and users of steam and gas motors. There is at present a noteworthy change from the reciprocating engine of large size to the steam turbine. Gas engines of large power have recently been installed, and the development of this type of motor bids fair to be more rapid in the near future. Still newer types of motors are being proposed from time to time, the gas turbine being one that at present occupies much attention as an attractive possibility.

For the user of power, the Station can investigate questions relative to the economy of various types of power installations with given conditions of service. For the builders of motors it can investigate the new and perplexing problems that have arisen. The properties of the various fluids used in heat motors need careful study. Superheated steam is essential to the proper working of a steam turbine, yet many of its properties remain to be investigated. The properties of ammonia and other fluids used in refrigeration are not known accurately, and even the properties of saturated steam are based on Regnault's experiments made nearly seventy years ago. A careful investigation of the properties of heat media of all kinds, extending if necessary over a series of years, would furnish data of the greatest value to engineers, and would in addition be a noteworthy contribution to science.

Considerable work for the railroad interests has already been done by the railway engineering department of the university. This department owns jointly with the Illinois Central Railroad a dynamometer car equipped for steam road experimental work. With this car have been made numerous road tests for the establishment of tonnage ratings. The department also owns a 200 H.P. electric car of the interurban type, especially designed and thoroughly equipped for electric traction work. Railway work with both these cars will be prosecuted vigorously under the direction of the new school of railway engineering and administration recently organized.

It is expected that the Experiment Station will prove helpful to the manufacturing and building interests. In the first place, it will supply accurate data regarding the properties of the materials used in engineering structures and buildings. The laboratory of applied mechanics with its extensive field needs much greater facilities for this line of work, as the reinforced concrete tests now in progress show great possibilities. In the near future, an extensive series of tests on cast-iron columns, and on various forms of steel and iron members is contemplated. Secondly, the Experiment Station will investigate manufacturing processes. As an example of this kind of work the high-speed steel tests are cited. Thirdly, problems relating to design and construction will be studied, and all useful results will be published for the benefit of those engaged in design or construction.

As a rule the Experiment Station will undertake only such investigations as will lead to results of fundamental importance, results that will be helpful to a large class of engineers or manufacturers. It will not, in general, undertake work of importance to individuals only, e. g., the testing of a device or invention for the sole benefit of the inventor.

The Station is now planning to make a more systematic study of the industrial and engineering interests of the state of Illinois, more particularly with the thought in mind that these industries should be advised as to the work already accomplished by the Station, and also that more exact knowledge may be obtained concerning the needs of the various industrial interests throughout the state.

Professor Kenneth G. Smith in the capacity of Industrial Visitor, has during the year, visited the manufacturing centers of Illinois in order to become acquainted with the problems confronting these various interests so that such fundamental problems as affect a large number of our industries can be taken up and such study of these problems made as facilities and funds permit.

There are at present, as already pointed out, fully fifty persons doing some work for the Station; of this number only twenty are devoting all of their time to the station work, the remainder giving but a part of their time to its interests. There are now (May, 1909) in progress nearly sixty different investigations which could doubt-

less be grouped under ten general heads. There are now fully one hundred available investigations waiting for an opportunity to be started and for funds for carrying them forward, as soon as a preliminary survey proves them to be worthy. There will always be, for a station like Illinois, a continually increasing need of such investigations as are planned to be made by the Engineering Experiment Station. The Station is growing to be for the State a *Public Service Research Laboratory* in the realm of industrial science just as it was originally intended it should be, and the results of its experiments will surely add to the wealth of the State, to the prosperity of the industries and to the health and comfort of its people. There will always be fundamental problems of economic importance underlying the advancement of the industrial interests of this State. The Engineering Experiment Station should be ready to assist in the solution of the problems in the field of engineering research. Of fundamental importance are such problems as are indicated by the following list:—

1. The determination of the strength of materials used in constructive engineering work. A very large and important field.

2. A study of the properties and strength of fabricated articles, such as bridges and frame work of important engineering machines and structures.

3. A study of the development, safety and economical use of the machinery and appliances used in mining operations.

4. A study of the problems relating to the economic transportation of passengers and materials by rail (steam and electricity) by water and by air.

5. A study of the economic construction and maintenance of roads.

6. A study of municipal water supply and sewage disposal as affecting public health.

7. A study of the best methods of using economically the fuels of the state, not only for the production of power, but for the heating of buildings, metallurgical purposes, etc.

8. Use of Illinois coal in the gas-producer.

9. Economic production and use of steam.

10. Utilization of oil products for economical and industrial purposes.

11. A study of the development and economic production of manufactured products. A very large field and rich in problems.

12. A study of the generation, transmission and utilization of electrical energy, including economic and satisfactory methods of telegraphy and telephony.

With such a program it is plain that the work of the Engineering Experiment Station can not end so long as the industries of the State are to progress and develop, so long as the fuel problems of the State continue to play such a prominent part in industrial and in domestic use, so long as transportation by steam, by electricity and by water

continues to expand, or so long as a knowledge of the strength of materials continue to play, as it always will, such a vital part in the construction of engineering works, the erection of state and private buildings, and the design and construction of all manner and kinds of manufactured products which our complex civilization now demands.

Perhaps the slow growth of the Station will, in the end, be most satisfactory, but many problems are now waiting for help and much that is new to Illinois interests should be given prompt attention so that every advantage may accrue to its welfare. "A stitch in time saves nine" applies forcefully to scientific research. A knowledge of facts saves much waste.

It is the opinion of the writer,

(1) that the Engineering Experiment Station is now prepared to wisely and economically expend on engineering investigations $100,000 annually;

(2) that provision for this amount ought soon to be made, and

(3) that when this amount has been wisely spent, provision for future funds will be forthcoming. The greatest single need of the Experiment Station at present is for a new *Materials Testing Laboratory*. A laboratory suitable for this important part of the work of the Station would cost, with its equipment, $250,000.00. The State should be asked to provide such a building; the work to be done in it would more than repay its cost to the State in four years. The College of Engineering and the Engineering Experiment Station have always received the substantial support and approval of the members of this Society. It has appreciated this support and has endeavored to merit it. It is the hope of the writer that this strong engineering society will feel justified in taking a still greater interest in the engineering work of the State University. Why should not our various organized engineering, manufacturing and mining interests in this State support, back up and push forward the work of the Engineering Experiment Station in just the same way and for the same reason that the various agricultural interests support the interests of the Agricultural Experiment Station? The relation of the engineer and the relation of the Engineering Society to the public are well worth the careful thought of all of us. If the public is to be educated along engineering lines, it is the engineer who must do it. Let the *Western Society of Engineers* do its share in this work and let it do its share without waiting for some other organization to point the way.

Relation of the Station to the Industries.

It has already been shown that the growth and development of the industries of the State of Illinois have been truly marvelous. The work which the Engineering Experiment Station has accomplished, has now in progress or has in contemplation for the future, has been briefly reviewed. It will be seen that some work of the Station

will be helpful to *all* industries, that other work will be helpful to *special* industries and still other work will be of significant value to each and every home.

The continually increasing cost of lumber during recent years has emphasized the necessity of finding some material to take its place. Concrete is rapidly doing this. Everywhere we see this material entering into all sorts of structures. Its use is becoming universal. It is easily transported and handled. The desired mixture of cement, stone and sand can be prepared by machinery and unskilled labor. Combined with suitably located steel bars it is cheaper, stronger and more fire resisting than wood. The cement industry of the country has made the most rapid growth of any of our new American industries. It is extremely important that engineers, architects, and builders should know definitely and accurately concerning the strength and other physical properties of reinforced concrete in all its many and varied forms, mixtures and mechanical treatments. This information the Engineering Experiment Station has been endeavoring to supply, and with, we believe, much success. Eleven bulletins of the thirty-six published have referred to this subject. The first step was the installation of the 600,000-lb. vertical testing machine arranged for testing large and bulky specimens; then came the planning of the work, the making of the tests; then the labor of computations and finally the interpretation of the results and the publication of these results and the conclusions to be drawn from them. The last of these steps is of most vital importance. To do all of these things well is no insignificant task; but they must be done and those engineers who do not know what the results of such tests signify will either use materials wastefully or will design structures that will be temporary and unsafe. Such work as this can not fail to be far reaching and of large economic importance to all the engineering and industrial interests of the State. In the same way the tests of Illinois fuels which have been in progress for four years are of special value and interest to every manufacturer, every railroad company, every power plant both private and municipal and to every home in the State. They are equally valuable to the mining interests of the State. The examination and tests of Illinois coals have been carried forward by several cooperating departments;

(a) The Technologic Branch of the U. S. Geol. Survey.
(b) The State Geological Survey.
(c) The Chemical Department of the College of Science.
(d) The Graduate School and
(e) The Engineering Experiment Station and all aided by the special Conference Committee on Fuel Tests,—composed of representatives of the Western Society of Engineers; Western Railway Club; Illinois Manufacturers' Association; Coal Operators' Association; State Electric Light Association; and the Building Managers' Association of Chicago. Seven bulletins of the Station have related

to this important work. The composition, the heating value and the physical nature of Illinois coals have been most carefully studied and set forth as the result of the work carried on under the direction of Professor S. W. Parr, and his work will continue to be of increasing value as time goes on. The experiments by the experts of the Station concerning the burning of Illinois coals under power plant boilers, and in furnaces designed to allow perfect combustion and smokelessness have done much to make Illinois coals worth more in our own and in neighboring states, especially those states north and west of Illinois. A knowledge of the comparative expense of burning briquetted fuel, coke, hard coal, Virginia, Ohio and Illinois coals in different types of residence heating furnaces and boilers can not help but be of value to every home in the State. The bulletin of Dr. J. K. Clement, on the "Rate of Formation of Carbon Monoxide in Gas Producers" is a work of exceptional merit and is a first step in aiding the problem of Illinois coal as a suitable fuel for large gas producers. The coal produced by Illinois has an annual value of $55,000,000, a still larger amount is doubtless consumed by Illinois industries; the writer would welcome figures on this subject. If the economies pointed out as possible by the Station were carried out, and in many cases they have been, at least 5% of the coal consumed by the State could be saved.

What is true of the Experiment Station's work and tests of concrete and fuel, is equally true of its other lines of work, but thus far more time and money have been devoted to these two lines of work than to others. More need not be said to convince the engineer or the members of this Society, that the work of an Engineering Experiment Station may be as helpful to the progress of industrial Illinois as the work of the Agricultural Experiment Station has been and is to the agricultural interests of the State. It will, perhaps, take more time to educate the general public to understand the possibilities for good which might easily result from a more generous support of such a station. It will be for such societies as this to demand of the Station, such service as it should reasonably be expected to furnish, at the same time urging such generous support by the State for its work, as the results of its past investigations seem to justify or the possibilities of the future seem to promise. There are many investigations which must be made, they are vital to industrial progress. Many of these investigations can be better made by such a station as the one we are now describing than by any other agency. They can be made for less money. They can be made by scientific methods. While they are being made they will help develop the type of man needed by our industries for the more special investigations of the individual or the more highly specialized industry. Several foreign nations have agencies similar to this to make their fundamental industrial investigations. Are not the future interests of the State of Illinois of such importance as to demand the substantial development and extension of

the work now started by its Engineering Experiment Station and should not the engineers and the manufacturers themselves organize to cooperate with the Station in guiding, in protecting and in advancing the researches of the Station in a way that will serve the best interests of this great industrial State?

WHAT WILL AN ENGINEERING EXPERIMENT STATION COST?

The Illinois Enginering Experiment Station has been in active operation for four years. When it was first started it was a matter of some doubt about the wisdom of some of its tests. Funds were available in excess of the pressing needs. This was fortunate because some expensive equipment was necessary to carry out the plans of the future. This equipment was purchased. As soon as the bulletins of the Station began to appear and engineers and manufacturers became acquainted with the work and the objects of the Station, we began to receive requests for tests far beyond the capacity of the Station. At the present time it is absolutely impossible to take up one quarter of the work which comes to us for investigation. It has always been the policy of the Station not to do any work for pay. The reason for this is evident. We refer many inquiries to the proper commercial parties. We are not running a consulting office. The work we do must be of general interest to a large number of citizens. Some work may, nevertheless, be of special interest to certain groups of engineers or manufacturers. Young industries sometimes need preliminary help; it is good State policy to help them.

The expenses of the Experiment Station for the past four years have been as indicated below:—

Expenses of Engineering Experiment Station

1903-4	
1904-5	$ 25,000
1905-6	25,000
1906-7	30,000
1907-8	33,000
1908-9	37,000
Total	$150,000

It would have cost three times this amount to have done this work if it had been done independently of the educational work of the College of Engineering. It is clear to the writer that the Station has demonstrated its ability to organize, plan, execute and publish work of great value to the State. It can be trusted with much greater work and it will be better done in the light of past experience and better facilities. The problems in hand and before it for solution involve expense. Some problems must extend over several years in time. Three quarters of all the problems which the Station will investigate will relate to the conservation of the resources of the

Table 4

APPROPRIATIONS TO AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS AS AUTHORIZED BY FEDERAL LEGISLATION.

ACT	Date	Amount Appropriated for Agricultural Experiment Station Work	Amount Appropriated for Instruction in Agriculture, Mechanic Arts and Allied Subjects
First Morrill Act	1862	30,000 Acres of Public Land for each Senator and Representative	
Hatch Act	1887	$15,000 per Annum	
Second Morrill Act	1890		$15,000 for the year 1890 and an annual increase of $1,000 until the annual appropriation of $25,000 was reached in 1900.
Adams Act	1906	$5,000 for the year 1906 and an annual increase of $2,000 until the annual appropriation of $15,000 is reached in 1911.	
Nelson Amendment	1907		$5,000 for the year 1908 and an annual increase of $5,000 until the annual appropriation of $25,000 is reached in 1912.

During the year 1912 and thereafter $30,000 will be available for Agricultural Experiment Station Work and $50,000 for Instructional Purposes. No money has been appropriated or is available for Engineering Experiment Station work.

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YEAR	Annual Appropriation in Accordance with the Acts Approved		
	Annual Appropriation for Agricultural Experiment Station Work	Annual Appropriation for Instruction in Agriculture, Mechanic Arts and Allied Subjects	Total Annual Appropriation
	Expressed in Dollars		
1905	15 000	25 000	40 000
1906	20 000	25 000	45 000
1907	22 000	25 000	47 000
1908	24 000	30 000	54 000
1909	26 000	35 000	61 000
1910	28 000	40 000	68 000
1911	30 000	45 000	75 000
1912	30 000	50 000	80 000
1913	30 000	50 000	80 000

State and Nation. Where else shall the State go for aid in solving such problems as have been outlined in this paper?

Reference has several times been made to the extensive and valuable work which is being done for the State of Illinois by its Agricultural Experiment Station. This Station receives funds from the Federal Government for aiding its work, but by far the greater part of its funds is appropriated by the State. It is asking the legislature this year, for its use during the next two years, the amounts indicated in Table 3 below:—

Legislative Askings for the Agricultural Experiment Station
1909-1911

1	The College	$140,000
2	Live stock investigation	140,000
3	Soils	200,000
4	Crops	60,000
5	Horticulture	80,000
6	Dairy	102,300
7	Floriculture	35,000
	Total	$757,300

In addition to this amount for operating expenses, it is asking for buildings, $162,500.

The funds appropriated to the University by the Federal Government—a part of which are for Agricultural Experiment Station work—are set forth in Table 4. Is it any wonder that the work of the Agricultural Experiment Station should have been important and its researches extensive? No one doubts the wisdom of the expenditures and every one praises the results of its work.

The Engineering Experiment Station is now ready to do great things for the industries of the State. It will cost more money than has yet been appropriated if greater things are to be accomplished.

The writer believes that the industries can afford an extension of the work of its Engineering Experiment Station and that it will pay to make such extension.

Discussion.

President Allen: First let me thank Prof. Breckenridge, on behalf of the Western Society of Engineers, for his most timely and interesting address. Our Society should be in the closest possible touch with the great engineering schools of the West, and such evenings as this are most important in establishing and maintaining such relations.

It is the American idea, and preeminently the western idea, that the education of the people is a function of the State. To this end the State provides its schools, leading from the common school up

to the University, compelling everyone to take the rudiments of education, and offering the very highest facilities for advanced education to those who choose and are able to avail themselves of them. In this way the State itself and the whole people of the State come into a very intimate connection with the State educational system, and with the State University; on the one hand supporting it by general taxation, and on the other hand entrusting to it the education of their youth, and the Western Idea looking to it for instruction, advice and help in building up the industries of the State.

In Illinois—one of the greatest manufacturing and industrial states of the Union—our State University at Urbana is a splendid testimonial to the progress of this idea of mutual aid and cooperation. We all know the crying need of scientific development; how few things in the engineering world are done as well as they might be done, and how few people are trained, and have data at hand, to do things in a scientific and systematic way. The work of the Engineering Experiment Station, as described by Prof Breckenridge, is going to fill a big place in the development of our State. It is certainly a step in the right direction. A great work has been done already, and the possibilities for the future are almost limitless. The work should concern and interest every citizen of the State.

The paper is now open for discussion, and I am glad to see our State University as well represented here this evening. We would like very much to hear from Dr. Goss, Dean of the Illinois College of Engineering.

Dr. W. F. M. Goss, M.W.S.E.: I know, Mr. President, that you, as well as all members present, will agree with me, when I say that we are indebted to Prof. Breckenridge in a two-fold way tonight. We are certainly indebted to him for presenting in such a clear, logical and strong way this story of the problems and work of the Illinois Engineering Experiment Station, which, when published in our Journal, will put before the engineering public a great work and one which is at present somewhat peculiar to the state of Illinois, so far as it is a work which proceeds under state auspices. As yet no other state institution has a regularly organized Engineering Experiment Station proceeding in connection with its engineering college.

The second thing for which we as members of this Society, and as engineers in the state of Illinois, may feel indebted to Prof. Breckenridge, is the larger fact that it has been through his enthusiastic efforts that this Engineering Experiment Station has been established and brought to its present high state of efficiency. I think we may all be proud that we are members of a society in a state where so much has been accomplished for the advancement of scientific information for the benefit of engineers, and that we have with us tonight the man who has laid the foundations, aided in securing financial support, and put the station in a fine state of development.

These are two things for which we should feel especially grateful to the speaker tonight.

On my own behalf and the College of Engineering of the State of Illinois, I want to say that since Prof. Breckenridge is to leave us, and is to sever his connection with this State, there rests upon every one who is interested in the progress of engineering education and the introduction of scientific research, a new responsibility. The work he has carried on so well must be taken up by others, and it will require the reinforcement of interest on the part of everybody in the state who naturally should be interested in that work, in order that it may not fall below the high expectations Prof. Breckenridge has had for it. I take it that while we may have other desires and purposes, yet it will not be a fitting ambition on our part if we do not render all the assistance we can in this matter; we want the work carried on as Prof. Breckenridge wishes it to go on. That I think would be a high idea for the existence of this Station, but of course there are others reasons than that. I am sure the engineers generally feel a great pride in the work which has been already accomplished by the Experiment Station. Most of them know of that work and many have had a part in it, and I do not need to urge the members of this Society to do what can be done to sustain and foster the College of Engineering. Now we are reaching the time when we shall have to call on our friends, when we shall have to urge our friends to think of the needs of the College of Engineering and the Experiment Station, in order that we may go on to new standards and greater prominence. It is true that we have a great college and we are doing our work, but it is also true that our facilities are far below the facilities which ought to be available in this state, for the work which ought to be done. Those of us who stand in the place of Prof. Breckenridge will wish to lean heavily, frequently, on the clientage of the college, its graduates, its friends, and the engineers of the state, for encouragement and support. I cannot refrain from saying, just at this moment, after listening to this excellent address, that a beginning has been made, and the time is coming when, in place of efforts which have been made, we must put forth renewed efforts greater than anything which has yet been done.

Mr. W. L. Abbott, M.W.S.E.: The talk this evening has centered principally around the campus of the University of Illinois, and although there are many here tonight who owe allegiance to other colors and other engineering colleges, I know that each one feels a pride in the work which the engineering colleges of this day, in common with Illinois, are doing in the work of investigations.

One of the principal things which engages the Board of Trustees of Illinois is robbing neighboring institutions of their shining lights,—for instance, President James was secured from Northwestern University, and Dean Goss from Purdue University, and so on down the line. But we have cause to regret that while we were away on one of our foraging expeditions another institution came along and took one of our best men.

One would think, after contemplating the department that Prof. Breckenridge has built up in the past few years, that he would be content to stay and enjoy the fruits of his labor, but apparently he is possessed of that wanderlust which is characteristic of the Methodist minister, who, after having, by sacrifice and struggle, built a comfortable church in which he could stay the remainder of his life, instead of doing so looks for "new fields to conquer," and moves on again to a churchless parish. So Prof. Breckenridge is going to a benighted institution where he thinks the gospel is needed more than it is in Illinois. He is going to show the people of the East what Western civilization and Western hustle can do. He says that if he is able, he will develop an engineering school at Sheffield, which will compare with that at Illinois, but in case he is not able to do so, he will settle down in academic repose in the land of fried chicken and fresh oysters.

James Lyman, M.W.S.E.: After the remarks of the last speaker, I think it is incumbent upon me, as an alumnus of Yale and a fellow college man with our member Prof. Breckenridge, to call attention to the fact that the great universities and most successful colleges in the West have been started by Yale men. Prof. Breckenridge came West with a splendid groundwork in educational lines and the enthusiasm and spirit of Yale, and it was due partly to that and partly to the fact that he "hailed" from the state of Connecticut (which, although one of the smallest states in area, ranks highest in educational lines), that he has made such a record. The engineering department at Yale is a purely scientific school, and the engineering graduates are all rejoicing in the selection of Prof. Breckenridge to make Sheffield not only a scientific school, but one that shall minister to the needs of the great industrial enterprises of New England and all the East, in establishing such an engineering department as he has created for the state of Illinois. What is loss to the State of Illinois is gain to Connecticut and Yale.

Mr. A. Bement, M.W.S.E. (by letter): As a representative of the Western Society of Engineers on the Conference Committee, organized for the purpose of assisting in the fuel testing work of the Illinois Engineering Experiment Station, I wish to extend my hearty congratulations to Prof. Breckenridge, and to join with the rest of his friends in wishing him the fullest measure of good fortune and success in his new position, and to say that his genial presence will be missed.

The Engineering Experiment Stations are quite a new institution, something with which we have not had much experience, and it has occurred to me that it would probably be appropriate to offer some suggestions having a bearing on their usefulness.

I think it would be desirable to have some form of organization among different stations, so that each may know what character of

research is being conducted by the others, thus avoiding duplication of work. Also that broad and adequate consideration be given to the experimental work which may be undertaken, because it is no easy matter to expend to the best advantage appropriations made for such work. There is danger that the things selected for study may appeal only to the official in charge, and that his viewpoint may govern, rather than that of the requirements of the public.

Aside from the conduct of research, I think the experiment stations have an opportunity to be of great benefit at small expense, by assembling together, properly editing and presenting in bulletins, results secured by other experimenters, which would often be of as great advantage as work that the experiment station might itself conduct.

President Allen: The tide has been running for sometime from the East to the West; now we have the return tide, and Western business men are called to high executive places in the East; Western engineers are in charge of many of the most important engineering works in the East, and now Western educators are going to Eastern Universities. So the West is coming into its own; instead of being a missionary State it is sending its own missionaries abroad.

And now let us wish Prof. Breckenridge a career of splendid success in the East. Our best wishes go with him to his new responsibilities, and he will always find a warm welcome from the State and its citizens to whom he has given so many of the best years of his life.

Prof. Breckenridge: I desire to thank the members of the Western Society of Engineers for all the delightful things they have said to me. I shall always remember the many agreeable things that have come to me during my stay in the West, and when I come to Chicago, it is needless to say I shall always call on the Western Society of Engineers

I shall also greet with much pleasure members of this society that come to New Haven to visit Yale or to see me, and I shall always be glad to have any of you hunt me up and let me have the pleasure of showing you Yale and particularly the Sheffield Scientific School.