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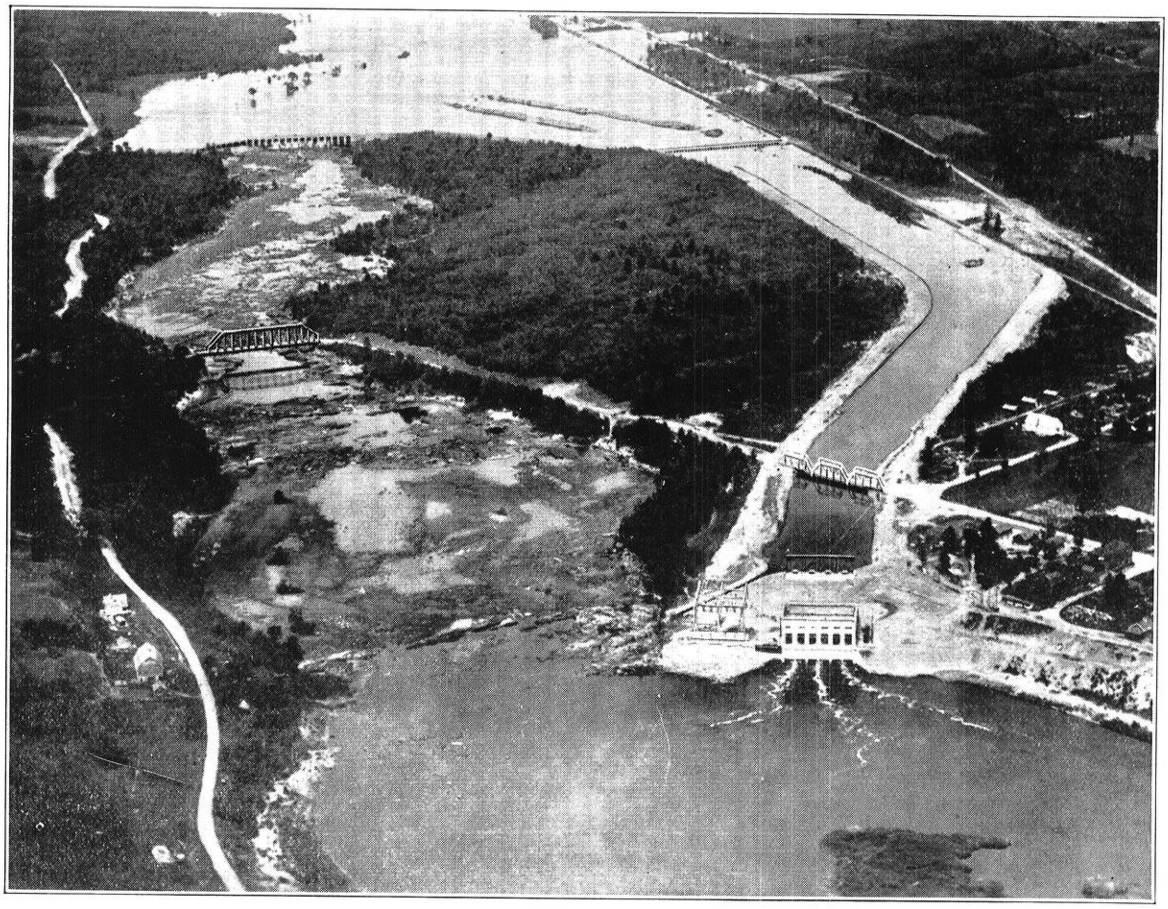
VOLUME XXXI NUMBER II



JIM FALLS DEVELOPMENT OF CHIPPEWA POWER COMPANY

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THE WIDE FIELD *of* APPLICATION *of* X-RAYS

By Lloyd L. Call, e'18, *Victor X-Ray Corporation.*

ALTHO the term "X-ray" is very fimiliar, the people who have the rays used on them are usually not in a position to inquire into their nature or the equipment used in their production. The application of X-rays has been extended to fields other than the medical one so rapidly in the past few years that any engineer is likely to be called upon to use them in connection with his work. It may be advisable to briefly describe their nature, the modern method of production, and the recent application of the rays.

Professor Lane and his colleagues proved that X-rays or rontgen rays are the same in nature as ordinary light; that is, electro-magnetic waves of definite wave-length. It has been shown since this discovery that color, absorbability, actinic, and chemical effects of X-rays depend, as they do for visible light, upon length. The difference between visible light and X-rays is that the wave length of X-rays is from 0.2 to 0.9x10 to the minus 8cm. while the wave length of visible light extends from 3800 to 6400x10 to the minus 8cm. These extremely short wave lengths have the property of penetrating substances that are opaque to visible light.

These penetrating waves are produced by the impact of high-velocity electrons (approximately 82,000 miles per sec.) on a tungsten target in highly evacuated vessel 5x10 to the minus 7mm. Hg.). In modern Coolidge X-ray tubes the electrons are obtained from a specially formed filament which is heated to approximately 2,500 degrees absolute. These electrons which are evaporated from the filament are accelerated by a high potential from 40,000 to 300,000 volts unidirectional current (maximum value) which is applied between the filament or cathode and the target or anode.

An X-Ray View of an Automatic

The design of these tubes must be such as to maintain the high vacuum, to withstand the mechanical forces produced by the high intensity electric field, to prevent puncturing by the high voltage, and to provide the proper dissipation of heat generated at the target by impact of the electrons. Extreme care is required to free from gas all metal and glass parts making up the X-ray tube by heating them in a vacuum before assembly. X-ray tubes are required to maintain a vacuum that is much higher than that required by most vacuum devises such as radio tubes, lamps, etc. The anode temperature rises to a cherry-red heat in air-cooled tubes. One of these air-cooled tubes is shown in Fig. 1.

For continuous operation tubes the anode is water-cooled. A complete line of tubes has been designed for every commercial application.

The tube is often considered the heart of the X-ray apparatus, but it cannot be used unless it is properly excited by suitable potentials. Means must be provided for controlling the filament temperature since the filament temperature determines the magnitude of the current that will pass thru the tube at a given potential across the tube. This current is read in milli-amperes and ranges from 2 to 500. The product of milli-amperes and the time of the exposure is termed milli-ampere-seconds and determines the amount of rays for a definite potential across the tube and a definite distance between the point of application of the rays and the target of the tube. The filament voltage is obtained from a step-down transformer altho storage batteries could be used to supply the filament power.

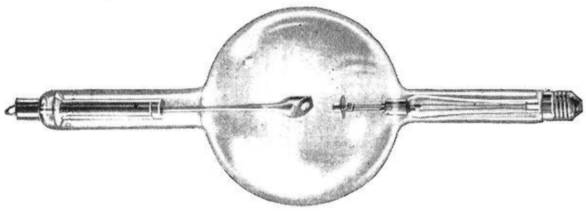

Fig. 1—An Air-Cooled Tube

The unidirectional potentials across the tube must be adjustable since this potential determines the velocity of the electrons which strike the target. This velocity in turn determines the wave-length of the radiation produced by the impact.

A mechanical rectifying switch in the secondary of the step-up transformer has been found to be the most practical source of high voltage unidirectional current for the tube. This rectifying switch is driven by a special type of synchronous motor. Some of the smaller outfits use what is called "self-rectification" in which the X-ray tube itself rectifies the high alternating voltage. Kenotrons are being introduced in various combinations to replace the mechanical switch but the life of the kenotrons at present is somewhat indefinite and the circuit not as fool-proof as that used with the mechanical rectifiers. Some of the mechanical rectifiers have been in continuous clinical operation for ten years with practically no service expense. Comparing this service with 1000-hour life of most vacuum devices calls for careful research before definite decisions can be made. A type of X-ray outfit that has served as a diagnostic aid in hundreds of hospitals, clinics, and doctors' offices is shown in Fig. 2.

Since the discovery of X-ray by Prof. Wilhelm C. Rontgen of Wurzburg in 1895, the physicists have applied them for fundamental research and medical men have applied penetrating rays for analysis of bone and tissue. The physicists have used the rays repeatedly to ionize gases in various investigations of the structure of the atom. Thus the famous Wilson photographs of the tracks of Beta particles ejected by X-ray from molecules of air were made possible. Millikan used the X-ray as the chief ionizing means in his classical oil-drop experiment, and it was Moseley's investigation of X-ray spectra that gave us the accepted atomic numbering. The result of these researches has revolutionized our ideas of electricity and matter in the past thirty years.

Medical men have applied X-rays more commercially than others to this date. Great strides have been made in the past ten years, however, in the application of X-rays in the medical profession, due principally to the invention of better equipment. The Coolidge tube was perhaps the greatest contribution to X-ray art since the discovery of the rays themselves. This tube immediately replaced the "cranky" gas tube with a tube that would operate consistently day after day. The fundamental laws of the operation of this tube are understood sufficiently well to enable the calculation of their characteristics.

The exciting equipment for the tube has kept pace with the tube development and the expression is common, "the tube is the limit". High voltage transformers which have definite characteristics widely different from power transformers, are required for this work. Potentials up to 300,000 volts (peak) are common. Controls for filament current and tube voltage have been designed into rugged, beautiful pieces of apparatus so simple that powerful installations may be operated by relatively inexperienced persons.

Measuring equipment for determining X-ray dosage has been continuously improved until the four factors, kilo-voltage, milli-amperage, time, and distance can be determined now with such precision as to enable technicians who may be unfamiliar with the theory of the apparatus to produce radiographs with detail which would have been unbelievable a few years ago. These improvements in equipment which were made primarily for the medical profession to enable them to meet their new problems, have resulted in many discoveries. The X-ray is no longer limited to location of foreign bodies and broken or misplaced bones, but is regularly used for diagnosis of soft tissues, such as in ulcers of the stomach, tuberculosis, various tumors, gall stones and obstructions of the intestinal tract. Last month the International Cancer Committee, composed of one hundred of the most eminent medical authorities skilled in handling cancer, met at Lake Mohawk and in their

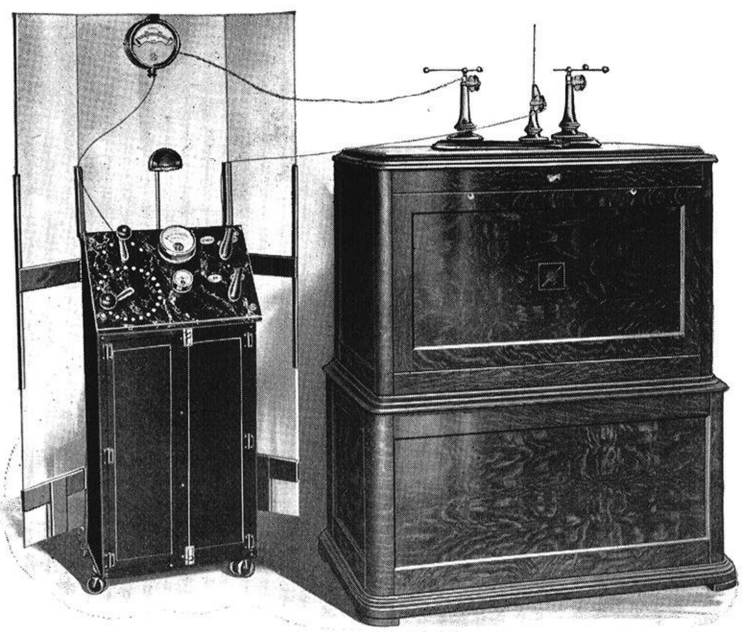

Fig. 2—A Type of X-Ray Outfit in Use in Doctor's Offices and Clinics.

statement as to the status of cancer research in the methods of recognized treatment, placed X-ray, radium, and surgery on an equal basis, thus recognizing officially the value of X-ray in the treatment of cancer. This fine work has been made possible by the expenditure of tremendous energy and millions of dollars on the development of X-ray equipment by men of science and men interested in practical application.

Altho the medical profession has made use of the X-rays commercially to a greater extent than other professions in the past, other fields are taking advantage of the penetrating property of the rays. Museum research workers have learned that important investigation of mummy-casings may be made quickly with the use of the X-ray without destroying the wrapping. The value of these mummy-casings and caskets depends upon their contents. Radiography has enabled the owners of these mummies to set a more accurate value on them. Many other rare specimens, such as sea shells, fossils, etc., can be investigated without destroying the specimen. Thus the scientist has been equipped again with a useful tool in the from of X-ray for carrying on his researches more extensively and more scientifically.

The application of the X-ray to museum research is, in reality, the application of the rays for inspection. It has been found practical to X-ray castings and metal assemblies in order to locate blow-holes and weak portions in the metal as shown in Fig. 3. Dr. H. H. Lester, research Physicist at Watertown Arsenal, Watertown, Mass., in an article, "X-ray Test Applied to the Problems of the Foundries,"* presents the following abstract:

> X-ray tests with collateral analyses indicate that defects in steel castings fall into a relatively few classes traceable to definite and simple causes, most or all of which are removable. When defects are detected by X-ray examination and corrected by changing casting technique, they tend to stay corrected. It is possible by this method to eliminate from 75 to 90 per cent of the major defects in steel castings.
>
> Metal sections up to three inches in thickness may be examined. Where the value of the product warrants it, X-rays may be used to test each individual casting. In other cases casting technique may be developed that will produce sound castings.

Thus the method of making these castings may be improved so that the defects may be eliminated from future lots.

It has been found an advantage to use X-ray in the investigation of plywood and other wooden assemblies to determine if hidden flaws existed in the pieces of wood. Even the golf ball has not escaped X-ray investigations, and the center of the ball, which is a determining factor in its flight, may now be definitely located. These tests have led to improvements in the construction of the product and some of the manufacturers of golf balls are using X-ray equipment for final inspection. It is not uncommon to have one's shoes fitted with the aid of a fluoroscopic screen which enables the wearer to see the position of the bones of the foot in the shoe. In addition to the above, the inspection of parts going to make up the final assembly of a product may be checked. A pistol, as shown in the illustration, or any other assemblage of small parts may be investigated to determine if these parts operate satisfactorily within the case. Such a check is particularly necessary in assemblies where the case must be in position for the proper operation of the mechanism. Any engineer could think of dozens of applications of X-ray inspection of parts where safety to human life is involved.

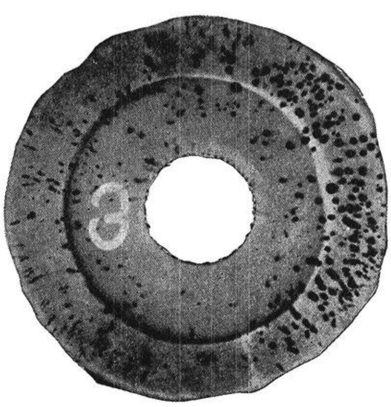

Fig. 3—How Modern X-ray Shows Up Blowholes in Metal Castings

The scientist has has found another very important commercial application of X-ray in the form of crystal analysis. It is now possible to make an ayalysis of a metal to determine the elements it contains in a few minutes with the X-ray and thus eliminate the long, laborious chemical analysis. The accuracy of this new method is better than that of the commercial chemical analysis. A number of the universities have installed crystal analysis outfits in their research laboratories and some of the more progressive large manufacturing companies have equipped their laboratories for routine work. The complete outfits with the special tubes are now available.

The above examples of application in a commercial form indicate the wide field in which the X-ray may assist the engineer. New uses and ideas of testing equipment come to our attention daily and this interest would indicate that a number of old inspection methods are going to be replaced in the near future by the more effective X-ray analysis.

Thus an engineer must be constantly on the alert to satisfy himself that he is not overlooking an opportunity of applying this new method which may perform his work more thoroughly than he has been accustomed to perform it and at less expense. One or two radiographs may save him hours of time in an important investigation.

Every man in his time must either wear out or rust out. I prefer to wear out.—Selected.

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*This paper presented before the American Society for Steel Treating. The best early paper on this subject was presented by Dr. W. P. Davey in The General Electric Review, Jan., 1915. His results were limited by the fact that modern high-power X-ray equipment had not been developed at that time.

PRESENT DAY HYDRO-ELECTRIC PRACTICE IN MIDDLE WESTERN STATES

By J. F. Roberts, m'18, *Hydraulic Department Allis Chalmers Company.*

It is a surprising fact that many technically trained engineers have never actually visited and thoroughly inspected a hydro-electric station. This is exceptionally true in our middle western states because there seems to be an inborn feeling that hydro-electric developments in this part of the country are relatively unimportant and insignificant. When one mentions water-power developments we unconsciously consider that this person is speaking of the great developments now in progress in the eastern part of the United States and Canada, especially those around Niagara Falls and along the St. Lawrence River.

It is surprising, to one who has not watched closely the developments of water power here in our own state of Wisconsin, that we have probably a more varied type of hydraulic development than any other state in the Union.

When mentioning the water-power developments in California and along the western coast, one usually has in mind the high-head impulse plants of from 1500- to 2000-foot head or the high-head Francis type units of from 350- to 700-foot head. When we speak of the large developments in the East, one usually thinks of the large capacity medium-head plants such as the 40,000- and 70,000-h.p. units at Niagara Falls, or the tremendous developments of 30,000- or 40,000-h.p. units along the tributaries of the lower St. Lawrence River. But on the other hand, when mention is made of the water power in our Central states it seems that we consider these as merely low-head and unimportant developments. Such

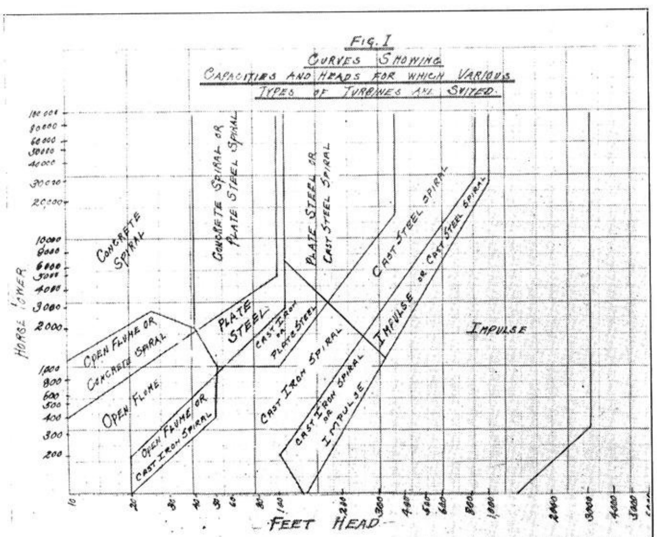


Fig. 1—Capacities and heads for various turbine types.

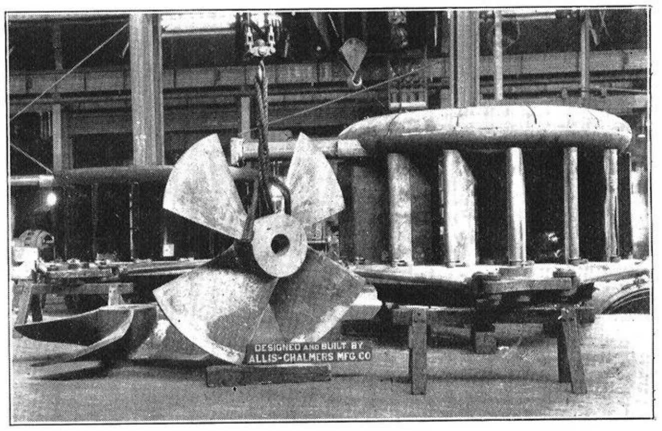


Fig. 2—Shop view of runner and guide-case for open-flume turbines.

is not the case, altho it is true that there are a large number of low-head developments in our Central states; but here in Wisconsin in addition to these low-head developments we have a surprising number of medium-heads and relatively large capacities, as well as several developments which might well come into that high-head class.

Fig. 1 is interesting in that it shows the various types of hydraulic machinery which are best suited for developing different amounts of power at different head conditions. For instance, for relatively small developments from 200- to 1000-h.p. and for heads from 7- to 30- or 40-feet, the open-flume turbine may be economically used. For larger capacities under these low heads or up to 70- or 80-feet, the concrete spiral cased setting is customarily used and as the capacity and head increases up to heads of 200- or 300-feet, the plate steel spiral cased turbines are usually employed. As higher heads are reached, the cast steel cased turbines are used and, for the extreme heads, the impulse or Pelton type wheels are used, altho the latter two types do not come into use extensively in Wisconsin.

The propeller type runner and guide case used for the modern low-head open-flume turbine, such as that installed in the Montery plant of the Wisconsin Power and Light Company, is shown in Figure 2. The runner, which is the name applied to that part of the turbine which takes the power from the water and converts it into rotating energy at the shaft, consists of a single casting having four radial blades and designed very similar to that of a ship's propeller, or the blades of an electric fan. This type of turbine runner is a relatively new development, having come into existence during the past six or seven years, the first important installations of this type having been made in 1916.

The turbine proper consists of a simple cover plate and discharge ring with movable guide vanes mounted between them. These guide vanes or wicket gates, as they are sometimes called, are pivoted so that the opening between them regulates the amount of water admitted to the runner which, in turn, controls the amount of power developed by the runner.

In the syphon type setting, the flume or chamber surrounding the turbine proper is sealed at the top and some means, such as an injector, is provided for sucking out the air and lifting the water up into the chamber. The syphon setting allows a considerable saving in the cost of the power house by doing away with the necessity of excavating and setting the turbine at such a distance below head water that air will not be drawn into the turbine gates. With the syphon setting, the top of the turbine itself may be practically on a level with the head water, the sealed chamber above preventing air from being sucked in between the guide vanes. Air would cause serious disturbances and temporary interruptions of the power output of the wheel.

The water from this particular unit is discharged into the tail race through a hydraucone or concentric type of draft tube, the upper part of which is provided with a plate steel liner to prevent the water from wearing away the concrete, the lower part being constructed of concrete. This is poured around built-up forms to provide the proper curves. This type of draft turbine permits of more efficient regain of the energy in the water discharged from the runner, and at the same time permits a considerable saving in excavation cost due to its requiring less depth. In this particular installation the head gates for shutting off the water at the inlet of the turbine are located inside of the building so that they may be raised or lowered with the same power-house crane which is used to handle the turbine and generator equipment. This has an additional advantage in that

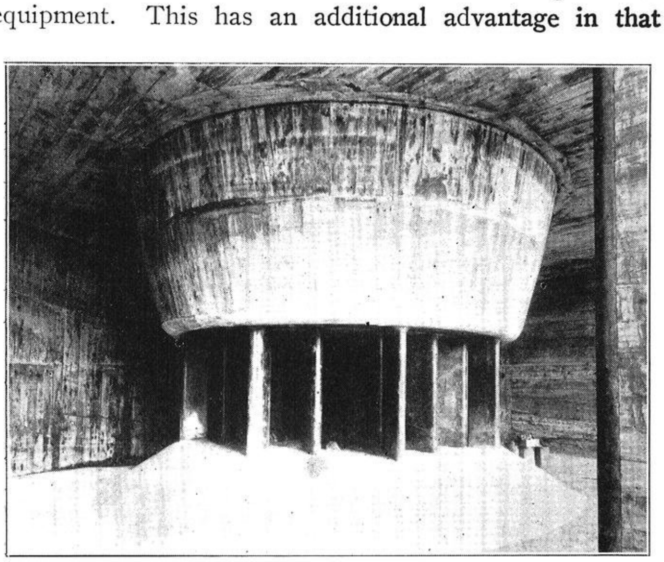


Fig. 3—Interior view of concrete turbine-casing of 2,500 h.p. turbine.

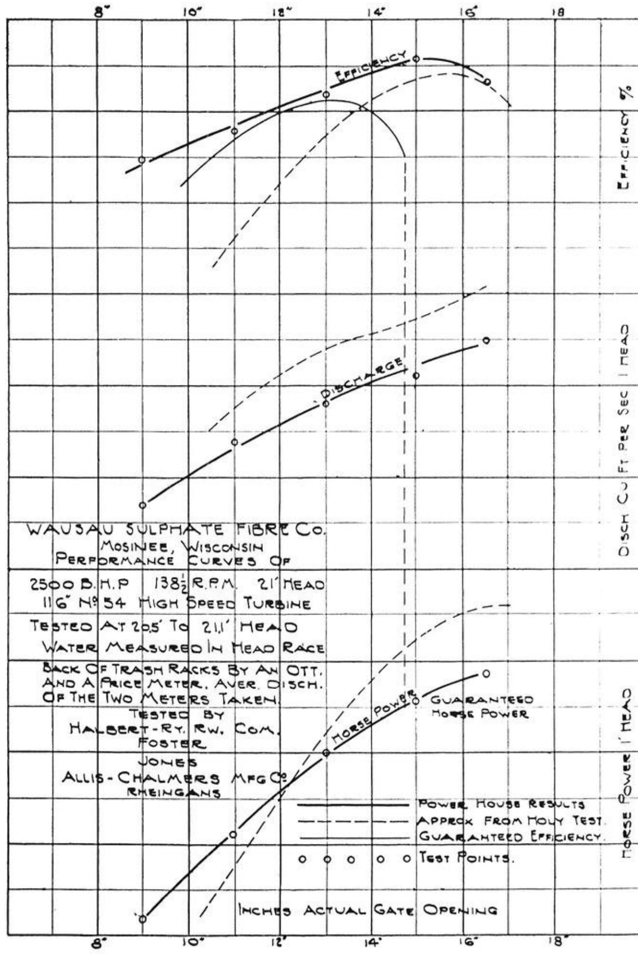


Fig. 4—Power-house efficiency curves for Wausau Sulphate Fibre Company

they are not subject to freezing or ice troubles in winter. The trash racks or screens, which consist of rows of bars on about two- to three-inch centers, for preventing drift-wood and logs from entering the turbine chamber, are set outside and located upstream from the power house.

The unit of the Montery plant is of the vertical open-flume type, the entire rotating weight being carried from a thrust bearing located on the top of the generator bridge, and the shaft being held in three steady bearings, the two in the generator being of the oil-lubricated babbitted type. The governor, which controls the power output of the turbine by regulating the amount of water admitted, is connected to the guide vanes by means of a vertical shaft which extends up through the generator floor. The governor contains a set of sensitive flyballs which, in this case, are driven by a small induction motor from the main generator, the speed of this motor varying almost directly in proportion to the speed of the large generator. An increase in speed in the flyballs causes them to raise a small valve which admits oil under pressure into the closing side of a cylinder which, in turn, causes the gates of the turbine to be closed. The oil pressure is obtained from small belt-driven oil pump which pumps into a pressure tank provided with an air cushion. A pressure of from 150 to 200 pounds per square inch is ample for operating the guide vanes.

There are many low-head open-flume installations in Wisconsin. Some of these operate under heads as high as 30- or 40-feet and capacities up to 1500-h.p. The essential point in determining whether or not an installation is of the open-flume type, is that in this type of turbine the links, levers and pins which control the operation of the guide vanes, as well as the guide pivots themselves, are exposed to the water and, as a consequence, their only lubrication is water. This type of gate mechanism is called the inside type because the gate operating mechanism is inside the water.

Another type of setting used in many recent developments in Wisconsin is the concrete spiral cased type installed in the plant of the Wausau Sulphate Fibre Company at Mosinee, Wisconsin. This unit also has a four-bladed propeller-type runner and the water is dircharged through a hydraucone draft tube constructed of concrete but in this Wausau turbine the water is led to the turbine through a form of spiral casing formed in the concrete. This chamber is shown clearly in Figure 3, which shows the opening between the guide vanes through which the water enters the turbine as well as the shape of the spiral casing. In this form of casing the water is led around to all of the guide vane openings at practically equal velocity and, since there are no dead corners or pockets, there is practically no chance for eddies or disturbances to be set up in the water.

The guide vane operating mechanism on this type of turbine is located on top of the cover plate and outside of the water, hence the name outside-type gate mechanism. The turbine bearing is of the water-lubricated, adjustable lignum vitae type where strips of lignum-vitae, a very hard and dense type of wood are wedged into grooves in cast iron bearing-shoes which form the bearing-housing. On this particular unit, on account of the long length of shaft required, there is an additional oil-lubricated intermediate steady bearing mounted on structural beams between the turbine and generator. On account of the extreme floods which occur in this particular locality, it was desirable to set the generator above the water level. Since the turbine center line should preferably be located within 10 feet of the normal tail water, it meant that there was a span of about 26 feet between turbine and generator. The critical speed of the shaft and the allowable deflection are the determining factors in deciding whether or not an intermediate steady bearing is required.

The efficiency of this type of unit is around 90% at its best point. The curve in Figure 4 shows an official power-house efficiency test made on this Wausau unit, with slightly over 90% at approximately 95% of full load, these curves being plotted on the actual inches gate opening, which is the opening between individual guide vanes.

Some of the installed units under heads as high as 40 feet are using the Francis or reaction type runner instead of the propeller type runner in Figure 2. The

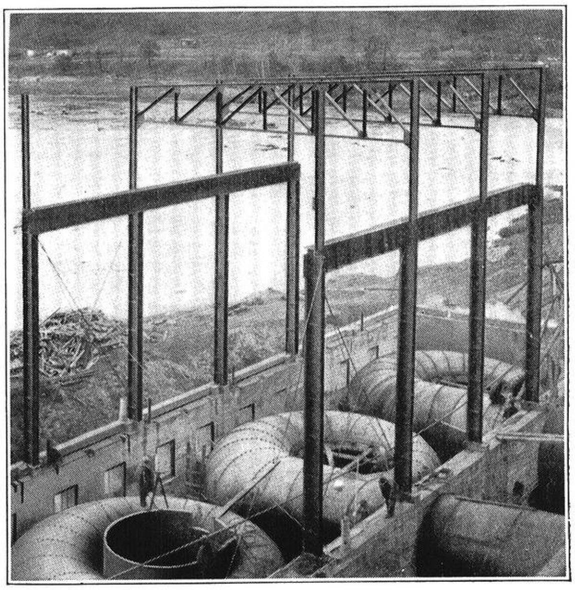


Fig. 5—Spiral casings after riveting, but before concrete has been poured

principal difference between the propeller type runner and the Francis runner is that of a given head and capacity the propeller type runner will operate at a considerably higher speed than the Francis runner. This higher speed results in decreased generator cost, because the cost of generators varies about inversely as the speed. The natural question arises, "Why not use the propeller type runner for all installations, instead of the Francis type runner, as this would mean lower generator costs?" This is not possible, however, because there is a definite upper limit of head above which it is not advisable to use the propeller type runner on account of the relatively high water velocities and resulting vacuum in the draft tube. This is similar to the condition of a ship's propeller. There is a definite upper limit to the speed at which any ship's propeller may be operated, as it is found that when a higher speed is used, pitting trouble on the propeller and rapid deterioration sets in. With the normal setting and the center line of the turbine 10 or 12 feet above tail water, it appears that the upper limit with the propeller runner is between 30- and 40-foot head. This may be increased somewhat by bringing the turbine down closer to tail water, thus decreasing the vacuum at the bottom of the runner and it may also be modified somewhat by increasing the area of the blades on the runner, even overlapping them somewhat, which results in a type of runner approaching the reaction of Francis type runner.

As regards the efficiency of the propeller type runner, if we take a relatively slow-speed propeller runner and a relatively high-speed Francis runner, both having about the same characteristics as regards speed and horse-power, their efficiencies thruout the full range of power would be about even. We find that slow-speed Francis runners have a much better part-load efficiency than high-speed Francis runners. The same is true of propeller runners, but since the propeller runner is usually designed with a much higher specific speed than a Francis type runner, it is natural that its part-load efficiency should be several per cent lower than the slower-speed Francis runner, altho the point of best efficiency in both cases is around 90%. There is, however, a saving to be obtained in the generator efficiency, since the slower-speed generator, which would be required if a Francis type turbine were used for extremely low heads, would probably be one or two per cent lower in efficiency than the higher-speed generator, which is possible with the propeller-type runner.

Our cover illustration shows an aeroplane view of the Jim Falls Development of the Chippewa Power Company, at Jim Falls, Wisconsin. This power house contains three 48,000-h.p. 50-foot-head vertical plate steel spiral cased units, water being brought down from above the dam through a canal excavated along the top of the hill, then down through individual penstocks, the discharge going directly into the river below the rapids.

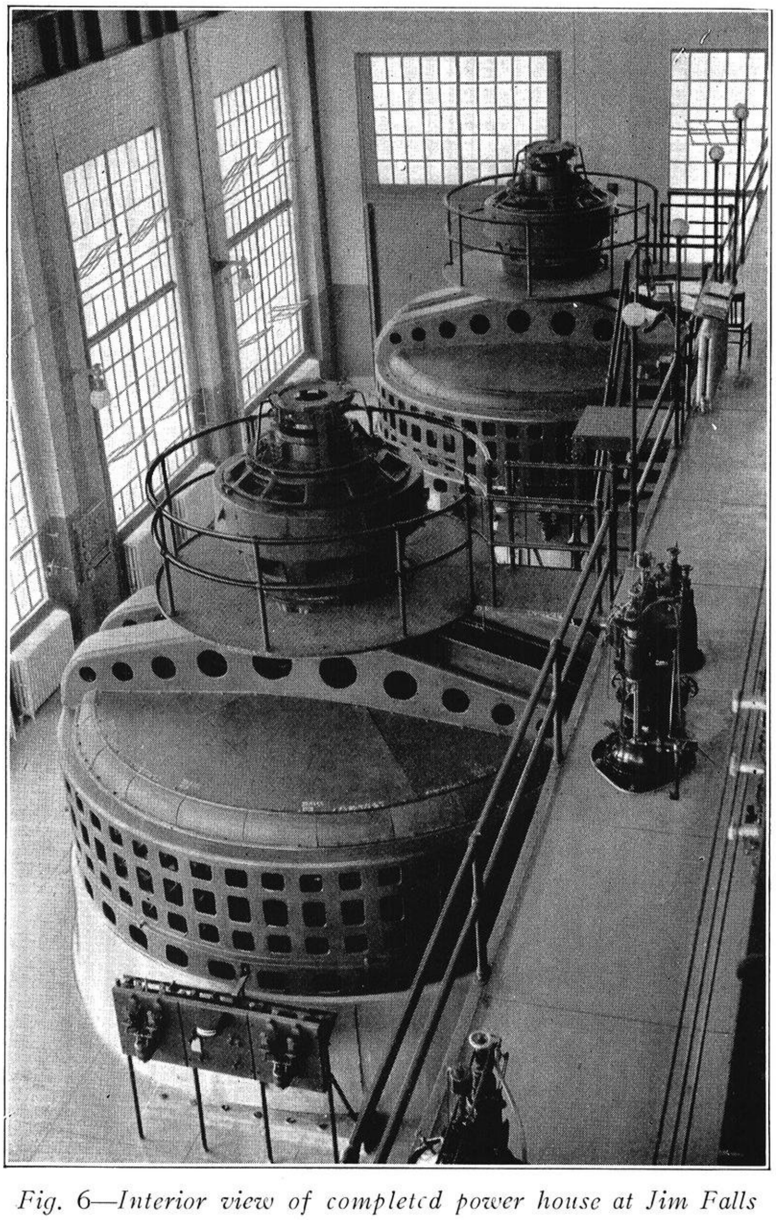


Fig. 6—Interior view of completed power house at Jim Falls

Figure 5 shows a view of the plate steel spiral casings just after they have been riveted up and before the concrete has been poured around them. During the past twelve years a majority of the medium-head turmines built by this company have been built with plate steel casings, altho before this time either cast iron or cast steel was used wherever a metal casing was required. Naturally the cast casings cost a great deal more on account of the necessity of patterns. There are many recent cases where construction engineers have proven that the plate steel casing was even cheaper than the concrete type of casing. This, of course, depends somewhat on the particular conditions existing at the plant. Where labor is scarce and carpenters are expensive, and where the weather conditions are not the best, the building of the complicated forms for concrete casing may run into a large amount of money. There is also the added cost of reinforcing steel and the labor of placing this. As higher heads are reached it is found that there is practically as much reinforcing steel required in a concrete casing as there is steel plate required in a plate steel casing and, in addition, the plate steel casing saves all the form work and enables construction to proceed much more rapidly.

Figure 6 shows an interior view of the completed power house, taken from the crane. Note the direct-coupled exciters mounted above the generators. The Kingsbury thrust-bearings are contained in an oil-proof housing just below the exciters, but above the generator, the entire weight of the rotating parts being carried on the heavy cast-iron bridges which span the generator stator.

The governor-stands which contain all the hand and electric controls for starting, stopping, synchronizing and adjusting the load or speed of the units are mounted on the upper walkway on a level with the excitor platforms. The regulating cylinders or servo-motors which control the position of the guide vanes are mounted in the turbine pit and are connected directly to the operating mechanism.

These three types of turbines, that is, open-flume, concrete spiral and plate steel spiral, are the principal types which are found in Wisconsin, altho there is one notable installation, namely, the Thompson plant of the Great Northern Power Company near Duluth, which contains six 13,500-h.p. 350-foot head vertical cast steel spiral cased turbines, the first unit of which was installed by this company in 1906 and are still in continuous operation.

To the engineer there is probably no more interesting and varied work than the problems found in hydro-electric developments.

(Continued on Page 78)

RESEARCH IN HIGHWAY ENGINEERING

By H. F. Janda, *Professor of Highway Engineering, University of North Carolina*
(Formerly Assistant Director, Highway Research Board).

THE average automobilist, in his mad rush, has no comprehension of the money and engineering labor required to build and maintain the modern highway. It has been estimated that $1,000,000,000 is spent annually for highways; but there can be no estimate of the long hours that are spent by the engineers in their research for more economical methods of construction and maintenance.

The modern highway to the automobilist, and even to many engineers, is merely a mass of concrete, or other material, smoothed out in the form of a road. The use of the highway has become so varied, however, that the highway engineer has often wondered just what this will lead to. The subject of the handling and routing of traffic, and the construction of a road-slab which will stand up, is each day becoming more puzzling. There was an old saying that "every day will be Sunday by and by"; and if one attempts to drive on Sunday nowadays, and has even the most casually deductive mind, he can readily understand that it won't be long before that prophecy is fulfilled—at least in regard to the traffic situation. A few figures may be interesting. In rough numbers, the automobile registration of the United States in 1926, is 20,000,000, while in 1895 there were but four.

A few years ago there was considerable speculation as to the "saturation point" of the automobile consumption, but so many predictions have been shattered that the highway engineer no longer indulges in guesses as to the number of cars that will travel the highways of the United States in the next ten years.

The improvements in the mechanical details of the automobile, and the mass production that has resulted in the low prices of cars, has caused an overwhelming demand for good roads. The highway engineer has been faced with this demand—backed up by large bond issues—and he knew his shortcomings; that a lack of knowledge to build roads that would endure in every case. Highway engineering is the infant in the various engineering groups, but it can point with pride to rapidly accumulating stores of knowledge. It is true that some of this has been gained from failures; but, nevertheless, it now knows the fundamentals of good practice. This knowledge has been gained from a "careful or critical inquiry or examination in seeking facts or principles" known as research.

An eminent highway executive once remarked that research was like a road sign in that it pointed the way. It is probable that there are well over 500 research projects being carried on by state highway commissions, universities and municipalities, and each year sees new information that points the way to the economical construction and maintenance of highways.

Research Completed and In Progress

In a limited article it is impossible to list all research projects, and, therefore, the following tabulation will serve merely to illustrate that scientific principles are being used to secure the necessary information.

Economics of Location, Wind Resistance, Tire Wear, Etc.—The results of a recent study have been published, in text form, which facilitate the location of a double spiral. The double spiral shows, in addition to its easier riding qualities, a saving in the amount of concrete when contrasted to a circular curve.

Several studies have been conducted to determine the magnitudes of all the elements of resistance to translation of the motor vehicle. Experiments to determine the wind resistance have been conducted and valuable data secured.

Front tire wear has been found to be from 50 to 75 per cent of the rear tire wear, but for comparative purposes it is necessary to show the wear on various road surfaces. With a tire index of 1.0 on concrete experiments have shown an index of 7.3 for a chert gravel road.

Subgrade—Subgrade studies are most important and additional information is needed. However, experiments have indicated several important conclusions.

When a soil has a "moisture equivalent" in excess of 20 per cent, or a lineal shrinkage value in excess of 5 per cent, it is probable that this soil will be unsuitable as a highway subgrade.

Bad subgrade soils may be improved by the use of a layer of fine granular material, or by the addition of suitable amounts of the granular material.

It has been proved in actual construction that a blanket course of fine granular material is effective in keeping the soft clay subgrade from penetrating upward into a macadam road, and this increases the resistance of the road to loads.

Drain tile should be used where free water is likely to exist, but it has been proved that the tile will not remove the capillary or vaporized moisture.

Design—There have been so many new designs, resulting from research, that it seems hardly necessary to enumerate them. The Bates Road, the Bureau of Public Roads Circular Track, the Pittsburg Test Road and others have contributed to the design of the modern highway.

(Continued on Page 60)

THE SENIOR CIVILS TAKE A TRIP

By E. A. ABENDROTH, *Senior Civil*

THE annual inspection trip of the senior civils is at an end without any great casualties of any kind. The trip, as usual, took place in Milwaukee on November 2, 3 and 4, and included a visit to the following places: The refuse incinerator, the Jones Island sewage-treating station, bridges, Wisconsin Bridge and Iron Works, Allis-Chalmers Manufacturing Company, and the Riverside Pumping Station.

The trip is over, yes, but the minimum acceptable length of descriptions of the various places visited is still staring most of the theatre-goers and "night-lifers" in the face.

Everything was fine on the first day of inspection until Chadwick discovered a good apple in the large pile of unmentionables at the garbage incinerator. As an example of thrifty and economical engineer, Bill ate the apple to the applause and admiration of his fellow men.

When *Edna* came from Jones Island especially to escort us to the sewage-treatment station, all the boys very courteously and cautiously boarded the small tug (remembering last year's mishap). While at the plant Jake Levin stepped to the fore and started to lead the boys around, at all times keeping a good tab on the guide to make certain that he would not omit any of the points of interest as noted on the mimeographed sheets which were handed out before the trip.

While looking at the clear-appearing effluent from the clarifiers, which mark the end of the sewage treatment, the thought arose in Ben Anderson's mind that the effluent was being wasted and that it really ought to be directed to the city's water supply system. It certainly must have been made pure enough for drinking water.

Thus ended the first day of the trip. The boys were quite low in spirits for no one had fallen into any of the large tanks at the sewage plant to cause any excitement. But this down-heartedness had short life for the Empress and Gayety are quite capable of enlightening the spirits.

From the Gilpatrick the troupe was led by Professor Corp, who, because of his small size, is easily followed in a crowd, to the City Hall. The boys assembled in the lobby and made quite a chesty front—it looked something like a policemen's convention because in general all of the lounging places by the radiators were appropriated.

Due to the great influence which Professors Corp and Kinne and Mr. Cottingham have in Milwaukee, the officials of the city gladly gave (loaned) a Peerless, a Cadillac and a Lincoln in order to make a comfortable inspection of some of the bridges in the city.

The boys traveled to the new Atwater Bridge and then to the State Street Bridge where they stopped the traffic to the great pleasure of the passing motorists. Thru the courtesy of the engineer in charge, the bridge was opened twice for inspection, and the passers-by decided their eye-sight was failing for they could see no tugs going thru.

The trip to the Wisconsin Bridge and Iron Works in the afternoon netted many things. The street car bearing the official delegation was delayed for some time, and the more lucky chaps who drove to North Milwaukee had considerable time to rest and loaf. A refreshment parlor in the vicinity was celebrating the election of Schallits for sheriff, and much to the pleasure of the gang. The celebration was not considered private.

The car arrived in time to prevent any hilarious celebration and the inspection of the plant was started. The contrast to the morning's cold detailment was appreciated, and we learned what becomes of the designs that we make for roof-trusses and plate-girders.

The next day, Thursday, the party was detailed to be at the Allis-Chalmers plant in West Allis at 9 a. m. Because this was the last day of the inspection everyone plugged along with new vigor, but Arthur Piltz was a bit too vigorous. He saw a bright, shiny rivet lying on the floor of the plant and decided it would make a good paper-weight or at least a fine souvenir. Art is nursing a few well-baked fingers, and has decided that the best paper weights come from the novelty stores. When one o'clock arrived, all were quite fatigued and famished, but Mr. Nichols, of the company, took away part of the feeling by announcing that dinner would be served at the club immediately.

Life was restored to the party to the tune of Virginia baked ham and apple pie, and after the feast skyrockets for the host vibrated the dining hall.

The last visit the party made was to the Riverside Pumping Station where Milwaukee's newest plant for serving the city with water was inspected. Those who were anxious to make the 5:45 train hurried the party along, giving their ohs and ahs, when viewing the large pumps, with just slight hesitation. The plant really appeased the thirst of some of the visitors, for the water seemed quite different from that seen on the first day of the trip.

In order to please all present, Professor Corp excused the inspectors at four-thirty. A hasty trip to the restaurants, and a more hasty trip to the depots brought some of the men on their way back to Madison, some on their way home, and others to parts unknown. At any rate there were few who appeared at classes on Friday.

The senior civil engineers wish to thank the inspection committee, Professors Corp and Kinne, and Mr. Cottingham, and, also, the officers of the places visited, for their good work in making the trip a success.

Campus Notes

PI TAU SIGMA CONVENES HERE

Pi Tau Sigma, honorary mechanical engineering fraternity, held its national convention at the university, October 29 and 30, and opened the proceedings with a banquet at the Park Hotel in honor of the new members of the local chapter. Prof. J. F. Martens, University of Minnesota, and A. Young, University of Purdue, addressed the convention. E. F. Vilter, '26 responded for the new members.

The newly elected members of Pi Tau Sigma are: F. Vilter, '27, N. J. Peters, '27, C. H. Traver, '27, E. T. Hansen, '28, D. E. Miller, '28, F. A. Mattka, '28, J. G. Baker, '28, H. L. White, '28 and R. Cahoon, '28.

The chapters represented at the convention were Illinois, Minnesota, Purdue, Missouri, Armour Institute of Technology, Cincinnati, Pennsylvania and Wisconsin.

The senior civils have completed their Milwaukee inspection trip, having seen the Empress and the Gayety, and are now capable of expounding on the subject: Why senior civils visit Milwaukee on inspection trips.

TWENTY-ONE ENGINEERS RECEIVE SOPHOMORE HONORS

Sophomore high honors were awarded to the following six engineers for excellence in scholarship: R. K. Neller, J. H. Forrester and W. B. Murphy, chemical engineering; A. T. Lenz and H. S. Merz, civil engineering, and W. H. Fuldner, electrical engineering. To merit sophomore high honors a student must make 165 grade points for 60 credits, and at least two grade points per credit beyond sixty.

These men received sophomore honors: civil engineering, P. D. Fell and J. A. Oakley; electrical engineering, F. R. Collbohm, B. A. Fairweather, R. W. Leach and H. Rommes; mechanical engineering, J. G. Baker, E. T. Hansen, F. K. Schefe and H. L. White; chemicals, C. E. Brown, N. H. Ceaglske, S. Fluegge, K. F. Johannes and L. C. Menestrena. Sophomore honors are awarded to those students who secure, during their first two years, 135 grade points, and 1½ grade points per credit for each credit above 60 required in their course.

A. I. E. E. STARTS ACTIVITIES

The local branch, A. I. E. E. started the semester's activities with a pepy meeting in the dynamo lab. on October 21. In getting re-acquainted the seniors swapped stories of the summer experiences. Prof. C. M. Jansky, faculty advisor, entertained with a short talk. The famous engineering triumvirate—Cider, doughnuts, cigarettes—were on hand throughout the evening.

MINING CLUB ELECTS OFFICERS FOR YEAR

The following miners have been elected to direct the affairs of the Mining club for the coming year: R. F. White, '27, president; H. C. Wiess, '28, secretary-treasurer; H. A. Smith, '28, junior representative to Polygon; R. M. Rodin, '29 and P. S. Rodin, '29, muckers.

UNIVERSITY CONCERT BAND BOASTS TEN ENGINEERS

When Congreve declared almost two centuries ago that "music hath charms to soothe the savage breast," he must have recalled the harmonious melodies to which St. Patrick drove the reptilian hosts from Ireland. To prove our point that since that memorable time the sons of St. Pat have been firm believers in the potency of music, we submit the following list of engineers who have been chosen to play in the university concert band: W. W. Behm, c'29; J. J. Reader, c'27; D. M. Britton, e'27; G. L. Lincoln, e'29; H. L. Stokes, e'29; J. K. Manning, m'28; R. Lhotak, m'30; J. E. Martin, ch'28, and R. E. Zinn, ch'27; F. A. Maxfield, e'29.

PAGE MARK TWAIN

In answer to the question: "Why is Venus a good drawing pencil?" given in the recent initiation quiz of the A. S. C. E., a junior wrote: "It has a figure you like to hold". The query, "Who was Henry VIII and why?" brought the reply that Henry wasn't to blame for what he was. Another initiate declared that Henry was the Eighth because his wife was the other seven-eighths.

Lawyer (sneeringly): Have you *ever* done anything on time?

Plumber: Hell, yes! I just bought a flivver.

IT SOUNDS REASONABLE

The word "development," to a locating engineer, means increasing the length of a railway or highway for the purpose of obtaining easy grades, but this is the way it is described by a junior civil in a recent quiz: "Development is the act of locating the line and developing the enthusiasm for the railroad among the towns which the line is going through and getting the support of all the farmers."

ENGINEERS IN UNIVERSITY R. O. T. C.

This year finds the engineers strong in the University Reserve Officers' Traing Corps. The following list of engineers who are commissioned cadet officers in the R. O. T. C. was obtained from the department of military science at the university:

Infantry—R. F. White, '27, lieutenant-colonel; J. C. Stowers, '27, and S. P. Zola, '27, majors; M. A. Brackett, '27, captain, and E. A. Jacobsen, '28, second lieutenant.

Artillery—M. J. Williams, '27, R. H. Brigham, '28, D. L. Harker, '27, and C. D. Highleyman, '27, captains; A. C. Herro, '28 and J. F. Gallbraith, '28, first lieutenants.

Signal Corps—R. D. Jordan, 27, major; V. B. Bagnall, 27, S. D. Cotter, '27, I. H. Gerkes, '27, W. H. Gilster, '27 and M. M. Morack, '27, captains; W. H. Fuldner, '28, R. Tyler, '28 and G. L. Beach, '28, first lieutenants; H. W. Zermuehlen, '28 and H. Romnes, '28, second lieutenants.

SO WOULD WE

Mr. Rose (in S & G 127): What would you do if your indicator-card showed that the compression and cut-off were late, while the release came early?

Buckmaster: Huh? I'd get a new engine!

Frosh Civil: How powerful is the telescope on this transit?

Mr. Beebe: When you look through that telescope, anything less than ten miles away looks like it's right behind you.

HATTON DRAWS RECORD CROWD TO A. S. C. E. OPEN MEETING

Speaks on Milwaukee Sewage Disposal Plant

Mr. T. Chalkley Hatton, chief engineer of the Metropolitan Sewerage Commission, Milwaukee, addressed a gathering of over 220 civil engineering students, members of faculty, engineers of Madison, and others, at an open meeting of the Student Branch of the A. S. C. E. at 7:30 o'clock, Thursday, October 28, in the Engineering auditorium, illustrating his talk with motion pictures.

"Who are you?"

"Justice."

"Justice who?"

"Justice good as you are."

Shy Little Thing to her Engineer Beau: Bill, are there divorces in heaven?

Engineer: Hardly. You've got to have a lawyer for divorces!

TECHNICAL SOCIETY VALUABLE TO THE ENGINEER, SAYS MEAD

That an active participation in the affairs and work of his technical society is as valuable to the engineering student as his achievements in the classroom, was the statement made by Prof. D. W. Mead, head of the department of hydraulics and sanitary engineering, at the mixer of the American Society of Civil Engineers, Thursday, September 30, in the Engineering auditorium.

Others who spoke at the meeting, which was attended by about 75 civil engineering students and members of the civil engineering faculty, were Prof. C. I. Corp, honorary chairman of the society, Jacob Levin '27, and Mr. Lewis H. Kessler, one of the charter members of the society.

In keeping with the spirit of the revival meeting, as one of the speakers aptly put it, the engineers were led by Mr. Kessler in singing some of the tunes that were created in the days of old to soothe the ruffled feelings of the lawyers across the campus. Of course, after having strained their vocal organs somewhat and having listened patiently to the various speakers, the engineers were regaled with cider and doughnuts, that time-honored symbol of good cheer.

"Bud" Lindner has quit smoking and is now saving five cents a day. The Stogie Company of America has recently entered a voluntary plea of bankruptcy.

The engineers have gone on a strike, declaring that if the "stiffs" in Science Hall can have elevator service there is no reason whatsoever why elevators cannot be installed in the Engineering Building.

PITY POOR NOAH

Professor Van Hagan reports the classes in Engineering English away to a good start this semester with the following definitions well out in front:

Biennium—a metal.

Flora—a species of animal somewhat like a fawn.

Riparian—a band of African rebels who recently engaged the French in warfare.

Sextant—a person in a church who rings the bell.

While passing through the cemetery, Bill came upon this inscription: Here lies the father of twenty-eight; there might have been more, but now it's too late.

Bill: "What are you doing now?"

John: "Oh, I'm running a filling station at the present time."

Bill: "Oh, you sell gasoline?"

John: "No, near beer."

TACKLING THE YEAR'S WORK

By Jacob Levin, *Senior Civil*

THIS attempt to arrange in definite form the principles and means of attacking the year's work is an outgrowth of a desire to pass on to undergraduate engineers some ideas that have been of much value to me in the several years that I have attended the university. If any of these suggestions go just part way toward making the year's work a little more enjoyable, and a little less monotonous, I will feel more than repaid for the time and effort put into this essay.

In the final analysis, the successful completion of the year's work depends entirely upon your work, day by day. To do justice to your daily work you must (1) have your materials when you need them, (2) know what you are going to do, and (3) do it. A little self-analysis will show that the five evils besetting your daily work are somewhat as follows:

1. Procrastination, or putting off until some other time that which you can do now;
2. The big dreamy idea of allowing your idle fancies to dominate your mind;
3. The endeavor to gather yesterday's loose ends;
4. Interruptions by loafers and callers;
5. Roundabout methods of work or lack of concentration.

"He who every morning plans the transactions of the day and follows out that plan holds a thread that will carry him through the labyrinth of the most busy life," philosophized the incomparable Hugo more than three-quarters of a century ago. A correct understanding and appreciation of this statement is the most effective way to eliminate the evils mentioned above.

As the first step in systematizing of your daily work, make a list of the materials and supplies which you will need during the semester. Even the best of roommates resents, and sometimes in no very uncertain terms, the Pardon-Me-May-I-Borrow-Your-Eraser-or What-Not chronic. A sure-fire roommate-insurance which will amply repay you during the course of the semester is to stock a plentiful supply of clips, pens, pencils, inks, blotters, erasers, report folders and paper. One of the fundamental principles in engineering is to plan with a good big factor of safety. Why not apply this rule to your desk-needs and buy your clips, rubber bands, paper fasteners and thumb tacks by the hundred, instead of forever hounding your roommate or neighbor?

A typewriter, paste-pot and pair of scissors, the time-honored tools of the journalist's craft, you will find indispensable in your daily work. Next to drawing instruments and India ink, the typewriter is probably the most important item of the engineer's equipment; and whether you are a "touch" expert or a "hunt and peck" artist, you will be able to turn out neat typewritten reports much like the ones you will write in later professional life. And here's a confidential tip you will appreciate: Ordinary scribbled reports, frequently as illogical as they are illegible, mean many a student's Waterloo; while neatly typewritten reports are an almost infallible means to create a favorable first-impression in the mind of your instructor.

We have thus far considered the tools and materials necessary for a successful attack on the year's work. Right now ask yourself, in the words of John Ruskin: "Am I inclined to work as an Australian miner would? Are my pickaxes and shovels in good order, and am I in good trim myself, my sleeves well up to the elbow, and my breath good, and my temper?"

The old Biblical saying has it: "To everything there is a season, and a time to every purpose under the heaven." This thought is really the secret of effective study—concentration. When you sit down to study, forget the little girl you danced with last Friday night, or what Jim said about Bob; and snap into your work. Do as the football man does: *Hit the line and hit it hard!* The following are suggestions for study which may be adapted to various courses and combinations:

(1) What is the purpose of the assignment?
(2) Review the previous lesson hastily before starting on advance work.
(3) Now get a preliminary reconnaissance of the new work—find the high spots first. Discriminate between essential and non-essential matter.
(4) Underline, as you go along, the important points in your text.
(5) Compare the text with notes taken in class or lecture.
(6) Supplement your study with articles from different texts.
(7) When you really understand the assignment, close the book and outline on paper what you have just studied. Compare with text and note omissions.
(8) Keep to your schedule of study so far as possible. Confine the work assigned to a certain time, and within that time try to finish the required work.

It is my hope that the above essay on "tackling" the year's work will be taken as suggestions to guide the way rather than as some magic formula for achieving the required results.

Editorials

THE E. C. M. A. CONVENTION The recent convention of the E. C. M. A. was, according to the reports of delegates, a most pleasant and profitable session of engineering journalists. The Minnesota Techno-Log was host to the association and provided plenty of good times on the side, thereby aiding the spirit of fellowship already existing between the magazines.

The convention discussed, among other things, the advisability of syndicated articles, ones to be published through all of the magazines simultaneously. One of the most marked advantages of this type of article is that successful engineers, too busy, perhaps, to write articles for a single magazine of limited circulation, might feel it worth while to give their time to write for the combined circulation of E. C. M. A. This would obviously help all the magazines, raising their standard, and as there is little or no overlapping of circulation, it would not interfere with the sales of the publications.

The question was raised, too, of backing more strongly the activities of the various engineering schools. Doubtless there is little enough cooperation at present and there seems to be a mutual lack of interest between the activities and the magazine in many schools. The remedy for this—more cordial and intimate relations between these groups, with the magazine fostering the activities—would be an advantage to all concerned.

A system of rating member magazines was discussed. The rating given by Barnhill for adherence or lack of adherence to good advertising practice will be continued, and a rating according to adherence to standards of practice in regard to editorial matter will be started. This rating is intended primarily to show each member magazine how it stands in this important matter in relation to the other publications. It is hoped that the members that come thru with a low rating for successive months will take the rating as an incentive to put out a better magazine. The relative progress of the magazines can be closely observed.

The *Wisconsin Engineer* wishes to thank the Minnesota Techno-Log for its kind hospitality, and to express its appreciation of the business-like fashion of conducting the meetings of this convention—one of the most successful ever held.

SELLING TECHNICAL TEXTBOOKS The Biblical action of Esau, who sold his birthright for a mess of pottage finds a ready repetition in the practice of certain engineering students who sell their technical textbooks to increase their present stock of sheckels. Many are the students who, having read a textbook in the course of the semester, appear at their favorite bookseller's and sell their valuable books for a mere "mess of pottage".

It is obvious that the second or third time we read a book we get out of it vastly more than the first time. Similarly, technical books that we have studied in the classroom and annotated with our particular system of hieroglyphics are certainly more valuable to us for the reason that we can readily find in them what we want. Furthermore, the technical books used in the engineering classrooms, being for the most part standard works in their particular fields, serve as indispensible references in later work. For the benefit of those engineers who are inclined somewhat toward economic reasoning, it may truthfully be said that although in the "short-run" we may gain by the sale of our textbooks, experience proves that in the "long-run" we lose by such action.

WACKER DRIVE Wacker Drive is completed. Chicago's newest and most astonishing engineering development was officially opened to traffic on October 20. Engineering ingenuity has been at work in Chicago for the past two or three generations. During the rapid growth of that great city, engineers kept pace. For a time the great commercial developments became so rapid that engineering-thought centered on specific details; skyscrapers, rapid transit surface lines, elevated railroads and automobiles. In the midst of all the development Chicago has become tied in a knot. The famous Loop, so necessary for rapid transportation, threatened to choke the very district which it fed. The enormous number of people pouring into the Loop district brought the most serious congestion.

With the opening of Wacker Drive comes a new chapter in the history of Chicago's rapid development. It is the newest attempt to meet the traffic problems brought on by such complete centralization—to relieve the congestion which has been brought about by continuous engineering developments keeping pace with rapid commercial growth.

Double-storied streets are now in order. Over eight millions of dollars have been spent in starting to build another Chicago on top of the one already present.

Wacker Drive is an engineering job of which Chicago may well be proud. It has improved the river-front in both appearance and usefulness; it has provided a by-pass for the Loop; it has attempted, not to solve the traffic problems, but to allay them—at least to loosen the knot temporarily; it is a tribute to engineering ability to keep pace with commercial centralization.

ENGLISH AN ENGINEERING ESSENTIAL "An American engineer's greatest asset is his ability to write and speak English correctly, elegantly, and vigorously. He can employ mathematical sharps to make his calculations, foreigners to translate letters written in foreign languages and to reply to them therein, specialists to help with advice and to make his plans, but he cannot hire any one to talk for him to capitalists and other men of importance or even to prepare his reports, although it is true that he might obtain a certain amount of assistance by having an expert writer to polish his literary productions."—*J. A. L. Waddell, in May issue of Professional Engineer.*

THE PLACE OF THE ENGINEER Within the memory of the elders of today, this nation has turned from a land of scattered agriculturists to a compact unit of industrial production. And this is in the face of a multiplying population with multiplying food requirements, in the face of increased acreage with increased output per acre.

The change has come through the development of a body of men known as engineers, who have delivered us from the consuming losses of chance by giving us the science of controlled and directed effort.

They have put machinery to do the drudgery of detail in office, store, factory, farm, and home. They have put methods into management, facts where guess-work had been, knowledge where ignorance had taken toll.

These engineers, of whom we hear so little and upon whom we are daily becoming more dependent, have carried out a successful revolution which has turned this country into the greatest of industrial nations.

Today they are making themselves felt in the reconstruction of our standards of intercourse, in the improvement of both social and industrial laws, in the betterment of ethical and moral principles.

They have earned this position of influence through having analyzed the purpose of life and through the evolution of a science of progress founded upon fact.

You will do well to follow the activities of the engineer. Your future depends upon him, not merely your financial success but the revaluation of our world and its progress out of chaos into sound prosperity.

—*Hotel Management.*

HIGHWAY RESEARCH

(*Continued from Page* 52)

The majority of new states now build their concrete roads of the thick edge section. This section, when properly balanced, results in an equal strength slab.

An extremely interesting article on "Computations of Stresses in Concrete Roads" has recently been published, and by using the tables, it is possible to investigate the balanced design of the various road sections.

The value of reinforcement in concrete roads has been studied and an exhaustive pamphlet has been printed that presents the results of a fact-finding survey. The conclusions, fourteen in number, are too long to permit of their appearing in this hasty survey.

The control of the cracking of concrete roads has received recent attention. One state, in experimenting with "planes of weakness," has reported interesting data. This study is still being carried on and is well worth watching.

The longitudinal center joint appears to solve the problem of preventing the unsightly longitudinal cracks appearing in the older roads. It is being rapidly introduced into many states.

Materials—The studies of materials goes on each year, and with gratifying results. Wear tests on concrete have given much information that is of assistance in the selection of the aggregate.

The tests of bituminous mixes on the Bureau of Public Roads Circular Track and those by Prevost Hubbard have resulted in a new concept of bituminous mix.

From elaborate tests on the fatigue of concrete, it has been proved that the endurance limit of stress is approximately 50 to 55 per cent of the static load.

Maintenance—The study of economical and proper maintenance has been carried on with the same vigor as the design and construction. Uniform guide and caution signs have been adopted and this will prove a blessing to the automobile driver.

Studies on crack fillers for concrete roads have been carried on in several places, as have those on zone paints which mark the highways.

Miscellaneous—During the past few years intensive experiments and fact-finding surveys have been conducted on culvert pipe for highway purposes.

A survey of existing culverts has just been completed. This study was undertaken in order that culverts could be "rated" and an economic value placed on them.

In addition to this survey, at least three large-scale tests have been performed in this country to determine the earth loads transmitted to the culvert. The writer has been in active charge of one of these tests and is much more familiar with these tests than others mentioned in this article.

Space will not permit a complete description of these tests, but it may be interesting to note that vertical weights, radial pressures and deflections at each foot height of fill are recorded.

From the brief resume of the highway research projects, it can be understood that there is vigorous action to secure adequate data to construct and maintain highways that will be an everlasting monument to the engineering profession.

Research is accepted today by all professions as a means to know the facts, and it is necessary for the progressive to follow the findings of the research and to apply them.

Throughout the development of civilization, language has been not only the essential vehicle but also the greatest stimulant for thought.—H. H. Higbie.

Engineering Review

FLYWHEEL EXPLOSION WRECKS POWER PLANT

Described as one of the most violent accidents of its kind occurring in recent years, a flywheel explosion took place at about 10:30 p. m., Wednesday, July 21, at the plant of the King Paper Co., Kalamazoo, Mich.

The engine was a cross-compound having 20-in. and 38-in. diameter cylinders, with 48-in. stroke. It carried an 18-foot flywheel and its normal operating speed was 85 r. p. m.

The watch engineer going off duty was attracted by an unusual noise in the engine room. He, with the engineer coming on duty, ran toward the engine, which at that time had attained considerable speed with the main drive belt in place. An attempt to operate the governor unhooking device by the use of the starting bar was unsuccessful. The engineer started to close the throttle, but was cautioned against doing so on account of the anticipated failure of the main drive belt and the wheel.

The men ran from the engine room to the boiler room just as the main drive belt broke; and the time between the failure of the belt and the failure of the wheel was estimated at two or three seconds. The wheel was of the twin type, having two parts with independent hubs, spokes and rims, but with provision for bolting the rims together to form a single wide rim, double-armed wheel, the face of which was 52 inches in width. Sections of the wheel, some of which weighed approximately a ton, were found more than a quarter mile from the plant. Those containing the joint, indicated failure took place in the rim of the wheel close to the joint, but the joint bolts were of such strength that they did not fail, and in fact showed very little stretching as the result of the stress set up by the over-speeding.

It is probable that the quality of the steam furnished to the engine following the blow-down of the boilers, caused the speed of the engine to decrease. Those operating the machinery noticed the drop of speed, so relieved some of the machines of their load, which, of course, would react on the engine to the extent that it would be inclined to speed-up, as it undoubtedly did. But it speeded up so rapidly that the governor belt, which may have been saturated with oil, failed to grip the pulleys, placing the engine beyond the governor control, which then attained a speed sufficient to disrupt the flywheel. —*Power.*

STEAM TURBINE UNIT OF 208,000 KW. CAPACITY

The steam turbine-generator unit rated at 208,000 kw., nearly three times as large as any of the giants in service today and nearly half again as large as any under construction anywhere in the world is being built at the Schnectady works of the General Electric Co., for the new State Line station on Lake Michigan.

This turbine-generator will be unique in many respects. Not only is it to be the largest, but it will incorporate the largest 1,800-r.p.m.-generator ever constructed, and it is said to be the first to use live steam for reheating. It will also be the first turbine-generator to generate current at 18,000 volts. The unit includes a high-pressure element and two low-pressure ones. Steam is admitted to the high-pressure 76,000-kw. element at 600-lb. pressure and at 730° F. From there, at reduced temperature and pressure, the steam passes to the reheater using live steam, where it is raised to a temperature of 500° F. It is then divided and passed to the two other turbines, each rated at 66,000 kw.

The enormous size of the unit is evident when it is stated that it has a rated capacity of 63 per cent of that of the Niagara Falls Power Company's hydro-electric generating station. More than two tons of Illinois low-grade coal will be consumed each minute for steam generation. Cooling water, which will be pumped from and back into Lake Michigan, will amount to 400,000 gallons per minute, and the generator-cooling air will total 350,000 cu. ft. per minute.

LUMNITE CEMENT USED IN RAISING SUBMARINE

An unusual use of quick-hardening cement was described by Commander Elsberg in telling of the difficulties encountered in raising the sunken submarine S-51. The main problem was to make the undamaged compartments water-tight so that the water might be expelled by compressed air. To effect this, scores of valves inside the submarine had to be closed by divers. This was done after a thorough schooling and rehearsal on the sister-ship S-50. Two large flap-valves on 24-inch ventilating ducts offered a serious problem, as it was impossible to fasten these valves closed against internal air pressure.

After all attempts to seal the large valves by fastening the flaps had failed, it was decided that they could only be sealed by filling them with some material that would solidfiy and make them airtight. Experiments with quick-hardening lumnite cement showed that this war-time product would harden quickly even under the deep-sea conditions involved. Divers then tapped holes in the large valves and attached valve connections for a heavy rubber hose leading up to the rescue ship, Falcon. On board the "Falcon" the lumnite cement was mixed in a heavy steel tank in the proportions of two

(*Continued on Page* 73)

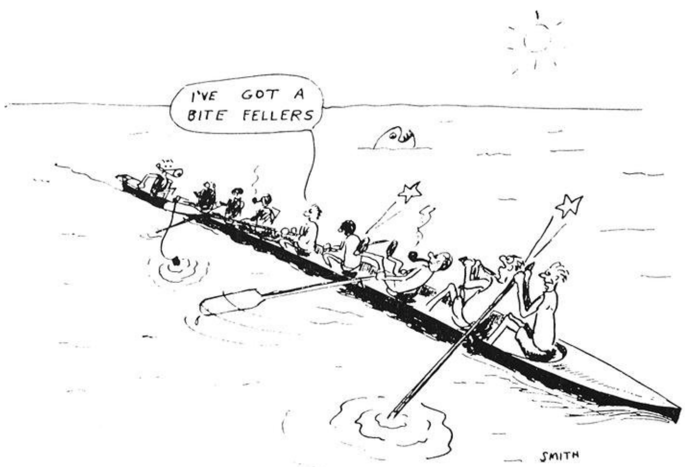
Alumni Notes

In the mid-summer issue of the Wisconsin Alumni Magazine, there appeared an article headed, "A Memorable Freshman Race," by L. W. Bridgeman, '06. There were eleven men on the squad that went to Poughkeepsie, and of those eleven men, seven were engineers. The following description will enable many friends of these Freshmen of 1903 to learn the whereabouts and something about the work of these men.

Cortelyou, George S., c'08 rowed at bow on the crew. Cortelyou is sales agent for the Griffin Wheel Co., Tacoma, Wash. His address is 911 No. G. Street.

Conway, William M., g'06 rowed at number two. Mr. Conway is a well-known contractor of Madison, Wisconsin. He has his home at 2105 Jefferson Street.

Johnson, Guy M., m'06 held down number four. Mr. Johnson is today with the Northern Indiana Gas and Electric Co. He is employed in the capacity of manager. His home is at 118 Pokagon Street.



Van Meter, T. E., g'07 rowed at number six. Today, Mr. Van Meter is manager of the Central Employment Office, Deere & Co., 1230 13th Street, East Moline, Ill. His home address is 2515 16th Avenue, Moline, Ill.

Burling, B. B., ch'06, E.E.'14 rowed at number seven. Mr. Burling is now head of the electrical department, Technical High School, Milwaukee, Wis. His home address is 747 51st Street, Milwaukee, Wis.

Johnson, F. Ellis, E.E.'09 was stroke on this memorable crew. He is now professor of electrical engineering at the University of Kansas. His address is 1630 Barker Avenue, Lawrence, Kansas.

Foster, Dean E., m'06 pulled an oar on the second varsity for three years and is now an engineer and natural gasoline manufacturer. His address is 304 New Wright Bldg., Tulsa, Oklahoma.

CHEMICALS

Greenidge, Charles, ch'26 is working on the development of a new coal carbonization process for the Milwaukee Electric Railway and Light Co., Lakeside Station. Address, Y. M. C. A.

Heimke, Hugo, ch'26 is working for the Du Pont Co. in Milwaukee.

Roberts, John, ch'23 was married to Miss Sada Buckmaster of Madison. They will live in Battle Creek, Mich., where Mr. Roberts is employed as an efficiency engineer.

Hansen, Russel, ch'26 is doing sales work for the Leeds Northrup Co. in the Chicago district. His present address is West Side Y. M. C. A., Chicago.

Harr, Russel, ch'26 is taking the College Training Course at the Western Electric Co., as preparation for Development work. His address is 612 N. Pine Street, Chicago, Ill.

CIVILS

Alk, Louis, c'25 was recently married to Miss Rosetta Segal, of Appleton, Wis. Mr. Alk is estimating engineer for the James B. Clow Co., of Chicago, Ill. Mr. Alk's address is 1009 Davis Street, Evanston, Ill.

Brumm, Roman, c'25 engineer for a Madison contracting firm, is in charge of the paving of highway No. 20 from Monroe to Juda.

Buck, Howard, c'17 football star and member of the All-American team in 1915 and 1916, has accepted a position as head football coach at Miami University, Miami, Fla. Mr. Buck is head of an automobile agency at Neenah and plans to spend but three months of the year, i. e., the active football season, in coaching work.

Harza, Leroy F., c'06, C.E.'08 consulting engineer of Chicago, has changed his address from 5470 Everett Avenue to 5210 Greenwood Avenue.

Howson, Elmer T., c'08, C.E.'14 is western editor of the Railway Age, 608 South Dearborn Street, Chicago, Ill.

Jensen, Harold W., c'25 is living at 47 South Boulevard, Oak Park, Ill., and working for the C. & N. W. Ry. He writes: "I am working in the shops as inspector on numerous jobs, which include a couple of 500-h. p. boilers, a cinder pit, extension of an engine house and concrete fire roads. Outside of that I have nothing to do, except that I like it."

Kueling, H. J., c'08, C.E.'11, Milwaukee, has entered into a contract to act as consulting engineer for the Krenn & Dato interests of Chicago, realtors. One of their largest operations at the present time is the building of the Edithton Beach, a model home city one-half mile south of Kenosha. Mr. Kuelling has bene closely identified with highway construction in Wisconsin, having been in charge of all construction work for the highway commission for the past eight years.

Lacher, W. S., c'07 is engineering editor of the Railway Age, 608 South Dearborn Street, Chicago, Ill.

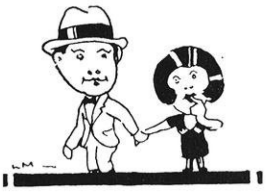
Moritz, C. J., c'11 president and manager of the C. J. Moritz Co., Inc., contracting company of Effingham, Ill., is author of a paper on Subgrading for Concrete Pavements, that was presented at the convention of the American Road Builders Association in January. The article appears in the April issue of Roads and Streets.

Mabry, Armon E., c'23 is on the engineering office force of Holabird & Roche, architects, of Chicago, Ill.

Reed, James O., c'08 is manager of the Garland Coal and Mining Co., Stigler, Okla.

Schmitt, F. E., c'00, C.E.'04 associate editor of the Engineering News-Record, is in Florida investigating the effects of the hurricane which swept across the southern part

of the state September 18. His mission it to report on the condition of engineering structures of various types in the storm zone and to suggest how the structural lessons learned in the Florida disaster may be applied to reduce or eliminate damage under similar conditions in the future. Mr. Schmitt will publish his reports in the Engineering News-Record.



Rheingans, W., c'20 was married to Miss Mabel Warnke, of Milwaukee, on September 4, 1926. Mr. Rheingans is test engineer for the Allis-Chalmers Co., of West Allis, Wisconsin. His address is 6505 National Avenue.

Swaty, D. Y., c'98 formerly with the Great Lakes Dredge and Dock Co., and the Cleveland Engineering Construction Co., has become an active partner in the firm of J. G. Kenan Co., general contractors, 6007 Euclid Avenue, Cleveland, Ohio.

Walraven, Peter, c'21 who has to his credit the superintending of the building of the largest reinforced concrete bridge in Michigan, located at Crystal Falls, has recently been elected the first city manager of Iron River, Mich. He was formerly city engineer of the same city.

Wheaton, Herbert, c'22 in charge of the Engineering Department of the State Teachers College, of Fresno, Calif., won a signal distinction among his colleagues and students when he planned a $50,000 stadium for the school, went out and raised the money for the building and finally took charge of the construction.

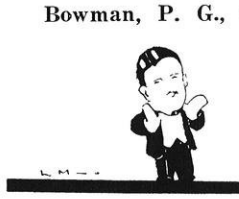
Thompson, Merville Spoor, ch'15, Ch.E.'24 chairman of the South Jersey section of the American Chemical Society, died suddenly September 6, 1926, following an operation for gall bladder trouble. He was a past secretary of the Section and had been active in its interests since it was formed.

Mr. Thompson was born in 1893 in Milwaukee, Wisconsin. Since 1915 he had been employed by the E. I. du Pont de Nemours & Company, for five years at the High Explosives Laboratory at Gibbstown, New Jersey, and the past six years at Jackson Laboratory at Deepwater, New Jersey, on dye research, where he had done some excellent work, especially on vat dyes.

While yet a young man he had shown marked ability in his profession and would have undoubtedly taken a leading part in future development of organic chemical industry. He will be greatly missed both among his business associates and in his numerous social contacts.

ELECTRICALS

Bowman, P. G., e'22 is with General Electric Co. at Schnectady, N. Y. The Edison Club Bulletin writes of him: "Mr. Bowman, who was at one time a 'Test-Man', was recently elected captain of the Edison Club canoe team for the coming year. He has always been an active member in the club and is well liked by all those who know him."



Chu, F. I., E.E.'14 informs us that he left Hanyang Works last December and is now employed as an engineer with the Government telephone administration, Shanghai, China.

Cowan, A. M., e'26 is in the Engineering Department of the Procter & Gamble Company, Cincinnati, Ohio.

Johnson, E. E., e'26 is with the Chicago Surface Lines as Test Engineer. Address, Room 1413, 231 So. La Salle Street, Chicago, Ill. He is living at 2935 Berteau Avenue.

Miller, Burton F., e'26 chief engineer of the radio station WHA, Madison, writes: "Tell the grads to get radio receivers ready for the basketball games. WHA will broadcast as many of them as possible. The wave-length is 535.4 meters, corresponding to a frequency of 560 kilocycles. Best wishes to all the old gang." Miller's address is 1303 W. Johnson Street.

McLenegan, D. W., e'21 is in the Industrial Engineering Department of the General Electric Co. McLenegan is also on the Edison Club canoe team, along with Bowman and Nerad, who are both Wisconsin engineers.

Nerad, A. J., e'23 entered the Testing Department of the General Electric Co. in June, 1925, and left in March, 1926, to take up new duties in Dr. Newkirk's department, the Mercury Turbine Development and Research Laboratory. Nerad is another man on the club canoe team.

Schleifer, A. C., e'08 reports that he is with the Squier-Rix Co., of Milwaukee, manufacturers of portable hoists. His home is at 296 Washington Avenue, Cedarburg, Wis.

Seastone, John, e'26 is taking the Student Graduate course at Westinghouse Electric Co., of East Pittsburg, Pa. His address is 7936 Susquehanna Street, Pittsburg, Pa.

MECHANICALS

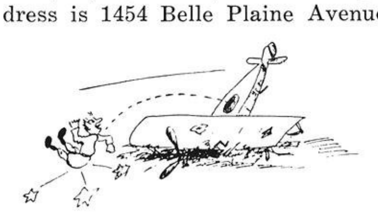
Clark, H. L., m'26 is an apprentice in hydraulics with Stone & Webster, Inc., of Boston, Mass. He is living at 820 Massachusetts Avenue, Cambridge, Mass.

Cox, E. L., m'22 is with the Monarch Products Co., manufacturers of weather strips, of St. Louis, Mo. In speaking of his trip from Madison to St. Louis this summer he says: "Arrived in St. Louis at 7:45 in the morning and immediately scouted around for a room. Nice job, I'll say—all you need is an unlimited amount of patience and no less than two pairs of shoes. You can bet I retired early that evening—was completely tired out." Address is 4960 Washington Ave., St. Louis, Mo.

Lathers, Victor, m'25 is employed by the Johnson Service Company, of New York City. His address is in care of the above concern at 118 East 28th Street.

Maurer, R. Edward, m'20 is with the Missouri Power and Light Company, of Mexico, Mo. He can be reached in care of the above concern.

Meyer, R. L., m'20 is employed by the Standard Oil Company (Indiana) as building superintendent. His address is 1454 Belle Plaine Avenue, Chicago, Ill.



Karnith, George P., m'24 writes to Professor Larson: "I will acquaint you with my history since I left school. I went to work with the U. S. Engineers, department of river and harbor improvement, serving in various capacities; running gasoline boats, testing these boats, and repair and construction of same, and lastly served as mate on steamboats. I also spent eight months as a flying cadet in the U. S. Air Service. I was very seriously injured in a crash and have spent the past two months in recovering my physical welfare." Karnith gives his present address as U. S. Str. Fury. Fountain City, Wisconsin.

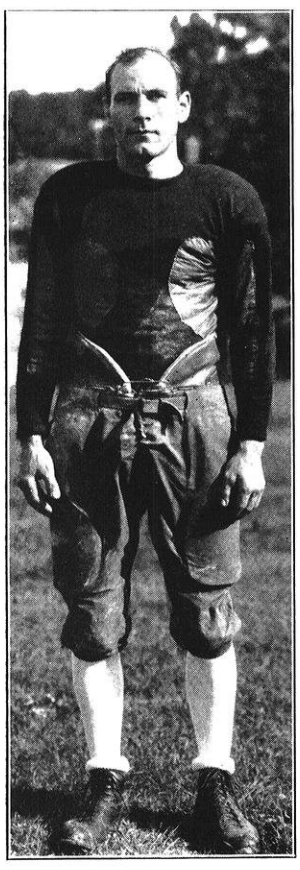
(Continued on Page 72)

Athletics

FOOTBALL

Slowed up a little bit by the combat with Minnesota, but never downhearted, the Badger eleven is preparing for a smashing finish to end the season. Since the beginning of school a large amount of likely material has reported for practice to Coach Little, and from this a varsity squad of 60 men has been selected to fight for Wisconsin. It has not been clear sailing, however. Night after night the fellows have been practicing hard, giving the best that is in them to the development of the Cardinal squad for the glory of Wisconsin. With the days growing shorter, spotlights and the ghost ball have come into use.

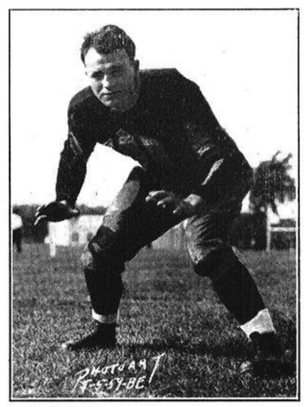
The College of Engineering, of course, has its representation in the grid machine, and to one carrying a heavy course in this college, football takes an appreciable bit of time. Six of the eight plumbers on the varsity squad are sophomores who, in their first year of the Big Ten competition, are doing very well. Binisch and Stupecky are soph civils; Puelicher and Cappa, electricals, and Engelke and Riviers, mechanicals; Schweers, junior civil, who has seen active service in the Hoosier and Gopher games, is developing into a real tackle. Bill Splees, senior electrical, having already made a name for himself in wrestling, is in his second year of football, and is out for the end position.



Splees, Senior Electrical

The season's preliminary games with Cornell and Kansas were quite easily won, but the Jayhawkers showed a bit of unexpected strength. They were not a match for Coach Little's agregation, however. The Purdue game, played at Lafayette, proved to be no easy picking. After two hours of wading and stumbling through mud and stopping to wipe off the ball, the Badgers narrowly averted a catastrophe in the shape of a Boilermaker touchdown, and when the game had ended neither team had scored.

The first score made against the Cardinals occurred in the match with Indiana when, punting a ball out of a dangerous position near his goal line, a Wisconsin kicker stepped back of the safety line. However, the opponents were neatly outplayed throughout the game in matter of first downs and completed passes, and there was no doubt that Wisconsin deserved the victory of 27 to 2.



Schweers, Junior Civil

Minnesota, however, was a different story. Coach Speers brought with him a squad of well-trained, capable players who were to prove a menace to Wisconsin's title race. Badger players seemed not at their best, but there was no doubt about the ability of the Gophers. They plunged and passed through the line for gain after gain and first down after first down; the Badger game of passing was even excelled. The Cardinal players, however, followed the ball closely and promptly took advantage of any break coming their way, in a fashion to please any follower of the game. The Cardinals made the first score by a touchdown—Minnesota followed with another and then a place-kick, and led at the end of the first half by a score of 9 to 7. Wisconsin's kick in the second half gave them a one-point lead until the last few minutes of play when the Gophers broke away for a touchdown and a well-deserved victory.

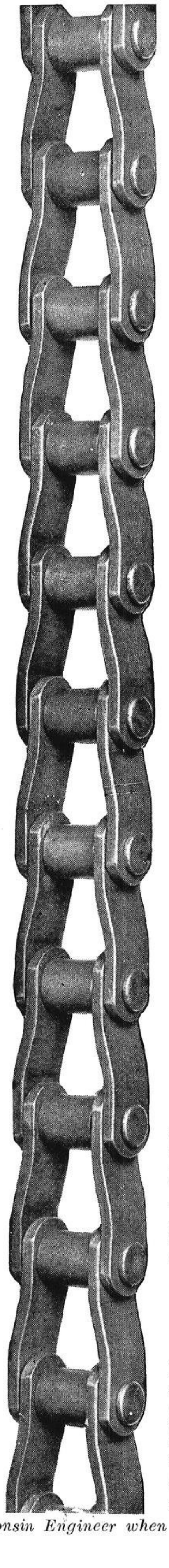
Without doubt Minnesota has one of the best teams in the conference, and the outlook for the future with Iowa and Chicago is favorable, more so than for the Michigan game. However, with the good material out and the excellent coaching of George Little and his assistants, Wisconsin need have no fear of the future. A conference championship may not be cornered, but at least the Cardinal is represented by a real team of hard-fighting, clean-playing Wisconsin men.

CROSS COUNTRY

Ordinarily at the opening of a season, with but two meets held, a prediction of a championship would be rather unfounded. But when the team has made such sweeping victories as the Badger cross country team has, such a prediction is quite in order. Coach Jones has a well among the first so that Wisconsin won by an easy years Wisconsin has rated ace-high in the field of hill-and-dalers.

The first meet, the quadrangular at Chicago, in which Chicago, Indiana, Northwestern and Wisconsin competed, was a walk-away for the Badger harriers. Four tied for first place, and four more finished before the representatives of any other school, and the remainder

Your Business & Ours



Whether you are
a student an executive or an engineer

Whether you are a student, an executive or an engineer, if you are interested in industry we would like to tell you more about material handling.

You can hardly be interested in industry without seeing the opportunities for conveying machinery.

Perhaps it may not appear so at first, but have you ever gone over the list of industries that have found a place for conveying during recent years? Automobiles, of course, but do you know that we have built conveyors for fig packers, for fisheries, for bottling plants, for washing machine manufacturers, for stove manufacturers, for foundries, for steamships, for warehouses and a host of others?

The men running these businesses put in these Systems because Rex Conveying reduced costs over other systems of material handling.

Your business needs Conveying—our business is to supply it. Why not write about getting together?

REX CONVEYORS

CHAIN BELT COMPANY
759 Park Street Milwaukee, Wis.

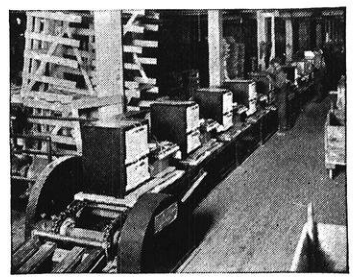
What Conveying Accomplishes

Conveying does more than carry.

A system of conveyors is more than a means of material transportation.

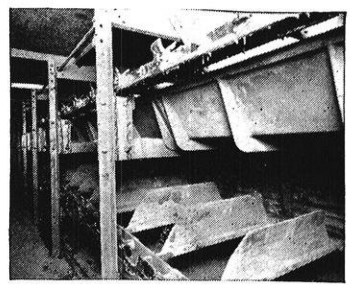
Some of the things that Rex Conveyors have done in manufacturing plants—some of the things they may do for you are:

Simplify Assembly
Balance Production
Reduce Costs



Rex Progressive Assembly Conveyor Handling Stoves

Improve Quality
Save Floor Space
Increase Capacity
Control Production
Reduce Accidents
Reduce Inventory



Rex Scraper Flight Conveyor for Recovery of Foundry Sand

Break the Bottle Neck
Reduce Time in Process
Simplify Production
Better Deliveries

Make Equipment More Productive, Labor More Efficient, Power Factors More Favorable, and Business Easier to Run.

If you are interested in any of the above, it is the time for us to get together.

Will you start by writing us?

Among the Products Manufactured by the
CHAIN BELT COMPANY
are:

Rex Conveying Machinery for handling materials of all kinds. Rex Chain for power transmission or conveying materials. Rex Concrete Mixers for construction work. Rex Concrete Pavers for streets and highways. Rex Power Transmission Equipment. Rex Traveling Water Screens.

THE CHAIN BELT COMPANY and its affiliated organizations employ approximately 2,000 men.

well up among the first so that Wisconsin won by an easy score. The score was Wisconsin 15, Indiana 57, Northwestern 67, and Chicago 71.

The next meet, with Minnesota, who had several veterans on the squad, was very similar in its ending. Four Cardinal runners again tied for first place and were followed by another, making the lowest possible score for the record time and winning from Minnesota to the tune of 15 to 40.

In both of the meets engineers have had strong representation in John Zola, junior chemical. He has run a fine race. Other plumbers out for the varsity squad are Ryden and Egger, soph civils; Walters, soph electrical, and Menestrena, junior chemical. With such a good start to their credit it seems as though Coach Jones' men would finish the season conference champions for the third consecutive year, a team and a coach of which Wisconsin may well be proud.

ALUMNI NOTES

(*Continued from Page* 68)

Nelson, C. O., m'23 is employed by R. B. Whitacre & Company, Inc., of St. Paul, Minn. The address is 201 So. Roberts Street.

Risteen, H. W., m'24 is with the State Highway Commission. His headquarters are at Eau Claire, Wis. His permanent address, 710 Coleman St., Chippewa Falls, Wis.

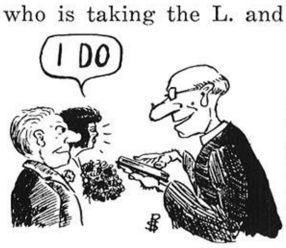
Rowley, Prof. E. B., m'05 is a member of the faculty in the Engineering Department of the University of Minnesota. Professor Rowley presented a paper, "Electrical Inventions" at the Electrical Engineers' Convention, held in Lexington, Kentucky, in June.

Fitze, Maurice E., m'24 is the happy and proud father of an 8-pound baby girl, born August 15, 1926. Mr. Fitze is the test engineer for the Milwaukee Electric Railway and Light Company, of Milwaukee.

Frank, R. A., m'18 is assistant genaral manager of the Unity Sheet and Steel Company, of Milwaukee, Wisconsin.

Shoemaker, William T., m'26 is with the Miller Lock Works of the Yale & Towne Mfg. Co., at Frankford, Philadelphia, Pa. He writes: "After spending a profitable five months with the Holeproof Hosiery Company, in Milwaukee, I came East in July and have been holding the job of Time Study Engineer with this company. Last week-end the firm sent me to Stanford, Conn., to see the Yale & Towne home plant. I was there Friday and Saturday and spent Friday evening in New York with Ted Ziegler and Wenzal Fabera. It was a treat to see them both at the same time and we had a great time talking over old times." Shoemaker's address is in care of the above concern.

Squier, Samuel H., m'15 of the Squier-Rix Company, of Milwaukee, was in Madison, October 26, visiting his brother, who is taking the L. and S. course.



Yeager, Walter C., c'22, and Miss Gertrude Renter, of Milwaukee, were married on May 12. Mr. Yeager is in the engineering department of the Wisconsin Telephone Co., at Milwaukee.

Stewart, F. C., m'23 is Professor in Engineering at the University of Texas, at Austin.

ENGINEERING REVIEW

(*Continued from Page* 62)

of cement to one of water. The tank was then closed and 150 pounds of air pressure applied to force the grout through 250 feet of hose to each of the flap-valves. The cement was allowed to harden for two days, and when tested the compartments proved to be water-tight. The submarine was then raised to the surface with the added lifting power of eight large pontoons.

FIFTY-MILLIONTH HORSEPOWER REACHED IN U. S.

With the arrival of the 50-millionth horsepower mark reached in the productive capacity of the United States, September 1 of this year, there has been realized a prime mechanical force of 450 h. p. for each thousand of population in this country. Regardless of war's depressions, or "business cycles," prime-mover machinery in industries and the power-houses of the country have increased with phenomenal regularity since the beginning of the present century. While the grand total of power is growing at an even rate, the installation is now showing a decline. Industries have, in some cases, found it more profitable to secure their power from the lines of the light and power companies rather than to make it themselves. The 450 h.p. per thousand of our population, it is pointed out, compares most favorably with 310 h.p. for Great Britain and may suggest one reason for the present disparity in the prosperity of the two countries.

LARGE ASPHALT BEDS IN PHILIPPINES

A large deposit of excellent asphalt has been discovered near the coast of the Island of Samar, according to reports from Manila. At least 40,000,000 tons of the bituminous substance are available, declare engineers who have examined the site. Operations are being planned for the near future. This is the second large asphalt deposit discovered in the Philippines.

The first was found on the island of Leyte and is now under Japanese control, having been sold to Japanese interests after vain attempts to interest American capital. The new asphalt tract is situated in the municipality of Borongan, within easy and close access of deep water navigable by ocean steamers.—*Engineers and Engineering.*

METAL MINE ACCIDENTS

Records of metal mine accidents compiled by the Bureau of Mines show the highest accident rates at mines working nine hours per day. The lowest rates were for mines working ten hours per day. A large majority of the metal mines are operated on the basis of eight hours per day; the figures for 1924 show 83% of all under-ground men were employed on this basis. The accident-frequency rate for the 8-hour group was 162 accidents per 1,000,000 man-hours worked in 1924, compared to 159, 146 and 147 in the three preceding years. The rate for the 9-hour group was 167 in 1924 as compared with 204, 159 and 146 for the three preceding years.—*Engineering and Contracting.*

MAINTAINING COMBUSTION EFFICIENCY BY THE AIR-FLOW STEAM-FLOW METHOD

By R. H. SOGARD, m'26,
On Test Force, Lakeside Station, T. M. E. R. & L. Company

THE heart of a steam plant of any kind lies in its boiler room, and it is there that the greatest economies can be effected. Nearly constant efficiency in prime movers is caused by careful design and construction on the manufacturer's part, but continuous high efficiency in the boilers is caused by good operation.

Efficiency in the boiler depends largely on complete combustion of the fuel with as little excess air as possible. The heat losses in a boiler are: (1) unburned fuel, (2) unburned gas CO, etc., (3) heat in flue gas up the stack, (4) heat in water vapor formed by combustion, and (5) radiation. The first three losses are controllable, and the last two practically unavoidable. To minimize these three controllable losses, the fireman must supply the correct proportions of air and coal to the boiler furnace.

Air is as much of a fuel as is coal, for it is the interaction of the carbon (largely) in the coal and the oxygen of the air that produce heat. Furthermore, air can be measured more easily than coal. So why not have a ratio of pounds of steam per pound of *air*, as well as steam per pound of coal? By analysis of the flue gas, the best ratio of air to steam (that one giving complete combustion with as low excess air as possible) can be found. Now, if a steam-flow meter and an air-flow meter are on the boiler instrument board, the fireman can maintain the correct ratio of air to steam (in other words, of fuel to steam). He knows that he is not supplying so much air (for a given steam-flow) that a great deal of sensible heat is going up the stack in flue gas. He also knows that there is sufficient air to insure complete combustion with minimum losses of unburned coal and CO. Too much excess air is a more common fault than to little. Though air seems the cheapest raw product used in a steam plant, too much of it will prove to be the most expensive when one considers the cost of the extra coal to heat that "too much" to 500° or more and then blow it to the sky.

Steam flow from the boiler is usually measured by either an indicating or a recording orifice meter. Air flow through the boiler furnace is measured by calibrating the furnace itself as an orifice: by measuring the pressure drop from the second pass to the last pass. Steam-flow units may be either: (1) thousands of pounds of steam per hour, (2) boiler horsepower, or (3) per cent of boiler rating. In whatever units the

steam-flow meter is calibrated, the air-flow meter is calibrated in those same units. The proper ratio of air to steam is unity; in other words, the best combustion efficiency is obtained when air-flow equals steam-flow. Thus, if the fireman sees that his boiler is (by the steam-flow meter) delivering steam at 175% rating, he so sets the air-flow that the air meter indicates 175%. Or (with different steam-flow units) if the steam-flow meter indicates 2200 boiler horsepower, the air meter should show 2200 on its scale of abstract units.

This system of maintaining combustion efficiency by the correct ratio of air flow to steam flow was originated and developed by the Bailey Meter Company, of Cleveland. It is in wide use today and has proven effective in reducing boiler losses in everyday operation. Its installation demands only calibration of the boiler furnace, checked by analysis of the flue-gas. At Lakeside station, it is customary to check the accuracy of the air-flow steam-flow instrument relations bi-weekly, by analyzing the flue-gas and checking its actual CO_2 content against that indicated by the ratio of air to steam.

The air-flow steam-flow installation (backed up by occasional checks with an Orsat flue-gas outfit) is greatly superior to automatic CO_2 machines in simplicity and reliability. The correct flow of air for a certain flow of steam may also be maintained by automatic equipment, instead of being manually controlled by the fireman.

For any one interested in combustion at present in boiler furnaces, there is an excellent article in the July, 1926, issue of *Mechanical Engineering*, entitled *"Limiting Factors in Reducing Excess Air in Boiler Furnaces,* by E. G. Bailey.

The damage done by marine borers to wharf timbers and piling from Antioch to San Pablo Bay, California, in one two-year period, is estimated to have amounted to $15,000,000.

SLEEP TESTED ELECTRICALLY

That the electrical resistance of the human body is markedly increased during sleep, and that the quality of our sleep may be measured and studied experimentally by electrical methods, is the unusual discovery made by Dr. C. P. Richter at Johns Hopkins Hospital in Baltimore. In one case the onset of sleep automatically raised the electrical resistance of the body from 30,000 ohms to 500,000 ohms.

By means of his equipment Dr. Richter has proved the idea that the resistance is localized almost entirely in the skin of the body. A puncture thru the skin with a needle reduces the resistance almost instantaneously to a value practically equal to zero. In one case a hole through the skin of the left hand caused a drop of 250,000 ohms. Later a hole punctured thru the skin of the other hand caused another drop of 235,000 ohms. —*Scientific American.*

HELL GATE TO HAVE 160,000-KW. TURBO-GENERATOR

According to an announcement made recently by the United Electric Light & Power Company, of New York, there is to be installed in the Hell Gate station a turbo-generator which will be the largest single unit in the world. The order has been placed with the American Brown Boveri Electric Corporation, and the installation is to be made under the supervision of Thos. E. Murray, Inc.

The new turbo-generator will have a rated continuous load-capacity of 160,000 kw., or about 250,000 h. p. It will generate current at 13,800 v., 60 cycles. The steam turbine will be of the reaction type thruout. It is designed to occupy the same space allotted to each of the other seven units now installed at Hell Gate and its installation will complete the equipment of the present station building. This will bring the station capacity up to 445,000 kw. The turbine will operate under the present steam conditions of the station, 265-lb. pressure at turbine throttle, with 200 deg. super-heat, and it is designed for bleeding steam for feedwater heating. The high-pressure turbine portion is designed to be capable of utilizing steam at a maximum temperature of 750 deg. F. The unit will weigh approximately 2,800,000 pounds and the heaviest single piece will weigh 330,000 pounds.—*Power Plant Engineering.*

PRESENT DAY HYDRO-ELECTRIC PRACTICE

(*Continued on Page* 51)

There are practically never two installations for which the same solution is applicable. Each set of conditions requires careful and thorough analysis with comparative estimates on different types and methods of construction. There is usually the alternative of low-priced, inefficient, short-lived machinery which, while meaning a decided saving in first cost, is liable to run into many unforseen items of upkeep. There is also the other extreme of spending an amount for machinery and equipment entirely out of keeping with the income derived from the plant. There are certain instances of plants on streams with variable flow where less-efficient and lower-priced equipment should be installed. It is up to the engineer to solve both questions, that is, the engineering features as well as the commercial feature, in order that the plant will result in a satisfactory and commercially paying proposition.

To those interested in the study of hydro-electric developments there are a number of plants within easy range of the central part of Wisconsin. For instance, the Kilbourn and Prairie du Sac plants, the Montery plant at Janesville, the Appleton Traction plant at Appleton, the plant at Mauston, the Kimberly Clark plant at Kimberly, and the Green Bay and Mississippi Canal Company's plant at Kaukauna. There are also a large number of plants around Eau Claire, Wausau, and Wisconsin Rapids. Practically all of these plants are open to visitors, or arranagements can be made so that engineering students can visit and inspect the installations.