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THE ROSE TECHNIC.

VOL. VIII. TERRE HAUTE, IND., MAY, 1899. No. 8.

THE TECHNIC.

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NOTICE TO SUBSCRIBERS.

Hereafter we shall follow the general rule regarding subscriptions, and shall continue sending THE TECHNIC to subscribers until notified to discontinue.

PAST experience has shown that the first few months of an editor's life is not at all one of ease of mind, and that preliminary experience of a month or two as an observer, will do much towards making his duties light at the beginning of his term of office, and giving him some confidence in himself and not a few ideas as to how to go about editing and making up the first number. Believing that such a plan would be advantageous to all of the editors upon the Board of THE TECHNIC, the election for next year, was held a month earlier than usual in order to give the new men a chance to try their ability, if they so desired, and also to have the opportunity of observing the various operations and methods adopted in getting out a college journal. As the result of the election, the following Board will have charge of THE TECHNIC, assuming their new duties at the beginning of the year with the best wishes and congratulations of the retiring Board:

R. K. Rochester . . . . Editor in Chief.
R. N. Miller . . . . Assistant Editor.
J. I. Brewer . . . . Alumni Editor.
W. F. Huthsteiner . . . . Athletic Editor.
David Meriwether . . . . Artist.
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Chenoweth Housum } . . . . Local Editors.
E. L. Flory . . . . Business Manager.

The retiring Board will be represented by three men on the new Board. Mr. Rochester, who has held the position of Assistant Business Manager and Athletic Editor in the last two years, will be the Editor in Chief. He assumes that position with a reputation already won as a successful editor, having edited the *Dayton High School Times* for one term, with both honor to himself and credit to one, if not the best, of the High School journals of the West.

Mr. Miller, as Assistant Editor, will, without doubt, give the same interest and careful attention to his department as he has shown in the position of Local Editor during the last year. His talent has already been recognized by his class, in making him Editor of the *Modulus*, and THE TECHNIC is proud that he has consented to carry the additional work of editing Rose Leaves and acting as Assistant Editor. Mr. Flory has likewise shown his ability as a business manager of a college journal, by the interest and enthusiasm with which he has filled the position of Assistant Manager during the past year. And the financial side of THE TECHNIC will, without doubt, be cared for in the most satisfactory manner. The remainder of the Board are all new men, but the reputations they have made for themselves in other organizations of the school, in which they have served as officers, assures THE TECHNIC of their faithful performance of the duties which will be required, to the best of their ability. The Assistant Business Manager will not be elected until the beginning of next year. The editing of the department of Exchanges has been slightly changed and will hereafter be conducted by the Editor in Chief. It having been decided that a department of reviews and comments upon the current engineering literature would be more interesting and valuable than an exchange department, where the larger part of the exchanges are from literary schools, and any reviews or criticism must be upon subjects that are not in thorough touch with the work that is carried on in a strictly technical institution. Several changes have been made in the last year in the administration of the affairs of THE TECHNIC. The financial condition has been greatly benefited by the action of the Council which assures the support of the entire student body. In doing this we feel confident that the interest will also be increased and that each student will feel that he has a share in the success of THE TECHNIC and will take an active part in its promotion. A number of the Alumni have also expressed a deeper interest in the journal that keeps them in touch with their Alma Mater and have shown their interest in more than one way.

THE Rose Tech has withdrawn from the Intercollegiate Field Meet which is to be held on May 27th in Indianapolis. The date for field day was set early in the year for May 20th by the delegates from the various colleges that met in Indianapolis to discuss the coming meet and decide on the place and time. All seemed to be in fairly good condition and the Intercollegiate Athletic Association was considered a permanent organization with a definite object in view and a constitution and by-laws to govern its actions. Later on in the spring a number of the delegates met again and upon the request of several the date was placed on May 27th, upon the pretext that the weather would be better and more time would be given for training. This was in a measure agreeable to all concerned as there were the accepted reasons. However, it turned out that Notre Dame, who has lately entered the Association, was the instigator of this change and that she desired to enter into a field meet with Chicago University on the 20th, therefore the date was changed by a little pulling of wires. The Secretary's books were not to be had and the minutes of the last meeting could not be obtained. When it was known that the date had been changed to accommodate Notre Dame objection was raised by a number of the colleges as to the right of making such a change without consulting all of the colleges and that the meeting was unconstitutional as the minutes of the last meeting were not to be had and the action taken then could not be set aside without a majority vote. The President declared the change unconstitutional and set the date again for the 20th. All seemed to be settled and preparations were going on and the training progressing rapidly for the meet on the 20th when word was received from the University of Indianapolis on the 16th that the date had been again changed to the 27th. No authority was given for this change and no valid reasons except that it was the desire of the University of Indianapolis, who had the meet in charge. A meeting of the Rose Tech Athletic Association was at once held and the Secretary was instructed to withdraw the name of Rose Tech as they did not desire to enter into a meet that was conducted on such loose principles as the I. I. A. A. seems to stand at present. Something is radically wrong and a thorough investigation should be made by the colleges who are interested in clean athletics. The constitution of the Association should be revised and a few ironclad by-laws drawn up that will prevent in the future such unbusiness-like methods of conducting the affairs. If the present delegates have not the ability to conduct the business of the Association in the proper manner, each institution should appoint a new man and give him full instructions as to the needs of that particular school and what they desire to have done in regard to the future field meets. If the proper interest is shown by each school the Association can be placed on a strong basis and the coming meets be conducted in a manner that will reflect credit upon the athletic interests in the State.

☙ ☙ ☙

THE Quadrangular Field Meet which was to have been held on May the 6th between the State Normal, Y. M. C. A., High School and the Rose Tech was declared off on account of the wretched weather which had prevailed for several days. The committee having the arrangements in charge decided that the meet should be held at some early date in the near future and Saturday, May the 13th was chosen by a majority vote, the Rose Tech voting in the negative as it would be impossible for them to enter on that date as a ball game with De Pauw had been scheduled for two months. However, the other three contestants were decided in their determination to hold the meet on the 20th. The Rose Tech then withdrew as they could not cancel the ball game as it was one of the regular scheduled games and there was no other open date on which the game could be played. It was then clearly impossible for the Rose Tech to enter into both contests as several of the ball team were also members of the track team and besides if both contests were entered into much of the interest and enthusiasm would be taken from the ball game. Considering this, the President of the Association withdrew the names of the contestants from the entries. This at once seemed to stir up a spirit of resentment and a series of newspaper notices have appeared giving various reasons why Rose Tech was afraid to enter the contest and that she withdrew because she was not in a condition to compete with the other institutions. Inside affairs of the Rose Tech Athletic Association were thoroughly reviewed and commented on by several supposed well informed authorities. The criticism and comments reached a climax in the contemptible and spurious programs which were scattered broadcast at the field meet. Such conduct we are inclined to believe originated with a few and was not the expression of the feelings of the mass, yet whatever the source, it is beneath our notice except to express utter contempt for the originators and supporters of such a cowardly and ungentlemanly act.

☙ ☙ ☙

"THE Development of the Fast Trans-Atlantic Passenger Steamers" was the subject of one of the most delightful lectures that have been delivered this year, to the student body. Dr. Gray has closely watched the development of the Trans-Atlantic Steamer, and gave the students the results of his observations and studies of the wonderful progress that has ever been made in the service of the ocean grey hounds during the last half of the century. In the first of his address, Dr. Gray, traced the early history and application of the steam engine as a propelling power to steam boats. He began with the first efforts of Blanco de Garey in Spain, Jonathan Hull in England, and Fulton in America, and minutely described the primitive steam vessels and their power equipment. The development for the succeeding years was slow and little was done and still less left for the historian to relate. The true history of the Trans-Atlantic Service dates back to the year 1819 when the Savannah made the first trip across the Atlantic, and her name has been handed down through history as the first steamer to cross the ocean propelled by steam. Her propelling engines were clumsy and the paddle wheels only temporary affairs that could be taken on deck when not in use. Only two trips were made by this historic vessel when she was relieved of her engines and returned to her sails as motive power.

From that time on the development of the ocean grey hound was steady, but not until a quarter of a century later when the British and North American Navigation Co. was organized, did steam navigation become a commercial success. Rapid improvements followed and company after company were formed, to compete in the Trans-Atlantic service. During the quarter of a century, from the time of the foundation of the British and North Atlantic Navigation Co. in 1838, when forty days were spent on the trip across the ocean, to 1863 when the Scotia of the Cunard Company made the trip in 8 days and 3 hours the progress was rapid and the development and perfection of the marine engine most marked. During the next twenty five years the time was reduced, in 1885, to 6 days and 2 hours, by the Etruria and the Umbria of the Cunard Company. During this time the size of the vessel had undergone as marked a development as the power and speed, the Savannah was only a vessel of about 400 tons, the Collins Company were building vessels, the Atlantic, Pacific, Arctic and Baltic, of 2860 tons, 290′ x 46′ x 32′ 6″ in 1850. The Great Eastern is perhaps the most remarkable vessel ever constructed considering the times and the developments of steam navigation at that period. It is one of the largest vessels ever constructed and only within the last one or two years has it been excelled in length. The City of Paris of the Inman Line in 1889 brought the record down to 5 days 19 hours 18 minutes westward and 5 days 2 hours 50 minutes eastward. This record has been broken time and again, until now the record is held by the Kaiser Wilhelm der Grosse, of the North German Loyd Company which is the fastest ship afloat. Dr. Gray gave many interesting particulars of the construction, equipment, and operation of the many types of vessels which have crossed the Atlantic in the last half century. Interesting data was also given in regard to the ratio of the power required to propel modern vessels, to their length.

The Influence of Mechanical Draft upon The Ultimate Efficiency of Steam Boilers.

W. B. SNOW,
WITH B. F. STURTEVANT & CO., BOSTON, MASS.

[Lecture delivered before the students of the Rose Polytechnic Institute.]

A DISCUSSION of the influence of mechanical draft upon the ultimate efficiency of steam boilers, may very properly be introduced by a presentation of the apparatus and the methods employed in its production. In its generally accepted form the apparatus consists of a fan blower enclosed in a case and provided with the necessary means for its operation. The fan wheel itself consists of a number of radial blades carried upon steel arms, cast into the hub. Side plates bind the blades together and provide two inlets concentric with the shaft, one on either side of the wheel. The air enters through one or both of these inlets, and is, by the action of centrifugal force, delivered tangentially at the tips of the blades, which conform to the outer circumference of the wheel. By means of a surrounding case, the air thus discharged is conducted to an outlet in its circumference. In all but the smallest sizes, the casing is usually constructed of steel plates. Its shape and proportions may therefore be made to exactly comform to the requirements.

Although a mechanical draft fan may be readily driven by belt, it is rendered much more effective if equipped with a special engine directly connected to its shaft. Its operation is thereby rendered entirely independent of any other source of power, it may be driven at any desired speed, automatically regulated to the exact requirements of the fire, and, if desired, started up before the main engine is put in operation. Special forms of construction will appear in some of the succeeding illustrations.

Mechanical draft may be applied under either of two general methods, the plenum or the vacuum. Which is to be employed must depend upon the circumstances, for it cannot be asserted that either is unqualifiedly superior under all conditions. As ordinarily applied, under the plenum or forced draft method, the air is delivered to the closed ashpit under pressure, and thence finds its escape through the fuel on the grates above. Its success depends largely upon the manner of introduction of the air to the ashpits. For this purpose a special form of damper is desirable.

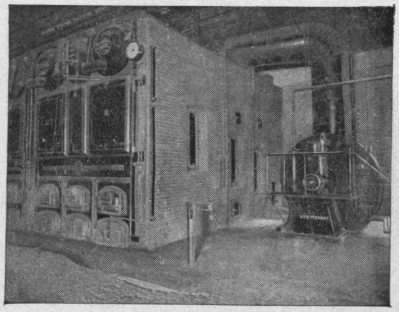


Fig. 1. Forced Draft Plant of United States Cotton Co., Central Falls, R. I.

In Fig. 1 is shown a typical forced draft plant. The fan is so designed that the air may be discharged into an underground brick duct, extending along beneath the boilers, whence it passes through branch ducts to the individual dampers in the ashpits.

In a new plant the bridge wall may be left hollow and utilized as an air duct; a damper being set in its front and operated from the boiler front by means of the notched handle bar. The effect of both forms of damper is to spread the air evenly over the entire bottom of the ashpit, whence it rises in even volume and at low velocity.

Under the vacuum or induced method, the fan is introduced as a direct substitute for the chimney, creating a vacuum in the furnace, and drawing therefrom the gases generated in the process of combustion. As the draft is thus rendered positive and practically independent of all conditions, except the speed of the fan, it is only necessary to provide a short outlet pipe to carry the gases to a sufficient height to permit of their harmless discharge to the atmosphere.

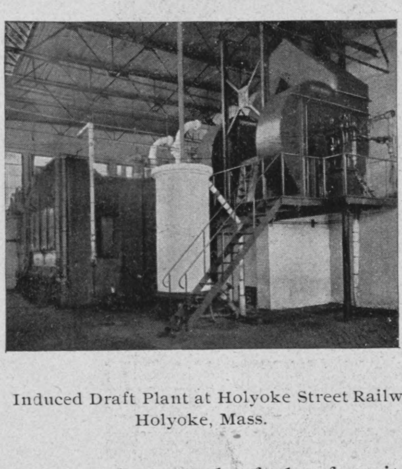


Fig. 2. Induced Draft Plant at Holyoke Street Railway Co., Holyoke, Mass.

In practice the capacity of an induced draft fan as measured by the weight of air or gases moved, necessarily varies with the temperature of the gases it is designed to handle. Therefore the density, which varies inversely as the absolute temperature, should enter as a factor in all such calculations. Various arrangements of induced draft are usually possible with an ordinary boiler plant. As a rule the simplest arrangement consists in placing the fan or fans immediately above the boilers, leading the smoke flue directly to the fan inlet connection and discharging the gases upward through a short pipe extending just above the boiler house roof. A duplex, induced draft plant, having two fans, each of sufficient capacity to produce the required draft, is shown in Fig. 2. Each fan is provided with a direct connected engine, and either or both may be connected at will. A simpler arrangement with one fan is the one in Fig. 3.

The ultimate efficiency of a steam boiler is dependent upon three principal factors.

First. The primary cost of the entire plant and the fixed charges thereon.

Second. The quantitative efficiency of the plant as a means of burning the fuel supplied and transfering its heat to the water evaporated.

Third. The operating expense, including the fuel.

In addition there are always distinct advantages or disadvantages which, while of marked importance, can only be measured qualitatively in their relation to the superiority of any given arrangement or appliance.

In so far as mechanical draft has a direct influence upon any of these factors, it is the purpose to here consider its ultimate effect upon the efficiency of the steam boiler plant to which it may be applied. Naturally, the question of primary cost first enters into the consideration, and secondly, that of maintenance and operation, while both of these items are to be viewed in the light of the efficiency secured. In the matter of first cost, comparison is fundamentally made between the cost of a chimney and that of a mechanical draft plant which may be introduced as a substitute.

In the accompanying curves, Fig. 4, are presented the relative costs of chimneys and of equivalent mechanical draft equipments in a number of boiler plants widely different in character and rated capacity.

In certain of these the cost of the existing chimney is known and that of the complete mechanical draft plant is estimated, while in others the cost of the mechanical draft installment is determined from the contract price, and the expense of a chimney to produce equivalent results is calculated. Costs are shown for both double and single, forced and induced engine-driven fans and for duplex engine-driven plants in which either fan may serve as a relay. An apparatus of this latter type is evidently most complete, and is necessarily the most expensive. It finds its greatest use where economizers are employed.

An average for the costs for these nine representative plants shows the total expense for installing a forced draft plant to be only 18.7 per cent. that of a single induced fan and accessories 26.7 per cent., and that of a complete duplex induced draft plant 42 per cent. of that of a chimney. In each case a short steel-plate stack is included.

In other words, if a chimney be estimated to cost $10,000, there could be saved on a basis of these averages, the respective amounts of $8,130, $7,330 or $8,800 in the first cost, according to which system of mechanical draft is substituted.

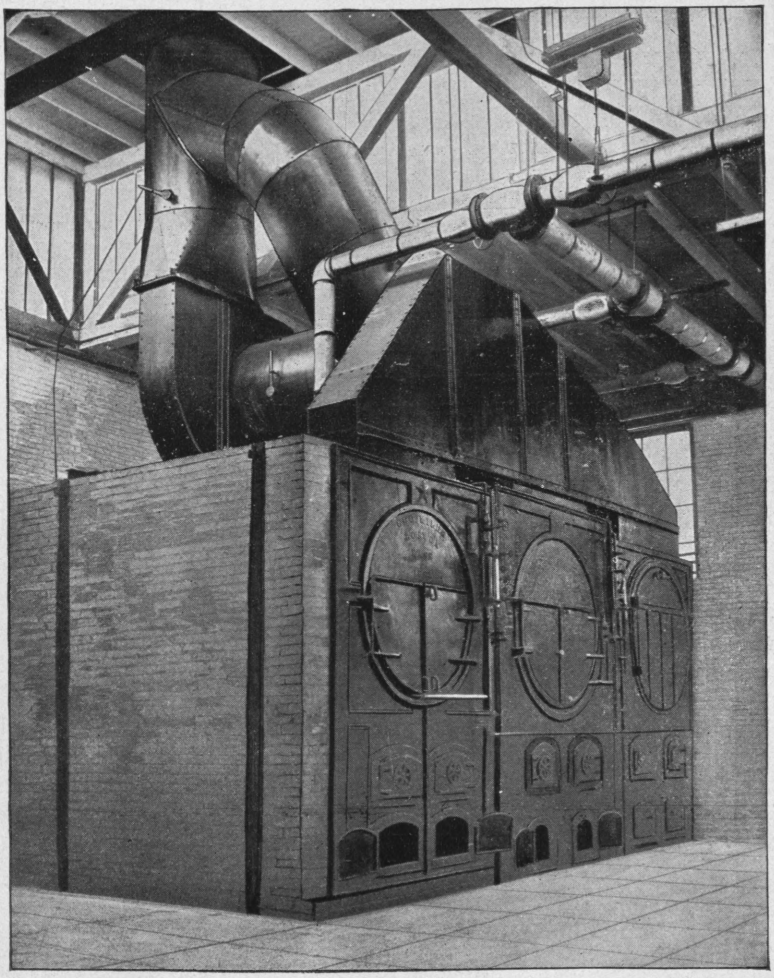


Fig. 3. Induced-Draft Plant at the works of the B. F. Sturtevant Co., Jamaica Plain, Mass.

Interest	5	per cent.
Depreciation and repairs	4½	" "
Insurance and taxes	1½	" "
Total	11	" "

Experience has shown that these figures also hold good for a well designed mechanical draft apparatus, and are therefore accepted here. On the other hand the fixed charges on a chimney may be fairly assumed as:

Interest	5	per cent.
Depreciation and repairs	1½	" "
Insurance and taxes	1½	" "
Total	8	" "

Upon this basis the cost and fixed charges on a $10,000 chimney and its substitutes would be as follows:

METHOD OF DRAFT PRODUCTION.	FIRST COST.		ANNUAL FIXED CHARGES.	
	Amount.	Ratio.	Amount.	Ratio.
Chimney	$10,000.00	$1 00	$800.00	1.00
Induced draft plant, 2 fans	4,200.00	.42	462.00	.58
Induced draft plant, 1 fan	2,670.00	.267	294.00	.37
Forced draft plant, 1 fan	1,870.00	.187	206.00	.26

The fact that the mechanical draft apparatus can usually be placed overhead or on top of the boilers where it occupies no valuable space and that the space otherwise occupied by the chimney is at the same time rendered available, makes possible a further saving which is necessarily dependent upon the land values. Within city limits it may readily amount to $1,000 in a plant of a thousand horse power.

A concrete case illustrating the possibilities of mechanical draft is presented in the accompanying drawings, Figs. 5 and 6. These show a plant of 2,400 h. p. of modern water-tube boilers, 12 in number, set in pairs and equipped with economizers. Fig. 5 indicates the location of the chimney 9 feet in internal diameter by 180 feet high, designed to furnish the necessary draft. Fig. 6 shows the same plant with a complete duplex induced-draft apparatus substituted for the chimney and placed above the economizer con-

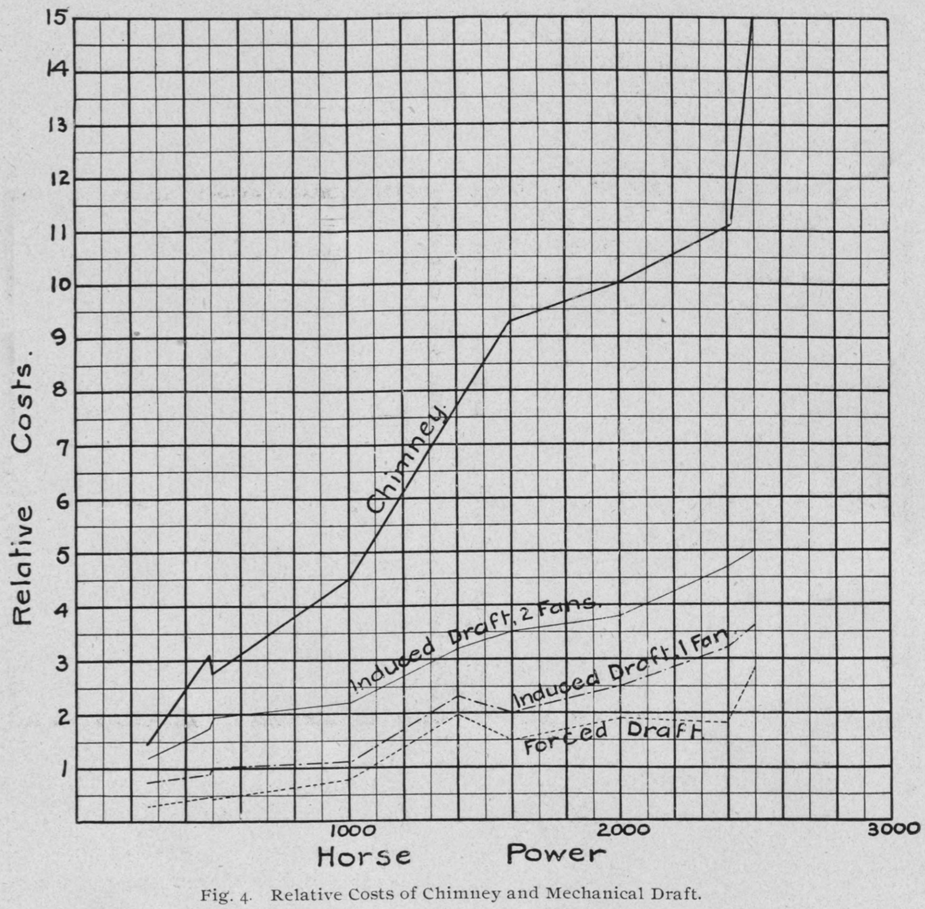


Fig. 4. Relative Costs of Chimney and Mechanical Draft.

nections. Each of the two fans is driven by a special engine, direct-connected to the fan shaft, and each is capable of producing draft for the entire plant. A short steel plate stack unites the two fan outlets and discharges the gases just above the boiler house roof. All of the room necessary for the chimney is saved and no valuable space is required for the fans.

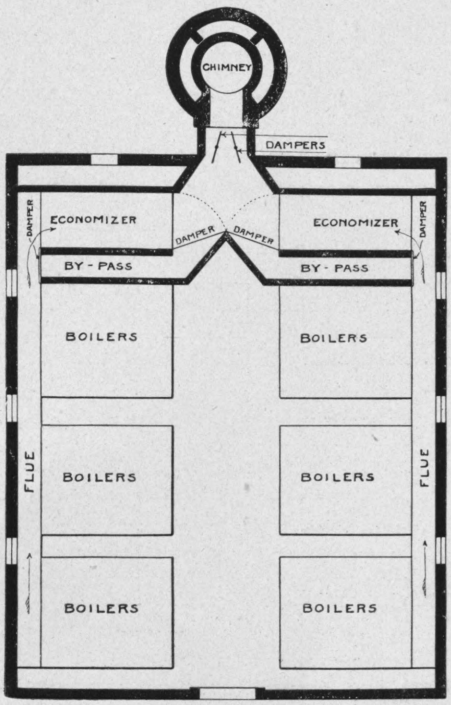


Fig. 5. 2400 H.P. Boiler Plant with Chimney Draft.

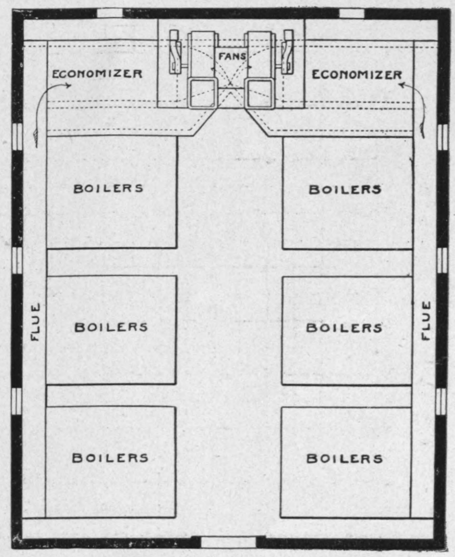


Fig 6. 2400 H P. Boiler Plant with Mechanical Draft.

COST OF BOILER PLANT WITH CHIMNEY.

12 boilers	$37,000
2 economizers	10,500
Boiler and economizer settings and by-passes	9,000
Automatic damper regulators and dampers	400
Chimney, including foundations	10,700
Boiler house	11,500
Total	$79,100

RELATIVE COSTS.

CHIMNEY DRAFT.		MECHANICAL DRAFT.	
Cost of chimney	$10,700	Cost of mechanical draft plant, complete	$4,700
Cost of damper regulators and dampers	400	Saving by using mechanical draft	6,400
	$11,100		$11,100

In round numbers the cost of the plant is in detail as here shown. The costs of the chimney and the mechanical draft apparatus which are also indicated, show a saving in first cost of $6,400 as the result of using the mechanical draft method.

The comparatively low rates of combustion which have heretofore obtained are largely due to the inability of the ordinary chimney to overcome the increased resistances incident to the maintenance of a higher rate. Boilers have naturally been proportioned to meet these conditions, but it is manifest that by changes in design or by the introduction of heat-abstractors, they may, under the influence of mechanical draft, be readily operated at considerably above their original ratings, with substantially the same efficiency. As a result, it is possible to obtain a given output with a plant of less size and first cost than is possible with a chimney. This is particularly true where the steam consumption is liable to sudden fluctuations for comparatively short periods.

The typical boiler plant already presented will serve as an excellent illustration. Suppose it is determined to omit two of the twelve boilers, say one for each pair at the end farthest from the economizers, and to force the remaining boilers up to the original rating, which can be easily done by mechanical draft, as a substitute for the chimney. This will decrease the rating to 2000 H. P., or by 16⅔ per cent. The volume of air required per pound of coal, with the higher combustion rate, deeper fires and mechanical draft under automatic control, will be somewhat less than that with the chimney, while if economizers remain the same, their capacity relative to the heating surface of the boilers will be greater, so that the ultimate waste by heat in the escaping gases will certainly not be increased.

RELATIVE COSTS.

2,400 NOMINAL HORSE-POWER PLANT, WITH CHIMNEY DRAFT.		2,000 NOMINAL HORSE-POWER PLANT, WITH MECHANICAL DRAFT.	
12 boilers	$37,000	10 boilers	$30,833
2 economizers	10,500	2 economizers	10,500
Boiler and economizer settings and by-passes	9,000	Boiler and economizer settings and by-passes	8,500
Automatic damper regulators and dampers	400	Boiler house	11,000
Chimney, including foundations	10,700	Mechanical draft plant complete	4,700
Boiler house	11,500	Saving by using mechanical draft	13,567
	$79,100		$79,100

The original costs under the two conditions will be about as indicated. A total possible saving of $13,567 is thus shown, of which $7,167 is due to the reduction in nominal horse-power made possible by the introduction of mechanical draft.

A problem that has to be faced sooner or later in most boiler plants is that of increased capacity. This differs from that just presented in that the chimney already exists, and it becomes a question whether the desired results shall be obtained by forcing the existing boilers or by adding to their number. The former method demands an increase in intensity of draft, which with the given chimney, operating well up to its capacity can only be obtained by considerable increase of height at excessive expense, while with either method a larger volume of air is required. As a result, increased output frequently demands not only more boilers, but a new or higher chimney. Here mechanical draft steps in and presents a simple solution of the problem.

RELATIVE COSTS.

2,800 NOMINAL HORSE-POWER PLANT, WITH CHIMNEY DRAFT.		2,400 NOMINAL HORSE-POWER PLANT, WITH MECHANICAL DRAFT.	
2 additional boilers	$ 6,167	Fan, dampers, ducts	$ 1,500
Settings, etc., for 2 boilers	1,250	Saving by using mechanical draft	8,617
Addition to building, etc.	2,700		
	$10,117		$10,117

Considering the matter of increased output solely in the light of comparative cost between the introduction of more boilers or the introduction of mechanical draft and disregarding any possible cost of change in the chimney, we may again take for illustration the plant of 2,400 rated h. p. Suppose it is desired to increase its capacity to 2,800 h. p., or by 16⅔ per cent. Then the relative costs under the two conditions will appear as here indicated.

We may now turn to that portion of our discussion which relates to the quantitative efficiency of a boiler plant.

No greater waste occurs in modern steam boiler practice than that which is inherent in the employment of a chimney for the production of a draft, namely, the loss of heat in the escaping gases. As the chimney depends for its action upon the maintenance of a temperature difference between the internal gases and the external air, it is manifest that with a chimney this waste can never be eliminated. It may be palliated, it is true, by the building of higher chimneys so that the same intensity of draft may be obtained with a lower stack temperature. But such means of providing for the utilization of the otherwise waste heat is expensive.

In the case of a fan, however, the power expended as measured in heat units necessary to produce the same results, may, under ordinary conditions, be only about one seventy-fifth of that necessary with a chimney. In other words, the fan renders available for utilization practically all of the heat wasted by the chimney, while it possesses the further advantage of readily creating the additional draft required when heat abstracting devices are introduced.

Messrs. Donkin and Kennedy in seventeen independent boiler tests found the heat lost up the stack when no economizer was used to range between 9.4 per cent. and 31.8 per cent. of the total heat of combustion. As it is not practicable to cool the gases to atmospheric temperature it is evidently impossible to utilize all of the heat, but the ordinary economizer should, with mechanical draft, show a saving of between 10 and 20 per cent.

The average results obtained by Roney from tests of nine plants thus equipped were as here presented:

Temperature of gases entering economizer	526 3	deg.
Temperature of gases leaving economizer	269.6	"
Decrease in temperature of gases	256.7	"
Temperature of water entering economizer	150 4	"
Temperature of water leaving economizer	297.1	"
Increase in temperature of water	146.7	"
Fuel saving, in per cent	14.64	

The importance of mechanical draft in the adoption of means for utilizing the waste heat, is well exemplified in the introduction of retarders and of ribbed tubes. Both of these increase the resistance and almost invariably require fan draft to enable them to create the saving of 5 to 10 per cent which may be thus secured.

The facility with which the intensity of the draft and the volume of air supplied can be regulated when a fan is employed for draft production, has always been recognized as one of the most valuable characteristics of this method. Such regulation makes possible the most perfect distribution of the air and its reduction to the minimum amount which will produce satisfactory combustion.

For the mere chemical requirements of the combustion of one pound of ordinary coal, about 12 pounds or 150 cubic feet of air is required. But under the conditions of chimney draft this amount is greatly exceeded. Donkin and Kennedy showed in the results of 16 tests that the air supply ranged from 16.1 pounds to 40.7 pounds.

As the gases pass onward through the tubes they become cooled, but those of higher temperature part more readily with their heat, and at the same time their volume and consequent velocity are reduced still further facilitating heat transmission. On the other hand, the gases of lower initial temperature, transmit their heat less rapidly and the final result is that within practical limits, the temperature of the escaping gases is least with the greatest excess of the air supply.

The fact just presented points toward the economy to be secured by comparatively high rates of combustion, when the proper rate of heating surface to grate surface is provided. A high combustion rate manifestly requires a thicker fire, which in turn presents a better opportunity for contact between fuel and air with consequent economy in the supply of the latter. Less air results in a more intense fire, a higher furnace temperature, a greater transmission of heat to the water within the boiler and a resultant higher evaporative efficiency. But a thicker fire requires a greater intensity of draft to overcome the increased resistance, while the relatively smaller area for passage of air necessitates a higher velocity of that air, and furthermore, the increased intensity to produce this velocity, must be proportional to the square of the rate of flow.

This condition is most readily met by the fan, which, under normal conditions, produces an intensity exceeding that of an ordinary chimney, and which can without trouble maintain the highest practicable rate of combustion.

Whitman found that with a certain mechanical stoker in which the air distribution was almost ideal, an excess of 85.6 per cent. was used when the rate of combustion was 12 pounds while almost perfect evaporative efficiency was maintained when the rate was 46.4 pounds and the air supply actually 11.2 per cent. below the chemical requirements.

The loss resulting from the formation of smoke is absolute, for it is equivalent to directly robbing the fire of a part of the fuel from which not only has no heating effect been secured, but upon which heat has actually been wasted in raising it to the temperature of the escaping flue gases. Fortunately, from a purely economic standpoint, this loss seldom if ever exceeds one per cent. of the total calorific value of the fuel. In fact, the prevention of smoke is not to be considered so much in its economic aspect as in its relation to the stringent laws which are being enforced in many communities. It thus becomes a question of life or death, for unless the smoke is prevented the boilers cannot be operated. For the prevention of smoke, sharp, intense draft is necessary, properly regulated and capable of furnishing the required amount of air, both below and above the coal at the very moment when it is most needed.

This result can be best secured by the introduction of mechanical draft which is ordinarily so regulated that the decrease in steam pressure resulting from the opening of the fire doors, the charging of the furnace, or the clearing of the fires, instantly causes an increase in the speed of the fan and in the intensity of the draft and in the volume of the air. The inherent ability of mechanical draft to maintain a high furnace pressure co-operates to make the discharge of smoke almost impossible. In addition, the positiveness of the draft makes possible the introduction of some form of smoke-scrubbing device if it be found advisable.

A loss incidental to poor draft is that due to the formation of carbonic oxide. The formation of this gas instead of the complete product of combustion, carbonic acid, results from a lack of air, and may under adverse conditions mount up to a resultant loss of five or ten per cent and over of the calorific value of the coal. Thick fires and large charges of cold fuel are certainly not conducive to the ready flow of air under only slight pressure, such as is maintained with the chimney. Under these conditions any operation of the flue damper, automatic or otherwise, only serves to vary the volume of the air but in no way increases the intensity of the draft. This can only be secured by some means like the fan, which under automatic regulation increases both the intensity of the draft and the volume of the air when required. As a result, the pressure forces the air in sufficient quantity to all spaces between the fuel, and renders the combustion practically perfect. Numerous tests of the flue gases fail to reveal the presence of any carbonic oxide when mechanical draft is employed.

By far the most important of the factors connected with the operating expense of a boiler plant, is the cost of the fuel. When burned under suitable conditions, the decrease in its cost far outstrips its decrease in efficiency, so that the solution of the problem involves itself with the provision of the proper conditions. As a rule the cheap fuels, like the fine anthracites, require for their combustion an intensity of draft, which the ordinary chimney is incapable of producing. Speaking of the chimney in this connection, Coxe asserts that "it is always very difficult, in fact almost impossible, to obtain with it sufficient blast to burn the smallest sizes of anthracite coal, which require a strong and concentrated draft." It is here that mechanical draft presents itself as a solution, for it fully meets the most exacting requirements as regards intensity, costs far less for its installation than a chimney of equivalent capacity and is capable at all times of producing the blast necessary for securing the best results in the furnace.

What these requirements are is evidenced by the accompanying figures from careful tests by Coxe.

RESULTS OF TESTS OF PEA AND BUCKWHEAT COAL.

KIND OF COAL.	Rate of combustion per square foot of grate per hour	Pounds of water evaporated from and at 212° per pound of coal.	Air Pressure in inches of water	Maximum limit to size of coal in inches
Oneida Pea Coal .	13 63	8 56	0 375	7-8
" No 1 Buckw't	13.58	7.94	0.5	9-16
" No. 2 "	11.40	8 60	0 625	3-8
" No. 3 "	11 34	8.65	1.04	3-16
Eckley No 3 . . .	9.44	8.75	1.125	3-16

These coals which are among the smallest in size, were burned on a special form of travelling grate and the air pressure was maintained in the chamber beneath.

It is noticable that with practically constant combustion rate and evaporating efficiency, the draft increases very rapidly as the size of the coal decreases.

RELATIVE EFFICIENCIES OF VARIOUS COALS.

KIND OF COAL.	Water evaporated from and at 212° by one lb. of Dry Coal.	Relative efficiency in per cent. Cumberland = 100	Cost of coal per ton.	Fuel cost of evaporating 1,000 lbs. of water from and at 212°.	Relative efficiency in per cent. measured by cost to evaporate 1,000 lbs. Cumberland = 100.
Cumberland	11.04	100	$3.75	$0.1698	100
Anthracite, Broken	9.79	89	4.50	0.2297	74
Anthracite, Chestnut	9.40	85	5.00	0.2660	64
Two parts Pea and Dust and one part Cumberland	9.38	85	2.58	0.1375	123
Two parts Pea and Dust and one part Culm	9.01	82	2.58	0.1432	119
Anthracite, Pea	8.86	8[illegible]	4.00	0.2259	75
Nova Scotia Culm	8.42	76	2.00	0.1187	156

The comparative efficiency of various coals as determined by Barrus is indicated in the accompanying table, which speaks for itself. The evidence in favor of burning low grade fuels is conclusive. Such results can, however, only be secured by positive and intense draft.

It is true that as the quality of coal grows poorer and the size of the particles less, it becomes more necessary to provide some special form of grate or stoker for its proper burning. But even without an economizer to utilize the waste heat, the burning of cheap fuel by mechanical draft will, under perfect conditions, show a decided saving, after due allowance is made for fixed charges on the special furnace arrangements and the cost of operating the fan.

The possible savings with low grade fuels and mechanical drafts are still further evidenced by the accompanying tables which show for a 1,000 horse-power plant the annual saving, based on 312 days of 10 hours each, which would result from the substitution of a cheaper fuel for, say Cumberland coal, costing, in round figures, $4.00 per ton and evaporating 11 pounds of water from and at 212° per pound of coal. Under these conditions the annual fuel expense would be $19,568. If the assumption be made that a coal costing $2.50 and evaporating only 9 pounds of water is substituted, the annual saving would be $4,621. The cost of operating the fan, even if the exhaust steam was not utilized and it required 1½ per cent. of the total coal burned, would be only $224, and if this were charged against the saving it would still amount to $4,897, a sum sufficient to show a most creditable reduction in the operating expense, even if there was also charged against it any additional labor and the fixed charges on a complete equipment of the special appliances for burning the lower grade fuel.

ANNUAL SAVING RESULTING FROM BURNING CHEAP COAL

Water evap. from and at 212° per lb of coal.	COST PER TON.														
	$0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
11.00											4892	3669	2446	1223	0000
10.50										5474	4193	2912	1630	349	
10.00									6115	4770	3424	2079	734		
9.50							8240	6823	5407	3991	2575	1159			
9.00						9105	7610	6115	4621	3126	1631	136			
8.50					10,074	8491	6909	5326	3743	2160	578				
8.00				11,180	9.478	7797	6115	4433	2752	1070					
7.50			12,393	10,599	8,805	7012	5218	3424	1630						
7.00	15,724	13,803	11,881	9,959	8.037	6115	4193	2272	350						

A reduction of over $125 per week, equivalent to $6,500 per year, has been made in actual practice in the case of a boiler plant of 1,000 horse-power, by the introduction of mechanical draft and the burning of yard screenings with a slight mixture of Cumberland.

Of the advantages of mechanical draft, which are purely qualitative in their character, much might be said, but time will not permit. It must suffice to merely refer to the more prominent points of advantage.

When the fan is employed for draft production, the steel plate construction, the comparative lightness, the portable character and the absence of heavy foundations, render extremely simple its adaptation to the exact requirements. Being portable, it is also salable, and hence an asset of real value, as compared with the chimney. It may be used either for forced or induced draft and placed where it will occupy no valuable space. It may be operated by direct-connected or belted engine or motor, and so proportioned as to produce any desired draft pressure.

In operation, the fan is both positive and flexible, independent of the weather, but capable of regulation to the finest degree and of adjustment to the necessities of the fire at any particular moment. A mere increase in the cut-off of the fan engine brings about a result only secured with a chimney at the expense of adding to its height, while a change in the fan speed alters both the volume handled and the intensity of the draft produced.

If this discussion of the influence of mechanical draft on boiler efficiency has rendered clear the factors concerned, it has with equal force shown that this influence is beneficial—in many ways markedly so. In the light of this fact, the present active interest in the subject points to the future general substitution of the fan for the chimney.

A New Speed-Varying Countershaft.

E. K. HOOD,
DESIGNING ENGINEER, REEVES PULLEY CO.

THE counter-shaft shown and described in this article was designed to meet a demand for a device capable of receiving power at a uniform speed and of delivering that power at different speeds, the variation being by infinitesimal degrees. Heretofore, this has been done, in a measure, by the true cone principle, consisting of two parallel cones having a movable belt held between them, but the practicability of this device is very questionable, especially where any considerable amount of power is to be transmitted.

The countershaft herein described, consists, primarily, of two parallel shafts, carried in a suitable frame, and each shaft carrying a pair of truncated conical pulleys having their smaller bases facing each other. These pulleys are feather-keyed, or splined, to their shafts, and a unique belt, stiff in cross-sections, but flexible longitudinally, is stretched between the pairs of pulleys.

Referring to the cuts, figures 1 and 2, it will be noted that the pairs of pulleys are connected by levers *D*, pivoted between the shafts and bearing against the hubs of the pulleys, and as they are actuated by the right and left-hand screw shaft *E*, one pair of pulleys move apart and the other pair together, simultaneously. This causes the belt to assume different relative diameters upon the driving and driven pulleys, thereby varying the speed of one shaft relatively to the other. The shaft *A*, receives power at a constant speed. When the parts are in position shown in Fig. 1, the belt is upon a small diameter of pulleys *C*. This imparts to the belt a comparatively slow linear velocity, which is transmitted to shaft *B*, through its pulleys, the belt upon the latter pulleys being upon a larger diameter.

As shown here, the shaft *B*, will be revolved considerably slower than the shaft *A*, of course the ratio depending upon the relative diameters of the large and small pulleys. By manipulating screw shaft, *E*, the pulleys on shaft *A*, are caused to approach each other, and simultaneously therewith the pulleys on shaft *B* recede from each other, thereby causing the belt to assume a larger diameter on the pulleys carried by shaft *A*, which imparts a greater linear velocity to the belt, thereby revolving shaft *B*, at an increased speed.

Many interesting problems presented themselves when the fundamental principle of the device was worked out into a practical machine.

The belt for a device of this kind must be continuous and of a predetermined length, and with

FIG I

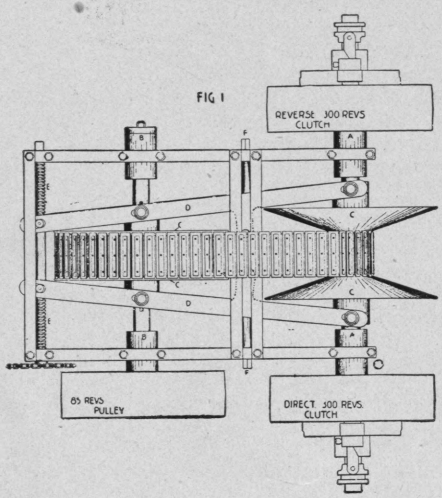
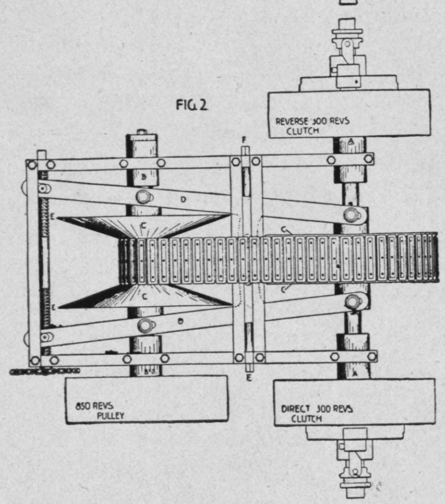
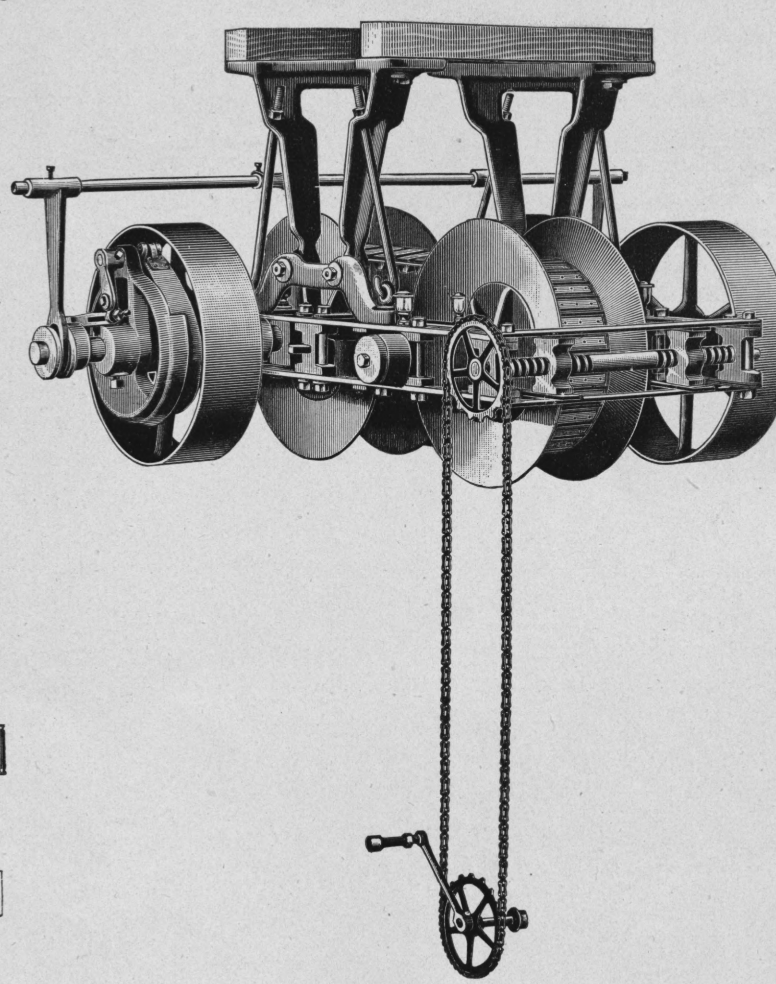


FIG 2





this as a basis the machine must be built around it.

A general theory met many times in the line of power transmission is, "More belt is required to pass around and connect a large and small pulley than is required to pass around and connect two pulleys of the same diameter, the mean between the large and small one, both pairs being spaced the same distance on centers."

This means that we will require more belt to connect the largest diameter of one pair of pulleys and the smallest diameter of the other pair of pulleys, than would be required to connect the pulleys when the belt was upon the mean diameters of both pairs.

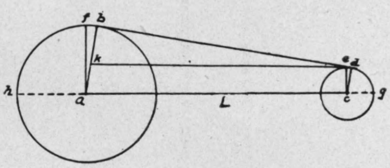
This was compensated for by arranging levers *D*, so that they would give a differential sliding movement to the pairs of pulleys, so that proper diameters of the driving pulleys would be presented to the belt to maintain it at a uniform tension.

By referring to the cuts it will be noted that the center pivots for levers D, are out of line with the points of contact of the levers on the pulley hub.

It will also be noted that the levers are slotted where they take against the pulley hub. Now, if the levers are moved, the leverage on the approaching pair of discs are moving gradually slower. While this is taking place the receding discs are moving gradually faster on account of the lengthening of leverage.

The result of this is explained clearly by supposing the mean driving diameters of the pulleys were, say 9″. Now, if both pairs of pulleys were moved the same distance the belt would have to pass around and connect, say a 3″ and 15″ diameter on the pulleys when they were moved to their limit, but by this differential movement a 2¾″ diameter and 14¼″ diameter are presented, so as to take the same belt as the two 9″ diameters.

This belt requirement for pulleys is a plain trigonometrical problem, and will go to show that some of your simple examples come very handy in practice.



Let D = length of belt

L = distance of pulleys on centers.

R = ½ diameter of large pulley.

r = ½ diameter of small pulley.

Lines ab and ce are parallel, each being perpendicular to tangent belt line, bd.

af and ce are parallel, being perpendicular to line of centers L, therefore angle fab = angle ecd. Denote this angle by θ.

It is evident that the total length of belt will be $2\,(bd + arc\ hb + arc\ dg)$. $dk = ac = L$ and in triangle kbd angle kbd is a right angle.

$$\therefore\ bd = \sqrt{kd^2 - kb^2} = \sqrt{L^2 - kb^2},\ kb = (R - r)$$

$$\therefore\ bd = \sqrt{L^2 - (R - r)^2}$$

Arc hb = arc hf + arc fb and arc hf = ¼ circumference of large pulley, which equals

$$\frac{2 - R}{4} = 1.57\ R.$$

$$\text{arc } fb = \frac{R\theta}{180} = 0.0175\ R\theta\ \therefore$$

$$\text{arc } hb = 1.57\,R + 0.0175\,R\theta = (1.57 + 0.0175\,\theta)R$$

arc $gd = ge - ed$ and substituting we have

$$\text{arc } gd = (1.57 - 0.0175\theta)\ r$$

$$\therefore\ D = 2\,(\sqrt{L^2 - (R - r)^2} + R\,(1.57 + 0.0175\,\theta) + r\,(1.57 - 0.0175\,\theta)$$

angle θ can be found with a protractor or

$$\sin\theta = \frac{(R - r)}{L}.$$

By the use of this formula the different belt requirements can be accurately found and the length of the off-set pivot can be found by graphics. Of this I shall speak in a later article.

This machine is manufactured by the Reeves Pulley Co. of Columbus, Ind., and is going onto the market rapidly in many lines of manufacture. The smallest machine runs a sewing machine and the largest transmits the power to drive a 22-ton suburban coach driven by a gasoline engine.

ALUMNI NOTES.

J. T. Montgomery, '98, is with the Roebling Construction Co., 121 Liberty street, New York.

W. O. Mundy and W. S. Speed, '93, visited the Institute while in the city attending the McKeen wedding.

W. L. Decker, '96, has accepted a position with the Graphic Smelting Works, at Magdalena, New Mexico.

W. J. Ehrsam, '92, of the firm of J. B. Ehrsam & Sons, mechanics and founders, Enterprise, Kansas, spent several days in Terre Haute the first of the month.

Mason Galloway, 90, has resigned his position as electrician for the Marion City Ry. Co., and has secured a position with the Snoqualmie Falls Power Co., at Seattle, Wash.

Mr. and Mrs. S. E. Rumsey announce the marriage of their daughter Dolly to Mr. J. H. Hellweg, Jr., Wednesday, April 10th, 1899, Chicago, Ill. At home Thursdays after April 26th, 10009 Oak avenue.

Mr. Lawrence E. Troxler, '95, has been advanced to the position of Station Superintendent and Engineer of the Louisville Electric R. W. Co.

Mr. Barclay G. Merring, of the Class of '87, of Buffalo, N. Y., has accepted the position of Mechanical Engineer for the American Cereal Co., with headquarters at Chicago, Ill.

Mr. W. Offutt Mundy, '95, Station Superintendent of the Louisville Electric R. W. Co., has accepted the position of Engineer with the Prescott Steam Pump Co., Milwaukee, Wis.

H. Stillson Hart, '93, late of New York, spent several days looking over the improvements which have been made since he graduated. He has just accepted a position in Chicago, and his address is 3716 Lake ave.

W. R. McKeen, Jr., '89, who was appointed Alumni orator for Commencement, has been forced through ill health to decline, and Edwin S. Johonnott, '93, has been appointed to fill his place. Mr. Johonnott has lately taken the degree of Ph. D. at the University of Chicago, and is assistant in the Department of Physics, University of Chicago.

Mr. Elmer Brown, of the class of '94, died very suddenly in Philadelphia, on April 25. He was visiting Philadelphia on business and was taken suddenly ill with typho-pneumonia, which proved fatal. The remains were brought back to Terre Haute, where the burial took place. Mr. Brown graduated in the class of '94, having taken the chemical course. He then located at Sparrows Point, Md., where he was employed by the Maryland Steel Company as an expert chemist.

THERE is a growing tendency in some of the schools in the Middle West to indulge in a species of professionalism, which is not recognized as such, nor is it usually spoken of so frankly. But nevertheless a number of schools retain men from year to year only because of their physical ability and the strength they add to the athletic teams. There seems to be no danger of the professional player ever securing a foothold in college athletics; still there is this tendency towards professionalism in retaining good athletes which is gaining a steady hold in the make up of college teams and if measures are not taken to place the athletics of the state on a strictly amateur basis, the games will be degraded to a lower level of athletic sports. The prevailing opinion is of course much opposed to allowing the field sports, foot ball and base ball to sink to a lower level, but the rivalry of colleges and the close quarters into which the managers are often thrown gives an excuse, and throws a veil over the methods often used in securing and retaining valuable material. Where the line between amateurs and professionals is to be drawn is hard to define as the two merge together so gradually that it is almost impossible to draw a line that will not be over stepped in some way by one or the other. Yet a distinction must be made and the athletics of colleges be kept clean if the highest degree of good is to be obtained from the friendly rivalry which promotes the games between different institutions. The responsibility for this condition does not rest entirely in the hands of the managers of the teams, whose enthusiasm and interest may often lead them to adopt measures and go beyond their cooler judgment. Often the faculty are as much in the wrong as the managers in encouraging games with colleges and athletic associations where a tendency to professionalism prevails and inducing and permitting men to enter college for the only reason that they will strengthen the team. Whether it is advisable to put the management of athletic affairs more fully into the hands of the faculty is a question which is being seriously considered.

The athletics of the State need a thorough revision, and strong legislation should be adopted to regulate the affairs of the State at large. Laws must be passed and enforced that a suspicion of professionalism will debar any college from entering into a game with the other institutions and that institution playing with colleges in which there is any question as to athletics will be thrown out of the Association. As soon as this is recognized and the Athletic Association is thoroughly reorganized and placed on a firm footing with the necessary authority to enforce its powers, the athletic interest of the State will be given a stimulus and the intercollegiate meets will again become the center of interest for all of the colleges.

INDIANA STATE NORMAL 9, ROSE TECH. 5.

Even after the recent inglorious defeat at the hands of De Pauw, the base ball team had hopes, but how those hopes were blasted and how another defeat was chalked up for Rose is a story too sad to relate.

Some times the nine seems to be playing good ball and then again they play as though they were decidedly new to the game and had no ambition to even learn how it should be played. The very fact that each man on the team has at some time or another distinguished himself by brilliant grand-stand plays, and this in some instances repeatedly, shows what the team would be able to do if they played together and put that spirit and life into the game, which is a requisite to success.

It would be useless to attempt to pick out the weak places on the team or to attempt to name a remedy, in fact it would be impossible, for the errors which have been so costly have never occurred twice in succession at the same place. As was said before, the team is most decidedly weak at the bat, but this alone does not account for the recent defeats.

While it is unjust to blame any one man for the defeat, the Normals were allowed to get a big lead early in the game by an error from one of our best players. This lead they managed to maintain throughout the game and easily won out by a score as above stated. From the third to the seventh inning both teams played the game as they should and gave as pretty an exhibition of ball tossing as has been witnessed on the campus for some time.

Meriwether pitched throughout the game and while he does not pose as a crack pitcher he certainly did himself credit by his fine work last Saturday. He is one of the most reliable men on the team.

The teams were as follows:

NORMAL.	ROSE.
Wilson 2b.	Meriwether p.
Headlee c. f.	Gibbons 2b.
Hill 3b	Nicholson s. s.
Pierce s. s.	Trumbo 3b.
Douglass 1b.	Hadley c.
Jeffers r. f.	Hills 1b.
Lindley c.	Grimes r. f.
Marshall l. f.	Sloo c. f.
Langford p.	Troll l. f.

Umpire Dan Miller. Time of game 2hrs 50 min. Attendance principally Normals. The box-car aggregation was unusually large and on several occasions roasted the opposing team in one collossal voice, which could easily be distinguished above the shouts of encouragement from the Normal rooters.

The score by innings was as follows:

	1	2	3	4	5	6	7	8	9	R	E
R. P. I.	0	1	1	0	0	0	0	3	0	5	9
Normal	3	0	0	0	0	4	2	0	x	9	5

Other games which the team have are:

May 20, Normals at Terre Haute.

May 30, Wabash at Terre Haute.

June 3rd the team goes to Crawfordsville.

The manager is also trying to get a game with Culver Academy. Culver is playing winning ball this year.

INDIANA STATE NORMAL 2, ROSE TECH 14.

Saturday, May 20, the I. S. N. base ball team was defeated by the Rose Tech by the above score. This is revenge for a defeat mentioned elsewhere.

During the early part of the day rain began to fall and it continued to drizzle till almost time for the game when the clouds rolled away and preparations were made for the game. Sawdust was scattered over the diamond in the wet spots and although the ground was somewhat damp it was not muddy enough to interfere with good playing. The pitchers, however, had some difficulty in controlling the ball.

Rose Tech team was early upon the grounds and indulged in a half hour's lively practice when they withdrew to allow their antagonists to follow suit. All week the students had been informing the team what would happen to them if they allowed the Normals to carry off the honors of the day. The team was determined to win and every night during the week they had practiced diligently. With the appearance of the Normal rooters and their blue ribbons and husky voices the vision of defeat flashed before them and they determined upon revenge; for revenge is sweet.

By mutual consent Mr. Shepherd was chosen as Umpire and the game began with the Normals at the bat. Wilson came to the bat amid the cheers of his farmer friends and got a hit. Pierce sent the leathern sphere whizzing out to left field but Likert was there and made a pretty catch. Wilson got in on a pass ball scoring the first run for the farmers. Did the rooters yell? They simply went wild: "but he who laughs last laughs best." Two men were put out at first and Rose Tech came to the bat. Lickert was put out at first, Trumbo got a hit but was put out in attempting to steal home. Gibbons got to first on an error and Troll flied out to left field. Score 1 to 0, favor I. S. N.

During the second inning neither side scored, both teams putting up an excellent game. At the end of the third inning the score was 1 to 1. Gradually the Normals gave out and Rose Tech grew stronger till in the sixth Wilson, the Normal pitcher, went up in the air and allowed the Rose men to get eleven hits in rapid succession, netting them eight runs, not so bad for one inning.

In the eighth, by a couple of errors, Wilson was allowed to get in. Then the Rose men took a brace again and at the end of the game the score stood 14 to 2.

With the exception of the sixth inning the game was as nice an exhibition of ball tossing as one would wish to see. At the bat the Rose men did their best work for some time and Trumbo made a pretty sacrifice where it was most needed. As a whole the team played an excellent game and redeemed themselves for their recent defeats.

The positions and players were as follows:

ROSE TECH.	I. S. N.
Likert, l. f.	Wilson, p.
Trumbo, 3b.	Pierce 2b.
Gibbons, 2b.	Headlee, c. f.
Troll, c. f.	Douglass, 1b.
Nicholson, s. s.	Lindley, c.
Hadley, c.	Hunt, s. s.
Meriwether, p.	Hill, 3b.
Grimes, r. f.	Marshall, l. f.
Fishback, 1b.	Brice, r. f.

The score by innings was as follows:

	1	2	3	4	5	6	7	8	9	R	H	E
Rose Tech	0	0	1	2	2	8	0	1	x	14	18	3
I. S. N.	1	0	0	0	0	0	0	1	0	2	7	9

DE PAUW 16, ROSE TECH 4.

Saturday, May 13th the preachers paid us a visit attired in their base ball uniforms and again succeeded in defeating our team, though not by such a score as before. We are sorry to say that the base umpire who was from De Pauw was a decidedly unprincipled personage and on several occasions did not hesitate to give his team the best of the decisions.

For the first five innings the Rose players submitted to the treatment like men, protesting several times but still continuing to play the game, although it was evident that they were getting the worst of the deal. Fate seemed against them. As the game progressed the decisions became ranker, until at the end of the fifth inning, when the score stood 4 to 5 in De Pauw's favor, the men saw there was no chance of their winning, and they became disheartened and went to pieces. De Pauw made several hits and these assisted by several nice hits and a few presents from the umpire easily won the game.

In the second inning Troll made a nice hit and brought Nicholson in scoring the first run in the game. Shortly afterwards he stole third and finally made a grand rush for home making one of the prettiest slides imaginable.

During the later half of the second De Pauw scored three runs. For the next two innings

Rose failed to score, while De Pauw scored once. In the fifth Nicholson came to the bat with two men on bases and he knocked a pretty two bagger, bringing in both men. After this Rose failed to score again while De Pauw piled up run after run.

The players and score were as follows:

DE PAUW.	RORE.
J. Boehn, l. f.	Likert, l. f.
Haynes, c. f.	Trumbo, 3b.
Pulse, p.	Gibbons, 2b.
P. Boehn, 2b.	Nicholson, s. s
Ellis, 3b.	Meriweather, p.
Conklin, 1b.	Troll, c. f.
Longwell, s. s	Hadley, c.
Conn, r. f.	Grimes, Fishbeck. } r. f.
Price, c.	Hills, 1b.

	1	2	3	4	5	6	7	8	9	R.
De Pauw	0	3	1	0	1	1	7	3	x	16
R. P. I	0	2	0	0	2	0	0	0	0	4

Base on balls, by Pulse 4, by Meriwether 5. Struck out, by Pulse 7, by Meriwether, 7. Hits, De Pauw 15, R. P. I. 4. Errors, De Pauw 3, R. P. I. 8. Two base hits, Nicholson, Haynes and Price.

Umpire, Shepherd and Fisher.

MEETING OF ATHLETIC DIRECTORS.

At a regular meeting of the Athletic Directors held April 28th, the manager of the track team was authorized to purchase a set of much needed vaulting standards. The tennis committee was authorized to spend a sum, not to exceed $10, in the repair of the tennis courts.

Mr. R. York was appointed delegate to represent Rose at the meeting of the Executive Committee of the Indiana Intercollegiate Athletic Association. The meeting was held in Indianapolis on the following day and Mr. York reports as follows:

"President Elliott of Earlham in the chair. Neeley of De Pauw acting secretary. Wabash College, Indiana State Normal, Purdue University and Notre Dame were not represented. The Association was found to be upon a sound financial basis and able to pay all out-standing debts.

"A report relative to the State field day was read by the representative from the University of Indianapolis. After some discussion it was decided to postpone the field day one week in hopes of having more favorable weather. This makes the date Saturday, May 27th. A committee consisting of Messrs. Jump, Ragsdale, and Neely was appointed to draw up a new constitution and report as soon as convenient.

It was decided that all members of the Indiana Intercollegiate A. A., who do not pay their debts to the same before field day shall not be allowed to participate in the events on that day.

A general discussion in regard to the details of the arrangements for the coming meet followed and the delegate from U. of I. was appointed to investigate any further difficulties which might arise in regard to the same."

At a special meeting of the Athletic Directors held may 8th, it was decided not to participate in the events of field day if Notre Dame was allowed to enter. This action on account of several differences which have arisen recently between the various institutions composing the I. I. A. A. Notre Dame has displayed an utter indifference to all save her own selfish interests, and if the proper course were taken she would be expelled from the Association.

ATHLETIC NOTES.

In a recent athletic contest at the fair grounds, in which the Poly. did not take part for various reasons, the Normals easily won out, taking all the first places by such scores as follows:

100 yard dash, 11 sec.
120 yard hurdle, 20 1-5 sec.
220 yard dash, 23 4-5 sec.
Half mile run, 2 min. 30 sec.
220 yard hurdle 29 2-5 sec.
Quarter mile run, 51 2-5 sec.
Mile run, 6 min. 10 sec.
High jump, 5 ft.
Shot put, 31ft 7½in.
Standing broad jump, 9ft. 7¼in.
Hammer throw, 82ft. 8½in.
Pole vault, 9ft. 6in.
Running broad jump, 19 ft.

The Single Phase Alternating Current Motor.

W. A. LAYMAN, '92.

Lecture Delivered Before the Students of the Rose Polytechnic Institute.

In preparing this paper on the Single Phase Alternating Current Motor I have assumed that the greatest value will be derived by avoiding a discussion of the finer theoretical questions involved in the subject and confining myself to its more practical aspects. I feel warranted in this treatment of the theme in that your regular course work either has or will take up fully all supplementary technical considerations.

The incentive to produce a commercial single phase motor has been very great indeed since the earliest comprehension of the general properties of the alternating current, for the reason that practically this one element alone has been lacking to make the single phase system of current distribution the highest form of development in the field of central station practice.

Many able investigators have devoted time and thought to it, but until a comparatively recent date, scant reward in the way of a practical and durable form of motor has repaid their efforts.

Early efforts to produce such a motor were broadly confined to two characteristic types:

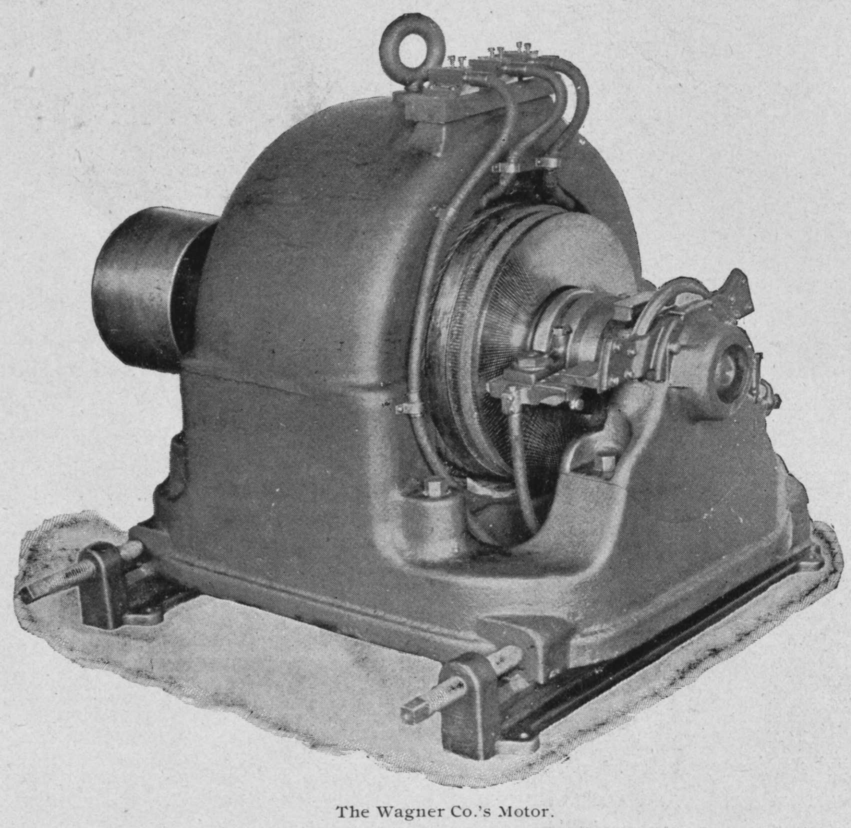
1st. The Synchronous Motor.

2nd. The Direct Current Motor especially constructed to operate on alternating currents.

The synchronous motor, as you know, is a simple reversal of the ordinary alternating current dynamo, in which the fields are magnetized by a direct current source of supply and the armature supplied with alternating current corresponding in wave form and frequency to the current which the same machine would produce, at the same speed, operating as a dynamo. Two disadvantages arise, however, the combined effect of which has been to prevent commercial introduction of this form of motor for general power purposes. *Such a motor will not start from rest.* Furthermore, to avoid fluctuations of the current necessary to operate with or without load, *the strength of the field must bear a definite relation to the load.* Such relationship is maintained with difficulty. Sometimes when the load is very irregular it cannot be maintained at all. When this arises the motor causes pressure fluctuations over the entire circuit from which it is supplied, practically crippling incandescent lighting from the same mains.

Many ingenious efforts have been made to overcome both difficulties and not without a fair degree of success in one or two forms of motors. Two well known manufacturing companies have, in fact, deemed their success such as to warrant them in putting single phase synchronous motors upon the market. These companies were the Ft. Wayne Electric Corporation, and the Excelsior Electric Co. In the Ft. Wayne motor no attempt was made to overcome the line pressure fluctuations with variable loads. The designer's ingenuity was entirely confined to developing a satisfactory starting device, and providing for the self excitation of the motor after up to running speed. These ends were accomplished by providing a double armature and also a double field winding. One armature winding was of the customary direct current form, duly connected to a well sub-divided commutator. The other was somewhat similarly wound but connected to a pair of collector rings instead of commutator. The motor was started as a series motor on the commutator end, utilizing one set of field coils and one armature winding. When up to synchronous speed as indicated by a pilot lamp on the frame casting, the connections were so changed by switching as to throw the alternating current supply into the collector rings, and simultaneously connect the second field winding so as to be fed through the brushes from the commutator. The field strength was adjusted to a fixed value, in combination with a small external resistance, for the condition of average load.

The motor built by the Excelsior Co., differs from the Ft. Wayne in that it has one or two refinements, lacking in the latter. The Excelsior Co. has endeavored to accomplish an automatic regulation of the field strength to the needs of the motor by introducing a small series transformer in the armature supply circuit. The secondary current from this series transformer is rectified by means of a two part commutator, and sent into a special field winding. The second field winding corresponds to and serves the function of the compound winding in a direct current machine, and accomplishes the object of steadying the armature current, so I have been informed, with some degree of practical success. The criticism on this motor, however, is that it

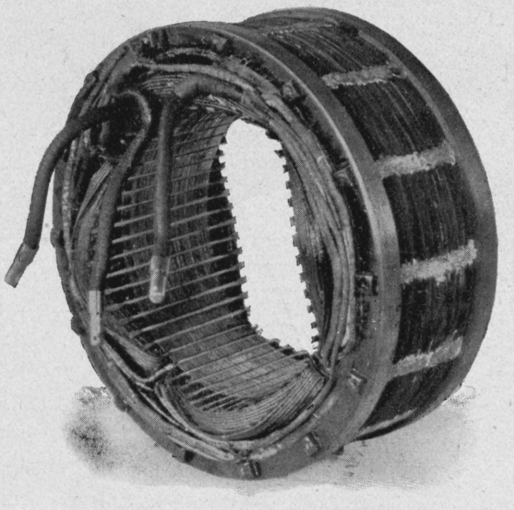


The Wagner Co.'s Motor.

is complicated ; having two commutators and a pair of collector rings, two field windings and two armature windings.

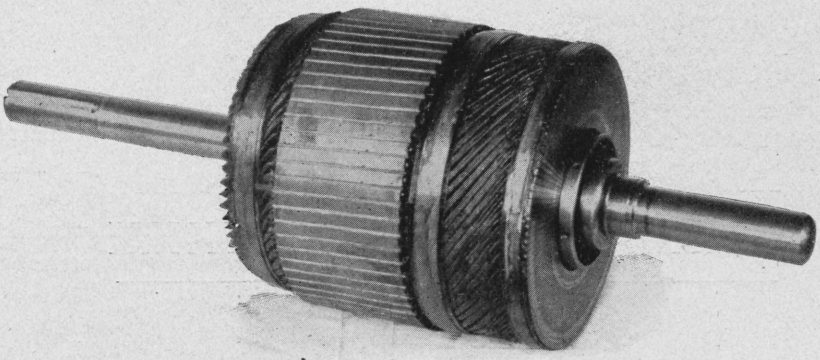
Just what degree of success both companies have met with in introducing their motors for practical power purposes, I am unable to state, but the prevailing impression is that there are comparatively few of the motors in service. Indeed the synchronous motor has found but one field in which it serves at present, an almost indispensable end. This is in its application as a rotary transformer to the derivation of direct currents from alternating. For this service it has been designed to operate on two and three phase circuits.

The second general type of single phase motor attempted by early investigators, namely, the direct current motor constructed for alternating currents, has also run the gauntlet of innumerable efforts to make it practical, but has entirely disappeared for all kinds of work except those involving very small amount of power.



The Wagner Co.'s Field after Winding.

Aside from other disadvantages, this motor is barred from the field by one consideration that electrical actions arise in the armature which make the destruction of the commutator by sparking very rapid. This feature of armature trouble is worthy of some discussion in detail.



The Wagner Co.'s Armature.

It arises from what may be termed a transformer action taking place in the machine.

You are familiar with the fundamental fact in alternating current work, that a conductor introduced into an alternating magnetic field will have induced in it alternating currents, conforming in periodicity with the periodicity of this field. Application of this action is made in the familiar static transformer, as shown in Fig. 1. Here a primary coil (a) is wound upon an iron core (b). A secondary coil (c) also wound upon (b), has alternating currents generated in it by induction when an alternating current is supplied to (a).

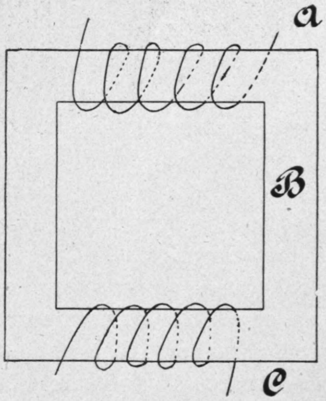


Fig. 1.

Exactly the same thing takes place in the armature of the direct current motor when it is attempted to operate it upon alternating currents. The effect of this action may be seen in Fig. 2.

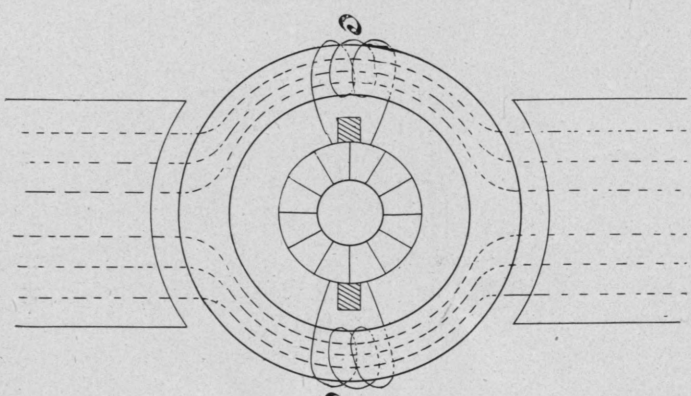


Fig. 2.

The coil (c) which is a portion of the armature winding, is in the position, when by its rotation alone it is generating no electrical pressure, and therefore supplying no counter electro-motive force. In the direct current motor this wire is practically dead at this instant. With an alternating magnetism, however, the coil is in the position to act as the secondary of a transformer, and since it is short-circuited by the brush bearing upon the commutator, it is evident that a heavy current will flow through it. When this short circuit is broken by the brush passing on to the succeeding segments of the commutator, heavy sparking results. This sparking is such as to make continuous operation in this manner altogether impracticable.

The single phase, alternating current motor, therefore, in so far as these two types of construction go, has proven to be largely a practical failure, and it has only been in recent years, since the discovery of the principle of operation of the induction motor, that there has been offered to investigators any promise of success in this field of development. Since the introduction of the induction motor, several avenues of promised success in single phase work have been opened up. In all, however, the fundamental element of success is the proper application of the induction motor principle.

What is this induction motor? Nothing more nor less, from one point of view, than a special form of the alternating current transformer. It consists of three elements:

1. A primary winding or field.
2. An iron magnetic circuit.
3. A secondary circuit or armature.

In other words it is a form of motor construction in which the outside supply circuit feeds the field windings only. By its function as a transformer, the motor generates for itself armature currents, which currents under proper control set up rotation.

Its earliest exemplification, as thus defined, was in a type of construction probably designed to run, as motors above described, upon the same general principle as direct current motors. This was the motor devised by Messrs. Anthony, Jackson and Ryan, illustrated in Fig 3. Here the armature still is of the same construction in all details as the ordinary direct current motor. The brushes bearing on the commutator are,

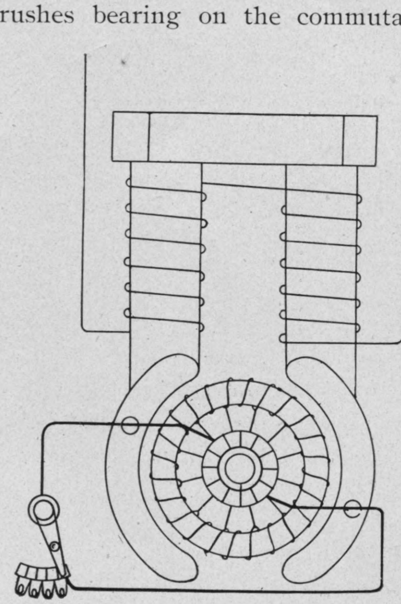


Fig. 3.

however, connected to a locally closed circuit, and in this locally closed circuit is introduced resistance, the amount of which may be varied at will. In operation, an alternating current sent into the field produces by induction, alternating currents in the armature. These armature currents are commutated to produce rotation.

But, notwithstanding this great advance toward the goal, the disadvantage of commutator sparking still existed, and although this motor was brought out as early as 1887, nothing has ever been done with it commercially, except in a special use as will be hereafter described.

The Anthony, Jackson and Ryan motor, although operating purely upon the induction principle, was not what is generally known today as the induction motor. The present day induction motor, except in the special instance to be hereafter described, requires no commutator. Its armature windings are short-circuited without commutation of the induced currents, and it may

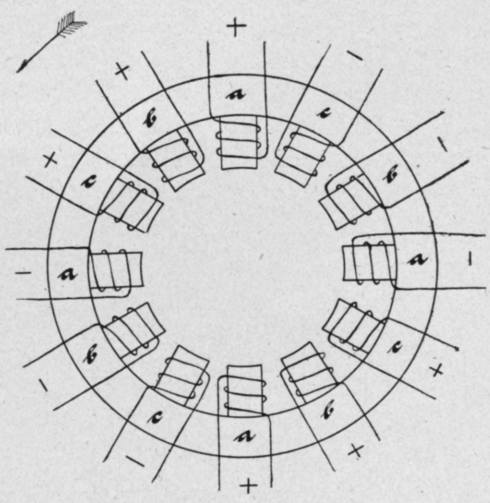
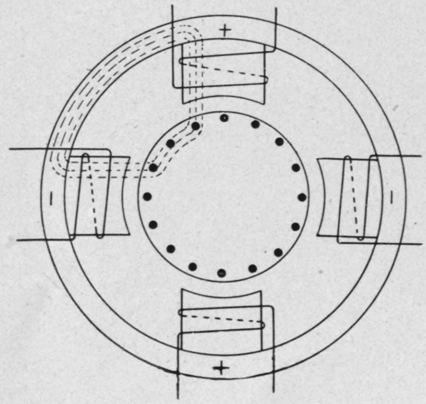


Fig. 4.

be constructed without involving collector rings, brushes, or any of the complicating details incident to most motors. Indeed, it is the ideally simple electric motor.

To Tesla is largely due the honor of having produced this true induction motor. He it was who first hit upon the fundamental principles involved, and through comprehension of them, made development at the hands of others comparatively easy. After much experimenting, he found that commercial results could be secured if currents of two or three phases were used to produce, in this type of motor, a so-called rotating magnetic field, or in other words the effect of a strong magnetic pole revolving around the surface of his short-circuited armature. In a form of



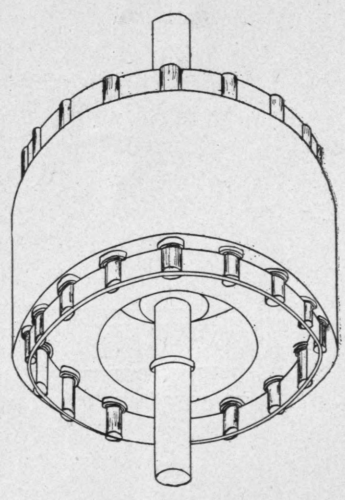
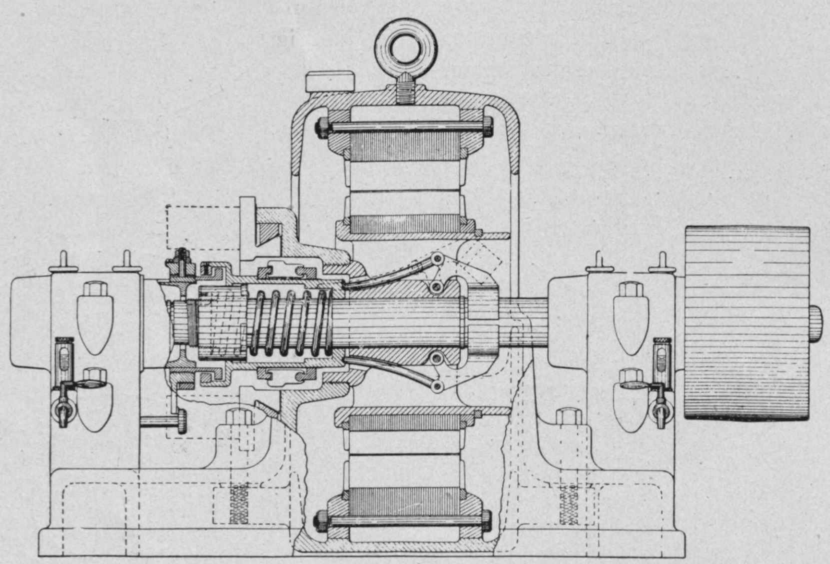


Fig. 5.

motor such as Fig. 4, for example, he would wind what would ordinarily be a 12 pole machine in such a manner as to give him three sets of four poles. Into each set he would introduce one phase of a three phase current supply. The poles produced by one phase, or for example "A A A A" would be immediately succeeded in point of time by poles produced in "B B B B" by the next phase of current and so on around the periphery of the field, thus shifting the pole from "A" to "B", "B" to "C", etc. With such a field winding, it was, in course of time, found best to use a form of armature such as is illustrated in Fig. 5. In this armature the winding of copper conductors consists simply of a large number of bars completely short-circuited at both ends, with respect to each other, by a copper ring. The resemblance of this form of winding to an old style squirrel cage, gave rise to the popular name of a squirrel cage winding. Such an armature placed in a rotating magnetic field, will start from rest with a great deal of torque, and will quickly run up to a speed slightly less than the number of alternations of the current supply divided by the number of poles of the winding. However, such a motor supplied with single phase currents will not start from rest, and therefore, up to this point, the induction motor is not practicable for single phase circuits. This arises from the consideration that a single phase current will not produce a rotary field *while the armature is at rest.* The currents generated by induction in the armature conductors when the armature is standing still, select such paths of flow as to produce no resultant turning couple, with reference to a stationary field pole. Some of the currents tend to produce rotation in another direction. They nullify each other in so far as the turning moment goes. In the two and three phase motors, a different condition exists. The currents produced in the armature by any one set of poles bear the right relation to the poles of the next phase to afford an effective turning couple, and therefore the multi-phase motors are very effective in starting from rest.

When up to running speed, however, a motor constructed for a single phase supply, *with armature corresponding to that of multi-phase motors,* will run in all respects practically as well as a two or three phase motor. In other words, the disadvantage of the induction motor operating on a single phase, as compared with two or more phases, is that the motor will not start from rest, but requires some auxiliary device for this purpose.



In the development of starting devices, several types of motors have been produced, and I may speak of these in general as *modern single phase motors,* thus distinguishing them from the motors previously described. These motors have taken two forms:

1st. Those in which two and three phase currents are produced *artificially* from single phase current, for the purpose of creating a rotating magnetic field in starting.

2nd. Those falling back on the principles of the direct current motor for starting.

In the first class might be placed all of the two and three phase motors of today, where the construction is such that the entire field winding can be fed either from single phase or poly-phase without changing the number of poles. In other words, a standard two phase or three phase motor could, if properly connected, be fed from a single phase circuit and operated on single phase currents, *after having attained running speed*. But for starting, various devices for phase splitting, as it is termed, are resorted to, to artificially produce two and three phase starting currents. Some of these devices are fairly satisfactory. The fault with all is that a very large amount of energy is taken from the supply circuit to produce differences of phase which are *variable* from low speeds up to full speed, and which, furthermore, do not provide a large amount of torque.

The other type of motor, of which I have a sample here before you, is the one to which I chiefly invite your attention this morning, and is one which has been brought out by the Wagner Electric Manufacturing Company of St. Louis. Broadly speaking I may say that this motor starts according to the method first used by Messrs. Anthony, Jackson and Ryan, and illustrated in Fig. 3. After getting up to running speed, connections are automatically changed so as to transform the motor into an induction motor pure and simple. This is accomplished by a complete short-circuiting of the commutator. The combination of the Anthony, Johnson and Ryan method of starting with the short circuiting of the commutator at running speed is covered by the patents of E. Arnold, owned by the Wagner Company.

In mechanical construction, this motor is, in many respects, very similar to that of the two and three phase motors upon the market. A

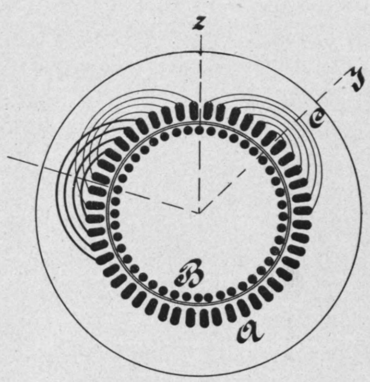


Fig 6

field is built up of iron plates very much like "A" of Fig 6 and an armature core is also built up from iron plates very much like "B" of Fig. 6. The field is wound with so-called pan-cake coils threading through the slots of the punchings, as shown at "C," Fig. 6, thus producing a magnetic pole of intensity, varying from a maximum along the radius "X Y" to zero along the radius "X Z." The armature core is wound with an ordinary direct current progressive winding, connected up to a commutator in exactly the same fashion as is the direct current motor winding.

The commutator of this armature is so designed that it may be completely short circuited by introducing into it a short-circuiting circle of copper segments. When so short-circuited, the winding affords a substitute for the squirrel cage form of winding, above described, differing from the squirrel cage, in that instead of currents being able to select paths for themselves, they are restricted to flowing in paths afforded by the individual coils. The operation of this motor, as stated, is based wholly upon the principle that an induction motor with a completely short-circuited armature will, when up to the running speed, operate on single phase current supply in exactly the same manner as does a two or three phase motor with two or three phase current supply. Therefore, after the advent of the rotary field induction motor, in developing a successful single phase motor, the problem to be met was the provision of a starting device which would afford ample starting torque at all speeds between rest and running speed, without excessive consumption of current, and of a mechanical construction equally durable with the rest of the motor. In doing this, the Wagner Company has brought out a line of small motors claimed to be equal to the best two and three phase motors.

As to its starting characteristics of torque and current, this motor corresponds closely with the series direct current motor. The armature winding is, however, short-circuited through carbon brushes bearing upon the commutator surface, and the currents flowing in it are generated by induction from the field. These currents flow out through the carbon brushes either into an outside resistence box, or where a direct short circuit of the brushes is provided, out through one brush and back into the armature through the other. By the shifting of the brushes on the commutator surface, they are forced to take such position relative to the magnetic poles of the field, that repellant action between them and the poles of the fields is effected, and rotation results. In other words, the currents which would be ineffective in the induction armature at rest, are forced to take such positions that they become equally effective with the starting currents produced in the armatures of two and three phase motors. When running speed is attained, the brushes are no longer required and the armature winding is completely short-circuited, as stated. In the mechanical development of this form of motor, many novel features have been introduced. The commutator is of a radial instead of the horizontal type. The short circuiting ring is made up of small copper links, which links, being in turn mounted upon a short-circuiting band, are thrown into the annular opening in the commutator and by making close contact with the individual segments, produce a very effective short circuiting of the entire armature winding. In the operation of the motor, it is very advantageous to have this short-circuiting operation performed either at or slightly below the running speed. To remove all uncertainty of this being done at the proper instant, these motors are built with an automatic device for performing this operation. This device consists of a set of governor weights acting against a spiral spring. The centrifugal action of the weights will, at the proper speed, force the short-circuiting links into the commutator, against the action of the spring. At the same instant and by the same means, the brushes bearing upon the commutator are thrown off.

These motors are so designed as to carry a large percentage of overload without any serious consequence. If this capacity for overload is exceeded, the motor will come to rest in exactly the same way as will a two or three phase motor, under the same conditions. If the overload is temporary, however, the motor will, without attention, run back to speed, as in slowing down the brushes are automatically thrown back on the surface of the commutator, and the motor is again placed in a starting condition.

With this motor, as in fact, with any electric motor, the points to be considered in determining the excellence of design are:

1st. Its starting torque.

2nd. Its starting current.

3rd. Its consumption of energy while running idle.

4th. Its efficiency at all loads.

5th. Its power factor.

6th. Its drop in speed with load.

The starting torque of this form of motor can be made, by adjustment, large or small as desired, a feature certainly very desirable since the consumption of current in starting is proportional, practically, to the torque. This adjustment of torque is accomplished by shifting the brushes upon the commutator surface. When the motors leave the factory, the brushes are set so as to just bring up full load. The relation of torque and current under this condition is shown in Fig. 7.

As to the energy required to operate the motor without load, this is very small, being practically the same as that required by direct current motors. The efficiencies which have been secured in these

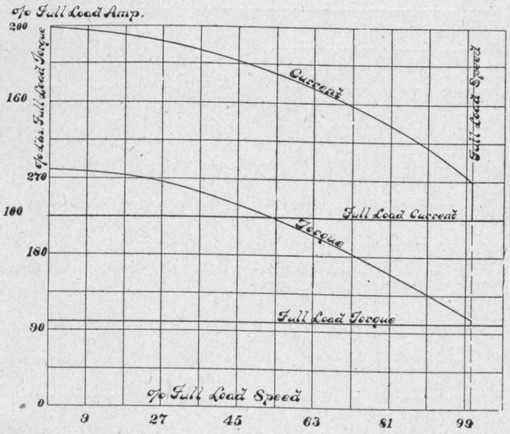


Fig 7.

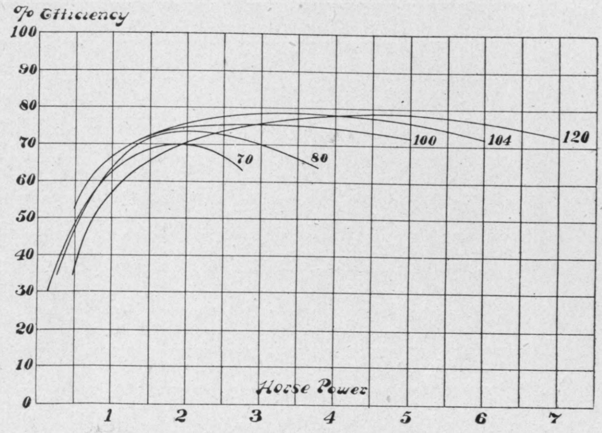


Fig. 10

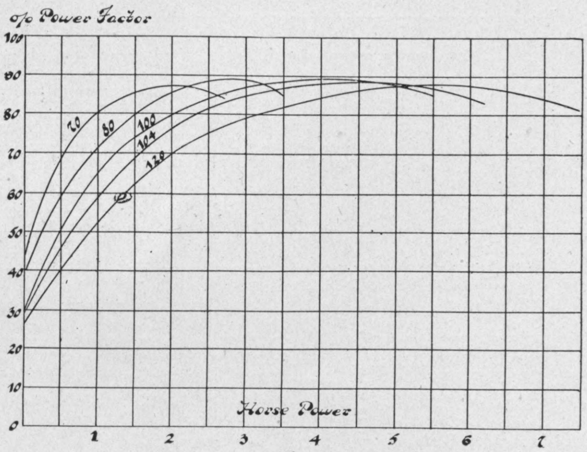


Fig. 8.

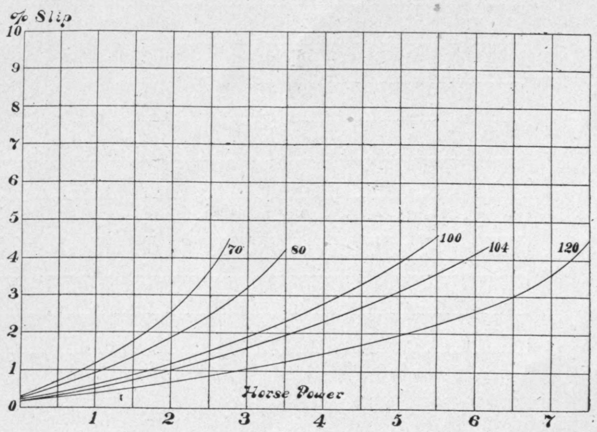


Fig. 11.

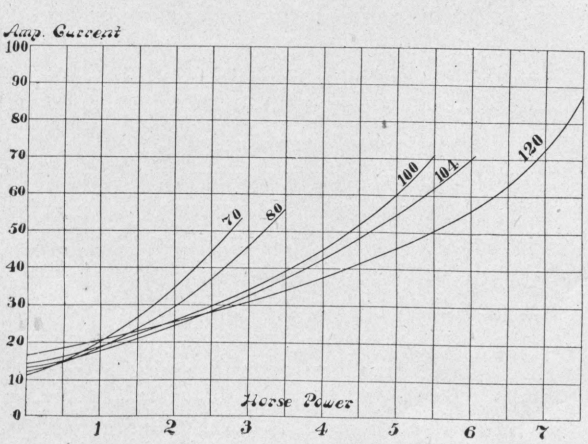


Fig. 9.

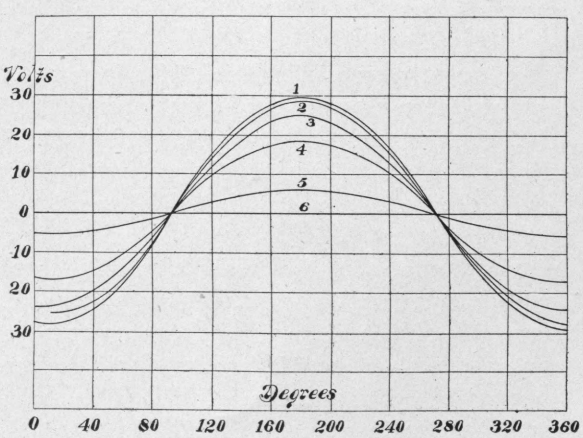


Fig. 12.

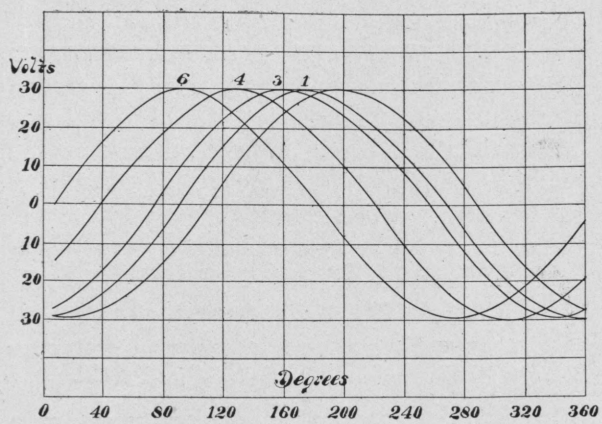


Fig. 13.

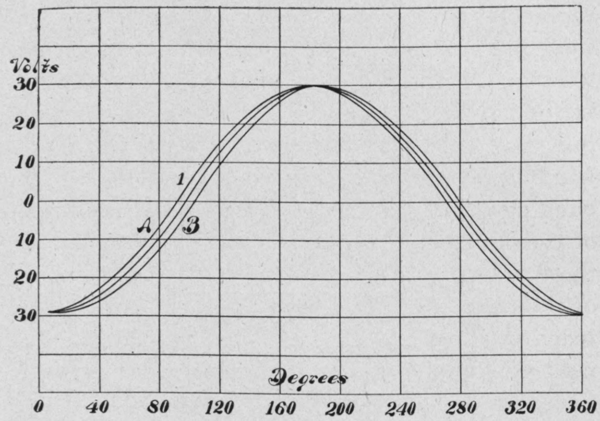


Fig. 14.

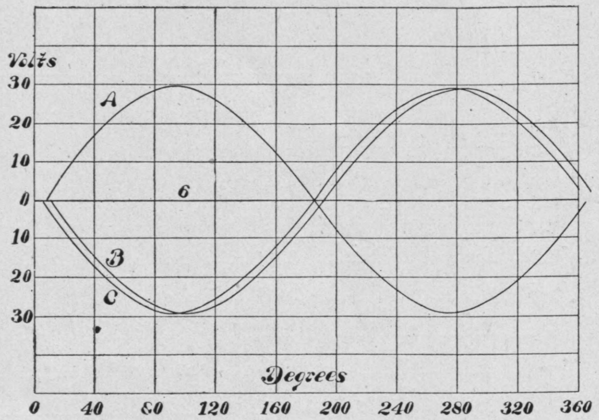


Fig. 15.

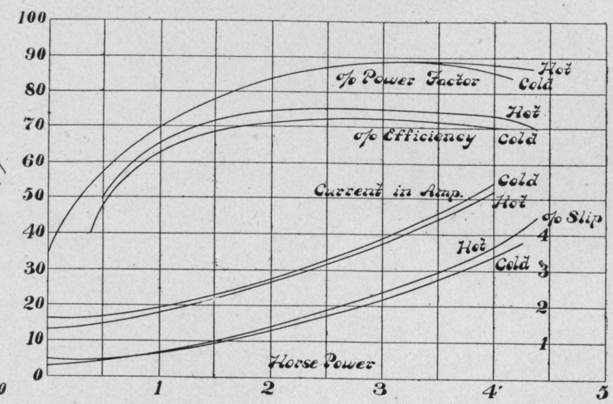


Fig. 16.

motors are also practically identical with those secured in the best direct current motors. The power factors are as high as those secured in two and three phase motors, and the drop in speed with load is very small indeed. In Figs 8 to 15 I have shown the results of a test upon a 5 H. P. sixty cycle motor, made by students of the University of Nebraska, during the spring of 1898, under the direction of Prof. R. B. Owens. One set of tests made by these gentlemen was the measurement of the various electrical factors with different applied electrical pressures at the terminals of the motor. In other words, the motor as sent out by the builders, was designed to operate on a pressure of 104 volts. Tests were made with a variation of this voltage in steps between 70 and 120. The effect of these various voltages upon the various factors are very nicely illustrated in Figs. 8 to 11 inclusive. The judiciousness of the ratings given by the builders is very clearly brought out in these curves. A particularly noticeable feature is the small percentage of slip at the rated capacity of the motor, namely 3 per cent.

Another set of tests made by these gentlemen was a determination of the exact magnetic actions going on in the motor. In other words, they attempted to determine, under all conditions of load as well as when standing idle, the exact form of magnetic field produced by their single phase sine wave current supply. For this purpose they introduced exploring coils in the slots of the field punchings. Each of these exploring coils embraced one-fourth of the slots of the entire field corresponding in that way to the exact breadth of the polar winding of the motor. These exploring coils were introduced progressively around the frame in such a way that the first one enclosed the entire winding of one pole, the next one 8-9 of the winding of the first pole, and 1-9 of the winding of the next pole; the third one enclosed 7-9 of the winding of one pole and 2-9 of the winding of the next, etc., progressively until a point was reached where half of one pole and half of the next pole was enclosed. By the proper introduction of measuring apparatus, they could tell just what the magnetic strength in the section of the field embraced by each coil was at any instant. Therefore, plotting these instantaneous results with respect to time, they could determine the exact form of wave and its net numerical value all around the interior surface of the field punchings. In Fig. 12, the results of their tests are shown with the motor standing still. The result here is just what might have been expected, namely, that in this condition of affairs, the field is a pulsating one and decreases in magnitude at any instant as you progress around the circumferance from the central radius of each pole. In Fig. 13 is shown the reactive effect of the armature upon the strength of the field immediately in the center of each pole winding, between the limits of no load, half load and full load. The displacement seems to correspond in per cent to the per cent of slip. In Fig. 14 are plotted the reactive effects on the magnetic field caused by the rotation and the current of the armature winding. A close study of these curves as compared with the curves of Fig. 12, reveals the fact that the armature reactions of the motor when up to speed are such as to entirely change the character of the magnetic field, actually producing as perfect a rotating magnetic field as is created by a multiphase current supply. In Fig. 15 is shown the reactive effect of the armature upon that portion of the field embraced in the exploring coil which gives a horizontal line in Fig. 12. Here curve 6 shows that the resultant magnetism enclosed by this exploring coil is zero when the motor is at rest.

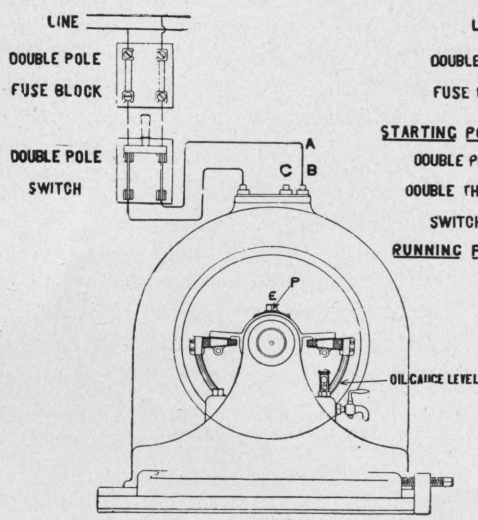


Fig. 18.

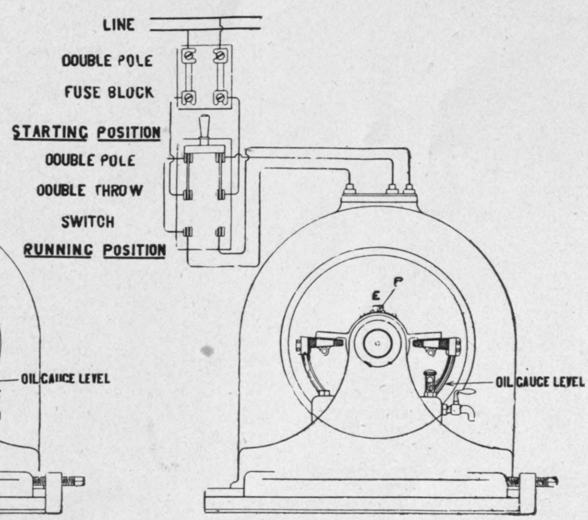


Fig. 17.

Curve A shows the condition of affairs with the motor running in one direction. Curve B gives the corresponding result with the motor running in the other direction. Curve C shows the displacement of B, due to load on the motor. These various magnetic curves are worthy of much closer study than can be given them in the limits of this paper.

Another test made by the University students was to determine the effect of continuous load upon the motor. In other words, to compare the electrical conditions of the motor operating cold and hot. These results are shown in Fig. 16, and disclose the fact that the motor is more efficient and operates with better results in every respect except slight increase in the percentage of slip, when hot than when cold.

In the winding of these motors, it is possible for the builders to secure a variety of results. In other words, where a large starting torque is required an auxiliary connection can be made, the

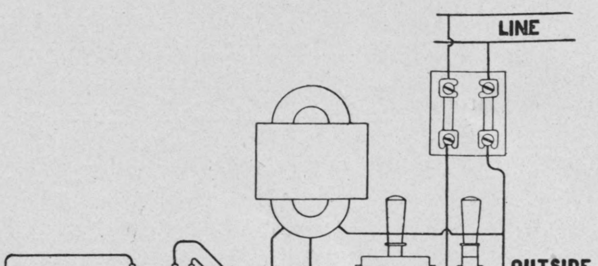


Fig. 19

effect of which is to rate up the motor in capacity. The builders term this a loop connection and for this connection provide a third terminal upon the terminal board. If the circuit is connected to this terminal and the common terminal for starting, 50 per cent, 75 per cent, and in extreme cases 100 per cent overload may be brought up to running speed. When up to running speed connections are changed by means of a throw over switch in the supply circuit, so that the current is supplied to the normal winding of the field. The diagrams for connections under such circumstances, are shown in Fig. 17. Where the starting torque required is normal, the diagram for connections is as per Fig. 18. If it is desired to limit the starting current for the purpose of avoiding line drop of pressure, the builders furnish a small transformer for reducing the pressure applied to the motor terminals. The connections under such circumstances are as shown in Fig. 19, and the result accomplished is approximately the cutting off of that portion of the torque and current curves of Fig. 7 above the 150 per cent. line.

The extreme simplicity of the motor arises from the fact that it can be connected upon the same circuit with incandescent lamps and operates thereon without any disadvantageous effects. Furthermore, operating on a low tension, there is no danger from accidental contact. If it is desired to operate on higher voltages, windings will be provided to correspond. The manufacturers have designed alternating current motors of this character up to and including 20 horse power capacity for 60 cycles, and 15 horse power for 133 cycles. Larger sizes are to be brought out in the near future. The limit of adaptability of this motor to various kinds of power work is set by the frequency of starting necessary, as explained above. The motor cannot be continuously operated upon the commutator, and in so long as the starting is of infrequent character, satisfactory results can be guaranteed. For ordinary running service, where starting but once or twice a day is necessary, the life of the commutator is indefinite.

CONTINUOUS LABORATORY AND OFFICE.

April has witnessed the second attempt at continuous practice for the Seniors and the result is eminently successful. With the class of '98 was inaugurated the scheme of continuous practice and the plan was tried during the month following commencement at the end of their Junior year; but it was found objectionable to remain so long after commencement, the summer being so materially broken into. The results were so satisfactory, however, that the Faculty revised the Senior hour plan for the class of '99 by moving up April recitations into the fall and winter's terms and placing the practice in the April hour plan. The degree examinations being placed at the end of March also saved a week that has formerly been devoted to these examinations at the 1st of May.

The Civil Engineering laboratory class carried out a number of tests on several commercial cements variously mixed and allowed to set in air, water, or both, and subjected at various ages to tensile, cross-breaking and crushing loads. Tests were also made on briquettes and cross-breaking specimens 660 days old mixed by the class of '98 in June '97. Paving, pressed and building bricks, obtained promiscuously in the open market were tested for cross-breaking and water absorption. Extensive experimints were made upon wood specimens for failure as struts; moisture and physical make up being noted, and comparisons drawn with "The Cambria Hand Book," values for the ultimate fibre stress at rupture for that particular wood and ratio of length to least radius of gyration. An 18′ white pine specimen 8″ x 8″ in section was also tested for deflection under cross-bending and then broken; from these notes the modulus of elasticity for cross-bending and the ultimate fibre stress at cross-breaking were computed. A 30″ chimney header of 2″ x 12″ pine joist was made in the shops exactly as those used in ordinary building construction, this was placed in the large testing machine with the pump plunger at the centre of the double cross-joists; the wrought iron nails failed by bending at about 2½ tons weight.

Another very interesting and extensive set of experiments was the measurement of the end reactions for various loads on the model steel swing bridge, these results showed a remarkably close agreement with the reactions as calculated by continuous girder formulas and by the $\frac{\text{"pul"}}{E}$ formula of Professor Johnson, with scientific reasons why exact agreement was not attained. Professor Howe has given this bridge considerable attention this year and his results will be very valuable to bridge engineers. It will be very interesting to the few who are acquainted with the work done on this bridge to know that the early difficulty experienced at the second panel joint has been entirely overcome by placing a heavier dead loading in the opposite arm at the panel point adjacent to the pier.

The last week of practice was devoted to hydraulic experiments; tests were made for the coefficient of efflux through thin plate circular orifices of brass of ⅛″ to 1¼″ diameter under heads ranging from 30′ to 63′; these coefficients show close agreement with those obtained in the thesis work of Sanborn and Sinks, '96, with perhaps some improvement in uniformity due to some improved facilities for measuring the exact head of water at the orifice during flow. Short tube measurements were made and also tests for the coefficient of flow through commercial wrought iron pipes. A series of experiments were conducted for the efficiency of flow through various valves, elbows, hose and other pipe fitting appurtenances.

The facilities of the Civil Engineering laboratory are excellent and fully capable of exhaustively treating tests of the above nature. Photographic records were made of a number of the tests and the methods through which they were carried.

Twenty hours per week were devoted to the completion of the design of a 185′ span, Pratt truss, for the Wheeling and Lake Erie R. R. The period was completed by an inspection visit, under the direction of Professor Howe to a number of railroad and highway bridges in the vicinity of Terre Haute.

Kittredge, the only Chemist in the class of '99, spent the first three weeks of April in the fractional distillation of coal tar oil. This oil is commercially known as the "light oil" and contains benzine, toluene, xylenes, cumenes, indene, besides some napthlene and higher boiling compounds.

The apparatus used to affect a more perfect separation than the common distilling bulb was the Hemple glass bead column. This consisted of a glass tube about 3 cm. in diameter and about 46 cm. long, having a smaller tube about 1 cm. in diameter sealed on the bottom and the neck of a distilling tube sealed on the top. The large part of the tube is filled with glass beads. The oil being boiled the vapors of the higher boiling compounds which are sure to be carried up by the other vapors are condensed and run back thus giving a cleaner separation.

The first set of fractions were taken through comparatively long intervals about the boiling points of the various compounds. In each succeeding set these limits were narrowed and finally they were collected as follows. Benzine 80°-82°, Toluene 110°-114°, Xylenes 138°-142° Indene 176° 182° (Centigrade). The indene fraction was especially desired as it was to be used later in thesis work.

The last week was spent in analyzing a sample of paint oil. Resin oils, fatty acids, per cent volatile with steam, and ash were determined.

In the Shop the students in Mechanical and Electrical engineering have been working upon the multiphase alternating current generator, designed last year by Stilz, '98, and upon the universal grinding machine, designed by Mr. Harris. The work on the alternator is considered of first importance, and all the men that could be worked to advantage were kept busy upon it. These are the most important machines now under construction, but since the first of the term two air compressors have been turned out for bicycle use. Some work has been put upon the gas engine, and considerable repairs and experimental work upon the ice machine.

The machine design for April was largely a continuation, or properly a completion, of the regular course in this subject, excepting that power plants and appurtenances were given considerable discussion.

The same comment can be given the mechanical and physical laboratories, special mention being made of the tests upon lubricating oils by means of Dr. Gray's "Journal Testing Machine." The Mechanicals were given a chemical laboratory course under Dr. Noyes, in the proximate analysis of coals, Indiana coals being made use of. Smoke gases were also analyzed, the methods of Bunte, Hempel and Orsat being used.

In the physical laboratory most of the men taking the electrical course have been working with alternating currents; other students, including the Civils and a few Electricals, have been making preliminary thesis experiments.

To accomplish the foregoing in thirty days has required ten hours per day, but the results are conspicuously creditable, and the Professors unite with the students in scoring success to continuous practice for the Seniors.

THE HONOR SYSTEM.

Attention has been called from time to time to the question of "the honor system" as practiced in a number of the larger eastern colleges, and that the faculties of many institutions are giving the question the most serious consideration.

The success and general favor with which this movement has been met by both faculty and students bids fair to bring the "honor system" into the smaller school and in course of time into all schools where the student has reached the age at which he can appreciate the obligations placed upon him. After years of trial in some of the eastern colleges the faculties have decided that it is by far the best plan devised, and the results of the examinations show that the work of the student is a large per cent. better where they are placed on their honor and given all freedom necessary to bestow their attention on the work under hand and not feel the restraint which naturally comes with the consciousness that you are being watched. The argument has often been made that no one who is thoroughly honest should object to being watched. This is true, but there are few who can do themselves credit when they feel the presence of some one who is ever on the alert for dishonesty.

There is another side of the question for which a remedy is harder to find than the above; that is, the men who, either through laziness or lack of principle, depend on the assistance they can gain from outside sources, either classmates or prepared memoranda. A new difficulty is offered here which has so far never been solved by placing a guard over the class, for in spite of the vigilance of the professor, no matter how alert, there are some who succeed in using unfair means. Beyond the demoralizing influences such men have over the class their actions are not fair to the other men. While the professor may fail to note such a man, it is not often that one escapes the attention of his fellow students, and the injustice to them is not passed unfelt.

The only solution that has been found which in any way offers a satisfactory remedy has been in the "honor system," in which after the examination questions have been given by the professor, no faculty supervision is exercised, and the entire government of the examination is left in the hands of the student body. Thus the responsibility is thrown on the class as a whole and each feels his individual responsibility. Experience has shown that those who are inclined to either give or receive aid, under the "honor system" are much less apt to make the attempt than when only the faculty are concerned. The pledge of honor which must be signed and the fear of detection by his class-mates in a breach of faith to them, are much more likely to prevent unfair means than supervision by a professor.

PRINCETON'S HONOR SYSTEM.

We reproduce from one of our exchanges, *The Mirage*, a part of the Princeton Honor System, in order that the students may observe the rules governing the conduct in one of the largest Universities in the country:

ARTICLE III.

Sec. 1. The committee shall have the power to summon the accused person and witnesses and conduct a formal investigation, and in case of conviction shall determine the punishment under the following regulations:

First, in case of a violation of Honor System by a member of the Senior, Junior or Sophomore class, the penalty shall be recommendation to the faculty of his separation from college, with the addition in extreme cases of publication to a mass meeting of the college.

Second, in case of a violation of the Honor System in the Freshman class, the penalty shall be recommendation of suspension for a time determined by the committee.

Sec 2. The committee shall make a single report to the faculty of all cases acted upon during one series of examinations, consisting of a brief resume of evidence taken, their decision in the case, and recommendation of the penalty to be imposed.

ARTICLE IV.

Sec. 2. The trial shall be formal and conducted in the following manner, with the President of the Senior class as chairman, and the President of the Junior class as clerk; witnesses against the accused shall be taken first and then testimony taken in full. The accused shall then be called separately and allowed to make his statement, presenting witnesses for his defense. All witnesses and the accused may be questioned by the members of the committee, and a decision then rendered according to the law and evidence.

Sec. 3. Five of the six votes shall be necessary to conviction.

Sec. 4. All evidence possible shall be procured in every case, and in no event shall a man be tried a second time for the same offense, except in the light of new and important evidence.

ARTICLE V.

Sec. 1. Violations of the Honor System shall consist in any attempt to receive assistance from written aids or from any person or his paper, or in any attempt to give assistance, whether the one so doing has completed his own paper or not. This rule holds within or without the examination room during the entire time in which the examination is in progress; that is until all papers have been handed in.

STUDENT COUNCIL.

One of the by-laws of the Council provides that proceedings may be kept secret, if this is deemed best, and unfinished deliberations are usually of this nature. During the past month a communication has been received from the Sophomores and acted upon, but the reply from the faculty has not yet been received. A long communication has also been received from Dr. Mees, and this has occupied the attention of the Council for almost two full meetings, and as yet no reply has been drafted.

The necessity of a treasurer to care for the "Student Fund" has caused the election of Richardson, '00, to this office. A voucher system has been provided, and the Vigo County National Bank made the repository of the Council. The first fund of the students is over $250, which will be appropriated almost entirely to the needs of the Athletic Association and THE TECHNIC.

NOTES.

The hand book, which the Y. M. C. A. will issue this year, will far surpass anything ever attempted before. It will be bound in a red leather cover, with map of the city, diary for each day in the year, schedule blanks, score cards, records of athletics, base ball and foot ball, and the general news about the school, which will be of interest to both old and new students.

The Rose Tech Y. M. C. A. has been given the room on the third floor which formerly belonged to THE TECHNIC, to be used as a reading room. This will be repainted and fitted up with comfortable and easy chairs, tables, lounges, games, etc., so as to make it as attractive as possible. The best reading material will be provided, consisting of a number of the current literary magazines as well as the scientific literature. The room is to be open all hours of the day and will be for the use of all the students who desire a comfortable place to spend an hour in study or amusement. This is a step in the right direction and the officers of the Y. M. C. A. are to be heartily congratulated for providing a long felt want. Just some such place has always been desired in order that the men would not have to sit around the halls to talk, as it is impossible to talk in the library without disturbing some one. There is no doubt that this plan will prove a success and that the students will deeply appreciate the advantages and privileges offered and will most heartily make use of them.

Mr. Wells, the President of the Y. M. C. A. at Wabash, and Mr. Collum, President of the Y. M. C. A. at Purdue, spent Sunday, the 15th, with the members of the Rose Tech Y. M. C. A. At the meeting at 8:30 on Sunday, plans and prospects for the coming year were discussed, and the fall campaign was laid out. A more determined effort than ever will be put forth by the Association to offer the advantages which it possesses to the new students, and it will use utmost ability to help all those entering college, as well as the men already here, in every way possible.

Congratulations, Mr. Perkins.

The Sophomore class have completed their work in the electrical laboratory.

The Sketching Club met recently. A member of the ball team was sketched in his suit.

The Board of Managers held their regular monthly meeting on Tuesday, May 16th.

The Senior chemistry class seems to find it a very hard matter to keep awake during the laboratory hours.

Professor Howe's investigations on bridge reactions appeared in full in the new periodical, *Bridge Engineering*.

Osborne, '01, constructed an upright engine of 2 horse power in the shops. He expects to run a small boat with it.

Every one is mourning the fact that the engine on the campus has no steam in it. It would be a splendid thing for a ball game.

Hommel is still looking for the left-handed monkey-wrench, which, year after year, the Freshmen have so unsuccessfully sought.

The "Starved Cubans" are still carrying out their celebrated anti-pun policy. One dose of the water cure seems to be effective against the disease.

Schwable, '99, spent several days at his home in Greenville, making plans of the hotel, for which he expects to design an electrical equipment.

Prof. A. A. Faurot read a paper before the Terre Haute Literary Club on Monday, May 6th, upon the French novelist Emile Zola. The paper was admirably composed, and held the closest attention of the audience.

The Sophomore Civils have been spending the whole of Mondays for several weeks in field work near Ellsworth, under the direction of Professor McCormick.

Mr. McCormick has expressed his wish to become a mind-reader. Some of his classes may be glad to hear this, as an indication that he is not one already.

We hear that Schwartz, in an organic chemistry recitation, gave Dr. Noyes elaborate details as to the method of manufacturing carbolic acid from animal refuse.

Dr. Noyes suggests a yellow pigment as a color for portrait painting, but later limits its usefulness in that direction to the painting of the "heathen Chinee."

While Lyon was guessing the name of a mineral Dr. Noyes told him he was warm. While Lyon has for a long time believed this, he is glad to be at last appreciated.

Two members of the Sophomore class who went rowing recently, created great doubt as to their veracity, by asserting that they rowed down the river and sailed back.

Rochester, fiercely, to Normalite: "What, you obstructing the sidewalk and getting in my way?" Normalite (in crowd of fifty) "No, no; I ain't gettin' in nobody's way."

The Freshman drawing classes went out the other afternoon on the annual sketching trip. They sketched the coal sheds from the grandstand. Some of the work was very creditable.

Professor Hathaway will deliver a series of lectures on Quaternions at the Summer Quarter of the University of Chicago.

Training costumes were never more attractive (to the attention). Clay's three color patriotic combination is striking while Tallmadge in his uncanny bath-robe, has the appearance of a giddy but skinny witch.

The spring meeting of the Indiana Academy of Science will be held in Crawfordsville May 25, 26 and 27. On the 26th a trip will be made to the "Shades of Death." It is understood that the meeting next spring will be held in Terre Haute.

Some interesting experiments are being made upon standard electrical instruments, in the electrical laboratory, showing that in certain alternating current measurements there are serious sources of error, arising from weather conditions.

Professor J. A. Wickersham read a paper before the Terre Haute Literary Club on Monday, April 25th, entitled "Rudyard Kipling's Works, Analyzed," which showed a critical study of the poet, and evidenced much skill and discernment in preparing this excellent paper.

Howell and Thompson have undoubtedly completed their thesis, or have taken as their subject, "An Experimental Determination of the Probability of There Being a Personal Equation which must be taken into Consideration in Angling in Ketchum's Fish Pond."

Professor Hathaway was explaining a rather difficult point, when a piece of chalk rolled up to him from the direction of his appreciative audience. With hand pointing out the equation and eye watching the chalk, he asked, "Now, do you see where this comes from?" Strange to say, this was a point about which the class knew more than he did.

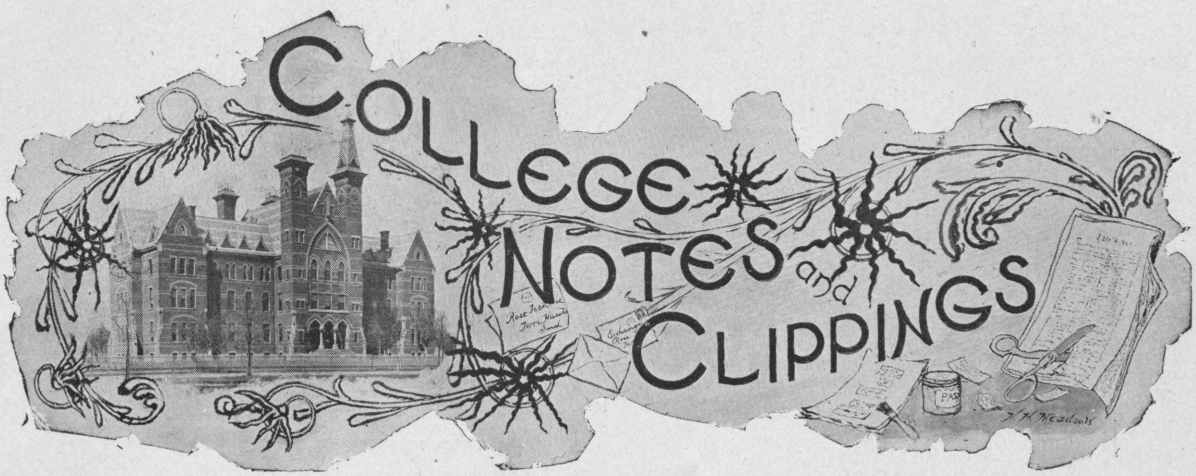
Schwed, Stone and Kidder expect to make their tests for bridge deflections upon a pin-connected Pratt truss on the Vandalia near Reelsville, and if time permits, will also test a plate girder upon the same road. All of the necessary recording apparatus has been prepared, and several improvements upon the former instruments have been devised.

Jumper, Likert and Froelich have abandoned the "Test of the Terre Haute Brewery's Cold Storage Plant" as the subject of their thesis, on account of the impossibility of getting control of the plant while making the test, without interfering with the regular operation. They have taken the same subject, but will make the test at the plant of the Vigo Ice & Cold Storage Co.

Mr. John D. Collett and Mr. George H. Buskirk of the Union Trust Co. visited the Institute to arrange for the transfer of the John Collett geological cabinet to the Rose Tech. This collection has been stored at the school in boxes for several years, and it was Mr. Collett's intention that it should become the permanent property of the Institute. As soon as the transfer has been been made it will be unpacked and placed in the museum.

Some changes in theses subjects have been made, among others: Keyes will take up the study of the "Dielectric Strength of Insulating Materials." Burt, "The Design of an Electric Motor Plant for the R. P. I. Shops, and the Comparison of Cost of Operation Under this System and the Present Belt Transmission." Schwable, "A Design for An Electric Plant for the Turpen House, Greenville, Ohio, for Both Lighting and Power." McLellan, "Test of the Gas Engine of the Louisville Telephone Co."

Dr. Gray will not be able to present his paper before the spring meeting of the American Society of Mechanical Engineers, upon the subject of "Ball Bearings and the Properties of Steel Balls," as the results of his experiments so far have not been entirely satisfactory, because the quality of the steel which has been used, although the best obtainable, is not of the necessary degree of hardness. Further experiments will be made during the remainder of the year, until the results are entirely satisfactory.



Electrical World and Engineer for May 13, publishes an article by Prof. Edwin Place on Phase Angle Measurements. As outlined it is more of a laboratory method but with a few simple alterations in the meters the method could be put into practical use to great advantage.

The Murphy System third rail electric railway at Manhatten Beach was subjected to an intensely practical test on April 12, and was remarkably successful. This system is very ingenious and it is very unfortunate that we cannot describe it in full. A live section of the rail was covered with mud moistened with salt water but the leakage amounted to only 0.2 ampere which is not sufficient to hold a switch closed.

The switches are opened by a large storage battery that is carried in the car which also supplies power for the electric lights. In all previous systems the storage battery was a source of trouble both from size and from the frequency of necessary recharging. The Murphy System requires only ten cells, instead of 250 as hitherto considered necessary, and by means of a "motor-dynamo" these are continually charged at all times when the car is in motion. The car lamps are in parallel and one or more may be lighted at a time. When the power house current is absent the motor-dynamo operates the switches.

The amount of data and "things we want to keep" now appearing in technical journals is something overwhelming and at the same time perplexing. If we put by his magazines to have them bound he loses sight of an article and if he cuts out what he wants he destroys his file. In *American Machinist*, Robert Bruce has been giving data on nelical springs. That is very valuable and Frederic Cole in *American Engineer* is presenting the design of locomotive parts. Information on these subjects is very meagre but these are only two of the many things that are put before us each week and some of them lost because we have not the time to do them justice.

About two months ago one of the popular magazines printed a paper on liquid air with the result that might be anticipated when such magazines try to treat scientific subjects. From time to time since these various periodicals more or less scientific in their nature have argued the thing back and forth with no degree of success. Prof. Elihu Thomson in the *Engineering Magazine* settles all of these squabbles by pointing out that Mr. Triplee said it required three gallons of liquid air to do the cooling for the production of ten gallons of liquid that has been compressed by these means. With this fact in mind he goes on to tell rationally what are the possibilities of liquid air. Prof. Thomson is one of the profoundest of scientists in the country today and his remarks on this subject are extremely valuable just now where something authentic is desired.

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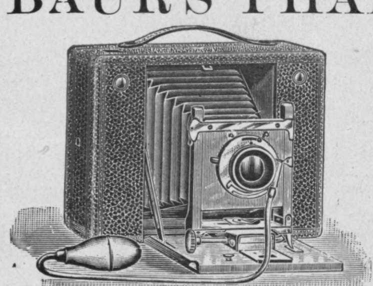

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