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THE CIVIL ENGINEER AS A GUARDIAN OF THE PUBLIC HEALTH.

By J. B. JOHNSON, Member of the Engineers' Club of St. Louis.

The sphere of the engineer has rapidly widened with the new applications of scientific knowledge in the promotion of the convenience, the comfort, and the happiness of mankind. The widening of this sphere has also led to a multitude of subdivisions of engineering work and even the field of civil engineering is often subdivided. But since any civil engineer is liable to be called upon to provide means to promote the general health of the community, I shall here consider the duties of civil engineers as a class in the field of public sanitation.

Sanitary science may be said to have grown along with the science of bacteriology. While Jenner, with vaccination as an antidote for smallpox, in 1798, took the first important step in the way of prevention of disease, the means to be employed for the general avoidance of all kinds of infectious diseases could not have been formulated until the specific causes of these diseases had been found. The proof that all infectious and contagious diseases, together with several not hitherto so considered, such as malarial and intermittent fevers, are caused by taking into the system, either in the air we breathe, in the water we drink, or in the food we eat, pathogenic or disease-producing bacteria, has now been established beyond a peradventure. As soon as this is admitted it becomes somebody's duty to look well to the elimination of these ailments by preventing their causes from reaching their natural prey. On reflection it will be found that the carrying out of these preventive measures devolves largely upon the civil engineer, and furthermore, he is called upon to determine what measures will prove at once most economical and most effective in preventing the spread of these fatal maladies. Our census reports indicate that fully 40 per cent. of all deaths occurring in the United States are from these ordinary germ diseases. These are, in the order of their virulence, consumption, pneumonia, diarrheal diseases, diphtheria, typhoid fever, malarial fever, measles, whooping cough, scarlet fever, and smallpox. It will be noted that these do not include such occasional visitations as cholera and yellow fever, but only those ordinary, every-day diseases which are found with more or less frequency in almost every community.

The tracing of all these species of sickness to the ravages of micro-organisms which are not native to the human body, but which find, in weakened or diseased systems, conditions favorable for their propagation, has created a greater revolution in our lives and is likely to be of far more benefit to the race than Darwin's and Spencer's theory of evolution, or than all other discoveries of this century combined. Second only in importance to these discoveries of the causes of infectious diseases come the various means of prevention which have already been found, most of which it is the business of civil engineers to provide. Now, I hold that if the provision of the preventive means falls within the sphere of duties of the civil engineer, then it becomes his further duty to thoroughly inform himself as to all these causes and remedies and to lead in the work of educating the public to the point of providing the necessary legislation and funds to carry out such measures and to build such works as are required.

Here is where the emphasis of this paper lies. I believe civil engineers, as a class, are not sufficiently informed on this subject, and, further, that those who are informed are not sufficiently zealous in leading in the campaign of education required in every community in order to get the necessary acts passed and the funds provided. Engineers are known for their extreme modesty, but modesty becomes culpable neglect when it keeps us from coming forward at any and all times to aid in forming the right kind of public opinion on these subjects.

I wish it distinctly understood that I include myself in this condemnation. We are, I believe, all alike guilty of culpable negligence in this matter. For instance, out of the 1,400 active members in the American Public Health Association in 1894 there were listed but 33 engineers, only one of whom was from this city. Practically all the rest were physicians. This is a ratio of 42 physicians to one engineer who are struggling in America with the sanitary problems of the age. It may be that this is about the ratio of the total membership in these two professions in this country, but I should be surprised to learn that the disproportion is so great. As that association is doing a vast amount of good in gathering and disseminating information on this the greatest of all sciences, so far as life and health are concerned, surely it should be better supported by the engineering profession. We should remember that it is the primary duty of physicians to cure disease, whereas it is the primary duty of the sanitary engineer to prevent it. We should expect to see, therefore, a public health association, devoted to the prevention of disease, composed mainly of bacteriologists and sanitary engineers rather than of physicians. It is greatly to the credit of the medical profession and to the discredit of the engineering profession that the reverse is the case.

Let us now try to evaluate the engineer's responsibilities in these matters. You will all admit that it is solely the engineer's business to provide the drinking water, to dispose of all sewage and garbage wastes, to make healthful streets and alleys and to keep them clean. The business of heating ,lighting and ventilating large assembly halls, hospitals, school buildings, and railway stations and cars is also now coming to be regarded as the business of engineers, and soon the artificial cooling of such buildings will be added to their duties. But the census reports show that one death in every seven is caused either by a diarrheal disease or by typhoid, malarial or intermittent fevers, and nearly all these deaths are known to be caused by impure drinking water. In the year 1890 over 120,000 persons died in the United States of these diseases, and without doubt we may charge this number of deaths to the use of impure water.

It is further shown that the average annual death rate in 1890 from typhoid fever alone was the same in the large cities as in the smaller towns and country, being in both cases an average of 56 in every 100,000 persons. In 1896 this rate had fallen to about 30 in 100,000 in twenty-eight of the leading cities, owing to improvements made in the drinking water in the meantime. Thus the Chicago rate dropped from 83, 160, and 104 per 100,000 in 1890, 1891, and 1892 to 31, 32, and 46 in 1894, 1895, and 1896 respectively. This was traceable directly to bringing into service the water inlet four miles from shore in place of two miles out, which change was made in 1893. That is to say, this change in the intake of the water supply reduced the deaths from typhoid fever in that city during the three years, 1894, 1895, and 1896, from 1,856 to 576, or a saving of 1,280 lives annually.

If a life is worth $5,000, as the laws of many states, including Missouri, have determined, then the money value of the lives saved in these years and since has been over $6,000,000 annually. If to this we add the value of the loss of time by sickness on the part of those atacked by this disease and who recovered, which is usually about six times as many as die, we have a saving of 7,680 cases of typhoid sickness. If we estimate a loss of six weeks' time to each patient, and a combined money loss of time and expense of $200 for each case, we have $1,500,000 more to be credited annually to the improvement caused by taking the water from a point two miles further out in the lake.

Again, the city of Lawrence, Mass., had an annual typhoid fever death rate in 1890 of 123 per 100,000, but after the use of filters in 1892 the death rate from this cause fell off to 15 per 100,000 in 1896, or to less than one-fourth the former number.

But even this number of typhoid fatalities is large in comparison with that in many of the cities of Europe. Although in these cities the water is very often taken from very polluted streams, yet it is effectively and intelligently filtered under government regulation and supervision until practically a perfect drinking water results. Thus in 1896 the average annual death rate from typhoid fever in Berlin, Vienna, Hamburg, Munich, Hague, Dresden, Stockholm, Copenhagen, and Breslau was only 5 per 100,000, while the best American average of 16 or 17 could be made up from the cities of New York, Brooklyn, St. Louis, Lawrence and Milwaukee.

There is no American city found in the first class of European cities named above, while Atlanta, Pittsburg, Denver, and Jersey City fell in the lowest class (in 1896) along with (but not so bad as) Alexandria, Cairo, and St. Petersburg. As showing how far behind we are it need only be said that no city in all Germany is allowed to supply an unfiltered surface water to its inhabitants. Even so pure a source of supply as Lake Zurich, at the foot of the Alps, has at times been the source of typhoid fever, and now all the water coming from it for domestic uses is carefully filtered. There is, in fact, no surface water free from contamination either by man or by domestic animals, so that we should immediately adopt the one and only means for purifying these waters for drinking purposes,—viz., sand filtration. Although America has the credit, in the experiments carried out under the Massachusetts State Board of Health, of establishing most clearly the efficiency of sand filtration and the reasons therefor, Europe had long been practicing the method and reaping its practical advantages. On the contrary, while we have fully established the theory of the efficiency of sand filters, we have made little or no progress towards availing ourselves of their benefits. In this, as in many other directions, we are trusting to luck, or to the "genius of American institutions," or to the "hand of destiny" or to some such *ignis fatuus* to bring us along all right without being obliged to plan our lives and to guard the public health by means of these extraordinary precautions which "the effete nations of Europe" find it necessary to take.

While the annual typhoid fever death rate of St. Louis is now only about 20 per 100,000, in 1892-93 it rose to 103 and was considered epidemic. It is now just a year since a terrible epidemic of typhoid fever raged at St. Charles, Mo.* This epidemic was traced to a local contamination of the water supply from their own sewer system,† whereas the St. Louis epidemic was not traced to any local cause. If the same proportion of citizens of this city had been stricken down with typhoid fever we should have had 18,000 cases and over 1,500 deaths. What a terrible possibility this is to contemplate! Now, in the case cited at St. Charles, somebody is surely responsible. The sewage contamination was well known to the city engineer, and presumably to the other city officers. The danger arising from such contamination was also well known, or should have been.

As a sequel to a similar epidemic at Ashland, Wis., in 1893-94, a case was tried in the state courts in November, 1897, wherein the company supplying the city with polluted water was held liable for the death of the deceased in the (legal) sum of $5,000. I have not heard of this case being reversed‡ by a higher court, and if it should stand it would become a leading case in making the authorities responsible for the lives of the victims of their own negligence.

If a man loses life or limb by falling into an unguarded excavation or into a cellarway on a city street he collects damages from the city. Why should he not obtain damages for disease brought upon him through the culpable negligence of city officials in any other direction? I believe he should, and I also be-

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*A town of 7,000 inhabitants on the Missouri River a few miles above its mouth.

†See article by Dr. H. H. Vinke in *The Medical News*, July 30, 1898.

‡Since the above was in type, I have learned that the Ashland judgment was reversed in the State Supreme Court, on the ground of contributory negligence. It was shown that it was common knowledge, and had been for months previous, that the water was polluted, and it was further held that the water company was only a carrier. This case would seem to clear a private corporation, but whether or not it would clear a city corporation furnishing water to its own people is another question. The private corporation could be attacked on its contract with the city to furnish pure and wholesome water, in a suit brought either by the city or by a citizen, but as it is a creature of the city government, the city itself would seem to be the proper party to look to for damages for allowing impure water to be furnished to the citizens. The case therefore does not bear the marks of finality.—J. B. J.

lieve we are now ready to make such suits lie against any city or private corporation furnishing polluted water to the citizens. What more right have they to sell to unsuspecting citizens a drinking water containing the seeds of fatal diseases than they have to sell a poisonous drug as a medicinal remedy, or to take life and health in any other way? Evidently they have no more right, and as soon as the state of science becomes such as to make certain to the minds of twelve jurymen that the drinking water was the cause of a death, and that the authorities had been warned and had reason to believe that the water was polluted, and yet continued to supply it, just so soon can the legal compensation be collected by the heirs of the deceased.

When this day arrives it will soon be discovered that preventive means cost a great deal less than the damages will amount to at $5,000 per death. And then our cities will be driven to devise the appliances, and our city governments to furnish the means for freeing the drinking water from these fatally poisonous germs. But does the conscientious civil engineer who knows, or ought to know, the character of the water he is supplying, and the dangers resulting from its use, propose to sit idly by until he is compelled to act as a means of economy only to avoid legal liability? Such a man should be unworthy of our respect, and yet such is exactly what all we civil engineers in America are doing as a class. One would suppose that as soon as a public official becomes satisfied that he is furnishing polluted water to the inhabitants over whom he is placed as a guardian in this respect he surely would immediately exert himself to the utmost to have the city water taken from a purer source or purified by an efficient system of filtration. But the accomplishment of either of these ends involves the education of the citizens up to the point of acting in this matter and agreeing to pay the cost of the proposed change. In this country all improvements come from the people themselves, and hence come much more slowly than they do in a country like Germany, where a few men only need be convinced of the necessity of a given measure and it is done. All the more reason, therefore, in this country that the few who do understand the necessity of any proposed change should consider themselves charged with the duty of forming and leading public sentiment by all suitable means to hasten the dawn of a better day. And the civil engineer knows, or ought to know, for it is his business to know, the relation between water supply, sewerage, street and alley conditions, the condition of school premises and buildings, and the air conditions in assembly halls, in street and railway cars, in hospitals and in asylums, he knows, I say, the relation of all these to the public health, and, as the construction and operation of all these fall within his professional jurisdiction, he is in duty bound to continually do what he can to teach and lead the public in such matters.

The means of preventing the spread of disease through the drinking water is a rational or scientific filtration, such as has now been shown to be effective. The means of prevention of disease from the decay of organic matter caused by these bacterial parasites, and thence their passing off into the air we breathe, is to immediately remove all organic wastes from the confines of the city. This includes not only sewage or house drainage proper, but all garbage, street sweepings and alley filth, and the prevention of the vast and luxuriant growth on vacant lots of weeds, which are not only the cause of hay fever from their pollen-laden atmosphere, but which, in finally rotting on the ground, breed and give off other swarms of parasite germs to further burden the human system. But the rapid and thorough removal of street accumulations means a smooth, clean and impervious pavement. In place of this we find in this city, in most of the resident districts, either a mud-covered macadam or a rotting wooden reservoir and nest of all possible foulness. I believe there is no possible kind of excuse for a pavement so unsanitary as the wooden block after it has begun to decay. It not only retains nearly all the filth dropping upon it, but it becomes itself alive with those parasitic growths which constitute the decay of timber. Such a pavement is, therefore, the very quintessence of that particular kind of putrefaction and living filth of which we are today standing in such awe, and against which we are summoning all the devices of sanitary science. How much the city civil engineer could do if he would to prevent the further use of these abominations!

Again, the most elementary and fundamental principle of sewerage is not only to move all filth off as quickly as possible, but when once it has started it should be kept going till it passes into some large river or goes to some kind of purifying terminus. How do we comply with this provision in this city? In almost every back yard in this entire city will be found a brick privy vault into which the house drainage flows on one side, and out of which it is supposed to flow to the sewers on the other side. It is the most common experience in the world to have these stop up. The near proximity of the coal shed and kindling stall is too great a temptation to the average American child, and sticks, rags, bricks, stones and coals are continually finding their way into these catch-basins and stopping them up. In rented premises the tenant dislikes to go to the expense of having the sewer connection dug up, and commonly the owner will not do it; and so we find that they become filled, and that their contents back up into the house cellars. Often the basins remain in this condition for weeks and even months at a time.

In the report of the St. Louis Health Commissioner for 1895-96 I find that in one year over eleven thousand such cases were found, the vaults being in such a condition as to be declared nuisances, and usually full and overflowing. Probably many times this number of stoppages occurred, only those being reported to the Health Department which were not promptly attended to. These primitive and absurd devices are a remnant of ante-sewer days, when they were earthen vaults or cesspools. When sewers began to be constructed these cesspools were, properly enough, connected with the sewers, but that fact did not justify the further building of them on new premises in sewered districts. And yet this filthy practice has been almost universally followed in this city, and is so to this day, without any protest, so far as I am aware, from the city sewer department and without any prohibitory legislation. For engineers to admit that this is the best that can be done is to acknowledge incapacity in this line of sanitary engineering.

Again, in violation of the same fundamental law of sewer construction, namely, the keeping of all sewage moving without hindrance after it is once started, we find in this and in almost every other city, at every street intersection, one or two sewer inlets for storm water and street and alley drainage which are purposely built as catch-basins or as filth depositories. We all know that these are seldom cleaned until they become clogged, and we all know, too, that each of these clogged basins contains a mass of black nastiness which is doubtless swarming with micro-organisms of all sorts, pathogenic amongst the rest. How many tens of thousands of these open pest holes we have in this city I do not know, but I find in the report of the Sewer Commissioner for 1895-96 that 9,933 of them required cleaning out and that 16,145 cart loads of filth were taken from them in one year. What is out of sight is out of mind, but if the citizens of this city could but see what lies a few feet below the pavement at every street corner they would raise their hands in holy horror. To claim that these pest holes are necessary in order to keep impediments out of the sewers is, I think, invalid. I would guard these inlets by screens at the surface, and trap them from the escape of sewer gas by flap valves, and so eliminate these catch-basins which, by breeding, harboring, and giving off into the air all kinds of bacterial life, become veritable man traps. Our sewers all have an abundance of slope, and in time of storm will carry along anything that can get into them through properly screened inlets; and if it is not their purpose to carry off the abominations that stop now in these vaults a new definition will have to be made for them. In my opinion both of these appendages to our sewer system are unnecessary, unsanitary, and uneconomical to such a degree as to warrant their abatement as public nuisances.

And now to return to the question of our drinking water. Since we use a surface water, it is of necessity more or less polluted. All running streams are open sewers in the sense that they drain the tributary watershed and carry all the offal which is removed, in solution or in suspension, by the cleansing rains. The particular character of these polluting ingredients varies constantly from season to season, and from day to day. The general fact, however, remains, to be read of all men, that we take our drinking water from the great sewer of the Mississippi Valley. Not only does it contain its legitimate amount of pollution, but in a year or two there will be added to it, a few miles above our waterworks intake, the offscourings of a city of nearly two millions inhabitants, which city lies entirely outside of the Mississippi Valley, and hence is not naturally tributary to it. If it is not good law it ought to be, that in the matter of stream pollution every natural basin should take care of its own, and not change the face of nature to a neighbor's hurt. When the law was enacted for the construction of the Chicago Drainage Canal, the question of the potability of water rested wholly upon a chemical basis. The science of bacteriology was so far in its infancy that it was not yet in use as a tool for sanitary purposes. Now the healthfulness of a drinking water rests wholly upon a biological basis. We now want to know how much life there is in it, and the probable source of this life. As a chemical question we in St. Louis felt that no good case could be made against the scheme. It was then supposed that a running stream purified itself in the course of a few miles, and I see the Secretary of the State Board of Health of Illinois was quoted a few days ago as still holding to this delusion. He ought to know that, so far as the removal of bacterial life is concerned, there is probably not a river in America long enough to purify itself of typhoid fever germs when once charged with them. These germs live for weeks in comparatively pure water, and there is absolutely no possibility of a stream purifying itself from them simply by its flow. If the stream carries a large amount of sediment this is always settling out in the quieter pools along the way, and in this way it is constantly purifying itself, as a clear stream can not do, since this sedimentation carries down also a large proportion of the micro-organisms. But to claim that they are all carried down in any known distance is to claim what no one knows to be true, and what would seem to be very improbable from the known persistence of some of these organisms and from the theory of probabilities. In our St. Louis settling basins we do remove a large proportion of these germs, but many remain, and the only way we can remove these is by filtration. If, after settlement in our basins, so much silt still remains in the water that gravity sand filtration is impracticable, then should we not have known this long since? If the filtration of settled water will not remove the bacteria because of the sedimentary removal of those forms of vegetable life which alone can make a sand filter effective, then should we not have known this before now, or at least should we not be finding it out as fast as possible? And if one or both of these causes would make gravity filters impracticable for St. Louis there would still remain mechanical filters to be used with coagulants in conjunction with sedimentation, which, if properly constructed and operated, would doubtless perform the work.

I think a reasonable solution of these problems could be found for a moderate sum, and I believe if we civil engineers as a class, and those of us charged with the administration of the water supply in particular, should unite in demanding that this thing should be done, and done at once, there would be little or no delay. Several years ago Mr. Robt. Moore read a paper before this Club* in which he showed the necessity of filtering our water supply, but our Board of Public Improvement has as yet not moved in the matter. The city Health Commissioner has been crying loudly for years that this should be done, but I cannot find that his hands have been strengthened in any way by our civil engineers, either in or out of the city's employ.

I have tried to show that it is peculiarly the duty of civil engineers to provide clean and sterile streets; to quickly and continuously remove from the streets and dwellings all natural refuse and human wastes, and to supply the citizens with an abundance of pure and wholesome water. Also, that when all these things will have been done the cases of sickness and death will be greatly reduced, the average length of life prolonged, and earthly happiness indefinitely increased. Furthermore, that it is peculiarly the duty of all civil engineers to lead in forming a public sentiment which will insure the accomplishment of these results.

I do not wish to imply conscious official or culpable private neglect on the part of any one but I think we have all as yet declined to take upon ourselves the responsibility which has recently come to rest upon us, the responsibilty of leading public sentiment on these questions instead of waiting till this has crystallized into a particular scheme, and then, when called upon, saying how the thing may be done. Our duties in this respect

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*Journal of the Association of Engineering Societies, Vol. XIV, p. 41, 1895.

have entirely changed with the new theory of infectious diseases. He is now the good citizen who foresees what ***should*** be done and then persuade the people to resolve that it *shall* be done. The man who really ***does*** it is small and weak in comparison with such a one. Why should not civil engineers be public benefactors as well as public servants?

THE NEEDS OF A CITY.

CHARLES G. CARPENTER, C. E. '82.

Engineer of Parks, Omaha, Neb.

One of the easiest ways of judging the character of a person is to find out what pleases him, and what recreations he has. In the same way you can find out the culture and artistic tastes of a community or city by looking at the public parks and boulevards. How many cities and towns that boast of many thousands of people that do not have a single park or shady square where a tired stranger may stop and rest. How many cities are so engrossed by business or other things that they let desirable park locations slip out of their hands simply by neglect of acquiring the land in time. As a city increases in size the more desirable parts are taken up by business blocks and residences, and there is no room apparently for a park, and generally the people of a city do not imagine there can be such a thing as a public park until the city gets 25,000 inhabitants or more, and by that time the choicer parts of a river bank or the land lying along some lake shore has been taken up by persons far-sighted enough to see the value of such land for residences or private grounds, so when the park proposition is broached they find that all the best and most desirable pieces of land have been occupied. It is a mistaken idea that only smooth, high land will make a beautiful park, as some of the prettiest parks in the country have been made from the most unsightly ravines. One of the real pleasures of a park is to stroll through some shady path where the wild vines and flowers have been left to their own fancy, when all sights and sounds of city life are still and when everything pertaining to business is blotted out. Parts of the park should be cleared of all bushes and undergrowth and sowed to grass or planted to flowers, but such is not the real beauty of a park. What the people want is a change from the dry and dusty streets and buildings to some shady grove or running brook, or rippling lake shore.

A private park is better than nothing, but to get the full enjoyment it should be public. There is a sense of ownership and pride in a park that we all help support,—much more so than trying to take comfort by resting in the shade created by the public spirit of some wealthy private citizen.

A park should be as near the center of the city as it is possible to have it in order to have it easy of access to everyone whether they have a conveyance or not, as over nine-tenths of the people who enjoy a park on a Sunday afternoon do not come in carriages, so if the park is not near, street car fare must be paid when sometimes it can not well be afforded by many poor children to whom the outing is the greatest boon. In the city of Omaha there are parks almost in the center of the city and others from one to three miles out, and it is needless to say, the ones close in are the best patronized. One small square,—indeed, it only contains one block of ground,—almost in the business center of the city, has been improved, trees and flowers planted and the grass kept cut. Settees have been generously placed in the square among the trees, and during the summer months you can not go by without seeing the settees filled with people glad to avail themselves of this little breathing spot who would not go to the trouble to go to a distant park.

These little parks, or squares, as well as the few shady acres around a public building in a city, are all right as far as they go, but they do not take the place of the real park whose length and breadth is so great that residences in the immediate vicinity may be hidden from view, which of course may be done in some cases by border planting. Cities underestimate the importance of acquiring desirable land for park purposes before it is all taken by private individuals and built upon so as to be so valuable that it can not be afforded. As a business proposition the cost of a park will be returned to the treasury many times over by the increased taxable values of the land in the vicinity and the effect is immediate. For instance, two years ago the city of Omaha acquired the right of way between two of the parks that are about two and one-half miles apart. This piece of land was generally about 150 feet wide, and in some places it widens out into park-like areas of from ten to twenty acres. This strip of land has been made into a boulevard with drives and walks—bridges, where necessary, and planting of trees and shrubbery. Along this boulevard a speedway half a mile in length parallels the carriage drive, and the immediate effect of all this is to make this part of the city put on a new dress; new houses were put up, old ones repainted, terraces sodded and trees planted, and a general appearance of thrift prevails when before the boulevard was put through, that part of the city was practically dead; and another point is really important, the selling price of property in the immediate vicinity advanced from 25 to 50 per cent.

This much pertains principally to the advisability of every city, town or village acquiring land in its immediate vicinity for park purposes, and they can not be too quick about it. The most available piece of land for park purposes should be chosen, but any piece of land, it matters not how bad, can be improved and beautified by proper landscape treatment. The selection of the piece of land to be used is, you might say, an economic or business proposition, although some locations have greater possibilities for beauty or scenery than others.

To the landscape engineer the plans and development are of the first importance, as they increase or diminish the natural beauty of the location, as a piece of landscape work may be said to be perfect when the completed work looks so natural that the hand of man is not visible in the development.

In working up the plans for a park the preliminary surveys are quite simple. The land is first laid off into fifty-foot squares and staked with two-inch pine stakes, each one marked with a number and a letter—the numbers counting in one direction and the letters in a direction at right angles to the numbers. These lines should be definitely referenced, so that any stake could be replaced if lost. Elevations are then taken at every stake and as many intermediate points as are necessary to make a complete topographical map. The location of large trees or groves or any important object should be noted. Then a contour map with five-foot contours should be made at a scale of fifty feet to the inch. After the map has been made the ground should be carefully studied, and so many different points should be considered that it will be impossible to more than give general directions, as the conditions of each location are so varied. It is not advisable to have too many roads in a park. Every part should not be accessible by carriages, as it destroys the seclusion which is one of the principal features. Roads should run to all important points, especially if points of observation can be reached that will give a view of the surrounding country or other portions of the park. An ordinary park road should not be more than twenty feet wide. On the more important lines they may be made thirty feet, but rarely wider, as the cost of maintaining is an important item. The grades of park roads should be as light as possible. If the grade must be more than 4 per cent. or 5 per cent. arrange it so the maximum grades are thrown into a very short section, as in short turns ten or twelve feet may be gained in 75 or 100 feet, and there is no particular objection to it. Many places in a park road should be practically level, so that the horses can rest. Steep roads require a great deal of care to prevent washing out of the gutters during rain storms. Catch basins should be placed not farther apart than 200 feet and closer on steep grades, and even then brick gutters are needed. It is best to conduct the water away from the gutter as soon as possible, and for that reason small catch basins placed closer together give better results than larger ones farther apart, and besides the small basins are cheaper. I have designed a small basin which gives excellent service on the boulevards. It is simply a cast iron cover which fits into the socket end of a sewer pipe. The opening has bars across similar to the spokes of a wheel. They are made to fit 10-inch and 12-inch pipe and cost $1.50 and $2.00 each. A ring of brick headers placed around these basins makes a perfect finish. As a covering for the drives the regular McAdam pavement is by far the best. In this city gravel is used more extensively and when well rolled makes a road nearly as good. A good cheap road can be made of cinders spread over the drive from four to six inches deep. This is a dry road at all seasons of the year; it requires a good deal of attention but is very easily kept in repair. Cinders can be had for 30 cents per cubic yard, while broken stone or gravel is worth about $1.30.

The location of trees or shrubbery is one of the important things in park development, or in case the park is already covered with trees the question is which ones should be cut out. As a general rule park trees should not be planted so close together that the shade will destroy the grass. Trees of the same kind should be kept together, or at least appear to have sprung from some parent clump and not scattered all over the park evenly, as that is not natural. Openings or vistas should be left, so the eye will catch glimpses of monuments or some fountain or a church steeple. Let the line of sight be as long as possible, as it creates an impression of magnitude, and arrange the planting so the eye can not take in the whole place at one glance. Make it necessary for the visitor to travel over the whole park to see all its beauties. Trees and shrubbery should be massed along the borders of a park so one on the inside is not able to see outside objects except at intervals. Flowering shrubbery is taking the place of annuals and carpet bedding in the most modern parks. The varieties of trees and shrubs that are to be used is a matter to be decided by climate. For instance, the hard maple which is such a beautiful tree, both summer and autumn, in Wisconsin, will not grow satisfactorily in Nebraska on account of the dry climate. One must select the trees to suit the locality, even if your own choice is for something else. Sometimes one of your old favorites will withstand the climate for several years and your hopes will be raised only to be disappointed by one hard winter. In this locality our principal native trees are white and red elm, basswood, red oak and walnut. As none of these trees except the elm transplants easily, our planting on the boulevards is confined almost to soft maple, white elm and the Carolina poplar. This last, although a new tree here, promises to be one of the best. The box elder, although a thrifty grower, is always troubled with the web worm. The catalpa is a beautiful tree in places not exposed to the wind, but on the boulevards the leaves are whipped to pieces, which destroys their beauty.

In conclusion, I will say the planting of the trees and shrubbery, the laying out of the drives and parkways, the designing of the ponds and improving the brooks, and everything that goes to make up the modern park are matters of detail that can be worked out as the work progresses, but what is of prime importance, as I said in the beginning of this article—every city, town and village should acquire land in the immediate vicinity that can be made into a public park. Select the ground whose possibilities for park purposes are the greatest, decide on a plan for its future improvement, and year by year following it as a guide, do something towards its final development.

LAYING OUT A VALVE GEAR DIAGRAM FOR A CORLISS VALVE AIR COMPRESSOR.

By A. L. GODDARD, '96, Camden, N. J.

Machines for compressing air in cylinders are classified as blowing-engines and air-compressors. The term blowing-engine is applied to machines which press air to but about fifteen pounds or less above atmosphere. These machines do not usually require water jacketing. The term air-compressor is applied to machines which press to higher pressure, usually for power purposes, to forty pounds and upwards. For pressures over sixty pounds the compression is usually conducted in two or more stages to prevent excessive heating of the air and machine and to attain greater efficiency in the operation. After being compressed part way to the desired pressure, the air is conducted to an intercooler, which cools the air heated by compression to about the normal temperature, after which the air is led into another cylinder, where it is further compressed. Since the air during this second stage of compression has a smaller volume than it would were it not cooled, less power is required to perform the work. These compressors are thus called two-stage compressors, three-stage compressors, etc.

Air compressors may, from the nature of their valves, be classified into: mechanically operated valve compressors, half automatic valve compressors, and full automatic valve compressors. The mechanically operated valve compressors may have either slide valves or rocking valves. Slide valves are but little used and then usually because of special conditions, of which more will be said later. Rocking valves may be operated from a wristplate similar to that of a Corliss steam engine, whence they are called Corliss valve compressors or by means of cams, notably the Norwalk compressors.

So-called Corliss valve compressors in no wise embody the essential Corliss valve principle, which is a quick release of the valve arm, thus closing the valve at any desired point of the stroke within the range of cut-off; however, the name has become pretty generally used in this connection and will probably so continue.

In half automatic valve compressors, the inlet valves are mechanically operated; while the outlet valves are automatic, and open whenever the pressure in the compressor cylinder reaches a point a little above the receiver pressure. In full automatic compressors, both inlet and outlet valves operate automatically.

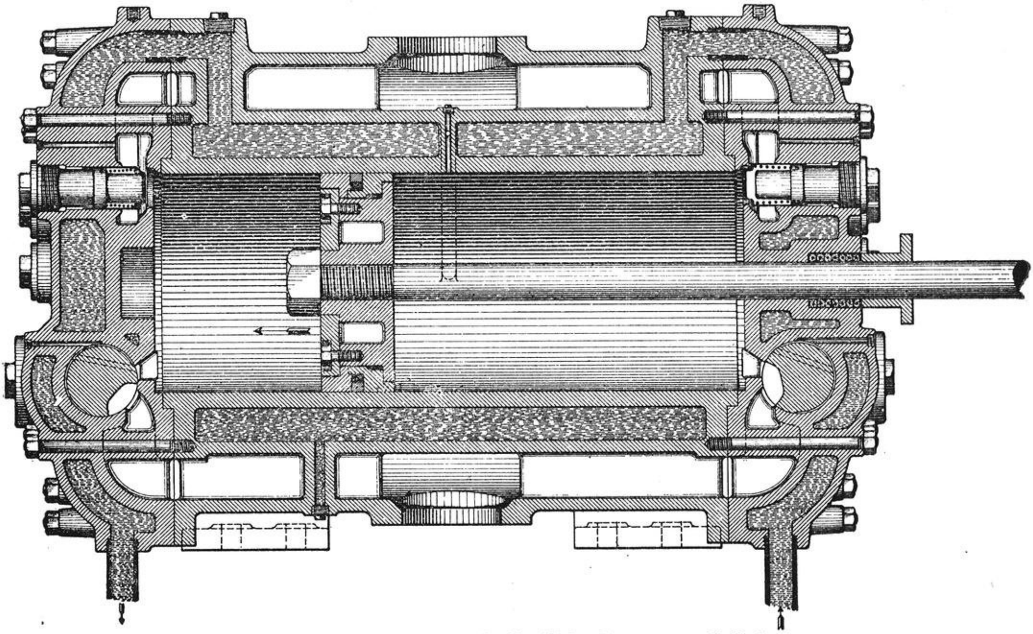


Fig. 1.—Section of Nordberg Corliss Valve Compressor Cylinder.

Like all existing machines, these different types have their various applications. Where economy of operation is of secondary consideration or where small first cost is of prime importance, the full automatic valve compressors hold undisputed sway. Where grit is present, as usually occurs with natural gas, poppet valves must be used as a rocking valve, and will soon leak; and here again the automatic valves, which are usually of the poppet type, are in favor. Where the receiver pressure is never constant, automatic valves are to be preferred on the score of economy of operation; mechanically operated valve compressors maintain a fixed point of outlet opening and with a variable receiver pressure, much useless work would be done in compressing above the existing receiver pressure. This is not always the case, as frequently, mechanically operated valves are fitted with small automatic poppet valves inserted in them (see Fig. 1) to make it easier to start up and to guard against damage to the compressor in case of accident to the valve gear. Where the air must be compressed so high in a single stage that the discharge valves would remain open less than one-third of the stroke, a mechanically operated discharge valve of the Corliss type would not be satisfactory as the valve opening would be small and the valve would travel a good deal on its seat while closed, thus causing excessive wear. A mechanically operated valve, moved by cams, could however operate satisfactorily with short period of opening.

Where economy of operation is of prime importance, mechanically operated valves are to be preferred; for smoothness of working they are more satisfactory than automatic valves, as there is less violent action; hence they generally require fewer repairs; if properly designed they give fuller opening, thus preventing much loss from wire drawing. In a well designed Corliss valve compressor the inlet line corresponds to the atmosphere line after one-tenth stroke. Automatic valves are provided with springs to close them promptly at the end of the stroke; and if the springs are sufficiently stiff to close the valves promptly enough to prevent slippage of air when running at high speed, they will constrict the opening. Thus with automatic valve compressors, the inlet line, during at least one-half stroke and frequently all the stroke, is at least one-half pound below the atmosphere line. As the M. E. P. of the L. P. cylinder of a two-stage compressor, compressing air to about one hundred pounds gauge, is about fifteen pounds, one-half pound loss is a considerable item; a similar though smaller percentage loss is found in the H. P. cylinder.

The outlet valves likewise cause a loss of work though their action is not so important, as they are open but a part of the stroke. This loss of work is shown by the overlapping of the

H. P. and L. P. cards of a two-stage automatic valve compressor. (See American Machinist, March 3, 1898, p. 158.) On the cards of a Corliss valve compressor this generally occurs to but a slight extent (see Fig. 4).

Where impure gases containing grit and impurities which both clog and cut the valves are to be compressed, slide valve compressors have been found to give satisfaction.

We will now consider the laying out of a diagram for a two-stage Corliss valve compressor to compress 4,000 cubic feet net of free air from an atmosphere of 14 1-2 pounds to 100 pounds gauge at a piston speed of 600 feet per minute. This piston speed might safely be as high as 700 feet per minute, but as almost every air compressor installed for power purposes is overloaded before it is running a year, it is generally best to order a compressor with some marginal allowance after all known factors have been taken into account. The atmospheric pressure where the compressor is to operate should be carefully determined, for frequently, in mining work, this is not more than 12 1-2 pounds, and as the work of compressing the air should be equally divided between the two air cylinders the initial pressure is an item of importance. The compression curve is generally an adiabatic line. If it varies much from this it safe to suspect either a leaky piston or leaky valves, unless the compressor is a small one of comparatively long stroke and is running slowly; for in large compressors, the surface of the cylinder walls and heads is too small in comparison with the volume to have their cooling effects make any appreciable change in the pressure. The chief function of the water jacket is to keep the cylinder walls from getting too hot to operate and to prevent too rapid oxidation of the oil necessary for lubrication of the piston head and rod.

The formula for this curve is according to Peabody, approximately

$$\frac{p}{p_1}=\left(\frac{v_1}{v}\right)^{1,405}$$

The index of this curve is used variously from 1.4 to 1.41, but the value given it in this article will be 1.405. A good explanation of the method of constructing this curve is given by F. A. Halsey in the American Machinist of March 3, March 10, and March 31, 1898, together with some excellent tables.

Fig. 6 shows compression curve from several initial pressures, and also gives the value of $\frac{p}{p_1}$ for various points of compression so that a compression curve from any initial pressure can be quickly constructed by multiplying the initial pressure by the successive values of $\frac{p}{p_1}$, and plotting the results to scale.

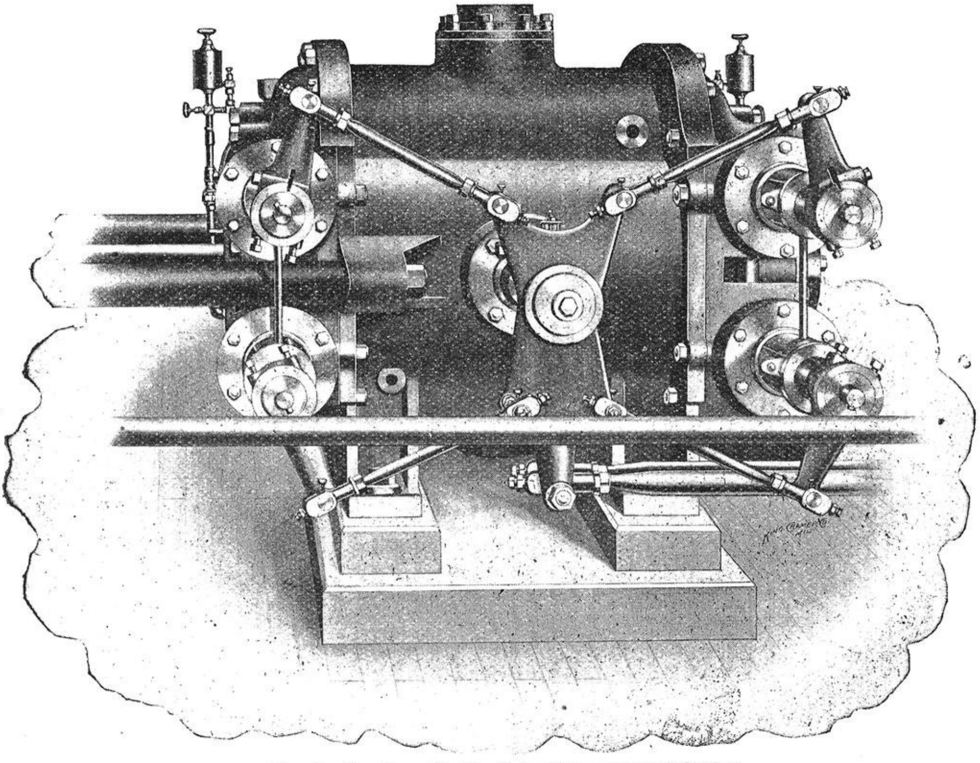


FIG. 2.—Nordberg Corliss Valve Compressor Cylinder.

While the proper points of opening the exhaust valves and the M. E. P. of the air cylinders can be calculated, it is generally safest to lay out the compression curves to avoid errors. It is convenient to use for the initial volume, L B of the compression diagram Fig. 5, some measure that can be conveniently divided into tenths. Ten inches is about right for this in ordinary compressor work. The stroke, H. B. then, will be such a part of this length as the piston displacement per stroke is to the displacement plus the volumetric clearance of either end of the cylinder. We will assume this clearance to be .8 per cent., which is a fair value for the L. P. cylinder of a compressor of this capacity. This percentage is usually calculated on the volume of the piston displacement per stroke as a basis; but as the difference is inappreciable it can be calculated either on the total volume or the piston displacement indiscriminately.

If we have complete cooling between the two stages of compression the point of pressure p_2, at which the L. P. discharge valve should open so as to divide the work equally between the two cylinders, and give the greatest gain from intercooling, can be determined by the formula

$$p_2 = \sqrt{p_1\, p_3} = \sqrt{14.5 \times 114.5} = 40.75,$$

or it can be determined graphically by completing the parallelogram, O A C D, and drawing the diagonal, O C.

The intersection of O C with the isothermal curve through $p_1\ v_1$ gives the point M corresponding to the pressure 40.75 lbs.

We have then, B J as the compression part of the stroke and J E as the outlet part of the stroke. The "camel's back" at J is caused by the inertia of the air in the cylinder and air passages. These are much larger, of course, with long or small pipe connections to the intercooler, or when running at high speed. See Fig. 4 for this difference when a compressor is running at half and at full speed.

At E, the end of the stroke, we have both outlet and inlet valve closed and the clearance spaces filled with air at the intercooler pressure. This should be allowed to expand down to atmospheric pressure before the inlet valve is opened. By opening the inlet valves too early, there is a considerable loss. The air confined in the clearance spaces is hot and if made to do work by expanding against the piston, the heat of compression is changed into energy; otherwise it would blow out into the admission passages and heat the incoming air, thus decreasing the actual amount taken in at each stroke; further, it would set the air in the admission passages in motion in the wrong direction, thus increasing the admission hump on the diagram.

From the properties of curves of this kind plotted in this manner we can locate the point G by making $\frac{LG}{LB}=\frac{KE}{KJ}$. In the same way we can locate as many points of the curve E G as we wish; or if we have a point of any other adiabatic line to be drawn to the same scale, we make horizontal distances, from the clearance line, O D, of points of equal pressure, of the two curves, proportional. Now, since G B represents the volume of air drawn by the L. P. cylinder at each stroke and E M represents the volume of the same amount of air, compressed and cooled, which should be drawn in by the H. P. cylinder at each stroke, then $\frac{EM}{GB}=\frac{.348}{.983}=\frac{.354}{1}$ is the ratio of the net areas of the two cylinders.

The compression curve for the H. P. cylinder can be constructed by plotting it with the use of the values of $\frac{p}{p_1}$, given in Fig. 6, starting at N, or by making horizontal distances from the clearance line O D, of points of equal pressure of the two curves proportional to $\frac{KJ}{KN}$. This is readily done by the use of proportional dividers. To locate the point N, we must first determine or assume the percentage clearance of the H. P. cylinder. This must be referred to the L. P. cylinder by multiplying it by the ratio of $\frac{EM}{GB}=.354$; thus, 1.8 per cent. clearance for the H. P. cylinder, $=.018 \times .354 = .006$ to scale on the diagram. Next, locate F by making $\frac{KF}{DR}=\frac{KJ}{DS}$; then make F N = E M. A convenient method of constructing this second adiabatic curve if proportional dividers are not at hand is shown on the diagram. Having located N, from any point as W in the clearance line, draw lines to N and J. Then from any pressure as 50 on the curve B J S run vertically upward to the line W J, then horizontally to the line W N, then downward to the pressure line 50. Now $\frac{XY}{XZ}=\frac{KN}{KJ}$; therefore, γ is a point of the H. P. compression curve.

Now, the per cent. of the stroke which the pistons should travel over before the outlet valves should open is represented, for the L. P. cylinder by the ratio of $\frac{UB}{HB}=\frac{.52}{.992}=.542$ stroke, and

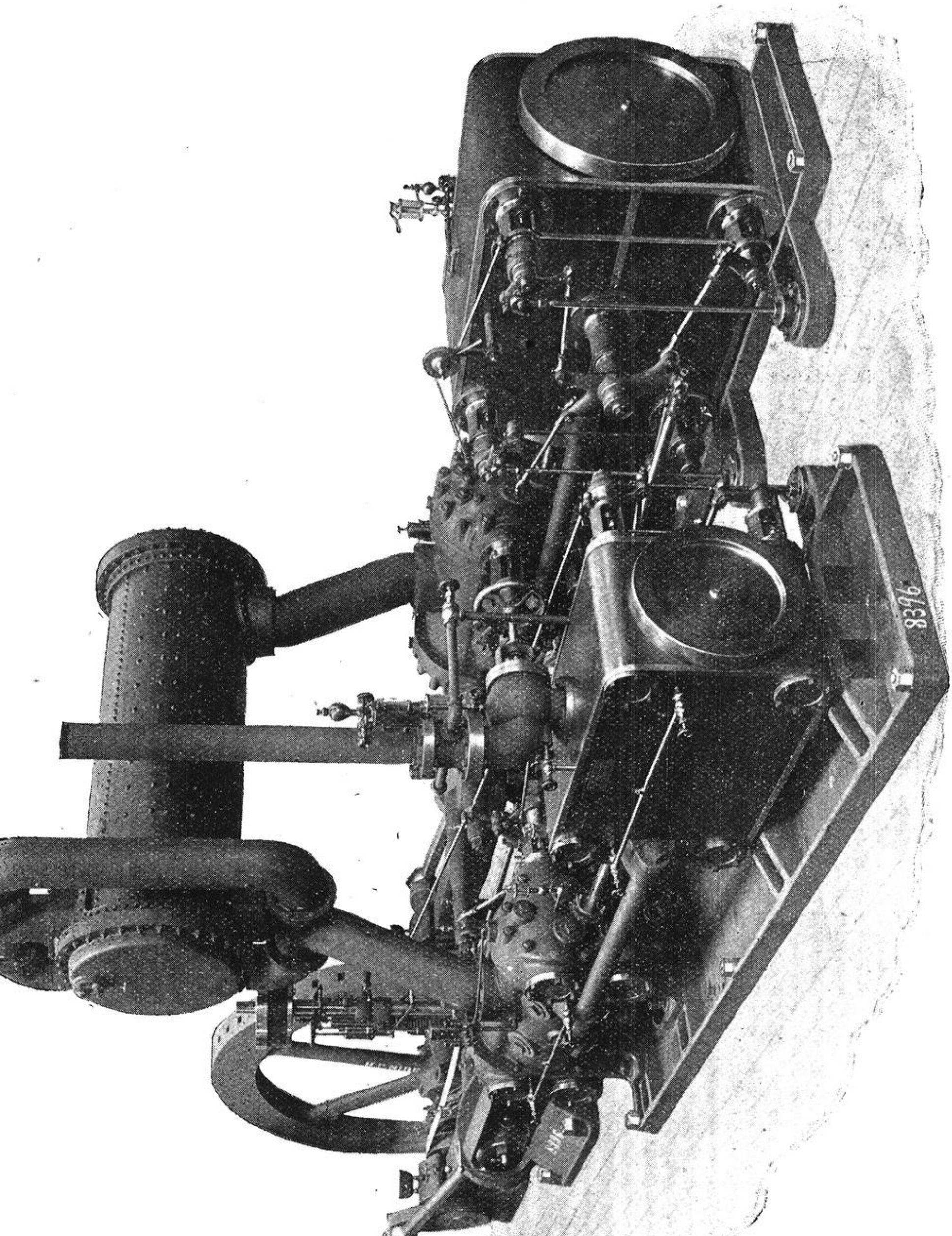


FIG. 3.—Nordberg Two Stage, Cross Compound Compressor 12½ in. and 21 in. x 36 in. Air Cylinders.

for the H. P. cylinder by the ratio of $\frac{VN}{IN} = \frac{.189}{.355} = .532$ stroke. The points of the stroke at which the inlet valves should open is found by taking the ratio of $\frac{GH}{HB} = .018$ stroke for the L. P. cylinder and $\frac{IF}{IN} =$ (2 stroke for the H. P. cylinder.

By finding the M. E. P. of this diagram, we can determine, by making proper allowance for friction, the horse-power required to drive the compressor. By finding the ratio of inlet period to stroke (= .99) we can determine the ratio which our L. P. piston displacement per minute must be to our output to fulfill our requirements. This gives $\frac{4000}{.99} = 4050$ cu. ft. At 600 ft. per minute piston speed this requires 6.75 sq. ft. or 972 sq. in. net piston area. We will allow 7 sq. in. for the area of a 3 in. piston rod; then, our L. P. piston should have a total area of 979 sq. in., which is about the area of a 35 1-4 in. diameter circle. The H. P. piston would have a net area of 972 × .354 = 344 sq. in., or a total area of 351 sq. in. This would require a piston 21 1-8 in. diameter. Pistons 35 in. and 21 in. diameter would have almost the same ratio of net area and could be used by running at a little higher piston speed if the specifications need not be too closely adhered to. If the piston rod does not extend through both heads, no allowance need be made for it in determining the ratio of the cylinders, though it should be considered in determining the capacity of the compressor. The stroke for cylinders of these sizes should be about 48 in. This would require an engine speed of about 75 R. P. M.

If we wish to determine the proportions of our compressor without laying out the compression curves, we determine our intercooler pressure by the formula

$$p_2 = \sqrt{p_1 \, p_3} = \sqrt{14.5 \times 114.5} = 40.75$$

and the volume at this point would equal

$$\left(\frac{p_1}{p_2}\right)^{\frac{1}{1.405}} \times V_1 = .48$$

With a clearance of 0.8 per cent. the point of opening of the outlet valve would be $\frac{1-.48}{1-.008}=\frac{.52}{.992}=.524$ stroke. The inlet valve would open at

$$\frac{.008\times\frac{1}{.48}-.008}{.992}=.01 \text{ stroke.}$$

Now, if the L. P. outlet and inlet lines of our diagram were carried back to the clearance line O D, the area L B J K representing the work of compressing and expelling a volume of gas, V_1, represented by the length L B, would be:

$$W_1=p_1v_1\frac{1.405}{1.405-1}\left[\left(\frac{p_2}{p_1}\right)^{\frac{1.405-1}{1.405}}-1\right]\dots\dots(1)$$

(Peabody: Thermodynamics, p. 406, equation 312.) The M. E. P. of this area would of course be found by dividing W_1 by L B $= V_1$. Now, the area G B J E is to the area L B J K as G B is to L B, while the M. E. P. of this smaller area would be found by dividing its area by the volume of the piston displacement represented by the line H B.

Therefore, the M. E. P. of the area G B J E $= W_1\times\frac{GB}{LB}\times\frac{1}{HB}$
Since we have made L B = unity, this becomes M. E. P.

$$=W_1\times\frac{GB}{HB}=W_1\times\frac{1-LG}{1-LH}=W_1\times\frac{1-LH\frac{1}{KJ}}{1-LH}$$

This is the ratio of the inlet period to the stroke. Now, since L H is always small compared to L B, adding L H to both numerator and denominator of the fraction, will not appreciably change its value and M. E. P. =

$$W_1\,\frac{1-\frac{1}{KJ}LH+LH}{1}=W_1\left[1-LH\left(\frac{1}{KJ}-1\right)\right]$$

Now, since L H represents the per cent. clearance of the L. P. cylinder, we have:

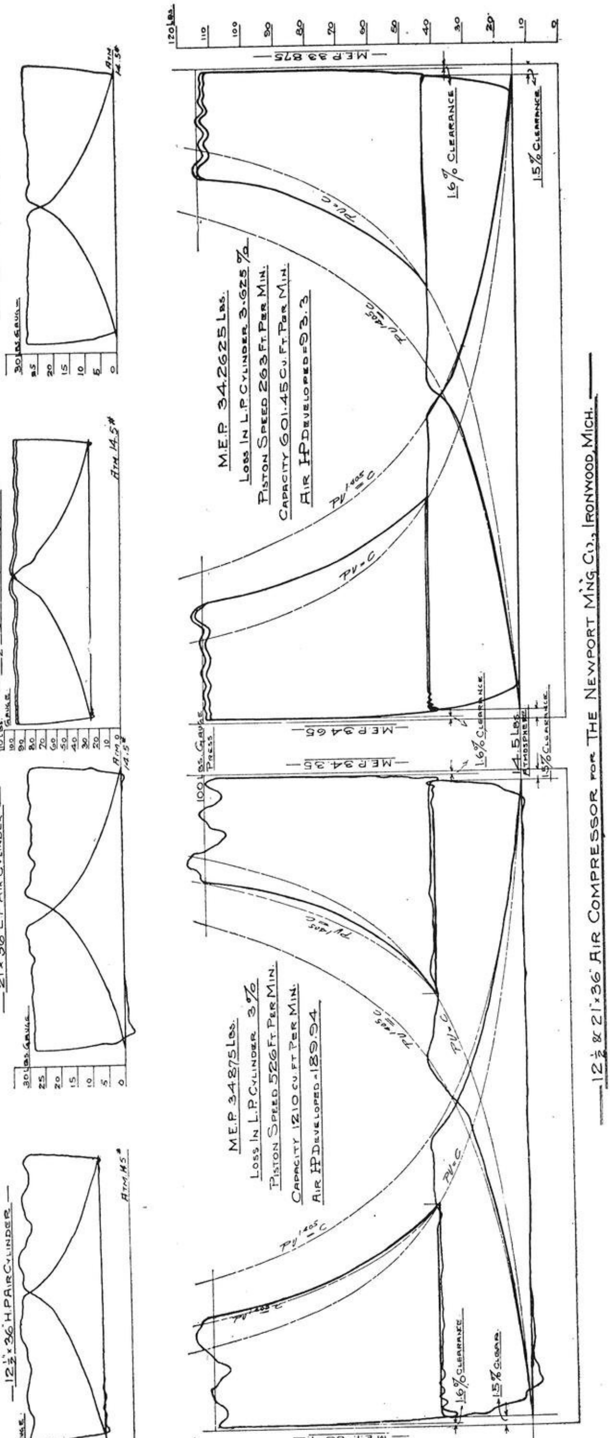


FIG. 4.—Cards from Nordberg Two Stage, Cross Compound Compressor.

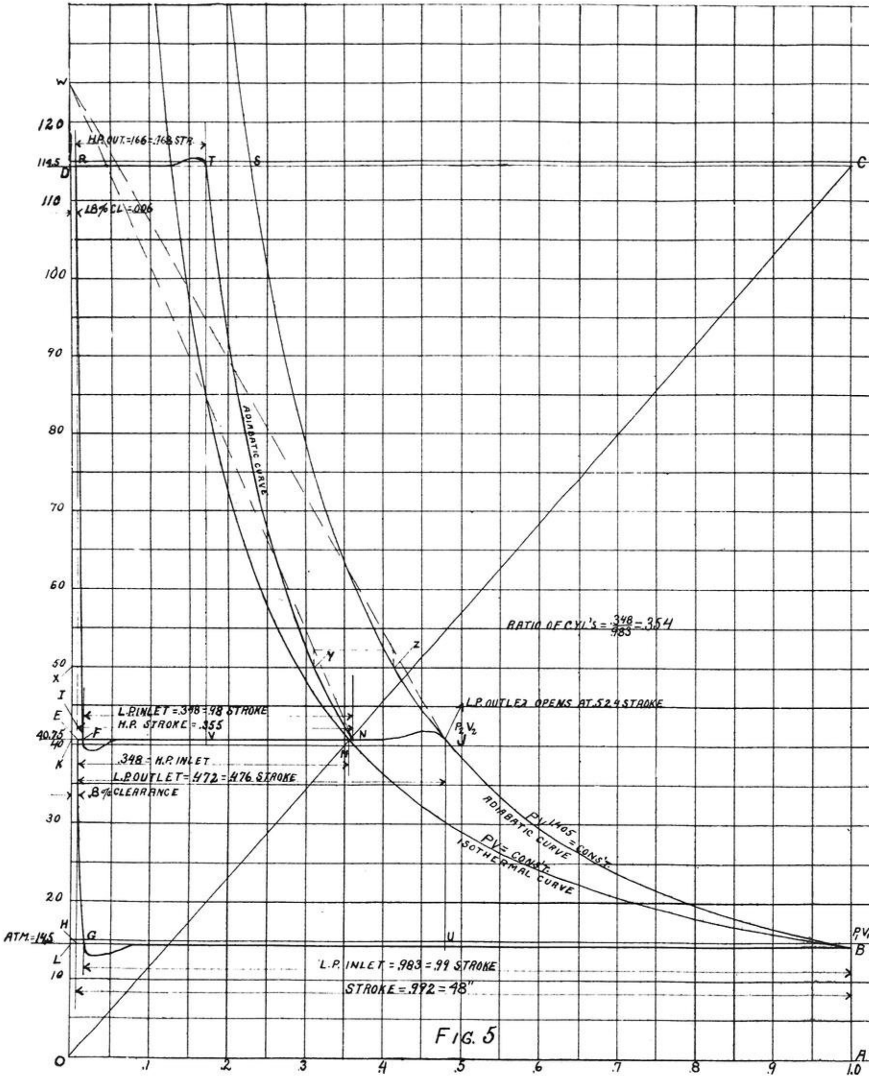

W
120
H.P. OUT. = .166 = .168 STR.
114.5
R
T
S
D
C
110
LB % CL = .006
100
90
80
70
60
ADIABATIC CURVE
RATIO OF CYL'S = .348/.983 = .354
Y
Z
50
X
I
E
40.75
40
L.P. INLET = .348 = .98 STROKE
H.P. STROKE = .355
V
F
N
M
L.P. OUTLET OPENS AT .524 STROKE
P_2V_2
K
.348 = H.P. INLET
L.P. OUTLET = .472 = .476 STROKE
.8 % CLEARANCE
30
ADIABATIC CURVE
$PV^{1.405}$ = CONS'T.
PV = CONS'T.
ISOTHERMAL CURVE
20
H
G
U
ATM. = 14.5
P_1V_1
B
L
10
L.P. INLET = .983 = .99 STROKE
STROKE = .992 = 48"
A
O
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 5

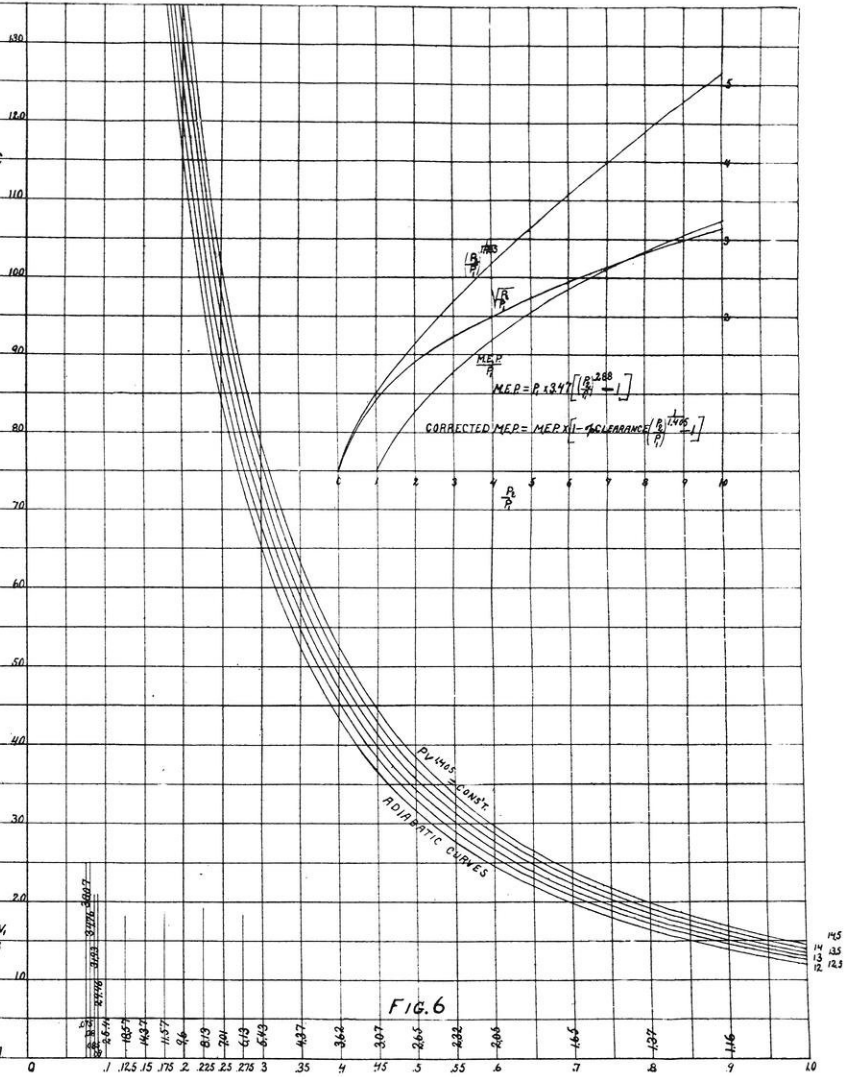

130
120
110
100
90
80
70
60
50
40
30
20
10
0
5
4
3
2
$\left(\frac{P_2}{P_1}\right)^{.1783}$
$\sqrt{\frac{P_2}{P_1}}$
$\frac{M.E.P.}{P_1}$
$M.E.P. = P_1 \times 3.47\left[\left(\frac{P_2}{P_1}\right)^{.288} - 1\right]$
CORRECTED M.E.P. = $M.E.P. \times \left[1 - \%\,CLEARANCE\left(\frac{P_2}{P_1}\right)^{\frac{1}{1.405}} - 1\right]$
1
2
3
4
5
6
7
8
9
10
$\frac{P_2}{P_1}$
$PV^{1.405}$ = CONS'T.
ADIABATIC CURVES
38.07
34.76
31.93
29.46
.075
.08
.085
25.41
18.57
14.37
11.57
9.6
8.13
7.01
6.13
5.43
4.37
3.62
3.07
2.65
2.32
2.05
1.65
1.37
1.16
14.5
14
13.5
13
12
12.5
0
.1
.125
.15
.175
.2
.225
.25
.275
.3
.35
.4
.45
.5
.55
.6
.7
.8
.9
1.0

FIG. 6

$$\text{M. E. P.} = p_1 \times 3.47 \left[\left(\frac{p_2}{p_1}\right)^{.288} - 1 \right] \times \left\{ 1 - (\text{pr. ct. clearance}) \left[\left(\frac{p_2}{p_1}\right)^{\frac{1}{1.405}} - 1 \right] \right\}$$

We have already found that

$$\left(\frac{p_1}{p_2}\right)^{\frac{1}{1.405}} = .48.$$

The reciprocal of this equals 2.01 very nearly, then:

$$\text{M. E. P.} = 14.5 \times 3.47\ [1.316-1]\ [1-.008\ (2.01-1)] = 14.5 \times 3.47 \times .346 \times .992 = 17.2 \text{ lbs.}$$

In short, to find the M. E. P. of the cylinder multiply the result obtained by equation (1) above by the ratio of the inlet period to the stroke; this is theoretically correct. Or, multiply the result obtained by equation (1) by

$$1 - \text{per cent. clearence} \left[\left(\frac{p_2}{p_1}\right)^{\frac{1}{1.405}} - 1 \right];$$

this is very nearly correct.

The M. E. P. of the H. P. cylinder, referred to the L. P. cylinder, that is, multiplied by their ratio, .354, should of course equal 17.2 also. For losses by inlet and outlet humps and possible overlapping of the L. P. outlet and H. P. inlet, we should allow about one-fourth lb. on each card; making a total M. E. P. referred to the L. P. cylinder of 35 lbs.

In Fig. 6 are shown curves giving the values of $\sqrt{p_1 p_2}$ for various ratios of compression, also values of M. E. P. by equation (1) and values of

$$\left(\frac{p_2}{p_1}\right)^{\frac{1}{1.405}}$$

for correcting the M. E. P. for clearance when it is necessary.

Thus for a compression in a two-stage compressor to six times the initial pressure we find the intercooler pressure should be 2.45 times the initial pressure, and that the M. E. P. without allowance for clearance for a cylinder compressing 2.45 times the initial pressure would be equal to the initial pressure; and if this cylinder has 1.5% clearance this should be multiplied by $1-.015(1.9-1)=.988$, or the corrected M. E. P. would be .988 times the initial pressure. The M. E. P. for both cylinders would then be double this plus allowance for losses by overlapping, etc. It will be noticed that the calculation for the combined M. E. P. depends on the percentage clearance of the two cylinders being nearly enough alike so as to cause no appreciable error; if there is much difference the correction can be applied to each separately or allowed for, with the losses.

(To be continued.)

NOTE.— For the use of a number of the illustrations used in this article, we are indebted to the courtesy of the Nordberg Mfg. Co., Milwaukee, Wis.

THE PROPOSED SHIP CANAL TO CONNECT THE GREAT LAKES AND THE ATLANTIC OCEAN.

By JAMES H. BRACE, '92, Albany, N. Y.

The idea of connecting the Great Lakes with the Atlantic Ocean antedates the Revolution, and its origin is sometimes attributed to Washington. He proposed to so improve the Potomac, Monongahela and Ohio rivers, by canals and otherwise, that the fur trade of Detroit and the Northwest would be diverted to Alexandria.

In 1788, Elkanah Watson of New York proposed to counteract Washington's plan by improving the Oswego and Mohawk rivers and Wood Creek, and connecting the two latter by a canal. In 1791 the New York Legislature appropriated five hundred dollars for the surveys for this project.

The first attempt at improvement in internal navigation was made by the Western Canal Company, who, by means of short sections of canal and locks, provided communication for boats of sixteen tons capacity from Schenectady to Seneca Falls.

The Erie canal was begun in 1817, and completed in 1825. It was hardly completed before it was apparent that enlargement was necessary, but this work was not completed until 1862. Up to that date the State of New York had expended $52,500,000 on the Erie canal, and no less than $80,000,000 on all the state canals. Meanwhile the Canadians have been making great efforts to secure a part of the commerce of the lakes and at present offer the only ship canal connecting the lakes and ocean.

The Canadian Canal System consists of the St. Mary's canal connecting Lakes Superior and Huron, the Welland canal connecting Lakes Erie and Ontario, and the St. Lawrence canals around the rapids of that stream. The capacity of this system is limited by the size of the locks on the Welland and St. Lawrence canals. They are fourteen feet deep, two hundred seventy feet long, and forty-five feet wide, and can float vessels of about 2,500 tons register. Although this is much smaller than the most economical type of lake vessel, these canals are destined to enter into competition for the foreign trade. This fact is evidenced by the recently reported sailings of the Carnegie boats from Conneaut to England, loaded with steel, and also by the proposal of a Buffalo syndicate to build large elevators in Montreal.

Deep Waterway Surveys.

The first step, toward a comprehensive examination of the ship canal project, was taken in 1894 when, largely through the efforts of Senator Vilas of Wisconsin, a bill was passed appropriating ten thousand dollars for a complete investigation of the subject. The sum was too small to allow more than the compilation of existing data, but this work was ably done by a commission consisting of Messrs. Lyman E. Cooley, James B. Angell and John E. Russell. In 1896 they presented their report which recommended that an appropriation be made for complete surveys and estimates.

During 1897, Congress authorized the beginning of surveys, intrusting the work to a commission to be appointed by the president. He, with his usual good judment in selecting able men, appointed Lieut. Col. Chas. W. Raymond, Corps of Engineers U. S. A., Alfred Noble and George Y. Wisner. Headquarters of the commission were established in Detroit and work was promptly begun. The bill authorizing the work directed that estimates be made for canals of twenty-one and thirty feet depth of water, and that the merits of each be compared.

The work required to connect Duluth and Chicago with the Atlantic consists of: First—The improvement of the interlake channels, that is, those connecting Lakes Superior and Huron and Lakes Huron and Erie. Second—A canal around Niagara Falls connecting Lakes Erie and Ontario. Third—A canal from Lake Ontario to the Hudson river.

The Inter-Lake Channels.

In the natural state, the St. Mary's Falls prevented all navigation between Lakes Superior and Huron. The obstructions in the Detroit and St. Clair rivers and Lake St. Clair did not allow a draft of vessels of more than nine feet. Improvements made by the United States government in both these connecting channels now permit a draft of eighteen feet. In accomplishing this result the cross sections of the connecting stream's have been increased, and consequently, the levels of the upper lakes permanently lowered. To remedy this and to counteract the effects of further increasing the cross section of the connecting lake channels, it was necessary to devise some means to control the level of the lakes, and especially of Lake Erie. Before the preparation of plans for this work could be begun it was necessary to know the discharge of the Niagara river at Buffalo. Accordingly, the work of gauging was commenced in October, 1897, and continued throughout most of the following year. The methods used have been described by Mr. Clinton B. Stewart in The Journal of the Western Society of Engineers, for December, 1899.

The topography of the various lake channels had been pretty well determined by the surveys of the Lake Survey and later by those of the U. S. Engineering Corps, so that beyond connecting some of the bench marks used, little was required in the way of surveys.

General Description of Surveys.

The field work was divided into nine divisions, each under an assistant engineer: 1. The La Salle, Lewiston and Tonawanda, Olcott Routes. 2. The Oswego, Mohawk Route, Western Division. 3. The Oswego, Mohawk Route, Eastern Division. 4. The Hudson River Survey. 5. The Champlain Route, Hudson River Division. 6. The Champlain Route, Northern Division. 7. The St. Lawrence River Survey. 8. The Niagara River Survey, and 9, Water Supply Surveys. The first division made the surveys from the Niagara river to Lake Ontario and also performed the work of the fifth division, that is, from Troy to Port Henry on Lake Champlain. The second and third divisions did the work from Oswego to Troy, the fourth division the soundings of the Hudson from Troy to deep water below the city of Hudson. The sixth division surveyed the route from Lake Champlain to Lake St. Francis, while the seventh and eighth did the necessary work along the St. Lawrence and Niagara rivers. To the ninth was assigned the examination of the streams flowing out of the Adirondack Mountains, to determine the best means of supplying water for the summit level between Lake Ontario and the Mohawk river.

The divisions were made up of a base-line and level party, a sounding party, if necessary, and as many stadia and boring parties as were required. Uniformity of stadia methods was secured by complete instructions to field parties issued by the Board, and to be found in their forthcoming report.

The work was controlled by a base-line run as nearly as convenient through the center of the territory to be covered by the survey. Whenever practicable, however, the base-line was run along a highway or railroad in order to facilitate the measurements and that the points might be more readily found by the stadia parties. This line consisted of a series of courses, varying from five hundred to three thousand feet in length, and depending on the length of sight that could be obtained. The courses were carefully measured with a steel tape, a spring balance being used to secure uniform tension and plumb-bobs to overcome inequalities in the elevation. Small wooden pegs, with a pencilled crow's foot at the exact point, were used for markers. The stationing was marked on the pegs in the usual way, and as an additional safeguard on the marking, a set of chaining pins was carried to act as counters. The distance between instrument stations was roughly checked by stadia readings on the flag pole. At every instrument station and at intervals not exceeding one thousand feet, where the courses were more than 1,500 feet long, oak hubs $1\frac{1}{2}''\text{x}1\frac{1}{2}''\text{x}12''$ were driven and marked with a copper tack. These hubs were referenced by measurements to surrounding objects, and if at an instrument station, by reading azimuths to prominent objects, as church spires. The azimuths of the courses were carefully read both by the instrument man and recorder. The station of all fences, highways, railways, etc., crossed by the line was noted. The temperature was observed at each instrument station. About every five miles an observation was made for azimuth on some circum-polar star, usually Polaris. At these points a stone monument was placed and carefully referenced. During the early part of the work, a separate level party followed the base-line party, but later, one party did both base-line and level work.

The level work consisted of a duplicate line of levels, run in opposite directions along the base-line. The elevations of all the base-line hubs were taken and bench marks established about every half mile. Effort was made to make these bench marks as permanent as possible and to distribute them on prominent objects, especially in towns, so that they might be easily found in the future. The limit of error was $\sqrt{.05}$ distance in miles both between bench marks and from the origin of the line of levels. After one party assumed both the transit and level work, the organization was as follows: An instrument man in charge, a recorder, a rodman, who acted as head chainman, a rear chainman, a flagman and an axman. The transit line would be run forward about five miles, and an observation for azimuth secured. Then an observer, a recorder and two rodmen would take up the levels, and carry them forward as far as the base-line had been run, while the two remaining members of the force were employed on the office work. This work consisted of correcting all the observed azimuths for convergence of the meridians, the distribution of the errors of observation from one observation station to another, the correction of the length of courses for change of temperature and the computation of latitudes and departures of all instrument stations. Copies of the corrected lengths and azimuths of all courses, the latitude and departure of all hubs, their elevations and references, also descriptions and elevations of all bench marks were made and transmitted to the assistant engineer, for the use of the stadia parties. When this was completed the party was ready to move to the next location, and take up the transit work where it had been left off. The parties boarded at the most accessible points and usually all of the members of each party at the same place for convenience in adjusting the notes in the evening.

Stadia Parties.

Stadia parties were usually assigned strips of territory covering about two miles of the base-line, as this length could be plotted on one of the protractor sheets furnished for the purpose. These divisions were called sheets. In starting the field work on a sheet, the party was furnished with a copy of the base-line and level notes that served to control the topography. The stadia parties consisted of six men: an instrument man, in charge, a recorder, two rodmen, a stadia man, and an axman. Elevation points were taken close enough to enable the contours to be platted at two-foot intervals. All buildings, fences, streams, roads, and other important features were located. A special attempt was made along streams to secure high water marks. The plan of the work was to start all circuits from base-line stations and to close usually on some other base-line station. Ordinarily, the instrument man or recorder ran the instrument while one of the rodmen acted as recorder. The instrument man or recorder, as the case might be, acted as head rodman, picking out the next instrument station, and directing the party generally. The second rodman and the stadia man covered the territory to the sides. The length of circuits usually did not exceed two miles. The limit of error was 1 in 500 for horizontal closure, and .5 of a foot for elevation per circuit. In computing the horizontal closure, the base-line was assumed to be correct, and its length not included. The average error in closure was 1 in 1,200 to 1 in 1,600, and elevations were seldom more than .2 of a foot off. The stadia boards were graduated to read ten-foot intervals, and the nearest foot could be readily interpreted. The boards were marked in accordance with the formulae given in the Tables by A. Noble and Wm. T. Casgrain. Sketches were made of territory covered, contours, as well as artificial features, being included.

Field Reduction of Notes.

Latitudes, departures and elevations of each stadia station were computed, the latter by the use of the tables already mentioned. After these had been checked, the circuits were plotted on the protractor sheets. Then all important locations were plotted and checked. In this way any errors were detected and corrected before the party left the locality. The difference of elevation of all stadia points, and the horizontal distances were reduced and checked by the use of the stadia diagram described by Mr. M. K. Trumbull in the Journal of the Western Society of Engineers for December, 1898. The elevations of the points were next deduced and checked. On the completion of this work for each sheet, the note books and protractor sheets were turned in to the assistant engineer, in whose office the working maps were prepared.

Borings.

In order that the nature of the material to be excavated might be determined, borings were made. These were put down to the rock, or to a point well below the probable canal bottom. They were usually in cross sections of three holes each, across the most probable route of the canal. The cross sections averaged 2,000 feet apart, but where excavation was likely to be partially in rock, and its surface irregular, the holes were placed closer. Several different forms of machine were used for this work, but a fair type was the Sullivan machine. This consists essentially of a casing of flush jointed steel pipe and hollow drill rods. The rods work inside the casing. The drill rods are tipped with a chopping or cross bit and are connected with a hand force pump that can force water through the opening in the bit. A derrick is provided for working the drill rods, and pulling the casing. The hole is started by chopping the drill rods up and down by means of a rope over a pulley, at the top of the derrick. Two men were required for raising the rods, and a third man for turning them with a pair of pipe tongs. At the same time, the jet was forced through the rods, washing away the loosened material. After the hole was started, the casing was placed in it, and worked down by turning with pipe tongs. The drill rods then worked in the casing, being constantly a little ahead of it. If a boulder or very hard material was encountered, it was broken up by lowering and exploding a stick of dynamite, care being taken to first lift the casing. The loosened material was washed up between the drill rods and casing, and by catching the overflow and allowing the water to drain off, fair samples were obtained and preserved.

The outline given was the basis of the work on all the divisions, but there were necessarily many modifications to fit conditions. In cases where the line followed large streams, as the Hudson and Mohawk rivers, a sounding party was required. The method adopted of making soundings was to establish ranges on shore, and mark them so that a boat could be kept on line. The soundings were then located by the single intersection method. The ranges were located either by the stadia parties or by the sounding parties themselves.

Working Maps.

As soon as the field books were turned in to the office of the assistant engineer, a force of draughtsmen began the preparation of the field maps. These were made on sheets of heavy egg-shell paper mounted on linen. The sheets were originally of a uniform size, but a cutting line was plotted on each, and ultimately the sheets were cut on these lines so that they could be matched to form a continuous map. For most of the work a scale of 1 in 5,000 was adopted, but in a number of localities 1 in 2,500, and in other places 1 in 1,000 was used. Buildings, fences, highways, railways, streams, bridges, borings, etc., were shown. The contours were plotted at two-foot intervals. No attempt was made to produce fancy work, but effort was made to make the sheets as plain and serviceable as possible.

The Regulation of Lake Erie.

The report of the Board on this portion of the project was transmitted to Congress early in the last session, and is now in print. Briefly, it is proposed to maintain the lake surface at some fixed point at or below high water. The stage on which estimates were passed is 574.5 feet above sea level, or three feet above normal low-water. It is proposed to accomplish this by building a number of stone sluice gates and a submerged weir across the head of the river at the rock reef that forms the rapids at Buffalo. By means of the sluice gates, the outflow may be increased at high, and decreased at low stages, by an amount sufficient to maintain the lake at a uniform stage. It is estimated that, if the lake be regulated at the stage proposed, Lake St. Clair will be raised two feet above low water, and Lakes Michigan and Huron, one foot, thus lessening the amount of dredging in the Detroit, St. Clair, and Lower St. Mary's rivers, and in Lake St. Clair, as well as improving the lake harbors.

The Inter-Lake Channels.

Between Lakes Huron and Superior.—The channels in both the upper and lower St. Mary's river would require to be deepened and widened for both 21′ and 30′ channels. For 21′ navigation, the present locks would answer, but a 30′ channel would require a new lock.

Between Lakes Huron and Erie.—For a 21′ channel the St. Clair and Detroit rivers require deepening and widening, particularly at the St. Clair Flats and the Lime Kiln Crossing, the latter a rocky reef. The channel through Lake St. Clair also requires deepening and widening. The present minimum depth frequently falls below 18′, depending on the stage of the water. For 30′ navigation, improvements must be made, not only at the places mentioned, but in the lakes themselves. For a considerable distance in Lakes Huron and Erie, the water does not much exceed 21 feet, so that a channel must also be cut there.

Lake Erie to Lake Ontario.—Between the head of the Niagara river and the International Bridge, a distance of about two miles, there is a gradual fall over a rocky ledge of about eight feet. The government has cut a channel through this ledge, that allows the passage of lumber barges to Tonawanda. From the International Bridge to La Salle, a distance of about fourteen miles, the fall does not exceed two feet. The depth of the river channel is quite variable, but to Tonawanda the bed is mostly soft material that can be easily dredged. From Tonawanda to La Salle, the bottom is largely rock, and the depth of water about 12 feet. From some point near La Salle, a canal must be cut around the Falls, to the vicinity of Lewiston. About one mile south of Lewiston is what is known as the Escarpment. This is an abrupt ridge whose crest is at an elevation of 620 feet above mean tide at New York. The land slopes gently from the crest of the ridge back toward the river at La Salle. The elevation of the water surface in the river at that point is about 563 feet. The base of the ridge has an approximate elevation of 350 feet. From this point, there is a gradual descent toward Lake Ontario, whose elevation at low water is 244.5 feet. The total difference in elevation between the two lakes is 330 feet, for the proposed regulated stage of Lake Erie. The rapids of the Niagara end at the Escarpment, and from that point to its mouth it is a broad, smooth stream from forty to sixty feet deep, with the exception of a small bar at its mouth, where the depth is a trifle less than thirty feet. The river from Lewiston to its mouth forms one of the finest harbors in the world.

The surveys for this work involved, first, a shore line survey of the river from Buffalo to La Salle, together with soundings in the river; and second, a survey of a strip of territory about one-fourth mile wide from La Salle to Lewiston, a distance of eight miles, and soundings at the mouth of the river. The difficulties of this line are the rock excavation under water, from Tonawanda to La Salle, and the fall of 319 feet that must be overcome in a little over a mile, at Lewiston.

Tonawanda–Olcott Route.

In order to avoid the two difficulties just mentioned, it has been proposed to leave the Niagara at Tonawanda and follow a natural depression in a northeasterly direction to a point two miles west of Lockport, then north to Lake Ontario at Olcott. At the point at which this line changes direction it passes through or alongside of a natural depression known as The Gulf. This was probably an old outlet of Lake Erie at a time when it was much higher than now. It has many of the same features as the Niagara Gorge, including the probable site of a former whirlpool. This gorge forms a somewhat more gradual descent to the Lake Ontario plain, but is too crooked to be of much use for a ship canal. Near Olcott the line follows the gorge of Eighteen Mile Creek. This line involved the survey of a strip of land from one-fourth to one mile wide and about twenty-four miles long. The two gorges are extremely irregular, and required much labor. Although the locks are better distributed on this line, it has about twenty-four miles of restricted navigation, against eight miles on the La Salle–Lewiston route. A harbor must also be constructed at Olcott.

Ship Canal From Lake Ontario to the Hudson River.

In general, there are two possible routes for this canal,—the Oswego–Mohawk route, and the St. Lawrence–Champlain route.

Oswego–Mohawk Route.—This route leaves Lake Ontario at or near Oswego, follows the Oswego river to Fulton, thence across country to Lake Oneida, thence through the valleys of Wood creek and the Mohawk river. The elevation of Lake Ontario is, as previously stated, 245.4 feet, that of Lake Oneida 369 feet, and of the summit of the divide between Wood creek and the Mohawk, or between the Lake Ontario and Hudson watersheds, 430 feet. The water surface in the Hudson below the Troy dam is only one foot above mean tide at New York. It is evident that a continuously descending canal cannot be built by this route but that locks must be constructed to lift vessels to or above the level of Lake Oneida, thus creating a summit level from which descending locks must be built to the Hudson. This necessitates the consideration of the question of water supply. If Lake Oneida be raised and made the summit level, an immense natural reservoir is supplied that will suffice. The lake surface, however, cannot be raised more than ten or fifteen feet, and a very long and heavy cut must be made through the Rome summit, which is of loose material. The other alternative is to construct a shorter and higher summit level at Rome, supplying this level wholly by water stored off the line of the canal, in the headwaters of the streams flowing out of the Adirondacks. Both of these plans are practical and the choice depends wholly on the questions of cost and expediency. Not the least of the difficulties of both the plans for this route is the wide variation in the discharge of the Mohawk and Oswego rivers. Also, the existing water-power developments considerably complicate the work.

St. Lawrence–Champlain Route.—This route follows the St. Lawrence to the lower end of Lake St. Francis, thence across the Province of Quebec, a few miles north of the international boundary to the Chazy river, which it follows to Lake Champlain at King's Bay, thence through Lake Champlain to Whitehall, across the divide to the Hudson, then down that stream to the tidal portion at Troy. The governing elevations on this line are Lake St. Francis, 150 feet above mean tide at New York; Lake Champlain, 96 feet; the divide between Lake Champlain and the Hudson, 150 feet; the Hudson at Fort Edward, 116 feet. A continuously down-grade canal by this route is practical. The St. Lawrence river generally affords more than thirty feet of water, except near the rapids. Here, however, locks must be constructed and some expensive work done in enlarging the cross section of the river in order to reduce the current.

The foot-hills of the Adirondacks extend northward to the boundary, thus precluding any possibility of a canal by this route wholly in American territory. Northward from the foot-hills a nearly level plain stretches toward the St. Lawrence. Much of the surface of this plain is below the level of Lake St. Francis. It is cut by rivers running towrad the St. Lawrence.

Rock is nearly everywhere near the surface. From King's Bay to Port Henry, Lake Champlain has sufficient depth of water for navigation by any class of vessel. From Port Henry to Whitehall the canal must be largely in excavation, but the material is soft. At Ft. Ann, is the divide between Lake Champlain and the Hudson river. For a short distance this is about 150 feet above the sea level, but the valleys leading north and south offer a natural canal route. From Ft. Edward to Troy the Hudson falls about 116 feet. This fall is now concentrated at several points by a series of dams for water power. This route has the advantage of much less lockage and of supplying its own water, but is longer and has the serious disadvantage of lying beyond our boundaries for a considerable distance.

Tidal Hudson.

As far south as the city of Hudson the river will require improvement. Below that point there is uninterrupted navigation to the Atlantic.

Estimates and Report.

The preparation of estimates and the reduction of the information collected into the form of a report was mainly done in Detroit under the immediate direction of the Board. The working maps were reduced for publication by pantagraph to a scale of 1-20,000. The location of the lines estimated and of proposed structures was shown on these maps. Plans of all important structures were carefully worked out. Cross sections showing the excavation and embankment were plotted and the areas of each determined by planimeter. The results of this work are given in detail in the Report of the Board, which has just been transmitted to Congress, and will doubtless soon be in print. To that report the reader who has become interested in this subject is referred for the plans in full and for a comparison of the relative advantages of the two routes. The broader subject of the Economic Dimensions for a Waterway from the Great Lakes to the Atlantic is ably treated in a paper presented to the Am. Soc. C. E. on Nov. 7, 1900, by Geo. Y. Wisner, C. E., from which paper the following tables are quoted.

TABLE NO. 1.—*Summary of Distances, Amount of Lockage, etc., Buffalo to New York.*

	OSWEGO, MOHAWK ROUTE.		CHAMPLAIN ROUTE.
	High level plan.	Low level plan.	
Total distance, miles	477.04	476.94	685.21
Fall, regulated stage of L. Erie to mean tide	574.5	574.5	574.5
Down lockage, feet	742.6	705.6	547.2
Up lockage, feet	170.6	133.6	0.0
Total lockage	913.2	839.2	547.2
Number of locks	39	37	19
Number of guard locks	1	1	2
Standard canal, miles	102.56	102.42	102.35
Canalized river:			
200 to 250 feet bottom, width miles	....	....	1.51
250 to 300 " " " "	20.38	20.38	....
300 to 350 " " " "	12.37	12.37	38.97
350 to 400 " " " "	2.59	2.59	....
400 to 450 " " " "	13.90	13.90	8.08
450 to 500 " " " "	8.99	8.99	11.59
500 to 1000 " " " "	39.15	37.65	73.65
Open lake and river	277.10	278.64	449.06
Total miles	477.04	476.94	685.21

TABLE NO. 2.—*Estimated Cost of Waterways.*

	30-ft. channel.	21-ft. channel.
Lake Superior to Lake Erie	$33,539,869	$6,961,818
Lake Michigan to Lake Erie	16,226,548	1,466,439
Lake Erie to Lake Ontario	73,435,350	42,393,203
Lake Ontario to New York, Oswego, Mohawk Route (high level plan)	206,253,553	155,324,968
Oswego, Mohawk Route (low level plan)	210,309,129	157,003,082
St. Lawrence Champlain Route Duluth to New York	213,123,864	141,127,415
Oswego, Mohawk Route (high level plan)	313,238,772	204,679,989
Oswego, Mohawk Route (low level plan)	317,284,348	206,358,103
St. Lawrence Champlain Route Chicago to New York	320,099,083	190,382,436
Oswego, Mohawk (high level plan)	295,915,451	199,184,610
Oswego, Mohawk (low level plan)	299,971,027	200,862,724
St. Lawrence Champlain Route	302,785,762	184,887,057

"The estimated net running time for a round trip between Chicago and New York for a vessel capable of steaming 12.5 miles per hour in the open lake (the speed of the modern lake freighter) is 11 days and 8 hours, via the Mohawk route, and 12 days 9 hours via the Champlain route. The navigation season via the Mohawk route will average 245 days and for the Champlain route 230 days. Allowing four days' detention in port, the 12.5 mile boat could make sixteen trips per season via the Mohawk route and fourteen trips over the Champlain route."

In conclusion it may be of interest to state that the state of New York is now making estimates of the cost of transforming the Erie canal into a large canal capable of transporting barges of 1,000 tons burden and drawing ten feet of water.

FIREPROOF BUILDING CONSTRUCTION.

By J. T. RICHARDS, '95.

Supt. Factory "P," Perth Amboy, N. J., National Fireproofing Co., Pittsburg, Pa.

The general public naturally questions the term fireproof, in regard to building construction, and it has a tendency to treat the matter rather skeptically. It is perhaps justified in so doing in some cases, but, as a rule, it does not stop to consider what the term really means. A "Fireproof Building" should be defined as a structure that will not burn from without, no matter how high a heat it is exposed to, and which will confine a fire to one room without injury to the rest of the building. The contents of an office or living room are, of course, inflammable, and to limit a fire to one room is the main requisite of a fireproof structure. Every fire that has occurred in a fireproof building can be traced to some weak point or overlooked condition, and it is always the unlooked for that happens. For example we cite the fire that occurred in New York City in '97, when the Home Life Insurance building was damaged. The burning of the wooden structure standing north of it, occupied by Roger Peet & Co., while a gale blew from the northeast, was a very severe test. No iron shutters were provided the Home building, consequently the fire drew in through the windows, the inflammable materials catching fire and ruining the upper eight stories. Again, in the same building, the space between the 3x4 sleepers under the floors was not filled up with cinder concrete and it allowed the fire to travel underneath. So we have the two defects in one building, giving a chance for a fire from without, and from within. It takes but one small defect to give the flames an opportunity to spread and for this reason every point must be closely guarded.

In order to reach the highest ideal in any undertaking we attempt, we must employ the best of everything available. In a building the best design, the best specifications, the best materials, and, lastly, the best inspection possible, are the main requisites. The development of a fireproof building has been like many other things, by stages, and is at present far from perfect.

The first attempt was the placing of iron beams on the brick walls and filling in the same with segmental brick arches, the entire weight being carried to the walls, making them of primary importance. With the introduction of soft steel, built-up columns came into use, and, together with the steel beams, a complete skeleton work was formed, the brick work taking a secondary place as a filling material. One of the first buildings of this type was our own Science Hall at Madison. The use of steel in this line is ably discussed by C. T. Purdy, C. E., printed in the Journal Assoc. Eng. Soc. (Vol. XIV., No. 3, Mar., 1895). Our object being to take up and discuss the different methods of fireproofing the steel work, and the manufacture of the same and the application to the building, we will take up the different methods in the next paper.

STEEL GAS HOLDERS.

A Suggestion for a Thesis in Structural Engineering.

By W. A. BAEHR, Denver, Colo.

The study of Gas Holders in connection with other structural engineering problems is one that is largely neglected in our engineering schools and universities. Yet it is one whose importance is increasing very rapidly of late, as a natural result of the more universal application of gas as a source of light, heat and power. This increased demand for gas has necessitated larger storage capacity, and holders are now built of such magnitude as would appall the engineers of fifty years ago.

In general the cost of a steel gas holder per unit of capacity decreases as the size of the holder increases. The first question then to present itself is, "What is the limit of size of gas holders in view of our present knowledge of the properties of structural steel, considering the point where economy ceases?" In other words, shall we build one holder of, say 12,000,000 cubic feet capacity, or two of 6,000,000 cubic feet each, or three of 4,000,000 cubic feet each, assuming, of course, that the business justifies such an amount of storage.

The study of the design of steel gas holders naturally divides itself into four parts, viz., the foundation, the tank, the holder and the guide framing. Each of these subjects presents a field for investigation fully as rich in research as the design of the steel work for a high building or of a large bridge. There are, of course, other kinds of gas holders besides those built entirely of steel with guide framing, such as those with tanks of masonry or cast iron, combination tanks of steel and concrete, holders without guide framing or with peculiar forms of guiding, and those whose framing does not extend entirely to the top of the holder when full.

The foundation presents numerous problems, and some of these contain conditions which the engineer may never solve to his entire satisfaction. In the first place the ground must be tested thoroughly, borings made to determine the character of the soil, and its stratifications, due weight being given to surrounding conditions, such as proximity of railroad tracks, where passing trains might induce vibrations, or possibly the chance of damaging other important structures nearby would introduce factors of a complex nature.

If piles are deemed necessary they should if possible be driven below the level of the ground water, in order to preserve them. In this connection the question of number of piles required, their arrangement, bearing power and kind constitutes an important item. A proper arrangement for admitting the inlet and outlet pipes is very important.

A bed of concrete for the tank to rest upon may be placed over the top of the piles, or if these are omitted, and the character of the soil permits, the concrete may be laid directly upon the ground when properly excavated. Here the question of depth of concrete bed necessary is probably the most vexatious, for it is difficult to find suitable precedents. Then the composition of the concrete and the kind of cement to use must be determined. There is no doubt that good Portland cement is by far the best kind to use in a climate where the winters are at all severe, as in Wisconsin. This is particularly true where the foundation must stand over winter before the tank is placed upon it. In finishing the surface of the concrete it must be borne in mind that this must be as nearly level as possible, because if not so, the guide framing and holder will be thrown out of plumb, and its working impaired.

In all calculations respecting piling and concreting it is necessary, of course, to calculate the superimposed load very carefully, and to distribute the piles in such a manner as to best resist the various forces acting upon them.

The proper design of a steel tank of the size required in gas holder work involves many nice problems. The great amount of water contained produces heavy stresses, which can be calculated very nicely, however. In order to show the amount of these stresses, it can be demonstrated that in a tank 184 feet in diameter by 34 feet deep, the side plates of which are arranged in seven courses, with an allowable unit stress of 13,500 pounds per square inch, the bottom course of side plates should be 1¼ inches thick. This tank would be suitable for a four-lift holder of 3,000,000 cubic feet capacity.

When steel shapes or plates as thick as 1¼ inches are employed a great many conditions enter into the design which do not occur in thin metal. This particular plate would require 1¼-inch rivets, and that would mean that holes for these rivets could not be punched. In fact, in first-class tank construction holes in plates over ½ inch in thickness should be drilled. There are very few shops in the United States equipped for such heavy work as bending, cutting and drilling such large plates. Another important feature is that all such work should be carefully laid out and fitted in the shop in order to go together neat and tight in the field. Field work on heavy material is very expensive.

The vertical joints in the tank shell should be designed for a maximum efficiency. One of the best known forms is a double strap butt joint, with the riveting so arranged that the efficiency varies from about 91% to 94%. Horizontal joints may be single riveted lap joints.

The tank bottom may be built of rectangular or radial shaped plates, and the thickness is arbitrary when on a good foundation, ¼ to ⅜of an inch is sufficient. All joints must be well caulked and pneumatic caulking is preferable. How shall a tank bottom be lowered onto its foundation after being riveted and caulked? There is something to think over.

A good standard grade of medium steel carefully tested, ought to be selected for this work.

In the holder or gas containing part the chief points to be dwelt upon are as follows: Shall the crown be trussed or untrussed? How shall the upper curb, goose necks and cups be designed? What is the most economical radius for the crown? Other important points are the design of radial and tangential rollers, the weights of the crown and side sheeting required, the best method of securing a gas-tight joint in the plating, the size and spacing of rivets employed, and proper stiffeners for each lift.

Of course the whole detail depends largely upon the proportionate design of the entire structure. What is the most economical and safest relation of the diameter to the height of a holder? In the answer to this question there are the most complex factors. A wind load amounting to possibly fifty pounds per square foot, and a snow load of perhaps six inches distributed over the whole area of the crown or massed entirely on one side, must be taken into consideration.

The guide framing, of course, is designed to transmit the stresses due to the various loads into the tank shell. As generally built now they are a number of posts built up of various standard shapes, such as I–beams, channels, angles and plates, connected by a system of horizontal struts and diagonal braces. The economical distribution of material in the posts so as to best resist the various stresses is a great study by itself, when one takes into consideration the standard shapes readily obtainable in the market. Shall rods or angles be employed for the diagonal bracing? The trend of opinion seems to favor the stiff bracing. Shall these connect to the front or back chord of the posts? The answer is that the bracing shall lie in the plane through which the stress would be transmitted from one post to the other. Can such a design be made?

In general, when one finds that a steel gas holder of 3,000,000 cubic feet capacity contains some 1,800 tons of steel, the magnitude of such a structure can be better appreciated.

This topic has been written in order to point out to the student a few of the problems connected with one part of gas engineering. Gas holders, of course, form but a small portion of a gas plant, and in order to appreciate and understand the process of gas manufacture a thorough knowledge of chemistry is necessary. Too many engineering students neglect the study of chemistry. I have always been hopeful that the universities would some day add gas engineering to the list of courses given by them, and my ardent wish has been to see the University of Wisconsin lead the others in this matter. Why not?

THE COMPLETION OF THE ENGINEERING BUILDING.

J, B. JOHNSON.

The new Engineering building was described in the June number of the Wisconsin Engineer with a cut showing its exterior. To recapitulate the conditions under which this building was erected, it may here be stated that at the meeting of the executive committee of the Board of Regents in November, 1899, it appeared that no plans had as yet been presented for the building which could be adopted. At that meeting resident architect J. T. W. Jennings and the writer were authorized to prepare plans for such a building, and these gentlemen expressed the opinion that such plans could be prepared and the building erected before October 1, 1900. The plans were ready for inspection at the December meeting of the executive committee and were then adopted. The detail plans and specifications were ready for adoption the first of January; the work was at once advertised, and the contracts let February 1st, at a meeting of the Board of Regents. Excavations were begun on the site about the first of March by blasting the frozen ground; these were completed about the first of April and the building begun. Had it not been for one or two unavoidable delays in the delivery of material, caused by accidents in the factories, the building would have been practically completed by the contract date, October 1st. As it was, the work continued in the basement until about the middle of October. On the opening of the college year in the latter part of September, however, the building was sufficiently completed on the main floor and all above to allow the work of the school to be carried on regularly. The appliances in the steam and testing laboratories were moved over from Science hall and from the shop buildings in August, September and October, so that early in November these laboratories were also in operation.

The building is beautifully decorated on the interior, all the walls having been colored in suitable tones to make them at once beautiful and restftul to the eye. The interior finish is mostly oak, with considerable marble and terra cotta in the main entrance, which is rather imposing. The building was completed with very few extras for the sum appropriated, namely $100,000. For this sum there was obtained the building proper, including a fan system of heating and ventilating with automatic regulation, a very unusual amount of electric wiring of both light and power in nearly all parts of the building, also a large amount of plumbing, including gas distribution in all the laboratories, a tunnel from the building to the boiler house for the steam pipes, and a proportionate part of the salary of the resident architect.

Because of the building being placed upon sloping ground there is a sub-basement under the eastern portion, and this, together with the four large drawing rooms in the attic, place the work of the building upon six floors.

There is an auditorium on the main floor at the east end (on the right as seen in the frontispiece), which seats three hundred and sixty. Into this auditorium and into the testing room in the sub-basement below was thrown the space of the basement story proper, giving to the auditorium a height of about twenty feet and to the testing laboratory below a height of about sixteen feet. This was made possible only because of the sloping ground on which the building was placed, the natural surface having a fall of twenty feet in the length of the building. On the up-hill side of the building the natural surface has been removed in such a way as to make the basement story fully as well lighted as any of the upper stories, and on the down-hill side the sub-basement goes but little below the natural surface of the ground.

The portion which has now been built is only about one-fourth of the entire building. When completed the building will have four exterior faces similar to the one shown in the cut, this being the southern front, facing upon the upper campus or quadrangle, nearly opposite the Law building. The east and west fronts of the completed building will be considerably longer than the south front, this having a front of 172 feet. When completed, the entire interior court, which will then have an area of about 70 x 100 feet, will be occupied by the steam-testing laboratory. Only one-half of this laboratory has now been built, this standing north of the center portion of the present building and west of the wing on the east.

This is perhaps the best lighted and ventilated and most satisfactory steam-testing laboratory in the world. It is lighted by skylights in the roof, and is practically two stories in height. The sloping roof near the walls of the main building, however, allows for the lighting of the interior rooms of the main building on the first floor, through the upper halves of such windows. The second story of this laboratory consists only in a gallery, eight feet in width, which entirely surrounds the laboratory. On the north side, however, this gallery is twelve feet in width and is closed off from the laboratory by glass windows, and is to be used as a computing room for students engaged in laboratory work. On the sides of this gallery surrounding the steam laboratory, museum cases will be placed containing exhibits which will not be affected by moisture. In the roof there are four fixed ventilators and sixteen openings in the skylights which will be used only when experimental work is in progress. The entire basement and sub-basement stories are given up to experimental laboratories of various kinds. Those portions of the experimental electrical laboratory in which the steam power is required, and also the electro-chemical laboratory, remain in the shop building as before, but with about double the floor space which they formerly had. All the other electrical laboratory work, not requiring steam power but in which electric power only is employed, including photometry and experimental thesis work, will be carried on in the west end of the main basement of the new building. On the main floors there are, besides the auditorium, three lecture rooms, the Dean's offices, a large reading room, in which are placed the engineering periodicals and a duplicate technical reference library, one professor's office, and a large room in which are placed in suitable upright cases with glass doors all the surveying instruments; this room has a wide outer door opening to the north, through which these instruments are carried for field work. This floor opens to the north directly upon the gallery of the steam laboratory. On the second floor are six lecture rooms, ten offices, and two instrument rooms. On the third floor are six large drawing rooms, one office, and one lecture room. In the attic are four large drawing rooms, one of which is now used as a museum room.

The number of students in the College of Engineering is rapidly increaisng. Thus, in 1898–9 the number of students was 242, in 1899–00 it was 327, and in 1900–1 it will reach 400. It is expected that next year our drawing rooms will be filled, and the year after they will be overcrowded, so that in 1903 it will be absolutely necessary to extend this building, as our numbers will then be at least 550. During the present year some of the classes in the German department meet in the building.

The walls of the new building are being decorated with a very choice collection of large pictures, all of engineering interest. These pictures have been contributed to the building by railroad and steamship companies, construction companies of all kinds, and various engineering and industrial works. These have been obtained by request from all over the country, and without exception they are contributed freely and even thankfully. Nearly all of them come beautifully framed, with express charges prepaid. It is estimated that at least $1,000 worth of pictures have already been contributed, and more are expected. With these the beautiful colored walls will be fully decorated, and the building will have more the appearance of a home than that of the ordinary college building. The Dean and some of the professors have added to the homelike appearance of their offices by placing rugs upon the floors, and they have moved into these offices their private libraries and expect to make these rooms their studies. They then become accessible to students at all hours of the day, which is, in many ways, a great advantage to the school. It is thought that these surroundings will have a refining, and in many ways a wholesome, influence upon the students who frequent the building, and that they will be inclined to take better care of the building than is ordinarily the case. This is already observed in their conduct in the reading room. While this reading room was purposely placed adjoining the offices of the Dean with a door opening between for the purpose of oversight, it is never found necessary to enter the room or even to leave the door ajar.

The grounds in the immediate vicinity of the building will be planted with suitable shrubbery and vines upon the steep slopes, and enough low ornamental shrubbery to give the building a beautiful setting. This work is in charge of the newly appointed landscape gardener, Mr. O. C. Simonds, of Chicago. With the gradual development of this planting about the building, and with the extension of the building northward towards the lake, it will become the most beautiful, and perhaps the most imposing, building upon the upper campus, especially when seen from the east. As seen from the west, or up-hill side, the building looks low because it has been set so deep into the hill. On this side the building comes within about seventy feet of North hall. When the building is finally completed it will be 172 feet east and west, and about 202 feet north and south, with the interior court of 70x100 feet, all of which will be occupied by the steam laboratory. It is thought this entire building will be required in the course of fifteen or twenty years, and possibly sooner.

THE HENNEPIN, OR THE ILLINOIS AND MISSISSIPPI CANAL.

By HENRY FOX, '92.

U. S. Inspector, Princeton, Ill.

The antique village of Hennepin, Putnam county, Illinois, is located upon the high right bank of the Illinois river. There is nothing of particular importance to be mentioned in regard to this town, other than its geographical location.

A trip upstream of fourteen miles on the steamboat Polar Wave will land you in the industrial and thriving city of La Salle. This city being the head of navigation on the Illinois river, has also the distinction of being the southern terminus of the Illinois and Michigan barge canal. The Illinois and Michigan canal was completed by the commonwealth of Illinois in 1848 at a cost of $8,654,337; this canal is 102 miles long, has a depth of six feet and a width of sixty feet, or approximately the same dimensions as were the original ones of the Erie Canal. From La Salle the Illinois and Michigan Canal follows the Illinois and Des Plaines rivers to Summit, and from thence to Bridgeport and Lake Michigan. The freight traffic on this canal was equivalent to 1,000,000 tons in 1890, notwithstanding the sharp competition offered by the rail routes.

The present engineering problem of the enlargement and improvement of the Illinois and Michigan Canal, or to construct a new channel so as to meet the probable increase in volume of traffic on the one hand or the utilization of the Chicago Drainage Canal for a distance of 34 miles between Chicago and Joliet in connection with the proposed improvement of the Des Plaines river for a distance of 19½ miles and the improvement for a distance of 62 miles of the upper Illinois river between the junction of the Des Plaines and Kankakee rivers and Hennepin has taken a definite form, and estimates and plans are now being prepared by the U. S. Engineer Department for congressional consideration during the present session of Congress. However, let us return to our starting point on the great bend of the Illinois river and pursue a southerly course for a distance of 208 miles; here the waters of the Illinois and the Mississippi rivers mingle at or near Grafton, Illinois.

Before leaving the discussion of the Illinois river it may be stated that the lower reach of 208 miles has been made navigable by the construction of four locks and dams, thus forming a system of slack-water navigation and thereby obtaining a minimum depth of seven feet of water. The work of improving the lower Illinois river was inaugurated by the state of Illinois about 1870, and the project was finished by the federal government about ten years later.

Continuing our journey northward from Grafton and following the Mississippi river 287 miles, we have now reached an island known as Rock Island, at a point 4½ miles above the place where the Rock river empties into the Mississippi river. Upon this island are located the numerous buildings, shops, factories and warehouses comprising a most elaborate and extensive plant, erected by the United States, for the manufacture of ordnance and other munitions of war.

Geographically Rock Island is about 75 miles west of Hennepin, although the water route previously described between these points is 495 miles long.

As an economical and cheap route for the transaction of the commercial products of the northwest, that is to say, between St. Paul and a point 120 miles north of St. Louis the Hennepin Canal was designed as a cut-off from the upper Mississippi river to Lake Michigan in connection with the existing waterways described or the improved routes of greater capacity that are now under consideration. The military and naval consideration involved in the Hennepin Canal project centers about a provision in the treaty with Great Britian, which stipulates that a warship can not be maintained upon the Great Lakes; it will, therefore, be manifest that upon the completion of the waterways between the Mississippi river and Lake Michigan a fleet of gunboats can easily be equipped with guns and ammunition at the Rock Island Arsenal, and in case of war these vessels can be used to protect the shipping and cities on the Great Lakes. Generally speaking, the main line of the Hennepin Canal passes through the counties of Bureau, Henry and Rock Island, while the navigable feeder passes through Whiteside and Bureau counties.

The surveys, estimates and a general discussion of the benefits to be derived from the Hennepin Canal were made by the U. S. Engineer Corps in 1871, 1883–5–6 and 1890 and reported upon to Congress.

The general specifications of the canal upon which the foregoing surveys and estimates were based called for locks of sufficient capacity to pass most of the steamboats then operating upon the Mississippi river.

The following statement compiled in 1890, showing the number and draft of all craft navigating the Mississippi river and its tributaries, is herewith introduced:

687 boats, drawing 7 feet of water or less.
25 boats, drawing 7 to 8 feet or water.
14 boats, drawing 8 to 9 feet of water.
3 boats, drawing 9 feet or more.

Inasmuch as 94% of all the craft, as shown by the above table, draw 7 feet of water or less, the depth of 7 feet of water was decided upon for the Hennepin Canal and declared ample to meet the demands of the traffic upon the upper Mississippi river. Furthermore this canal is designed for navigation by barges and tugs only with all bridges to be fixed, giving 17 feet clear head room.

The capacity of the canal was originally calculated upon the basis of 3 boats passing through a lock each way every hour, aggregating 144 boats per day of 300 tons each, or 8,640,000 tons in 200 days, or about the length of each season of navigation.

The preliminary surveys of 1871–1883–6 developed three possible routes between Hennepin on the Illinois river and Rock Island on the Mississippi river, while the navigable feeder route remained common to all; that is to say, it obtained its water supply from the Rock River at or near Sterling, Illinois, and connected with the main line on the summit level, near Sheffield, Illinois.

The relative estimated cost of these three routes may be summarized in the following manner:

First or cheapest, Marias d'Osier route, about 64 miles long.
Second, Watertown route, about 64 miles long.
Third, Rock Island route, about 75 miles long.

The next progressive step taken by Congress was the passage of an act dated August 11, 1888, authorizing a change in the name of the Hennepin Canal to that of the Illinois and Mississippi Canal and the Secretary of War was granted the power to have said canal located and final plans prepared for the construction of the same.

Pursuant to this act of Congress, and after much deliberation, the Rock Island route was approved by the Secretary of War. The location survey of this route was made, plans and estimates prepared and another report on the same was made to Congress in 1890. The estimated cost of the entire project was at that time given as follows:

Cost of main line	$5,067,562
Cost of feeder	1,858,398
Total cost	$6,925,960

The above estimate was made the basis of all subsequent appropriations by Congress, although the plans were changed afterwards to a certain extent so as to secure the building of a canal 80 feet wide at the water line and 7 feet deep, with locks 170 feet long between quoins and 35 feet wide; this lock was estimated to admit a barge of 600 tons capacity.

The final location of the Illinois and Mississippi Canal leaves the Illinois river at a point 1½ miles above Hennepin and ascends the valleys of Bureau and Ponds Creeks, in Bureau county, to the summit level on the 18th mile. The ascent of 196 feet from the Illinois river to the summit level is accomplished by the construction of 21 locks of varying lifts.

Eastern section.

Mile.	Number of lock.	Lift feet.	Date when built.	Class of masonry.
1	1	9	1895	Portland cement concrete.
2	2	9	1895	Portland cement concrete.
2	3	9	1895	Portland cement concrete.
4	4	9	1895	Portland cement concrete.
5	5	8	1895	Portland cement concrete.
7	6	10	1895	Portland cement concrete.
8	7	8	1895	Portland cement concrete.
9	8	8	1898	Portland cement concrete.
9	9	8	1898	Portland cement concrete.
11	10	9	1898	Portland cement concrete.
11	11	9	1898	Portland cement concrete.
12	12	8	1898	Portland cement concrete.
13	18	10	1898	Portland cement concrete.
14	17	10	1898	Portland cement concrete.
14	15	10	1898	Portland cement concrete.
15	16	12	1898	Portland cement concrete.
15	17	11	1898	Portland cement concrete.
16	18	9	1898	Portland cement concrete.
17	19	10	1898	Portland cement concrete.
18	20	11	1898	Portland cement concrete.
18	21	12	1898	Portland cement concrete.

The feeder junction on the 28th mile, which is located about four miles northwest of Sheffield, Bureau county, is the end of the eastern section of the canal.

The summit level is about eleven miles long. At its western end, at Lock No. 22, which is located about midway between Sheffield and Mineral Bureau county, the drop to the Rock river commences; this occupies about 33 miles of the canal's length, makes use of 8 locks and accomplishes a descent of 75 feet, connecting at Lock No. 29 with the Rock river just above the mouth of the Green river in Henry county.

Western section.

Mile.	Number of lock.	Lift feet.	Date when built.	Class of Masonry.
29	22	9	All of these locks not constructed.	
38	23	10		
49	24	11½		
54	25	8½		
55	26	9		
57	27	6		
61	28	10		
62	29	11		

From Lock No. 29 on the 62nd mile slack-water navigation of the Rock river is used until the lower rapids of the river are reached on the 70th mile. The rapids extend from the 70th mile to the mouth of the Rock river at the 75th mile. The construction work for this last named section was begun in 1892 and required the building of two wing dams and a guard lock across the arms of the Rock river at the head of the rapids; also the construction of 4½ miles of canal trunk, including two locks.

Lower rapids Rock river.

Mile.	Number of lock.	Lift.	Date when built.	Class of masonry.
70	Guard lock.	....	1893	Portland cement concrete.
73	36	6	1894	Portland cement concrete.
75	37	12	1894	Portland cement concrete.

That portion of the canal from the 62nd to the 75th miles was opened for navigation in April, 1895. At the northern entrance to the navigable feeder the project also provides for a dam across Rock river near Rock Falls; at the southern end of this dam the guard lock is located. The feeder canal has the same general dimensions as the main canal and has a fall of 2 3-10 feet in its entire length of 29 miles. The general direction of the feeder canal is south through Whiteside and Bureau counties and forms a junction with the main canal 4 miles north of Sheffield.

The Secretary of War having approved the located line, the first act taken towards the construction of the canal was that of calculating the areas and writing the descriptions of the lands to be taken, obtaining the abstracts of title, signing of the agreements with the land owners, and finally the proceedings in the U. S. courts for the purpose of securing the right of way. This step alone involved the expenditure of $400,000, and the number of acres taken for canal purposes may approximately be estimated at 4,000 acres.

The field engineering required the taking of accurate levels and the establishment of permanent bench marks near the location of each structure. Numerous borings were made along the line and a profile of these borings compiled for the purpose of giving the contractors, when bidding upon the earthwork, a fair knowledge of the materials encountered.

A greater portion of the earthwork is done under contract, although a portion, such as building the highway bridge approaches and filling about other structures is done under the immediate supervision of the U. S. Engineer Department. Where the canal trunk is formed by embankments the center lines of the same are located as far apart as the conditions of the right of way will permit. The specifications for the construction of a canal embankment require the removal of all vegetable matter between the slope stakes; the plowing of the surface so as to form a bond, in addition to the excavation and refilling of a seep ditch 4 feet deep built along the center line of the embankment; after all this preparation the embankment is constructed with a top width of 10 feet; inside slope 2:1 and the outside slope 1½:1. Where the embankments are more than 9 feet high the foregoing proportions are increased by adding a banquette along the

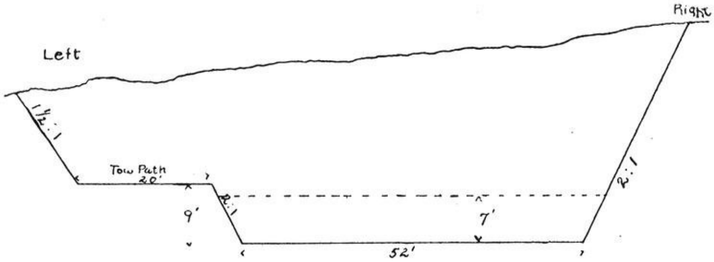


Fig 2

outside of the embankment, below the bottom grade of the canal.

The specific dimensions of the canal in excavation are: Bottom width of canal, 52 feet; side slope of the cut on the right, 2:1; on the left or tow-path side the slope of 2:1 stops on the tow-path level of 9 feet above the canal bottom. Here the section is level for 20 feet; then the side slope continues 1½ to 1 to the surface of the ground.

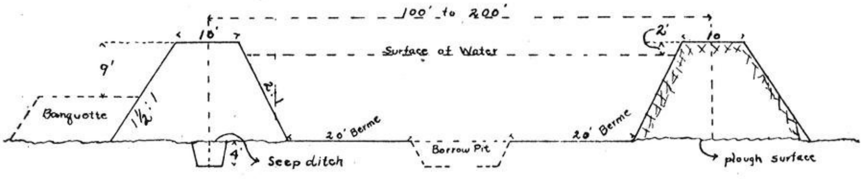
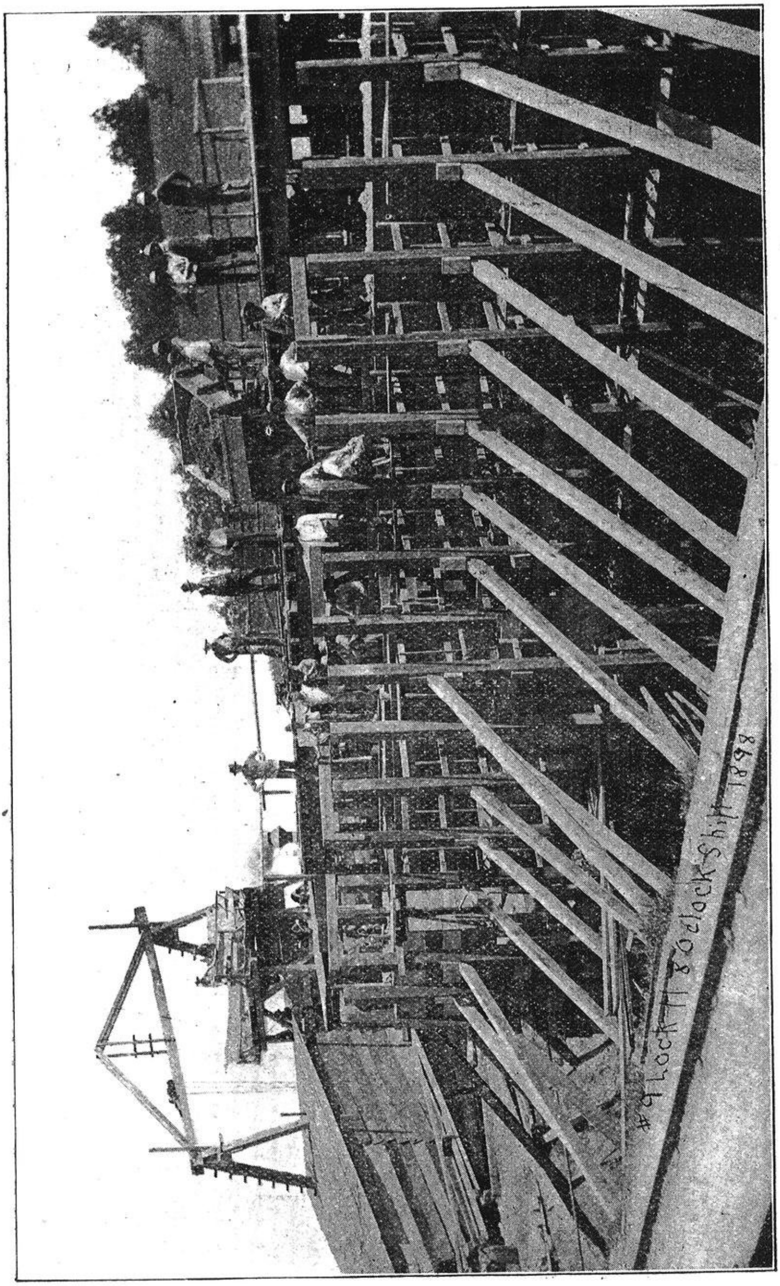


Fig 1

To obviate the effects of wave wash the canal is lined on each side at the water line with rubble stone revetment; this revetment is constructed on a slope of 1 to 1, has its footing 4 feet below the water surface, and extends 1½ feet above the water line. To build one mile of this revetment requires the purchase of 2,700 tons of rubble stone by contract and the laying up of 6,700 square yards of revetment by hired forces. The lime stone, or blue stone, required for the construction of the eastern section of the canal is obtained at Joliet or in the vicinity, while that required on the western section of the main canal and the feeder is secured at various places along the Rock river. Wherever a small water course is crossed by the canal, the stream having a direction perpendicular to the axis of the canal, provision is made by means of a cast iron pipe culvert, or a Portland cement concrete masonry arch culvert, for the passage of the water beneath the grade of the canal bottom; some of these structures are practically submerged (owing to the necessity of building the culvert below the regular slope of the water course in order to get under the canal), and easily fill up with sediment. To provide for the removal of all matter obstructing the culvert an automatic flushing arrangement has been devised by which water is to be taken from the canal and used under a full head to flush out all sediment lodged in the culvert. Where a watercourse of considerable size



Shows offsets in back of wall. Dumping car of concrete — maximum fall 26 feet.

of importance is crossed an aqueduct bridge is constructed; this sub-structure consists essentially of two abutments, with intermediate piers spaced 35 feet center to center, all the masonry being Portland cement concrete. The steel superstructure forming the skeleton outline of the canal trunk is made up of 24″ I–Beams connected up by rods and cast separators. The interior of the steel frame work is lined with plank and timbers, thus forming a water-tight conduit, or the canal prism.

The country contiguous to the canal is well developed. We therefore find many overhead highway crossings to construct and maintain. The work of remodeling the old highway so as to secure a crossing with 17 feet in the clear between the bottom of the span and the surface of the water in the canal involves the construction of two Portland cement concrete masonry bridge abutments, a tow-path retaining wall, bridge splay walls on each side of the canal for a distance of 200 linear feet and a through or pog steel span 100 feet long of the Warren or Pratt type of riveted truss. Besides all this the work of grading the highway approaches to the bridge and the building of suitable fences must be added to the list of items entering into the cost of taking care of a public highway crossing. An idea of the magnitude of the work required to complete one highway bridge crossing may be had from the following statement, which includes the material and labor charges:

Earthwork, highway approaches	$4,362
122 cu yds. natural cement concrete, foundations	747
232 cu. yds. Portland cement concrete	1,851
121 cu. yds. rubble stone masonry, rock faced	584
684 sq. yds. bridge splay wall	918
One–100 ft. steel span, single roadway 12 ft	2,500
Fencings	241
Total	$11,203

The work of erecting a lock may be divided into two parts:

1st. The construction of the lock foundation by contract.

2d. The construction of lock walls by forces employed by the U. S. Engineer department.

The contract work on the lock foundation may be again subdivided thus:

1st. Excavation of lock pit.

2d. Pumping out lock pit.

3d. Driving piles.
4th. Driving sheet piling.
5th. Timber grillage.
6th. Concrete work.

The foundation of a lock consists of 8 rows of piles, there being 73 piles in each row. After the piles are cut off to the proper grade line they are capped with 10″x10″ longitudinal timbers, and these are again crossed with 6″x10″ timbers. The spaces around the pile heads and between the grillage timbers are filled with 1,043 cubic yard of natural cement concrete. Four lines of Wakefield sheet piling are driven across the foundation to prevent the water cutting out under the foundation.

The size of the lock foundation is 57′x235′ and the contract price about $10,500.

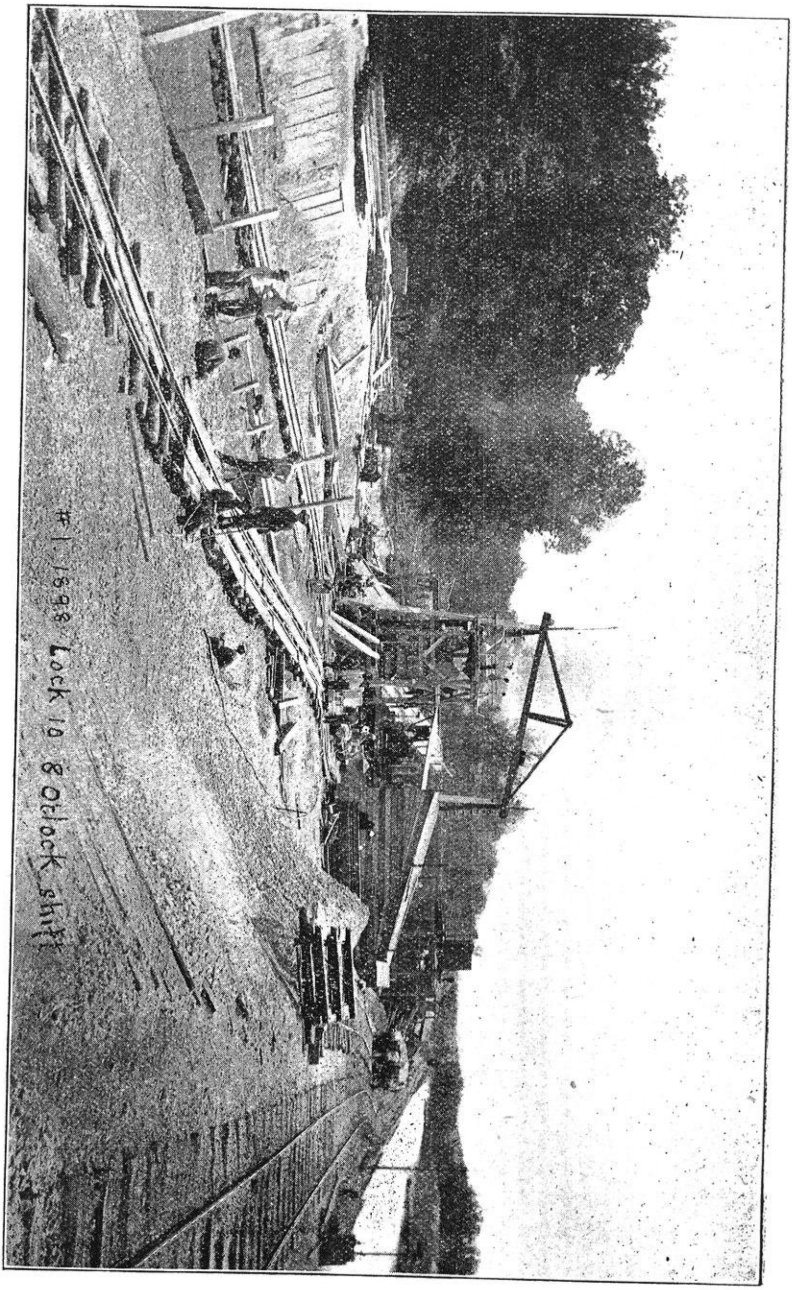
The lock construction work accomplished by the U. S. Engineering Çorps may also be classified as follows:

First, Erection and removal of forms.
Second, Delivery of materials.
Third, Erection of mixer and machinery.
Fourth, Concrete work, mixing, depositing and tamping.

The first step taken after the completion of the lock foundation was that of erecting the concrete masonry forms for the lock walls by a force of carpenters and laborers under the supervision of a master carpenter.

While the lock forms were in the course of erection, all of the crushed limestone, gravel and sand required for concrete work were delivered at the lock site by means of a 3-foot narrow gauge railway; this railway, as operated on the first 18 miles of the Eastern Section, has an equipment of 3 locomotives, 42 flat cars and 50 1½ to 3 cu. yd. dump cars.

The Portland and natural cements received at the beginning of each season's work were stored in large warehouses and before entering the concrete work these cements were also subjected to a series of tests in accordance with the established rules of the American Society of Civil Engineers. An important factor in the rapid output of concrete work is a mechanical mixer; this apparatus consists essentially of a cubical steel box set upon a timber framework and driven by a portable en-



#1. 1898 Lock 10 8 O'clock shift

Crushed stone is received on inclined boards. Construction work Lock No. 10; Bureau Creek diversion on the right.

gine at a rate of nine revolutions per minute. The charging box was filled at the ground level of the mixer plant with the following proportions or aggregates, and making 1.18 cu. yds. of concrete in place:

Proportions for one charge of mixer:

20 cubic feet crushed limestone.

20 cubic feet gravel.

5 cubic feet Portland cement.

Water added in sufficient quantity to give the mixture the proper consistency.

The charging box was then hoisted by means of a wire rope cable and hoisting drum to the hopper above the cubical mixer. The contents of the charging box were then dumped into the mixer and revolved for two minutes or longer if possible; the product thus obtained was dumped into a car standing on a track beneath the mixer and conveyed from thence to the section of the lock then under construction by means of a wire rope cable and hoisting drum or engine.

For the concrete work each lock wall was subdivided into 10 sections of 20 feet each in length. All sections are monolithic and the alternate ones were constructed first. By the employment of 3 shifts of men the concrete work was prosecuted day and night without intermission (with the exception of Sundays) until the completion of the structure. During the night the work was illuminated by the use of Wells lights. The time required to build the lock walls of a lock which involved the construction of about 2,800 cubic yards of concrete masonry was usually about 8 days, and the labor and materials expended amounted to $25,000. The best season's work of this character was accomplished from May 1st to November 10th, 1898, as during this interval the concrete masonry for 14 locks was completed.

Admitting that years have passed since the conception of the Hennepin canal project, we can now also realize that in a short while, possibly two years, it will have been completed. The work still remaining incomplete on the first 18 miles consists in dredging the channel for a short distance between the Illinois river and the entrance to Lock No. 1; in equipping 21 locks with valves and gates and in building the lock-keepers' houses.

The construction of the canal from mile 19 to mile 24 has just begun, while that part of the canal between mile 24 and mile 28 is about complete, with the exception of the erection of the highway bridges.

The construction work on the feeder canal is well advanced, while on the western section of the main canal from mile 28 to mile 62, about 20 out of 34 miles of grading the canal trunk is now under contract; on these miles the locks and highway bridges remain to be constructed.

The extreme western part of the canal between mile 62 and mile 75 is now open for navigation, as was hereinbefore mentioned.

In this age of rapid and extended development of railways, one would hardly deem it practicable to invest private capital in the construction of internal waterways; nevertheless, it is generally conceded that, in order to obtain a potent and efficient regulation of freight charges, the federal and state governments should develop all internal waterways which come in competition with the movement of freight by the rail routes.

THE COMPUTATION OF THE COST OF PIPE SEWERS BY FORMULAE.

The cost of the construction of a pipe sewer varies as the square of the depth of the trench in which it is laid.

To the average thinking person the above statement would seem unreasonable and absolutely false. But such, however, happens to be the case, and this paper will have fulfilled its mission if it succeeds in convincing the reader of the veracity of this statement.

It is evident that the cost of a sewer greatly increases as the depth of the trench becomes greater; that the cost of a sewer depends upon the size of the pipe which is used and the ease with which it is laid.

The cost of the pipe, of course, varies with the size; the cost of laying the same depends almost entirely upon the physical characteristics of the soil in which it is laid.

There are no doubt different conditions enough in any one locality to make the cost of any sized sewer at a given depth vary from the least possible cost to many dollars per linear foot. So that, if from such conditions we should attempt to discover the law of increase in cost for an increase in either size or depth by plotting the various values of size, depth and cost, we would have our diagram completely covered with points and no law visible, just as most persons would naturally expect.

However, if we should extend our field for the collection of data and take in an area, say as large as the United States, and let our observations extend over a period of years, carefully noting all the prices stated on a definite size of pipe and depth of trench, and at the end of the time take the average of each set of figures, we might have something a little more tangible to start from to work out our relationship of cost, size and depth.

TABLE I.

DEPTH OF TRENCH IN FEET.	SIZE OF PIPE 6 IN.				SIZE OF PIPE 8 IN.				SIZE OF PIPE 10 IN.			
	Average cost.	First computation.	Second computation.	Third computation.	Average cost.	First computation.	Second computation.	Third computation.	Average cost.	First computation.	Second computation.	Third computation.
6	20.5	20.4	21.6	21.5	28.9	28.7	28.3	27.5	37.6	35.4	34.2	34.2
8	25.0	26.6	27.6	27.5	34.8	34.8	34.6	33.7	42.6	41.9	40.7	40.7
10	33.3	34.6	35.2	35.1	42.4	42.7	42.6	41.7	50.2	50.3	49.3	49.3
12	43.2	44.4	44.6	44.5	51.8	52.3	52.3	51.5	57.7	60.5	59.3	59.3
14	55.4	56.0	55.6	55.5	64.5	63.7	63.9	63.0	70.9	72.6	71.4	71.4
16	70.6	69.3	68.4	68.3	76.5	76.8	77.2	76.4	81.4	86.6	85.4	85.4

DEPTH OF TRENCH IN FEET.	SIZE OF PIPE 12 IN.				SIZE OF PIPE 15 IN.				SIZE OF PIPE 18 IN.			
	Average cost.	First computation.	Second computation.	Third computation.	Average cost.	First computation.	Second computation.	Third computation.	Average cost.	First computation.	Second computation.	Third computation.
6	40.9	41.1	41.1	41.1	52.6	52.3	50.6	52.8	65.2	65.7	65.7	65.7
8	48.2	47.9	47.9	47.9	61.0	59.8	57.9	60.1	74.3	73.7	73.7	73.7
10	57.0	56.7	56.7	56.7	66.7	69.4	67.4	69.6	84.5	84.0	84.0	84.0
12	67.5	67.4	67.4	67.4	78.6	81.1	79.0	81.2	96.4	96.5	95.6	95.6
14	79.7	80.1	80.1	80.1	88.7	95.0	92.7	94.9	111.3	111.4	111.4	111.4
16	87.3	94.7	94.8	94.8	91.8	110.9	108.5	110.7	128.4	128.6	128.6	128.6

For it is possible to imagine that it would be possible out of a large collection of data to get an average which would follow some law in case there be one.

The writer made such a collection of data during the years of 1894 to 1898 inclusive.

The source of information was the actual bids of contractors upon work in which the depth of the trench, the size of pipe and the cost at so many cents per foot was given.

These prices include only the straight pipe, cement, sand, etc., trenching, backfilling and laying. All manholes, catch basins, flushtanks, etc., are extra and are not considered in this paper at all. No prices were taken upon rock excavation. The sewers are supposed to be laid in soil, so called, meaning by that, glacial drift, lake and river deposits and the natural decayed rocks in situ. About 300 of these bids upon 6, 8, 10, 12, 15 and 18 inch pipe sewers from 6 feet to 18 feet deep were collected by the author.

The averages of each of the sets of cost prices for each size of pipe and each depth of trench were taken and tabulated as in Table I, under the heading, Average Cost.

Then with the depth of the trench as ordinates and the cost in cents per foot as abscissae, curves were plotted similar to those shown in Fig. I.

From an inspection of these curves it would appear that they were parabolas whose equation was $y^2 = ax - b$.

TABLE II.

Size of pipe.	Average value of a.	Computed value of a.	Average value of b.	1st computed value of b.	2d computed value of b.	Value of b when = 118.
6	4.50	4.7	55.89	65 52	65 05	66.00
8	4.57	4.5	95 00	91.49	87.66	88.00
10	4.30	4 3	111.11	111.11	110.94	110.00
12	4.10	4 1	132.51	132.51	132.51	132.00
15	3.75	3.8	160.10	156.18	164.50	165.00
18	3.50	3 5	194.04	194.04	194 04	198.00

For convenience of notation the following symbols will be used:

y, depth of trench in feet.

x, cost of sewer in cents per foot.

a, coefficient of x and is a function of the size of the pipe.

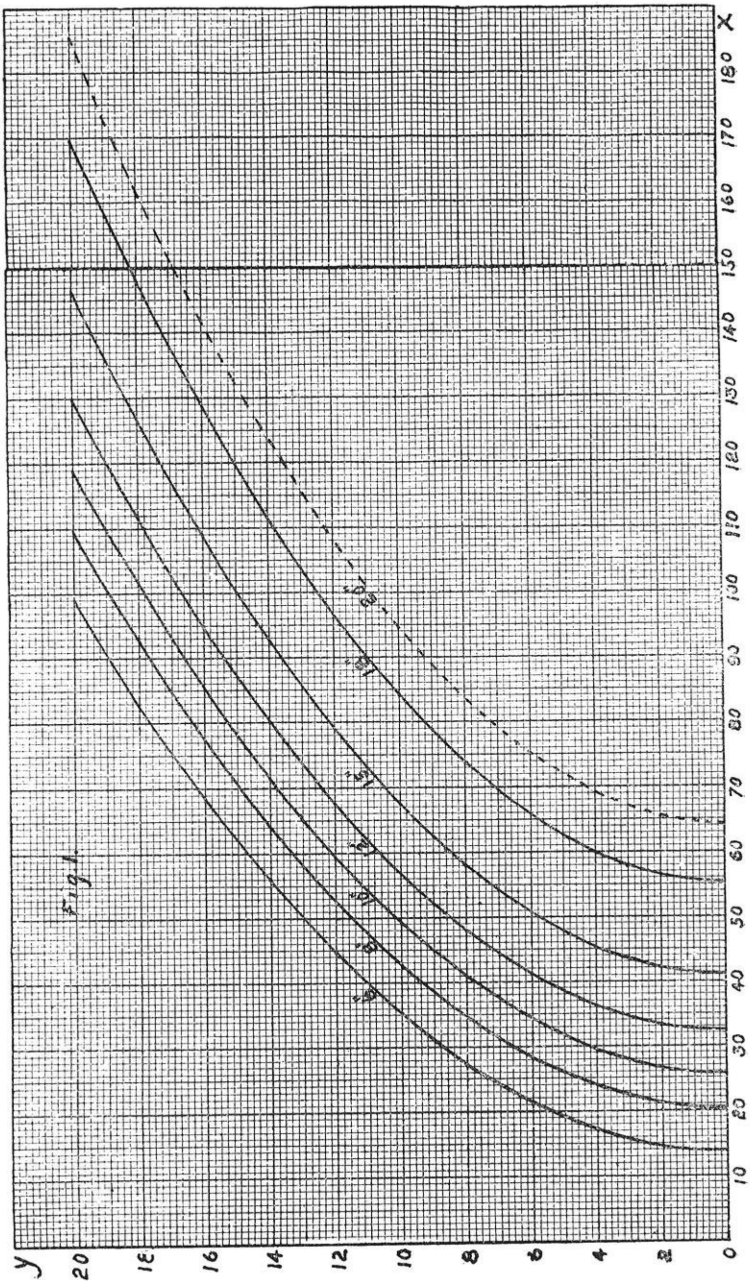


Fig. 1.
X
Y
0
2
4
6
8
10
12
14
16
18
20
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
20"
18"
15"
12"
10"
8"
6"

b, a contant for any given size of pipe, is a function of the same and is equal to ax when y equals zero.

s, diameter of pipe in inches.

With the value of x given for stated values of y equations between a and b were obtained, by a solution of these equations and taking the average of the values thus found and substituting them in the above equations, a relation between the depth of the trench and the cost in cents per foot was found for each size of pipe.

The values of a and b for each size of pipe are given in Table II under the headings, "Average Values." By the use of these equations curves were plotted to compare the results of the formulae with the original data. The values of x for y equal to 6, 8, 10, etc., are given in Table I under the heading "First computation."

The agreement between the values of x is surprisingly close in most every case and especially so with 18-inch pipe.

It is to be expected that in comparing any observations in the laboratory or those of some practical test in the shop or power house that the results although known to follow some theoretical law will not agree precisely with it, owing to the many conditions and factors in the determination which are difficult to control or to observe.

So it is not surprising that our data should not agree exactly with the values determined by a formula.

There are a few axiomatic facts in connection with the derivation of this law which it will be well to consider.

We should expect that when the depth of the trench was made zero in our formula, that the resulting value of x should be something greater than the cost of the pipe alone to cover the cost of all that part of the work and materials which does not vary with the depth of the trench.

That as the size of the pipe increases this value of x would increase and probably faster than the direct ratio of the sizes for the quantity of material comprising the pipe and the amount of other materials used in laying, increases as the square of the diameter of the pipe.

It is also evident that if the curves representing these equations should approach each other as the depth increases, the cost of the larger of the two sizes thus compared would eventually become less than the cost of the smaller size which, of course, could not reasonably be true.

It would also seem apparent that for larger sizes the cost would increase more rapidly as the depth was increased than for small ones.

Noting what has been said and referring to Table II we see that as s increases a decreases and b increases. The former shows that for large sizes x increases more rapidly than for small sizes, and the latter shows that the value of x when y equals zero increases as s increases.

It would appear that there should be some fixed ratio between s and a, and s and b.

In Figure II, at the left hand side s is plotted as ordinates and a as abscissae, each value of a is shown by a circle.

The line which fits this data best is a straight line whose equation is given as

$$S = -10\,a + 53 \text{ or } a = \frac{53-S}{10}.$$

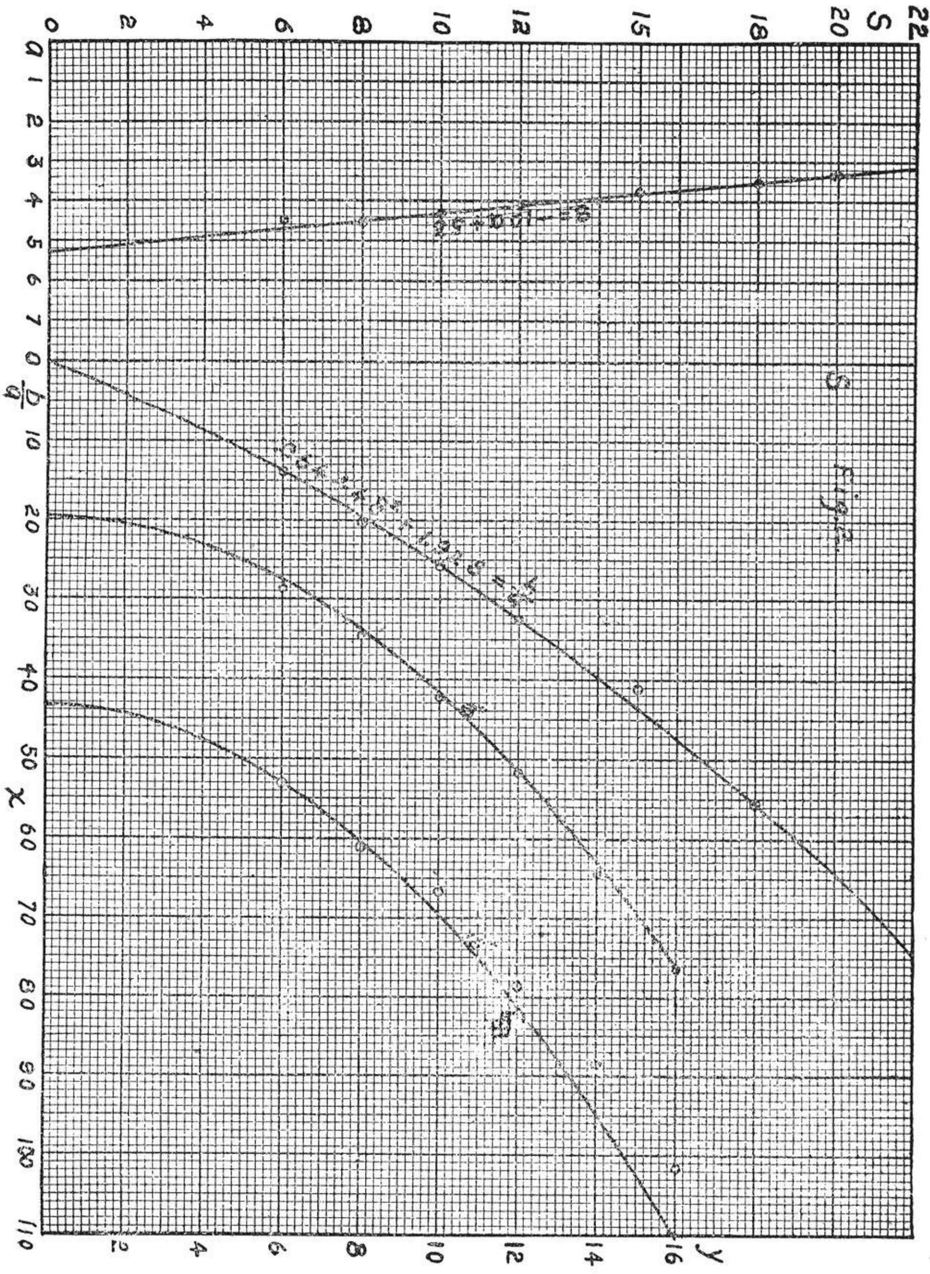
As will be seen by the diagram this line will change the values of a for 6, 8 and 15-inch sewers. This difference is also shown in Table II under "computed values of a."

By substituting this value of a in terms of s in the general formula we have

$$y^2 = \left(\frac{53-S}{10}\right)x - b$$

In as much as we have corrected a for 6, 8, and 15-inch sewers,, we must again resort to our original data for these three sizes and compute new values for b for each size of pipe.

These new values of b are found in Table II, fifth column, with these values of b substituted again in our formula we have computed values x as before. As will be seen by Table I under "Second computation," the change has been very slight in most cases from average values or those of the first computation. It is with these second computed values of x that the curves of Figure I were plotted which agreed very closely with the curves drawn through the original data (not shown), and as before said, Table I shows exactly how closely the mathematical law differs from the original data.


S
Fig. 2.
0
2
4
6
8
10
12
15
18
20
S
22
a 1 2 3 4 5 6 7
0 D/a 10 20 30 40 50 x 60 70 80 90 100 110
2
4
6
8
10
12
14
16
y

It would therefore appear to the writer that a sufficiently close agreement between theory and practice had been obtained to demonstrate that the average cost of pipe sewers varies as the square of the depth of the trench, or as is represented by the formula

$$y^2=(\frac{53-S}{10})x-b$$

and that the statement made at the outset of this paper is an undeniable truth, and for practical considerations it might be well enough to let this suffice; but as we have only applied the formula to the limits of our data and have not shown whether the formula can be made entirely general by expressing b in terms of s, we will continue to work out if possible these relationships, s.

In the equation $y^2 = ax - b$, the "b" does not affect the form of the curve in the least; it simply sets the curve a greater or less distance from the axis of y as we increase or decrease its value, and by substituting for x,

$$(x+\frac{b}{a})$$

b will vanish from the equation and the resulting equation will be $y^2 = ax$.

Now, the values of $\frac{b}{a}$ for all sizes thus far used is readily obtained either by division or by reading them off from the bottom of Fig. I where the curves cut the axis of x.

These figures must of course represent a portion of the cost which is constant for all depths, and as the pipe, cement, sand, etc., are constant for all depths and a given size of pipe, these figures must represent the cost of the same.

Therefore, if these cost figures be subtracted from the total cost at each depth for each given size of sewer the result will be the cost of that portion of the sewer which varies with the depth.

We could, therefore, by the use of our formula

$$y^2=(\frac{53-S}{10})x$$

extend the application of the law to larger sizes than those already used, and from the values thus obtained plot curves showing the relationships when applied to these sizes.

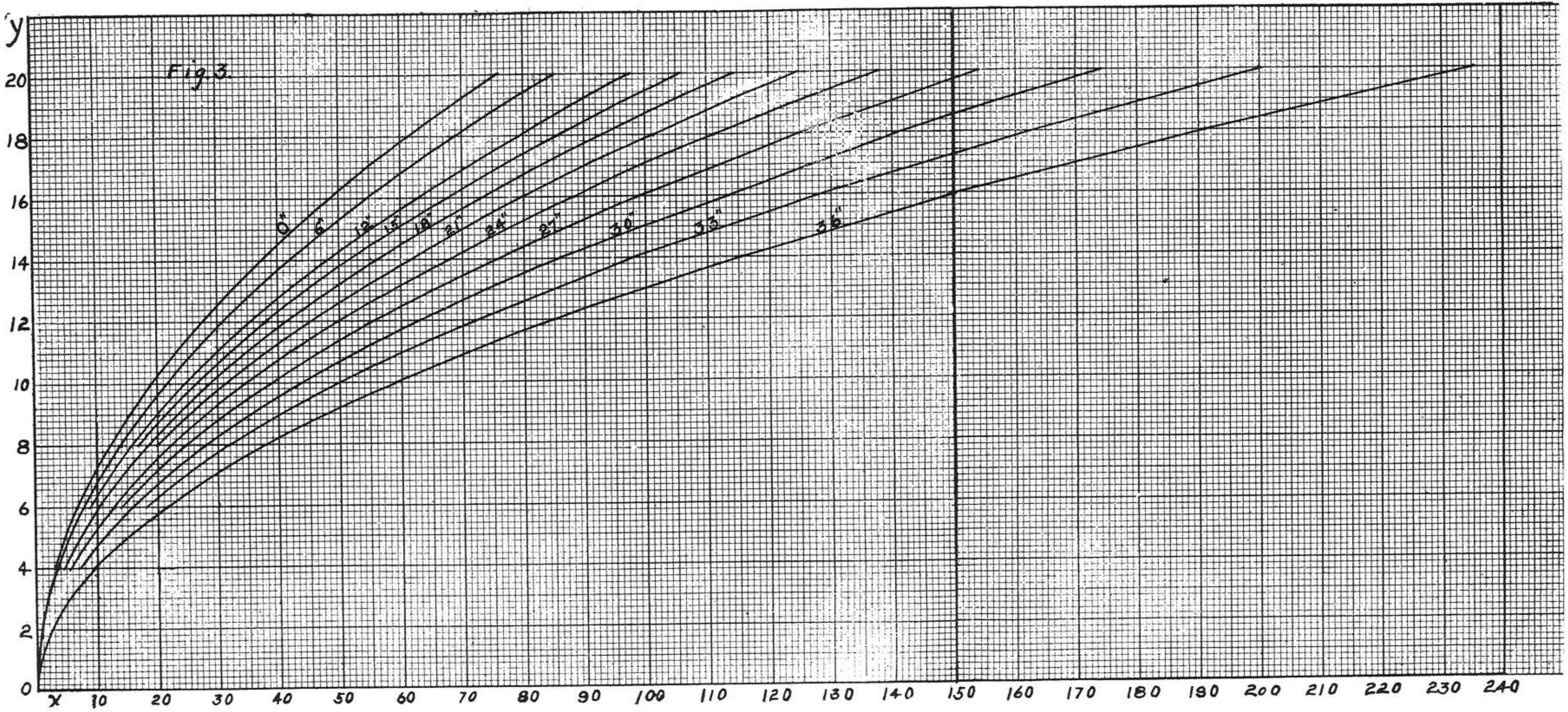


Fig. 3.

y
20
18
16
14
12
10
8
6
4
2
0
x
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
0"
6"
12"
15"
18"
21"
24"
27"
30"
33"
36"

Fig. III shows the form of the curves for some of the larger sizes up to 36-inch pipe, when the fixed cost covering the pipe, etc., is not taken into consideration.

From these curves we note that none of the curves approach each other as the depth is increased, that the cost for larger sizes increases somewhat faster than the direct ratio of the sizes of pipe.

Now, if the cost of the pipe, cement, sand, etc., or the fixed cost for any size, as we may say, is known, we can make some practical use of these curves for larger sizes of pipe for the form of the curve will not be changed and we can arrive at the total cost by adding to the values of x given by the curve, the fixed cost which we may call C, and is equal to $\frac{b}{a}$ or the same expressed in formula would be

$$x = \frac{10y^2}{53-S} + C$$

From the above it may be seen that the curves plotted in Fig. III may be used at least as a guide to compute the average cost of a sewer when the fixed cost is known.

If, however, the fixed cost was not known but it was known that a sewer, say s inches in diameter, could be constructed when the trench was 10 feet deep, at c cents per foot, and it was desired to know the cost at a depth of y feet, we could from the proper curve of Fig. III read off the value of x for 10 feet deep which would give us that portion of the cost which is variable, and if this amount be subtracted from c the remainder will equal $\frac{b}{a}$ or the fixed cost; with this determined it will be easy to compute the cost at any depth as y.

This would be true only when the conditions of the particular case were equal to or very nearly approached average conditions.

So far in this discussion we have used a different value of "b" derived from the original data for each size of pipe and our general formula

$$y^2 = \left(\frac{53-S}{10}\right)x - b$$

is only applicable when we have some means of determining the value of b or when it is eliminated as previously described

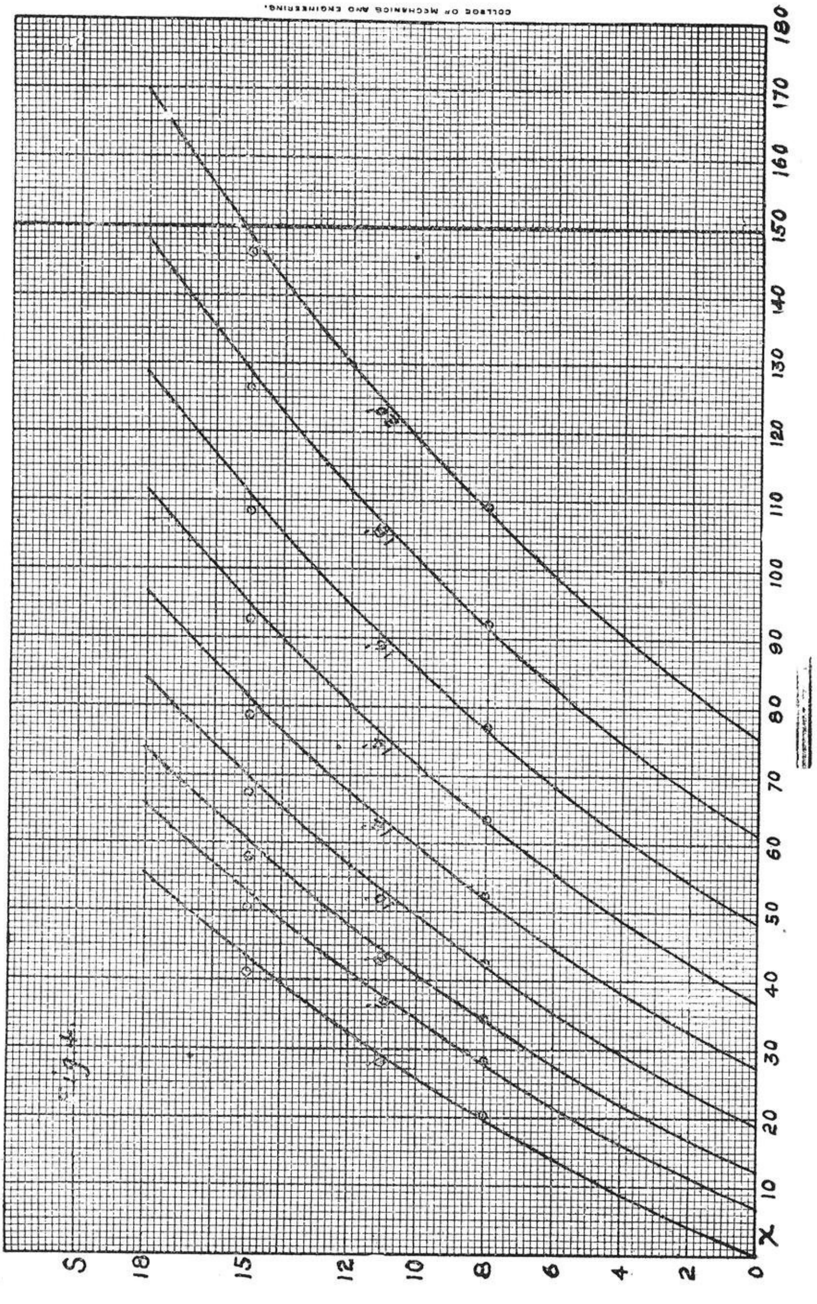


Fig 4
S
18
15
12
10
8
6
4
2
0
X
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
COLLEGE OF MECHANICS AND ENGINEERING.

As before stated, it would appear from Table II that there was some fixed ratio between s and b. This we would naturally expect in as much as it is b which gives value to x when y equals zero, or in other words, it represents the fixed cost which of course should increase with the size of the pipe.

In the central portion of Fig. II, s is plotted as ordinates and $\frac{b}{a}$ as abscissae.

For reasons previously stated we should expect that the equation showing the relationship between these two quantities should be of the second degree, or similar to the form

$$AS^2+BS+C=\frac{b}{a}$$

With the values of $\frac{b}{a}$ known for successive values of s the co-efficients of A and B were found, C being zero, the resulting equation being

$$.06444S^2+1.92S=\frac{b}{a}$$

With this equation new values of b were computed and tabulated in Table II as "Second computed values of b." These are seen to agree almost exactly with the first computed values except when s equals 8 or 15.

To show what effect this would have upon the curves for these sizes, they were plotted as in Fig. II with these new values for b and the original average cost prices were plotted also as shown by the circles.

The agreement is close in case of the 8-inch, but is somewhat farther away in case of the 15-inch. In as much as this is the only size out of the lot which does not follow closely to the law, it would seem as though we should not discard the whole as being untrue.

The co-efficients of s^2 and s not being finite numbers the values determined by the formula are slightly less than the former computed values of $\frac{b}{a}$

From the above equation it follows that $b = -.006444s^3 + .15s^2 + 10.18s$.

Substituting this value of *b* in the general equation we have

$$y^2 = \left(\frac{53 - S}{10}\right)x - (-.006444S^3 + .15S^2 + 10.18S)$$

which is the complete equation expressing the relation between size, cost and depth.

From the construction of this equation it can be seen at every step that the formula was built upon relationships between y, x, and s, which gave values close to those of our original data; it is therefore evident that this formula will apply to all sizes of pipe and to all depths of trench within the limits of the data.

The value of *b* in the above formula is somewhat complicated and would be cumbersome to use although it expresses the correct relationship. For greater convenience at a sacrifice of as close an agreement it has been found that the expression $-.006444s^3 + .15s^2 + 10.18s$ is approximately equal to $11s$, thus simplyfying the equation, and as will be seen by Table II, causes a very slight change in the value of *b*. This would also change the value of $\frac{b}{a}$ which would now be given by the expression

$$\frac{110S}{53 - S}$$

As for the extension of the application of the formula beyond the limits of the data, it can only be estimated. There is no reason to doubt the correctness of the use of the formula so far as it applies to the variable part of the cost as shown by the curves of Fig. III.

The doubtful part, if any, is that which applies to *b*, for as the larger sizes are approached the cost of manufacturing increases so rapidly and the fact that there are at present so few firms making large sizes of pipe that it would not be at all strange if the formula for the fixed part of the cost did not fail to give large enough values.

Now that we have the formula derived it might be of interest to show how the cost varies when y is made constant and s is made variable. For this purpose the curves shown by Fig. IV were plotted with s as ordinates and x as abscissae and the value of y is given on each curve.

The circles show the original data of 8 and 15-inch pipes which do not agree with the law; all of the others do.

In the extension of these curves to the axis of x we have a peculiar condition, that of a cost of a sewer when the size of the pipe is zero.

This could be interpreted to show the minimum variable cost, these same values of x could be obtained by the same formula by which the curves of Fig. III were plotted by putting $s =$ to zero.

A curve showing this condition has been added to Fig. III denominated as 0″, it differs but slightly from the one for 6-inch pipe, which might be accounted for by the fact that it would be possible to make a trench narrower at the bottom than was necessary to lay a 6-inch pipe in. Also, inasmuch as every function of y or s which we have considered has followed some law, it would not be surprising that the cost of increasing the width of the trench for an increase in s should not follow some law and would account for the difference between the 0″ and 6″ curves.

Therefore it should be possible for us to divide the cost of the sewer into three parts as follows: When $y =$ zero $x = .064444s^2 + 1.92s$ when

$$s = \text{zero}\ x = \frac{y^2}{5.3}$$

and a function of y and s which will take care of the widening of the trench.

By placing our general formula in the form

$$x = \frac{10y^2}{53-S} + .06444S^2 + 1.92S$$

we will have

$$\frac{10y^2}{53-S} = f(y, S) + \frac{y^2}{5.3}$$

for the reason that the third term of the general equation is equal to the first named value of x and the remainder must equal the sum of the other parts, one of which is known.

From this relationship f(y,S) or the cost incident to the widening of the trench is equal to

$$\frac{Sy^2}{280.9-5.3S}$$

Our general formula now becomes

$$x = \frac{y^2}{5.3} + \frac{Sy^2}{280.9-5.3S} + .06444S^2 + 1.92S$$

The correctness of this expression for cost of widening the trench was proven by comparing values of x as derived by it and the actual values found by subtraction.

In our general equation we have a relationship between three variables, y, x, and s.

If we were to imagine values of y plotted along a perpendicular axis and the values of s and x plotted along axes at right angles to each other and to the axis of y our equation would represent a warped surface whose trace on the plane x, y, would be given by $y^2 = 5.3x$, and whose trace on the plane s, x, would be given by $x = .06444s^2 + 1.92s$.

Out of the varied and complicated conditions under which the original data was necessarily subject to, the writer has been able to show that locus of the average cost of pipe sewers, within the limits named, to be a warped surface whose equation is as stated above.

W. G. Kirchoffer, B. S. C. E., '97,
City Engineer, Baraboo, Wis.,
Member of Western Soc. Engrs.

THE U. W. ENGINEERS' CLUB.

By A. J. QUIGLEY, '03:

As its name signifies, this club is a University society whose membership is made up of students of Wisconsin's "College of Engineering." Its purpose is to meet the wants of the engineer along the social and literary line, the same as the "Hill societies" do for the "Hill man." The Club is, however, too well known to warrant further general remarks as to its present state, but a short historical review of the club will be fitting at this time.

The class of '88 must be given the credit for launching an Engineering Club at the U. W. and starting it out onto waters that have since proven very troublesome and treacherous. No less than four times has the club, under different names, gone down in the sea of University activities only to reappear in a year or two for a part in those activities, clearly demonstrating that we must have an Engineers' Club.

Under the name of the "Association of Engineers," the class of '85 organized in '83–'84 and held monthly meetings during that and the year '84–'85. As this organization was made up almost entirely of '85 men, it died a most natural death at the close of that year.

In the fall of '86, after a lapse of one year, the association was reorganized on broader lines, which permitted all engineering students to join, and in fact the membership did at this time include a large proportion of the engineers. The club continued with varying success till the fall of '88, when a new constitution was adopted, which brought into effect as the most important change weekly, instead of monthly, meetings. With this fresh start the club flourished for three more years, or until the spring of '91, when it again met its fate.

After another period of a year the association again took form, but this time lasted but the one year, '92–'93, and '93–'94 passed without any organization of this nature.

So far as has been possible to obtain, the names of the presidents to this time were:—

1883–84—G. E. Wolds.
1884–85—(No record found.)
1886–87—L. M. Hancock.
1888–89—E. T. Eriksen.
1889–90—E. R. Maurer.
1890–91—O. B. James.
1892–93—(No record found.)

That resting time for one year brought about wonderful new life to club ideas. When the semester opened in the fall of '94 one lone club couldn't contain all the enthusiasm that existed among the engineers, so two clubs were formed. Still there was ardor to spare, and so a third club was inaugurated.

One name was closely connected with all the rapid evolution of that fall of '94; the same name has been consistently connected with club work ever since. It is the name of Prof. J. G. D. Mack, and we are glad of this opportunity to give him the credit that is due him for so ably assisting the students, at first in their work of formation and for the generous interest that he has since taken in club work of all kinds.

The first club to take shape that fall was composed of Sophomores, and was called the U. W. Engineers' Club. The first meeting of what is really our present club was held Oct. 4, '94, and C. F. Rider was chosen first president. On Oct. 17th the second club, The Engineers' Association, held its first meeting, and W. J. Hanson, '90, was elected president.

On Oct. 19th the '98 Freshmen organized, calling themselves the " '98 Engineers' Reading Club." Their existence was short, as it was deemed best early the next spring for them to unite with the Sophomore club. They had two presidents up to the time of going over to the other club, H. R. Crandall and Harry Spence.

On account of the enthusiasm that naturally accompanies new organizations, and with three clubs bidding for honors along the same lines, these were red letter days for engineering societies.

Much interest was kept up all that year, and in the following year a joint debate was arranged. In the spring of '96 a good joint debate was given, in which the Engineers' Association was represented by C. W. Hart ('96), G. H. Jones ('97), and H. C. Schneider ('98), while F. J. Newman ('98), Hal Murley ('98), and R. D. Jenne ('98) represented the U. W. Engineers' Club.

The latter were defeated, but on April 3rd of the next year the tables were turned by R. F. Nommensen ('99), T. G. Nee ('99), and John Barr ('99), of the U. W. Club, who defeated Paul F. Lueth ('98), H. J. Thorkelson ('98), and Max H. Spindler ('98), of the Association. At the end of this year the Association again expired, due perhaps to the fact that for various causes so many of its members left that spring. Then in the fall of '97 the Club held undisputed sway, as it has done since and to the present time.

The presidents of the Engineers' Association were:
1894-95—W. J. Hanson, '95; F. I. Hartwell.
1895-96—C. H. Parr, '96.
1896-97—G. H. Jones, '97.

The Club Presidents have been:
1894-95—C. F. Rider, Walter Alexander, I. H. Fowle.
1895-96—L. Owen, J. G. Smith, Ed. Schildhauer.
1896-97—John Allen, W. F. McGregor, F. Short.
1897-98—Max W. Zabel, H. Spence, F. J. Newman.

1898–99—C. Keller, Edward Freschl, John Barr.
1899–00—A. A. Radke, C. B. Barnes, L. E. Moore.
1900–01—A. Meyers, H. T. Plumb.

The following are a few names of those who have been active U. W. Engineer Club members, and have been or are connected with the University:

F. I. Hartwell, '95, now deceased.
O. B. Zimmerman, '96, now instructor at U. W.
R. W. Hargrave, '96, now instructor at U. W.
Geo. Wilder, '97, now instructor at U. W.
W. Alexander, '97, now professor at Armour Institute.
M. C. Beebe, '97, now with Westinghouse Co., Pittsburg.
W. H. Kratsch, '97, now with Challoner Mach. Works, Oshkosh, Wis.

As in the past, so at the present time the Club is composed of men who are here to get all the training they can out of college life, and just for that reason they come to the weekly meetings of the Club where they are brought in contact with practical engineering subjects. There also they get practice in parliamentary forms, in debating and thinking while before people, all of which is invaluable to the engineer. The engineer is too apt to be a recluse in his profession — one who knows that profession himself but is unable to state to others simply and off-hand what he knows. Ability to talk this way means dollars to the engineer in practice, and four years of practice in the Club will go a long way towards giving a man this ability. Regular attendance, we will admit, is irksome sometimes, but any former club man who has thus attended the meetings will bear out the statement that "it pays."

Another advantage of the Club is that it furnishes a real source for various movements. The recent petition to the Board of Regents was an example of this. The petition read as follows:
To the Board of Regents of the University of Wisconsin:

Whereas, The Board of Regents of the University of Wisconsin has seen fit to raise the incidental fees of the students of the College of Mechanics and Engineering over and above that of the students of the College of Letters and Science and of the Long Course of the College of Agriculture, by the sum of ten dollars per year for resident students and of twenty dollars per year for non-resident students, we, the undersigned, students of the College of Mechanics and Engineering, do hereby most earnestly petition that, if in the opinion of the Board of Regents the interests of the state will be best served by a continuance of this discrimination in incidental fees, the amount of this excess be added to the regular income of the College of Mechanics and Engineering so that our laboratories may receive the benefit of the same.

This petition emanated from the Club, which was also responsible for its circulation among the students. It was signed almost without exception, and though the petition was not formally acted upon, it was well received, and the annual budget for the College of Engineering was increased by an amount greater than the excess of fees amounted to for the current year.

The limit of membership is fifty. Our present membership shows six less than that number, the forty-four names being:

Ray Palmer, '01; H. I. Townsend, '01; W. P. Hirschberg, '01; A. A. Nicholaus, '01; H. T. Plumb, '01; A. Meyers, '01; J. G. Hammerschlag, '02; P. J. Kelley, '02; M. Pesta, '02; F. C. Stieler, '02; W. Thorkelson, '02; S. J. Lisberger, '02; W. R. Mott, '03; E. A. Ekern, '03; J. G. Zimmerman, '03; C. I. Zimmerman, '03; L. H. Lathrop, '03; E. B. Mueller, '03; C. W. Hejda, '03; C. J. Hedja, '03; J. N. Cadby, '03; C. C. Douglass, '03; B. F. Lyons, '03; O. C. Atkinson, '03; A. F. Alexander, '03; G. C. Dean, '03; W. W. Gore, '03; W. P. Howland, '03; P. Trowbridge, '03; V. R. Holt, '03; W. E. Crandell, '03; F. G. Borden, '03; H. L. Stevens, '03; L. H. Levisee, '03; A. J. Quigley, '03; F. J. Petura, '04; J. H. Gulick, '04; L. F. Shoelkopf, '04; E. A. Olin, '04; W. E. Brown, '04; L. H. Skeels, '04; Irving Seaman, '03; E. H. Bull, '04; A. B. Zeigweid, '04.

In concluding, let us urge upon the engineering student body the desirability, yes, the duty, of forming another Engineers' Club. The successful days of '94, '95, '96 and '97 prove that nothing would give more life and spirit to this important work than friendly competition. By such competition the Hill societies remain important factors in the University. By the same competition the engineering interests would be raised to the level that their importance demands. Out of 400 engineers there must surely be 100 who would lend their efforts to such work as this. The only question remaining then is, "Who will take the initiative?"

THE CIVIL AND MECHANICAL ENGINEERS' INSPECTION TRIP.

By W. P. HIRSCHBERG, '01.

The senior engineers took their annual trip this fall, leaving for Chicago November 12 at 8:30 a. m. on the C. & N. W. R. R. It was at first proposed to visit Pittsburg, as was done last year, but as the number of seniors desiring to take so long a trip was not large enough, it was decided to go to Chicago and remain there the entire week.

The party consisted of Prof. Turneaure and Prof. Bull, with the following civils: R. J. Hawn, F. E. Washburn, C. Berry, C. G. Collins, L. D. Williams, W. C. Burdick, T. J. Hurd, N. P. Curtis, W. P. Hirschberg; and the following mechanicals: H. H. Wood, F. Vea, C. H. Watson, A. C. Fricke, F. W. Buerstatte and A. Anderson.

We arrived at Chicago at 12:30 p. m., almost all of the party registering at the Briggs House.

In the afternoon the entire party went to the Fourteenth street pumping station, which is equipped with three vertical triple-expansion Corliss pumping engines of the E. P. Allis make, and one Erie Iron Works pumping engine similar to the Allis engines.

Tuesday morning the entire party went to South Chicago to visit the Illinois Steel Company's works at that place. Formerly the seniors were unable to obtain passes to go through the works, but this year they were successful. The guide first took us to the docks where steel ore boats were being unloaded. We then were taken to the blast furnace, past the large air compressers, and then to the Bessemer converter house, where three converters were in operation. This was very interesting, as each step in the manufacture of the steel was plainly visible. From here we went to the rail mill, where steel rails were being rolled from the ingots and cut to the desired length.

The handling of the hot iron was done entirely by machinery. We were then taken to the plate mill where large steel plates were being rolled out, much of the handling of the iron in this mill being done with electro-magnets. We were then shown into the building containing the open hearth furnaces, and from here we went to the testing laboratory.

In the afternoon we visited the South Chicago Ship Building Company's yards, where several large steel ships were under construction. The large machine shop of this company was thoroughly modern in all respects. Everything was kept in the neatest order, and in one part of the building a reading room was maintained for the employes. The mchanicals visited the Mohr Boiler Works later in the afternoon.

Wednesday afternoon the civils went out to the Lassig branch of the American Bridge Building Company and went through the works. The iron was taken from the piles, marked by templates, punched, assembled, riveted and painted. This was done in a long shop, the iron starting at one end and continuing on through the different stages, until it reached the other end, a finished piece. The turntable of a large swing bridge was under construction in one part of the shop, and the assembling was watched by the class.

The mechanicals, with Prof. Bull, went to the McCormick Harvester Machine Company's plant. This is said to be the largest and most complete works of its kind in the world, the buildings covering an area of one square mile. The class were first taken to the foundry, which is the largest foundry of its kind. Here the moulding is done almost exclusively with moulding machines. From here the machine shops were visited, where the large number of automatic machines made the shop one of particular interest to all of the party. All small bolts, nuts, screws and many other small parts are made by the ton by the machines. One man is able to take care of several, being required only to keep the machines supplied with stock. All of the morning was spent in these shops, but even then there was much left unseen. Dinner was served the party in the company's lunch room, which is maintained for the office force. In the afternoon one of the five new twine mills was visited, where the hemp and sisal-fibre is manufactured from the crude material. This twine is used on the McCormick binders. In the time remaining one of the Chicago Edison power stations was visited. The power required for some of the electric street cars is here generated.

The civils set aside Thursday to see the Chicago Drainage Canal. In the morning they left the city via the Chicago & Alton for Lockport. High heaps of rock and earth were seen on the way, marking the course of this great sanitary canal. As the railroad follows along its course for most of the way, a good view of the canal was obtained. The locks and dam at Lockport were seen and the bear-trap dam was operated for the benefit of the class. It is 160 feet wide and is controlled by hydraulic power. About 300,000 cubic feet per minute were passing, part through the sluices and part over the dam. An electric lighting plant was being built, the power to be received from the water of the canal.

Joliet was the next place visited. A high masonry dam is situated here, and an electric plant is being installed, utilizing the water power of the Des Plaines river.

The mechanicals spent the morning at the Northwestern railroad repair shops, where the repairs to locomotives, cars and all rolling stock are made. They were shown the indicator cards of a locomotive which had been built at the shops. The cards showed an indicated horse power of 1,500, developed at a speed of 70 miles per hour, the average horse power being 1,100. In the shops many interesting things were seen, and, all things considered, was one of the most interesting places visited during the trip.

A part of the afternoon was spent at the Northwestern Elevated R. R. power station. Three 2,000 H. P. Allis engines were here seen, direct connected to S. & H. generators, also a 1,000 H. P. Allis engine, also direct-connected, besides many others. The California street station of the Union Traction Company was next visited, where some interesting machines were seen. Part of Friday morning was spent in another of the Chicago-Edison power plants. Here a very crowded state of affairs was seen. New machines have been added without increasing the floor space, making it dangerous to walk around while the machines were in operation.

The civils went to see the pumping station for the old Illinois canal. From here they went to the Stewart Avenue signalling and interlocking station where the switch and signals are operated by electricity and compressed air. This is one of the largest switching and interlocking systems of its kind in the world. The rest of the morning was taken up at the elevated railroad crossings and switching stations in this vicinity.

On Saturday morning most of the members of the party visited attractions of Chicago, not dealing directly with engineering subjects—places such as the Art Institute, Chicago Public Library, Field Columbian Museum and others. The trip was finally concluded by going out to Marshall Field Saturday afternoon and helping the Wisconsin rooters give the good old yell at the Wisconsin-Chicago game. This was very successfully accomplished and was a fitting conclusion to a successful trip.

This is but a brief summary of the trip, mentioning the most important places visited, necessarily omitting all of the details. The trip was, as a whole, one which brought before us many interesting subjects, giving us a better insight into the practical side of engineering, and demonstrating that trips of this nature are important parts of an engineering course.

NEW MEMBERS OF THE FACULTY.

Dr. J. C. Shedd, formerly instructor in Physics in the University of Wisconsin, is now Professor of Physics at the University of Colorado.

Mr. George Wilder succeeds Dr. Shedd as instructor in Physics. Mr. Wilder graduated from the University of Wisconsin in '96, and for two following years he acted as assistant in the physics laboratory. He then went abroad and spent two years in the study of Physics at Zurich, Switzerland.

Sands, Edward Emmet, instructor in Civil Engineering, was born Jan. 5, 1877, at Columbus, Ohio, so that he is probably the youngest instructor in the university. He graduated in Civil Engineering from the University of Wisconsin in the class of 1900, has spent two summers on the United States Geological

Survey, the summer of 1900 as city engineer for Sparta, Wis., and has since had charge of descriptive geometry and surveying classes in the university.

Lehner, Victor, graduated in chemistry in 1893 from the University of Pennsylvania, and for three years following was assistant to Professor W. B. Rising, in the chemical department of University of California. From 1896 to 1898, he was engaged in pursuing special studies in chemistry, mineralogy and geology at the University of Pennsylvania, receiving the degree of Ph. D. from that institution in 1898.

Dr. Lehner has been a regular contributor to various chemical journals, and is now engaged in translating Moissan's "Le Tour Electrique." He was on the staff of instructors at Columbus University before coming to the University of Wisconsin.

Mr. Augustus Trowbridge, Assistant Professor of Mathematical Physics, received his early collegiate education in the School of Mines of Columbia College. After spending three years at the college he entered the field of practical engineering. In 1893 he was engaged in engineering work on the World's Fair grounds, and the following year in railroad engineering. Mr. Trowbridge then went abroad to continue his study of Mathematics and Physics, and in 1897 he took the degree of Ph. D. at Berlin. After teaching Physics for two years in the University of Michigan, he accepted the position which he now holds.

Burnside, Charlee Howard, graduated from Columbia University in Architecture with the class of 1898; took degree of A. M. in Mechanics the year following. The next year was spent with Mr. John F. Williams, whose specialty is tall office building construction.

Zimmerman, Oliver Brunner, graduated from the University of Wisconsin in class of 1896 in Mechanical Engineering, took Master's Degree in 1900; thesis, "Heating and Ventilation of West Division High School, Milwaukee." For three years after graduation he was in the Manual Training Department of the West Division High School, Milwaukee, being appointed director after two years. The summers of '97–'98 were spent in the shop of E. P. Allis Co., and summer of '99 with Professor F. R. Jones, changing to electric the power transmission system of the Niles Tool Co.

Having accepted a position on the instruction staff of this university, he spent the summer of 1900 with E. P. Allis Co., studying their methods with a view to their application in university instruction, then came to Madison to assume his duties as instructor in descriptive geometry and machine design.

Mr. Zimmerman is a member of the Wisconsin Natural History Society, Wisconsin Academy of Arts, Letters and Science and the Science Club.

Brilliant Junior (searching the draughting room for a beam compass): "Who's seen that sixteen-inch radius?"

Sophomore to Freshman: "Just open the window and watch the fire escape."

Senior Engineer: "For an elective I'm going to take Least Work under Eddie."

Flunked Junior: "That's an impossibility."

PERSONAL.

Mr. A. L. Goddard, U. W. '96, has been for a year and a half head draftsman of the Mechanical Engineering Department of the New York Shipbuilding Co. of Camden, N. J.

Jesse M. Boorse, '95, and Miss Jessie Powrie were married at Waukesha, Wis., June 7th, 1900. Mr. Boorse is assistant wire chief of Monroe Division of the Chicago Telephone Co.

Invitations have been issued announcing the wedding, the 22d of this month, of Mr. Walter J. Parsons, '00, and Miss Olive M. Gibson of Chicago. Mr. Parsons was business manager of the 1900 Badger. He will make his home in Chicago.

J. M. Barr, M. E. '99, has returned from Switzerland, where he has been pursuing studies in the engineering schools of Zurich and Munich, and he is now with the Westinghouse Co., Pittsburg, Pa.

Paul Biefeld, E. E. '94, who has recently taken the degree of Ph. D. at the University of Zurich Switzerland, is now head professor of Electrical Engineering in the Engineering School of Heilberghausen, Germany.

Professor C. I. King spent a month this fall visiting eastern schools and colleges.

Professor Charles F. Burgess attended the wedding on January 12th at Harrisburg, Pa., of Professor Fortenbaugh, former student here, and at one time assistant professor of Electrical Engineering.

OBITUARY.

As we go to press it is with great sorrow that we must record the death of Charles Graham Collins, C. E., '01, he having died January 14th, of pneumonia. Just on the eve of finishing his college course he was taken from us, having been ill but a short time. His bright disposition and good heartedness will ever be remembered by his colleagues, who greatly mourn the loss of such a worthy friend and esteemed classmate.

As a tribute to the deceased, the members of the Senior class in civil engineering were relieved of all college duties on the day of the funeral, Wednesday, January 16th. All members of the Junior and Senior classes in the College of Engineering in all courses were also relieved of college duties between the hours of 11 and 1 on the same day.

Resolutions of sympathy and condolence were sent to his bereaved mother by the Senior class in civil engineering and their instructors, and also by the whole Senior class of the University.

NOTES.

CHANGES IN ENGINEERING COURSES.

The work in the freshman and sophomore years in the College of Engineering has been reduced from the twenty-one-hour schedule of the current catalogue to nineteen hours in the first semester of the freshman year, and to twenty hours for the remaining part of these two years. This reduction has been made in mathematics, one-fifth; in chemistry, one-fifth; in descriptive geometry, one-fifth; in technical German, one-fifth, and in mechanics or in machine design, one-fifth. In the electro-chemical course there has been added four-fifths chemistry in the sophomore year in place of an equivalent amount of shop work and machine design.

TESTING OF ROAD MATERIALS.

The Geological Department has purchased an abrading machine and an impact testing machine to be used in determining the value of different stones for macadamizing purposes. The abrading machine is used to determine the wearing quality of stone and the impact testing machine to determine the binding capacity of the stone.

So far tests have been made from seventeen different quarries of the state, and it is expected that before the completion of the work all the stone from the more important localities will be tested in similar manner.

The Department has collected considerable data on all the paved streets in Wisconsin. This data supplies some valuable information regarding the kind of material used, mileage, capacity, annual cost of repair and cleaning per mile, the difficulties experienced and the cost of construction. This systematized data is received from the city clerk and engineer. After complete tests have been made the material will all be compiled in form of a report under the auspices of the State Geological Survey.

It will be noticed that the Department is promoting the obtaining of considerable practical knowledge on subjects of interest and improvement about the state.

The second meeting of the Graduate Club of the University, held at University Hall November 23rd, was addressed by Mr. Oliver B. Zimmerman, '96, of the College of Engineering. Mr. Zimmerman gave a very interesting talk on the birds of Wisconsin, illustrated by the lantern slides recently obtained by the Madison Audubon Society.

Professor E. A. Birge of the Wisconsin Geological and Natural History Survey, and Dr. E. R. Buckley, assistant superintendent in charge of the economic geology, are influential movers in arranging for a meeting of the clay men of the state of Wisconsin, to be held in Madison February 5th and 6th. It is thought that to effect a permanent organization would materially benefit and promote the interests of manufacturers of brick, tile and clay wares by a free discussion of all questions pertaining thereto.

Mr. A. H. Sabin of New York delivered an interesting lecture before the engineering students on January 8th. His subject was "Preservative Coatings for Metallic Structures." The talk was very instructive and greatly appreciated by the students.

POPULAR LECTURES IN ENGINEERING

A course of popular, illustrated lectures upon the great engineers whose names appear on the outside of the new Engineering building, will be given in the auditorium of this building on successive Friday afternoons at 3 o'clock, beginning on Friday next, January 11th. These lectures will be both biographical and descriptive of development of engineering science and practice from the middle of the 18th century to the present time. The course is as follows:

January 11th, George Stephenson, by Dean Johnson.
January 18th, James Watt, by Prof. Bull.
January 25th, Thomas Telford, by Prof. Turneaure.
February 1st, Joseph Henry, by Prof. Jackson.
February 15th, Prof, Rankine, by Prof. Maurer.
March 1st, John Ericson, by Prof. Mack.
March 8th, Lord Kelvin, by Prof. Trowbridge.
March 15th, Zenobie Gramme, by Prof. Swenson.

March 22d, Ernst Werner Siemens, by Prof. Burgess.

March 29th, Sir Henry Bessemer, by Robert W. Hunt of Chicago.

April 5th, O. H. Corliss and Edwin Reynolds, by Prof. Richter.

April 12th, The Development of the Railway Locomotive, by Prof. King.

These lectures will fairly cover the complete development of civil, mechanical and electrical engineering work up to the present time, and will be of considerable interest to all students of 19th century progress.

The state of Wisconsin has appointed a Board of Commissioners and appropriated $25,000 for defraying the expense of the representation of Wisconsin manufacturing interests at the Pan-American.

The demand for exhibition space in every department of the Pan-American Exposition is far beyond its capacity, liberal as was the estimate and allowance for that purpose. This fact indicates that the practical business men of every section regard the Exposition as an assured success in the promotion of trade, commerce and industry and in the spreading of a knowledge of the western world and its resources.

Five thousand horse power of electricity will be delivered in Buffalo from the plant of the Niagara Falls Power Company at Niagara Falls, for use in illuminating the buildings and grounds of the Pan-American Exposition, and turning the wheels for operating machinery; 5,000 horse power will also be generated on the grounds. The service arranged for contemplates the utilization of the water power of Niagara, the use of gasoline for motive power, of gas both under boilers, producing steam, and in gas engines, producing energy; thus giving the Pan-American the greatest variety of sources of power ever enjoyed by any Exposition.

The conventions of the American Institute of Electrical Engineers and of the Congress of Engineers, Mining, Mechanical, etc., will be held in May during the Pan-American Exposition at Buffalo.

TAU BETA PI ELECTIONS.

Tau Beta Pi, the honorary engineering fraternity, has announced the election of eight new members—seven seniors and one junior. The following are the names of those elected:

Seniors—Alfred Rollman, E. E., Chilton; Lewis D. Rowell, E. E., Madison; Leroy R. Salsich, C. E., Hartland; Harry A. Severson, Milwaukee; Fritchjof J. Vea, M. E., Stoughton; Frank E. Washburn, C. E., Sturgeon Bay; Henry H. Wood, M. E., Stebbinsville.

Junior—Carl F. Stillman, M. E., Milwaukee.

A GEOLOGY ROMANCE.

One day when the geology class were examining and discussing rocks a bright senior passed around a nut caramel to be classified. Many pronounced it a conglomerate, but a certain young lady upon seeing it declared that it was positively gneiss (nice). The reverend senior was so struck with her answer that he immediately presented her with a box of delicious bonbons. The conclusion is interesting, but it were best that we do not proceed.

Why are all class officers railway engineers? Because they give grades.

What engineering article do you find on a freshman's face after he has passed an exam.? A continuous beam.

An engineer's transit—A freshman leaving for home at the end of the first semester.

WHEELS.

When they stopped the machinery and dragged the crumpled workman from beneath the wheels they feared he was finished. However, he opened his eyes, and spoke in a faint, far-away voice: "You kin say wot you please," said he, "but as fer me, this traveling in cog ain't the game they make it out to be."—Princeton Tiger.

BOOK REVIEWS

FREE HAND PERSPECTIVE.

A volume of 257 pages, by Victor T. Wilson, Instructor of Drawing in Cornell University, has recently been issued from the press of John Wiley & Sons.

This book in its typography is similar to the publishers' high standard, the illustrations being especially fine, in each instance illustrating clearly the points which it is desired to bring out by figures.

The illustrations represent free-hand pencil drawing and shading with accuracy, and convey an entirely different impression to the reader than is formed with smooth, mechanically executed lines, as sometimes appear in works of this character.

The work is introduced from the standpoint of Descriptive Geometry, although any person not familiar with this science could readily grasp the principles.

A sufficient amount of the theory of Perspective is given to illustrate its general methods, and the applications made to numerous problems in the sketching of architectural subjects and machine parts.

The author's method of showing the construction lines used in drawing the perspective ellipse in its various positions and forms is to be commended. Equally good is the portion illustrating the forming of a perspective sketch from the working drawings, this being one of the most necessary applications of perspective drawing in the drafting room, as it is often required that illustrations of a machine be prepared before even the patterns are made. The subjects of shading and shadows, usually made problems of considerable complexity, appear as clear as the general subject.

Mr. Wilson's work is to be regarded as a useful addition to the literature on the subject of Mechanical Drawing, and as a most excellent text book or book of reference.

A copy of the twelfth annual edition of the "Practical Engineer" pocket book for the year 1901 has been received. This annual of 462 pages is published by the Technical Publishing Co., Manchester, England., all their publications being kept in stock by D. Van Nostrand Co., New York.

The "Practical Engineer" is pocket size and contains a great amount of valuable information on boilers, steam, oil and gas engines, coal, belting, gearing and general mechanical engineering subjects.

In the book is a diary of fifty pages on cross-section paper, convenient for recording data, notes or sketches.

In the front portion of the book appear a number of advertisements of prominent English engineering firms, which feature allows the book to be sold at the very low price of about forty-three cents, including postage.

Dynamo Electric Machinery.—Its Construction, Design, and Operation. Direct Current Machines. By Samuel Sheldon, A. M., Ph. D., assisted by Hobart Mason, B. S. New York: D. Van Nostrand Company. 281 pages, illustrated. Price, $2.50.

Dr. Sheldon is in charge of Electrical Engineering at the Polytechnic Institute of Brooklyn, and the work is laid out along the lines of the lectures and instruction as given at the Institute. The authors state that although primarily intended for use in connection with instruction in electrical engineering courses in institutions for technical education, it is intended equally as much for the general reader who is seriously desiring information concering dynamo machinery, and also as a book of reference for engineers. The matter is divided into fourteen chapters, the mathematics are simple, and it is profusely illustrated, many of the cuts being taken from trade bulletins of manufacturers. The style is clear and the book is well up to date, the introduction of matter from the American Institute Rules being a valuable feature. The chapter on armature winding might be considerably improved by a more complete explanation of the commoner types, and a discussion of the practical application of the various types illustrated. Owing to the small size of the book, and also to the fact that a great deal of space has been devoted to cuts of machines and apparatus, the theoretical side of the treatment is too limited for a thorough course in dynamo machinery such as is necessary for students in Electrical Engineering. On the other hand, the book is admirably adapted for use in the more general courses where the time allotted to the subject does not permit of so complete a study of the theoretical side.

THE ALUMNI DIRECTORY.

The "Engineer" desires to call the attention of the alumni to the fact that it is impossible to keep the directory up to the desired standard without the co-operation of the alumni. We feel that the benefits of such a directory as this are manifold. It shows better than anything else the material turned out by the university. It gives the boys an opportunity to see what their former class-mates are doing and where they are.

We trust that the alumni will help us in this work and notify us of any change in their address and also send us any article of interest.

Adamson, Wm. H., B. S. C. E., '86. 725 24th Ave., S. Seattle, Wash.
Ahara, Edwin H., M. S. C. E., '92; M. E., '96. 2854 N. Lincoln St., Chicago.
Ahara, Geo. V., B. S. M. E., '95. With Fairbanks, Morse & Co., 827 4th St., Beloit, Wis.
Ahara, Theodore H., B. S. M. E., '00. Fairbanks, Morse & Co., Beloit, Wis.
Albers, John F., B. S. C. E., '77; C. E., '78. Druggist, Antigo, Wis.
Alexander, Walter, B. S. M E., '97. Instructor, Armour Institute, Chicago, Ill.
Allen, Andrews, B. S. C. E., '91. Contracting Engineer, Wis. Bridge Co., Monadnock Bldg., Chicago. Ill.
Allen, John S., B. S. E. E., '97. Supt. Elec. Light & Water Works, Elkhorn, Wis.
Alverson, Harry B., B. S. E. E., '93. Elec. Eng., Cataract Power & Conduit Co., 40 Court St., Buffalo, N. Y.
Arms, Richard M., B. S. C. E., '94. Missouri Elec. Co., St. Louis, Mo.
Aston, Jas., B. S. E. E., '98. Falk Mfg. Co., 1042 National Ave. Milwaukee, Wis.
Austin, W. A., B. S. M. E., '99. 218 La Salle St., Chicago, Ill.
Baehr, Wm. A., B. S. C. E., '94. Mg'r Denver Gas Works, Denver, Col.
Baldwin, Geo. W., B. S. C. E., '85. Lumber Dealer, Crete, Neb.
Bamford, F. E., B. S. M. E., '87. Lieut. U. S. A., Atlanta, Ga.
Barnes, Chas. B., B. S. M. E., '00. C., M. & St. P. Ry. Address care of West Milwaukee Shops, Milwaukee, Wis.
Barr, J. M., B. S. M. E., '99. Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.
Baus, Richard E., B. S. M. E., '00. Western Elec. Co., Chicago, Ill.
Bebb, Edward C., B. S. C. E., '96. U. S. Geol. Survey.
Beebe, Murray C., B. S. E. E., '97. Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.
Bennett, Chas. W., B. S. M. E., '92; Mech. Eng. American Tin Plate Co., Elwood, Ind.

Benson, Frederick H., B. S. C. E., '91. Civil Engineer, 591 Jefferson St., Milwaukee, Wis.

Bentley, F. W., B. S. M. E., '98. 411 Sixth St., Racine, Wis.

Berganthal, V. W., B. S. E. E., '97. Stanley Elec. Mfg. Co., Pittsfield, Mass.

Bertrand, Philip A., B. S. E. E., '95. Supt. Peoples' Gas & Elec. Co., Peoria, Ill.

Biefeld, Paul A., B. S. E. E., '94. Head Professor of Elec. Eng., Engineering School of Heilperghausen, Ger.

Bird, Henry, B. S. C. E., '94. Died Dec. 22, '91, Citronelle, Ala.

Bird, Hobart S., B. S. C. E., '94; LL. B., '96. San Juan, Porto Rico.

Bliss, Wm. S., B. S. M. E., '80. Sec. and Treas. J. M. Dennis Lumber Co., Williams, Arizona.

Boardman, Harry B., B. S. E. E., '93. Boardman Engraving Co., 259 E. 62 St., Milwaukee.

Boardman, Horace P., B. S. C. E., '94. Civil Eng'r, C. & A. R. R., 6600 Ellis Ave., Chicago.

Bohan, Wm. J., B. S. E. E., '95. Signal Inspector C., M. & St. P. Ry., Milwaukee.

Boley, C. U., B. S. C. E., '83; C. E., '99. City Engineer, Sheboygan, Wis.

Boorse, Jesse M., B. S. E. E., '95. Assistant Wire Chief Monroe Division of Chicago Telephone Co., 85 Sangamon St., Chicago, Ill.

Bossert, Chas. P., B. S. M. E., '88. With Pfister & Vogeler Leather Co., 555 Ninth St., Milwaukee, Wis.

Boynton, C. W., B. S. M. E., '98. Valders, Wis.

Brace, Jas. H., B. S. C. E., '92. U. S. Deep Waterways Com. With Niagara Ship Canal, 34 Congress St., W. Detroit, Mich.

Bradish, Geo. B., B. S. C. E., '76; C. E., '78. Civil Engineer, La Crosse, Wis.

Bradley, Wm. H., B. S. C. E., '78. Mgr. Junction Iron & Steel Co., Mingo Junction, Ohio.

Brennan, Wm. M., B. S. C. E., '94. Civil Engineer, Wis. C. R. R., Manitowoc, Wis.

Broenniman, Arnold E., B. S. E. E., 97. Asst. Eng. U. S. Deep Waterways Com., Rome, N. Y.

Brown, Geo. W., B. S. C. E., '86; C. E., '90. Civil Eng'r Gov. Works, Dry Tortugas, Fla. Via Key West.

Brown, Perry F., B. S. C. E., '97. Civil Eng'r, Kurtz & Brown, Mills Bldg., San Francisco, Cal.

Brown, Samuel L., B. S. M. E., '89. Asst. Supt. Smelting & Refining Co., Station S, Chicago.

Brown,,, Thane R., B. S. C. E., '95. With Wis. Bridge & Iron Co., Milwaukee, Wis.

Bucey, John H., B. S. C. E., '95 Died Dec. 4, 1896.

Buckley, W. J., B. S. E. E., '99. Madison Gas & Electric Co., Madison, Wis.

Burgess, Chas. H., B. S. E. E., '95. Assistant Professor of Elec. Eng., University of Wisconsin. 609 Lake St., Madison, Wis.

Burgess, Geo. H., B. S. C. E., '95. Bridge Insp. Penn. Lines, Chief Engineer's Office, Pittsburg, Pa.

Burkholder, Chas. I., B. S. E. E., '96. With Gen. Elec. Co., Schenectady, N. Y.

Burton, Wm. C., B. S. E. E., '93. With J. S. White & Co., 29 Broadway, New York City.

Buttles, Ben E., B. S. E. E., '00. Illinois Steel Co., S. Chicago, Ill.

Campbell, Bert, B. S. C. E., '98. Engineer, Chicago, Ill.

Carey, Jas. L., B. S. M. E., '88. American Straw Board Co., 1325 Old Colony Bldg., Chicago, Ill.

Carlson, Chas. J., B. S. M. E., '96. Chicago Telephone Co., Chicago, Ill.

Carpenter, Chas. G., B. S. C. E., '82; C. E., '85. Civil & Landscape Eng'r, 123 N. 40th St., Omaha, Neb.

Carter, B. B., B. S. M. E., '83. Monadnock Bldg., Chicago.

Caverno, Xenophon, B. S. M. E., '90. Vice Pres. and Gen. Mgr. Kewaunee Gas Light & Coke Co., Kewaunee, Ill.

Clausen, Leon R., B. S. E. E., '97. 422 W. Jackson Blvd., Chicago, Ill.

Cochrane, Robt. B., B. S. M. E., '97. Teacher Springfield Inst., Springfield, Mass.

Comstock, Nathan, B. S. M. E., '97. Attorney, Seattle, Wash.

Connolly, Pat. H., B. S. C. E., '85. Civil Eng'r, Riverside, Ill.

Conover, Allen D., Ph. B., C. E., '75. Architect, 151 West Gilman St., Madison, Wis.

Conradson, C. M., B. S. M. E., '83; M. E., '85 N. Y. Ship Building Co., Philadelphia, Pa.

Cook, Thomas R., B. S. M. E., '00. Penn. Ry., 105 Barr St., Fort Wayne, Ind.

Coombs, Edward C., B. S. C. E., '97. Civil Eng'r with C., M. & St. P. Ry., Chicago, Ill.

Cooper, A. S., B. S. C. E., '81; C. E., '83. U. S. Asst. Eng'r, Savannah, Ga.

Cosgrove, J. F., E. E., '96. Instructor in Scranton Correspodence School, Scranton, Pa.

Cornish, Ross C., B. S. C. E., '97. Supt. of Distribution, Milwaukee Gas & Light Co., Milwaukee, Wis.

Crandall, H., B. S. M. E., '98. In printing business, 23rd St., between Grand Ave. and Wells, Milwaukee, Wis.

Crane, Edgar W., B. S. E. E., '95. Supt. San Gabriel Elec. Co., Azusa, Cal.

Crenshaw,, Thos. P., B. S. E. E., '95. Elec. Eng'r for Gen. Elec. Co., Schenectady, N. Y.

Crowell, Robinson, E. E., '96. Mount Low Ry., Los Angeles, Cal.

Dixon, Fred, B. S. C. E., '97. New London, Wis.

Dixon, John E., B. S. M. E., '00. Brooks Locomotive Works, Dunkirk, N. Y.

Dodge, Jos., B. S. M. E., '84. Hinsdale, Ill.

Dodge, McClellan, B. S. C. E., '84. L. J. Pickarts & Co., Madison, Wis.

Dousman, Jas. H., B. S. C. E., '84. Milwaukee Engineering Co., 73 31st St., Milwaukee, Wis.

Duffy, Wm. F., B. S. C. E., '84. Cannot be located.

Durand, Samuel B., B. S. C. E., '91; C. E., Stanford, '94. Sec. Unity Mfg. Co., Milwaukee, Wis.

Dutcher, John E., B. S. E. E., '97. Electrician for Swift & Co., Kansas City, Mo.

Earll, C I., B. S. M. E., '85. Consulting Engineer, 120 Broadway, New York City.

Egan, R. A., B. S. C. E., '99. Brooklyn, N. Y.

Ela, Edwin S., B. S. C. E., '96. Recorder Govt. Survey, Rochester, Wis.

Ellis, John F., B. S. C. E., '87. Died, Evansville, Wis., Dec. 9, '90.

Elser, R. C., B. S. C. E., '98. Died, May 17, 1900.

Emerson, Fred M., B. S. C. E., '00. Milwaukee Bridge Co., Milwaukee.

Erbach, Wm. Z., B. S. M. E., '93. Mgr. Lumber business and saw mill, Athens, Wis.

Eriksen, Erik T., B. S. C. E., '89; C. E., '90. 2991 N. Winchester Ave., Chicago, Ill.

Evans, Edward M., B. S. C. E., '94. Racine, Wis.

Evans, Geo. B., B. S. C. E., '94. Wis. Bridge & Iron Co., N. Milwaukee, Wis.

Fairchild, David L., B. S. C. E., '90. With Minnesota Iron Co., Duluth, Minn.

Falconer, Robert C., B. S. C. E., '95. Structural Eng'r (Purdy & Henderson), 1402 Havemeyer Bldg., New York City.

Farris, James A., B. S. M. E., '00. Instructor Fond du Lac High School, Fond du Lac, Wis.

Fehr, H., B. S., B. S. M. E., '84; LL. B., '86. Attorney, 301 9th St., Milwaukee, Wis.

Fisher, John J., B. S. C. E., '76 U. S. Dept. Mineral Surveyor, Prescott, Ariz.
Fisher, John R., B. S. C. E., '74; C. E., '80. Lumber dealer, Beaver Dam, Wis.
Ford, Arthur H., B. S. E. E., '95. Acting Professor of Elec. Eng., University of Colorado B,oulder, Col.
Ford, Fred H., B. S. E. E., '93. Northern Electric Co., Milwaukee.
Fowle, Fred. F., B. S. E. E., '93. Draughtsman, Milwaukee Bridge and Iron Works, 120 7th St., Milwaukee.
Fowle, Harry H., B. S. E. E., '95. Electrician (Fowle & Fowle), Milwaukee.
Fox, Henry, B. S. M. E., '92. Inspector of Ill. and Miss. Canal, Tiskilwa, Ill.
Frankenfield, Budd D., B. S. E. E., '95; E. E., '96. Instructor in Elec. Eng., University of Wisconsin, Madison, Wis.
Fratt, Fred W., B. S. C. E., '82. Supt. of Texas Midland R. R., Terrell, Texas.
Freschl, E., B. S. M. E., '99. 3301 Wells St., Milwaukee, Wis.
Fugina, A. R., B. S. C. E., '98. U. S. Geol. Survey, Cincinnati, O.
Fuldner, Henry C., B. S. C. E., '97. 366 Greenbush St., Milwaukee, Wis.
Funk, Wm. F., B. S. M. E., '91. Supt. M. Funk Boiler Works, 1407 Main St., La Crosse, Wis.
Gerdtzen, Gerdt A., B. S. M. E., '93. Ill. Steel Co., S. Chicago, Ill.
Gerlach, T. A., B. S. C. E., '98 Draughtsman, Paige Iron Works, 675 Warren Ave., Chicago.
Goddard, Arthur L., B. S. M. E., '96. Hadden Heights, N. J.
Golder, Lloyd W., B. S. M. E., '95; B. S. E. E., '96. C. & N. W. Ry., Chicago.
Gooding, Wm. H., B. S. C. E., '73. Civil Engineer, Independence, Iowa.
Granke, Leo E., B. S. C. E., '00. La Crosse, Wis.
Gregerson, Louis T., B. S. C. E., '95.
Gregg, Hendrick B., B. S. M. E., '92. Asst. Supt. Timber Treating Plant A., T. & S. F. R. R., Bellemont, Arizona.
Griffith, John H., B. S. C. E., '93. 31 Chestnut St., Potsdam, N. Y.
Grover, A. J., B. S. C. E., '81; C. E., '83. Civil Engineer and Merchant, 1137 Park Ave., Omaha, Neb.
Grover, Allison S., B. S. M. E., '95. With Niles Tool Works, 153 N. 3rd St., Hamilton, O.
Hackney, Robert H., B. S. M. E., '93. With Fox Pressed Steel Co., Joliet, Ill.
Hain, Jas. C., B. S. C. E., '93. Assistant Engineer with C., M. & St. P. R. R., 1529 Monroe St., Chicago.
Hambuechen, C., B. S. E. E., '99. Graduate student, University of Wisconsin. 151 North Butler St., Madison, Wis.
Hamilton, Harvey F., B. S. C. E., '92. Asst. Eng'r G. N. R. R., Great Northern Bldg., St. Paul, Minn.
Hancock, L. M., B. S. M. E., '88. Chief Electrician Nevada Elec. Power Co., Nevada City, Cal.
Hansen, Oscar, B. S. E. E., '94. Western Electric Co., Chicago.
Hanson, A., B. S. E. E., '99. Chief Electrician Gov't Bureau of Printing & Engraving, Washington, D. C.
Hanson, Walter S., B. S. M. E., '95. Inspecting for Walburn-Swenson Co., Headquarters, Shawnee, Okla.
Hargrave, R. W., B. S. M. E., '98. Instructor in Shop, U. W. 728 University Ave., Madison.
Harrison, C. N., B. S. C. E., '82. Studying at Johns Hopkins, Baltimore, Md.
Harriman, Florian J., B. S. C. E., '89. Surveyor, Appleton, Wis.
Hirshheimer, Harry J., B. S. M. E., '91. Vice Pres. La Crosse Plow Works, 425 N. 8th St., La Crosse, Wis.
Hart, Charles W., B. S. M. E., '96. Hart, Parr & Co., Madison, Wis.
Hartwell, Frank I., B. S. M. E., '95. Died, 1897.
Harvey, John L., B. S. M. E., '00. Mondovi, Wis.

Hayden, Charles B., B. S. E. E., '96. Sun Prairie, Wis.

Heald, Eugene H., B. S. C. E., '00. Oak Park, Ill.

Hegg, John R., B. S. C. E., '00. C., M. & St. P. Ry., Marion, Ia.

Hedke, Chas. R., B. S. C. E., '00. Chemist, with Holland Beet Sugar Mfg. Co., Holland, Mich.

Heine, R. E., B. S. C. E., '98. Milwaukee Elec. Light & Ry Co., care of Chief Electrician, Milwaukee.

Hile, Chas. H., M. E., '94. Supt. of Wires, Boston Elevated Railway, Boston, Mass.

Hinrichs, Christian, B. S. M. E., '90. With "Cramp & Sons' Ship Yards,' 3245 Park Ave., Philadelphia, Pa.

Hobart, F. G., B. S. M. E., '86; M. E., '90. 724 Prairie Ave., Beloit, Wis.

Hogan, J. J., B. S. E. E., '99. Western Electric Co., Chicago.

Holt, F. W., B. S. C. E., M. L., '88; LL. B., '89. Room 253, U. S. Patent Office, Washington, D. C.

Hoskin, Arthur J., B. S. M. E., '90. Surveying and Engineering, Box 1062, Cripple Creek, Col.

Hoskins, L. M., B. S., '83; M. S., '85; C. E., '87. Professor of Mechanics, Stanford University, Cal.

Hoyt, Warren A., B. S. C. E., '00. Altoona, Pa.

Humphrey, C. W., B. S. E. E., '00. Western Electric Co., Chicago.

Hunner, Earl E., B. S. C. E., '00. U. S. Geol. Survey, Washington, D. C.

Icke, John F., B. S. C. E., '00. Asst. City Engineer, Madison, Wis., and Instructor in U. W.

James, Ben W., B. S. M. E., '97. Ill. Steel Co., 1109 Cass St., Joliet, Ill.

James, Oscar B., B. S. M. E., '91. Machinist, Richland Center, Wis.

Jenne, R. L., B. S. E. E., '98. Chicago Telephone Co., Chicago.

Jones, Geo. H., B. S. E. E., '97. With Chicago Edison Co., Chicago, Ill.

Johnson, Carl A., B. S. M. E., '91. Manufacturer (Gisholt Machine Co.), Madison, Wis.

Joyce, Patrick F., B. S. C. E., '93. De Pere, Wis.

Keller, C. A., B. S. E. E., '99. With J. G. White & Co., Washington, D. C.

Kiehl, Wallace P., B. S. E. E., '97.

Kirchoffer, Wm. G., B. S. C. E., '97. City Engineer, Baraboo, Wis.

Klug, L. J., B. S. C. E., '98. Draughtsman, American Bridge Works, Chicago.

Knowles, J. H., B. S. C. E., '99. U. S. Geol. Survey, Salt Lake City, Utah.

Kremers, John G., B. S. E. E., '98. Beet Sugar Industry, Menominee Falls, Wis.

Kratsch, Wm. H., B. S. M. E., '97. The Geo. Challoners Sons Co., Oshkosh, Wis.

Kurtz, Chas. M., B. S. C. E., '97. Civil Engineer, Kurtz & Brown, Mills Bldg., San Francisco, Cal.

Kurtz, Edward, B. S. M. E., '94. Laclede Power Co., St. Louis, Mo.

Lademan, Otto T., B. S. E. E., '97. St. Louis Elec. Const. Co., St. Louis, Mo.

Landgraf, F. K., B. S. M. E., '98. 1505 Newberg St., Marinette, Wis.

Lapham, Chas., B. S. C. E., '81; C. E., '81. Division and Asst. Eng. C., M. & St. P. R. R., 3118 Mt. Vernon Ave., Milwaukee.

Lardner, Henry A., B. S. E. E., '93; E. E., '95. N. Y. Electric Illuminating Co., New York City.

Lawton, E. W., B. S. M. E., '89. Draughtsman and Bookkeeper, De Pere, Wis.

Leich, Oscar M., B. S. E. E.. '98. Western Electric Co., 442 W. Jackson Blvd., Chicago.

Lemon, Luther E., B. S. E. E., '96. With Vindex Electric Co., 158 Iowa Ave., Aurora, Ill.

Leuth, Emil S., B. S. M. E., '97. Deering Harvester Co., Chicago, Ill.

Leuth, P. F., B. S. M. E., '98. Fairbanks & Morse Co., 1010 Parks Ave., Beloit, Wis.

Lindem, Olaf J., B. S. C. E., '00. N. P. Ry., St. Paul, Minn.
Lindeman, A., B. S. M. E., '85; M. E., '87. With J. P. Lindeman & Son, 730 Clybourne St., Milwaukee.
Lippert, A. B., B. S. C. E., '99. Milwaukee Harvester Co., Milwaukee, Wis.
Lloyd, Conrad C., B. S C. E., '96. Asst. Engineer, C., M. & St. P. R. R., 860 Cass, St., Milwaukee.
Logemann, R. T., B. S. C.. E., '99. Asst. Engineer, C., M. & St. P. Ry., Milwaukee.
MacGregor, Wallace F. B. S. M. E., '97. J. I. Case Mfg. Co., Racine, Wis.
Maldaner, Arthur, B. S. C. E., '96. Gilbert & Hortzog, Minneapolis, Minn.
Malec, Anton, B. S. M. E., '98. Gisholt Mfg. Co., Madison, Wis.
Maurer, Ed. R., B. S. C. E., '90. Asst. Professor of Pure and Applied Mechanics, U. W., 215 Prospect Ave., Madison, Wis.
Mayer, August, B. S. C. E., '83. Planter, Shreveport, La.
Marvin, Arba B., B. S. E. E., '00. Gen. Elec. Co., Schenectady, N. Y.
Mason, C. T., B. S. M. E., '99. Illinois Steel Co., 1109 Cass St., Joliet, Ill.
McArthur, Arthur R., B. S. M. E.. '00. American Tin Plate Co., Elwood, Ind.
McCulloch, Alfred L. B., B. S. C. E., '95. Draughtsman, Northern Elec. Co., Madison, Wis.
McDonald, Clinton, B. S. C. E., '97. Asst. Engineer C. & N. W. R. R., Evansville, Wis.
McKim, Jas. A., B. S. C. E., '91. Chief Engineer of Haugh-Noelke Iron Works, 1164 N. Pennsylvania St., Indianapolis, Ind.
Mead, Geo. A., B. S. E. E., '95. Ohio Brass Works, Mansfield, O.
Mead, Olin A., B. S. C. E., '92. Estimator for R. McMillan & Co., 636 Pacific St., Appleton, Wis.
Melville, Jas., B. S. C. E., '75; C. E., '78. Teacher, Sun Prairie, Wis.
Merriam, H. N., B. S. C. E., '98. Civil Engineer with Canadian Pacific Ry., Boorklyn, N. Y.
Merrick, Eldridge G., B. S. E. E., '00. Danbury, Conn.
Meyer, Ed. W., B. S. M. E., '95. With Nordburg Mfg. Co., Milwaukee.
Minch, Herman J., B. S. M. E., '92. Mgr. for B. M. Minch, 222 W. Gorham St., Madison, Wis.
Minch, Oscar J., B. S. M. E., '93. Miller (F. H. Minch & Sons), Paoli, Wis.
Minch, Walter B., B. S. M. E., '00. Western Electric Co., Chicago.
Monahan, John J., B. S. C. E., '95. With Filer & Stowell Co., Milwaukee, Wis.
Moore, Lewis E., B. S. M. E., '00. Beacon, Mich.
Morrow, Frank E., B. S. C. E., '92. Publisher and Consulting Eng'r, 216-220 Locust St., Evansville, Ind.
Mors, Geo. C. H., B. S. M. E., '92. American Tin Plate Co., Elwood, Ind.
Munger, Edwin T., B. S. M. E., '92. Mgr. Havana Elec. Co.; Pres. and Mgr. Havana Telephone Co., Havana, Ill.
Munroe, Wm., Ph. B., C. E., '73. Civil and Mining Engineer, P. O. B. 230, Great Falls, Montana.
Nee, T. G., B. S. E. E., '99. Chicago Telephone Co., Chicago.
Nelson, Clarence L., B. S. C. E., '00. Racine, Wis.
Nelson, Fred W., B. S. M. E., '97. Ishpeming, Mich.
Nethercut, Edgar S., B. S. C. E., '89. Chief Eng'r Paige Iron Works, 38 Ontario St., Chicago, Ill.
Newman, Fred J., B. S. E. E., '98. Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.
Nommensen, R. A., B. S. C. E., '99. Asst. Engineer C., M. & St. P. Ry., Room 7, Union Depot, Milwaukee, Wis.
Ochsner, Rudolph J., B. S. E. E., '94. Brown Hoisting & Conveying Co., Cleveland, O.

Older, Clifford, B. S. C. E., '00. Penn. Ry., Pittsburg, Pa.
Olson, L. W., B. S. E. E. '99. J. G. White & Co., Washington, D. C.
Olson, M. C., B. S. E. E., '99. Gen. Elec. Co., Schenectady, N. Y.
O'Neill, Wm. R., B. S. M. E., '87. Manufacturer (Pacific Vinegar Co.), 169 East 14th St., Portland, Ore.
Ostenfeldt, C. L., B. S. C. E., '85. Civil Eng'r, 1117 Schiller Bldg., Chicago.
Owen, Llewellyn, B. S. E. E., '97. Peoples Gas & Elec. .Co., 104 Flora St., Peoria, Ill.
Paine, Jas. P., B. S. C. E., '77. Civil Engineer, 223 Pleasant St., Milwaukee, Wis.
Palmer, Allen H., B. S. E. E., '96. Civil Engineer, 528 Georgia St., Escanaba, Mich.
Parman, A. L., B. S. C. E., '85; C. E., '89. Died Oct. 3, 1899, at Spokane Falls, Wash.
Parmley, W. C., B. S. Met. E., '87; M. S., '93. Asst. Eng'r Special Sanitation, 19 Burt St., Cleveland, O.
Parsons, Walter J., B. S. C. E., '00. Scherzer Bridge Co., Chicago, Ill.
Pennock, Wm. H., B. S. M. E., '83. Attorney, 606 N. Y. Life Bldg., Omaha, Neb.
Perkins, Jay H., B. S. E. E., '96. Mgr. Youngstown Elec. Co., 670 Bryson St.,Youngstown, O.
Phillips, Jonathan, B. S. C. E., '87. Died, 1893.
Phillips, Norman F., B. S. C. E., '77. With Monitor Mfg. Co., 423 W. 26th St., Minneapolis, Minn.
Pope, Geo. W., B. S. C. E., '98. Wis. Bridge Co., N. Milwaukee, Wis.
Potter, Wm. G., B. S. C. E., '90; C. E., '94. Chief Asst Eng'r. Alvord & Shields, 127 Hartford Bldg., Chicago.
Powell, A. O., B. S. C. E., '80; C. E., '90. Civil Eng'r, Army Bldg., St. Paul, Minn.
Powell, Emery H., B. S. M. E., '91. Draughtsman, Jobbins & Van Ruymbeke, 448 Garfield Ave., Aurora, Ill.
Powrie, Wm. R., B. S. M. E., '96. Civil Eng'r (Powrie & Son), Waukesha, Wis.
Prael, Fred W., B. S. M. E., '91. Foreman Pacific Sheet Metal Works, Astoria, Oregon.
Purdy, C. T., B. S. C. E., '85; C. E., '86. Eastern Mgr. for George A. Fuller Co., Contractors and Builders, 78 5th Ave., New York City.
Quirk, Jos., B. S. C. E., '73. Pres. and Mgr. Jos. Quirk Milling Co., Waterville, Minn.
Radke, Albert A., B. S. E. E., '00. Instructor Agricultural College, Kingston, R. I.
Ramien, Carl H., B. S. M. E., '96. Draughtsman, Filer & Stowell Co., 560 4th St., Milwaukee, Wis.
Ransom, Geo. B., B. S. C. E., '91. U. S. Ship "Boston," Yokohama, Japan, care of Post Office, San Francisco, Cal.
Reedal, Peter E., B. S. E. E., '96. Pawling & Harnishfeger, Milwaukee, Wis.
Reilly, Harry W., B. S. E. E., '97. Brooklyn Rapid Transit Co., Brooklyn, N. Y.
Rendtorff, Edmund J., B. S. E. E., '95. Northwestern University, Evanston, Ill.
Reynolds, W. E., B. S. E. E., '99. Chicago Telephone Co.. Chicago, Ill.
Rhine, Chas. A., B. S. E. E., '00. 755 Clybourne St., Milwaukee, Wis.
Richards, Jerry F., B. S. C. E., '98. International Clay Mfg. Co., Perth Amboy, N. J.
Richards, W. A., B. S. M. E., '99. Instructor in Mathematics and Manual Training, East Side High School, 201 Farwell Ave., Milwaukee, Wis.

Richter, Arthur W., B. S. M. E., '89; B. S. M. E., '91. Asst. Prof. of Experimental Engineering, U. W.
Robinson, Geo. P., B. S. E. E. '96. ,With Wis. Tel. Co., Milwaukee, Wis.
Rogers, Walter A., B. S. C. E., '88. Engineer of permanent constructions, C., M. & St. P. R. R., Chicago, 12 N. Chapel St. Elgin, Ill.
Rosenstengel, Rudolph, B. S. E. E., '94.
Rosenstengel, Wm. R., B. S. M. E., '87. Elec. Eng., 442 Northampton St., Buffalo, N. Y.
Ross, Harry H., B. S. E. E., 96. Deep Water Ways Survey, 34 Congress St., Detroit, Mich.
Ruka, Fred W., B. S. E. E., '96. Boscobel, Wis.
Rumsey, Spencer S., B. S. C. E., '97. E. P. Allis Co., Milwaukee, Wis.
Sanborn, Joe N., B. S. M. E., '81; C. E., '84. Master Mechanic, B. & N. M. R. R., Brainerd, Minn.
Sands, Edward E., B. S. C. E., '00. Instructor in Civil Engineering, U. W., Madison, Wis.
Sawyer, A. R., E. E., '96. Milwaukee, Wis.
Schafer, Otto, B. S. C. E., '98. Construction Dept. C., M. & St. P. Ry. Co., in Iowa.
Schieber, A. V., B. S. E. E., '99. Chicago Telephone Co., Chicago, Ill.
Schildauer, Edw., B. S. E. E., '97. Chi. Edison Co., Chicago, Ill.
Schmidt, Chas. J., B. S. E. E., '97. Chas. A. Brown & Cragg, 1450 Monadnock Bld., Chicago, Ill.
Schmidt, Fred E., B. S. C. E., '00. American Bridge Co., New York City.
Schroeder, F. A., B. S. E. E., '99. Johnstown, Pa.
Schuchardt, R. F., B. S. E. E., '97. Chicago Edison Co., Chicago, Ill.
Schulz, A. G., B. S. C. E., '75. Hardware, Porterville, Cal.
Schuster, J. W., B. S. E. E., '99. Fellow University Wis.
Schumann, Theo. F., B. S. E. E., '95. Died March 26, '96.
Schneider, H. C., B. S. M. E., '98. Baker Windmill Co., Evansville, Wis.
Scott, Henry H., B. S. E. E., '96. Elec. Eng'r, Library Bld., Ashland, Wis.
Seaman, Harold, B. S. E. E., '00. Elec. Storage Battery Co., Philadelphia.
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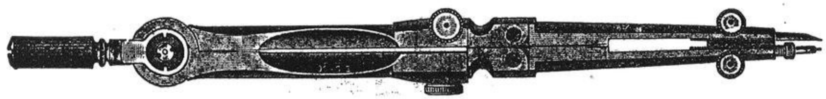

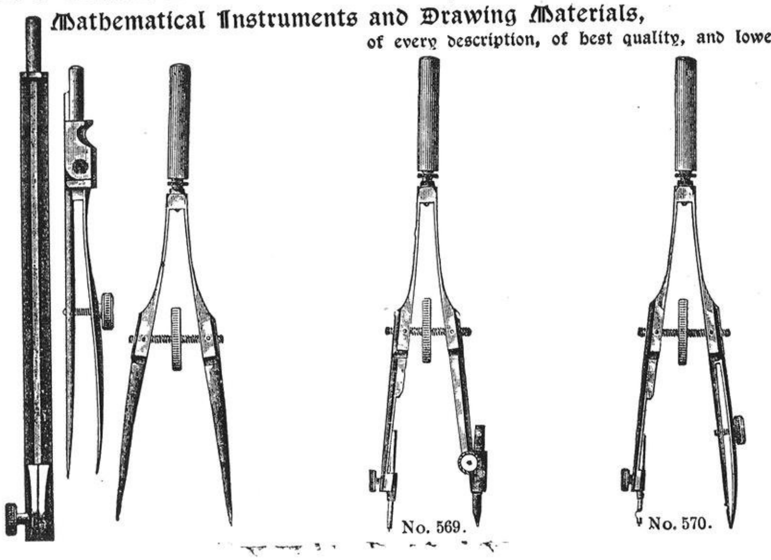

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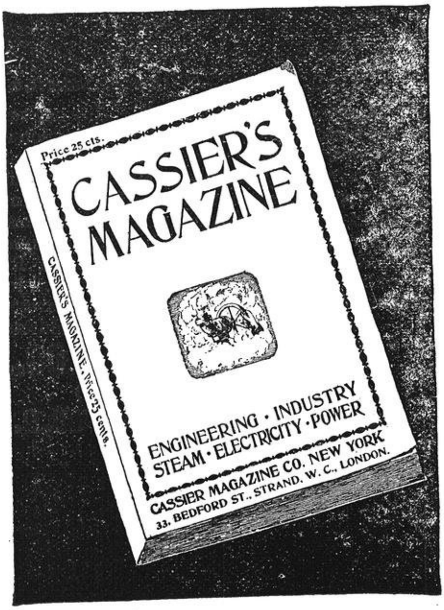


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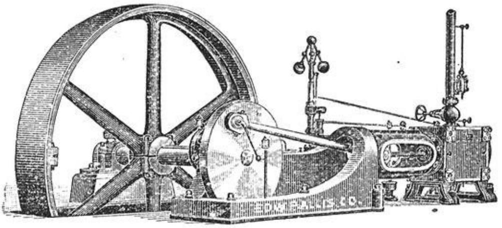
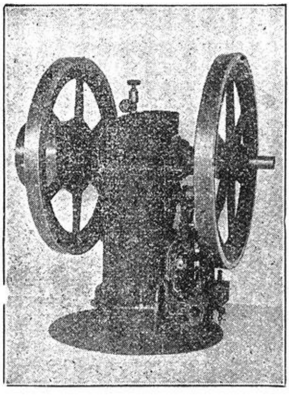
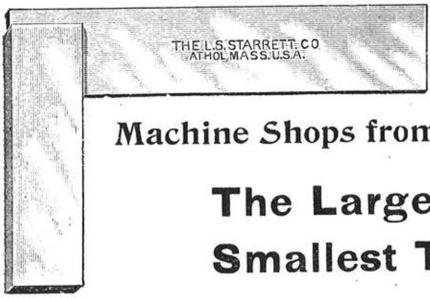
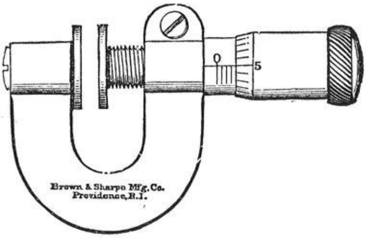





THE L.S.STARRETT CO
ATHOL, MASS. U.S.A.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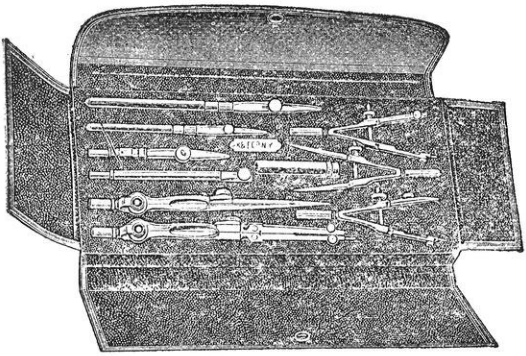
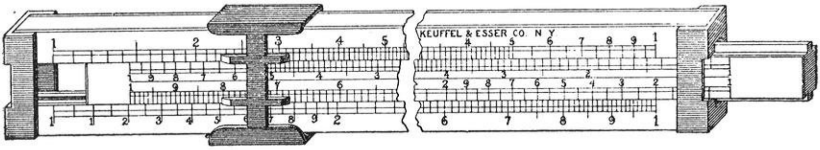
Brown & Sharpe Mfg. Co.
Providence, R.I.

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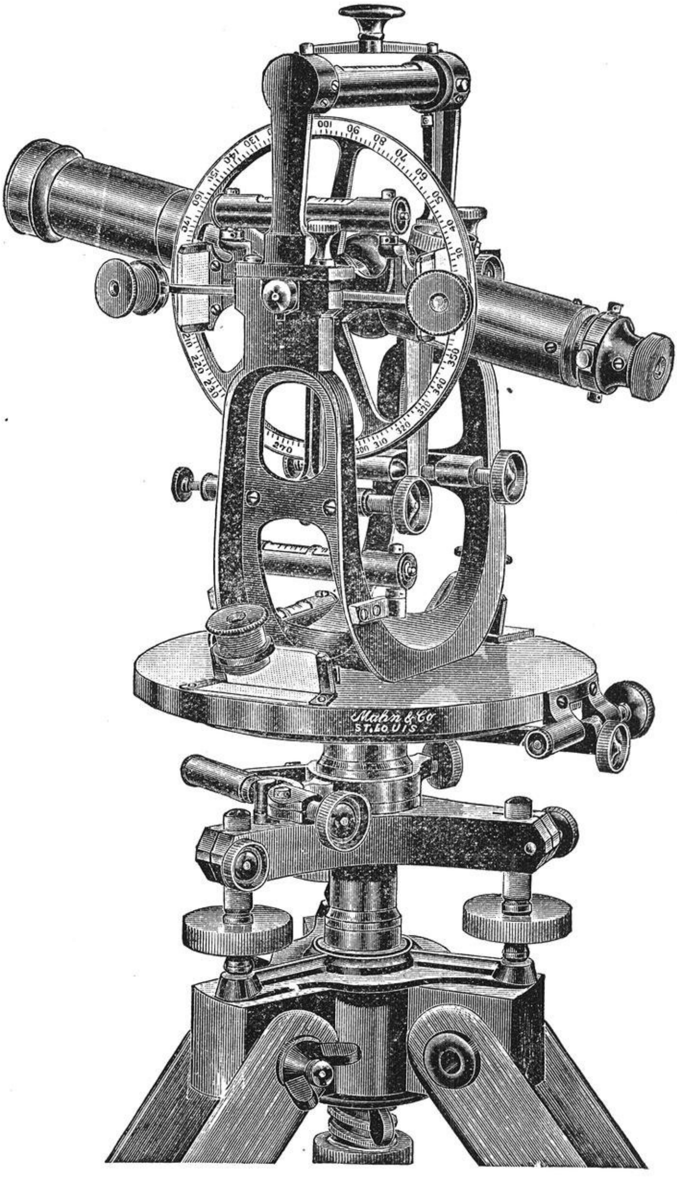
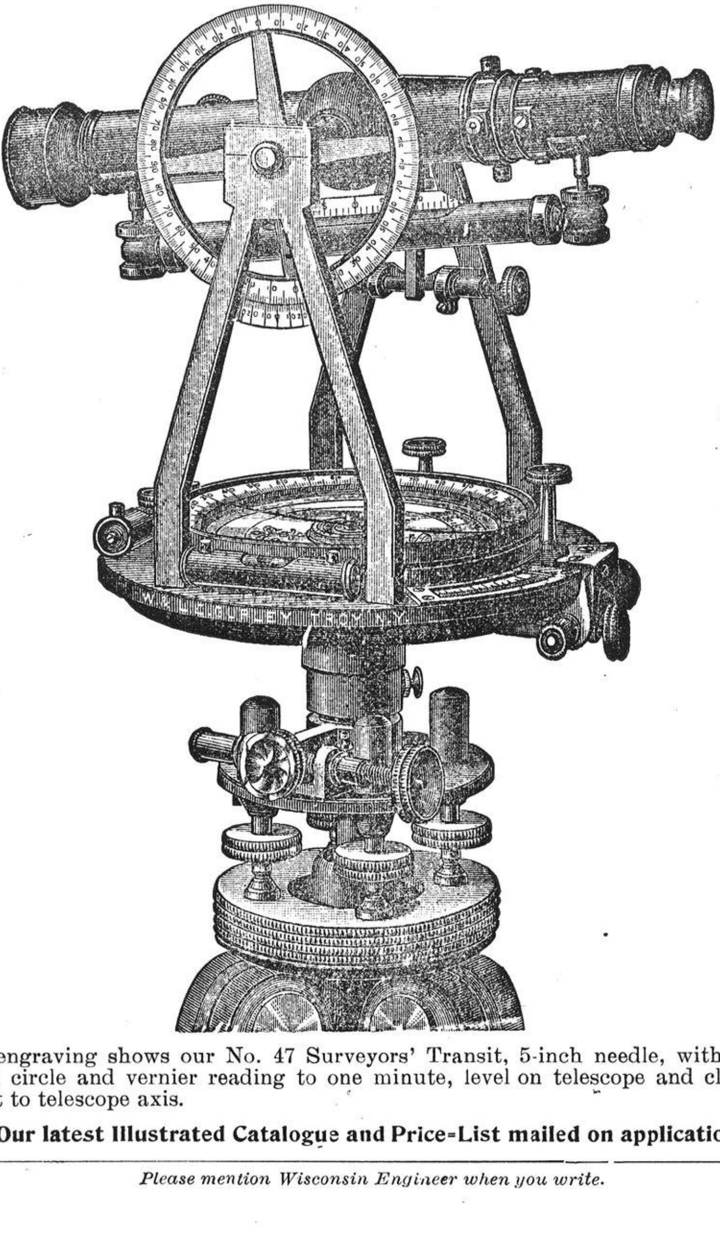

Mahn & Co
ST. LOUIS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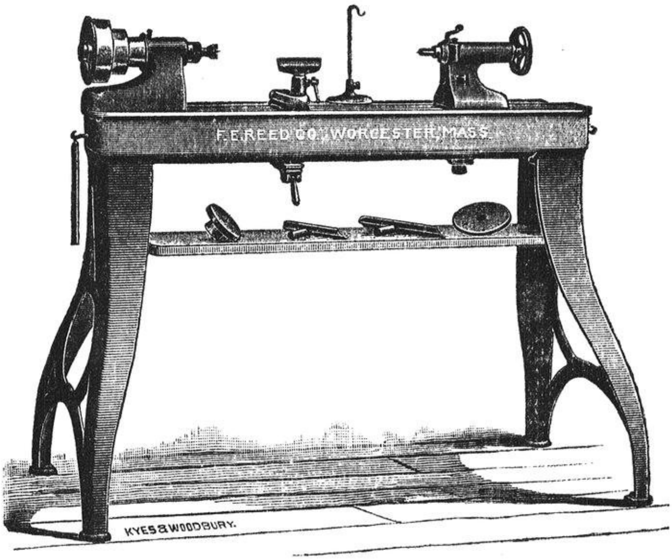
F. E. REED CO., WORCESTER, MASS.
KYES & WOODBURY.