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THE WISCONSIN ENGINEER

VOL. XIII JUNE, 1909 NO. 4

MESABI RANGE MINING.

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Introduction:—The object of the following article is to describe in such detail as its scope will permit, the three prominent methods of mining on the Mesabi Iron Range of northern Minnesota, the open-pit, milling, and underground systems, paying particular attention to open-pits and their development. The methods have been named, and will be treated in the order of their importance and economy.

Location and Geology.

The Mesabi Range occupies the "height of land" or drainage divide of northern Minnesota. It extends from Grand Rapids on the Mississippi River, or a little west of there (Range 27), in a general northeast direction, for 120 miles.

Lying on the southeast side of the granite core of this range, are the Lower Huronion slates and greywackes, and the Pokegama quartzite. Between the quartzite slates and granites, and the Virginia slates to the south, is the Biwabik iron bearing formation, which extends the entire length of the range. The whole Mesabi district has been heavily glaciated, and is covered by a moraine blanket. As a result only isolated outcrops of the Archean and Huronian rocks are found.

Ore-bodies.

The great mass of the iron-formation is a ferruginous chert (locally called taconite), together with the original greenalite and iron carbonates. Locally, where the circulation of ground waters has effected concentration, ore-bodies are found, in trough-shaped masses, whose longer dimensions lie in an east-west or northwest-southeast direction. Many of them are scores to a few hundred acres in extent, and average a few hundred feet deep. Their mass comprises 1 per cent to 2 per cent of that of the iron formation. The glacial drift covering the ore-bodies and iron-formation varies in depth from 10 feet to more than 150 feet, but local variations over an individual deposit are not so pronounced. The ore is a hydrated hematite, mixed with limonite, giving the whole mass an earthy appearance. It is unconsolidated in comparison with the ores of the old ranges of the Lake Superior district, though compact enough to stand in the bank.

The limits of the ore-bodies are characteristically different in different parts of the district. In some localities the ore grades gradually into taconite; in others, high grade ore often ends abruptly against a wall of this rock. On the north boundary of the formation a few bodies run into quartzites, the foot-wall formation, while on the south the ore generally grades into the Virginia slates. Between these limits the ore-bodies are bounded by taconite walls and basins.

Exploration.

The geologic limits and areal distribution of the iron-formation have been well determined through the work of the United States Geological Survey and the mining companies.* Therefore exploration is confined entirely to the area thus determined. The flat-lying nature of the formation and the moraine blanket covering it, make the use of drills and test-pits the most practicable method of exploration.

Mining claims are divided according to the common township-range-section system of land subdivision. Whenever a

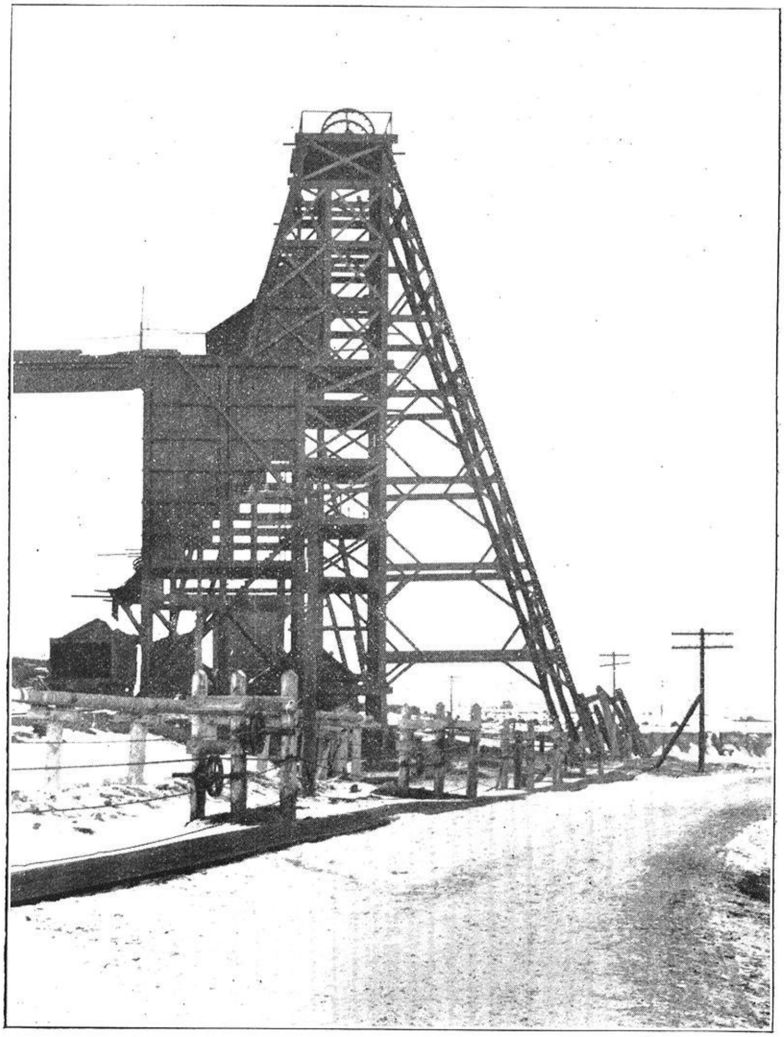
* Monograph No. 43, United States Geological Survey.

property is to be explored, a system of nine holes to the forty acres is commonly used. If ore is found these holes are interspaced with others, giving a system of holes spaced rectangularly, 300 feet apart. One hole per "forty" is drilled to quartzite. Test-pits were formerly used to a great extent down to ore, and as far into ore as ground-water would permit. The present practice is to drill from the surface. Drilling in rock is done with diamonds; in ore and surface the churn drill is used. Churning is continued through ore, and the hole is drilled to a considerable depth in taconite. If taconite is found immediately beneath surface, drilling is continued for 50 or 60 feet to be sure that no ore occurs beneath this rock. The depth to which to drill in taconite, whether immediately beneath surface or in the bottom of an ore-body, is a matter of the engineer's judgment, based on surrounding holes and neighboring ore-bodies.

In ore samples are taken every five feet and analyses of the ore, dried at 212° F., are made for iron, phosphorus, silica, manganese and alumina. The method of taking a sample is as follows: The hole is cased when ore is struck, and a stream of water is sent down the core-barrel as the churning proceeds. This water, rising up in the casing-pipe, carries the churnings with it. The overflow is allowed to run out and to settle in barrels. The settlings are dried and sent to the laboratory for analysis.

Determination of Method of Mining.

After a property has been drilled, circumstances and physical conditions determine how it shall be mined. If capped by taconite, or if the deposit is small and covered by a heavy overburden, underground mining is the logical method. If capped by paint-rock (altered ferruginous slate) or mixed-ore, and the deposit is large enough, it may be stripped, the lean ore stock-piled and the good ore mined in the common open-pit style. If the ore-body is small and the overburden not too great, the milling system may be used. Either open-pit or milling methods may be interfered with by natural location, inaccessibility, difficulty of approach, impossibility of obtaining suitable dumping grounds, drainage, or a combination of these factors. Lands necessary for approaches may contain ore or be in the possession of other parties, and



Wooden head-frame with pocket and stock-pile trestle.

the expense of acquiring such properties may be prohibitive. The demand for ore, the time limit of lease (if the property is a lease-hold), and the interest on development investment, are also considerations of importance. These and similar factors, rather than the best engineering practice, often determine the method of mining to be used.

Depth of surface is a very important factor in open-pit development. Depths as great as 100 feet are being removed in some pits, and plans have been made to remove depths of more than 150 feet. A ton of ore for a cubic yard of surface is the common criterion of a good stripping ratio.

Open Pits.

Importance; Operations and Equipment.

A few comparisons suffice to establish the great economic importance of the Mesabi and its open-pits in the iron-mining world. In elven years the Mesabi produced 46,000,000 tons of ore, an amount which it required forty-six years for all of the old Lake Superior ranges combined to produce. Of the total Lake Superior production up to 1909, the Mesabi produced 167,500,000 tons or 41 per cent, all during the seventeen years, from 1892 to 1909. One-sixth of this total was produced in 1907 alone. In 1906 the Mesabi produced 49.6 per cent of the iron-ore produced in the United States, and eight open-pits produced 53 per cent of this, or over a quarter of the United States production.

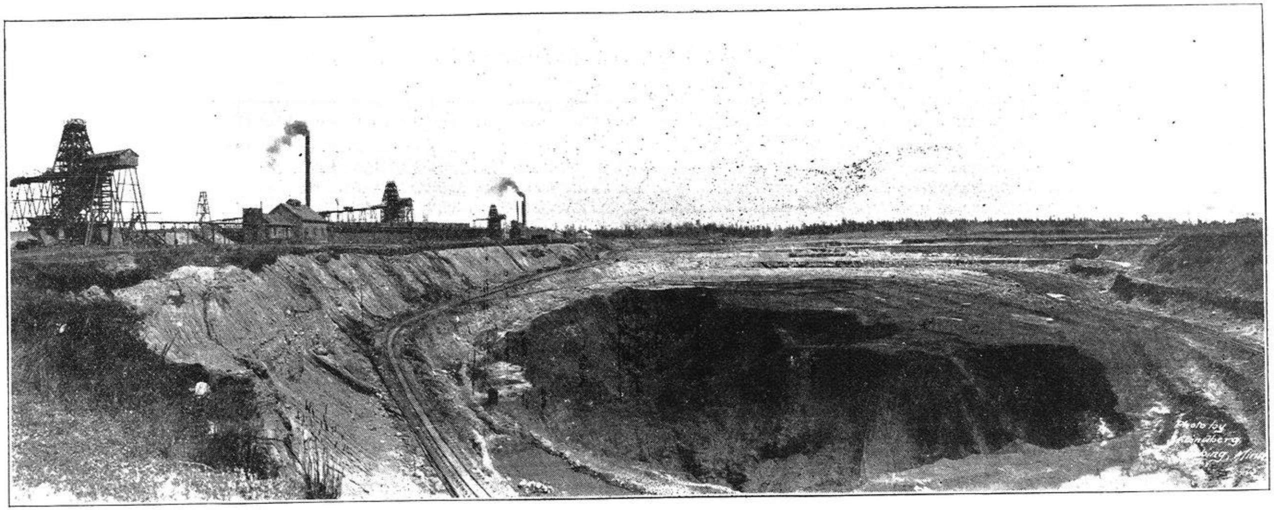
During August of 1908, one open pit on the Mesabi averaged close to 30,000 tons of ore per day. During the same month in 1907, in another pit, three shovels removed 246,000 cubic yards of surface, mixed sand, clay, and boulders. The haul was one and one-half miles. The operations just referred to were on double shifts of ten hours each. In 1906, 14,500,000 cubic yards of rock and surface were removed, and more than 13,000,000 cubic yards of ore were shipped from the Mesabi range. In 1907, 21,400,000 cubic yards of ore alone were shipped. Of the 57,900,000 tons of iron-ore mined in the United States in 1907, the Hibbing district of the Mesabi range yielded 14,800,000 tons, of which 14 open-pits produced 20 per cent or 12,000,000 tons.

The system in mining in open.pits is a direct result of physical conditions. The formation has a moderate dip to the south-east (from 5° to 20°, though local variations are not so pronounced). The average depth of surface is perhaps 50 feet to 75 feet. The ore is of an earthy texture, readily loosened by blasting. Deposits have great areal extent, (twenty to two hundred acres), and comparatively shallow depth (a few hundred feet at a maximum). The system which has resulted from these conditions has revolutionized iron-mining and established unprecedented records for economy of production.

Open-pit iron-mining requires a preliminary determination of the limits of the ore-body by drilling. This done, the surface, or glacial drift, is stripped off and dumped on barren ground, and the ore dug out and loaded into cars for transportation to the Lake Superior docks. Both operations are accomplished with steam-shovels. The pits at present thus formed range in size up to a hundred or more acres, and are 100 feet to 200 feet deep. The average present pit is one covering a forty acre tract and about 100 feet deep.

Stripping and shipping operations go on simultaneously during the season of lake transportation. This necessitates a complicated system of tracks in the pit, for ore and stripping rains. Shovels in stripping take cuts of 20 to 30 feet, until near ore. The final or "clean-up cut" is 6 to 10 feet thick. In the ore cuts are from 10 to 25 feet, depending much on the necessary grade of tracks, and on the particular part of the ore-body which is being cut. In both stripping and ore the bank is blasted down ahead of the shovel, with black powder, to facilitate digging.

The equipment used by the Oliver Iron Mining Company consists of either Marion or Bucyrus ninety ton steam-shovels, with two and one-half cubic yard dippers, both in stripping and in ore. In stripping operations, Baldwin or American 50-ton locomotives, hauling 6 to 14 Peteler cars of



Milling Pit—Monroe Tener.

seven cubic yards capacity each on standard gauge track, are used. In all operations 60 pound steel rails are used, but the more permanent tracks, as approach tracks, consist of 80 pound steel, laid on standard ties. Stripping contractors use 12 to 25 ton saddle-back-tank type dinkey locomotives, hauling 3 to 4 cubic yard Peteler and Western cars on 36 inch gauge, using 40 pound to 60 pound rails. They use 65 ton Marion or Bucyrus shovels, with one and one-half cubic yard dippers.

Development of an Open Pit.

Topography:—In any district where drillings show extensive ore deposits, topographic surveys are made, based on a co-ordinate control. Lines are run north-south and east-west, 100 feet apart, and elevations taken at intersections of these lines. If the underlying ore-body warrants the development of an open-pit, this "checker-board" system is extended; lines are run every 20 feet, and elevations taken at their intersections. The co-ordinate control thus established is preserved through all open-pit operations. It is most convenient for locating limits of ore body and stripping, tracks, buildings, drill-holes, and for planning mining operations. In estimates of stripping yardage by cross-section method, these 20 feet sections are used; the control is "carried down" into the pit.

Maps and Cross-sections.

From the topographic survey a co-ordinate-topographic map is made. A common scale is 1 inch = 100 feet. From the drill records contour maps of top and bottom of ore-body are made, based on the co-ordinate map. Cross-sections of the ore-body looking north and west, are made, and the outlines of the different grades of ore are marked on them. The limits of the different grades are given under "Estimates." These maps and cross-sections are of the greatest use in developing the mine, making estimates of ore, and planning the work.

Estimates.

Estimates will be described under three heads, ore estimates, stripping estimates, and operating estimates.

Ore Estimates:—After an ore-body has been thoroughly drilled, estimates are made of: total tonnage according to grades, total tonnage possible or advisable to mine with steam-shovel, using certain grades and curves on tracks, and the corresponding yardage necessary to uncover the ore. Upon the ratio cubic yards per ton depends in large measure the advisibility of stripping the ore-body.

The ore is graded according to the following classification. All ore above 49 per cent iron is of commercial grade. Ore between 40 per cent and 49 per cent in iron, if not diamond drilled, is classed as third-grade ore. Though not of commercial grade at the present time, it may be at some future time. If the ratio of iron to phosphorus is not greater than .00075 to 1, the ore is of Bessemer grade; if greater, the ore is non-Bessemer grade. This ratio establishes a sliding scale ranging from 64.00 Iron .048 Phos. to 49.00 (Iron) .037 Phos.

From the cross-sections and drill records the limits of the ore-body are platted on a general surface map, and the outline of the ore is drawn. Inside of this a second outline is drawn, representing a mean total ore area, assuming $\frac{1}{2}$ to 1 or 1 to 1 slopes, depending on locality and surface depth. The product of the area within this line by the average depth of ore in the ore-body, gives the volume of ore in the ore-body. The average grade of all the ore can be determined by a system of foot-units. If each sample analysis is multiplied by its depth in feet, the result is in foot-units. The total of iron foot-units in all holes divided by total depth of ore in all holes gives the average grade in iron of the whole ore-body. Careful specific gravity-volume determinations have established the volume per ton of ores of different percentages of iron. The total volume of ore in the ore-body divided by the volume per ton gives the total tonnage in the ore-body.

A different method of finding total tonnage is as follows: From the cross-sections an area is worked out for each grade of ore, on the general co-ordinate map. The average analyses and depths are found for each grade. The area of each grade by its average depth, divided by the proper volume per ton, gives the tonnage of each grade. The sum of the tonnages of the separate grades equals the total tonnage in the ore-body. To obtain the average grade, in say, iron, of the whole body, a system of ton-units is used. Tons x average analysis=ton-units. The sum of ton-units divided by sum of tons=average grade of the ore body.

Estimate of Tonnage in Proposed Pit, and to be Mined by Steam-Shovel.—For this estimate an ore area is outlined which looks favorable as a stripping proposition. Assuming $\frac{1}{2}$ to 1 slopes, if depths of ore and surface are not great, and 1 to 1 if they are, areas for the different grades are worked out and total tonnage in the pit is computed as above outlined. With the point of approach chosen, using say 2 per cent maximum grades and 15° maximum curves, a system of tracks is worked out with which to get down into the ore. Curved systems, switch-back systems, and combinations of the two are used. The elevations at which the different tracks cut the drill-holes are noted and the depths of cuts determined. Using the average cuts and areas worked out to correspond, the tonnages for one or any number of switch-backs are readily found. Operating costs place a limit to the number of switch-backs or spirals which can be used in a pit. Beyond a certain limit (differing for each pit of course), milling is more economical.

Surface or Stripping Estimate.—Assuming a 20 feet berm, toe of surface slope to crest of ore, and a 1 to 1 slope, an average area for surface to be removed can be worked out. The Area x the average depth, divided by 27, added to any possible yardage in the approach, gives the yardage necessary to be removed to uncover the pit and allow a certain steam-shovel production. Double track or three track approaches are used in all the more important pits. Track profiles are made for each track system.

Many of the pits are stripped by contract. The sole basis for the payment for such work is the estimate of yardage made by the engineer. The economic importance of such estimates is evident when the enormous volume of material handled is considered. Estimates are taken at the end of every month. Two methods are used, the level cross-section method, and the stadia method. In the former the coordinate control established over the original surface is carried down into the pit, and cross-sections are taken by levels every 20 feet. These are platted on cross-section rolls, which are preserved from month to month. Thus the area cut from each section during each month can be found by planimeter. The sum of areas (using $\frac{1}{2}$ of end areas), x $20 \div 27 =$ vol. in cubic yards of excavation. By stadia method a contour map of the "stripping" is made and sections picked from it, platted on cross-section rolls, and areas and volumes computed as in the level cross-section method. Contractors keep a rough check by counting the number of cars of excavation each day. Estimates are taken monthly and final estimates are taken at the end of a year or expiration of a contract.

Operating Estimates.—Operating estimates properly belong under the head of "Ore-estimates," but are treated separately, because as a rule they are estimates of operating rather than of proposed pits. They are made from year to year as the development of the pit progresses. Contour maps of the pits are made frequently and the surface of remaining ore is platted on the cross-sections from these. If the superintendents wish a certain production of a certain grade from a pit for the ensuing year, the engineer studies the cross-sections to determine the proper part of the pit to work for such grades. Given maximum grades and curves, he determines how much of an area to cut from each section. Knowing the distance between sections, the volume and tonnage are easily computed. A few trials usually determine the tonnage closely enough. Occasionally a number of such estimates with accompanying track plans and profiles are submitted from which the superintendents and engineers decide on methods of operation for the ensuing year or years.

The above description of ore estimates by no means cover all the types of estimates made. Different conditions call for different methods. Enough has been given to illustrate the general principles involved and to suggest their applicability to various conditions.

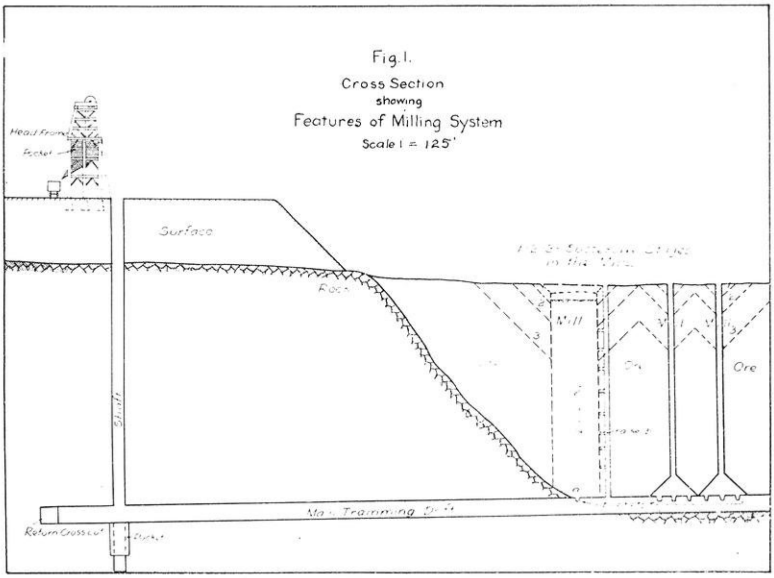
Future Development of Pits.

The question of future development of pits occasionally calls forth discussion, even at this primary stage of open-pit development. Many suggestions of a return to the old shaft and skip system have been made. Before any such methods are used, the present steam-shovel method will be worked to the limit of its economy, using steep grade climbing locomotives of the Lima or similar type. Each pit will present problems of its own, and no doubt the solutions will be as varied as the problems. Ultimately, the milling system or a pit system using an incline and skip, will doubtless be used to clean up ore remaining in benches, in pot-holes, and beneath rock ledges. Whatever system may be devised will aim to continue the cheap and rapid mining, characteristic of the present open-pits.

The Milling System.

When the ore-body is small and deep, the over-buraen of moderate depth, and open-pit methods impracticable, the milling system is used, if possible. This system combines features of underground mining and open-pit mining. The over-burden is stripped off the ore as in open-pit work. A shaft is sunk, preferably in rock near the edge of the ore-body. When the elevation of the bottom of the deposit is reached a drift is run out under the stripped ore. Raises, spaced 20 feet or 30 feet, are dug from below up to the surface of the ore; at the top of the drift these raises are enlarged to the shape of an inverted cone or pyramid, and pockets built, usually three to each mill. This is illustrated in Fig. 1. The ore is picked or blasted from the edges of the chutes or "mills," dropped down, is drawn out from the pockets into cars, trammed to the shaft, and hoisted. The enlarging of the lower ends of the mill prevents plugging and allows the ore to run easily. The tops of the chutes soon become enlarged, resembling craters. The system of mills and bottom drifts is extended until nearly the whole ore surface is dotted with "craters." The entire stripped ore-body is mined in this way.

Fig. 1 also illustrates another method of developing mills. A raise is put up from the tramway to surface. Then a large raise 30 feet square, is started at a point "a." A pocket is



built and ore is dug out to a height of six feet and dropped into cars through the pocket. Then the pocket is closed. The miners continue to cut down the "back" or top of the raise, using the loosened ore as a staging on which to work. When the loose ore fills up the working space, some of it is drawn out below. Communication is maintained with the tramway through the raise "b," as indicated in Fig. 1. The raise is continued up in this way to within about ten feet of the surface of ore. This top layer is caved in by blasting. All the ore can then be drawn out below and the system continued as with the smaller mills.

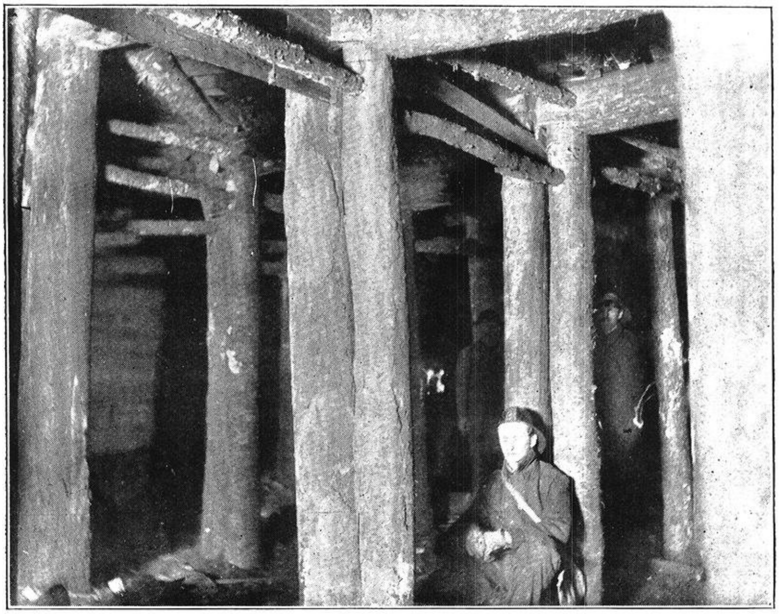
Fig. 1 is diagramatic, the object being to illustrate the systems of developing mills rather than to illustrate any typical milling pit. It shows relation of mills, pockets, tramway, shaft and head-frame.

A novel innovation was used in the Fayal pit at Eveleth, Minn., some years ago. A steam-shovel was used to dig the ore and cast it into the mills.

Underground Mining.

If an ore-body is capped by rock, if it is shallow, or small and deep and the depth of surface excessive, or if other conditions prohibit the use of open-pit or milling methods, underground mining is resorted to. This method is the slowest and most expensive of the three. Timbering costs are heavy, production is necessarily slow and oftentimes much ore is lost. In underground mining a shaft is sunk, located at the lower end of the ore trough to drain the mine, and preferably a short distance away from the ore-body, in rock. It is sunk to such a depth that a drift having a slight inclination towards the shaft will follow the bottom of the trough. Provision is made at the bottom of the shaft for the loading station, pumping room, and sump. Two parallel drifts are driven on the bottom level, looping to meet at or near the shaft. These are used as tramming drifts, haulage being done by mule or electric traction. Cross-cuts between these drifts are driven 50 feet apart. To block out the ore at either side of the main drifts, other cross-cuts are driven at right angles to the mains, spaced 50 feet. Above this bottom level sub-levels are established each 22, 33, 44, or 55 feet, depending largely on size and depth of ore-body. The drifts on sub-levels are made to overlie as closely as possible those on the bottom level. The system of "subs" is continued to the top of ore-body. Chutes running down from the subs to the mains, terminating in pockets there, are used to transfer the ore mined from the subs to the tramming level. Raises 4 or 5 feet square are the means of communication from level to level. An entrance is usually cut from the man-way compartment of the shaft to one or more of the subs, for the convenience of the miners. The entire system of drifts and cross-cuts, to the top of the ore-body, is usually laid out before active mining is begun.

The above description is that of an ideal development. All variations of the system are found. Rock layers and

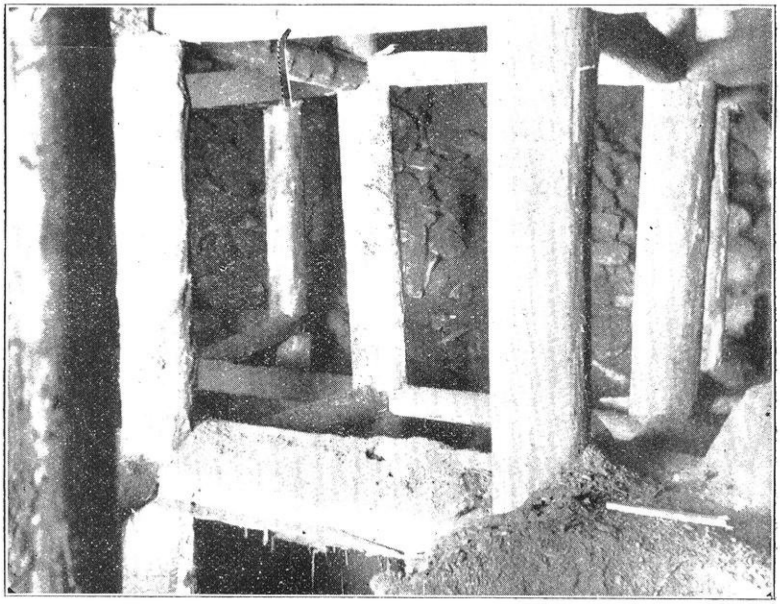


Timbering slice-sets. Note spags from posts to post and cap to cap.

"horses" often interfere. Poor judgment and management have contributed to spoil the development of many mines and to make mining operations doubly difficult and expensive.

A different system was tried some years ago and is still in use in many important mines. It consists of a main tramming drift and development drifts driven at angles of 45° to the main. The wedges of ore thus formed at intersections of drifts proved insufficient to carry the weight above, where surface and ore-body were deep. Heavy timbering and frequent retimbering was required. Present developments are on the rectangular system.

Difficulty is often experienced in "holding" the drifts. The unconsolidated nature of the ore allows a slow continual settlement and creep towards the drifts. Timbers are frequently crushed, splintered, and displaced, requiring constant atten-



Timbering in square sets. Contrast heavy timbering with slice-sets.

tion and replacement. Timbering on main levels is made exceptionally heavy, because these levels are permanent and must be used until the ore-body is worked out.

Two systems of mining are used, the square-set system and the slicing-caving system. The latter has almost entirely replaced the former system, due to economy of timber, labor, and rapidity of mining.

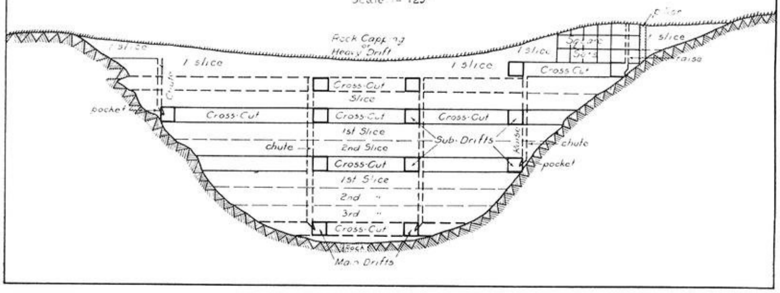
With the square-set system a room is opened up at the end of the top drift, three or four sets square and as many high as needed to reach the top of the ore-body. Standard dimensions of the square sets are 8 feet by 8 feet by 8 feet center to center. Birch, spruce, and tamarack are used and timbers are not dressed. Sets are put in one at a time to replace the ore as it is removed. When the upper surface of the ore-body is reached, lagging is put in to hold the overlying ground. When a block of ore six to ten sets long (between two cross-cuts) has been worked out, all the exposed surfaces of ore are covered with boards; and a few sticks of dynamite placed in the bottom posts cave down the timbering and supported surface.

With the slicing-caving system smaller rooms are opened up, and the timbering is not as extensive as in the square-set system. Square-sets are used in this system, however, and in fact are an essential part of it. The top drifts are run out to the shore-line of the ore, where the ore and the overburden meet, or where the ore thins out against the surface to 4 or 5 feet, the limit of safe mining operations under soft capping. The miners start at the extremity of the top drift farthest from the shaft, and work out a slice, say two or three sets wide, in to the shore-line on the far side of the drift, and possibly half way to the next crosscut on the side of the drift towards the shaft. The surface is caught up by poles or spiling driven ahead over the caps of the slice-sets, until enough ore is worked out to put in another set. After two or three slices are worked out all exposed ore surfaces are covered with boards and the room is caved down. While another slice is being worked out, a first slice is started on the drift next towards the shaft. In this manner the work progresses in steps, carrying the shore-line back approximately paralleling the original shore-line. After a number of slices have been worked out on the top slice, work is started on the next lower. Thus the slicing is carried down as well as back from the shore-line in steps.

If the surface is hardpan or rock, the work is much easier than if sand has to be supported.

A slice-set consists of two posts of height according to conditions, with a 7-foot cap and a sprag between them high enough up to allow clearance for the men. Oftentimes as the miners slice back from the shore-line, the surface will rise up to such a height that slicing is impracticable. Square-sets are then put in, two or three sets high, as needed, and continued until the surface drops down to the slicing limit. This is illustrated in Fig. 2 which gives a section transverse to the axis of a small typical ore-body, indicating the rela-

Fig. 2.
Ideal Cross-section of a Small Underground Mine.
[Transverse to Trough]
Scale 1" = 125'



tion of drifts, raises, chutes, cross-cuts and slices. In the upper right hand corner a 4-foot pillar is left between the caves of the slicing and the first set, which is removed after the sets are in place and before caving. Slices 20 feet high are occasionally taken, but 10-foot to 12-foot slices are more common. Between levels, one, two, or three slices are taken according as the distance from the top of one level to the bottom of the next above is 11 feet, 22 feet, or 33 feet, approximate distances.

In both systems of mining augers are used. The ore is blasted loose with dynamite or picked loose when possible, and then shoveled into tram-cars and trammed to the nearest chute, whence it goes to the bottom level, or to a sub from which it has to be retrammed. Such chutes are located at the end of each cross-cut. When the distance to the chute is not too great wheelbarrows are used.

Maps of all the mines are made and brought up to date twice a month in all the offices of the Oliver Iron Mining Co. Maps of all the different levels are made separately or in composite form, showing the different levels superimposed upon each other. The engineers make development plans, plumb the shafts, give lines for new drifts, cross-cuts and inclines, and in general assist the mining captains and superintendents in the proper development of the mines.

In the foregoing the greater space has been given to open-pit mining, because of its vast economic importance. Many details of all three systems have necessarily been omitted for brevity's sake. The object has been to point out the salient features of each system, giving such details as clear exposition demands.

COMPARATIVE EFFICIENCIES OF POWER PLANTS WITH SPECIAL REFERENCE TO THE EFFICIENCY OF A SUPERHEATED STEAM PIPE-LINE.

FRANK R. BROWNLEE, '08.

All machines or mechanical apparatus for either doing work or transforming energy have an efficiency less than unity. The difference between the energy expended and the useful work done, or the loss, is usually consumed either in overcoming friction or in doing work on bodies surrounding the machine from which no useful work is received. It can be seen that where more than one machine or operation is used in a series in a power transforming plant the efficiency of the entire series must necessarily be low.

The total efficiency of any power plant is the product of the efficiencies of the individual machines and transmissions. Taking a simple steam power plant for lighting purposes as an example, the total efficiency from the coal to the electric light is rarely if ever, above one per cent. The reason for this is that each step taken in the process of generating electricity in itself reduces the efficiency, and the combination of a large number of steps taken, necessarily reduces the total value. In the example taken, the total efficiency is comprised of seven individual efficiencies. Starting with the coal the efficiencies to be considered are boiler, furnace, steam pipe-line to the engine, engine (considered from both thermal and mechanical point of view), generator, electric transmission, and motor or lights.

The efficiency of each step depends upon the losses taking place in that step. The furnace efficiency depends upon the coal, grate, and flue-gas losses. The kind of coal and its combustion, whether complete or incomplete, is a large factor in the furnace efficiency. The grate design and size must be accurately worked out to suit the draft and other conditions of each furnace and coal used to give the best results. The largest loss is probably in the flue gas, depending upon whether the heat had been properly extracted therefrom by the boiler. The total furnace efficiency is between 80 and 90 per cent for ordinary boilers.

The boiler proper has a very high efficiency. Its only loss is radiation and this factor has in most cases been properly taken care of by insulation of the boiler. The efficiency can be estimated at about 90 to 100 per cent. The total efficiency of the boiler and furnace, combining the values of each given above, is (from 80 to 90) times (90 to 100) or from 70 to 85 per cent.

The pipe-line losses are radiation, friction, and condensation. The radiation depends largely upon the difference of temperature between the pipe and the surrounding air, and can be reduced considerably by good insulation. The friction is an uncertain quantity and depends largely upon the pressure of the steam in the pipe, its velocity, and the size of the pipe. It can be reduced by using a pipe considerably larger than necessary, but, by increasing the size of pipe the radiation is also increased, and an economic mean must be used for the best results. The condensation in most cases is considerable and is an important item even with superheated steam. It depends on friction and the difference of the temperatures of the pipe and the steam itself. Probably the best way to reduce this factor is by reducing as much as possible the friction and then using superheated steam. This has been done at a number of installations, as that at the Schlitz Brewery's new pumping station in Milwaukee. a test of which is shown later.

The efficiency of the engine can be divided into two partial efficiencies, thermal and mechanical efficiencies. The thermal efficiency of a steam engine is the ratio of the B. T. U. doing work as shown by the indicated horse-power to the B. T. U. supplied in the steam. Its value is very low and depends largely on the type of engine and the running conditions. The principal losses are imperfect expansion and compression of the steam in the cylinder, and cylinder condensation and radiation. The most efficient steam engines are probably the triple expansion Corliss condensing engines and the large power steam turbines. The thermal efficiency at a maximum, can be estimated at about 15 to 20 per cent. The mechanical efficiency is the ratio of the brake horse-power or power output to the indicated horse-power. It depends solely on the friction loss of the engine and can be estimated about 85 to 95 per cent. The total efficiency or product of the two is about 12 to 17 per cent. for the best type of engines.

As in the case of the engine, there are losses in the generator which decrease its efficiency. The most important of these are the losses due to field resistance, armature resistance, friction in the bearing of the machine, and those due to eddy currents and hysteresis. The field loss is due to the heat generated in the field windings by the field current, and represents the power required to excite the field magnets. The armature loss is due to the heat generated by the armature current in the brushes, in the brush contacts and in the armature windings. Hysteresis and eddy current losses chiefly in the armature core are due to the reversals of magnetization as the armature rotates, and appear as heat. Losses due to friction occur in the bearings and as air friction or windage due to the fanlike action of the rotating armature. The losses all add up and lower the total efficiency of the machine. There are several different efficiencies for the electric generator such as electrical, mechanical, and others. The one most generally used is the commercial efficiency which represents the ratio of the useful energy or output to the power actually absorbed by the machine in being driven. The efficiency of a generator should be between 90 and 100 per cent. at normal load.

The power from the generator is conducted to the lamps and motors using it, through wires, and here again is a loss which affects the combined efficiency of the power plant. The chief losses in the line are due to resistance and leakage.

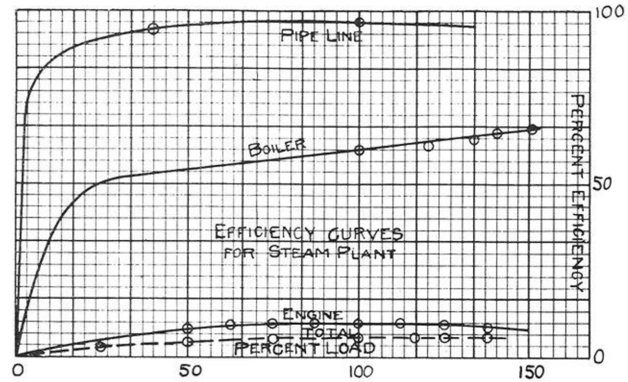
The last loss or resistance depends on the diameter, length, and material of the conductor, and the leakage is due to improper or poor insulation, especially noticeable in high tension lines. The usual efficiency for a conductor in lines of medium length is above 90 per cent.

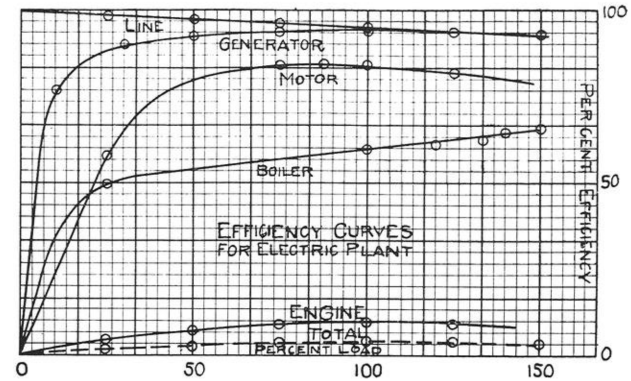
The last loss and drop in efficiency is brought about in the lamps or motor or other uses the power may be put to. In the case of motors the losses are the same as those of the generator and the efficiency is the ratio of the power received by the motor in horse-power to the actual horse-power delivered by it. Motor efficiencies vary from 85 to 95 per cent at normal load. The lamp efficiencies are very low, ranging from 3 per cent for incandescent lamps to 19 per cent for mercury vapor lamps. The excessive losses in the lamps are due to the heat caused by the extreme resistance necessary in the lamps.

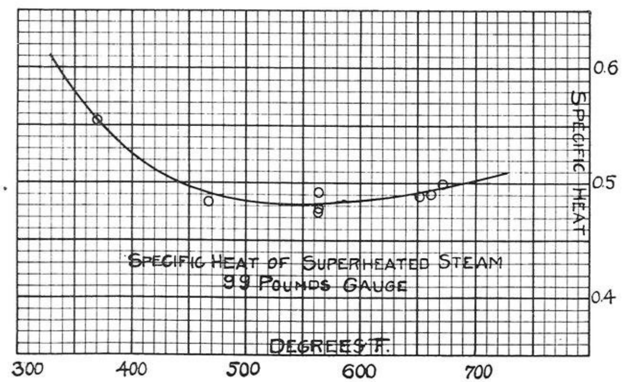
The efficiency data used in this investigation has been obtained in the following manner:

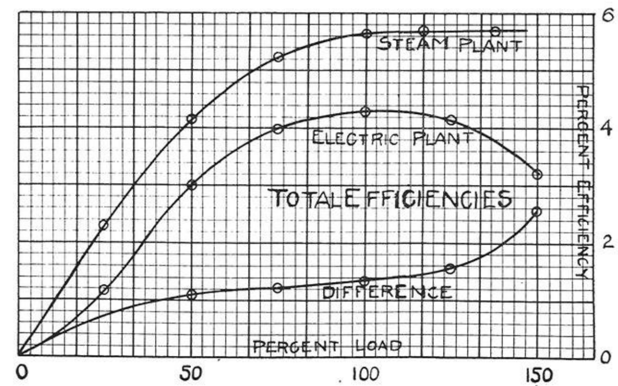
In gathering information on boiler efficiency, it was found that probably the most valuable work on this subject has been done by Prof. Breckenridge in a series of tests made for the United States at St. Louis. However, in his tests, several hundred in number, the efficiency of a boiler was found for various kinds of coal at normal load. No tests were made for efficiencies under various loads. The curve used herein for boiler efficiency from no load to 50 per cent overload was obtained from a number of tests made at a large Chicago power plant. This curve shows gradual increasing efficiency from 100 to 200 per cent load. In replotting the curve values below normal values were assumed as near actual conditions as possible. The efficiency in this case seems rather low, but this can be accounted for by the fact that the power output of the plant varies considerably and cannot be absolutely regulated.

The engine efficiency curve was taken from "Meyer's Steam Power Plants," page 54, curve 3. In this book Mr. Henry C. Meyer, Jr., M. E., shows the results of a large number of engine tests for different types of engines under various loads.


Pipe Line
Boiler
Efficiency Curves
for Steam Plant
Engine
Total
Percent Load
Percent Efficiency
0
50
100
150


Line
Generator
Motor
Boiler
Efficiency Curves
for Electric Plant
Engine
Total
Percent Load
Percent Efficiency
0
50
100
150


Specific Heat of Superheated Steam
99 Pounds Gauge
Degrees F.
Specific Heat
0.6
0.5
0.4
300
400
500
600
700


Steam Plant
Electric Plant
Total Efficiencies
Difference
Percent Load
Percent Efficiency
6
4
2
0
50
100
150

His results are shown in a series of economy curves giving pounds of steam consumed by the engine per indicated horse-power per hour under loads from zero to 50 per cent overload. In selecting a curve it was decided to use a cross-compound Corliss condensing engine as a fair basis for this study. The curve given was transposed from an economy curve to an efficiency curve by the following formula:

$$\text{Efficiency} = \frac{1}{\dfrac{\text{lbs. steam} \times 1200 \times 778}{33000 \times 60}}$$

In calculating these values the normal load was taken at 39 lbs. mean effective pressure on the curve. The value 1200 was used as the B. T. U. per pound of steam, giving a minimum value of efficiency, the value 778 equals foot pounds in 1 B. T. U. and the value 33000 equals foot pounds per minute in 1 horse-power.

S. P. Thompson in his book "Dynamo Electric Machinery," gave the best available information on generator efficiency. On page 657 he shows an efficiency load curve for a 550 kilowatt, Oerlikon Co. generator which has been used in this investigation in connection with the other curves plotted. This curve was chosen as a fair average for generators and shows efficiencies about 90 per cent. for loads from 150 K. W. to 700 K. W., or from 30 per cent. load to 40 per cent. over-load with efficiencies at other loads as indicated on the curve.

In searching for an efficiency curve for an electric transmission to take the place of the steam pipe-line in steam transmission, it was found advisable to calculate efficiencies from an assumed line, since efficiencies for varying loads on a wire transmission were not available. The case assumed is for transmission of 250 K. W. normal load at 550 volts with a 5 per cent. drop in voltage at the load.

$.05 \times 550$ equals 27.5 volts drop equals R I

$$I = \frac{250 \times 1000}{550} = 455$$

R equals $\frac{27.5}{455}$ equals 0.0605 Ohms resistance in line.

R equals $10.8 \times \frac{2\,L}{d^2} \times d^2$ equals $\frac{10.8 \times 2 \times 1200}{0.0605}$ equals 429000.

d equals 429000 equals 655 mills or $\frac{5}{8}$-inch cable.

Efficiency equals $\frac{\text{Output}}{\text{Input}}$ equals $\frac{\text{Input—loss}}{\text{Input}}$ Loss equals I^2 R.

For normal load,

Efficiency equals $\frac{250-[.0605 \times (455)^2] \div 1000}{250}$ equals 95 per cent.

In this manner the efficiency at any load can be found since the resistance of the line is a constant. The values of efficiency for various loads are indicated on the curve.

The efficiency curve for a motor closely resembles that for a generator. The motor efficiency is a trifle lower and in the curve taken, it is 84 per cent. at full load. The curve used is taken from Franklin and Esty "Direct Current Machinery," page 142, for a compound motor.

Practical information in regard to steam pipe-line efficiency, especially when superheated steam is used, is lacking. Otto Berner, of Berlin, Germany, gives some valuable information on the subject in regard to heat losses. He experimented with short pipes, using both steam and hot water, and determined heat losses. From his results a formula was derived for heat loss by using a combination of formulas for radiation as calculated by Du Long and Petit and Péclet. However in using any information given by him it must be remembered that the results were taken from a pipe only about six feet long and superheated steam was not used.

The superheated steam pipe-line at the Jos. Schlitz Brewing Company, of Milwaukee, designed by Mr. J. C. White for D. W. Mead, Consulting Engineer, offered excellent opportunities for obtaining information on pipe-line efficiency. It was designed to carry steam at 120 pounds gauge pressure and 250 degrees superheat, a distance of about 1170 feet. The steam is used for operating two pumps, a De Laval steam turbine with centrifugal pumps, six million gallons capacity, and an Allis-Chalmers cross compound heavy duty pump of the same capacity. The steam is taken from a battery of Babcocks and Wilcox boilers, with superheaters, at about 100 degree superheat. It is then passed through a Foster, separately fired, superheater and the temperature is raised to the desired degree of superheat. The pipe-line which was tested starts at the superheater and delivers the steam to a small receiver in the pumping station. The pipe is so connected that steam can be taken either through the superheater or directly from the boilers. It is made of steel pipe four inches in diameter and $\frac{1}{4}$ inch thick, with flanged joints. The joints were closed by means of special steel gaskets, patented by Mr. White, the engineer in charge. All turns in the pipe were made by easy bends of large radius so as to avoid any extra losses at elbows. There were two bends, one of 51 degrees and one of 90 degrees. The entire pipe had a total drop in elevation of about 15 feet. The pipe-line was covered with $2\frac{1}{2}$ inch, 85 per cent magnesia covering and enclosed in a concrete tunnel 3 feet high and 4 feet wide. A manhole was situated at each bend. In designing the entire plant a discussion arose whether electric transmission with motors would be more efficient than the plant now in use. In testing the pipe-line it was desired to obtain an efficiency curve and by combining it with curves obtained for the efficiencies of engines, boiler, generator, motor and electric transmission, comparative total efficiencies can be obtained for the two methods of delivering the power at the pumping station.

The main object of testing the pipe-line was to determine the best efficiency, the pressure loss and the general performance of the line. The heat energy at several points along the line, and especially at the ends was determined by taking readings of pressure and corresponding temperatures at the points. Throttling calorimeters were used at the ends of the line, but it was found that the steam was superheated in all cases and the calorimeters were not necessary.

The instruments used in the test were thermometers, pressure gauges, calorimeters and apparatus for weighing the condensed water. The instruments in which any inaccuracy was liable to be present were carefully calibrated before the test. In selecting a method for obtaining the temperature of the steam two ways presented themselves. The first was to use electric pyrometers with a common connection so that all readings could be taken simultaneously at some common point. The second was to use a high reading mercury thermometer with a socket at each point of reading. Information was obtained from the Bureau of Standards at Washington in regard to the first method and it was found that a complicated amount of calibration for the pyrometers and wiring might enhance the accuracy of the readings. It was decided to use mercury thermometers as a simple, and in this case probably more accurate method of taking the temperatures.

The thermometers were made by Taglibue and read from 200° to 800° F. The instruments were screwed in a brass cup made especially for them, which was threaded into the steam pipe and extended to about the middle of the pipe, thus giving an accurate reading of the temperature of the steam. These thermometers were calibrated with a standard thermometer which had recently been calibrated at the Bureau of Standards at Washington, and for which the correction was known. A stem connection was also applied which accounted for the temperature of the air surrounding the stem. Both thermometers, the standard and the Taglibue were immersed in an oil bath and various readings taken up to 500° F. Above this melted lead was used as high as 700° F. Both thermometers were exposed as nearly alike as possible in the melted substance so an exact comparison could be obtained. After the apparatus had been set up and a full set of readings taken the amount the Taglibue thermometer was in error was computed for approximately every 40° by the following formula and a table made showing the corrections on that instrument. The stem correction formula, was as follows:

$0.00016 \times n (T^\circ - t^\circ)$,

where: n equals number of degrees emergent from bath,

T equals temperature of the bath,

t equals mean temperature of tangent stem.

The pressure gauges were all calibrated with an instrument which consisted of a small cylinder filled with oil and a piston on which was a table. The guage was connected by a pipe to the cylinder. To obtain a given pressure on the gauge a given weight was placed on the table and the piston caused the desired pressure in the cylinder and therefore on the gauge. Knowing the diameter of piston and weight upon it the exact pressure on gauge was determined.

The instruments for the test were placed at four different points. At the boiler house, at the first bend (51°) 416 feet from the boiler house, at the second bend (90°) 640 feet from 51° bend and at the pumping station, 114 feet from 90° bend. Those used at the boiler house were two calorimeters, two pressure gauges, two thermometers for steam pipe and one for room temperature. A thermometer, pressure gauge, and calorimeter were placed on the steam pipe before entering the superheater and also a set on the pipe leaving the superheater. In this way the work done by superheater could be exactly determined. While the superheater was in operation the coal used and the ash remaining from it were weighed. At the 51° bend a thermometer and pressure gauge were tapped into the pipe and a thermometer was also used to obtain the tunnel temperature. The same apparatus was used at the 90° bend. A pressure gauge and thermometer were tapped into the steam pipe as it entered the pumping station and just ahead of the separator. Suitable apparatus was supplied here for weighing all water from trap in connection with separator which represented the entire amount of water discharged from the pipe-line. Similar apparatus was also supplied for weighing the condensed steam from condenser in connection with the turbine.

The tests, four in number, were run from two to four hours and readings were taken simultaneously at all four points every fifteen minutes. Before these tests, one was made to determine the condensation in the line at no load. In this case the water in the trap connected before the receiver at the pumping station was weighed for two hours. As the line has a drop throughout its length the amount of condensation was accurately measured at this point. The first two tests were conducted with the steam not flowing through the superheater. In these tests the steam was taken directly from the economizers or superheaters in connection with the boilers at about 100° superheat. All tests were run with the turbine alone in operation, its output varying from 2.5 to 4.0 million gallons.

With the data taken it is possible to obtain the number of B. T. U. per hour contained in the steam passing any of the four points where instruments were used. By multiplying the number of pounds available steam passing any point per hour by the sum of the total heat of steam at that pressure and the specific heat at that temperature times the number of degrees snperheated, the actual number of B. T. U. delivered by the steam passing this point per hour is found. This value of B. T. U. was found at all four points and the drop due to condensation, friction, and radiation was found for each length of straight pipe. The efficiency of the entire line was determined by dividing the actual number of B. T. U. delivered at the pumping station per hour by the actual number of B. T. U. delivered to pipe at the boiler house. The pressure loss was also determined for the line from pressure readings taken at the four points.

Formula:

B. T. U. at any point equals $[H + c\,(T_1 - T)] \times$ pounds steam passing per hour,

where H equals total heat of steam,

T_1 equals temperature of steam at that pressure,

c equals specific heat of steam.

Values of specific heat of superheated steam were taken from an article in "Power" by Prof. Sydney A. Reeve, and a curve plotted for 99 lb. gauge pressure. As all pressure valves averaged about 100 lbs., this is thought justifiable for lack of better information on the subject.

The results of the tests were as follows:

No load test—

The average condensation per hour in the line was 238.5 pounds with an average steam pressure of 110 pounds and an average temperature of the steam of 360 degrees Fahrenheit.

B. T. U. loss equals 238 (1185.9 + .558 × 22.5) equals 285000 B. T. U. per hour.

B. T. U. loss per square foot of pipe surface per hour equals 285000 ÷ 1200 (area) equals 237 B. T. U.

Two hour test (without superheater).

Average data.

Reading point	*Temperature*	*Pressure*	*Degrees Superheat*	*Specific Heat*
Entering superheater ..	447.2	108	104.6	.496
Leaving superheater ..	421.4	104.5	80.9	.510
51° Bend	382.1	106.3	40.5	.538
90° Bend	363.8	101.2	25.5	.556
Pumping Station	362.7	101.1	24.5	.558

Condensed steam 7085.2 lbs. Total per hour 3603.6 lbs.

Condensation in pipe 122.0 lbs. Barometer 14.5.

Total 7207.2 lbs. Average temperature of tunnel 72° F.

Calculations:—

Available B. T. U. at any point equals $[H + c\,(T_1 - T)] \times$ lbs. steam at that point.

Available B. T. U. entering superheater 4,459,237.8 per hour.

Available B. T. U. leaving superheater 4,421,980 per hour.

Available B. T. U. at 51° bend 4,331,408.6 per hour.

Available B. T. U. at 90° bend 4,254,636.6 per hour.

Available B. T. U. at pumping station 4,246,749 per hour.

Equivalent horse-power delivered equals $\frac{787 \times 4{,}246{,}749}{33000 \times 60}$ equals 1,668.

B. T. U. total loss in pipe equals 4421980 — 4246749 equals 175,228.5 per hour.

B. T. U. condensation loss equals $\frac{122}{2}$ (1185.5 + .534 × 50) equals 73,932 per hour.

B. T. U. radiation and friction loss equals 175,228.5—73,932 equals 101,296.5 per hour.

Total efficiency of pipe equals $\frac{4,246,749}{4,421,980}$ equals 96.0 per cent.

Three hour test (without superheater).

Total efficiency of pipe equals 96.52 per cent.

Four hour test (with superheater).

Total efficiency of pipe equals 94.5 per cent.

Five hour test (with superheater).

Total efficiency of pipe equals 95.51 per cent.

The results of the test on the superheated steam pipe-line are very satisfactory. The efficiency seems a trifle high for a line of that length, but this result can be accounted for by the good construction of the line, especially in regard to the heat loss. The tests show that a moderate degree of superheat as used in the first two tests give the best results since the radiation and friction are not large and the condensation is moderate. When high superheat was used, the condensation was reduced to a minimum and the radiation and friction became extremely large, giving a correspondingly greater total loss. The average per cent drop in pressure of the steam in the line was about five per cent. This factor is low for the reason that the pipe-line was designed somewhat larger than absolutely necessary and the drop in pressure is necessarily reduced. The pressure reading of the steam leaving the superheater is low due to a sudden turn in the pipe increasing the velocity and decreasing the pressure of the steam slightly. The average total loss in B. T. U. of the four tests is about 194,000 B. T. U. per hour or about 162 B. T. U. per square foot of pipe surface per hour. The average drop in superheat for the first two tests when the Foster superheater was not used was about

57 degrees or about one degree Fahrenheit for every twenty feet of pipe. This is considerably better than was estimated in the design. On the other hand, the drop in degree superheat in the last two runs averaged 133 degrees, showing a loss of one degree for every nine feet length of pipe. This value is about what was expected with the high superheat.

The normal load on the pipe-line was determined by using a velocity of steam of 6,000 feet per minute and multiplying by the area of the pipe in square feet. This value gives the amount of steam delivered by the pipe in cubic feet per minute and by multiplying by 60 and dividing by 3.5 (specific volume of steam under the given conditions), the number of pounds of steam passing through the pipe per hour is determined:—

$$\frac{6000 \times (4)^2 \times .7854 \times 60}{144 \times 3.5} \text{ equals 9,000 pounds per hour.}$$

Using the average number of pounds of steam used in the four tests—3600 pounds per hour—and knowing the average efficiency, one point on an efficiency curve is found. Since this point gives the efficiency at 40 per cent. load at about 95 per cent., the efficiency at full load is estimated to be about 96 or 97 per cent. With these two points, an approximate curve was drawn showing the pipe-line efficiency for various loads on the pipe.

Combining the individual efficiency curves comprising each type of power plant as taken in examples, comparative total efficiencies can be found as shown in the total efficiency curves given.

The total efficiency of the steam plant is the product of the individual efficiencies of the boiler, pipe-line and engine and has the following values for various loads:

Load.	*Efficiency.*
25	2.3
50	4.15
75	5.15
100	5.65
125	5.65
137.5	5.67

These values of efficiency show a gradual rise for increasing loads and are fairly representative of the actual total efficiency of a steam plant such as taken.

The electrical installation as assumed has a total efficiency somewhat less than that given above and shows a maximum value at normal load and a drop in efficiency at overload. The total efficiency is comprised of the efficiencies of the boiler, engine, generator, electric transmission, and motor. The value of total efficiency for various loads in the electric installation as assumed are:

Load.	*Efficiency.*
25	1.15
50	3.01
75	3.94
100	4.30
115	4.13
150	3.15

In comparing the two types of power plants given above it was found that a curve giving the differences of efficiencies at various loads shows the resulting advantages most clearly. The steam plant has a high total efficiency at all loads, and is especially well adapted for overloads. The values showing the advantage of the steam plant over electrical are:—

Load.	*Difference of efficiency.*
25	1.15
50	1.14
75	1.21
100	1.35
125	1.50

These differences are smaller in actual percentage being only 1.35 per cent at full load. However, as a comparison, the percentage difference on the total efficiency is high and has a value of $\frac{1.35}{5.65}$ equals 23.9 per cent. This percentage shows a decided economic advantage in favor of the steam plant and the only item which might be able to counter-balance this advantage would be the difference of total investment necessary to install each type of power plant used in this comparison. In the case of the plant built at the Schlitz Brewery it is estimated that the total costs for each type would be very nearly the same and in this case the Steam Power Plant has every advantage in the economic use of power.

THE FOUNDRY IN ITS RELATION TO CHEMICAL ENGINEERING.

BY JAMES ASTON.

Within the past few decades there has been a decided awakening to a realization of the necessity of the injection of modern methods into the management of the foundry. The oft-voiced sentiment that "anything will do for the foundry" is today recognized as the expression of a penny wise, pound foolish spirit which has happily given way to that better policy of recognizing the foundry department as an integral part of the well organized manufacturing industry.

To a great extent the old feeling was a result of conditions. The seeming crudity of the moulding operation, the simplicity of the general equipment, the preponderance of hand labor, threw over this department a mantle of conservatism which for a long time resisted the injection of technical science. The real awakening came with application of chemical analysis to the control of iron mixtures; an advent met at first with skepticism and scorn, then with toleration, and finally with approval. It was all very well in the earlier days to mix by fracture grading, when the brand name of a pig iron was sufficient guarantee of its ore origin, its condition of manufacture, and its impurity content. But these conditions are of the past, and today practically all pig iron is graded and sold upon the chemical basis.

An example of this antagonism falls within the memory of the writer, in the case of a very large and very well managed plant. Long continued difficulty with unsatisfactory iron in their castings, forced the adoption of mixing by chemical analysis. The charging mixtures were given to the foreman for execution, but the resulting iron was no better than by the old method, and the casting analyses were not as calculated. After a sufficient trial, and upon the verge of the adandonment of this experiment, the chemist finally undertook the execution of his own orders, with the immediate agreement of calculation and result. It soon developed that the foreman had been disregarding the new fangled orders, and had been sticking to the methods of his forefathers.

In the management of the foundry a knowledge of chemistry is of fundamental importance; a knowledge of technical analysis and the interpretation and application of the results obtained. The melting stock is bought upon guaranteed analysis, and must be checked upon receipt. The castings must be of a specified carbon content, and fall within fixed limits of Si, S, P, Mn, etc. To fulfil these specifications, the composition of fuel and fluxes must be predetermined, and their effect neutralized in the mixing. Refractory materials must be composed of the proper constituents to have their required acid, basic or neutral character, and the impurities must not be in amounts great enough to destroy the heat resisting qualities. In like manner molding sands, facings and a large number of other supplies must be carefully watched.

But the modern foundry requires for its direction more than a knowledge of chemical science; it requires also an engineering training. Under the new regime it has become a place of specialization, of rapid production and cost reduction, with the introduction of machine operations and labor saving devices and their accompanying engineering problems.

In the well equipped plant of today we have the electric light, the electric motor the electric crane, the electric welder for the repair of defective castings, and the electric furnace as a probability of the near future. For the melting operation there is air blast apparatus for the cupula and Bessemer converter, and the gas producer or fuel oil burner for the open hearth furnace. Hydraulic power finds application in the operation of elevators and in the tilting of the open hearth and Bessemer furnaces. The molding floor is well stocked with machines for the du plicate work, and the most efficient of these are operated by compressed air.

The engineering training incidental to the supervision of the equipment is augmented by that necessary for the calorimetric measurement of the coal and coke, fuel oil, and producer gas, for the mechanical testing of casting specimens, and for the pyrometric regulation of annealing ovens, and the like. And most recently, the use of the microscope in the metallographic examination of the product is being recognized as a valuable adjunct to the chemical analysis.

Also, the management of the foundry enters the broader field of commercial engineering, with its infinite variety of problems in the handling of labor, in the estimation of cost and the making of quotations from drawings and specifications, in the devising of suitable equipment for special jobs, all part of the general effort for maximum production at minimum cost. In short, the direction of the modern foundry requires a general engineer with a special knowledge of chemistry—a chemical engineer.

That foundry practice is a field of profitable endeavor for the engineer is beyond question. On the one hand the value of technical training is becoming recognized, and the demand for men of such qualifications is growing, as is shown by the fact that many of the large manufacturing corporations have foundry engineers to deal with such special problems as may arise. On the other hand, it is equally necessary that the young engineer break away from his present tendencies to drift into the glitter and glamour of the profession, that he enter this generally shunned field, and by the proper application of his abilities, break down the final barriers of conservatism, and make the foundry engineer a recognized essential in the management of this old and interesting business.

SOME SEWAGE PURIFICATION PROBLEMS IN WISCONSIN.

G. J. DAVIS, JR.

During recent years there has appeared, in the various technical periodicals and official reports, a considerable amount of discussion on the subject of the proper design and operation of sewage purification plants. This discussion has been based largely on theoretical considerations, so far as questions of design are concerned, and on the results of laboratory experiments as regards questions of operation. Interesting and valuable as the investigations in laboratories and small experimental plants are known to be, it has been realized that deductions drawn from them may not be strictly applicable to the design or operation of full sized plants working under normal conditions. Furthermore, there are no experimental sewage purification stations in Wisconsin, and deductions drawn from results obtained in the operation of experimental plants in England, in Massachusetts, in Ohio or other places are likely to be misleading when applied to the design or operation of plants in Wisconsin where the climate, soil and other conditions are essentially different.

There are now operating in the State of Wisconsin some eighteen or more sewage purification plants, their location being shown on the map on page — by a circle, yet there are no published data to show which features of their designs and what methods of operation are best suited to Wisconsin conditions. The number of purification plants in the state will rapidly increase, due to the growing demand for sewerage in the smaller cities, for it is the policy of the State Board of Health to refuse permission to discharge untreated sewage into the smaller water courses. There are over sixty towns in the state having either partial or complete sewerage systems discharging crude sewage into the lakes and streams.

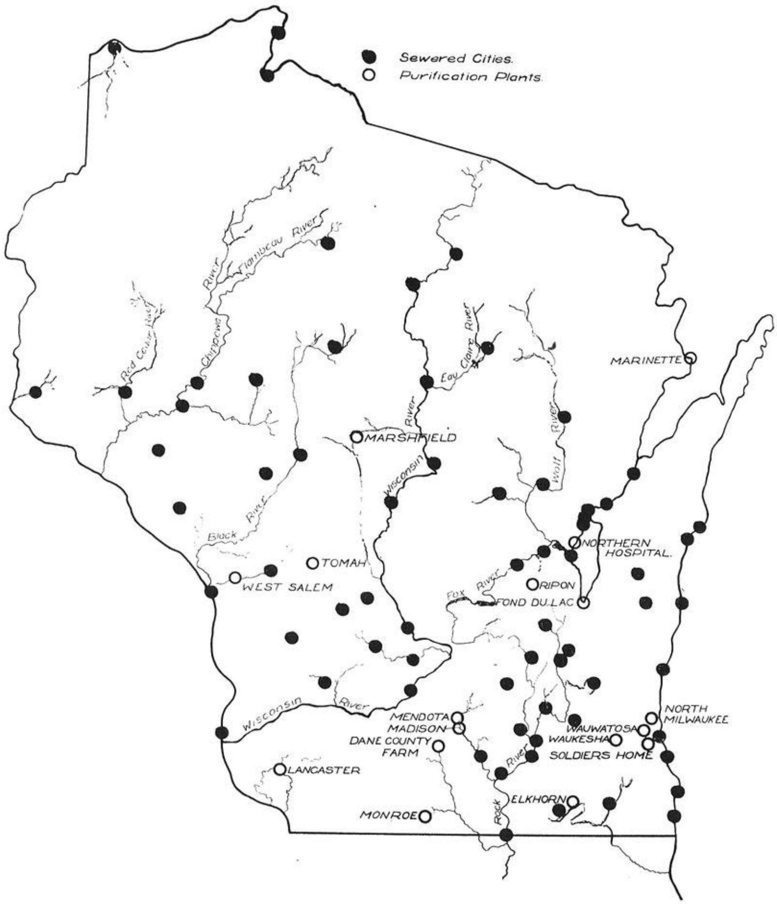


Fig. 1—Map of Wisconsin Showing the Location of Sewage Purification Plants.

These were mostly constructed before the State Board of Health was given control of sewage disposal, in 1905. Their locations are shown by the solid black dots on the map. A large number of these places will eventually have to build purification plants on account of the creation of nuisances by the polution of streams.

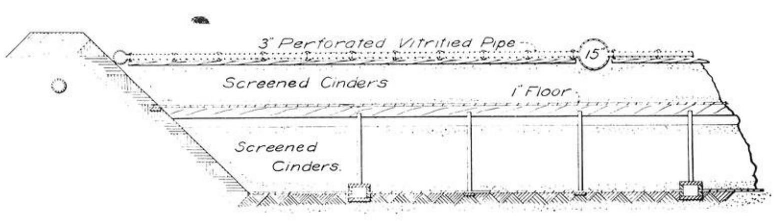
A large amount of capital is invested in the existing purification plants of the state and a much larger amount will in a short time be invested in the prospective plants; but notwithstanding this fact practically nothing has been done to secure the information necessary for intelligent design or to find out whether a fair return on the investment is being had in the way of efficient operation of the existing plants. In fact some of the existing plants are practically useless owing to improper methods of operation, or errors of design which might be corrected at slight expense, and yet the cities owning them seem wholly indifferent to the fact that under these conditions the money they have invested in the plants is a dead loss. Of far more importance than this commercial aspect of the question, however, is the matter of the protection of the public health and comfort of the state. Purification plants should be operated with this end in view, even at increased expense over less efficient methods.

There is, therefore, an urgent need of reliable information concerning details of design of plants, methods of operation and results obtained under the various conditions existing in different parts of the state. Without such information a design will at best be only a guess, but with such information at hand the designing engineer, with a thorough knowledge of the underlying principles, can choose those methods and features best suited to any particular locality.

Before the question as to what is the best method of sewage purification for a given locality can be answered there are several others which must be asked, such as,—For what sized city?—For what kind of sewerage system?—For what degree of purification?—What materials are most available?—Where must the plant be located, with reference to habitations?—What funds are available? Answers to these questions can readily be found by the engineer and their effect on the probable design will be quite definite. There are other questions, however, such as,—For what climate must the plant be adapted?—and, For what character of sewage?—the effect of the answers to which is uncertain.

Take, for instance, the question as to the effect of climate. It may be the judgment of the engineer, from a consideration of the other phases of the problem, that it would be desirable to install a trickling filter; but the uncertainty as to whether such a filter can be successfully operated thru a Wisconsin winter may deter him from using this type. There are at present at least two trickling filters in Wisconsin from which the desired information could be obtained at slight expense. The one is located at Madison and treats the municipal sewage. The original portion of the filter consists of a floor of one-inch rough hemlock boards, with wooden underdrains every 16 feet; a lower bed of fine cinders 2 feet deep; a second or upper floor of one-inch boards 4 inches wide, with $\frac{1}{4}$-inch openings between them; an upper bed of coarse cinders 2 feet deep, and a distributing system of 3-inch perforated vitrified pipe. The upper 6 inches of the upper bed and the entire lower beds are composed of screened, head-end, locomotive cinders which had passed thru a $\frac{1}{2}$-inch mesh revolving screen, but were held on a $\frac{3}{8}$-inch mesh. The lower two feet of the upper beds are composed of cinders which passed thru a screen with 1-inch mesh and were held on a $\frac{1}{2}$-inch mesh.

The four newer beds added to the plant in 1905 differ in several respects from the older ones. The new ones are solid



Section through Madison Trickling Filter.

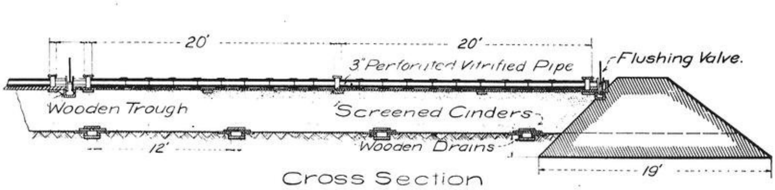


Fig. 2—Section through Madison Percolating Filter.

from top to bottom and are only $2\frac{1}{2}$ to $3\frac{1}{2}$ feet deep, the variation in depth being due to the slope of the bottom. The upper twelve inches are clean, head-end locomotive cinders; the remaining cinders being a mixture varying from one-half inch to one and one-half inches, free from dust and dirt. Cross-sections of these filters are shown in Fig. 2.

To distribute the sewage on to the older beds, a line of double "Wyes," decreasing in diameter from 15 inches to 8 inches, was laid down the middle of each bed. Three-inch, perforated, vitrified pipe laid on 2-inch planks branch from the wyes and end in a line of "Tees," every seventh one of which is a "cross," connected to a flushing valve. In the newer beds the main distributor and the flushing drains instead of vitrified pipe are made of 2-inch plank. This has been found to be an improvement, as there is less breakage of the tile in the new construction and repairs are more easily made.

When a dose of septic tank effluent is discharged on to a bed through this system of piping, a fountain of water spurts from each hole in all the 3-inch pipes. The distribution of sewage over the beds is perfect, and the method is very satisfactory during most of the year, but trouble is experienced in cold weather, due to the freezing of the 3-inch tiles. Attempts have been made to prevent freezing by covering the beds with straw, but this method was not successful and attempts at winter operation of this plant have been abandoned.

The plant at the Allis-Chalmers works differs radically from the one at Madison. It is about five feet deep, and is composed of broken stone graded in size, the smallest, about $\frac{3}{4}$ inch in size being on top, and the larger sizes below. The sewage is distributed to the beds by means of wooden troughs supported about two feet above the surface of the filter. From small holes, about $\frac{1}{2}$ inch in diameter, the sewage sprinkles from the troughs onto the filter at each discharge of siphons, which was occuring at about eight-minute intervals at the time of the writer's visit. The filters are covered with a timber roof, and board sides are provided to keep out the winter winds. The sides are put up in the fall and taken down and piled near by in the spring. With this protection it is possible to operate the plant during cold weather. But such protection by roof and sides is too expensive for use in a large plant.

It would be valuable to carry on some experiments to determine whether it is possible to operate the plant without the sides in position, and if so whether the roof could also be dispensed with.

Experiments have been carried on at both Columbus, Ohio, and at Boston, Mass., with trickling filters, and it was found possible to operate large grain filters at temperatures as low as 7 degrees below zero.

The types of sprinkler used and the appearance under severe winter conditions are shown in Figs. 3 and 4. Whether filters could be operated with these types of sprinklers during periods when the temperature ranges 20° or more below zero for a couple of weeks at a time, as it often does in Wisconsin, is a question waiting to be answered by experiment.

The majority of the purification plants in Wisconsin have sand filters for treating either crude sewage or septic tank effluent. On some the sewage is distributed by terra cotta tiles discharging at numerous points onto the beds; in others wooden troughs are laid down the middle of the beds, the sewage discharging from them laterally through holes about two by three inches in dimensions, spaced about three feet apart. In all cases the beds are operated with their surfaces flat and smooth. Attempts to operate the beds in this condition during the winter has met with failure, owing to the freezing of the sewage held in the upper layers of the filter. Sand filters have been successfully operated in other states, under temperature conditions nearly as severe as those prevailing in Wisconsin winters. The sealing of the filter by freezing has been prevented by plowing its surface and flowing the sewage down the furrows thus formed; the greater volume of sewage, as compared with its exposed surface, enabling it to retain sufficient heat to remain fluid until it has

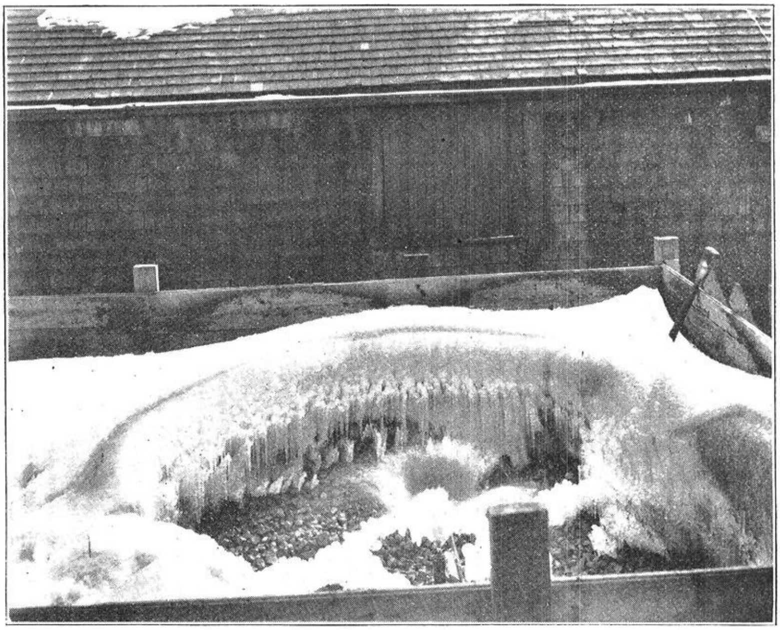


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Fig. 3—Columbus Type of Sprinkler Under Winter Conditions at Boston.

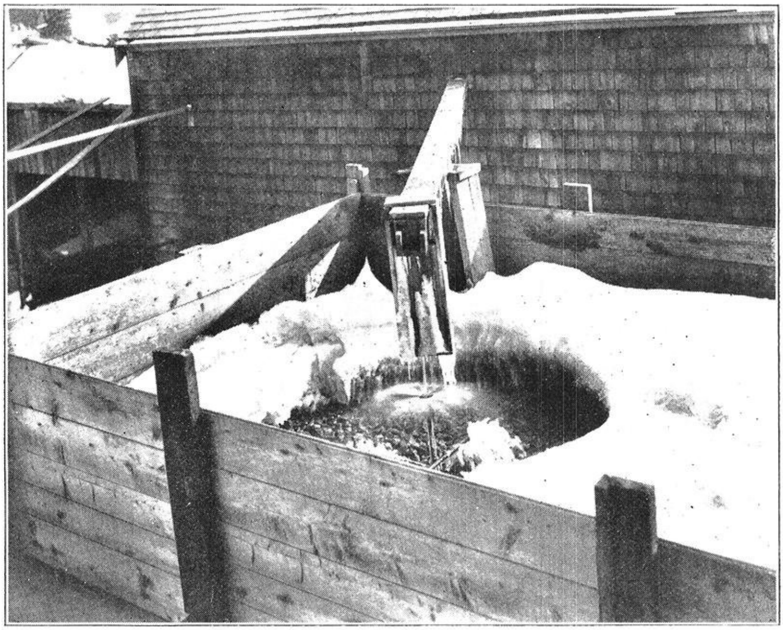

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Fig. 4—Gravity type of Distributor used in Boston Experiments.

seeped into the sand. What would seem to be a better method, has been tried successfully in Massachusetts. It consists in placing stones or piles of material at numerous points on the surface of a smooth filter, and flowing on so large a dose of sewage that a sheet of ice a couple of inches thick will form before the sewage seeps away. As the sewage level drops, the ice will be left supported by the stones, forming a roof which will protect the filter surface from snow and from cold. It would be of value to know whether either of these methods are suitable to Wisconsin conditions, and if both are, which is the best.

Turning to the question as to the effect of the character of the sewage on the design of a plant, we may for illustration call attention to the extreme difference between municipal sewage and the wastes from creameries. The organic solids in municipal sewage are usually mostly liquified without difficulty by the sewage bacteria in a septic tank; the creamery sewage, however, which is very offensive, is quite resistant to such action and must be left in the tank several times as long. The proper length of time that either creamery sewage or the sewage of any of the Wisconsin municipalities should remain in a septic tank is still an open question, and the effect of the various factors, such as temperature and strength of the sewage or the presence of unusual amounts of any of its constituent impurities, has on the proper period of rest in the tank, needs further investigation.

In the preceding pages only a few of the problems arising in connection with sewage purification have been pointed out. Others are suggested in a discussion of Sewage Purification shortly to appear as a bulletin of the University of Wisconsin. This bulletin has been prepared in the hope of stimulating a more active interest in the matter of sewage purification and of furnishing a guide for the proper operation of the plants of the state.

WISCONSIN'S WATER POWER RESOURCES.

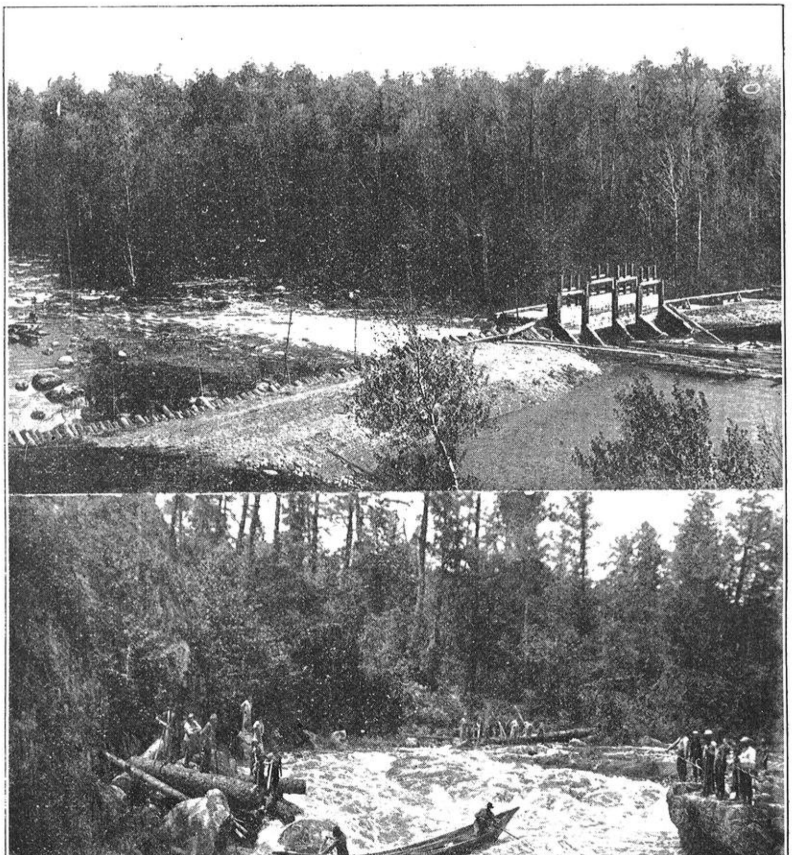
L. S. SMITH, ASSOCIATE PROFESSOR OF TOPOGRAPHICAL ENGINEERING, IN CHARGE OF WATER POWER INVESTIGATIONS OF WISCONSIN GEOLOGICAL SURVEY.

The water power resources of Wisconsin excel those of any other state in the middle west, indeed they are probably excelled by only six or eight states in the entire Union.

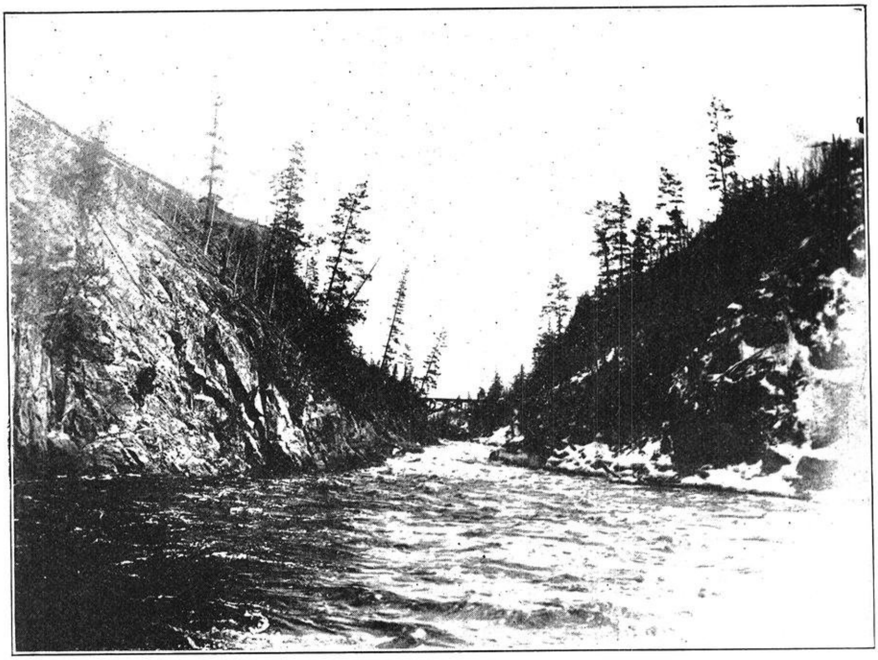
Their importance is due to the unique topography of the state. A wide and comparatively flat plateau region crosses the northern part of the state, varying in elevation from 1900 feet near the Michigan boundary to 1000 feet above the sea near the Minnesota boundary. This plateau region extends to within about 30 miles of Lake Superior. From this elevated region the rivers descend radially in all directions except eastward. Due to the fact that Lakes Superior and Michigan bound the state on the north and east, while the Mississippi river forms a large part of the western and southern boundary, all the rivers must needs find a low trough into which to discharge, and that at a comparatively short distance from their source. This condition insures a rapid fall in the streams, a large part of which occurs in the middle third of their length, where the underlying rock changes from the hard pre-Cambrian crystalline rock to the softer limestone and sandstone rocks.

The importance of water power resources to a state so remote from coal mines as is Wisconsin is not likely to be overestimated. Unquestionably these water powers, if properly husbanded and developed, are destined to exercise a profound influence upon the development of the state. Indeed this result can even now be observed in localities, like the Lower Fox river, where the important water power developments have created a great industrial center.

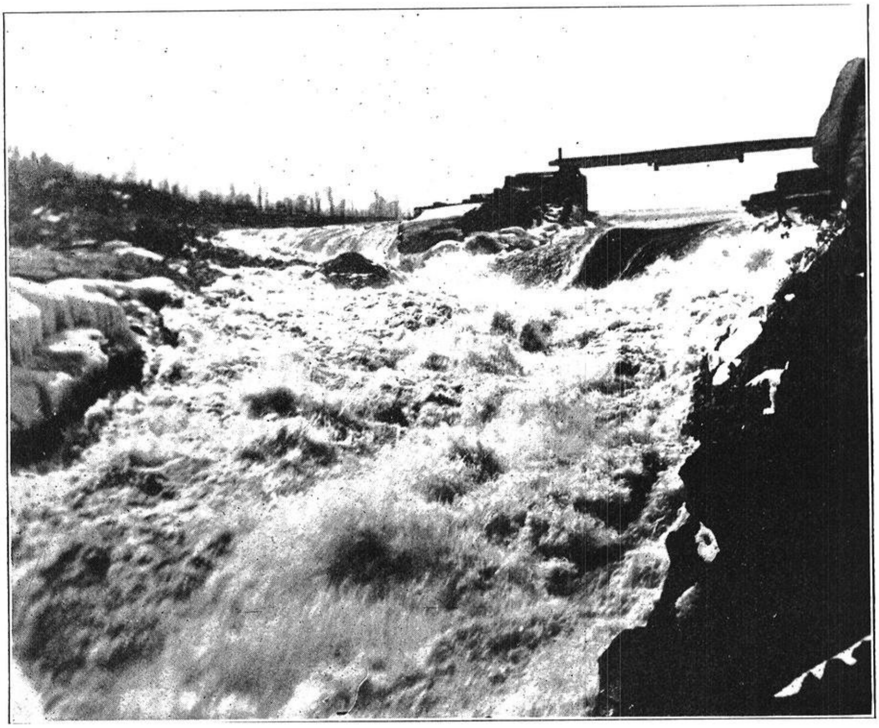
A river may be said to be valuable for water power purposes in proportion to the amount and uniformity of its flow.



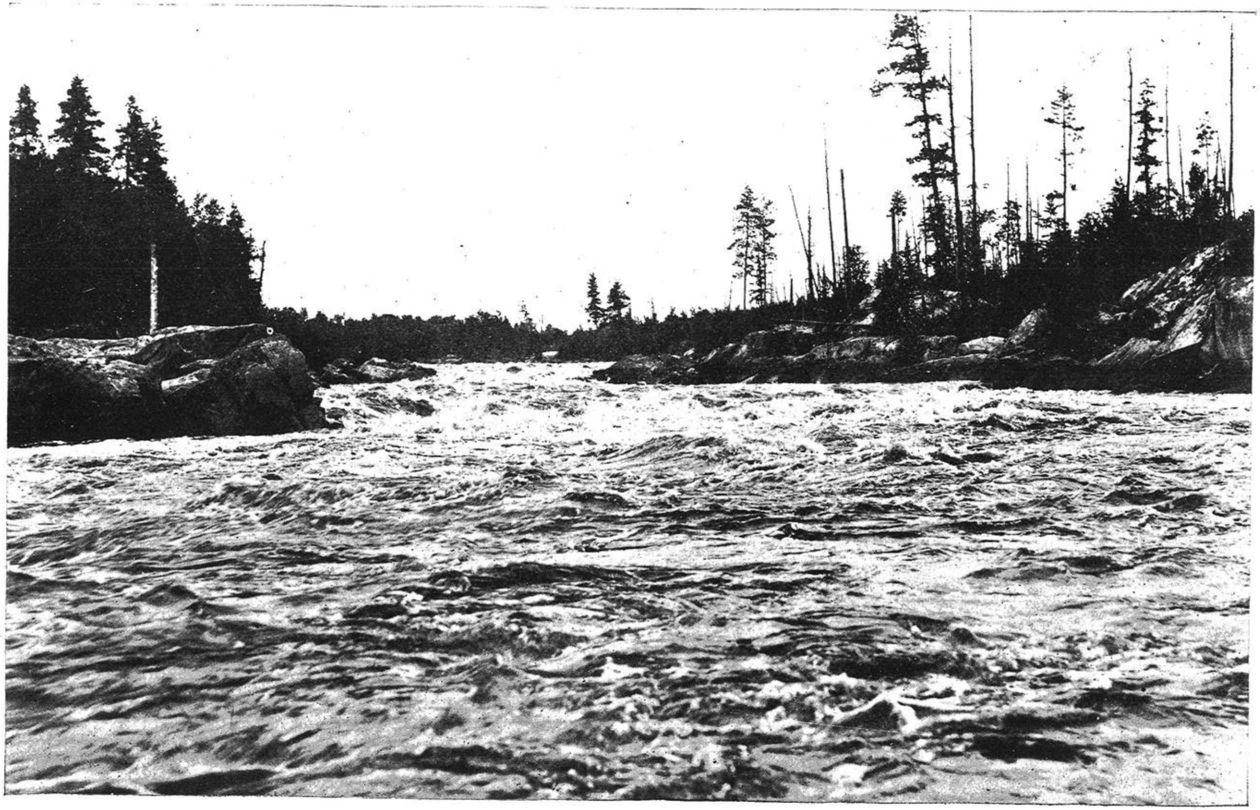
Rapids in the Dells of Wolf River.



The Horse Race, Menominee River



Upper Quinnesec Falls, Near Iron Mountain, Mich., Menominee River, 54 feet head improved.



Near the Foot of Grandfather Rapids, Wisconsin River. The river has a fall of 90 feet in 1½ miles. One-third developed.

Unfortunately it appears that as the lands are cleared and cultivated and the marshes drained, the river floods increase in size only to be followed by a still lower low water stage. Large turbine installations under such circumstances are possible only when a large pondage is available or when expensive steam auxiliary power is provided.

Of the two methods of increasing the low water flow, by reforestation and by reservoir systems, engineers are not agreed as to which is best. In Wisconsin a beginning has already been made toward installing both methods. Several hundreds of thousands of acres of cut-over lands in the northern plateau region are being acquired and planted to trees by the state, while a private corporation, known as the Wisconsin Valley Improvement Company, organized by Chapter 335, Laws of 1907, has already acquired reservoirs on the upper waters of Wisconsin River with a total capacity of about 7,000,000,000 cubic feet. This is only a fractional part of the reservoirs possible on the headwaters of this river. A similar movement is being inaugurated on the headwaters of Chippewa and F'ambeau rivers.

The curve shown in Fig. 1 shows the rate and amount of water power development in Wisconsin since 1860. By reference to this curve it will be seen that between 1860 and 1890, the rate of increase was quite slow, being only about 1,000 horse power per year. Beginning, however, with 1890, the curve changes suddenly, showing a much larger increase in water power development. In fact, the new power developed in the past twenty years, 140,000 horse power, is over twice as great as the total power developed before 1860. These figures bring out clearly how unlike other great natural resources of a state, such as coal, the other mineral wealth, are the water resources. The former are strictly limited in amount and when once used are gone forever, while water power simply uses what would otherwise go to waste, a resource, in fact, which can be made as eternal as the sunshine itself. The conservation movement, now causing such widespread interest, suggests that these

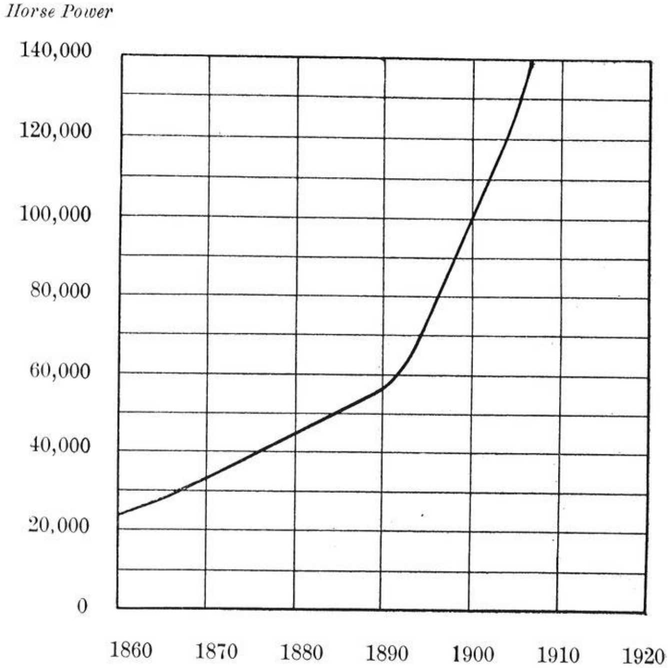


Fig 1—Wisconsin Water Power Developed.

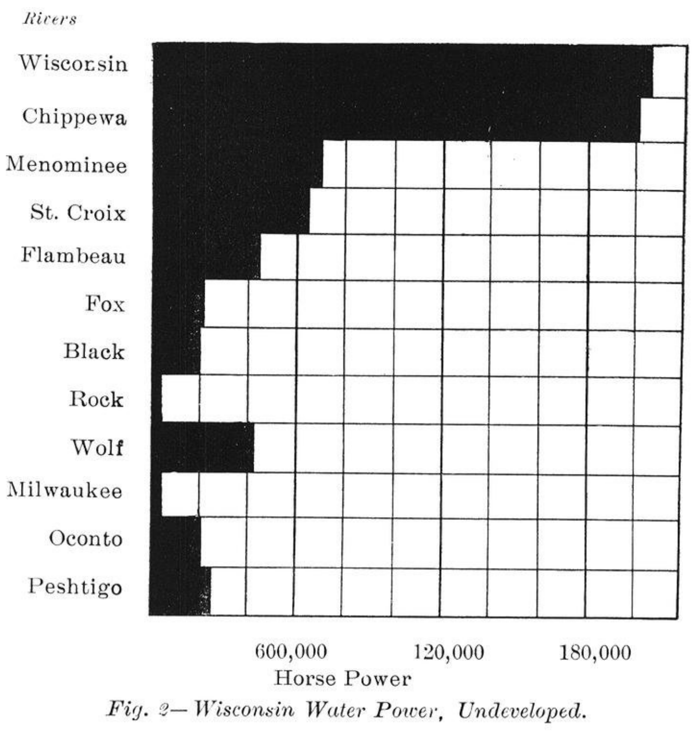


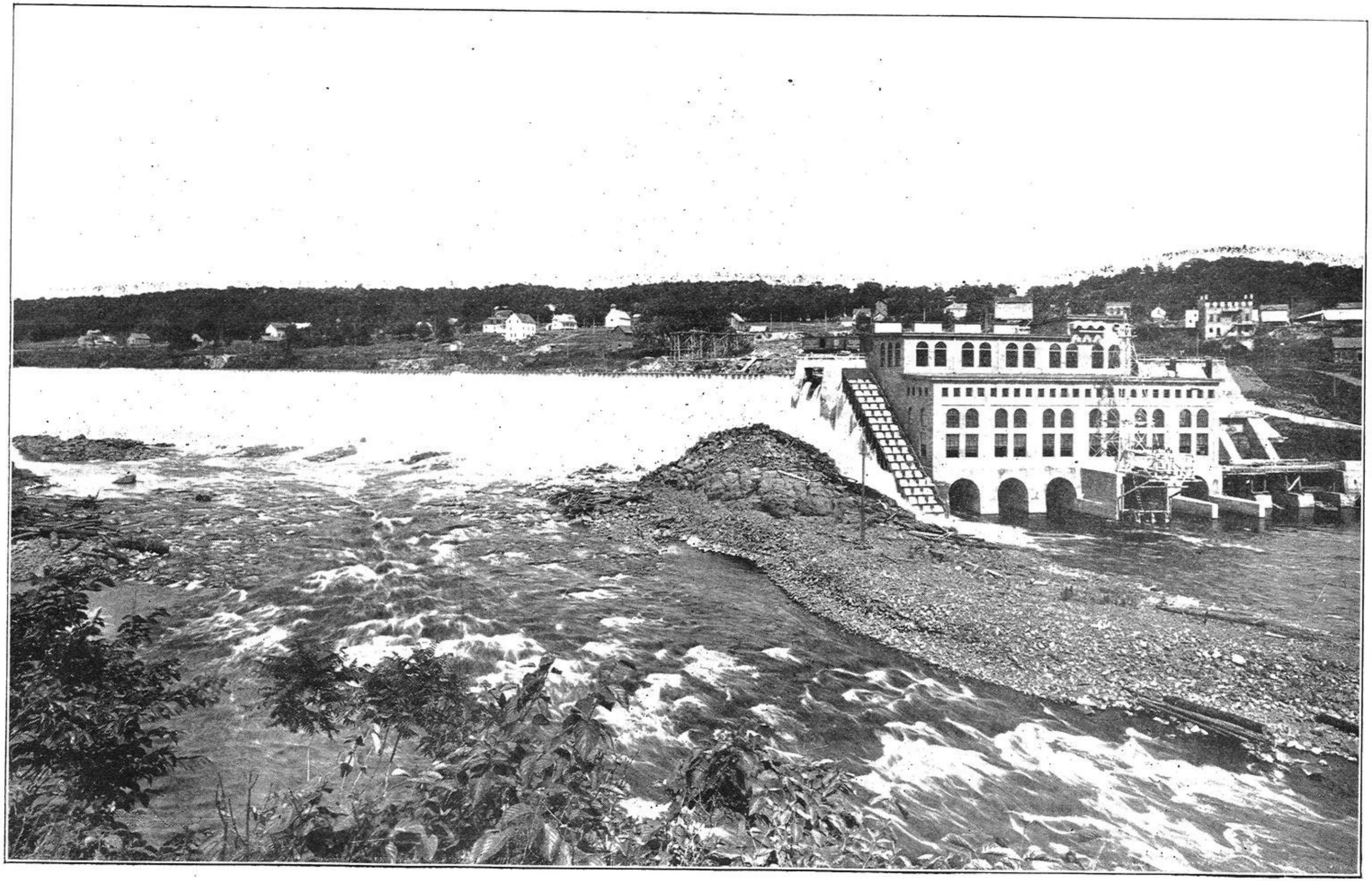
Fig. 2—Wisconsin Water Power, Undeveloped.

powers be utilized to their fullest extent as soon as practicable. In this way the equivalent amount of coal can be saved for future generations.

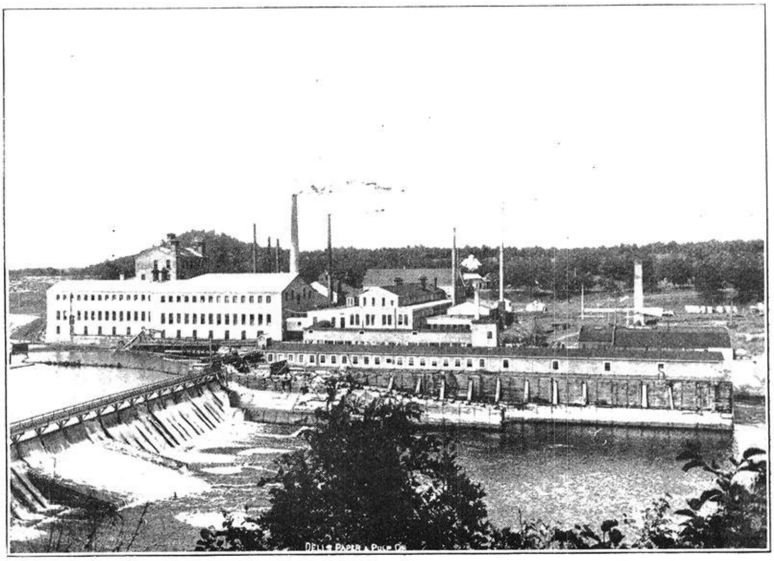
Unquestionably no single factor has contributed so much to bring about this wholesale use of water power as the recent development in the electrical generation and transmission of power, permitting, as it does, the generation of power at a distant point, where it may be found in great quantities and transmitting it to other localities where transportation or other facilities render it more valuable. Electrical transmission also permits the joining by wire of a number of relatively small powers on the same or adjacent rivers, and transmitting the combined power to a single central plant where it can be used to greatest profit and economic advantage. Every reason exists for the belief that improvement along the line of electrical generation and transmission of power will continue to be made, improvement which will even more profoundly enhance the value of our water powers.

During the past summer, the writer was engaged in making an approximate estimate of the total undeveloped water power in the entire state for the State and Federal Conservation Commissions. The result of these computations, while only approximate because of insufficient data, are so interesting that I have put them in graphical form in Fig. 2. On a single river (the Wisconsin) the undeveloped powers (203,-000 H. P. exceed the total powers now developed in the entire state. It is safe to say that a water power is located sufficiently near every city in the state to be used for either power of light or both, and that at a large saving in the cost of production as compared with steam power.

The limits of this paper preclude descriptions of any pasticular powers. Interested parties may obtain maps and profiles of 500 miles of the most important Wisconsin water power streams, made from our recent Federal and State Cooperative Survey. Copies of these maps may be obtained on application to Dr. E. A. Birge, Madison, Wis. These maps include the Wisconsin River from Kilbourn to Tomahawk,

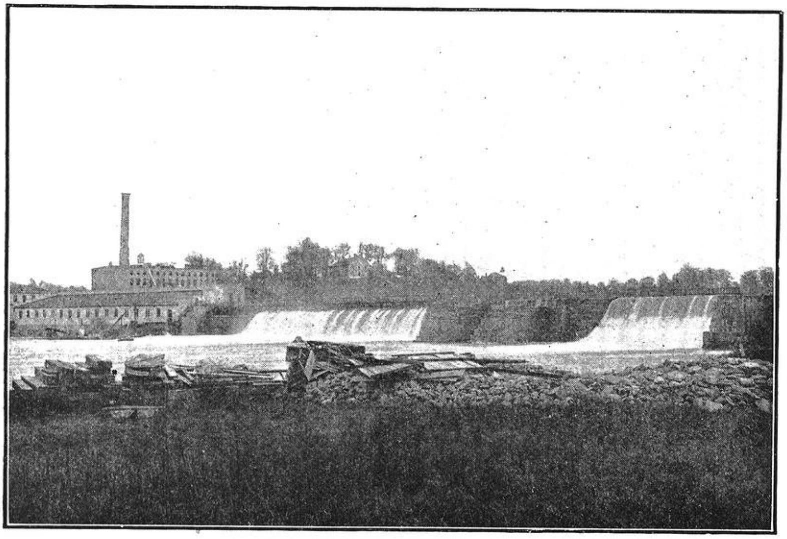


St. Croix Falls Concrete Dam and Power House, St. Croix River. Head, 50 feet. Cost $3,500,000. 27000 h. p.

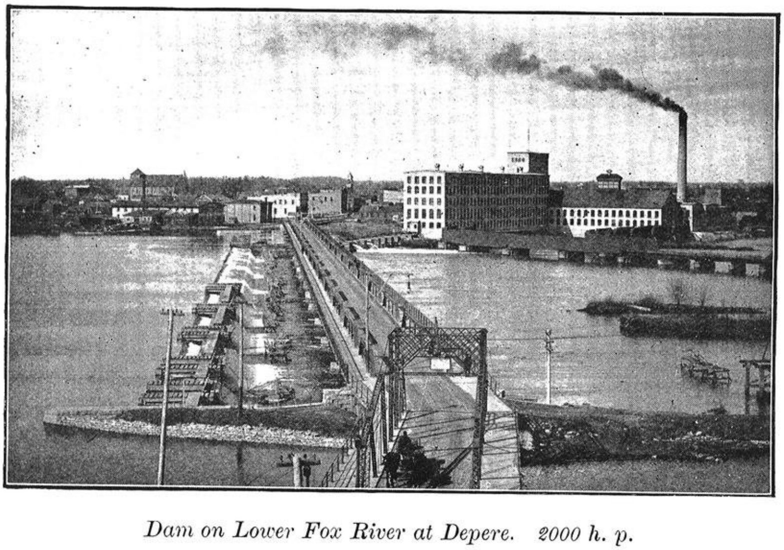


The Dells Paper and Pulp Co.'s Dam and Mill, Eau Claire, Wis.
Head 26 feet. 8250 h. p. installed. Chippewa River.

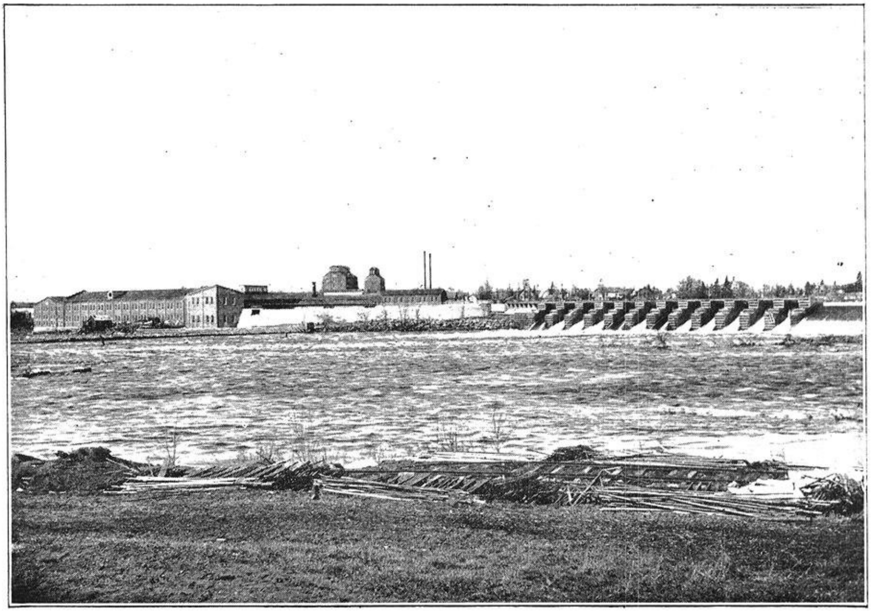
Brunette Falls, Chippewa River. Undeveloped. 35 feet Head possible.



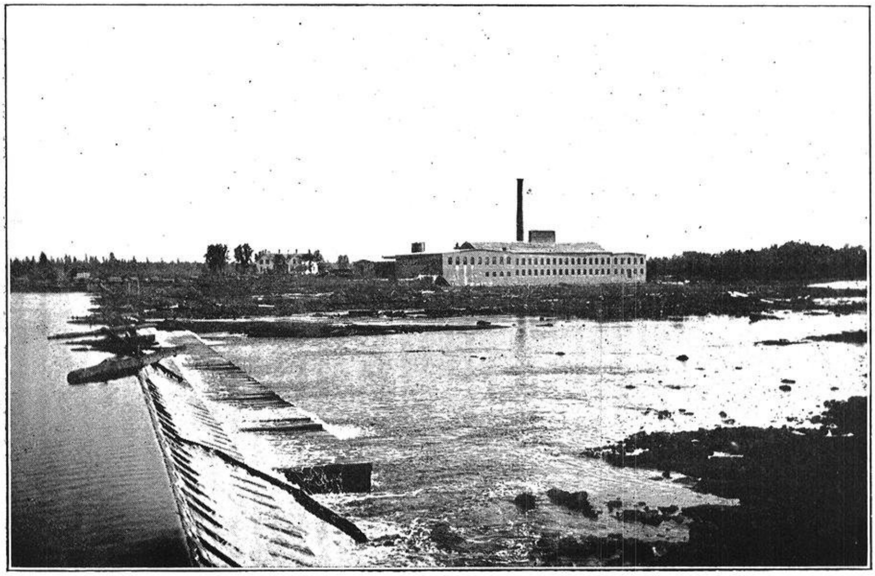
Combined Locks Dam on Lower Fox River at Little Chute.
Private dam; cost $1,250,000. 4440 h. p.



Dam on Lower Fox River at Depere. 2000 h. p.



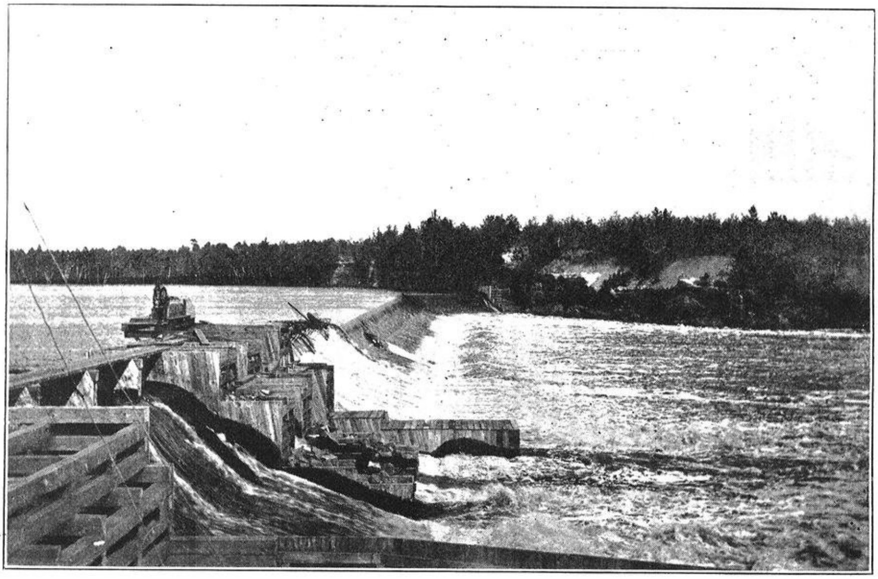
The Consolidated Paper and Power Co.'s Dam and Mill, Grand Rapids, Wisconsin River. Head, 25 feet. 6500 h. p.



Grand Rapids Pulp and Paper Co.'s Plant at Biron, Wis., on Wisconsin River. Head, 12 feet. 3000 h. p.

197 miles; Black River, from Black River Falls to Withee, 63 miles; Flambeau River from its mouth to a point 23 miles above Park Falls, 120 miles; Peshtigo River from Peshtigo to a point 82 miles above; and the Eau Claire for the 26 miles between its mouth and the Dells. These maps show the height of the banks by ten foot contours, while the profiles show the concentrations of fall. From both maps and profiles the amount of fall in any particular length or section can be obtained and the approximate possible head of a proposed dam be determined. It is hoped that by thus advertising the powers on each river, to insure their early development, not by a privileged few, but by any one who is interested in power development.

Still further publicity concerning our water power resources is given by a report on this subject, prepared by the writer and issued by the State Geological Survey during the past summer. This report of 350 pages, illustrated by



Nekoosa Paper Co.'s Dam, Nekoosa, Wis., Wisconsin River. Head, 17 feet. 4560 h. p.

70 plates and figures, can be obtained of Director E. A. Birge, Madison, for only the carrying charges, 25 cents.

The statements of water powers available are based principally upon the river surveys referred to before, and to the daily stream measurement made by the U. S. Geological Survey during the past six years on the large rivers. To realize the full power given during the dryest seasons, reservoirs for storing the flood waters should be constructed near the head waters of the streams. Otherwise auxiliary steam power would need be installed and used at such time.

The following table gives the most important facts regarding the principal water power rivers of Wisconsin:

River System.	Drainage Area.	Total Fall.	Already Developed.	Easily Developed.	Horse Power now Developed.	Horse Power now Undeveloped.
	sq.miles	feet	feet	feet		
Wisconsin	12280	1044	308	430	67200	386500
Fox	6400	170	150	13	38250	11500
Wolf	3650	800	....	400	2580	34000
Menominee	4000	550	130	307	12600	72500
Peshtigo	1123	1040	30	880	2190	33800
Oconto	994	245	60	725	2885	21000
Black	2270	570	95	400	2200	16500
Chippewa	9573	†730	30	700	20000	*156000
St. Croix	7576	322	50	200	18600	45800
Rock	3500	132	67	14	7700	1000
Milwaukee	840	437	122	100	3700	4300
Flambeau	1983	575	60	†370	5200	45000

*Omitting Flambeau River.
†Including Dore Flambeau.

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EDITORIALS.

THIS issue closes another volume of the WISCONSIN ENGINEER. It marks the second year that the new policy of its management has been adopted. We feel that the change in the busines management was a step toward putting the ENGINEER on a firm basis. We had some money turned over to us by the last board. This enabled us to get a good start which is essential to the successful completion on any task. The ENGINEER has been supported loyally by the students, especially of the upper classmen, and the faculty. As a result we will be able to give to the new board a better financial start than we received. We wish at this time to express our thanks to those who have aided us in making this volume of the ENGINEER a success, and especially those who contributed articles.

AT present plans are being drawn by Architeet Peabody for an addition to the Engineering Building. The present congested state of affairs will be greatly eleviated when these plans are carried into execution. The basement of the addition will give the mechanician's department more room, and also suitable rooms for surveying and geodetic instrument; the first floor will be divided so as to give additional recitation rooms and offices and enlarge the present reading room; the second floor will be devoted to recitation and lecture rooms for Mining and Electrical Engineering, the third floor will give much room for the Junior and Senior drafting rooms, and the attic rooms will be used for Freshman drawing.

The final plan is to raise both the east and west ends of the building to full story, and to build a wing to the north on each, but at the present time only the wing on the north end will be constructed.

PLANS have also been drawn by the University architect for the new laboratory for the testing of timber which the United States government recently decided to have located at the University of Wisconsin. The new building will be located at Camp Randall, near the C. M. & St. P. tracks.

Excellent opportunities will be offered to study the various kinds of timber and their strength, as the government proposes to carry on all the tests of timber, between the Appalachian and Rocky Mountains, at this laboratory.

At the present time much is being said about the danger of the canoe on account of the two fatal accidents which have occurred this year to students. The canoe in itself is not dangerous if properly constructed and handled. The danger lies in the management and construction of the canoe. At least nine out of every ten canoes on Lake Mendota have their seats within an inch and a half from the top. This makes the canoe unstable because the center of the load is very high above the water. A canoe in comparatively quiet water with the center of its load near the bottom is safer than a buggy with a frisky horse hitched to it. Thus far nothing has been suggested to prevent canoe accidents, except to prohibit canoeing. This will not prevent students from going on the water. If they can not use canoes they will use row boats and sail boats. The sail boat can only be used when the wind is fairly strong, and it is liable to be used in a gale. The row boat is dangerous in a storm. A better solution to the problem is to regulate the use of row boats and canoes by requiring them to be made according to certain specifications so that they will be in a stable condition, and allow them to be used only when the atmospheric conditions are favorable. Some person could be appointed to give a signal at the approach of a storm, which would require every student on the lake to return at once and prohibit others from going upon the lake until it would again be safe.

Since the last issue of the Engineer four lectures were given in the auditorium of the Engineering Building by Dr. Herman von Schrenck on Structural Timber. Dr. Schrenck spoke of the large demands for Timber and the necessity of conserving our forests. Our forests are conserved by (1) economical use of material, (2) purchasing and managing forest lands, and (3) planting trees on waste lands. The purchase and management appears to be of no immediate gain to the purchaser. Hence the purchase of timber land is the work of the state. At the present time the United

States government owns one thirty-seventh of the timber land in this country.

Economy is effected by investigating the size of timber and making the factor of safety as low as possible. Often the material used is excessive. A composite stringer has two or three times the life of a one-piece stringer. Timber is destroyed in three ways: (1) wasted, (2) mechanically, (3) decay. The mechanical destruction of timber consists of impact and abrasion such as on depot platforms. The decay is of two kinds: (1) atmospheric weathering, which is very small, (2) fungus action. The fungi grow on the wood and obtain their nourishment from the fiber similar to the way wheat gets its nourishment from the soil. In order to develope they need food which they obtain from the timber, some heat, moisture and oxygen. If any one of these is absent it is impossible for the fungi to develope. Timber which was covered in the delta of the Mississippi River for twenty thousand years, according to geologists, was perfectly sound when uncovered because of the absence of oxygen.

There is a large variety of the fungi which grow upon wood. They may roughly be put into two classes: (1) those that grow on live trees, and (2) those that grow on dead timber. Nearly all of those of the first class attack only the heart wood and use for their food the encrusting substance of the wood fiber. The wood appears perfectly sound except that it has some white spots and the tensil strength is descreased. This form never gets into a tree except through a wound, and it dies as soon as the tree is cut down. The second class attacks only the sap wood and destroys everything except the encrusting material of the wood fiber. Many specimens were shown in which the wood appeared perfectly sound on the outside while a large portion was decayed on the inside.

Preservatives are of a large variety, but those most successful are creosote or dead oil of tar and zinc chloride. The objection to zinc chloride is that it is very soluble in water and consequently does not stay permanently in the timber, and also it corrodes the spikes driven into the timber.

The preservative must be applied so that it penetrates the wood deeper than the season checks. The spores get into the check and if the wood is not treated where the spores strike, they will grow and destroy the wood below the treated portion. Nearly all of the processes for treating the timber apply pressure to secure penetration. The process most used is the Lowre Process. In this process the timber is put into a tube and the creosote is pumped into the tube until the required amount of oil is forced into the timber. For railroad ties this is about seven gallons per tie. The oil is then let out of the tank and a vacuum applied to suck part of the oil out of the timber again.

The quantity of the oil left in the timber depends upon the purpose for which the timber is to be used. In permanent structures such as bridges the full treatment is used, which consists of fifteen pounds of oil per cubic foot of wood. In timber which is subjectcd to mechanical destruction, the oil should be just sufficient to preserve it until it is worn out.

THE newly established department of Mining Engineering at the University of Wisconsin has just published a bulletin announcing thirteen special courses in mining engineering for undergraduates, leading to the degree of bachelor of science in the mining engineering course, and an advanced course is being arranged for next year, for which the professional degree of enginneer of mines will be conferred.

As the duties of the mining engineer are diverse and comprehensive, the four-year undergraduate course is designed to give the student fundamental training in structural, mechanical, and electrlcal engineering, chemistry and mineralogy, and special work in geology, and the application of these subjects to mining, ore dressing, and metallurgy.

ORE dressing and assay laboratories are to be equipped in a building formerly occupied by the heating plant, where, in addition to the instruction of students in the principles of ore dressing by hand and the representative machines, experimental and research work will also be conducted. A course in practical assaying will follow those in general chemistry and quantitative analysis.

The course in excavation and quarrying will include railway grading, support of excavations, canal and submarine excavation, explosives, blasting and allied subjects. Tunneling, boring, and shaft sinking will form the subject of another course in which the ventilation, drainiage, and timbering of mine shafts will be considered, with the methods of sinking shafts through quick sands, rock, and earth, and hoisting expedients.

In the course on prospecting and mine development, the relation of mining geology to exploration will precede a consideration of the various forms of prospecting on the surface and by shafts and drifts, and the development of veins discovered. A separate course in exploitation of mines will give the student opportunity to learn methods of hydraulic and dredge mining, ways of coal mining, and salt and sulphur mining, with the maintenance of entries and air-ways.

MINE accidents, their causes, control, and prevention will be treated in the general eourse on mine engineering, in which the design, installation and operation of all sorts of systems for draining, ventilating, lighting, hoisting, hauling, and signaling in mines will be taught. The generating and transmitting of power for surface plants, with the buildings, roads and water supply for them will be a part of the work.

One of the advanced courses will cove.ı the subjects of gold and silver milling and cyanidation, showing how stamp-mills are operated, the forms of amalgamation, and methods of treating precious metals under various conditions. The senior thesis work of mining students will consist of the design and working drawings of the principal structures and machinery for a mine, with a detailed report of the development and equipment.

Brief courses in railway location, construction and maintenance and in steam and gas engines will accompany the more purely mining branches of study, so that students will be prepared for such railway and engine problems as may come to them for solution in their practical mining experience.

ENGINEERING SOCIETIES.

U. W. Engineer's Club.

During the spring term several new men were elected to the club and the prospects are good for those who return in the fall to start with a strong, active membership.

There have been four programs prepared since the last issue of the WISCONSIN EFGINEER.

On the evening of May 14 we had the pleasure of a lantern slide talk by Dr. O. P. Watts on Metallography and the Microscopic Analysis of Alloys, etc., and its importance. This proved of much interest to all who were fortunate enough to be present.

The engineers who took the Eastern Trip gave a very interesting series of talks on various points of interest as follows:

Niagara Falls—H. J. Newman, '10.
Pittsburg—W. F. Lent, '10.
Milwaukee—H. H. Koonig, '10.
Gary—W. R. McCann, '10.
Detroit—Ljoblom, '10.

At the first meeting after the election of officers for the spring term, the following program was rendered:

Morgan Gas Producers—H. A. Wilson, '12.
Recent Models of Prime Movers—F. W. Ives, '08.
Portland Cement Manufacture—W. C. Andrews, '10.

These topics were well prepared and proved of much interest to all.

At the meeting on April 23, Mr. I. H. Spoor, '10, gave a very instructive talk on Carbon and its Effect on Iron and Steel, showing the results of various percentages of carbon in the iron by curves and tables.

Mr. H. H. Magdsick, '10, gave a talk on the value of n in the equation $P V^n = K$, followed by a talk on Shaft Plumbing and Mine Surveying by H. H. Hunner, '09.

On the evening of May 28th, the annual banquet was given at the Trumpf Hotel, which was attended by all the active members and several of the alumni. It proved a most enjoyable affair and will long be remembered by the class of 1909 as one of the big events of the senior year.

Civil Engineering Society.

During the past year the Civil Engineering Society has made rapid progress not only by materially increasing its membership but also by bringing about quite a radical revision in its program. Heretofore the programs consisted of lectures rendered by faculty members or instructors, which of course exempted the students almost entirely from taking any active part in speaking before an audience. Engineering students especially, are deprived from this opportunity, which doubtless is a great weakness in the Engineering College. The C. E. Society, realizing this defect, now installed a system whereby each member of the Society is given an opportunity to train and develope this faculty of speaking by appearing before the public.

Moreover the efforts and interests shown in the promotion of the revision indicate that the members are greatly in favor of listening to the experiences of their Society members, and other articles presented by them, rather than secure some other or outside speaker which was often quite difficult. Provision has, however, been made to meet jointly with the U. W. Engineers' Club about once a month, whence outside speakers are generally procured.

This new scheme was introduced, tried and tested now for over a year, is strongly approved by the members and has conclusively proved a success.

Although being the youngest of engineering societies, it now has an enrollment of 55, and until recently was not reprepresented on the Students' Conference Committee, but owing to its rapid growth and activity among other societies, entitled us to membership this semester.

The officers for the last semeter were:

President—H. C. Kuhl.

Vice-President—H. E. Balsley.

Secretary—F. E. Bates.

Treasurer—F. E. Canfield.

ALUMNI NOTES.

W. J. Bohan, '95, who has been with the Northern Pacific Railroad since his graduation has recently invented a system of train lighting, which is a combination of the head-end system and the individual axle lighting method. Mr. Bohan has been working on this system for the past five years.

In this system but one dynamo is used and it is mounted in the baggage car. It is driven by means of self-adjusting belts from the axle to the truck at one end of the car. The generator is entirely within the car, where it and the automatic regulating apparatus can be readily inspected. The equipment does not take up very much room, however, and can be enclosed to prevent unnecessary disturbance with it. Storage batteries are provided for supplying the load when the train is stationary.

A recent test of the system with a four coach train showed that it was fully capable of brilliantly lighting the train at all times. Its initial and maintenance cost is said to be but a small part of that required for the regular axle system, over which it has the further advantage of accessibility for inspection and repairs. Compared with the steam-driven, head-end method, it is claimed to cost about one-half.

Prof. Beebe has for some time been gathering information about graduates from his department regarding the nature of the work in which they are engaged and the position which they are holding. It is quite interesting to note the number of various lines of work in which they are engaged. Taking the total number who have reported as 100 per cent. the classification is as follows:

	Executive.	*Technical.*
Central Stations	7.50	17.50
Telephones	2.50	7.80
Electrical R. R.	.70	4.30
Steam R. R.	.70	.36

Manufacturing	2.50		11.70
Sales	1.80		2.50
Construction	1.42		1.07
Contracting	.36		.70
Teaching		11.00	
Research		1.80	
Apprentice		3.20	
Unemployed		2.84	
Rate Commission		2.14	
Insurance		.70	
Steel Manufucture		.39	
Horticulture		1.07	
Music		.35	
Mining		1.42	
Y. M. C. A		.36	
Navy		.36	
Transmission		.36	
Draftsman		1.42	
Consulting		2.84	
Journalism		1.07	
Patent		1.80	
Design		1.07	
Banking		.70	
Testing		.70	
Law		.36	
Chief Eng		.36	
Dead		.36	

This does not include the total number of graduates, but only such as have sent in the statement.

R. S. Peotter, '05, who was formerly with D. W. Mead, of this city, is now with the Gulf Coast Irrigation Co., of Brownsville, Texas, and is located at Mercedes, Texas. Mr. Peotter expects to receive his degree in Civil Engineering this year.

Mr. F. C. Stailer, '02, who has been with Westinghouse Electric and M'f'g Co. at East Pittsburg for the past three years, is now connected with Pennsylvania Terminal and Tunnel Railroad Co., of New York City.

F. E. Fisher, '06, who for several years was assistant to the chief engineer with the Northern Electrical M'f'g Co., of this city, has accepted a position with the Diehl M'f'g Co., Elizabeth, N. J.

A. I. Bucherker, '08, is located at Victoria, B. C., and has a position as switchboard operator in the substation and auxiliary steam plant.

Mr. B. H. Peck, '06, was in the city a few days ago on a matter of business which was not of an official nature. On May 6 he was married to Miss Letta Whelan, U. W. '07, at the home of the bride's parents, 411 W. Washington Ave., Madison, Wis. Only relatives and near friends were present and all were united in their best wishes for the happy pair. Mr. and Mrs. Peck will reside in Irving Park, Chicago, Mr. Peck being with D. C. and Wm. B. Jackson, of that city.

C. J. Hejda, '03, is now employed in the Testing Laboratories of the Commonwealth Edison Co., of Chicago.