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Volume 10 Number 3

The WISCONSIN ENGINEER

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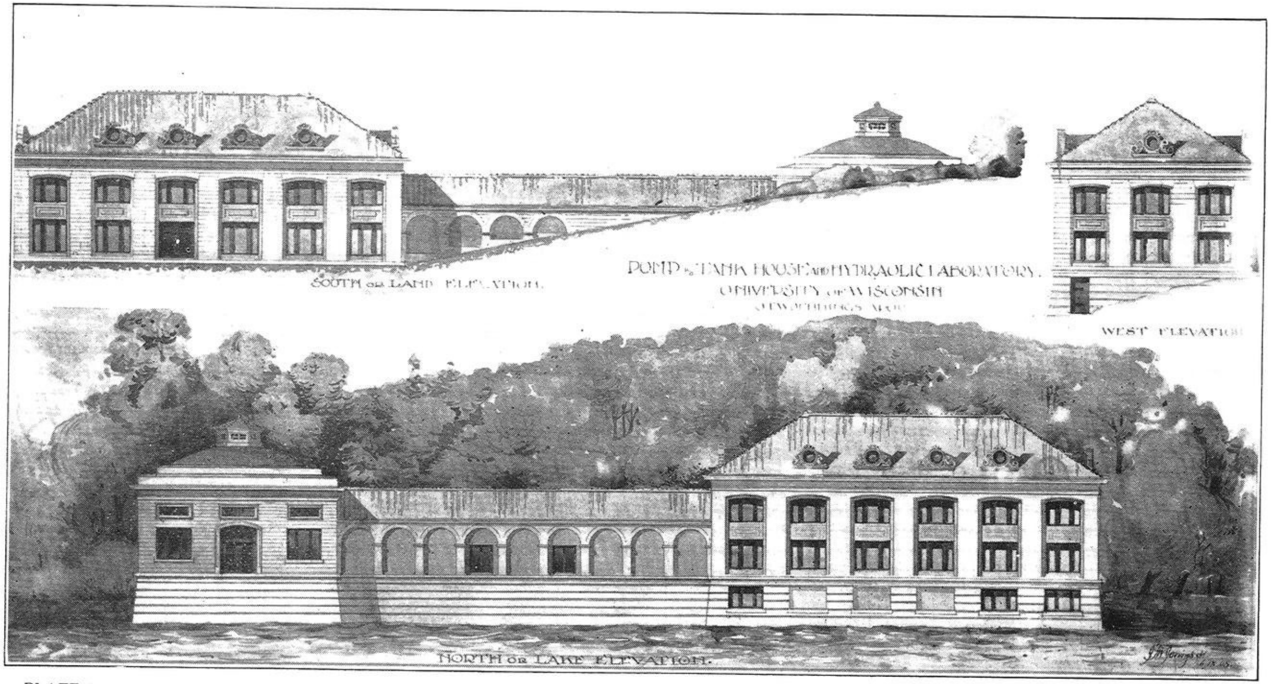

SOUTH OR LAND ELEVATION.
POND & TANK HOUSE AND HYDRAULIC LABORATORY.
UNIVERSITY OF WISCONSIN
WEST ELEVATION
NORTH OR LAKE ELEVATION.

PLATE I

THE WISCONSIN ENGINEER

VOL. 10 MARCH, 1906 NO. 3

THE NEW HYDRAULIC LABORATORY AT THE UNIVERSITY OF WISCONSIN.

D. W. MEAD.

The rapid development in all lines of hydraulic engineering during the last decade has been phenomenal. The gradual perfection of methods for the electric transmission of energy has made accessible to many commercial and manufacturing centers, sources of natural hydraulic power formerly inaccessible. The growth of population has caused a rapid increase in land values which has directed attention to the drainage and protection of low and submerged lands and the irrigation of arid and semi-arid areas. The concentration of population in cities has made the questions of pure water supplies, and of water purification and protection, and the questions of municipal drainage and sewerage and of sewage disposal of much importance. The same development has awakened renewed interest in river improvements and in inland navigation. All of these factors, and many others which might be mentioned, have brought to the attention of the public, and especially to engineers, the necessity of a thorough knowledge of the principles of hydraulics, and of a more exact and extended investigation of hydraulic phenomena.

This increased demand for special information and training in hydraulics has led to the better equipment of the hydraulic laboratories in many technical schools.

At the University of Wisconsin this department of engineering, instruction and research will be specially well provided for in the new laboratory now nearing completion.

The new hydraulic laboratory at the University of Wiscon-

LONGITUDINAL SECTIONAL ELEVATION.

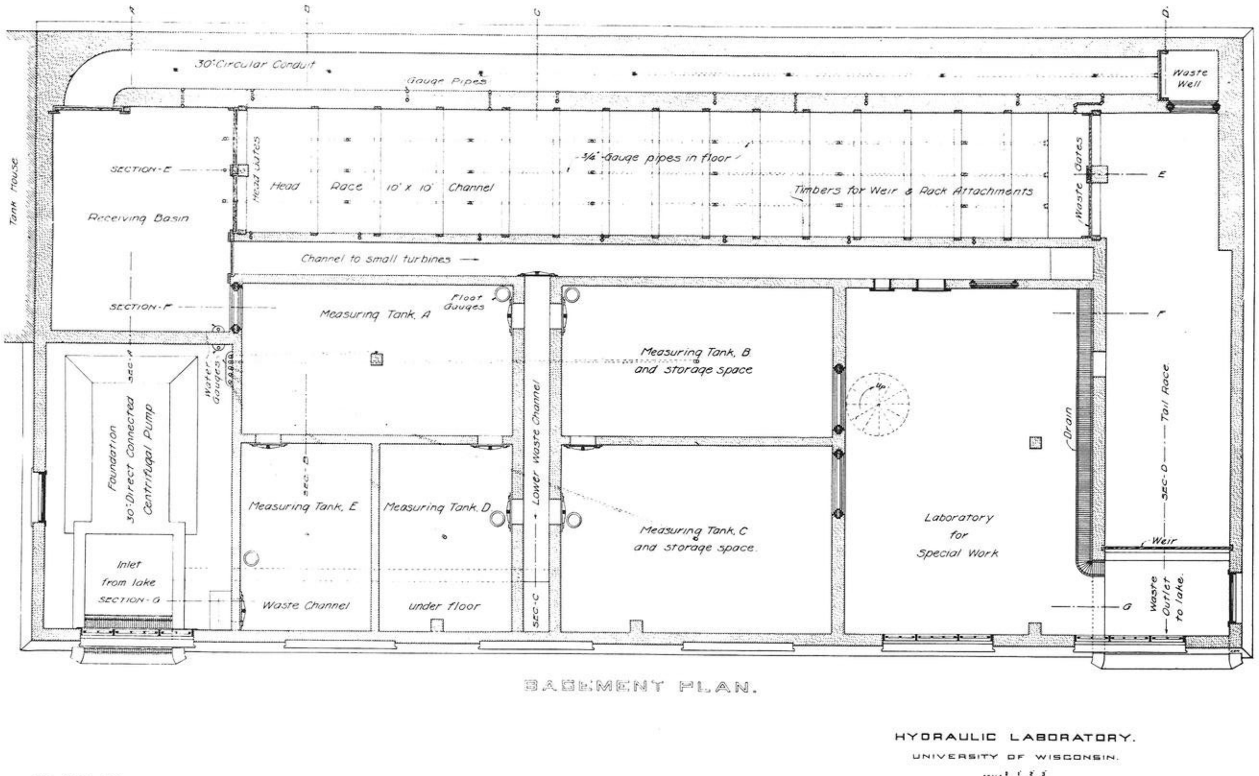
HYDRAULIC LABORATORY,
UNIVERSITY OF WISCONSIN.
SCALE. 1' 3' 5' 7'

PLATE II

sin is located on the shore of Lake Mendota, which borders the University campus on the north and immediately adjoins the university pumping station and tank house. In this location an unlimited quantity of water is available for hydraulic experiments under low heads, and high heads up to about a hundred and seventy feet are provided for by the university water works pressure storage tanks. The bluffs of the lake at this point are about fifty feet above the lake level affording a site for a storage reservoir for moderate heads, which while not yet constructed, is one of the accessories which it is intended to add in the near future.

The foundation, basement, walls, columns and floor of the laboratory building are constructed of reinforced concrete. The walls of the building above the basement are of concrete blocks and the roof is an open truss type covered with red tile roofing.

The building consists of three stories, each 48 feet in width by 98 feet in length, including the basement, which is placed about eighteen inches above the water level of the lake. In one corner of this basement, is located an engine room containing a large pumping engine installed for the purpose of furnishing large quantities of water under low heads for large flow, weir and water power experiments. This pump consists of a Morris centrifugal pump, direct connected to vertical twin engines and with a single 30-inch suction and 30-inch discharge, located and arranged as shown in the illustration. This pump takes its suction from a ten-foot canal leading directly from the lake and of a sufficient depth to provide for the flow of water when the lake is frozen over. The pump delivers the water into a receiving chamber of considerable size from which it may be taken for purposes of various experiments under heads up to ten feet. With this chamber are connected various conduits and channels by means of which investigations can be made on a scale of considerable magnitude concerning the laws of flow in such channels and conduits together with the effect thereon of the presence of dams, weirs, racks, submerged orifices and other features encountered in water power work.



30" Circular Conduit
Gauge Pipes
Waste Well
Tank House
SECTION-E
Receiving Basin
SECTION-F
Head Gates
Head
Race
10' x 10'
Channel
3/4" Gauge pipes in floor
Timbers for Weir & Rack Attachments
Waste Gates
Channel to small turbines
Measuring Tank, A
Float Gauges
Water Gauges
Foundation
30" Direct Connected Centrifugal Pump
Inlet
from lake
SECTION-G
Measuring Tank, E
Waste Channel
Measuring Tank, D
under floor
Lower Waste Channel
SEC-C
Measuring Tank, B
and storage space
Measuring Tank, C
and storage space.
Laboratory
for
Special Work
Drain
Tail Race
SEC-D
Weir
Waste
Outlet
to lake.
BASEMENT PLAN.
HYDRAULIC LABORATORY.
UNIVERSITY OF WISCONSIN.

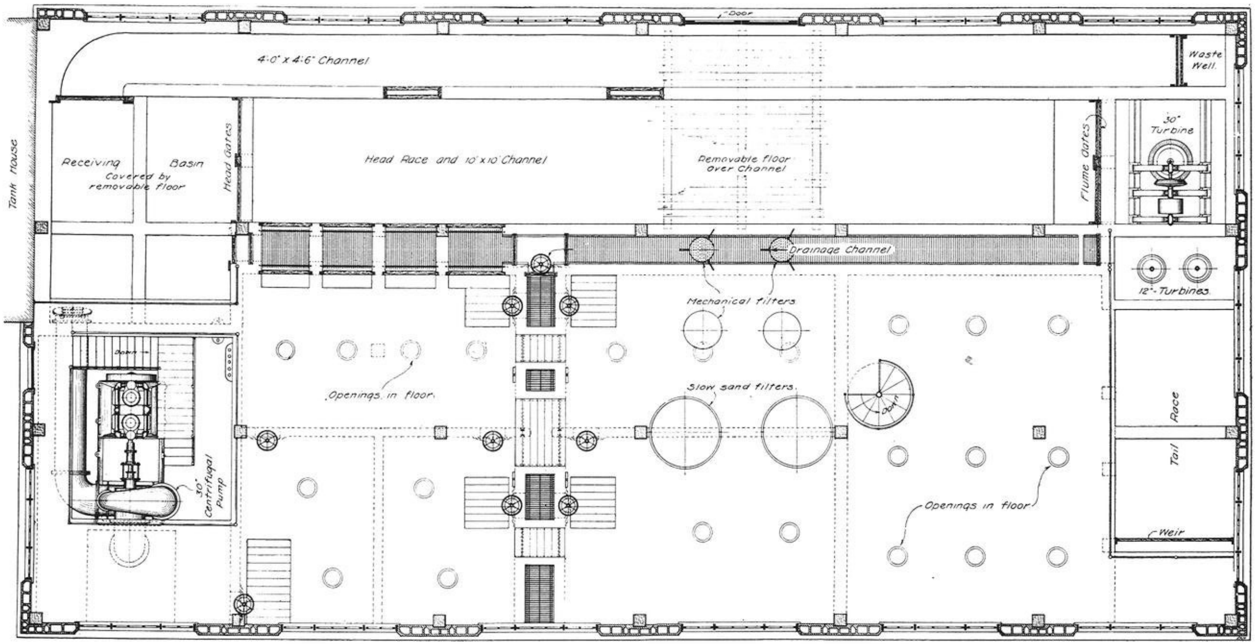
PLATE III

The receiving chamber is connected by double head gates with a channel or race-way ten feet in width and ten feet in depth which is intended to serve for large flow experiments, and also as a head race leading to the larger turbine installation. In this channel flow measurements may be made with various depths of water in the channel as constructed, or with varying depths and widths by the temporary restriction of its cross-section. The volume of water available, which will be from 25,000 to 35,000 gallons per minute, offers a considerable opportunity for research work with reference to large apertures, weirs and racks.

In addition to this large channel, a small channel has been constructed four feet in width by four and one-half feet in depth, parallel and adjoining the former on the south. This will be used in connection with various channel experiments on a smaller scale, and also for the purpose of rating current meters and pitot tubes. Below this channel is a 30-inch circular concrete conduit where the phenomena of flow in closed channels may be observed.

In addition to these permanent concrete channels a smaller wooden channel for similar purposes has been constructed and placed on the main floor of the laboratory. A weir box at the head of this channel discharges into the same, giving a measured quantity of water from which the relations of channel flow are obtained. The gradient of the channel is readily adjustable and the relations of volume, section and gradient can be varied, thus providing conditions more satisfactory for instructional work than with the large channels, but not of as much value for advanced and research work.

In the basement have been constructed five measuring chambers as shown on the plans. These chambers are arranged so that they can be operated independently, or together in two groups. In the double grouping of the chambers each group will contain about five thousand cubic feet, giving a total capacity of about ten thousand cubic feet. It is intended to use these measuring tanks in experiments where measurements of a high degree of accuracy are desired of



FIRST FLOOR PLAN

HYDRAULIC LABORATORY.
UNIVERSITY OF WISCONSIN.

PLATE IV

considerable quantities of water. Their capacity will be carefully calibrated between definite points which will be accurately determined by hook gages. In the volumetric measurement large discharges of water will be allowed to flow into a chamber or group of chambers until it or they are practically filled, then by closing one valve and opening another the discharge will be directed into another chamber or group of chambers while the first is being emptied. By this means experiments can be carried on for an unlimited period of time, and the errors of limited observations thus obviated. By means of proper floor openings these chambers can also be used as suction pits for pump experiments when desired.

One group of measuring chambers is so arranged that they may be utilized for storage or experimental space when not desired for the purpose of measurements. They can be readily opened for such purposes, or closed and utilized for volumetric measurements.

In addition to these large permanent measuring chambers, movable tanks and scales are provided for the measurement of water by weight, for use in smaller experiments. There are also provided various similar movable measuring tanks for the smaller volumetric observations.

Various weir boxes have been provided for the determination of weir conditions and weir constants. These are arranged to discharge into the measuring chambers in the basement, by means of which an accurate determination of the quantity of water flowing in a given time can be made. The weirs can be varied, with a range up to twenty-six inches in width and for heads as high as eighteen inches. In addition to the simple weir boxes there is also provided a double weir box for the investigation of the relations between various shapes of weirs and between free and submerged weirs. A fixed weir is constructed at the central partition, and may be duplicated in form at the lower end of the partition in a movble weir. By raising the end weir any degree of submergence within the range of the apparatus can be obtained in the center weir, and the effect of submergence on the discharge

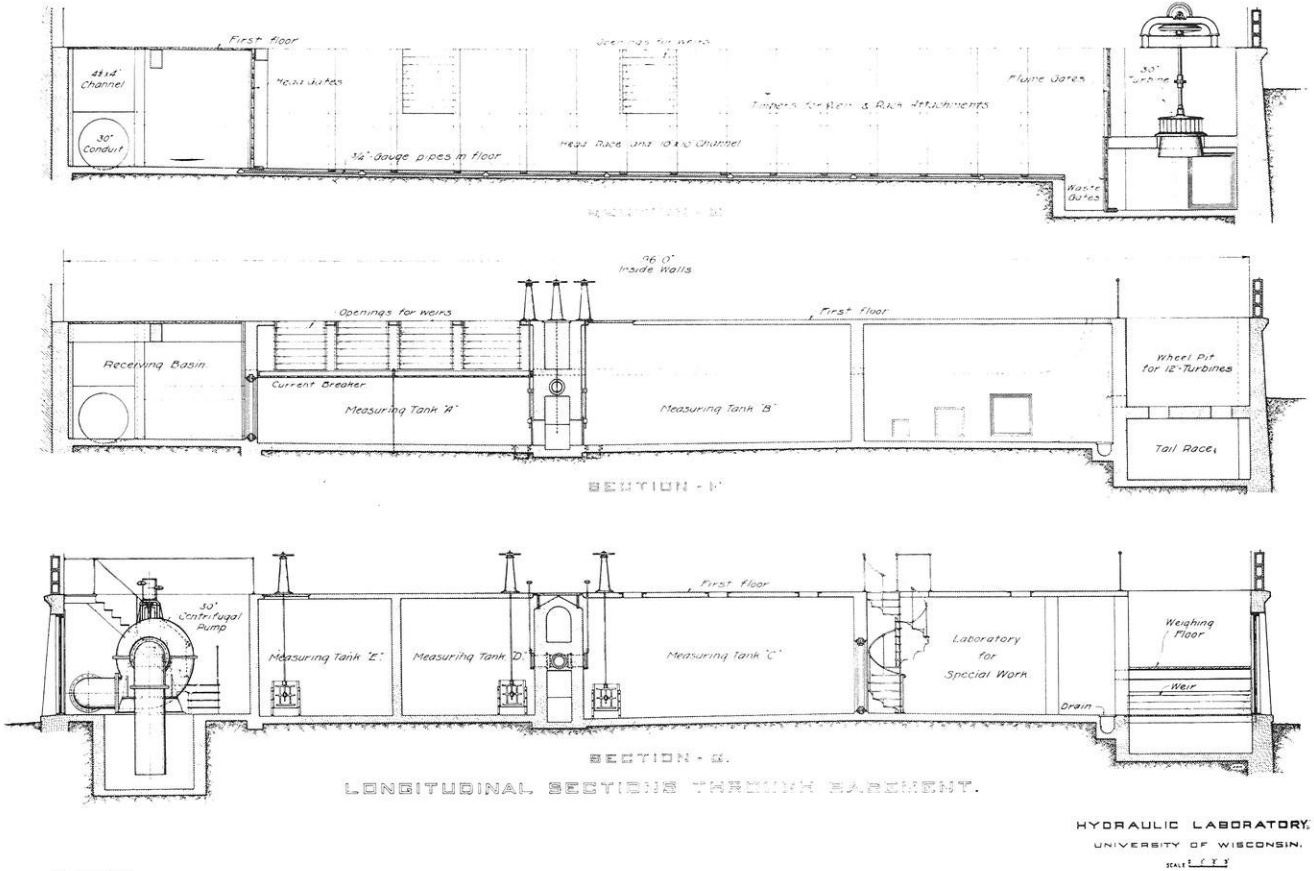
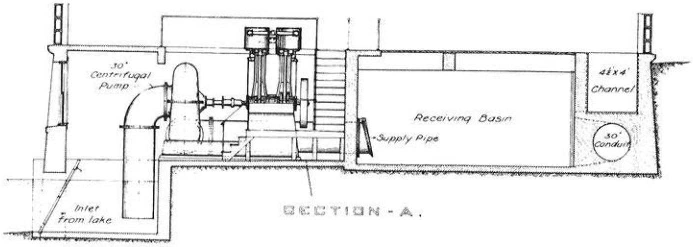

First floor
Openings for weirs
4'x4' Channel
30" Conduit
Head Gates
3/4" Gauge pipes in floor
Head Race and 10'x10' Channel
Timbers for Weir & Rack Attachments
Flume Gates
30" Turbine
Waste Gates
96' 0" Inside Walls
Openings for weirs
First floor
Receiving Basin
Current Breaker
Measuring Tank 'A'
Measuring Tank 'B'
Wheel Pit for 12" Turbines
Tail Race
SECTION - F
30" Centrifugal Pump
Measuring Tank 'E'
Measuring Tank 'D'
Measuring Tank 'C'
First floor
Laboratory for Special Work
Weighing Floor
Weir
Drain
SECTION - G
LONGITUDINAL SECTIONS THROUGH BASEMENT.
HYDRAULIC LABORATORY.
UNIVERSITY OF WISCONSIN.

PLATE V

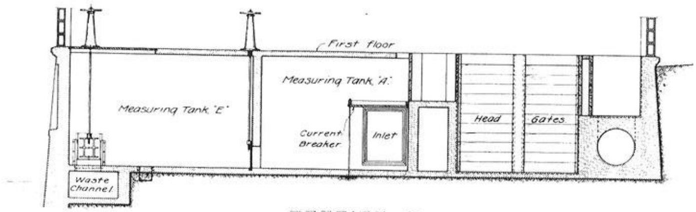
determined by proper comparisons. In addition to this, weirs or other openings of various shapes can be compared by using one of each kind in the two weir openings and observing the relations of the depth of water over each under uniform flow. A second combination of tank and weir boxes gives an opportunity to measure the losses in submerged orifices, and compare the flow with the flow of a standard weir over which the water passes after the orifice is passed. For weirs up to twenty-six inches in width and eighteen inches in depth it is designed to make careful volumetric observations of relative discharge under varying head. For larger weirs and weirs of various arrangements of breadth and section, experiments will be made in the main ten-foot channel. By admitting the water from the receiving chamber through a movable partition into measuring chamber A, the water may be passed over a number of standard weirs of smaller size, such as have previously been standardized volumetrically in the upper laboratory. By this means accurate determination can be made of the discharge of weirs of considerable magnitude in the main channel. It is also designed to arrange for experiments of considerable magnitude on the flow of water through submerged orifices and various forms of short conduits, such as are used in water power work. Studies will also be made of the effects of racks and other obstructions to the flow of water in this large channel.

Four turbines have been purchased, the largest of which, a 30-inch wheel, will develop about fifty horse power under the maximum available head. This turbine is located at the west end of the ten-foot channel, from which it receives its water supply. The water, after passing the wheel, is discharged into a tail race ten feet in width, and in which a five foot depth of flow will be maintained. In this tail race is arranged a standard weir. This weir, in connection with a prony brake on the wheel will permit of the accurate determination of quantities, velocities and efficiencies under various heads and conditions.

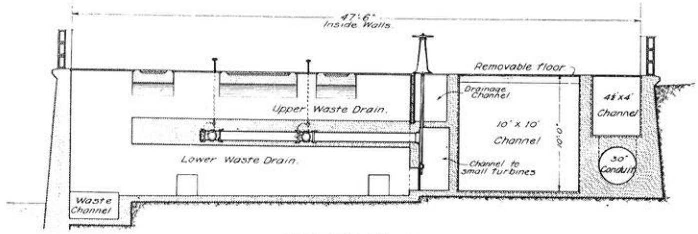
The smaller turbines are set in a separate wheel pit and



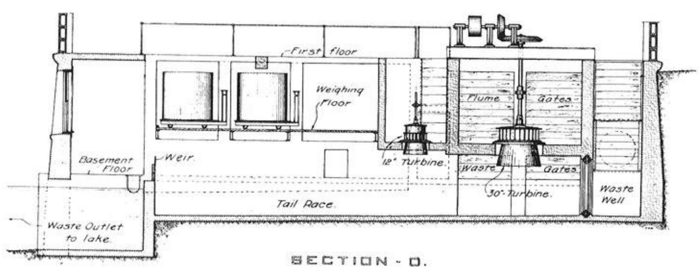
SECTION - A.



SECTION - B.



SECTION - C.



SECTION - D.

SECTIONS THROUGH BASEMENT.

HYDRAULIC LABORATORY.
UNIVERSITY OF WISCONSIN.

PLATE VI

receive their waters through a separate channel, discharging, however, at the present time into the same tail race as the larger turbine.

East of the hydraulic laboratory, directly connected with it and forming an integral part of the plant, are the University tank and pump houses. The pump house is equipped at present with one crank and fly-wheel compound condensing pumping engine, one compound direct acting duplex steam pump and one high pressure duplex steam pump. This station is soon to be reconstructed, greatly increased in size and provided with more modern machinery. The pumps deliver their water into the university mains, the excess being stored in the storage tanks under 78 pounds pressure. This pressure is maintained constant, both with and without the pumps, by air pressure from two air tanks, which contain air at a higher pressure (100 to 150 lbs.). These storage tanks furnish water under the higher pressures needed for many experimental purposes.

From these tanks are operated two types of tangential wheels and a Girard turbine, besides several small water motors, and other apparatus for experimental work under high heads.

The air tanks and the compressor that supply them are also to be utilized for experimental study on the air lift and other types of pneumatic pumps.

The laboratory is provided with two hydraulic rams. A number 20 Rief ram which is in use for general experimental purposes is provided with a two-inch drive pipe which is arranged in six foot sections. The supply tank to the ram is adjustable and can be so arranged that it will supply water to the ram under heads varying from 18 inches to 10 feet. This variation in head and length of drive pipe together with the variation in the pressure of discharge gives a considerable range for experimental work and provisions are made for the accurate determination of the effects of such variations on efficiency and service. A new ram has been especially designed for experimental purposes and will be installed in the

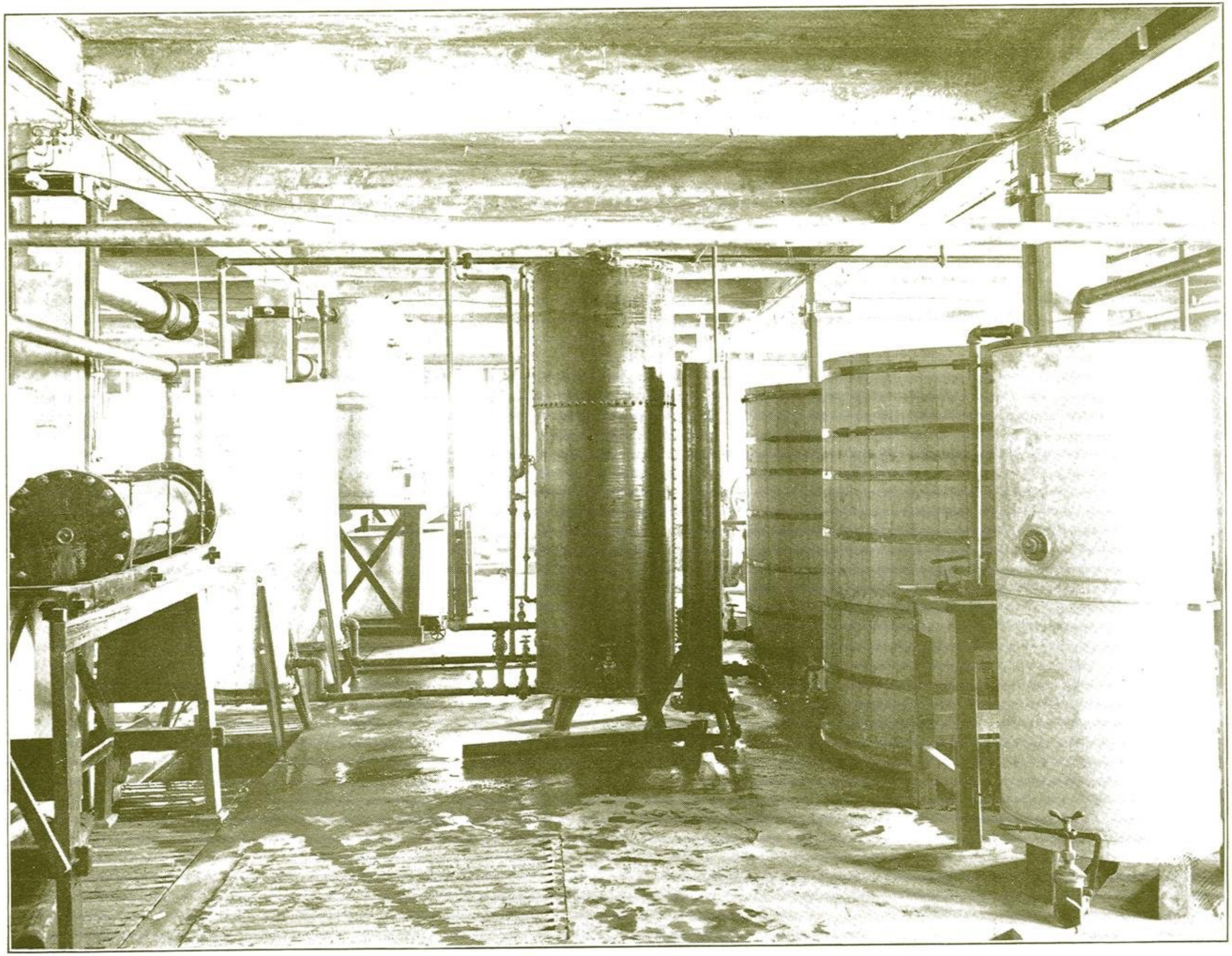


PLATE VII INTERIOR VIEW OF HYDRAULIC LABORATORY SHOWING FILTERS near future. In this ram arrangements will be made for variations in valve area, valve lift, air chamber capacity, etc., for the purpose of a detailed study of efficiencies under considerably greater heads and greater length of drive pipe than are now available. The new ram will also be arranged for 4-inch drive pipe, placing the experiments on a larger and more satisfactory scale. A smaller ram is provided capable of being worked under supply heads up to 50 pounds pressure, but with smaller quantities of water.

Two tanks are provided for the determination of the friction of water flowing through sand and gravel. Plans have also been matured for the construction of a larger sand tank by means of which the laws of the flow of ground water through sands and soils and the principle controlling the operation of wells can be studied.

In connection with the hydraulic and sanitary work, there has been provided in the laboratory, four water filters. Two of these filters are slow sand filters and consist of tanks 6 feet in diameter by 8 feet in height. In addition to these, one Jewell gravity filter has been purchased, and one mechanical filter containing Norwood Strainers has been furnished and presented to the university by the Norwood Engineering Company of Florence, Mass. These filters have been fully equipped for experimental work.

Apparatus has been provided for the study of the flow of water in straight and curved pipes and hose of various sizes and materials, also for the investigation of losses due to sudden expansion and contraction and to valves and other forms of restricted passages. The laboratory is also supplied with various reciprocating pumps, centrifugal pumps, vacuum pumps, jet pumps and various water meters, including those of the disc, piston and Venturi types.

A large assortment of accurate apparatus for the measurement of quantities, velocities and pressures, both in open and closed channels is available in the laboratory.

Arrangements have been made for the careful and accurate investigation of various types of instruments and of the methods used in conducting hydraulic experiments.

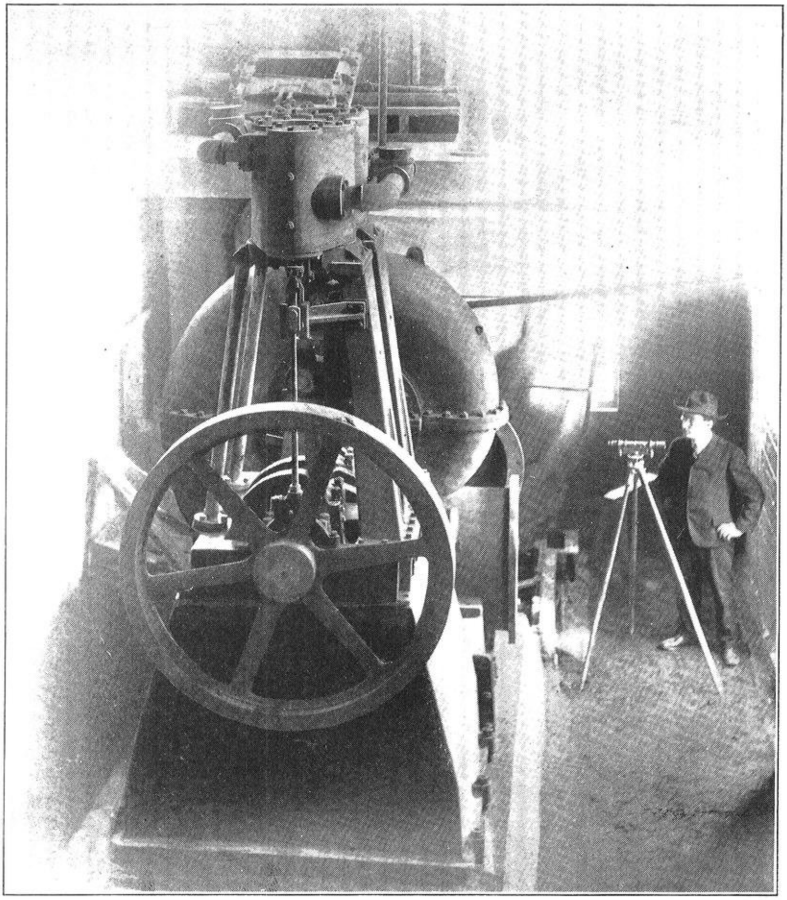


PLATE VIII

CENTRIFUGAL PUMPING PLANT
CAPACITY 25,000 GALLONS PER MINUTE

The regular course of instruction includes a careful selection of such typical determinations as will give the student familiarity with the application of the most important principles encountered in his theoretical work. Opportunities are offered for advanced work in practical hydraulics and hydraulic machinery and for research work on still more advanced lines.

On the upper floor of the laboratory, a lecture room 32x48 feet will be equipped during the coming summer. This

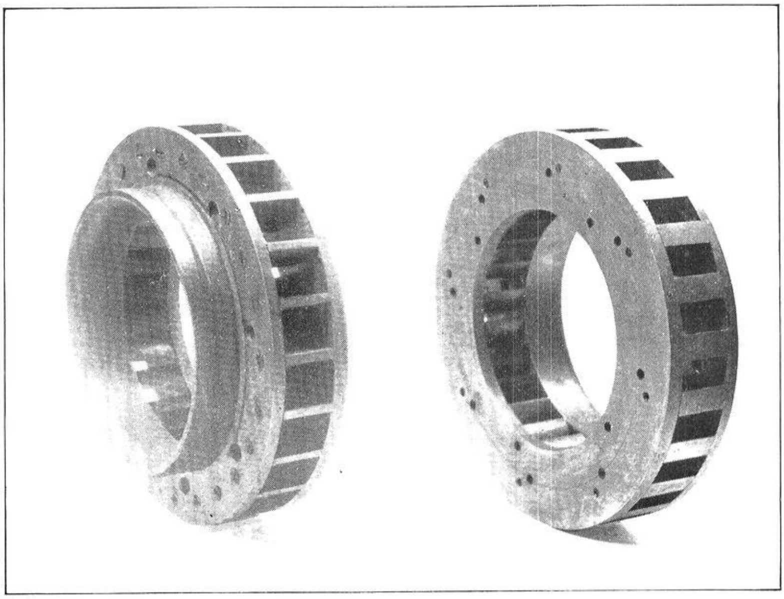


PLATE IX — FORM OF INCLOSED IMPELLER EXPERIMENTAL CENTRIFUGAL PUMP

room will be provided with apparatus by means of which many simple forms of experiments can be performed before the class in theoretical hydraulics, thus establishing by means of actual and visible results the principles which can be emphasized and impressed on the mind of the student only in this way. It is believed that a radical improvement in the method of teaching theoretical hydraulics can be made by this means, and that the information so conveyed will be of a more thorough, lasting and substantial character.

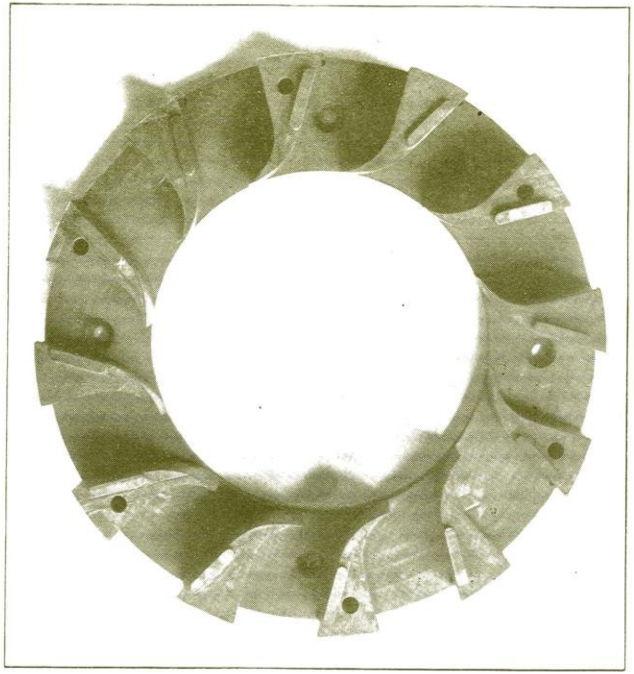



PLATE X

FORMS OF IMPELLER BLADES, EXPERIMENTAL CENTRIFUGAL PUMP

As has been before intimated, considerable attention will be given in this laboratory to advanced and research work. It is intended to direct advanced and thesis work into lines where further information is desirable, and to so direct and check such work by expert advice and supervision that the results obtained will be reliable and of general value. Results of interest will be further investigated, checked and extended, and as fast as the conditions seem to warrant, will be published.

Special lines of important research work will be investigated by expert experimenters. One special line of experimentation which has been under way for about a year is in relation to centrifugal pumps. For this purpose a special pump has been designed which is sufficiently flexible to admit of a wide range of change in detail. Six forms of cases have been designed, some of which can also be varied by the addition of various forms of fixed turbine blades. Twenty-four forms of closed impellers, in which the number and shape of the impeller blades vary, have been constructed. The general form of the closed impellers is shown in Plate 9, and two forms of the impeller blades are shown in Plate 10. All of these are to be increased in number and varied in design as the results of the experimental work may warrant. This experimental pump is operated by a variable speed electric motor, and can be run at a wide range of speed. The motor current is determined by the most accurate forms of laboratory testing instruments, and the motor losses are determined with great care, so that the actual power reaching the pump is known with a considerable degree of accuracy. Provisions have been made for a careful study of pressures and velocities in the cases and passages of the pump, and the discharge is obtained over a carefully calibrated weir.

The object of this series of experiments is the establishment of the laws of flow in machinery of this type and the determination of the features which will result in high efficiencies and permit of the attainment of high heads. A special vertical type of centrifugal pump, intended primarily for

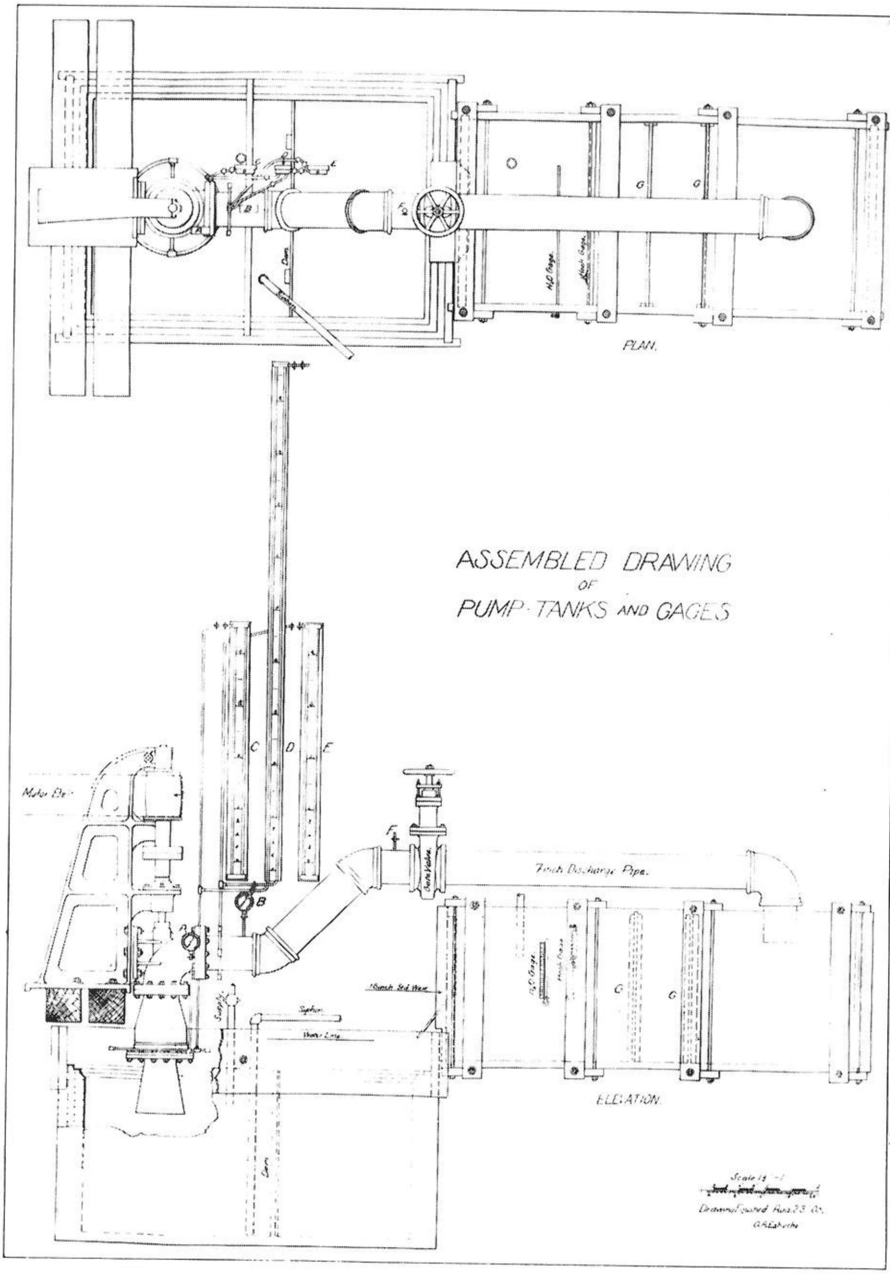


PLATE XI EXPERIMENTAL VERTICAL CENTRIFUGAL PUMP deep well work, designed by Mr. John W. Alvord, of Chicago, has been presented to the laboratory by Mr. H. H. Porter, president of the Chicago Clearing and Transfer Company. The general form of the pump as arranged for testing is shown in Plate II. It is also being tested in this series of experiments, which, it is expected, will also be extended to pumps of various standard designs and manufacturers.

The construction of this laboratory marks a distinct advancement in the opportunities and character of hydraulic instruction at the University of Wisconsin, and it is hoped that the opportunities offered for advanced and research work may have a considerable influence on the advance in the knowledge of this important subject.

DISPOSAL PLANTS IN THE STATE OF WISCONSIN.

JOHN F. ICKE, CITY ENGINEER, MADISON, WIS.

The rapid growth of the cities in this state and the resulting necessity of providing for better sanitation has naturally lead to the building of water works and drainage systems; the first to provide fire protection, primarily, and a purer water, secondarily; the second to remove the wastes incident to any community by collecting them in a common carrier and generally emptying them into the nearest water course.

Unfortunately it has not always been possible to select a water supply free from danger of pollution. While the system was still in its infancy the source of supply in many cases was all that could be desired, but the increase in population and number of cities has often made changes in supply necessary. Often a little foresight would have shown that some sources of supply, although pure in the beginning, could not remain so indefinitely, especially not after the completion of proper drainage systems. In many cases a river, with cities on its banks, as yet unprovided with drainage systems, served as a satisfactory water supply. The building of drainage systems, however, soon required the purifying of the wateror of the sewage, or even made a change in the source of supply necessary.

Many of the cities on Lake Michigan and Lake Winnebago are using these as sources of supply, while at the same time they are running their drainage into them. In some cases the water intake reaches out to a point where the danger from pollution is quite small; in others the water is purified before being used, and possibly in some cases, the sewage will eventually have to be purified before being passed into the lake.

A number of cities in this state, as yet but partially sewered, and not situated on any of the larger streams or lakes, have been compelled to empty their sewage in small streams or creeks, which but for the sewage flowing into them, would at times be running dry. Such a procedure might be tolerated for a time, while the number of connections was small, but obviously could not continue indefinitely with the growth of the drainage systems.

The small streams and creeks are not suitable as sources of water supply, but in flowing through meadows and pastures, are often used by cattle for drinking purposes. The owners of land adjacent to such streams can demand that the water flowing through their lands shall be uncontaminated by the wastes of any communities above them, and can compel such communities to purify their sewage before discharging it into the streams. To communities confronted with such a demand, the question of adequate ways and means for the purification of sewage becomes an important one. Until about eight or ten years ago it would have been difficult, if not wholly impossible, to suggest an economical method of purifying the sewage of a great many cities in this country which are now provided with purification works.

One of the methods of purification most widely used before that time, made use of chemicals to precipitate the solids in the sewage, the effluent from the process being passed through sand filters to complete the purification. Another method was to use the raw sewage to irrigate land from which crops were raised, and still another method was to pass the sewage onto the land, usually sandy in nature, without attempting to grow crops thereon. All of these methods were expensive, both in first cost and in cost of operation. A serious problem confronted the small cities at this time, when called upon to purify their sewage.

Within the last eight or ten years the methods of purifying sewage have been perfected along liues both economical and effective. The same methods have been equally well adapted for large and small communities. No expensive chemicals enter into the processes, but use is made of the innumerable bacteria naturally present in sewage and capable of increase and development under favorable conditions. Progress in the future will no doubt lie in learning and perfecting the conditions of the growth and development of the bacteria.

Present Processes in Use.

The cities of Berlin and Paris dispose of most of their sewage by irrigating with it large areas of land lying near them. The land, sandy in nature, and naturally very unproductive, is made to grow crops, the sale of which helps to defray a large part of the cost of disposal. Not all cities are so fortunate in having waste land near by and have been compelled to prepare artificial beds of sand which have been used as filters, primarily, it being impossible to grow crops on them because of the high rates of filtration employed. Quite an impetus was given this method of disposal after the noteworthy experiments of the Massachusetts State Board of Health, which for the first time made a study of filtration along scientific lines. These experiments showed that from 20,000 to 100,000 gallons of sewage could be disposed of, per acre of sand bed, the amount depending upon the strength of the sewage and upon the care put upon the beds. The practical operation of numerous filter beds showed that a removal of the suspended matter in the sewage would greatly decrease the necessary area of filter.

Septic Tank.

The most effective way thus far found of removing a large part of the suspended matter in sewage is by allowing it to pass slowly through a tank where a sedimentation of the suspended matter can take place. A portion of the suspended matter is acted upon by the bacteria which change it into harmless liquids and gases. The solid residue remaining must be removed from the tanks from time to time. The effluent from the tank in many cases needs no further purification, and can be turned directly into any water course without creating a nuisance. In other cases it must pass through some form of filter before this can be done. Ordinarily the tank is built of masonry or concrete and is several times longer than it is wide, and from four to ten feet deep. In some cases the tank is surmounted by a frame or brick building; in other cases it is covered by a simple roof a few feet above the level of the sewage. The sewage enters the tank at one end at an elevation three or four feet below the level of the sewage in the tank, flows slowly through it and passes out at the other end, usually over some sort of a weir. No universal rule can be given for determining the correct size of a tank. Some tanks will fill with sewage in six hours, while others will require more than twenty-four. Some require the removal of the accumulated sediment every four or six months; others every two or three years. In several instances the tanks have been designed with several compartments, all, or only a part of which, may be used at one time, giving us the so-called "elastic" tank.

The septic tank will no doubt remain a prominent feature of every disposal plant, and we hope that the future will give us some rational method of determining the size of tank for a sewage of given strength.

Filter Bed.

Although the sewage after passing through the septic tank is purified about 40 per cent., there are still enough impurities in it to cause a nuisance if discharged into a watercourse where very little dilution can take place. In such cases the effluent must be passed through some sort of filter to give it the additional purification desired. If the exigencies of the case demand a high degree of purification, the sand filters will be chosen; if not, then some form of rapid filter, either of cinders, coke or broken stone.

There are several types of rapid filters now in use. First, the so-called intermittent continuous filter; second, the contact bed. The effluent from the septic tank is usually collected in an auxiliary basin, from which it is discharged onto the filter bed from time to time. In the case of the continuous intermittent filter, the sewage filters through and is collected and carried away in underdrains; in the case of the contact bed, the sewage is automatically held in contact with the filtering material for several hours, and is then allowed to slowly drain away. The contact bed requires a water-tight embankment, while the intermittent filter does not, and is therefore somewhat more expensive. These rapid filters are are able to purify from 400,000 to over 1,000,000 gallons per acre per day.

Disposal Plants in Wisconsin.

The city of Madison for some time operated a chemical precipitation disposal plant, but now operates a septic tank and an intermittent continuous filter bed; the city of Fond du Lac operates a septic tank and a cinder contact bed; the city of Wauwatosa operates a septic tank and sand filters; the city of Lancaster, two septic tanks; the city of Berlin, a sand filter, to which raw sewage is applied.

The city of Marshfield has constructed a septic tank and cinder filter beds; the city of Waukesha operates a septic tank without filters, while the city of Monroe has a septic tank.

Some of the above plants possess some very novel features, by the use of which the designers have been able to obtain highly satisfactory results, while using extremely high rates of filtration.

Sewage Disposal at Madison, Wis.

Madison, the capital city of the state of Wisconsin, is beautifully situated on a comparatively narrow strip of land lying between Lakes Mendota and Monona. The shortest distance between the two lakes is about 3,000 feet. The land bordering Lake Mendota is, generally, some 60 feet higher than the water, while the land along Lake Monona is about 40 feet above the water in the lake. The two lakes are connected by the Yahara river, a gate at the head of which, regulates the height of Lake Mendota, keeping it about 5 feet higher than Monona. The greater portion of the city naturally drains into Lake Monona. The soil is a glacial drift, consisting of clay, gravel and sand.

The two lakes are a source of pleasure and profit for the people of Madison, and will become more and more so as the city grows.

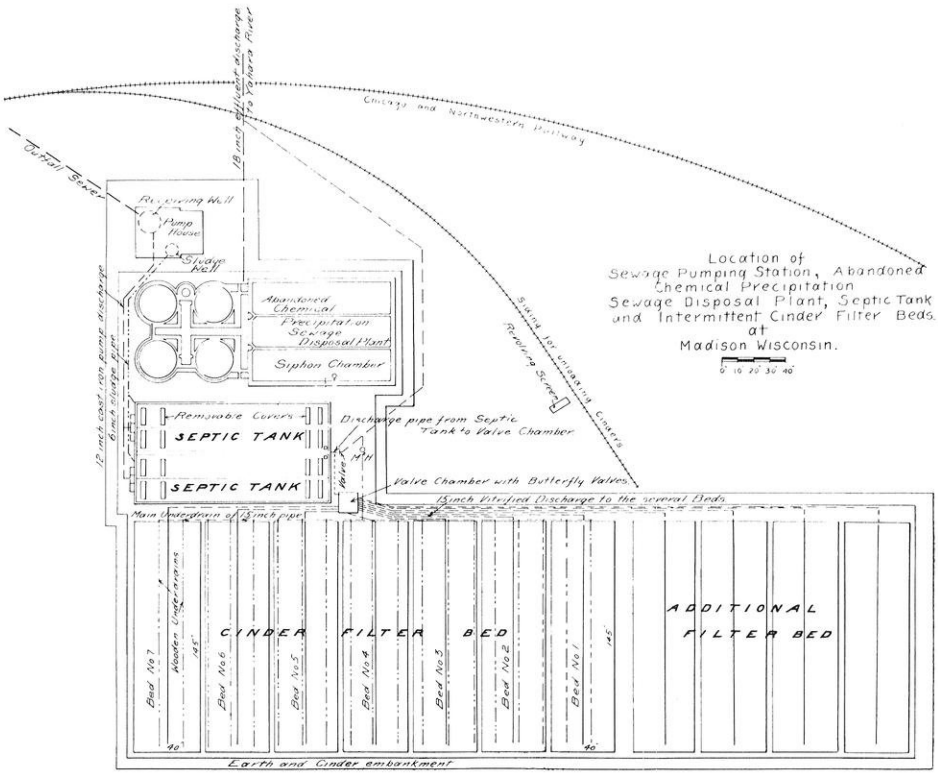


FIG. I

Madison is distinctly a residential city. It is the seat of the University of Wisconsin, with an attendance of 3,000 students. There are few factories and industries pouring manufacturing refuse into the sewers. The population is about 25,000 and is increasing rapidly.

The separate system of sewers is used, although considerable roof water is allowed to enter the sewers, principally from the business section of the city. In 1885 a system of sewers for the central portion of the city was designed and built. The topography of the city did not allow of a single discharge for the whole city, consequently the city was divided into several districts, the main from each district having a separate discharge into the lake. The vitrified pipe main usually ended near the shore and was continued into the lake several hundred feet with cast iron pipe.

The sewers built in 1885 drained only the high portions of the city, it being impossible to sewer the land along quite a number of the lower streets until an intercepting sewer and a pumping station were constructed. An intercepting sewer over two miles long, for the most part twenty-four inches in diameter, was constructed in 1895 and a pumping station in 1898.

The total number of connections in 1900 was 1621.

The total number of sewer connections at this time is about 2600.

The average flow of sewage during the past year has been 1,600,000 gallons. The water supply is from artesian wells which furnish a pure but quite hard water.

A large number of the sewers are laid below lake level and collect considerable ground water. During heavy storms and continual rains the intercepting sewer flows as an inverted siphon. At such times a sedimentation takes place and when the rains cease and the pumps succeed in lowering the water, a very concentrated sewage results for some time.

Agitation for a Disposal Plant.

As mentioned heretofore, the original system was completed in 1885. Up to the year 1893 no very serious complaints were made against the practice of emptying the sewage into the lakes, but about this time a few dry seasons caused low water in Lake Monona and the sewers became nuisances. Weeds were multiplying along the shores at an alarming rate; in fact, conditions became so bad that the city in 1895 was made a defendant in two suits for damages of $5,000 each for maintaining a nuisance.

The engineers were instructed to prepare plans for a disposal plant. The plans proposed the use of lime to precipitate the solids and a sand filter to complete the purification.

Before, however, anything further was done a committee was appointed to ascertain whether there was some land near by suitable for land treatment of the sewage. The committee reported that twenty-five or thirty acres lying a few miles west of the city could be had for that purpose.

The estimated cost of pumping station, pipe line, preparing beds, etc., was $60,000.

The engineers were instructed, however, to proceed with their plans for a chemical precipitation plant, which was to consist of four rectangular tanks of 100,000 gallons each and three and one-half acres of specially prepared filter beds.

While the engineers were busy with the details of their design a representative of the American Sanitary Engineering Company represented to them the merits of a plant which they were desirous of introducing into this country from England. The precipitant was to be ferrozone, and the chief element in the filter was to be a powerful oxidizer—polarite.

The company was willing to guarantee results and give a satisfactory bond. Acting upon the advice of the engineers, the city contracted with the company to install a plant for the sum of $37,200.

Some of the provisions of the contract may be of interest in showing the great faith of the promoters in the chemical purification of sewage. The contract provided that "the effluent shall be at least as pure in all respects as the effluent from the sewage of the city of Madison would be if treated with lime, alum or copperas, or lime and alum, or lime and copperas, or any combination of these, at the discretion of the city surveyor, and afterwards filtered through five feet of specially prepared beds of sand, operating at a rate of 200,000 gallons per acre per day." That the effluent "shall be as pure as the water of Fourth lake (Lake Mendota), as shown by an analysis of said water made by Prof. Daniells, of the State University, at the request of the city, in the year 1888, and published in the Water Commissioner's report of that year."

The cost of operation was not to exceed $3,600.00 per year when treating 600,000 gallons daily.

The plant was put in operation by the company in May, 1899, and operated until January 12, 1900, and was then abandoned by the company. The city continued to operate it until January 1, 1901, and then abandoned it also. The cost of operating the plant at this time was $7,360.00 a year, while treating about 600,000 gallons daily, or about twice the sum given in the contract.

In the spring of 1900, Prof. Turneaure, now dean of the College of Engineering, was elected city engineer, and soon after made an extensive report on the operations of the disposal plant. He advised the city to abandon the plant and substitute for it a septic tank and a rapid filter. The plant was abandoned; the bond of the surety company was declared forfeited, and the city attorney was directed to bring suit to recover the money already paid. Suit was begun and was won by the city in the circuit court, and upon appeal in the supreme court.

The plans for the septic tank were prepared during the winter of 1900–01, and work was begun in February. The tanks were placed in operation in August, 1901. The filters were begun in the fall of 1901, and completed the next summer.

Pump House.

The intercepting sewer empties into a well at the pumphouse at elevation minus 11.6, city datum, approximately the elevation of lake Monona. The well is thirteen feet in diameter, with its bottom about five feet below the invert of sewer.

The well has two centrifugal pumps, a 6-inch and an 8-inch on a level with the invert of the sewer. The power to run the pumps is furnished by 3-12 H. P., Fairbanks-Morse gasoline engines belted to a line shaft. The lift of the pump varies as the level of the water in the well fluctuates, but the maximum is about twenty-five feet. The cost of gasoline for the year ending December 31, 1905 was $2,148. The average sewage pumped was 1,600,000 gallons daily.

SEPTIC TANKS, MADISON WIS.

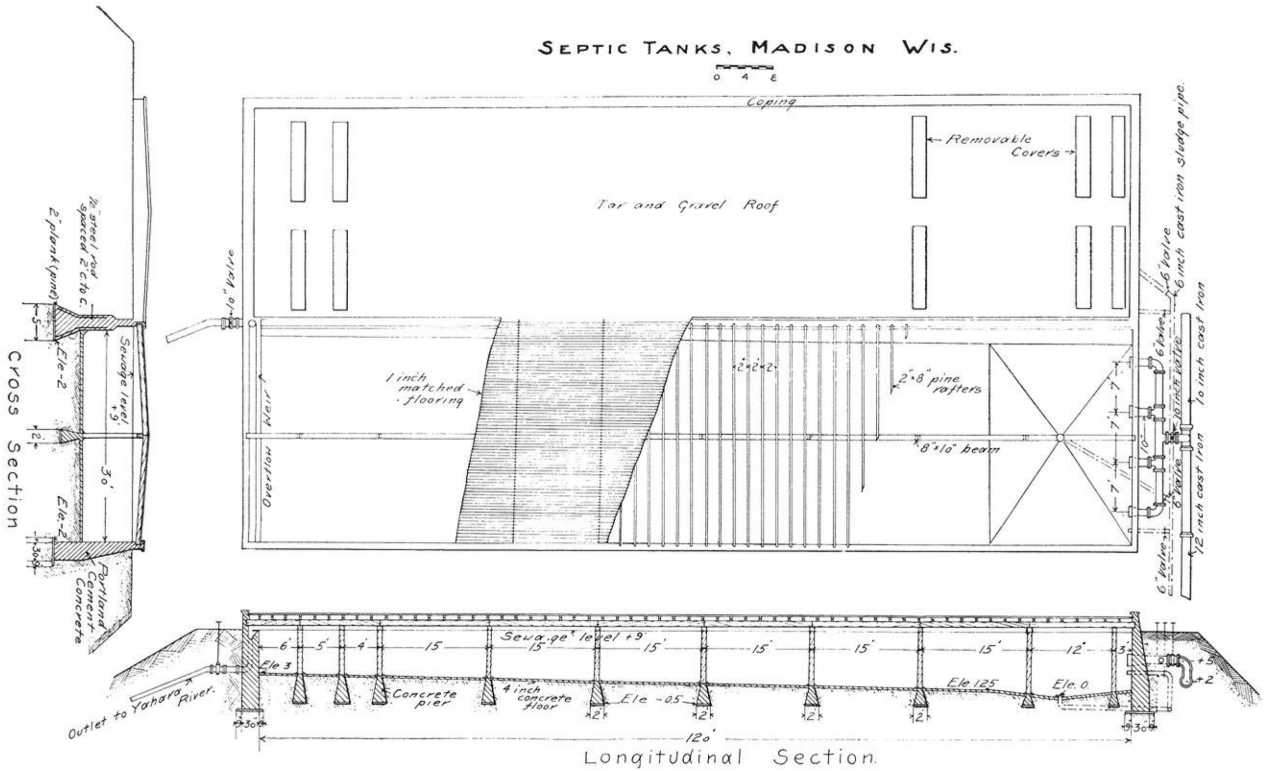


FIG. II

Septic Tanks.

The accompanying plate gives an idea of the size and dimensions of the septic tanks, of which there are two, side by side, each with a capacity of 200,000 gallons. The sides and bottom of the tanks are of Portland cement concrete, and have a tar and gravel roof a few feet above the level of the embankments. As the sewage enters the tanks it is distributed somewhat, by means of the 4-bell openings. It passes out of the tank over a perforated plank and may be diverted into the river or into the valve chamber. When the tanks were first set in operation, baffle boards were placed every fifteen feet, the intention being to intercept as much of the sludge at possible, and keep it at the upper end of the tank. We succeeded a little too well and had a scum of over two feet in depth in the first two sections and gradually growing less and less toward the outlet end. A more even distribution was obtained by removing all of the baffle boards, except the one just in front of the overflow weir.

The tanks are each 120 feet long and 30 feet wide. The sewage at the entrance end has a depth of 9 feet, and at the outlet 6 feet. The capacity of each tank being 200,000 gallons, gives a rest period of about 6 hours, with the present flow of sewage. The tanks were placed in operation August 17, 1901, and have been operated ever since. The first removal of sludge was made in December, 1902, or after running for 16 months. The effluent from the tanks at this time contained a large number of flocculent particles in suspension, having a maximum width of about 1-16 of an inch. When the tanks were first placed in operation, and for ten months thereafter, the usual, finely, suspended particles were present but did no harm. When, however, the larger particles of matter began to appear, they interfered with the operation of the filter beds in a manner hereafter described. By the month of June, 1902, a thick scum had accumulated on the tanks, about 24 inches at the upper end and 3 inches at the lower. A sediment of about the same depth had collected on the bottom. This sediment was very light and was easily put in motion. Large bubbles of gas would form in this sediment and would disturb it in coming to the surface. It was this sediment that was carried over the weir and gave us trouble from June until the tanks were cleaned in December. The scum in the upper end of the tank was so dense that it was easily shoveled into wheelbarrows and wheeled away. One man shoveling and two men wheeling away, worked about a week at this. The scum was wheeled a distance of 250 feet and dumped on the marsh. After removing as much of the scum as possible, the contents of the tanks were drained into the old sludge well in the pump house. This sludge well had formerly been used for the same purpose when the chemical plant was in operation. A triplex pump was used to raise the sludge into a trough which carried it into the marsh where it was held by embankments, the liquids seeping away. The triplex pump gave endless trouble from pieces of wood, cork, etc., getting under the valves. It took about a week to empty the tanks and remove the sediment. The total cost of cleaning the septic tanks for the first time was about $60.00.

The tanks were again put in operation and were not cleaned again until September, 1903, or at the end of about $7\frac{1}{2}$ months.

This time a 4-inch centrifugal pump run by 2 H. P. motor was used to empty the tanks. The time of cleaning was shortened to about 4 days. The contents of the tanks were pumped into the old filters of the chemical plant, and the water allowed to filter away. The sediment, after having been thoroughly drained, amounted to nearly 100 cubic yards.

The centrifugal pump gave us a great deal of trouble. We now have a very neat and efficient way of handling our sludge by means of an elevator, which consists of an endless chain with buckets attached, each bucket capable of holding about one quart of material. The endless chain passes around a sprocket wheel within a foot of the lowest point of the tank and around a sprocket wheel at a height of 16 feet above the roof of the tank. The contents of the buckets are emptied into a wooden trough which carries the sludge to the sludge bed. One tank is emptied at a time, while the other takes all the sewage during the interval.

One elevator is placed for each tank. The power for running the elevator is generated at the pump house. A two-horse power motor for running the elevator, with necessary speed reducing pulleys, is mounted on a movable platform and is shifted from one elevator to the other as needed. That portion of the elevator above the roof is housed in a suitable manner.

The cost of the septic tank complete was $7,047.

Original Filter Beds.

The contract to build the cinder filter beds was entered into in June, 1901. The contractor finished beds 1 and 2 by the 1st of December, and the remaining beds the following summer.

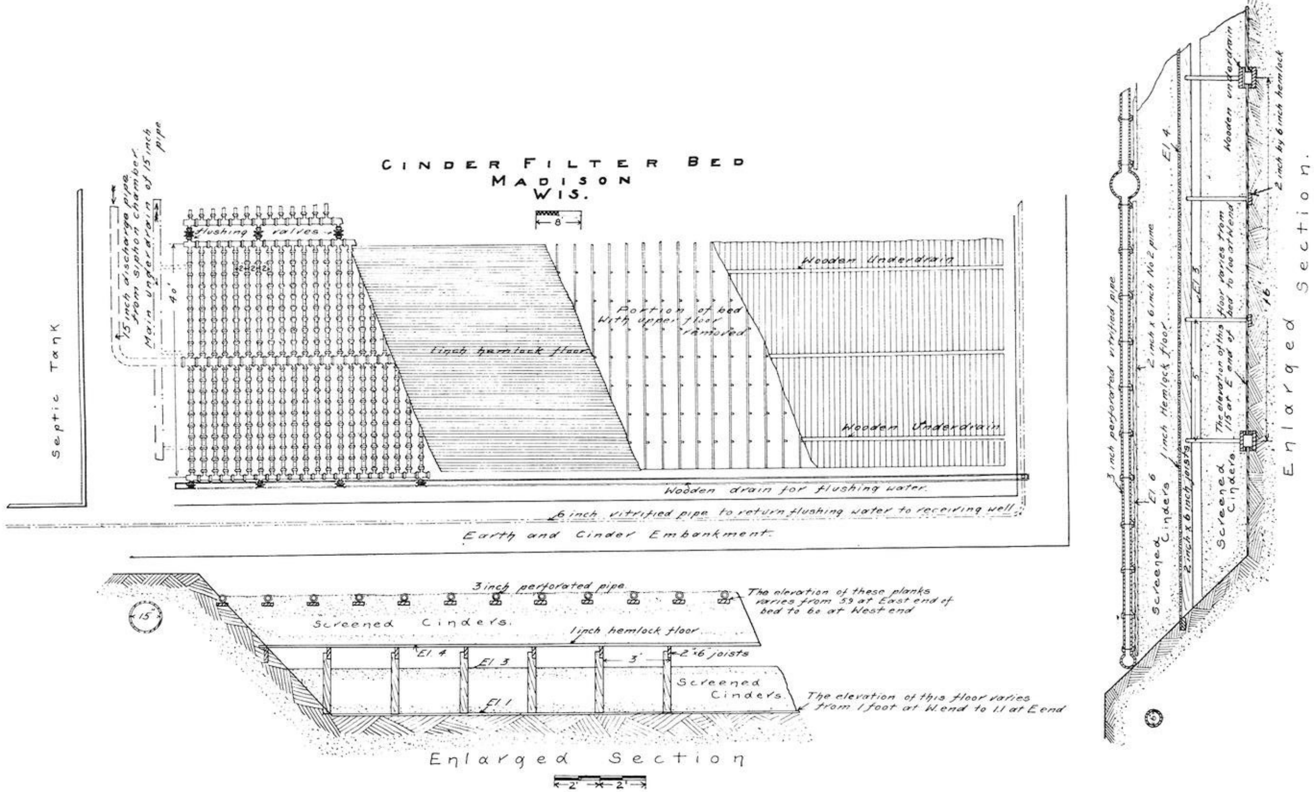
The accompanying plate shows the construction of the beds.

The site of the beds was a marsh, with an elevation of six inches above the Yahara river. The elevation of the floor was made 1, city datum, or about 1½ feet above ordinary water in the river. High water in the river rarely reaches elevation 0, so a fall of 1 foot, at least, is had between the filter beds and the river, a distance of about 700 feet.

The cinders were obtained from the following sources:

110 cars from Rockford, Ill., 68 from Portage, Wis., and 20 from local sources. They cost the city $5,745.

The total number of yards of screened cinders in the beds amounts to 7,000. It cost the contractor about 30 cents a yard to unload, screen and place the cinders. The screen was a cylindrical one, 4 feet in diameter, revolving about 30 times a minute. It had an inclination of about 1 foot. The upper or first screen was 4 feet long, and had a mesh of ⅜ inch; the second was 3 feet long, and had a mesh of ½ inch; the third was also 3 feet long, and had a mesh of 1 inch. A



CINDER FILTER BED
MADISON
WIS.
Septic Tank
15 inch discharge pipe from siphon chamber
Main underdrain of 15 inch pipe
40'
flushing valves
1 inch hemlock floor
Portion of bed with upper floor removed
Wooden Underdrain
Wooden Underdrain
Wooden drain for flushing water
6 inch vitrified pipe to return flushing water to receiving well
Earth and Cinder Embankment
3 inch perforated pipe
The elevation of these planks varies from 59 at East end of bed to 66 at West end
Screened Cinders
1 inch hemlock floor
2"x6 joists
El. 4
El. 3
El. 1
3'
Screened Cinders
The elevation of this floor varies from 1 foot at W. end to 1.1 at E end
Enlarged Section
3 inch perforated vitrified pipe
El. 6
2 inch x 6 inch No 2 pine
Screened Cinders
1 inch Hemlock floor
El. 4
2 inch x 6 inch joists
El. 3
Screened Cinders
The elevation of this floor varies from 115 at E end of bed to 100 at W end
Wooden underdrain
2 inch by 6 inch hemlock
Enlarged Section.

FIG. III

dynamo, used during the night to furnish light for the plant, was used during the day, free of expense to the contractor, to run a 2 H. P. motor belted to the revolving screen. The contractor received $9,180, which, added to the cost of the cinders furnished by the city, made the cost of the beds $14,925, or approximately $15,000.

The area of the beds is one acre.

The beds consist of a floor of 1-inch rough hemlock boards, with wooden underdrains every 16 feet; a lower bed of fine cinders 2 feet deep; a second or upper floor of 1-inch boards 4 inches wide, with $\frac{1}{4}$-inch openings between them; an upper bed of coarse cinders 2 feet deep, and supporting the distributing system of 3-inch perforated vitrified pipe. The upper 6 inches of the bed are screened, head-end, locomotive cinders. The cinders that passed through the first screen were rejected as material unfit for the beds, and were used in the embankments instead. The cinders that passed through the second screen were used in the lower bed and the upper 6 inches of the upper bed, and those that passed through the third screen were used in the lower 2 feet of the upper bed.

In a portion of bed No. 6 the upper floor is omitted and the bed made solid from top to bottom, using cinders from the third screen.

Distributing System.

Down the center of each bed is a line of double "Wyes" decreasing in diameter from 15-inch to 8-inch. Three inch, perforated, vitrified pipe laid on 2-inch planks branch from the "Wyes" and end in a line of "Tees," every seventh one of which is a cross, connected to a flushing valve. The line of "Wyes" down the center of each bed continues as a 15-inch pipe to the valve chamber and connects with a butterfly valve.

The flushing valves empty into wooden drains which carry the water to the end of the bed, to be returned to the receiving well through a 6-inch pipe. All joints are made with Portland cement mortar. A galvanized iron disc is inserted in the line of "Tees" every 7th pipe, thus dividing the 3-inch pipe into sections, each provided with a flushing valve. A 2-inch wrought iron pipe, with a valve, connects each line of 15-inch pipe with the main underdrain. By opening the valve the whole distributing system for the bed can be drained.

Operation of beds.

To dose any particular bed it is only necessary to open the butterfly valve in the dosing tank for that bed. This is done by the engineer from the pump house by means of a wire from each valve strung to the house for that purpose. To change the flow from one bed to another, the engineer has only to operate the proper valves. The system of distribution is perfect. From each hole in each pipe, a fountain of water spurts, varying in height for the different beds. The velocity of flow through the pipes is slow and a sedimentation of the fine particles of suspended matter takes place in the 3-inch pipes. This was especially the case when the effluent from the septic tanks contained the abnormal amount of suspended matter mentioned, as having occurred about nine months after the tank was started. The flushing valves did good service at that time. It was necessary to flush the pipes every day to prevent their clogging. After cleaning the septic tanks it was unnecessary to flush the pipes for weeks at a time.

The beds must be cleaned from time to time, depending upon the condition of the effluent from the tanks. It has been found that by cleaning the tanks every 4 months, we succeed in getting an effluent that is easily handled by the filters. We find it necessary to remove about one-half inch of dirt and cinders every six weeks or two months under these conditions.

It takes two men two days to clean a bed. The scrapings have been used to fill the adjacent marsh. From time to time new, screened, head-end, locomotive cinders have been placed to bring the beds to a level with the tops of the pipe. The cost of cleaning the beds and replacing the cinders has been about $500 a year.

During the last two winters the beds have not been operated during the months of December, January and February.

The effluent from the beds is clear and odorless. Some chemical analyses are given a little further along.

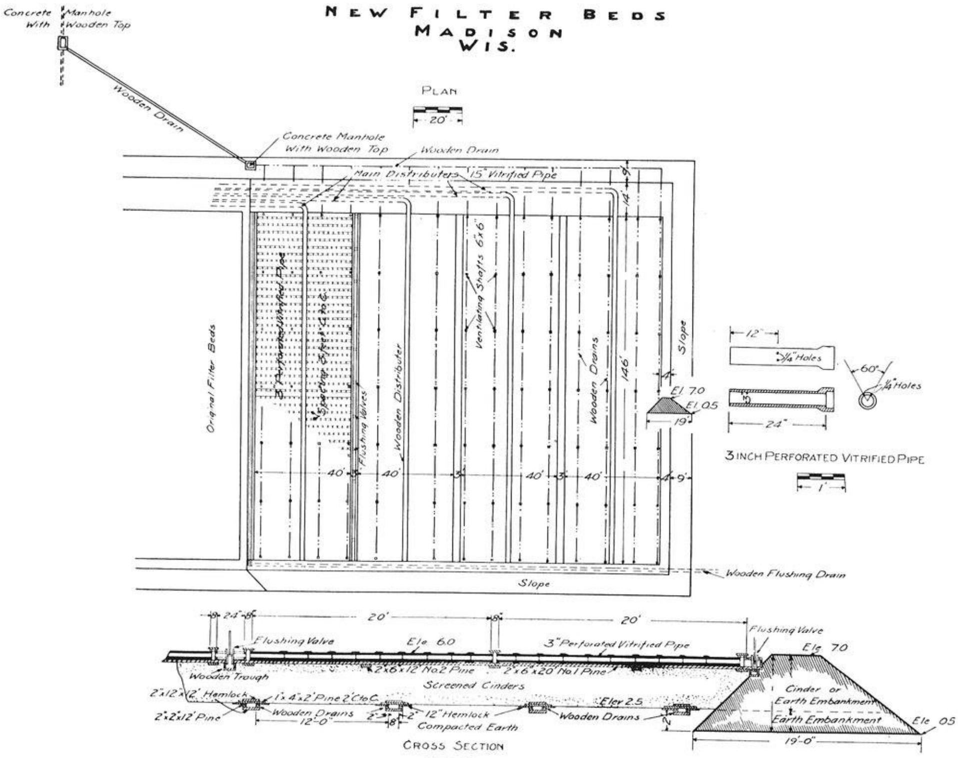


FIG. IV

New Filter Beds.

Four new filter beds covering an area of four-sevenths of an acre were built during the summer of 1905. These are shown on the accompanying plate. The new beds differ from the original ones in several respects. They are solid and vary in depth from two and one-half feet to three and one-half feet; the variation in depth being due to the slope of the bottom. The top of the bed is level. The upper twelve inches are clean, head-end locomotive cinders; the remaining cinders are a mixture varying from one-half inch to one and one-half inches, free from dust and dirt.

The main distributor instead of vitrified double wyes, as in the original installation, is made of two-inch plank. The three-inch perforated pipes rest on 2-inch by 6-inch planks, securely fastened at the end to the main distributor. A tight joint is made at the point where the 3-inch pipe enters the sides of the distributor, and again where it enters the flushing drain, which drain is likewise built of wood instead of vitrified tees, as in the original beds. The construction of the distributing and flushing drains out of wood has been found to be excellent, doing away with the annoyance incident to the use of vitrified pipe in the original beds.

Each underdrain has a number of ventilating shafts, six inches by six inches in cross-section, reaching from the top of the drain to a foot above the top of the bed. The shafts serve as ventilators and a convenient means for examining the condition of the underdrains.

Four additional butterfly valves were placed in the valve chamber, one for each new bed.

Chemical Analyses.

During the winter of 1901 and '02 an interesting series of analyses were made of the sewage effluents from the septic tanks and from the filter beds.

A few representative analyses and remarks follow:

Analyses for Week Ending December 14, 1901.

(Parts per 100,000.)

SEWAGE.

Date.	Total Solids.	Solids in Suspension.	Solids in Solution.	N as Free Ammonia.	Albuminoid Ammonia.			N as Nitrites.	N as Nitrates.	Chlorine.	O Consumed in 10 min.
					Total N.	N in Susp.	N in Sol.				
December 9 ...	82	21	61	2.88	1.08	.....	.....	Trace	0	7.0	13.6
" 10	82	25	57	2.88	1.14	.....	.....	"	"	8.3	14.0
" 11 ...	77	15	62	2.72	1.02	.....	.....	"	"	7.4	13.7
" 12	86	25	61	2.12	1.52	....	.....	"	"	7.9	14.7
" 13	64	17	46	2.40	.95	.....	.....	"	"	5.5	12.1
" 14	92	25	67	1.56	.78	.....	.....	"	"	7.4	12.0
Average	80	21	59	2.59	1.05	.....	.....	"	"	7.2	13.3

SEPTIC TANK.

Date.	Total Solids.	Solids in Suspension.	Solids in Solution.	N as Free Ammonia.	Total N.	N in Susp.	N in Sol.	N as Nitrites.	N as Nitrates.	Chlorine.	O Consumed in 10 min.
December 13....	60	14	45	2.40	.75	.....	.....	.....	.....	5.6	10.2
" 14....	71	6	65	2.28	.45	.....	.....	.....	.....	7.4	9.5
Average	65	10	55	2.34	.60	.....	.....	.....	.....	6.5	9.8

Analyst—Icke.

REMARKS.

On December 9–10–11 and 12 we had the ordinary flow of sewage.

It rained December 13th and the flow was increased. The chlorine determination shows this.

Analyses for week ending January 4, 1902.

(Parts per 100,000).

SEWAGE.

Date.	Total Solids.	Solids in Suspension	Solids in Solution	N as Free Ammonia.	Albuminoid Amonia.			N as Nitrites	N as Nitrates	Chlorine	O Consumed in 10 min.
					Total N.	N in Susp.	N in Sol.				
December 30....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" 31....	1.02	47	55	2.34	.90	....	.....	0	0	6.6	16.1
January 1....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" 2....	1.51	93	50	2.34	1.44	.....	.....	"	"	6.2	16.7
" 3....	.86	30	56	2.24	1.12	.....	.....	"	"	6.6	13.5
" 4....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average	1.13	56	57	2.64	1.15	.....	.....	"	"	6.4	15.4

SEPTIC TANK.

December 31....	66	6	60	1.80	55	.....	.....	0	0	70	10.0
January 2....	67	8	59	2.80	65	.....	.....	"	"	66	10.6
" 3....	76	6	70	3.40	90	.....	.....	"	"	70	11.5
Average........	70	7	63	2.66	70	.....	.....	"	"	69	10.7

CITY FILTER.

January 3.......	62	2	60	3.40	.12	.....	.....	.02	0	6.8	5.0

Analyst—Icke.

REMARKS.

The first analysis of an effluent from the city filter was made this week. The percentage of Alb. Ammonia removed by tanks and beds is 90. The effluent from the city filter is clear and odorless. It putrefies on standing in a room at 80° F.

Analyses for Week Ending January 25, 1902.

(Parts per 100,000.)

SEWAGE.

Date.	Total Solids.	Solids in Solution.	Solids in Suspension.	N as Free Ammonia.	Albuminoid Ammonia.			N as Nitrites.	N as Nitrates.	Chlorine.	O consumed in 10 minutes.
					Total N.	N in Susp.	N in Sol.				
January 20......	89	52	37	3.42	.78	.46	.32	Trace	0	.....	.87
" 21......	240	60	180	3.24	1.56	1.29	.27	"	"	.....	16.9
" 22......	96	57	39	3.42	.72	.38	.34	"	"	6.1	10.0
" 23......	101	57	44	3.80	1.20	.93	.27	"	"	6.2	11.3
" 24......	90	47	43	2.97	1.02	.69	.33	"	"	6.1	10.5
" 25......	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average......	123	55	68	3.17	1.05	.75	.31	"	"	.....	11.5

SEPTIC TANK.

January 21......	.90	70	20	3.80	.55	.24	.31	0	0	....	8.4
" 24......	.60	55	5	3.80	.80	.44	.36	"	"	.....	9.0
Average	.75	63	12	3.80	.67	.34	.33	"	"	.....	8.7

CITY FILTER.

January 24......	56	53	3	4.00	.24	.03	.21	.008	0	.....	4.2

Analyst—Icke.

REMARKS.

The filter is not doing very good work. It is being operated ata pretty high rate, about 600,000 gallons per acre per day, without any rest since starting.

The average albuminoid ammonia for the sewage was .90 and for the septic tank .53, giving a reduction of .37, or about 40 per cent.

The two analyses of the filter effluent indicate a reduction in the albuminoid ammonia of the sewage of between 80 and 90 per cent.

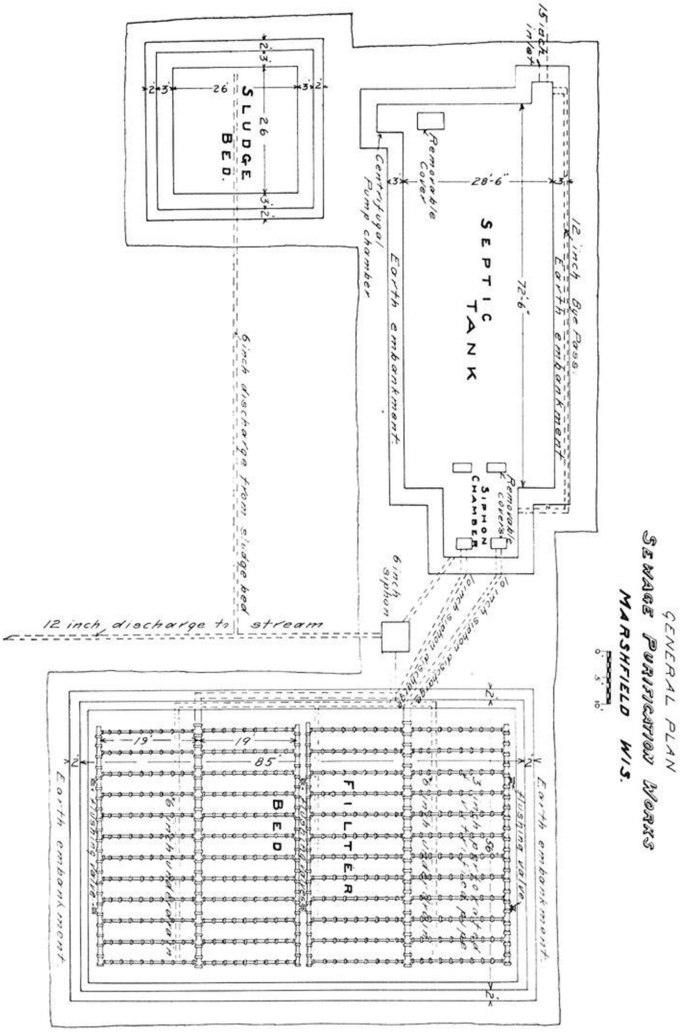
The engineers at the pump house collected samples of sewage for each hour of the 24 previous to the date of making an analysis. The samples taken for analysis therefor, represented the flow of the 24 hours previous to 7 o'clock of the date of the analysis.

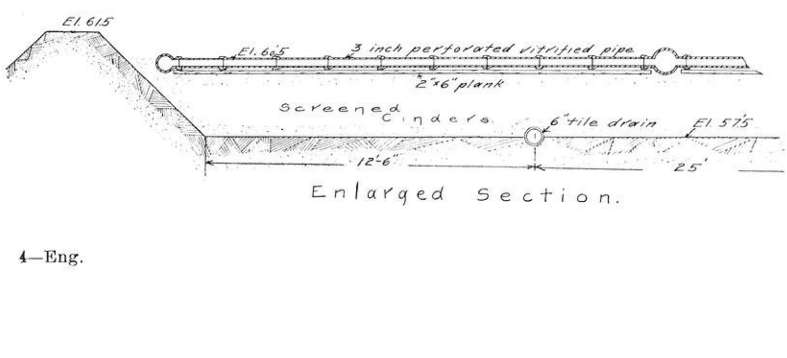
The sample from the septic tank was not a composite one, but was taken from the outlet pipe of the tank at 7 o'clock of the date of the analysis. The sample of filter effluent was taken from the main drain at the same time. All the precautions ordinarily prescribed were taken in collecting the samples for analyses. The analyses were started within a half hour after collecting the samples and were made in the laboratories of the University of Wisconsin.

Sewage Disposal at Marshfield, Wis.

The city of Marshfield is built on a ridge of land, and in making a design for a complete system of sewers it was neces-

PLATE V


GENERAL PLAN
SEWAGE PURIFICATION WORKS
MARSHFIELD WIS.
SLUDGE BED.
SEPTIC TANK
SIPHON CHAMBER
FILTER BED
Removable Cover
Removable covers
Centrifugal Pump chamber
Earth embankment
12 inch Bye Pass.
6 inch siphon
6 inch discharge from sludge bed
12 inch discharge to stream
28'-6"
72'-6"
85'
19'
26'


El. 61.5
El. 60.5
3 inch perforated vitrified pipe
2"x6" plank
Screened Cinders.
6" tile drain
El. 57.5
12'-6"
25'
Enlarged Section.

sary to divide the city into two districts. A deep sewer might have been built to connect one side of the city with the other, but the cost would have been greater than the cost of two outfall sewers and two disposal plants. Each outfall sewer will empty into a small creek, one of which is the outlet of a pond, and has running water in it at all times, while the other runs dry during the summer months.

A complete system of sewers was built two years ago.

The city has a population of about 5,000. The source of water supply is a ground water.

The number of sewer connections thus far made is 150. The soil is a somewhat impervious clay and considerable trouble has been had with water seeping into the cellars, therefore a great many of the first connections were made primarily to drain cellars. Very little manufacturing refuse enters the sewers as lumber industries are the chief ones of the town.

Disposal Plant.

The disposal plant is located about three-fourths of a mile from the center of the city, near the creek, mentioned above as being the outlet for a pond. It lies alongside of a principal highway entering into the city. The nearest residence is 600 feet away.

Septic Tank.

The tank is built with sides and bottom of Portland cement concrete. It has a wooden roof with composition covering. The tank is 70 feet long, 26 feet wide, and has an average depth of $6\frac{3}{4}$ feet, with a capacity of about 92,000 gallons.

The sewage leaves the tank over a wooden weir and drops into a trough which is connected with a siphon chamber containing two 8-inch automatic siphons. The tank is surrounded by an earthen embankment. A chamber at one end of the tank contains a 4-inch centrifugal pump to be used for pumping sludge.

SEPTIC TANK AT MARSHFIELD WIS.

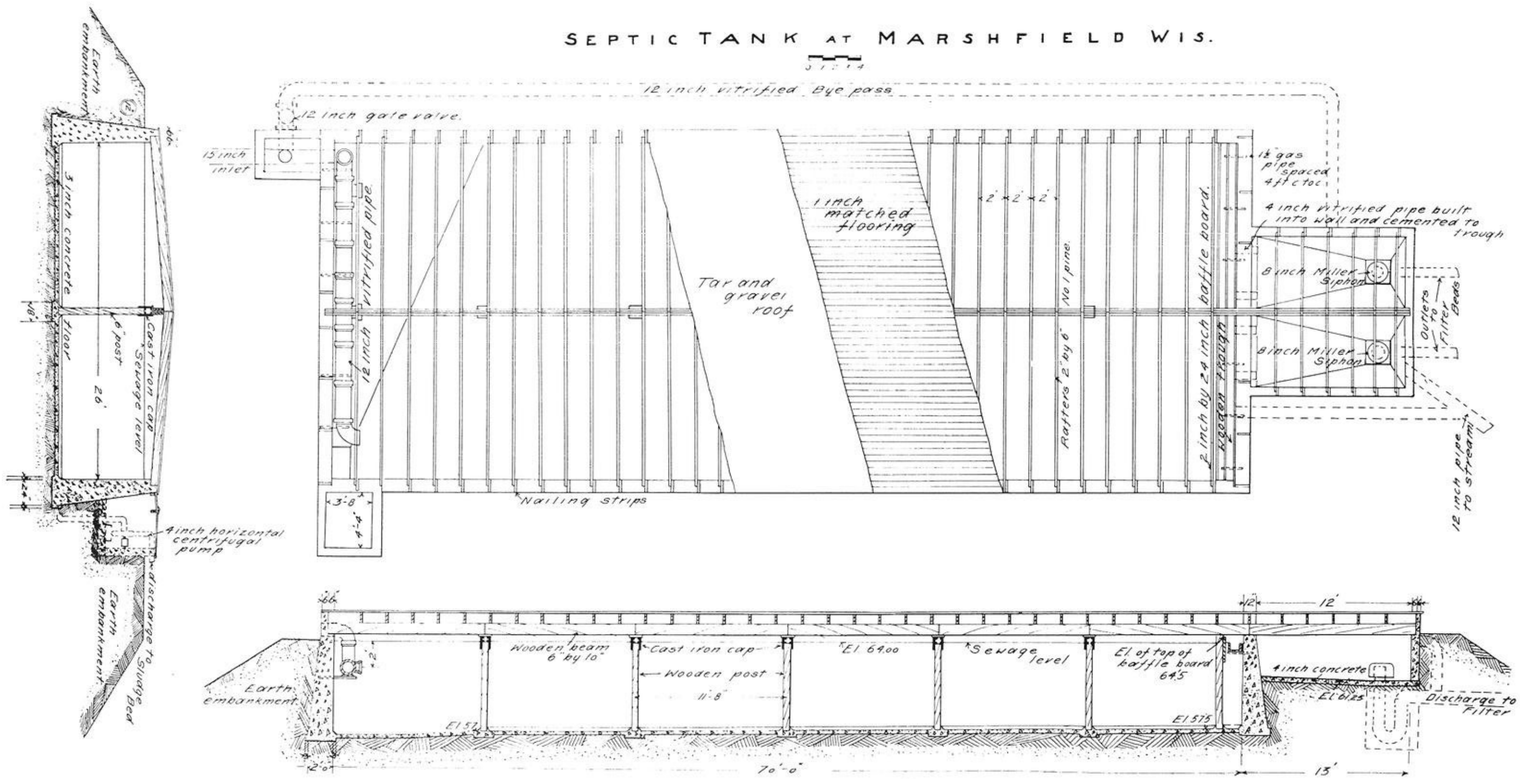


PLATE VI

Filter Bed.

The cinder filter bed has an area of 1-10 of an acre. The lower $2\frac{1}{2}$ feet are screened, coarse cinders, while the upper 6 inches are screened, head-end, locomotive cinders. A clay embankment surrounds the bed.

The method of distribution is similar to the method in use at Madison. The bed is divided into two sections; the main distributor for each is connected with the discharge from one of the 8-inch siphons. The bed is underdrained by three lines of 6-inch drains discharging into a main underdrain.

The bed requires occasional cleaning. The screened "sparks" collect the larger part of the matter in suspension in the effluent from the septic tank, retain it on the surface of the filter, which is the proper place for it, only to be removed as necessity demands.

Sludge Bed.

The sludge bed has an area of about 700 square feet, and is very simple in construction, having an earthern embankment, one foot of sand in the bottom, and the necessary underdrains. The bed is placed near the centrifugal pump, which is used to transfer the sludge from the tank to the bed.

The cost of the complete disposal plant was about $4,000.

Sewage Disposal at Monroe, Wis.

The city of Monroe has a population of about 4,500. About three-fourths of the city is provided with a sewerage system which is quite generally used. A private corporation owns the water works system. The source of supply is from artesian wells.

For a number of years the outfall sewer emptied into a creek about three-fourths of a mile from the center of the city. The creek is fed by springs and has running water in it throughout the year, and in flowing through the pastures, is used by cattle for drinking purposes. Some years ago a milk condensing factory was built, the waste water from which emptied into the creek at a point about 400 feet below the springs. During the hot summer months the creek became a nuisance, as a deposit of decomposing scum collected along its banks. The owner of the land through which the creek flowed was very much interested in having the stream remain uncontaminated, as his cattle used the water for drinking purposes. A joint arrangement between the owners of the factory and the city, resulted in extending the sewer about a mile down to a point where the main outfall sewer empties into the creek. The main outfall sewer was also extended a distance of about half a mile, using a grade such that the end of the sewer is $6\frac{1}{2}$ feet above ordinary water in the creek. The city has built a septic tank. It intends to operate it for a time and if the results are as satisfactory as they anticipate, meeting the demands of the immediate property owners below, the city will not build the beds until such time as it may be called upon to do so.

Septic Tanks.

The septic tank is very similar in design to the tank at Marshfield. It has a capacity of 75,000 gallons. The location of the plant necessitated the use of an inverted siphon of two parallel lines of 6-inch cast iron pipe. This pipe branches opposite the tank and enters it through four openings three feet below the surface of the sewage in the tank. A valve is provided in the siphon, the opening of which allows the sewage to pass around the tank and into the creek. The effluent from the tank will pass into a siphon chamber which will contain two siphons when the beds are installed. Until this is done the sewage passes out of the siphon chamber and into the creek through a sluice valve. The ordinary flow of sewage amounts to about 500,000 gallons a day.

The sewage is a domestic one, except for the presence of the waste water from the condensing factory.

Sewage Disposal at the County Institutions of Milwaukee County.

This plant was designed by W. S. Shields, C. E., of Chicago, and in many respects resembles the plant at Wauwatosa.

The plant is designed to purify the sewage from a number of separate institutions with a total population of 2500 people, including inmates and attendants.

The total amount of sewage treated is between 500,000 and 750,000 gallons of very strong sewage.

The following is taken from a description kindly furnished by the designing engineer:

"Prior to the building of the present plant, a committee of county supervisors made a pilgrimage to Champaign, Ill., and there were convinced that it was only necessary for them to build a similar tank. They purchased a set of their plans and built it. The result was that inside of three months it was overflowing with sludge and was abandoned."

"The present plant consists of this tank which is 6 x 17 x 54 feet and a new tank 6 x 20 x 65 feet."

"These tanks stand side by side and are covered with low, brick buildings and gabled roofs. They have a combined fluid capacity of 100,000 gallons and each is divided by a long, central, concrete partition into two compartments, with all inlets controlled by valves."

"The outlet in both tanks is over a wide weir into a trough, both of which are built of concrete and the water surfaces of the tanks are protected by deep trap walls. There are no grit chambers to either of these tanks, but both have iron sludge pipes provided with valves through which the sludge may be drawn off and be discharged by gravity into the river during the high water."

"The plant is located in the valley of the Menominee river, and the most available site for the filter beds was on the opposite side of the river from the septic tanks, consequently the sewage must be carried through an inverted siphon beneath the river, which at this point is some four feet deep and 100 feet wide. This siphon or submerged pipe is extended on a uniform grade through the filter plant and into the river some 600 feet below the crossing. This pipe, with the exception of where it crosses beneath the river, where iron was used, is of vitrified sewer pipe, double strength and deep sockets, carefully cemented; it passes directly under the dosing tank, where a shaft or manhole opens up into the bottom of the tank. In this shaft is a sluice valve with a long stem arranged to be operated from the outside of the tank. With the closing of this valve the sewer is closed and the tank effluent is forced to rise into the tank where at the flow or discharge line it is some 9 feet above the main pipe below. By the opening of the valve the discharge can be turned direct into the river."

"The filter plant consists of eight sand filter beds, each having an area of $\frac{1}{8}$ acres, arranged in two rows of four beds in each; the rows are 25 feet apart and 10 feet apart between beds. The four corner beds are each 50 x 110 feet in dimensions, while the four inner ones are 57.3 x 95 feet; the latter being shortened in order to provide more room for the controlling chamber and distributing pipes which are located in the center of the filtering area.

"The controlling chamber is a concrete basin 12 feet wide and 26 feet long, inside measurements, from the center of which is a brick building 12 feet x 12 feet x 11 feet high, covered with a tile roof. In the dosing tank are eight 15-inch siphons, one connected with each filter bed, where the water is distributed by two wooden troughs extending the entire length of the beds. The troughs have perforations on each side at the bottom at distances of three feet apart, to allow the water to pass freely and quietly upon the surface of the filter. In the chamber above the tank is a ball device for automatically putting the siphons into operation at the desired depth of water within the tank."

"The filter beds are composed of gravel and sand, the lower 12 inches being built of very coarse gravel, ranging from small cobble stones down to the size of an English walnut, while the next 12 inches is composed of fine gravel similar to roofing gravel. On the top of this is placed 12 inches of coarse, clean sand. The partition banks between the beds are of natural soil with sodded slopes, leaving a four-foot wide walk between the beds. The beds are drained with four lines of 4-inch, vitrified, sewer pipe, laid with open joints, discharging into 12-inch main drains, which lead to a central inspection chamber, four beds draining into one of these chambers. Each bed is provided with an overflow built of concrete through which water, if for any reason it should not pass down through the filters, finds entrance through the main outlet drain of each bed into the inspection chamber, which is connected with the main sewer, and is discharged into the river through the common outlet."

"The automatic device is so arranged that one or more of the beds may be out of service and the others operated."

"The plant has operated since the first of December in a very satisfactory manner. The final effluent is bright and clear and the plant has required very little attention, although it has passed through several periods of very cold weather, the temperature being as low as 15 degrees below zero, and during this cold weather the temperature of the sewage was reduced only a few degrees in passing the plant."

"Similar plants where sand filters are in use have been operated very successfully for the past two years, and this form of construction, where sufficient fall and areas can be obtained, promises to be popular, as it has no patented processes connected with it. It is very simple in construction and operation, and, where good filtering material can be had at reasonable cost, is not expensive to construct, as there is very little concrete or masonry required in the filters. The automatic device used in these plants has been very satisfactory, indeed. Experience has shown the necessity of using large siphons, which will not only discharge the contents of the dosing tank quickly, but will operate more promptly under an excess flow, which is liable to occur during storms.

The only trouble that we have had with these devices has been that at such times when there is an unusually heavy flow the siphons in some cases could not take the water out fast enough to break their seal when the tank was nearly empty."

"In the plant above described the 15-inch siphons were built of vitrified sewer pipe with galvanized iron domes, and are not intended to operate automatically of themselves, without the aid of the controlling device."

A recent visit to this plant found it in full operation. It was apparent that the plant was not receiving the attention that it merited. The scum in the smaller septic tank had accumulated to such a depth that it was being carried over into the effluent. The effluent from the tank itself was not as good as it would have been had the tank been receiving more attention.

The filters were working nicely. It took about three minutes to discharge the contents of the dosing tank each time a siphon operated. Each dose amounted to about 9,000 gallons, the siphon discharging about every twenty-five minutes.

Bed No. 6 was not filtering all the water; a part of it was escaping through the relief opening.

The effluent from the beds was clear and had but a slight odor, due no doubt to the admixture of unfiltered septic tank effluent passing through the relief opening in bed No. 6.

These beds are being operated at a rate much greater than is ordinarily employed for sand filters, and should receive more attention than they are getting.

Sewage Disposal at Lancaster.

The city of Lancaster has a population of about 2,500. It has an excellent water works system, the source of supply being a large spring about two miles north of the city.

The topography of the city made it necessary to divide it into two sewerage districts, the outfall sewer for each district emptying into small separate creeks. The flow of water in these creeks being very small, it was found necessary to build two disposal plants to purify the sewage before allowing it to enter them.

The two plants are similar in design, but differ in capacity. The tank for the east side has a capacity of 90,000 gallons, and a filter bed area of one-tenth of an acre. The filter bed for the west side has an area of one-tenth of an acre, while the capacity of the tank is about 60,000 gallons. Both tanks have been built, and the one for the east side has been in operation since the fall of 1902. The one for the west side was built primarily to purify the sewage which will come from the court house when completed. The number of connections to the sewer system, which as yet covers only the central portion of the city, is not very great, being about seventy for the east side district and fifty for the west side district.

The tanks are built with rubble walls, concrete floors and wooden roofs, covered with tar paper. Each tank has a siphon chamber containing two 8-inch siphons. The beds consist of a lower course of broken stone, $2\frac{1}{4}$ feet deep, and an upper course of screened, locomotive cinders, nine inches deep.

A visit to the plant, on the east side, was recently made to learn what the tank was doing. It was found that the flow of sewage into the tank was very small. The siphons probably do not discharge more than ten times a day. The rest period in this tank is longer than in any other one thus far installed in this state, but as the sewage is very weak, the effluent has been very satisfactory.

Sewage Disposal at Wauwatosa, Wis.

The city of Wauwatosa has a population of about 3,000. It is a suburb of Milwaukee and, primarily, a residential city.

The city has about $4\frac{1}{2}$ miles of sanitary sewers. The average flow of sewage is about 100,000 gallons. It is not a very concentrated sewage.

The disposal plant consists of a septic tank and intermittent sand filters. The topography of the city made it necessary to carry the outfall sewer some distance from the city, and at a very slight grade. Just before entering the disposal plant, the sewer changes to an inverted siphon, in order to pass under a railroad track and through some low land adjacent to the plant. The closing of the sluice valve raises the sewage in the siphon and discharges it into the septic tank, through four openings provided with gates. The tank is of concrete, surmounted by a brick house, with wooden roof. The tank is of the so-called "elastic" type, being divided into five compartments. As operated, at present, the wooden partitions have been removed and the whole tank is in use. The section farthest removed from the first opening, seems to get a denser sewage, the scum on this section being considerably heavier than on the other section.

The capacity of the tank is about 40,000 gallons, with a flow of 100,000 gallons, a rest period of about ten hours is thus given.

The effluent from the tank passes over a weir to the controlling chamber, or to the river, at the will of the operator.

The controlling chamber contains six 10-inch automatic siphons, with a single, positive, automatic, regulating device. Each siphon discharges through a 12-inch, vitrified pipe.

The filter area consists of 6 beds, each 30 feet wide and 60 feet long. The first or lowest layer of filtering material consists of 8 or 10 inches of coarse gravel, a second layer of finer gravel and coarse sand, and a top layer of clean, sharp sand, making a total thickness of about 3 feet. The beds are underdrained by means of 6-inch tile drains.

The cost of the tank, controlling chamber, automatic controlling device and filter beds was $5,370.00. The cost of the land on which the plant is located was $5,000.00.

Operation of Plant.

The plant has been in operation since Sept. 1, 1901. A recent visit to this plant elicited the following information:

The filter beds have not been in operation for some time. The city has considered the effluent from the tanks sufficiently pure to allow its passing into the stream without filtering it. The effluent from the tank had the finely suspended matter, common to septic effluents in general, but the water was otherwise clear. The first winter the whole plant was operated, not so much to secure a high degree of purification, but to demonstrate the possibility of operating the beds in cold weather. When the beds are in operation, the plant is visited by an attendant each day.

It has been found best to clean the septic tank every six months. The contents of the tank are pumped onto some low land, near by, a centrifugal pump run by a gasoline engine being used for this purpose.

Sewage Disposal at Fond du Lac.

The plant at Fond du Lac consists of two septic tanks and four contact beds. The tanks are nearly square in plan, being 45½ feet by 69 feet by 8 feet deep. The capacity of each tank is 185,700 gallons, or 371,400 for both.

The sewage enters each tank through four openings near the bottom. The pipes extend into the tank a short distance and are then turned upward, making the elevation of the discharge about two feet below the level of the water in the tank. The sewage leaves the tank through twelve rectangular chimney flues extending through the wall at an angle, and discharging into a concrete carrier which acts as a reservoir, or dosing tank, for the filter beds. The shape of these tanks differ from any others as yet built in this state. The usual construction makes the length of the tank from three to four times the width. The tank is covered with a low, wooden roof, having several openings. To provide for the removal of the sludge a 4-inch main is laid from the tanks to the pump house. The opening of a valve will take the sludge back to the house, there to be pumped into the river during high water.

The contact beds consist of about $3\frac{1}{2}$ feet of coarse cinders surrounded by earthen embankments. The septic effluent is distributed over the beds by a single distributor running down the center, having "Tee" branches at intervals.

The beds are underdrained by two lines of vitrified pipe, laid with open joints, and discharging into the main outlet. When in operation, it is intended to allow the main carrier to fill to a definite height and then, by opening a sluice valve, allow the dose to pass on any desired bed, there to remain in contact with the filtering material until the underdrain for that bed is opened. The presence of a man to operate the sluice gates is needed when the beds are operated.

The average flow of sanitary sewage, at this time, is about 350,000 gallons daily. More water than this is pumped, however, during rainy weather.

The necessity for a disposal plant arose because of a nuisance created in discharging the sewage into the Fond du Lac river, which at times is a very sluggish stream. The old system of sewers had several independent outlets into this river. A 24-inch sewer was built to intercept these several outlets and carry the sewage to the pumping station. The old sewers carried both storm water and sanitary sewage, and in laying the intercepting sewer, storm water over-flows were provided on the old outlets. The outlets are outward swinging valves which close whenever the pressure from the outside is in excess of the pressure from the inside, this occurring whenever the river is high.

To handle the ordinary sanitary flow a 5-inch, vertical, centrifugal pump driven by a 10 H. P., vertical motor is placed in the pump house. To handle the storm water a 10-inch, vertical, centrifugal pump driven by a 30 H. P. motor is provided. With this equipment of pumps the flow often exceeds the capacity of the plant and the water backs up in the intercepting sewer, flooding cellars, causing damage and inconvenience.

When the plant was placed in operation in February, 1902, both tanks were used. A visit to this plant (Feb., 1904) found only one tank in use, and although nothing had been done to this since February, 1902, in the way of cleaning it, no scum had formed, a very unusual thing in connection with a septic tank. The effluent was charged with considerable finely suspended matter, and had the characteristic odor of septic tank effluents.

The contact beds had never been operated for any considerable length of time, due to the faulty construction of the embankments, which permitted the escape of the water.

If the beds are to be operated as contact filters in the future, the embankments must be made water tight in some manner.

It might be cheaper to operate the beds as intermittent filters, as is done in Madison. The tank not in use might be converted into a dosing tank and siphons installed therein, thus doing away with the constant expense which is necessary for the operation of the sluice valves.

The pumping machinery and connections cost $2,950, and the disposal plant cost $11,500.

Sewage Disposal at Waukesha.

The city of Waukesha discharges its sewage into a small stream which in dry seasons would be considered a brook. The amount of sewage is probably 800,000 gallons a day.

A few years ago suit was brought against the city to compel it to purify its sewage before discharging it into this stream. Plans for a septic tank were prepared by the city engineer, and the tank was constructed under his supervision. No filter beds were provided. The tank was located at the end of the outfall sewer, one end of the tank being but a few feet from the stream into which the effluent is passed. The level of the invert of the outfall sewer at this point is practically the same as that of the river during high water. The work of building the tank consisted in making an excavation about 120 feet long by 40 feet wide and 6 to 7 feet deep, and building a tank to fit it. The sewer was connected with this tank at one end by two openings, while the other end was connected with the stream. Some baffle boards placed at intervals across the tank, and resting in the middle of the tank on a low concrete wall, which serves to divide the tank into two sections, intercept and hold the scum. The tank is covered with a wooden roof, the eaves of which are but a few feet from the ground.

The tank has been in operation for two years, or since December, 1901. A recent visit to this plant found the tank to be in urgent need of a cleaning. The scum at the entrance end of the tank had accumulated to a depth of probably 3 to 4 feet, gradually diminishing near the outlet where it was 4 inches thick.

The effluent from the tank was carrying with it a large amount of suspended matter, which seemed to indicate that the tank held considerable sediment on its bottom.

The purification given by the tank is insufficient to allow of passing the effluent into the stream during low water, and it is probably only a matter of time when the city will be compelled to complete the purification by the addition of filters.

THE RATIONAL MECHANICS OF CONDENSATION.*

FRED B. WHEELER.†

A gas engineer, when young, goes around with a thermometer in his hand, and when older carries one in his brain, because temperature, temperature, is the beginning, the end, of all his efforts to make things go.

Then to-day let us go through some details as to the most important part of the treatment of gas after it is made and journeying through the plant towards its final destination.

The gas leaves the furnaces of generation at a certain high temperature, which is immediately reduced by taking up considerable water vapor, and again reduced by travel through a more or less long pipe before it reaches the place in the plant where it is to be radically cooled down and contracted in volume, condensed, it is termed.

Our English cousins for years have devoted a great deal of attention to that long pipe mentioned above, and rightly so, for reasons I will show you later. American practice has paid little attention to that long pipe, but has devoted itself to entirely different ideas upon the subject of condensation, ideas which I will try and indicate to you by a diagram.

In order to cut out ancient history I shall omit the story leading up to the adoption of the present most popular form, the one known as the Guldlin Patent, supplied by the Western Gas Construction Co. The idea of this system is to cool the gas progressively, avoiding "shock" or sudden cooling, because of the injury which ensues to the illuminating power of the gas.

After leaving the "long pipe," in this case short, the gas is

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*Lecture before the Advanced Engineering Students of the University of Wisconsin, Nov. 4, 1905.

† Of the Semet-Solvay Co., Syracuse, N. Y.

put through the primary condenser, passing around air tubes, through which a current of outdoor air, entering at the bottom, passes upwards and out at the top, the velocity of the air current being regulated by a damper in the chimney flue off-take. The amount of cooling done is relatively small, but yet the gas is lowered to the temperature, say, of 135°–145°

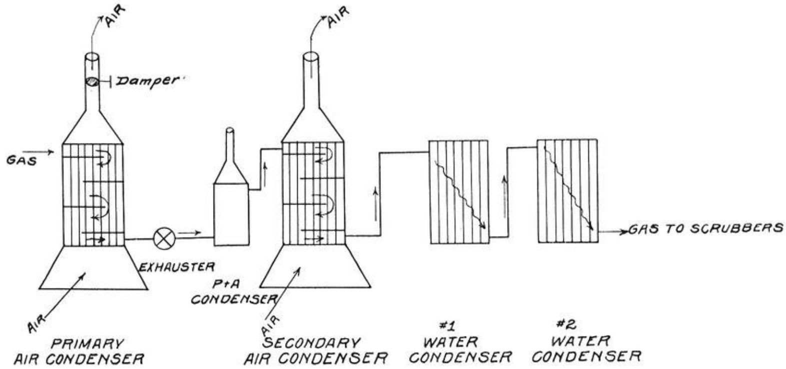

FIG. 1

F. at the exhauster inlet. The gas in being drawn through the exhauster takes up a little more heat, and then enters the P. & A. tar condenser, which is a pressure affair, squeezing the gas by force, through numerous small pinhole areas, into the outlet. This causes the deposition of a large amount of tar contained in the gas, and may be carried to such extremes of pressure and friction as to rob the gas of its benzols, and also cause the deposition of the naphthaline, thus making the gas poor in quality, as well as causing a general blockade, in time, of the works themselves, by the naphthaline deposits.

The next step in this system is to pass the gas through another air condenser, the secondary condenser, similar to the first. The gas then passes through one or more water tube condensers, going around the tubes, through which pass cold water at a considerable velocity. The gas is about 60° to 70° F. on emerging, to be then scrubbed for ammonia.

In passing through the two air condensers the velocity of gas is checked by baffle plates so as to force the gas current to go by a longer, hence slower, course through the apparatus.

By the time the gas has reached the outlet of the last one it has been cleansed of all injurious matter except ammonia, taken out in the washers and scrubbers, and sulphur compounds removed in the purifier houses.

These ideas are varied sometimes with slightly different shapes and arrangements, without really changing the fundamentals.

The latest expression of this type is at the new plant of the Semet-Solvay Co., at South Chicago. Here, after passing the primary condensers, exhausters and the P & A's, the gas enters the secondary condensers arranged in a square thus:

In ½ elevation thus:

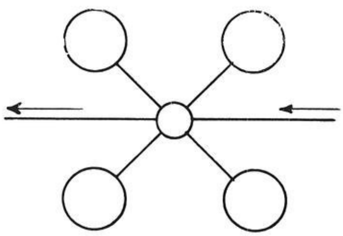

FIG. 2

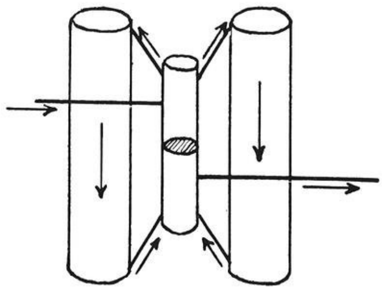

FIG. 3

going in at the tops of the four condensers simultaneously from a common central column, falling down the condensers, then simultaneously out of the bottoms into a common column, by-pass valves separating the incoming from outgoing gases in this column. From this block the gas passes to a final set of condensers of same design.

The secondary as well as primary condensers can be run both with air or water. This simple house has a capacity of 30,000,000 cu. ft. per 24 hours, and is the latest finished feat in this plan of condensation. I would say, however, there is a long large pipe out of doors, leading to the primaries.

If you were to look up accounts of condensation, you would find references to vapor tensions, and to the relative proportions of cooling surfaces and volume of cooling water required to abstract all the latent as well as sensible heat, but nobody except the European engineers seems to have paid any attention to the mechanics of this operation of condensation or cooling, or really both.

In Europe, especially England, the long pipe is a thing which when seen by American engineers is wondered at, and the exclamation is made, "Why, what an enormous piece of apparatus," "What an expensive thing." They never look into the reasons therefor, and they say, "We don't do things that way in America." I want to say right here that irrespective of coal and labor costs, they make their gas cheaper and better than we do here.

In considering the effect of two currents of different temperatures passing one another in opposite directions, as cooling water around the tubes and the warmer gas through the tubes, we must remember the effect of any exterior disturbance, such as a current of cold air blowing upon the outer shell of the condenser.

It has been found by taking off the cover of a tubular condenser and replacing it with plate glass, that in any set of tubes, we may discover a little batch of idle ones, through

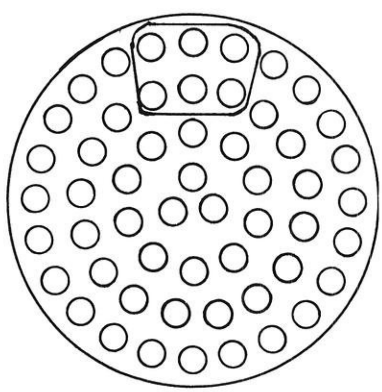

FIG. 4

which no gas seems to flow. Sketch illustrates this. The six tubes shown in the sketch do no work. Feathers dropped carefully in the different tubes will move swiftly out of sight in all tubes except those in the elliptical patch, where the feathers remain suspended as in equilibrium in the mouths of the tubes. During the twenty-four hours the position of this patch of idle tubes will slowly shift and rotate around the axis of the condenser, according to the exterior changes of temperature caused by changing currents of air and by the rate of speed of the cooling water, a slow speed causing a sluggish action of the whole upper section of the condenser, and a swift current of water causing a more uniform potential difference between the warm gas and the cooling water at any particular layer chosen. It is usually possible to condense all the gas in one-half the usual number of condensers by increasing the volume and speed rate of the cooling water.

Let us briefly consider this gas, the medium we now wish to discuss scientifically, so that we may have a clear conception of its composition. The gas has come off the furnace generators as a very hot elastic gas of a dark yellowish brown color, of a horrible smell, poisonous and very considerably loaded with water vapor in the form of steam, much above the temperature of boiling water, and usually more than 300° F. as it leaves for its journey. It is dense fog, full of particles of all shapes, some like flocks or disks of soot or lamp black, but most of a globular or ellipsoidal form.

The particles all possess mass and weight, and are subject to the same laws of mechanics as the stars in the heavens. While the gas is a chemical compound and a tenuous medium, it has in it, ab initio, a swarm of particles. It is a mixture really of gas and solid and liquid bodies. The true gas containing these heavy particles is an elastic resistant medium.

Let us consider the mechanical movements of these particles in this medium. Let a equal the dimensions of a single particle whose density is ρ. It falls in this medium whose density is δ with a velocity v. It is subject to three forces—

gravity $\kappa' a^3 \rho$

gas pressure $\kappa'' a^3 \delta$

inter friction $\kappa''' a^2 v^2$

α of course is a triple integral $\int_0^{R_1}\int_0^{R_2}\int_0^{R_3} dx\,dy\,dz$

Its velocity V becomes $V = K\sqrt{\alpha(\rho - \delta)}$, K depending on the shape of the particle and being a constant.

By inspection we see that $V\delta >$ as $\begin{cases} \alpha \text{ increases.} \\ \rho \text{ increases.} \\ \delta \text{ decreases.} \end{cases}$

Any two particles will fall together when their densities are different, if $K_1\sqrt{\alpha_1(\rho_1 - \delta)} = K_2\sqrt{\alpha_2(\rho_2 - \delta)}$. Any two spherical drops of tar and ammoniacal liquor will fall likewise together, if their diameters possess the ratio $\frac{\alpha_1}{\alpha_2} = \frac{\rho_2 - \delta}{\rho_1 - \delta} = \frac{\rho_2}{\rho_1}$ since δ is negligible. The fog at the entrance to a P & A condenser has the average diameter of its particles 0.010 mm and the density is 1.25. Then $V = K\sqrt{.010\,(1.25 - \delta)}$, neglecting δ, V becomes $K^1\sqrt{1.25}$.

Let us conceive a straight horizontal pipe whose height is h, whose area is E and whole length is L. Let our gas fog enter

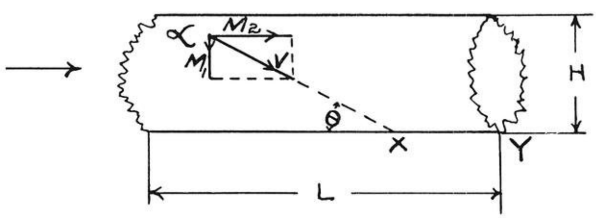

FIG. 5

with the arrow, with an impressed velocity due to exhauster of M_2 and having the particles α (size) distributed. Fix attention upon one particle α. It moves forward with velocity M_2. It also falls, due to the three forces, gravity, gas pressure and interfriction with a velocity M_1 of course less than M_2.

These two velocities are constant in amount and direction. The resultant velocity V is the diagonal which prolonged strikes the bottom of the pipe at X with an angle of incidence θ, whose tangent is $\frac{M_1}{M_2}$, L being the length of pipe, if $\tan\theta > \frac{h}{L}$. All particles will fall before reaching Y, the end of the pipe. If $\tan\theta = \frac{h}{L}$ the particles will all be arrested or condensed exactly in the length of pipe. If $\tan\theta < \frac{h}{L}$ there will be a flight beyond, or incomplete condensation. The conclusion is irresistible that an apparatus in which $\left\{\begin{array}{ll}\tan\theta & \text{is a max.}\\ h & \text{is a min.}\\ L & \text{is a max.}\end{array}\right\}$ or a long thin tube, is perfect. M is a constant velocity for each kind of particle, and we will assume the quantity of gas made, Q, constant, then as $\tan\theta = \frac{M_1}{M_3}$, as also $M_2 = \frac{Q}{E}$, the condition that $\tan\theta$ be a maximum is the same as that E be a maximum. Then our pipe has a maximum section $\left\{\begin{array}{l}\text{of small height}\\ \text{of great length.}\end{array}\right.$

You see now our English cousins' point in their works. The mathematical form is then an elliptical section.

Suppose we expand the tubes area to a cross section E_x, the original velocity M_2 becomes $M_2 \times \frac{E}{S} = M_3$. If, then, E_x is 100 E, M_3 is $\frac{M_2}{100}$, and in the chamber there is a large fall of particles ∞. From formula $\tan\theta = \frac{h}{L}$ we see that a chamber 50 feet long is equal to a pipe 500 feet long of $\frac{1}{10}$ diameter.

In this case the cooling surfaces are identical in area and the same quantity of metal is required in their construction. The section of this expanded pipe or chamber should still be elliptical. This chamber reduces friction loss, due to size. Practically, the more perfectly shaped ellipsoidal pipe is more costly to make than the round pipe, hence round pipe.

The gas in flowing with the new velocity M_3 through this chamber will take an intermediate course through the middle, forming a curve of velocities in the shape of

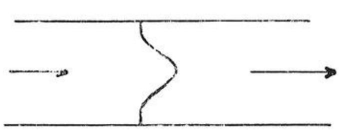

FIG. 6

To avoid this unfortunate occurrence two or more diaphragms of iron are stretched across the area with several elliptical holes in them. This breaks the formation of the velocity curves and delays the rate of progress, assisting the time limit of the gases' passage. You will find a discussion of this curve, I think, in John Perry's Calculus, 7 Ed., P. 123, etc.

In vertical condensers, to which this chamber in some degree corresponds, an addition to the theory is required because of the ballistic effect of the particles striking the walls at different angles. The greater the number of tubes and the smaller their diameter, the more efficient they are as coolers, but with a corresponding loss of pressure.

Centrifugal Force.

Let us see what effect a rotating spin will have upon this gas —fog—in a horizontal plane. The rotative force of the gas becomes $F_1 = m_1 W^2 R$ and of the fog $F_2 = m_2 W^2 R$ where R is the radius of the chamber and m_1, m_2 are unit equal volumes of gas and fog respectively. W is the velocity of rotation projected on the plane. $m_2 > m_1$ and $F_2 > F_1$. Immediately the dense particles are separated from the light gas and are radically projected on to the walls of the chamber, the gas going on to its proper exit in the side or top of the chamber. The particles of tar and liquids of various natures run down the sides and are drained off at the bottom.

Several different ways have been devised of applying this idea of a rotating spin, the first idea being to have the moving momentum of the gas stream itself rotate the centrifugal which would then be constructed with helicoidal vanes.

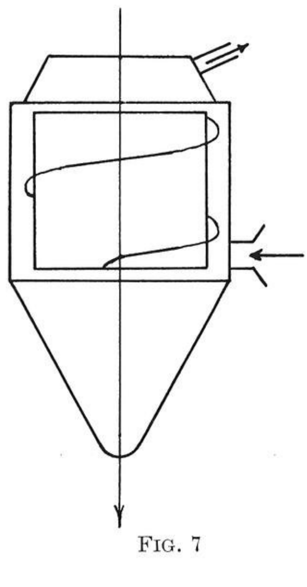

FIG. 7

The dimensions adopted in French gas works are to have the apparatus consist of a cylinder superposed upon a cone with a helix rotating inside.

The cone is $2\frac{1}{2}$ times the height of the cylinder and the cylinder is $1\frac{1}{2}$ times its own height in diameter. The helix makes $1\frac{1}{2}$ turns and rises $\frac{1}{5}$ of the diameter, so as to give a powerful helicoidal twist to the gas. The area of the inlet is made equal to the cross-section between two plates or vanes of the helix. From this area and the volume of gas, we obtain the velocity and from that W^2R. These helices are called in French parlance "cyclones." A cyclone 1 meter diameter—

$2\frac{1}{2}$ " high
Inlet area 0.20 x 0.24 meters
R = 0.50 meters

revolves 180 times per minute and this passes $1\frac{1}{4}$ millions in 24 hours successfully.

Let us calculate a helicoidal cyclone condenser for a delivery of 4,000,000 cu. ft. per 24 hours, as in our Milwaukee plant. The equation of a helix is $l^2 = (c^2 + h^2)n$, where
l is the length (say of outer edge of blade)
c is the radius of the helix
h is the height of containing cylinders and
n is the number of turns of the helix around the axis.

We already know that a 20″ main is required to deliver this volume inside the works. Let the diameter of the cyclone be assumed as 6′ and the height as 4′, then the volume is 2 l times the area or 26.86 cu. ft. contents of the twist.

$F = Qs_1 w^2 R$ where w = 3 rev. per sec. sp. grav. = 0.40.
$w^2 = 9$ " " "
$R = 3'$ $Q = \frac{4,000,000}{24 \times 60 \times 60} = 46.3.$

Area 20″ main = 314.16 sq. in. = 2.18 sq. ft.
and l = 6.1 ft.
$F = 46.3 \times .032 \times 9 \times 3$ $(s_1 = .0322)$
$= 1.4816 \times 27 = 40.00$ ft. passed per sec. required rotative force of
$\frac{40}{314.16} = 0.127$ ft. pounds per sq. in. of driving force required.
$\frac{0.127}{.036} = 3.5''$ = driving force required in inches of water column, as it must be remembered that the unit of measurement in all English speaking countries is for pressures and vacuums 1 inch of water column = 0.036 of a pound.

s_1 is the gas weight computed from the weight of 1 cu. ft. of air at 0° and 760 mm = .0807 x .40, sp. gravity of the gas; hence .0322. The assumed number of revolutions per second with the twist volume theoretically give 1.7 the required volumetic delivery, but the slip has to be allowed for in the clearance spaces between the blades and shell, hence we will expect to about realize the requirement.

The study of Fans by Chas. Innes, published by D. Van Nostrand & Co., N. Y., 1904, and Barr on Centrifugal Pumps in his Pumping Machinery, published by J. B. Lippincott, 1904; also Snow on Blowers are to be recommended.

Now if this cyclone as designed, were inserted in the gas condensing system it would naturally come somewhere between the primary condensers and the P & A. It is driven simply by the impelling force of the exhauster moving the current of gas and would consume, as we see, only 3.5 inches of water pressure. It will extract tar and oily liquids and ammonia liquor. The naphthaline extracted as all enclosed in little envelopes of water as it is whirled down and out. It is an extremely efficient type.

Next in order of centrifugal condensers come the so-called Thiesen (German) machines, rotating fans, vertical or horizontal, and principally used for taking out dust from blast furnace gases.

Next come the fans designed to fan the gas at a high rate of speed, turned not by the gas itself, but by belted motors. These fan out the gas impurities so completely that at certain speeds the entire illuminating power of the gas is lowered radically, and heavy deposits of naphthaline are formed, causing great trouble and showing that a check on the motor speed is necessary, and that it must be a variable quantity paralleling the volume running through. It is possible to water cool the outside of these rotaries.

I have made several references to the P & A condensers. The P & A is a Pelouze & Audouin's patent high pressure tar extractor. The gas is squeezed rapidly through a multitude of fine holes in a screen, depositing a large quantity of tar upon the screen. It is a very efficient piece of apparatus, but may be so mismanaged as to take out all the tars and light oils to such an extent as to precipitate a shower of naphthaline as soon as the gas has cooled to the temperature at which the vapor tension of naphthaline will cause deposition.

During this whole discussion thus far I have not said anything about drops in temperature and volumes of cooling air and water required, because in stating the analysis of the mechanics of cooling, I have kept the mechanics purposely separate from the temperatures. It is evident that hot gas, traveling in a long pipe at atmospheric temperature will be cooled by the laws of temperature at the same time that the falling fog drops under the laws of rational mechanics.

To cool the gas down you must abstract heat, and you must know how much is to be abstracted.

If H is the heat to be abstracted,

L is the weight of gas to be cooled.
S is sp. heat of gas.
θ_1 = Temp. gas, initial.
θ_2 = Temp. gas, final.
ϕ_1 = weight of vapor in one unit volume, initial.
ϕ_2 = weight " " " " " " , final.
c = total heat in 1 unit volume.

Then $H = Ls(\theta_1 - \theta_2) + L(\phi_1 - \phi_2)\ (c - \theta_2)$.

The first part of the right hand number is the amount due to sensible heat, the balance that due to latent heat.

To figure the transfer of heat between cooling air and a metal surface, the unit is $K = 2 + 10\sqrt{3.28\ V}$ where V is velocity of air in feet per second.

The surface S necessary to transfer H heat in X hours with a mean difference of temperature θ_m is

$$S = \frac{H}{X\,\theta_m\,K} = \frac{H}{X\theta_m(2+10\sqrt{3.28V})}$$

To find your mean temperature difference

$$\theta_m = \frac{\theta_1 - \theta_2}{\log\frac{\theta_1}{\theta_2}}$$

where θ_1 is the difference in initial temp. between gas and water.
and where θ_2 is the difference in final temp. between gas and water.

$$\theta_2 = \frac{P\,\theta_1}{100} \text{ where P= per cent., then } \theta_m = \frac{\theta_1\left(1 - \frac{P}{100}\right)}{\log.\frac{100}{p}}$$

If water enters at 100° and leaves at 80°

in opp. directions.

If gas enters at 100° and leaves at 50°.

$$\theta_1 = 50 - 10 = 40.$$

$$\theta_1 = \frac{100 \times 20}{40} = 50\ \%\ \text{of}\ \theta_1 \text{ or } P = 50.$$

$$\theta_m = \frac{40(1 - \frac{50}{100})}{\log.\ \frac{100}{50}} = \frac{20}{0.6931} = 28.85^\circ \text{ Centigrade.}$$

To find the weight and volume of cooling water

If W = Weight of gas.
C = Sp. heat of gas.
W_1 = Weight of water.
C_1 = Sp. heat of water.
θ_h = Highest temp. of gas.
θ_l = Lowest temp. of gas.

θ_1 = Highest temp. of water.
θ_2 = Lowest " "
then $W\ C\ (\theta_h - \theta_l) = W_1\ C_1 (\theta_1 - \theta_2)$.

$$W = \frac{W_1\ C_1 (\theta_1 - \theta_2)}{C (\theta_h - \theta_l)}.$$

It is customarily figured that the cold water enters where the gas leaves, the currents running in opposite directions and the temperature difference between the entering gas and the leaving warm water is fixed at 5° F. for good work.

I trust you all see the possibilities of relative spin for condensation. The small space and small power required are attractive features.

The vapor tension of aqueous vapor in gas is responsible for some 90 per cent. of the amount of heat to be removed. In reducing the temperature of gas from 140° F. to 60° F. over 13,000 B. T. U. per 1,000 cu. ft, must be removed, and from 165° F. to 60° F., about twice that amount. Velocity of flow of either cooling air or water is of as much consequence as area of cooling surface.

One of the great problems now before us is the high pressure distribution of gas and the compression of gas with compressors. The mechanics and thermodynamics of condensation come in here too. The problem is subdivided into sections

1° To determine the power required to compress any gas adiabatically.
The mean effective pressure.
The initial temperature.
The final temperature.
The final volume.

2° The flow of gas in pipes.
The diameters required for flow.
The loss of pressure in transmission.
The final available pressure.

If J = Joules equivalent = 772 ft. pounds.
W = weight of gas compressed.
c_p = specific heat at constant pressure.
T_0 = Absolute initial temperature.
T = Absolute final temperature.
L = Work done in ft. pounds.
P_0 = Initial pressure.
V_0 = Initial volume.

$$L = J\,W\,c_p\,(T - T_0) = \frac{V}{V-1}\,P_0\,V_0\left(\frac{T}{T_0} - 1\right) \qquad (a)$$

Since $J\,W\,c_p\,(T - T_0) = J\,W\,c_p T_0\left(\frac{T}{T_0} - 1\right)$, an identity.

From (a) we see the power expended depends entirely upon the final temperature T, and that it would pay to cool down the gas having this temperature T.

If we consider formula (a) as the first stage of a two-stage compression, the temperature T will then be the initial of the second stage. At 80 lbs. gauge pressure the saving of the two-stage system will be about 13 per cent. in power. In single stage compression we will have a temperature of 366° F. against a temperature of 195° F. in two-stage, a noteworthy difference. The volumetric delivery is 15 per cent. better in two-stage compression. Adiabatically, it takes 152 H. P. to compress 1,000 cu. ft. of gas to 80 lbs. gauge, and the strain on 100 sq. in. cylinder area is 8,000 lbs. versus 4,522 lbs. in two-stage compression.

Then there is considerable misunderstanding amongst gas men as to what is meant by high pressure in gas transmission. Formerly 3 lbs. was high. Now it is low in considering pressure lines. For 1,000 cu. ft. gas of per minute,

3 lbs. pressure has a final temp. of 84° F. and requires 15 H. P.

14.7 lbs. pressure has a final temp. of 158° F. and requires 61.5 H. P.

50 lbs. pressure has a final temp. of 293° F. and requires 145.6 H. P.

100 lbs. pressure has a final temp. of 420° F. and requires 220 H. P.

All from 60° F. and at 30″ barometer, single stage compression.

		$\frac{P_0}{P}$	$\frac{V}{V_0}$
3	lbs.	1.2	0.80
14.7	"	2.0	0.59
50	"	4.4	0.33
100	"	8.0	0.20

We see that at 100 lbs. the bulk is reduced 80 per cent., and the final temp. is such as to require condensers, as the temperature 420° is that of superheated steam.

For adiabatic compression for brake horse power, allowing for all wastes, the formula becomes H. P. = 325 $\left(\frac{T}{T_0}-1\right)$ to compress 1000 cu. ft. of gas at 60° F. and 30″ bar., to a temperature T.

For different gauge pressures we must compute the values of

$\left(\frac{T}{T_0}-1\right)$

3 lbs.	= .0466
14.7 "	= .1892
50 "	= .4483
100 "	= .6800

Thus for 100 lbs. pressure and 1,000 cu. ft. per min. or 60,000 cu. ft. per hour, we will have the constant expenditure of 220 H. P.

Dr. Poole many years ago devised an empirical formula for the transmission of gas. This formula is really very accurate for pressures up to two pounds, where the length of transmission is small. The formula is

$$Q = 1350\sqrt{\frac{d\ s\ h}{s\ l}}$$

where Q is quantity per hour.
d is diameter of pipe in inches
l is length of pipe in yards
h is driving force in inches of water
s is sp. grav. of gas

h, the driving force in this formula is $P_1 - P_2$, the difference of initial and final pressures expressed *always* in *inches of water column.*

When the length of pipe increases and the pressure increases, we have many modifications of the original Poole formula. The Pittsburg formula, used extensively by the natural gas engineers is one of the most accurate.

$$Q = 3450\sqrt{\frac{d\,s(P_1^2 - P_2^2)}{l \text{ in feet}}} \times \sqrt{\frac{0.60}{s}}$$

P_1 and P_2 in this are absolute pounds, that is, gauge + 14.7 lbs. There is also Cox's, $38\sqrt{\frac{d^5\ (P_1^2 - P_2^2)}{L\ s}}$ where L is in miles.

I have found in my own practice that a modification of this formula is more correct:

$$Q = 33.3\sqrt{\frac{d_5(P_1^2 - P_2^2)}{L\ s}}.$$

We have just completed a three-mile high pressure line where this formula came out exactly with the obtained deliveries. The effect of elbows, bends, and small obstructions in a pipe are most important in computing the requirements of a high pressure gas line.

I would advise you all to carefully study in Cox's edition of Weisbach's Mechanics, the section on hydraulic pressure transmission, and also his chapter on Friction. His elucidations of this rather difficult subject are remarkably clear.

One of the most annoying features of the gas profession is the effect that tiny, little differences of measurement have. It will be of the most extreme importance to you all to have the clearest conceptions of the concrete values of little pressure differences. A single millimeter is a pressure difference of tremendousimportance in regulating the gas operation of a coke oven plant. A water or kerosene oil guage standing just above the water level line in a hydraulic main means a pressure difference of two millimeters, or enough, if not promptly counterbalanced, to upset the entire oven operation as now conducted in these scientific days. The pressure gauge automatic regulators in our Detroit plant are adjusted to advise of a difference in gas pressure of $\frac{1}{10}$ of a mm.

On closing this skeleton outline lecture on some of the principles iuvolved in the mechanics of the condensation and compression of gas, I wish to acknowledge free use of the work of M. Philippard, of the Societe Technique de Gaz, and of the work of Mr. E. A. Rix, of San Francisco, Cal.

It must be borne in mind that in the consideration of these intricacies of temperature reduction, the greatest care must be exercised in the computations, as at this point both the initial capital cost and the regular constant operating cost, are involved in an especial degree.

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EDITORIALS.

There is of late a tendency which seems to have become prevalent among the engineers who attend our non-resident lectures in the Auditorium. We refer to the practice of leaving the room during the hour and thus causing interruption and oftentimes evident annoyance to the speaker. We do not refer to the men who leave the room at ten minutes to five to attend their five o'clock classes, or to attend military drill, as ample opportunity is usually afforded for all who wish to leave at that time to do so. We do, however, refer to the men who never spend over half an hour at the lecture and then prepare to leave. The fact that the speakers—all busy, professional men—are willing to give their time to come and deliver these lectures, and that the faculty urge student support, should offer a sufficient inducement for universal attendance. When the lecture is in progress the laws of common respect and courtesy to the gentleman speaking require that all unnecessary interruption be avoided. None should leave the room upon these occasions until an opportunity is offered at the close of the hour.

Heretofore it has been customary for THE ENGINEER to publish the Alumni Directory twice each year. Beginning with this year, however, it will be published in the second number only. The alumni department will, as before, endeavor to keep the directory as nearly correct and up-to-date as possible, but the expense has been more than the support given THE ENGINEER by the alumni, for whom the directory is largely published, would seem to warrant. The subscriptions received from the alumni the past few years have not paid the expense of even publishing the directory once a year, so we have decided upon this change.

With 650 alumni of the College of Engineering, the number of alumni subscriptions should be much larger than it now is, for less than 15 per cent. are subscribers to THE ENGINEER.

The directory will not appear in our fourth issue.

A Curtiss steam turbine, of twenty-five kilowatt capacity, has just been installed by the Experimental Engineering Department. The installation is an important one, owing to the increased importance of this class of machines in power plants, for the lighting of trains, for ship propulsion, and for other purposes requiring a limited amount of space and good economy.

The new machine is in part a gift by the General Electric Co., and will be used for the instruction of students and for experimental purposes.

A series of tests is now being made by Mr. M. L. Derge and Mr. W. O. Sustins, whose work will appear in a senior thesis. It is expected that the work of Mr. Derge and Mr. Sustins will be continued with a view to obtaining as much data as possible relating to the theory involved in the construction of a turbine.

Tests have also been made for the purpose of obtaining data to be used in connection with some recent tests on the lighting of trains.

In accordance with the new rules regarding the annual inspection trips which were published in our last issue, the members of the Junior class will go on their trips during the Easter recess. As before there will be two trips, the eastern and western, although the line will not be drawn as formerly between the civil and the mechanical and electrical students. About eighty in all will go, thirty taking the eastern tour. Eleven instructors will accompany the party, three going east and the remainder going with the western party.

Those going east will leave Madison on Friday, April 6th, going directly to Niagara Falls, where they will visit the various power developments and the large bridges. Sunday and Monday will be spent in Buffalo where the Lackawanna Steel Plant, the harbor improvements, etc., will be inspected. On Tuesday the party will visit the Brooks' Locomotive Works at Dunkirk, N. Y., going to Pittsburg in the afternoon. Wednesday, Thursday and Friday will be spent there, the civil engineers visiting the Conway Yard, Union Switch and Signal Co.'s plant, the Ohio River Improvements, the Pittsburg Water Works, the Amberg Plant of the American Bridge Co., and other points of interest, while the electrical and mechanical engineers will go through the Westinghouse plants, the Nernst Light Works, American Window Glass Works and the Flint Glass Works. The party will reach Chicago on Saturday morning and together with those who take the western trip, will go down the drainage canal, returning to Chicago and disbanding Saturday evening.

The students going on the western trip will leave Madison, Monday, April 9, and go to Milwaukee where the West Milwaukee Car shops, the new gas plant, Allis-Chalmers, Bucyrus Steam Shovel Works, National Electric Co., etc., will be visited. They will go to Chicago Tuesday night and will go through the Illinois Steel Company's Works, the South Chicago Ship Yards, Lassig Bridge Plant, the telephone tunnels, the Fisk Street Station and some sub-station, the 39th Street Pumping Station and other engineering works. The trip will end with the inspection of the drainage canal on Saturday.

Mr. S. Weyer, of Columbus, Ohio, gave an address before the Engineers on Jan. 26, upon the subject of Gas Producers. Mr. Weyer is a very interesting and instructive speaker to listen to, and those who attended the lecture have a much clearer conception of the immense possibilities which are ahead of the gas engineer who devotes his attention to this class of work. The speaker had high hopes for the producer gas plant, especially in the case of the small power user. He showed by diagrams and lantern slides the saving which might be brought about over the small and uneconomical steam plants in present-day use, and while the saving in large installations is not as marked, still the large gas unit threatens to become a serious rival of the steam engine.

On Feb. 23, Mr. L. R. Clausen, chief signal engineer of the C., M. & St. P. R. R., delivered an address upon the subject of Signal Engineering. His lecture was illustrated with lantern slides and diagrams of the various types of apparatus used in this, perhaps the latest, important branch of electrical engineering. He considered the details of his subject, largely devoting his time to a discussion of the individual operation of the signaling devices rather than to the general outline of their application to railroad service.

Andrews Allen, U. W., '91, contracting engineer, who represents the interests of the Wisconsin Bridge Company, at Chicago, lectured before the Engineering students, March 2, on "The Contractor and the Engineer." Mr. Allen discussed the proper relations which should exist between the contractor and the engineer, illustrating his remarks with many incidents arising in his own practice. Unrestricted competition in engineering construction will usually bring forward bidders of undesirable reputation or insufficient experience, who are likely to make too low a price on the work. The acceptance of such bids nearly always leads to unsatisfactory results, either as to the character of the work or the promptness with which it is completed. It is much better to accept bids which represent a fair profit, and in works constructed by private corporations competition restricted to certain selected bidders is the most satisfactory method of letting contracts. In executing work engineers should be ready to avail themselves of the skill and knowledge of the contractors, as they very frequently are able to make most valuable suggestions. In this way plans may often be modified with advantage to all concerned, but it often happens that the engineer looks with disdain upon the contractor's suggestions and insists upon the carrying out of the letter of the specifications. The best and most economical work in the long run is accomplished through the combination of the broad minded engineer and the experienced and reliable contractor. For many kinds of work the speaker favored the plan whereby the contractor undertakes the work under broad general specifications and becomes, to a great extent, his own engineer. In this way responsibility for results rather than the execution of certain specified construction would be placed upon the contractor.

An announced in the last ENGINEER, Mr. Frank Skinner, associate editor of the *Engineering Record*, delivered a series of twenty lectures, beginning March 12. These lectures were intended primarily for the civil engineering students, and were required work for the Junior and Senior Civils. The lectures covered the erection of girder bridges, viaducts, cantilever and suspension bridges, steel buildings and roof trusses, shaft sinking and methods of tunneling, the handling and transporting of earth and rock, building foundations and the razing and moving of buildings. The course dealt with the practical side of field erection throughout, and Mr. Skinner treated the various subjects in a manner which showed his thorough familiarity with the work.

At the semi-annual election of Tau Beta Pi the following juniors were elected to membership: E. E. Parker, C. E., Evansville; H. B. Sanford, E. E., Madison; C. W. Green, E. E., Chicago; S. L. Clark, C. E., Milwaukee; H. C. Estberg, E. E., Waukesha; C. F. Bleyer, M. E., Milwaukee; A. S. Diehl, C. E., Madison; J. F. Klug, E. E., Arcadia.

The men were initiated into the fraternity, February 28, and were given a house-warming on the evening of March 20 at the Chapter house.

NOTES AND PERSONALS.

H. R. Crandall, '98, is now employed in the Engr. Dept. of the Wisconsin Tel. Co. at Milwaukee, Wis.

W. H. Robinson, ex-'06, is located on the Pierre–Rapid City extension of the C. & N. W. Ry.

A. D. Ehrnbeck, '02, has moved from Port Casey, Wash., to Seattle, Wash., where he is employed as draftsman in the City Engineer's office.

Herbert J. Peters, '07, has accepted a position with the Great Northern Ry., and is located on construction work in Minnesota.

Carl Zappfe, '07, is superintending the drilling operations on the Cayuna Range for the Leith Exploration Party, and is located at Brainerd, Minn.

Rolland E. Shuck, '07, has accepted a position as instrument man on construction work with the Great Northern Ry. in Washington.

C. H. Perry, '03, has been transferred from the track elevation work of the C. & N. W. Ry. at Chicago to Wittenberg, Wis., and is now engaged on construction work on the Green Bay extension.

S. S. Long, ex-'06, is now acting assistant engineer on the construction of the Green Bay extension of the C. & N. W. Ry. with headquarters at Green Bay, Wis.

A. E. Anderson, '03, has resigned his position with the General Electric Co. at Schenectady, N. Y., to accept one as estimator with the Chicago Edison Company in Chicago.

John M. McNaught, ex-'92, died in Chamberlain, S. D., the latter part of February. Mr. McNaught was an assistant engineer on the coast extension of the C. M. & St. P. Ry.

Mr. A. B. Whitney, '07, has left school and accepted a position on the Chicago & Alton Railway.

M. A. Whiting, '04, is now employed in the testing department of the General Electric Co. at Schenectady, N. Y.

James B. Bingham, ex-'06, who is in the U. S. C. and G. S., is at present located on the triangulation of the Mississippi Delta.

E. C. Edwards, '05, is now assistant engineer on the C. & N. W. Ry., in charge of new construction in the Platteville Lead and Zinc district.

C. M. Larsen, '05, has resigned his position as assistant engineer of construction on the Mexican National Ry. to accept that of assistant engineer with the Wisconsin State Tax Commission at Madison.

B. C. Brennan, '05, has resigned his position with the U. S. G. S., and is now located with the Indiana Harbor Ry. as transitman.

James Curtin, ex-'06, is with the C. & N. W. Ry., as rodman on their Casper-Lander extension, being located on the Arapahoe Indian Reservation.

The classmates of Geo. W. Brown, '86, who has built, equipped and put in operation a coaling station for the navy department at Dry Tortugas, Fla., will note that he has been transferred to Tiburon, Cal., where he is looking after the interests of the same department in the construction of a larger coal depot in San Francisco harbor.

John Hurley, ex-'06, who has been working as rodman on the C. & N. W. Ry. in Chicago, has been transferred to Pierre, So. Dak.

E. S. Nethercut, '89, may be addressed at 705 Michigan Ave., Evanston, Ill. Mr. Nethercut is with the Buda Foundry and Mfg. Co., 637 Railway Exchange Bldg., Chicago.

H. M. Warner, '04, is with the Hile Construction Co., at Pittsburg, Pa.

X. Caverno, '90, president and general manager of the Kewaunee (Ill.) Light & Power Co., is spending a couple months in Cuba on a combined pleasure and business trip.

Charles H. Scheuer, '06, has accepted a position as rodman on the I. C. Ry. and is located at Burnt Mills, Miss.

John Flaig, '04, who located in St. Paul, Minn., after returning from Panama, has moved to 57 6th St., Hoboken, N. J., and is now employed in the Bridge Department of the D. L. & W. Ry.

J. G. Hammersley, '02, is at present with the Engineering Department of the Milwaukee Street Railway.

Victor H. Reineking, ex-'06, is working on the Wisconsin State Geological Survey investigations of the water power resources of the state.

The following notice which appeared simultaneously on the various bulletin boards on February 24, is self-explanatory.

"A university wedding occurred to-day in the marriage of Mr. Reuben S. Peotter, of the Department of Mathematics, and Miss Elmira Jane Gray of Montreal, Canada. Miss Gray arrived in the city this morning and was driven by the happy groom at once to Christ Church Manse where the pastor, Rev. Geo. E. Hunt, performed the ceremony that united them. After a brief trip they will return and establish their home at 127 North Franklin St., Madison."

THE ENGINEER extends heartiest congratulations to Mr. and Mrs. Peotter, and understands that a number of others are preparing to follow the example set by our graduate editor.

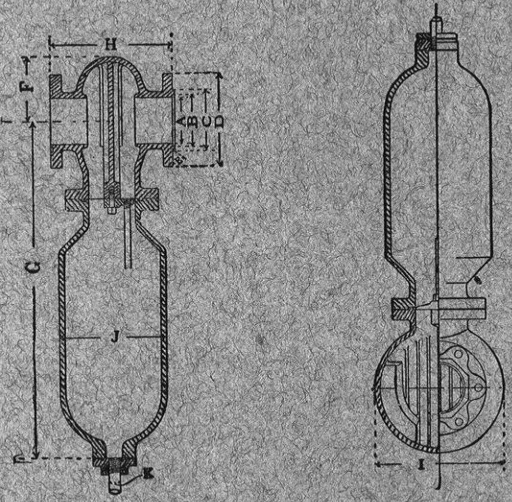
BOOK REVIEWS.

The Ventilation of Buildings, by W. G. Snow and T. Nolan, published by D. Van Nostrand Co., of New York; 50c. net. This is a book which presents in a concise manner the systems of ventilation, and, incidentally, many systems of heating for various types of buildings. The work is divided into three main divisions. The first considers the principles of ventilation, and from this standpoint takes up the theoretical requirements for good health and comfort. The second part analyzes the different methods of ventilation in most common use, while under the third division the authors consider the different requirements of various classes of buildings, such as schools, theaters, department stores, etc.

Upon the whole, the book is well worth the attention of architects, engineers or others interested in this branch of science, which is coming to be recognized as universally important.

THE ENGINEER is in receipt of Bulletin No. 7 of the Abner Doble company, entitled The Doble Tangential Water Wheels. The first portions of the catalogue contains general matter, descriptive of the essential features of the Doble wheels. This is followed by descriptions of several installations notable for the large capacity of the units involved. The latter part of the book contains a number of very useful tables for use in hydraulic work, and has a large amount of useful information in a small space, well arranged for ready use. Any one interested in water power work may secure the catalogue by addressing The Abner Doble Company, San Francisco.

Please mention the Wisconsin Engineer when you write.



Side and end sections of Cochrane Horizontal Steam Separators