FIRST ANNUAL REPORT.

BOARD OF WATER COMMISSIONERS,

YPSILANTI, MICHIGAN

1890

SENTINEL PUBLISHING COMPANY, YPSILANTI, MICHIGAN.

FIRST ANNUAL REPORT

OF THE

BOARD OF

WATER COMMISSIONERS

OF THE

CITY OF YPSILANTI.

PUBLISHED BY AUTHORITY.

YPSILANTI, MICHIGAN:
1890

PUBLIC DRINKING FOUNTAIN.

FIRST ANNUAL REPORT

OF THE

BOARD OF WATER COMMISSIONERS

OF THE

CITY OF YPSILANTI.

MAY 1, 1890.

To the Honorable, the Mayor and Common Council:

GENTLEMEN,—We have the pleasure of submitting to you our first annual report of the construction and maintenance of our present water works system, this being the close of the fiscal year of the city's business.

As to the general construction of the mains, hydrants, well, pumping station, and tower, we refer you to those portions of the report of our constructing engineer, Mr. W. R. Coats, to this Board, which relate thereto, and to tables A, B, C and D.

We shall confine our report to such matters as are not set forth in Mr. Coats' report, which we deem of interest to you and our citizens, and to the receipts and expenditures connected with the construction and running of the works to the present date.

We came into possession of the pumping station and power about June 26, 1889. After the machinery reserved by the Ypsilanti Paper Co. was removed, we removed such portions of the buildings as were not needed, took out the floor and timbers of the main building, removed the old shafting and gearing, and put in new cold rolled shafting with Collins' patent couplings, the journal boxes being bolted firmly to stone foundations. These and other changes were made, anticipating the removal of the electric light plant to this building. This has now been done, and the change we believe will prove to be one of economy, as well as giving general satisfaction.

Soon as the water mains were laid to the pumping station, a Holly rotary pump, belonging to the Ypsilanti Paper Co., was attached to furnish water for puddling back filling of the trenches while laying mains, for which purpose water was supplied by water power and steam power from the engine of the Ypsilanti Paper Co. until about September 15, 1889, at which time we had about 170 water consumers, and the water required to furnish them and for back puddling exceeded the capacity of the Holly pump, and in order to meet the demand made upon us we purchased a "Duplex Steam Pump," 16 inch steam cylinders, 12 inch water cylinders, and 10 inch stroke. This pump was started September 16, 1889, and used night and day, giving a direct pressure in the mains of 65 pounds at the station, and efficient fire protection as fast as hydrants were located. The water for this purpose was taken from the reservoir at plant supplied by the river until October 26, 1889, on which day the first water was pumped from the well, using the Flower pump, which we started that day, supplying the system by a direct pressure of 80 pounds until February 3, 1890, when the water was forced into the reservoir tank of the tower, which requires a pressure of 96 pounds at the plant to keep full.

Since the electric light plant was moved to the pumping station the Flower pump is started about midnight, and run moderately, by water power, until about 4:30 P. M., which supplies the daily use and leaves the tank nearly, if not quite full, for night consumption. The Flower pump can be operated by steam power, from the Corliss engine, in case the water should, from any cause, fail.

The capacity of the Duplex pump is 1,000,000 gallons per day.

The rated capacity of the Flower pump is 1,500,000 gallons per day but it has been worked with perfect success at the rate of 2,000,000 gallons per day.

The Duplex pump is connected with the reservoir and well. The Flower pump is connected with the supply well only, which now gives us an ample supply of excellent water, and no doubt will do so for many years to come.

MOTIVE POWER OF THE WATER WORKS PLANT.

One Little Giant Turbine Water Wheel, rated at 102 horse power.

One Houston Turbine Wheel, rated at 50 horse power, supplied by the Huron river.

There are three turbines in the flume, belonging to the Ypsilanti Paper Company, not yet removed.

STEAM POWER.

One Horizontal Tubular Iron Boiler, 6 feet diameter, 16 feet long, known as No. 1.

One Horizontal Tubular Steel Boiler, 6 feet diameter, 16 feet long, known as No. 2.

One Horizontal Tubular Iron Boiler, 78 inches diameter, 14 feet long, known as No. 3.

One Corliss Steam Engine, cylinder 26 inches diameter, 60 inch stroke.

One Duplex Steam Pump, 16 inch steam cylinder, 12 inch water cylinder, 10 inch stroke.

The new boiler that was purchased for the well, has been set in the boiler room for heating the building and can be used for starting oil fire under the large boilers if necessary. The heating pipes consist of 1600 feet of $1\frac{1}{4}$ inch pipe in one coil placed over head—for heating the whole plant; the water returning direct to the heating boiler.

PUMPING SERVICE.

No record was kept of the water furnished by the Holly rotary pump, which was operated night and day from June until September 15, 1889.

Since that date the amount of water furnished, figured by plunger displacement, is as follows:

	Duplex Steam Pump.	Flower Pump.
September, 1889	4,455,188	none
October "	8,910,675	949,440
November, "	1,135,540	5,523,776
December, "	41,860	6,157,568
January, 1890	none	7,333,024
February, "	none	7,496,416
March, "	32,340	6,359,820
April, "	none	7,273,268
	14,575,603	41,093,312
		14,575,603
Total to May 1st		55,668,915

Daily Average, 245,238.

The employes at the pumping station consist of one engineer and watchman.

HYDRANTS.

The number of hydrants now set is 125, all double nozzle. These have been placed so as to afford good fire protection to all property within the reach of mains now laid.

PERMITS AND CONNECTIONS.

The number of permits issued to date was 507, and number of service connections made 471, balance are being made rapidly as possible, and we hope and expect, by next winter, to have 800 consumers.

EXTENSION OF MAINS.

Conforming to our views as heretofore communicated to you, that all our city should be equally protected as against fire, and should also, if they so desire, be able to take the water for domestic or other uses, we would respectfully recommend, that the mains be extended on Adams street from Michigan to Harriet, along Harriet to and along the streets in Bartholomew's and Morse's additions, also east on Forest Ave. to the city limits, north on River street to the Highland Cemetery, and west on Ellis street to city limits.

COST OF WORKS.

REVENUE.

From Sale of Bonds			$ 125,000 00
"	Taxes		4,400 00
"	Contingent Fund		1,368 90
"	Sales (see Table E)		630 67
"	Rebate in Freight		100 16
"	Ypsilanti Paper Co. (use of water power)		91 67
"	D. L. Quirk (for labor)		35 00
"	Rebate, Pay Roll		6 00
"	Rebate, Robbins & Edwards		1 00
"	Water Rates:		
	Lawns	$ 150 78	
	Domestic	703 08	
	Stores and Offices	115 90	
	Manufacturers	62 75	
	Churches	10 50	
	Hotels	29 00	
	Breweries	41 67	
	Bath Houses	12 50	
	Liveries	10 00	
	Extras	13 00	
	Builders	12 11	
	Plumbers	6 00—	1,167 29
	Total		$ 132,800 69

EXPENDITURES.

PAID.

Making Preliminary Investigations	$ 561 37
Clerk of Board	500 00
Discount on Bonds and Interest	4,326 20
Printing Bonds	197 00
Office Supplies, Rent and Printing	487 75
Laying Pipe, Hydrants and Specials	64,941 05
Pumping Station and Power	33,285 65
Constructing Tower	21,378 68
Constructing Well	7,135 96
W. R. Coats, Engineer	3,000 00
Running Expenses	1,606 10
Connections for Consumers	5,651 94
Total	$ 143,071 70

UNPAID.

Detroit Pipe and Foundry Company		$ 118 35	
Webster & Maethe		39 25	
James Flower & Brothers		2,853 86	
Hall & Norton		26 02	
Ypsilanti Paper Co		62 91	
Sentinel Publishing Co		5 85	
Follmor & Scovill		76 42	
Crane Brothers Manufacturing Company		47 79	
Clerk		100 00	
Cleveland Electric Co		75 00	
Ypsilanti Gas Co		3 60	
Frank Smith		6 15	
H. T. Coe		3 00	
W. B. Campbell		5 00	
Shaw, Kendall & Co		52 44	
Fred D. Coats		25 00	
C. King & Co		188 81	
R. C. Hayton		50	
Total		$ 3,689 95	
Less Claims Due:			
Detroit Pipe and Foundry Co	$ 100 00		
C. King & Co	132 50		
City of Big Rapids	125 00		
Kenney & McCann	40 65		
Geo. Hurrell	42 00		
G. Fuller & Son	30 00		
M. S. Hall	3 00		
H. M. Curtis	2 10		
Jno. Kimball	1 20		
C. Smith	40	476 85	3,213 10
Total cost to date			$146,284 80
Amount Paid Preliminary Investigations		$ 561 37	
" " Clerk		500 00	
" " Discount and Interest		4,326 20	
" " Printing Bonds		197 00	
" " Office Supplies, etc		487 75	
" " Running Expenses		1,606 10	
" " Consumers' Account		5,651 94	13,330 36
Net Cost			$ 132,954 44

The amounts unpaid are chargeable as follows:

Office	$ 164 10
Tower	56 95
Pumping Station	2,828 08
Pipe Line	168 69
Well	44 97
Consumers' Account	373 52
Running Expenses	53 64
	$ 3,689 95

RECAPITULATION.

Amount expended		$ 143,071 70
Amount unpaid		3,689 95
		146,761 65

CONTRA.

Amount received	$ 132,800 69	
Amount due	476 85	133,277 54
		13,484 11
Amount to be credited by sale of bonds last issue		12,000 00
Deficit		$ 1,484 11

Owing to the excellent quality of our water and the quantity available, we can, we believe, safely say, if you will this year provide for the payment of the first eighteen months' interest on bonds issued, we will be able to take care of the deficit, running expenses, ordinary repairs, and the expenses of consumers' connections, with amount received from water rates.

RECAPITULATION.

COST OF PUMPING STATION, PIPE LINE, WELL AND TOWER, TO DATE.

PUMPING STATION.

		Cost.
Amount expended	$ 33,285 65	$
Amount unpaid	2,828 08	
	36,113 73	
Less cash sales and to collect	315 44	35,798 29

PIPE LINE.

Amount expended	64,941 05	
Amount unpaid	168 69	
	65,109 74	
Less cash sales and to collect	373 65	64,736 09

TOWER.

Amount expended	21,378 68	
Amount unpaid	56 95	
	21,435 63	
Less rebate sales and to collect	303 12	21,132 51

WELL.

Amount expended	7,135 96	
Amount unpaid	44 97	
	7,180 93	
Less sales and to collect	297 52	6,883 41

Respectfully submitted,

D. L. QUIRK, Pres.,
H. P. GLOVER,
H. M. CURTIS,
O. E. THOMPSON,
CLARK CORNWELL,
Board of Water Commissioners.

FRANK JOSLYN, Clerk.
May 1st, 1890.

BOARD OF WATER COMMISSIONERS

OF THE

CITY OF YPSILANTI.

DANIEL L. QUIRK, - - - - - - -	PRESIDENT.
FRANK JOSLYN (*ex officio*), - - - - -	SECRETARY.

HENRY P. GLOVER, - - - - - -	TERM EXPIRES 1890
HENRY M. CURTIS, - - - - - -	TERM EXPIRES 1891
DANIEL L. QUIRK, - - - - - -	TERM EXPIRES 1892
O. E. THOMPSON, - - - - - - -	TERM EXPIRES 1893
CLARK CORNWELL, - - - - - -	TERM EXPIRES 1894

FINANCE COMMITTEE.—Messrs. Glover, Curtis and Thompson.

WATER SUPPLY COMMITTEE.—Messrs. Cornwell, Glover and Curtis.

REPORT OF CONSTRUCTING ENGINEER.

To the Honorable, the Board of Water Commissioners:

GENTLEMEN,—As the highly important public work upon which we have been engaged during the past season is now practically completed, I deem it best to render to you a full detailed report of everything connected therewith. So far as your Board is concerned, such a report is scarcely necessary, or of very much importance, for you have all taken such a full and active part in the work, from beginning to end, as to make you almost as familiar with every detail as I am myself. But for those who come after you it is highly important that we leave matters in such shape that every detail of the entire work may be readily referred to and comprehended. The failure to do this has caused many of your sister cities throughout this state vast trouble and expense. Our work here has been in many respects unique, and a radical departure from the old beaten path so long pursued in water works construction. It has long been the fashion to depend upon lakes, ponds, rivers and small streams, for our public water supplies, and the majority of people are very slow to believe in the feasibility of any other source of supply. All these sources being contaminated with the filth taken up and absorbed in the surface wash of the tributary water shed, the water thus obtained is seldom in any sense fit for *potable* use.

In the construction of works to distribute these waters when obtained, the usual fashion has been, to either construct a pumping plant on the simple *direct* pumping plan, which must be run incessantly to insure a *constant* supply, or else resort to the common open earth reservoir, or that most ridiculous of all things, the "*stand pipe*," as an adjunct to the pumping works.

This work has possessed an all absorbing interest for me from the outset; as, being given full authority by your Board, to build the works in accordance with my own best judgment, I well knew that I could give you a system of works far superior, in every essential feature, to any system of water works in this state. And from the zeal manifested by all the members of your Board, I can readily believe that *your* interest in the work has been almost as great as my own. I think I may be permitted to say that the high excellence and efficiency of our work is chiefly due to this hearty co-operation and harmony of feeling and action between your Board and your engineer. It is not too much to say that more and better work has been accomplished with the time and money expended, than has ever before been accomplished in this field of work. Nor is it too much to say that the Ypsilanti Water Works as they stand to-day, are of more than double the value, as compared with any works of like extent anywhere, constructed in the *ordinary* way. Your works start out at the commencement of their *first year as a fully self sustaining* public enterprise; and this measured only by simple *dollars and cents.* Could we measure accurately their *sanitary* value to your beautiful city, you would all be amazed at the showing. I am very glad to see that very many of your people are already beginning to appreciate, in a very fair degree, the importance of this work, considered from a sanitary point of view, but a hundred years hence this will be understood and appreciated a thousand fold better than it is to-day, and you, gentlemen of the Board, will be remembered and blessed by the people for *all time* to come, for the grand work you have finished in this year of our Lord, 1890. I believe, gentlemen, that we have all builded far better than we knew, and that the good Lord has been with us, and helped us to successfully accomplish this grand, good work.

It is true that I knew from the first, that I could—if permitted—give you a water supply equal in quality to the best in all the country, and that I could give you all the physical features of the works in their present high degree of excellence; but no one not gifted with divine penetration could have foretold the marvelous sanitary excellence of this water. The value of this feature of our work is beyond measure, and constitutes a factor of constantly increasing importance and value. As your city increases in number and density of population, and the ordinary sources of water supply—private wells—become more and more dangerously polluted, the question of pure water for domestic use becomes of the utmost importance; of far greater importance than many of us understand. A much larger percentage of sickness and mortality is caused by the bad water used, than from any other cause, if indeed it does not exceed all other causes combined. Comparatively speaking, no community can be healthy, prosperous and happy, in the absence of proper sanitary rules and regulations, and with such rules and regulations properly enforced. And it is not possible to establish and maintain such rules and regulations without an adequate supply of pure water for general use. With proper drainage facilities, in connection with your splendid water supply, it will be easy for you to maintain a sanitary status of the very highest degree of excellence.

I do not know of a city anywhere possessing more favorable natural advantages for efficient and economical sewerage than the city of Ypsilanti.

It is very rarely indeed that we can find a city where nature has placed within such easy reach, every requisite for a complete and perfect public water supply and drainage system. Yet plain as all this is *now*, so far at least as relates to your public water supply, it was only by the very narrowest margin that you escaped an almost fatal mistake in carrying out this great and all important work. The doubts and fears as to the success of any source of water supply for the proposed works, other than the river, or Paint Creek, led the great majority to look to one of those sources for a water supply. Had your works been constructed as first projected, with a surface supply, they would not have been worth twenty-five cents on the dollar, as compared with their real value as they stand to-day.

Your works have cost nearly double the amount estimated for the small plant originally proposed, but the present works are of nearly double the extent, and of fully three times the *real value* of such works as contemplated by your first plans.

Notwithstanding the unusual extent and completeness of the present works, it would be a wise economy to add between four and five miles to the system of street mains, thus bringing every building within the city limits, under complete fire protection, from fire hydrants located within easy reach.

A detailed history of the discovery and development of the water supply, and a full explanation of everything pertaining thereto, will doubtless prove of interest to all, and will also serve to dispel the fears of any who may still feel inclined to doubt the permanency of the supply.

I think the great majority of your people had but little faith in the success of this branch of our work until success had been fully accomplished and demonstrated. Some still seem to believe that the supply will ultimately give out. From my first visit to your city three years ago, for the purpose of making an investigation relative to the development of a water supply for your contemplated water works, I have never entertained the slightest doubt as to the complete success of the work, precisely as it has since been accomplished.

It is not difficult to determine, with a reasonable degree of exactness and certainty, whether an adequate water supply can be developed from subterranean sources in any locality. The experienced and properly trained investigator can determine at a glance, in almost any locality, whether enough water is disposed of below the surface, to supply any desired requirement. The rainfall, area of water-shed, and the general topographical and surface conditions, will tell him this; but he cannot tell whether enough of this water can be diverted from its natural course and drawn to any one point, until he ascertains the character and conditions of the strata, through which this water passes. If we are confined to a water bearing stratum of *fine sand*, we cannot collect sufficient water at any given point—no matter how great the tributary supply may be—simply because the water cannot pass through such a stratum fast enough.

This is the reason the test well in the north part of the city held out no promise of success. To the inexperienced observer, the promise there was as good as at the point chosen; but, in real truth, it would not have been possible to have obtained one-twentieth the water there, that the location chosen affords. If we are in a water-bearing stratum of free open gravel, everything is changed. While there may be no more water tributary to this stratum, than in the case of the fine sand stratum, yet *all the water* there is, can be rapidly collected at any given point, from a large surrounding area. To illustrate: we will assume that we are in a locality where the rainfall is thirty-six inches annually—which is the mean of the entire globe—we will assume that sixty per cent. of this rainfall is absorbed and passes to the streams subterraneously; this simply means that over one million gallons of water *per day, for each square mile* of area of such locality, goes to the streams subterraneously; hence it is clear that if we can command an area of one square mile in such locality, we are sure of a water supply in excess of one million gallons per day; and pro rata for a larger or smaller area. There is nothing fanciful in all this. From actual practical tests I have demonstrated in several localities, in different parts of the country, that an area of one and one-half miles radius, can be commanded by a well located at a central commanding point. At one point in Nebraska, a water works well forty feet in diameter and forty feet deep, was subjected to a pumping test of three days, the water being held down twelve feet below normal level; this affected all the ordinary wells for the distance of one and one-half miles radius, showing clearly that we had this entire area under full command at this single point.

The correctness of this is also substantiated in many other cases where such close observations have not been made. There are many places where I have constructed water works supply wells, that have shown a capacity of three to five million gallons per day, and have been in use for years. Of course, it is clear that where we have a well yielding a given amount of water, it *must necessarily* command an area of water-shed and rainfall adequate to supply it. Of course, both the surface and subterranean water supplies come from the same source, the rainfall, and it necessarily follows that if either supply gives out, the *surface supply*, or upper levels, must give out *first*. In all my experience I have never known an instance where the yield of a properly constructed well has diminished from long use, except to the extent of the fluctuations due to the variations in the volume of rainfall.

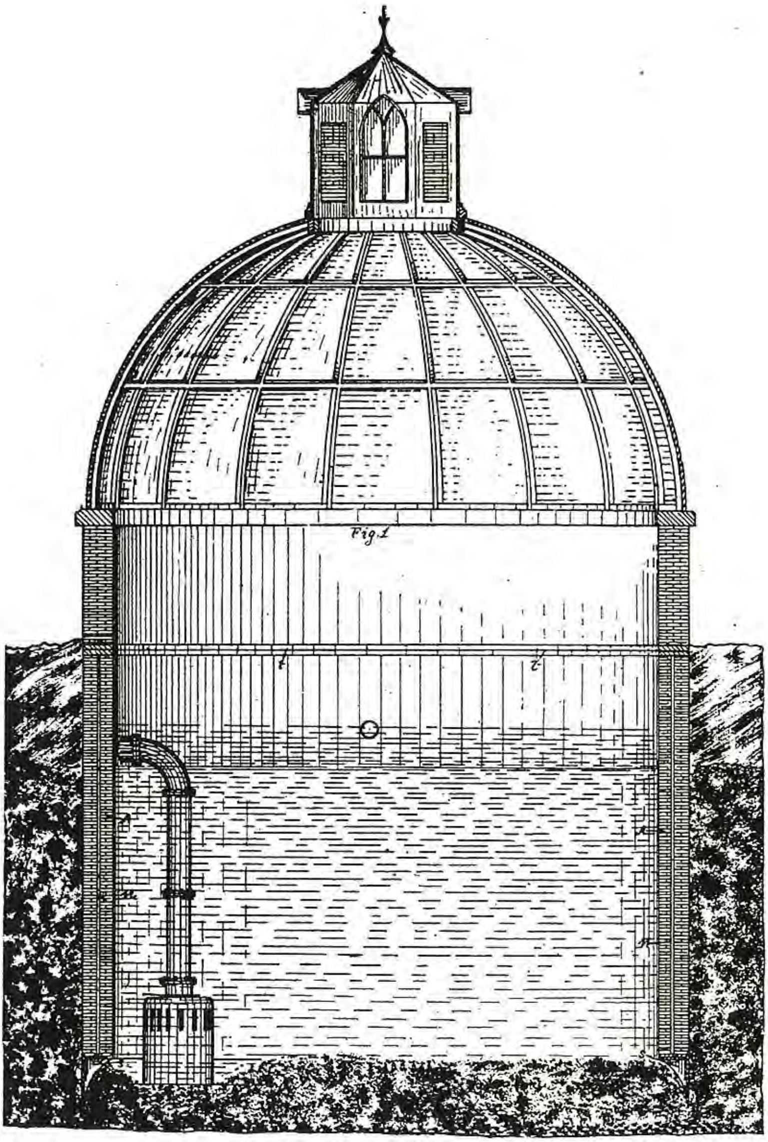
The first Kalamazoo well, constructed nearly twenty years ago, and used constantly ever since, I estimated at a capacity of three and one-half million gallons per day at the time I constructed it. It will yield as much water to-day as when first constructed, and has been tested within the last few years, showing a capacity in excess of four and one-half million gallons per day. Our well here will yield fifty per cent. more water now, than the day it was finished.

This is accounted for by the fact that the strata waters were at the lowest ebb ever known at the time the well was finished, since which time they have been very greatly replenished by the fall and winter rains. I think this ought to satisfy the most skeptical, of the reliability and permanency of your water supply.

The cuts on page 20 and inset page show the interior and exterior of the well as now finished and in use. In the construction of this well, I have met with many surprises. From my tests of three years ago, I ascertained the strata conditions to be about as follows: The first eight feet, from the surface down to the river level, is common soil, sand and gravel, with no water of any consequence; the next sixteen feet is a very dense tenacious hard pan; underlying this is a water-bearing stratum of sand and gravel of six feet in thickness; next below this lies another stratum of hard pan of much less thickness than the first hard pan stratum; and still below this lies an exceedingly free water bearing stratum of gravel, of unknown depth. This last stratum was my main dependence for our water supply, as I did not expect the first water-bearing stratum would yield a sufficient supply to meet our requirements. The unexpectedly large yield of water from this first level, and the dip of the hard pan stratum, very greatly increased the difficulty and cost of the well construction. Had the hard pan stratum laid *level*, as was first supposed, the plan in constructing the well was, first to make a circular excavation about forty feet in diameter down to within about six inches of the first water-bearing stratum, then put together the iron work and masonry of the caisson, after which break up the remaining hard pan, let the well fill with water, and then dredge out everything down to the second hard pan, break through that, and our well would be finished.

In making our first excavation, however, we unexpectedly broke through the hard pan into the water on the west side, three feet and six inches above the level indicated by our test tube, located forty-five feet north of this point. Here commenced our trouble. Of course, the water must be kept down while putting the iron work together and building the caisson wall. Not anticipating any larger amount of water than we could take care of with some old steam pumps we had on hand, we brought these into requisition.

It was soon found that nothing we had on hand would do the work, owing to the constantly increasing flow of water. And we sent to Chicago and purchased a pump that would handle 2600 gallons of water per minute. It was found before we got through that even this was not sufficient. We then obtained the use of another pump of 4750 gallons capacity per minute, and even then it was all we could possibly do to hold the water down, until we could remove this first hard pan, and sink our curb through it. We then allowed the well to fill with water and dredged out a portion of the sand and gravel, sinking the curb about half way through it, where we stopped, not penetrating to the second and larger supply at all, the first being deemed amply sufficient for all requirements. Some idea of the capacity of this well can be formed when I tell you that *three sets* of pumps of the capacity of our triplicate power pumps, all working together, could not handle the water that the well will yield just as it stands. Should it ever become necessary, the supply of the present well can be doubled by breaking through into the second water stratum. The water of the sec-



INTERIOR VIEW OF SUPPLY WELL.

EXTERIOR OF WELL.

ond stratum is purer, that is to say, carries less solid matter to the gallon, than does the water we now have, and yet I do not think that the lower water is of such excellence as a high grade potable water, as that we now have. Of this fact you may rest perfectly assured, neither of these water strata can possibly be contaminated by any of the surface filth or sewage seepage of the city. The curb walls of the well being impervious, no water from above can get through them, and the strong, upward flow of the waters entering the well from below, will repel and drive back all vagrant waters from above, even if such waters could otherwise penetrate the hard pan stratum overlying these lower waters. If our caisson wall had no openings, the water would rise and overflow the coping surmounting the walls when the pumps are not running.

The supply well is connected with the pumps through a sixteen inch cast iron main running under the bed of the river, and the race, to the pumping station on the opposite side of the river, nearly one thousand feet away.

The quality of the water obtained from this well has been the greatest surprise to me of anything in all my experience in this field of work. I knew that the water was of excellent quality, but I was not prepared for the marvelous sanitary excellence its use has shown it to possess. I had never before known that a simple high grade potable water could have such an effect upon the human system. I had always before supposed that all waters must be highly impregnated with foreign matter (so much so as to be more or less offensive to the taste) in order to work as medicinal or curative agents in the human system, but here we have a water of most remarkable sweetness and pleasant taste, and yet as a simple potable water possessing astonishing curative powers. To me it seems that this water is simply a water that most completely meets all the requirements of the human system, and most completely aids all the organs of the system in performing their natural functions.

The occasional yellowish or roily color of this water as it comes from the hydrants is caused in this way: When the water comes to the air and remains still, carbonic acid is released. This results in the precipitation of carbonate of lime with some carbonate of magnesia, the carbonite of iron in the water (one and one-half grains to each ten pounds of water) oxidizes or rusts this lime and magnesia and discolors the water.

This precipitation and discoloration does not take place when the water is in active motion, but it does collect on the inside of the water mains, to a certain extent, when the water is still, or comparatively so. In such cases whenever a sharp current is forced through the mains, it dislodges this matter and the water will be discolored for a brief time.

The more freely the water comes to be used the less this discoloration will appear. To the matter that causes this discoloration (carbonate of lime, magnesia and iron), is due the remarkable excellence of the water, and there is nothing harmful about the water even when it shows this roily color, or, as is sometimes the case, it emits a gaseous odor.

The cost of the supply well complete, has been $6483.91.

Prof. Kedzie, of the State Agricultural College, gives the following analysis of the water of the supply well:

Fixed residue of mineral matter per imperial gallon		34.91 grains
This mineral matter consists of		
Carbonate of lime	20.23	
Sulphate of lime	2.73	
Carbonate of magnesia	7.00	
Carbonate of iron	1.50	
Soluble silica	1.00	
Alkaline chlorides	2.45	= 34.91
Lithium	spectroscopic trace	
Nitrites	none	
Nitrates	trace	
Free pure ammonia in million parts		.03
Albuminoid ammonia		.02

Quality of water excellent. R. C. KEDZIE.

LANSING, February 26th, 1890.

The above analysis shows a purer and higher grade potable water than the Bethesda, the best of the famous group of springs at Waukesha, Wis., and has already resulted in several more remarkable cures of urinary and kidney diseases than any recorded of the Waukesha water, as testimonials following this report will show.

THE PUMPING WORKS.

All the plans relating to the pumping plant for the proposed Water Works that were considered up to very near the time of final decision and adoption, were based upon steam as a motive power.

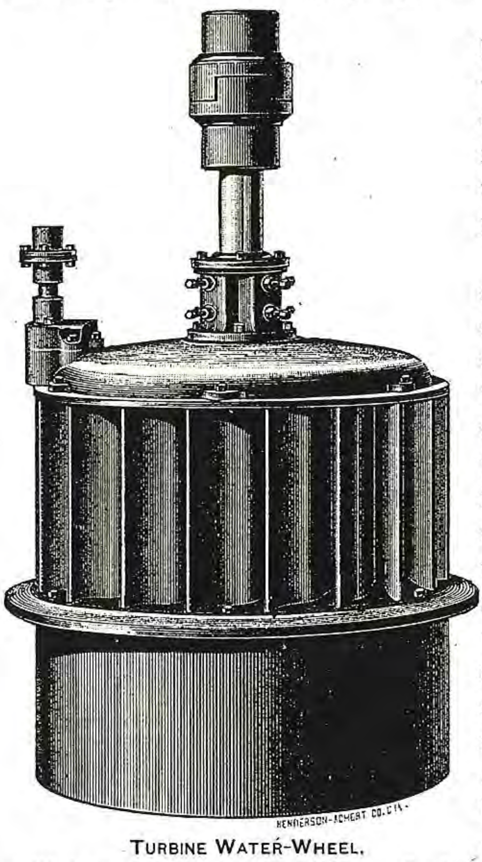
When it was found that the water power and buildings of the Ypsilanti Paper Company could be obtained upon favorable terms, it was deemed best for the city to purchase this property, locate the pumping station there, and utilize this water power in operating the pumping works.

The purchase price of this property was twenty-six thousand dollars. This included real estate—nineteen acres—power and improvements, buildings, water wheels, one large Corliss engine of three hundred horse power, together with some other items of minor importance. The appraised value of this property considerably exceeded the purchase price, without counting the naked power at all.

For myself I considered the power the chief factor of value, regardless of the sundries thrown in. This power is clearly worth to the city all that the saving in operating expenses, as compared with steam, will represent. The works can be run with this water power for at least twenty-five hundred dollars less per year than the same works could be run with a steam power. This capitalized at four per cent. represents sixty-two thousand and five hundred dollars. This I regard as a conservative estimate of the value of this power to the city for water works purposes alone. Whatever additional service is afforded in running the electric dynamos is so much more added to this value.

The first cost of this property was about double the cost of the steam pumping plant at first under consideration. To this must be added the cost of the power pumps, and the necessary repairs and alterations of the buildings, and three thousand dollars more for the piping between the well and the pumping station.

I had estimated that four thousand dollars would be sufficient to provide the power pumps and to make such changes in the buildings as would answer every purpose, until such time as the city should deem it best to put up a proper permanent building, and I felt that it was not wise to spend any more money than was necessary to accomplish this. No amount of expense could make anything of the old buildings, in their present form, that would prove at all satisfactory for a *permanent* structure. But we could at small expense put them in such shape as would answer temporarily, until such time as the city was ready to substitute a proper permanent building.

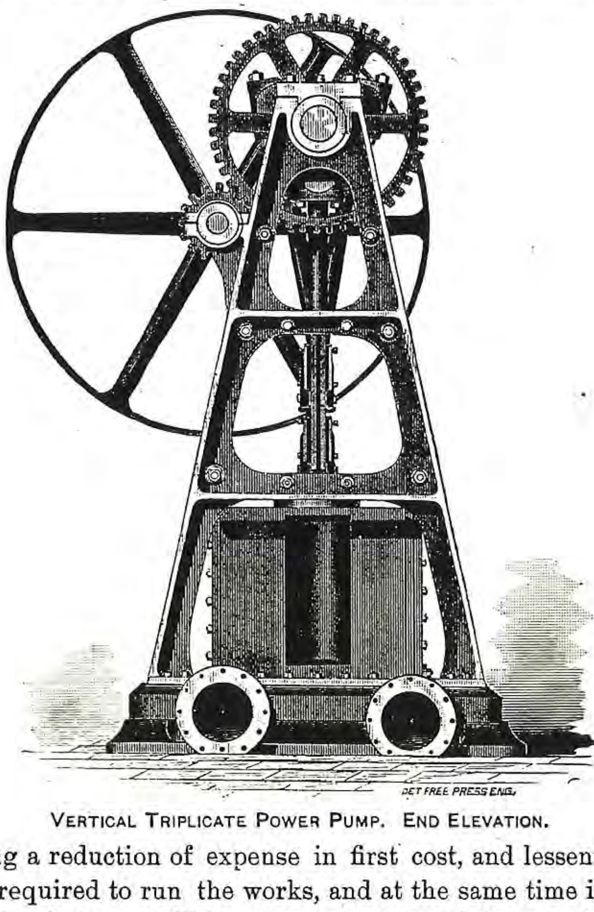


TURBINE WATER-WHEEL.

I think it would have been better had we put what we required of the old buildings as nearly in the shape desired for the new building, as possible.

A building sixty by seventy feet in dimensions will be needed for a permanent structure. This building should be divided into three compartments. The room for the pumps and dynamos should be about thirty-five by sixty feet in size. The room for the boilers should be about thirty by thirty-five feet, and the engine room the same. We could have put the buildings in this shape very easily, by simply utilizing sixty feet of the west end of the building, now used for the pumps and dynamos, taking away fifty-five feet of the east end entirely, using the boiler room as it now is, and by leaving thirty-five feet of the north end of the intermediate building, and using this for an engine room. This would have brought everything into good compact shape for advantageous work.

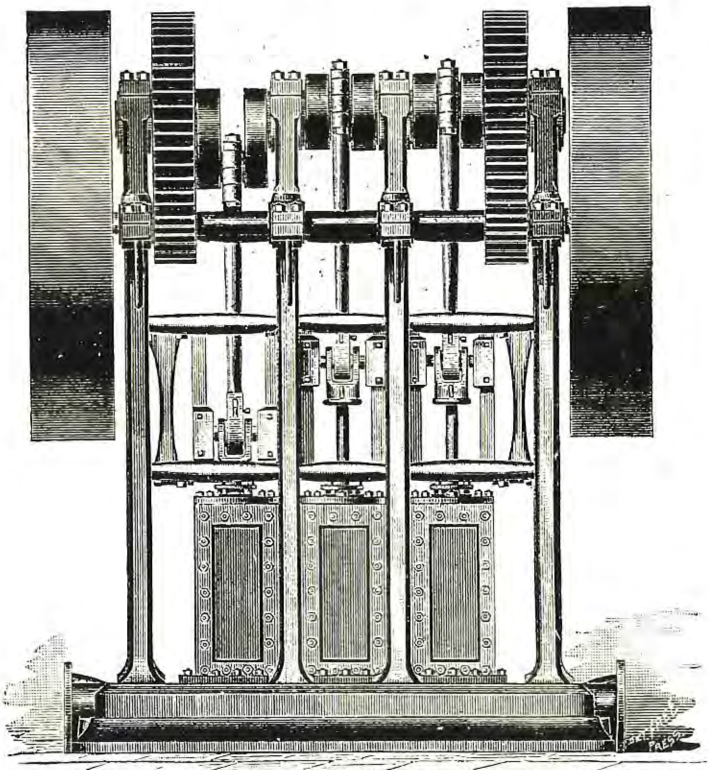
The engine and boilers would have been in close proximity, and in far more efficient working order than now. The line shaft would have been reduced in length fifty-five feet, thus



VERTICAL TRIPLICATE POWER PUMP. END ELEVATION.

securing a reduction of expense in first cost, and lessening the power required to run the works, and at the same time increasing their efficiency. This arrangement would have put everything in good shape for the new permanent building when the proper time came for putting it up. The building could have been heated more cheaply in this form.

If the large Corliss engine could be sold, I think it would be better to transfer the engine of the old electric light plant to the pumping station, as this engine is of ample power to do the work, and is in much better proportions for the situation. I think it would be wise to change things to conform with this outline before another winter sets in.



VERTICAL TRIPLICATE POWER PUMP. SIDE ELEVATION.

Built by JAS. FLOWERS & BROS., Detroit, Mich.

Notwithstanding any mistakes that may have been made, I do not think there is much cause for complaint, as even with this added expense the city is away ahead in the purchase of this water power, as all who have observed the action of the pumps during the six months that they have been running can readily see. And now the splendid action of the electric light plant, operated with the same power, adds still more largely to the value of this purchase.

The pumps are operated under a water pressure of from ninety-two to ninety-eight pounds to the square inch.

The pumps are triplicate power pumps, of an entirely new pattern, being the only set of the kind in this country. I regard them as of a very high order of excellence, and very economical in operation. Being the first of the kind made, they are not as perfect in action as added experience will make this type of pumps, but there is every reason to be entirely satisfied with them.

The pumps have been running over six months, about half this time constantly, pumping direct. Since the reservoir has been finished and in use, it has not been necessary to run the pumps but a few hours each day.

The cost of the pumping works as they now stand, inclusive of the power purchase, has been $36,207.00. I think this power will save to the city at least four per cent. on $100,000.00 in the running of the pumps and the electric dynamos.

STREET MAIN DISTRIBUTION.

The tables on the last pages will show the entire system of street mains, giving the size and position of the pipes in each street, and will also show the position of the fire hydrants, gates and specials.

In the construction of a public water works the street main distribution is one of the most important features in the work, and upon this very largely depends the general efficiency of such works. No matter how excellent and abundant our water supply may be, or how perfect the works may be made in all other respects, we can do nothing beyond the reach of our street mains. If we build a water works at public expense, and tax the entire city to pay for them, and only provide for a portion of the city, then it is obvious that an injustice is done to that portion of the city not provided for. This is taxation without representation, and although so commonly practiced, is contrary to the spirit of American independence. Yet this branch of a water works service is never made as complete in the outset as it ought to be made, and indeed it is very rarely the case that it is ever made so afterward.

Here in Ypsilanti you have made this improvement more complete and perfect in the outset, than it has ever been made before. Indeed your works are more complete and perfect at the commencement of their first year than any other works in the state, regardless of the time they have been constructed and in operation.

Take your sister city of Kalamazoo for comparison. Kalamazoo boasts of the excellency and efficiency of her water works; these works are in their twenty-second year, and have *cost fifty per cent. per capita more than your works have cost,* while the street main distribution of the Ypsilanti works is over *one hundred per cent. per capita greater, this first year, than is that of Kalamazoo in this, her twenty-second year.* You have four lines of mains running under the river, besides the sixteen inch main from the well to the pumps. This gives you a perfect service throughout the city on both sides of the river. At Kalamazoo the water mains do not cross the river at all, thus leaving *one entire ward without a single foot of street mains.* The Kalamazoo works have no storage reserve whatever. If their pumping engines stop from any cause, for a *single moment, the entire service is dead,* until pumping is resumed. In your case, the pumps can remain idle for twenty-four hours, and the entire service will go on as effectively as though the pumps were running.

Another feature of your service which is of transcendant importance consists of its *unvarying constancy.* You are under a *uniform pressure at all times,* and this pressure is adequate to meet and maintain the requirements of all branches of the service. If fire service is required, the pressure in the mains is always ready to furnish it. At Kalamazoo, under the pernicious direct variable pressure system, the pressure in the mains must be raised fifty pounds per square inch for fire service, *after* the fire calling for it breaks out, and even then there is nothing but the pumps to depend upon, and the pumps are handicapped with a double load as compared with the situation had they been working on the *uniform* pressure plan. There are many other superior excellencies in your works, as compared with the Kalamazoo works—which have long been considered among the best in the state—but it is sufficient to say in summing up, that notwithstanding the much higher excellence of your service in all its branches, yet its relative cost is much less than the Kalamazoo service, and while your city has less than one-third the population of Kalamazoo, the net revenue of your works for this *first year* will exceed the net revenue of the Kalamazoo works for their *twenty-first year*, as per official reports of the Kalamazoo works.

Liberal as is your street main distribution it would be in the interest of a wise economy to add four and one-half miles more of street mains. This would bring every building within your city limits under full fire protection from your street main system.

The unrivaled initial success of your works is chiefly due to the liberal street main distribution, and the manner of putting it in, and the public spirit of your people is worthy all praise for calling for this extended street service. It was not so much due to the excellent quality of the water that has enabled your works to start out with twenty-five times as many water takers as a neighboring city of like size, Owosso, whose works were finished some months before your own, for our supply well was not available until the close of the season. Most of these connections were made while we were still using river water, and before it had been demonstrated to the satisfaction of your people that the well would be a success. This great success was mainly due to the fact that we started out with water, filling our mains as fast as laid, using the water to puddle the back filling of the trenches. This put the water within reach for lawn sprinkling and other purposes as soon as the mains were laid, and the people were not slow in taking advantage of and appreciating this. The result is your streets are left in far better condition, and you start out with far more water takers than has been the case with any new works ever before built in the state.

The general plan for the street mains consists of two twelve inch lines running north and south through the city, one on each side of the river, and two central lines running through the city from east to west. One of the east and west lines is of twelve inch pipe, and one of eight inch pipe. The lateral mains are principally six inches in size, and run at right angles to the central mains, each lateral being supplied from both ends, and in many cases from intermediate points.

This frequent reinforcement of the smaller mains, and the complete circuit maintained, adds greatly to the efficiency of service of these smaller mains, making them of double the capacity as compared with the same size not in complete circuit, and not reinforced. The twelve inch main on the east side is not yet laid, and will not be needed until the capacity of the west side main is fully reached by the consumption. Under ordinary conditions the present single force main would be ample for five years to come, but the water is becoming so popular with your people that it may be necessary to supply this second force main sooner.

A fire hydrant has been placed at every street intersection. I should have preferred them more frequently could we have placed them so without curtailing the street mains, but our means did not permit of this; the same is true relative to the stop gates. The mains are laid six feet deep, which will secure them against frost even in the severest winters. The mains cross the river four times, exclusive of the sixteen inch suction main. One twelve inch force main crosses the river on Race Street near the lower bridge. This main is thoroughly imbedded and covered in the river bed. Another twelve inch main runs under the river at Cross Street. This is sunk beneath the bed of the river and covered same as at Race Street. An eight inch main crosses at Congress Street. This simply rests on the bed of the stream, as it is still water and deep, so there is no danger of frost. A six inch main crosses the river at Forest Avenue in the same manner as at Congress Street. A sixteen

LAYING RIVER MAINS.

inch main runs under the river and the race from the supply well and the pumps. The cut on page 31 shows the plan adopted in laying these river mains.

All the river mains, except the sixteen inch supply main, are forty per cent. heavier than the street mains. The object in using heavier metal is to secure additional safety in these difficult situations, as breakages in the river lines would be much more difficult and expensive to repair than breakages in the street lines.

One very marked feature in the development of our street main service has been the very liberal patronage given to the lines far removed from the central portions of the city. Although many of these outer lines were not contemplated in the first plans, and were not finally put in until the last, yet there are relatively more water takers now connected with them, than with the large central lines first laid.

I think this conclusively shows the wisdom of your Board in extending the street main service so far beyond the limits contemplated in the first plans, and I think it will be wise to profit by this lesson by making provision for such outlying portions of the city as are still without water mains. In all cases where a revenue from private consumption will pay the interest on the cost, I think mains should be put down. We then have left as a clear profit the value of the fire protective service, to say nothing of the sanitary betterment.

The cost of the street main distribution, including hydrants and gates, has been $64,608.62.

The fine bronze drinking fountain, a cut of which is shown as a frontispiece, was presented to the city by that generous, public spirited lady, Mrs. Mary A. Starkweather.

This lady has made other noble gifts in the interest of the public good of Ypsilanti. Her recent gift of the beautiful Memorial Chapel in Highland Cemetery, and her still more recent donation to the Ladies' Library Association, of a fine building and grounds, will stamp Mrs. Starkweather's memory for all time in the hearts of the people of Ypsilanti. These gifts overshadow, in cost and importance, the gift of the beautiful drinking fountain, yet in the hearts of the thousands who drink of its pure and sparkling waters, the drinking fountain will have the most friends, and will be most lovingly appreciated.

THE ELEVATED RESERVOIR.

The reservoir constitutes one of the most important and distinctive features of the Ypsilanti Water Works system. This reservoir consists of a large steel tank mounted on a substructure of masonry, and is placed at an elevation sufficient to furnish full effective fire service from the simple gravity pressure of its waters.

The primary object of the reservoir is to furnish storage for a reserve supply of water to carry the night service entirely without pumping, and also to furnish assistance to the pumps on extraordinary occasions.

With adequate storage facilities all the water required for the full twenty-four hours' service can be pumped during the day time, the excess of water beyond what is required for the day service being stored in the reservoir to carry the night service, thus relieving the pumps entirely during the night.

Under this arrangement only one set of men will be required to operate the pumping machinery. Without this reserve the pumping machinery must be kept running constantly, requiring two distinct sets of men. Without this storage reserve to carry the night service, thus relieving the pumps, the water power could not be utilized at all in running the electric light dynamos. With the reservoir to take the excess of water, the pumps can be run sufficiently in excess of the ordinary daily requirement, to fill the reservoir, the pumps can then be shut down, and the reservoir will take up the entire service. This will leave the entire water power available for running the electric dynamos during the night.

It is expected that the capacity of the reservoir is sufficient to carry the entire ordinary service during the night, with always a sufficient reserve to meet any extraordinary demands that may arise. The present reservoir has a capacity of thirty-five gallons of water per capita for the present population of your city. I had expected this would prove to be sufficient to meet all demands for the first five years, after which time the general plan contemplated a duplicate reservoir on high gounds in the eastern part of the city; but your water works and the water are becoming so popular that the consumption bids fair to reach the capacity of the present reservoir, and require the building of the second, before the end of five years. There will be no hardship in this, however, as before the capacity of the present reservoir is exhausted, the revenue of the works will be ample to provide for all needed improvements and extensions.

The object in locating the reservoir so far from the pumping station, and on the opposite side of the city, has been to secure greater efficiency of service, and to promote harmony of action between the pumps and the reservoir.

The pumping machinery and reservoir could not furnish as effective service both working together from the same point, as would be afforded if both were working from opposite directions. To illustrate: All large fires are usually to be looked for in the business heart of the city. If we are to fight these fires with water *direct* from the street mains, and are to depend upon the combined service of the pumps and reservoir for water, it is obvious that the pumps and reservoir should be so placed as to render the most effective service.

If we place them together and require them to work through the same main, it is clear that the combined service cannot exceed the capacity of this single main. On the other hand, if the pumps are located on one side of the city, and the reservoir upon the other side, a fire in the heart of the city can be operated on from both *front* and *rear*. We are thus able to do vastly better execution than would be possible with both pumps and reservoir working from the same point, and through the same main. Of course, the pumping works cannot in any event furnish water beyond the simple capacity of the pumps, while the reservoir is only limited by the capacity of the mains to carry the water.

Not nearly so much water is required for the extinguishment of fires as is generally supposed. A comparatively small amount of water, instantly available, will accomplish much more in the suppression of a fire, than a vastly larger amount not under sharp command.

With your elevated reservoir you should always have at command, at least, one hundred and fifty thousand gallons of water, independent of the pumps. It is very rarely that one-half this amount of water will be required upon any one fire. Kalamazoo, a city of three times the size of Ypsilanti, reports forty-three fires for the entire year, 1888, yet less than three-quarters of a million gallons of water in the aggregate, was used for all these fires. Ypsilanti will use less water relatively than Kalamazoo, for the water pressure upon your mains is always *uniform* and *constant*, and ready for fire service, while at Kalamazoo the pressure must be raised by the pumps, from ordinary pressure to fire pressure, *after* the fire breaks out and the alarm is sounded. It will be best that the reservoir be kept as nearly full as possible at all times, and it should invariably be full when the pumps are shut down at night and the power changed over to the electric dynamos.

It would have been better had the machinery been so timed that both the pumps and dynamos could have been run together, in case such necessity should ever arise. But I do not think it will ever be necessary to run both at the same time if care is taken to always start at night with a full reservoir.

The reservoir structure as it stands has cost $21,368.00 and it will cost $400.00 more to point it and put in a cement floor to fit it as a hose house for that part of the city. Changes have been made in the original plans for this structure that will account for this excess of cost over the first estimates.

The masonry has been carried ten feet higher than first contemplated. This additional height has added ten per cent. to the cost. Joliet stone was used in place of brick or common stone as at first contemplated. It was supposed the Joliet stone would not cost any more per cord laid in the wall than common stone, but this estimate was based upon the supposition that we would get full cord measure, but the result has shown that the Joliet stone were fifteen per cent. short of full measure.

Steel floor beams were substituted in place of wood. This item added five hundred dollars to the cost. These changes have added to the beauty and worth of the structure.

In planning this work my chief aim was to make the substructure of sufficient solidity and strength to safely carry the immense load that was to be put upon it, and to make the whole structure as fair in proportion and good looks, as was consistent with this main purpose.

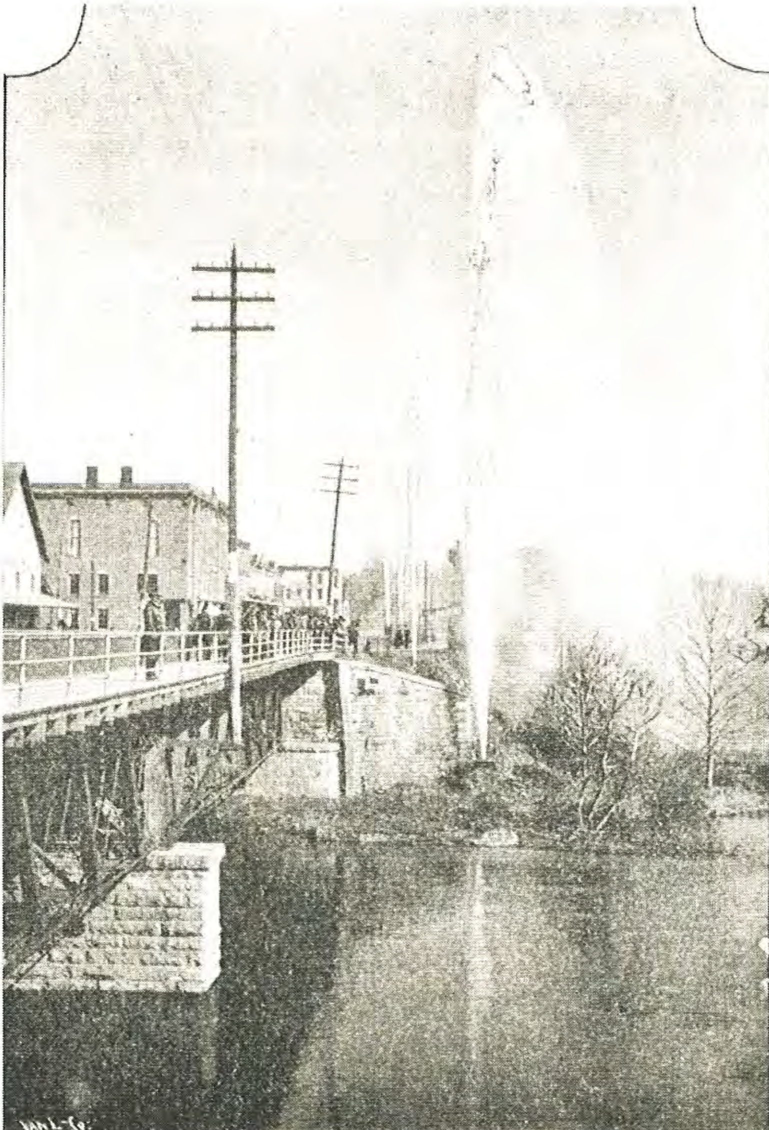
A proper cornice finish was designed for the point where the substructure and superstructure meet. No windows were intended in the outer walls of the substructure, thus leaving the walls to show clear and fair.

There would have been less danger from frost, in both upper and lower rooms, had the window openings not been made and the cornice finish been put on. Frost will not do much harm in the reservoir, but the pipes leading to the reservoir must be kept free from it. These windows will probably make it necessary to box these pipes to protect them in very cold weather. The plans were changed without consulting the engineer.

The gallery, or balcony, or whatever it may properly be called, was put around the outside and the cornice left off. The gallery and the four large circular windows have added considerably to the cost, and I think have very seriously marred the good looks of the structure.

The entrance to the reservoir room is much more difficult now than it would have been on the original plan.

An electric light has been talked of for the cupola over the reservoir, but upon more careful consideration I do not think it will be wise to put it there. It will be pleasant for your people to feel secure in the belief that nothing objectionable can get into your supply well or your reservoir. You cannot feel so secure in this belief if there is a roadway over the reservoir to the electric light that must be traversed every day, with the



FIRE STREAMS UNDER RESERVOIR PRESSURE.

necessary litter of the carbons, etc. Besides, if the hatchway leading to the light deck is ever left open, the birds and insects attracted and killed by this light, will fall into the reservoir waters below.

I think it will be well to submit to you in connection with this report, a paper giving an outline description of your water works which was prepared for the recent annual convention of the Michigan Engineering Society. This will enable those who wish to obtain general information relative to the works to get it without wading through all the details for the full report.

A few words here relative to the management of your water works will, I think, be proper. Of course, your Board has full power over everything pertaining to the works, but it will be necessary for the Board to delegate the executive management to one distinct head, and to hold this person responsible for everything. This person should be under the authority and direction of the Board, but no single member of the Board should be permitted to interfere with the management in any way. The electric light plant being under the management and direction of the City Council, and the water works under the management of the Water Board, makes things a little awkward, as both the pumps and dynamos must be operated by the same power. I think it would simplify everything for the Council to put the electric light plant under the management of the Water Board. What would be still better would be to change your Board of Water Commissioners into a Board of Public Works and put all the public works in their hands. This much is certain, you will require one head to have full charge of the pumping station. A divided authority there will result in confusion.

I have thought best in this report to make some comparisons between your own and other works. It seems to me that in this way a more comprehensive idea can be obtained relative to the practical working of the different systems, and especially of the value of the distinctive features of your own system.

The inset cut, opposite page 36, shows the vertical projection of four fire streams, one of two and one-half inches, and three of one and one-quarter inches in diameter, simultaneously to the height of more than one hundred and twenty-five feet, and illustrates the power of the reservoir waters as a fire protective agent.

YPSILANTI WATER WORKS.*

Mr. President and Gentlemen of the Convention:

I appear before you on this occasion for the purpose of reading a paper descriptive of the Ypsilanti Water Works. This paper has been prepared for this meeting of our State Engineering Society by request of your Board of Directors.

In the preparation of this paper it has been my aim to make everything as simple and plain as possible. While I should be glad to interest my professional brethern here, yet I feel it to be my chief duty to interest and instruct the great mass of the people, without whose aid and sanction we could not carry out any of these great public improvements.

I have been engaged during the past season in planning and constructing a system of water works for the City of Ypsilanti; and while there is nothing *originally* new or novel in the construction of these works, yet I think there is very much that is well worth the attention of all persons professionally or otherwise interested in such public improvements. I have planned work for several other cities with the same distinctive features as are involved in the construction of the Ypsilanti Water Works; but in no other case have my plans been faithfully carried out to full completion.

At Lansing, in 1884, I made an investigation relative to the development of a public water supply for that city, and ascertained beyond a doubt that one of the very finest supplies in the State could be easily developed there, and I recommended the

*This paper descriptive of the Ypsilanti Water Works was prepared for the recent annual convention of the Michigan Engineering Society, by W. R. Coats, C. & S. E., Kalamazoo, Mich.

It is thought best to insert it here for the benefit of those who may wish to obtain a comprehensive idea relative to the works, without going through all the details.

same style of works that I have, during the past season, constructed in Ypsilanti; but when the city came to act, a works very different from what I had recommended were built, the result being a *total failure* in water supply and only a partial success in other branches of the work. When I came to Ypsilanti, I found a Board of Commissioners in charge of affairs of sufficient caliber and broad good sense to understand the importance of placing the entire work in charge of their Engineer, holding him responsible for everything. The result has shown the wisdom of this course, as Ypsilanti is now in possession of the finest, most complete and effective system of water works of any city in Michigan, and the works have cost less money, relatively, than any other works in the State.

The plan of works adopted at Ypsilanti is based on the pumping and elevated reservoir service combined, both ordinary service and fire service being furnished direct from the street mains.

Of all the water works systems in vogue, where pumping is required, I claim the Ypsilanti system is by far the best in all respects.

It is far superior to the pumping and open earth reservoir system, from the fact that the water in the perfectly enclosed elevated reservoir cannot deteriorate from exposure, as in the open reservoir. It is infinitely superior to the simple, so-called *direct* pressure service so common in the cities of our State, both in regard to economy and efficiency of service. In the direct service, an instant's stoppage of our machinery, and our entire service *is dead*, and in no case (even under the most pressing necessity) can the service from such works possibly exceed the simple capacity of our pumps. Nothing can be stored up for use in time of dire necessity and peril; while to be prepared to meet extraordinary demands, even in an imperfect manner, we must keep expensive reserve machinery in constant readiness for use.

It is impossible to pump water economically in the direct service, because we never know what we have to do. At one hour of the day we may be called upon to run our pumps at their full healthy capacity; at another hour of the same day perhaps only one-fifth of this service will be required, yet we must be ready at *all times* to meet all calls as they come. With our elevated reservoir we are perfectly prepared at all times for all emergencies. We can run our pumps at all times at the same speed and under the same pressure, working to their full economic capacity regardless of the current consumption. Whatever excess of water there may be pumped above the ordinary consumption will go to the reservoir, there to be stored to carry the night service when the pumps are idle, or to meet any extraordinary demands (even while the pumps are running) that may temporarily exceed the pumping capacity. To illustrate: We are building works for a small city where half a million gallons of water per day will be the maximum consumption for ordinary service. If we are to have a fire service as well as ordinary service *direct* from the mains, we must be prepared to meet short calls for fire service *four* times greater than this maximum ordinary service. If we are working under the simple so-called direct pumping plan, having nothing but our pumps to rely upon, then these pumps must be of *five times* greater capacity than needed for our ordinary work, and this excess must always be kept in readiness for *instant* use. If we consult the statistics of the different cities we find that the amount of water required for fire service, for a whole year, averages less than *one day's* ordinary consumption for these various cities; yet to do this *one day's* work, on the direct plan, we must keep our four-fold excess of pumping capacity in readiness for *three hundred and sixty-five* days in the year.

The great claim made by the advocates of the direct service plan consists in the saving of the cost of the reservoir to start with, and that in working direct, the pressure can be regulated to meet the varying requirements of either ordinary or fire service; that while ordinary service will be usually satisfactory at a pressure of forty-five or fifty pounds per square inch, effective fire service will call for ninety-five to one hundred pounds per square inch, and that as the great bulk of the water is only required for ordinary service, it is much less expensive to raise it one hundred feet high than it will be to raise it two hundred feet high. · This would be true if we could work to advantage by running our pumps up to their full healthy capacity; but this is impossible, pumping direct to your consumers, for the pumps must follow the varying demands of the consumers, working to perhaps their full capacity at one hour, and at one-fifth capacity at another hour of the day.

Nor is this all, or even the worst feature of the varying pressure direct service. In nearly all our public water works systems the amount of water running to waste, greatly exceeds the amount used for strictly necessary purposes. I think it is safe to say that seventy-five per cent. of all the water used, escapes from faucets partially opened and constantly running. Of course, these openings are all gauged to give the required amount of water under the *ordinary* pressure. A fire breaks out, at once the pressure must be doubled. What is the result? Your waste is doubled, and your fire service handicapped from every direction. Your pumping machinery is usually not adequate to meet all these demands effectively. Your mains are not large enough to carry this extraordinary amount of water without a frictional loss that will very seriously impair the efficiency of such service as your handicapped pumps may still be able to render. And over and above all, in many cases your water supply will not be adequate to meet all these wants and wastes.

The city of Kalamazoo furnishes a striking illustration of this. This city built works on the direct, variable pressure service plan in 1868–9. The water supply is taken from a large well which for eighteen years has shown a capacity to meet any demands made upon it not exceeding four and one-half million gallons per day. During the dryest part of the season of 1887 the consumption of the city on some days reached the enormous amount of three and one-half million gallons per day, or three hundred and fifty gallons per capita per day, for all that part of the population supplied, and this only for ordinary service, and at the ordinary pressure of forty-five pounds at the pumping station. If at such a time, when the ordinary consumption is so large, a fire breaks out, calling for double the pressure, and water at the rate of two million of gallons per day in addition to the ordinary service, what can be done? The increase in the ordinary service, due to the increased pressure, would fully exhaust the four and one-half million gallon well, leaving nothing at all for the fire work.

Added to all this we must consider the great increase of work put upon our pumping machinery by this enormous increase of waste due to the increased pressure, and the further fact that the mains, rarely large enough for effective legitimate work, are here so greatly overtaxed that the resulting frictional loss renders effective work impossible. In 1887 the authorities at Kalamazoo saw the danger of the situation, and took steps to provide for it. But instead of taking the proper course and providing an elevated reservoir, [for which the natural conditions are very favorable at Kalamazoo,] another well was decided upon, constructed and connected with the old well.

The expense of this work was about thirty thousand dollars, and has resulted in an addition of about sixty per cent. in *quantity* to the water supply, but has very greatly impaired the *quality*.

If this same thirty thousand dollars had been expended in constructing a reservoir and properly connecting it with the street main distribution, it would have added four fold to the efficiency of the fire service, it would have largely decreased the running expenses of her works, her old well would have furnished an ample supply for years to come, and the quality of her water supply would have remained *unimpaired*.

With an elevated reservoir in connection with the pumping service at Kalamazoo, the reduction in *salaries* at the pumping station alone *would equal the interest on the entire cost of such reservoir;* and notwithstanding the fact that with the reservoir the pumps would necessarily be working under ninety pounds pressure instead of forty-five pounds, as now, yet the *fuel cost* would be less per million gallons of water pumped than now; and as before said, the efficiency of the fire protective service would be increased *four fold*.

The stand pipe cuts so small a figure in water works construction, considered purely on its merits, that but for the fact that the great majority of the people hold such vague ideas concerning it, it would not be worthy any extended notice.

The original intent of the stand pipe was to provide a relief for the pumping machinery and mains against the shock of suddenly changing pressures. A stand pipe of proper height, and in size equal to the force main, would serve this purpose as well as one of larger size. Of late years, stand pipes of much larger size have become quite popular with many engineers. The only added merit these larger stand pipes possess over the smaller ones simply consists in their added storage capacity, and this is at best too small to cut any important figure. Let us take for illustration a stand pipe fifteen feet in diameter and one hundred and fifty feet high. This seems to be quite a popular size. Such a structure would hold a little less than two hundred thousand gallons of water, counting from the *ground up*, and will cost ten thousand dollars, or five cents per gallon for every gallon of water it contains; and this will leave it entirely *naked, under full exposure.* If we enclose it as ought to be done it will cost as much more. But in such a stand pipe only *one-fourth* of this water will do *effective work*, so that this raises the cost of our structure virtually to *twenty cents* per effective gallon, if naked, or *forty cents* per gallon if enclosed. Such a structure cannot do fire service longer than *thirty minutes* without reinforcement from the pumping station, nor can it do good ordinary service long enough to enable us to reduce the working force at the pumping station; hence such a structure can never pay back, during its life time, *one-tenth its original cost.*

As an engineer I never feel justified in sanctioning such structures, even in cases where I find a strong popular prejudice in favor of them. I do not believe there exists any valid excuse for such structures, or that there is a man living who can give a *sane reason* in defense of them. I think that when this stand pipe folly is abandoned by our profession, one quite considerable obstacle to water works construction will be removed in many of our small cities.

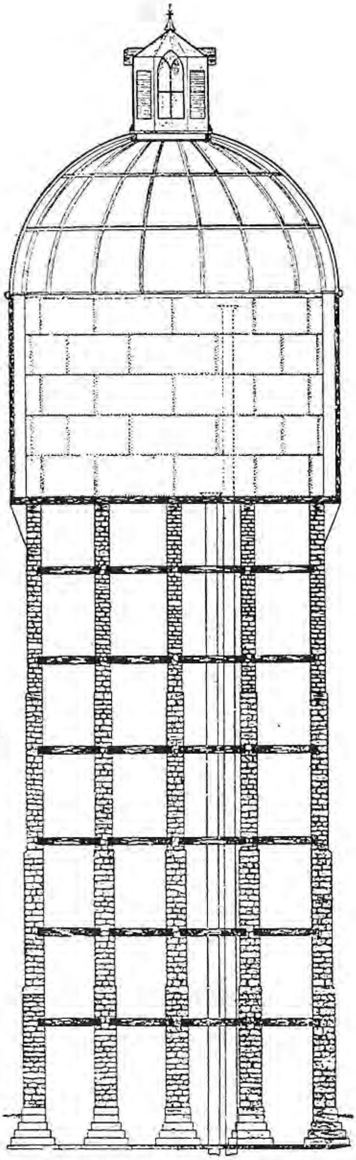
A properly constructed water works, on the pumping and elevated reservoir plan, should consist of a pumping plant of at least double the capacity required by the maximum consumption of the ordinary service, so that the full twenty-four hours' supply can be pumped by working half time and with one set of men, and a reservoir of sufficient storage capacity to carry the ordinary service during the night, and to meet the demands for fire protective service at all times. Of course the reservoir must be placed at sufficient elevation to afford efficient fire service by the simple gravity pressure of its waters.

In order to secure the best results the pumping station and reservoir should be on opposite sides of the city, the street main distribution lying between. This arrangement will reduce the frictional loss in the mains to a minimum, and secure the highest degree of efficiency in the service. The pumps and reservoir will be connected directly through the street main distribution, and when the pumps are running all the ordinary service will be supplied *direct*, the pumps always running to their full economic capacity without any regard to what may be transpiring throughout the distribution, the aim being to pump all the water in ten or twelve hours that will be required during the twenty-four hours.

Of course the excess of water pumped beyond the ordinary current requirements will pass into the reservoir, there to be stored for the night service, and to meet any extraordinary demands that may arise. Should a fire break out during pumping hours, calling for water in excess of what the pumps are delivering, no attention need be given it at the pumping station, as the moment the pumps fall short of supplying the demand the reservoir will come to the rescue with its reserve power, and both reservoir and pumps will work effectively and harmoniously together.

It is now that the importance of a proper placement of our pumps and reservoir will most plainly appear. If our pumping station and reservoir had been placed in juxtaposition, (as is usually the case with the stand pipe), thus compelling both to work through the same main, from the same direction, instead

OUTSIDE VIEW OF ELEVATED RESERVOIR.



INTERIOR VIEW OF ELEVATED RESERVOIR

of working in harmony and full effectiveness, there would be constant conflict, and at best but half service could be rendered. It would not be possible to establish a satisfactory and effective frictional equilibrium between the contending forces.

In planning and constructing the Ypsilanti Water Works, it has been my aim to harmonize all these elements, and to develop a practical working service of the highest possible degree of economy and efficiency in all its branches.

I believe this has been fully accomplished. It is true the natural advantages at Ypsilanti have been highly favorable to this end. Yet plain as have been these vantage points, to a correct view, an almost inexcusable blindness has defeated and deferred, for years, their utilization and the carrying out of this great improvement.

I believe, if Ypsilanti had built her present splendid system of water works ten years earlier, and had followed up with a system of sewerage, (and the natural advantages are as favorable here as in the case of the water works improvement,) the city would have had to-day *double her present wealth and population.*

Nearly three years ago I visited Ypsilanti and made a preliminary investigation relative to the development of a public water supply. I found everything favorable to the most complete success.

In April last the people voted almost unanimously to bond the city for seventy-five thousand dollars, the money to be used in developing a system of water works. Returning about this time from a two years' professional visit to California, I was employed by the Board of Water Commissioners of Ypsilanti to plan and superintend the construction of their proposed water works. In the commencement it was deemed best to only put in about ten miles of street mains, with a small steam pumping plant and an elevated reservoir.

Later it was found that an excellent water power, fully equipped for service, was available, and it was deemed best to purchase this water power and abandon the steam pumping plant part of the plan.

The adoption of the water power increased the first cost of the proposed works about twenty thousand dollars. As the work progressed, and the people began to appreciate the great advantages that would accrue from the improvement, a popular demand sprang up calling for a large extension of the street mains; the result being that an additional fifty thousand dollars in bonds were voted, and additional mains were put down, until the total street main distribution reaches nearly eighteen miles. This gives Ypsilanti *two and one-half miles of street mains for each one thousand of population*, which is more than double the average of the cities of the United States having water works; and renders her more perfectly and effectively equipped in her public water supply service, in all its branches, than is any other city in the State.

This very liberal provision in the outset has proven wise and fully justified by the results. The people are more generally satisfied, as the entire city now enjoys the *full benefit* of the improvement, whereas with only ten miles of street mains, as at first intended, only about one-half of the city would have been directly benefited.

The most remarkable feature in the development of these works is, perhaps, the astonishing fact that they start out from the day of their opening as a *self-sustaining* public improvement. I think this is the first case of the kind on record.

The plan adopted in constructing the works will account for this extraordinary send-off for the enterprise. Utilizing our water power, we brought into requisition a temporary pump, and taking water from the river filled the mains as fast as laid, the object being mainly to provide water for puddling the back-filling of the trenches and to furnish fire protective service from the hydrants as fast as set. In sixteen days from the opening of the first trench we threw fire streams ninety feet high direct from the mains in the *heart of the city*, three-fourths of a mile from the pumping station; and in ninety days all the street mains were in place and the city fully provided with a complete and effective domestic and fire protective service. Right here comes in the most remarkable feature of the enterprise. Soon after commencing pipe laying, applications began to come in for permits to tap the mains for water for lawn sprinkling. Very soon this demand far exceeded the capacity of the plumbers to meet, and kept in advance until the close of the season. Between four and five hundred connections were made before the works were completed and formally opened. Had the Board been able to keep pace with the demand of the applicants, there doubtless could have been *eight hundred* paying connections with the mains before the works were completed and formally opened.

From the first, I entertained no doubts as to the complete success of our proposed water supply development, hence we did not wait for the completion of this branch of the work before starting in on other parts of the work, but commenced and prosecuted all simultaneously.

The water power and buildings of the Ypsilanti Paper Company, located in the southern part of the city, were purchased by the city, and the pumping plant located there. The supply well was located about one thousand feet from the pumping station, on the opposite side of the Huron river, which, running from north to south, bisects the city. This well consists of a circular caisson thirty feet in diameter, constructed of iron and masonry, the sides being impervious, and sunk to the depth of thirty feet, terminating in a free coarse stratum of water-bearing gravel.

The pumps are connected with this well by a sixteen inch suction main, running under the river, in the same trench, and parallel with the twelve inch force main. One and one-half miles from the pumping station, diagonally across the city, is located the elevated reservoir.

The ground upon which this structure is built is one hundred and three feet above city datum.

The reservoir is constructed as follows: First, a substructure of masonry, circular in form, forty-two feet in diameter, and eighty-five feet high is constructed. The walls are of Joliet stone laid in cement mortar. The outer wall is in true circular form, three feet four inches thick at grade line, and two feet thick at top, or base line of reservoir. There are three parallel walls, at equal intervals inside, running entirely across and intersecting the outer, or circular walls. These walls are each of the same thickness and height as the outer, or circular wall. The excavation in which the foundation for these walls is laid is circular in form, and fifty feet in diameter, and covered solidly to the depth of six inches, with very rich cement mortar. Upon this are laid the footing courses for the walls above. These courses are of dimension stone laid in terrace form, each course being sixteen inches in thickness, the first course for all the walls being six feet in width, terminating at grade line in a course four feet in width.

Crossing the wall at top, in parallel courses two feet apart, at right angles with the walls, are steel floor beams ten inches in depth, for the reservoir to rest upon, the walls being built up between the beams flush with their upper surface. These beams project thirty inches outside the masonry all around.

The reservoir consists of a steel tank, circular in form, forty feet in diameter and twenty-seven feet deep, and rests on the floor beams and walls of the substructure. A sixteen inch main connects the reservoir with the street main distribution, and an eight inch over-flow pipe leads to the sewer. This reservoir is entirely enclosed with a structure of wood. This building rests upon a circular plate of steel, bolted to the ends of the projecting floor beams, is circular in form, rises perpendicularly as high as the top of the reservoir, and from this line a dome roof is sprung over the whole, terminating in a cupola with glazed windows in each of its eight sides. There is two feet of clear space between the outside of the reservoir and the inside of the walls of the enclosure, and twenty-two feet of clear space from top of reservoir to base line of cupola.

The cupola will be two hundred and fifty feet above city datum, and will be provided with a cluster of electric lights.

The capacity of this reservoir is a little in excess of a quarter of a million gallons, which is thirty-five gallons per capita, for the entire present population of the city, and *every gallon* of this water is always available for full, effective *fire service.*

The full reservoir will furnish six effective fire streams, for six consecutive hours, without reinforcement from the pumps. This reservoir will be ample to render full service to the city for at least five years, after which it can be duplicated on a corresponding summit on the opposite side of the river and city, a central twelve inch force main leading from one summit to the other. This main is already laid. The present force main from the pumps through the distribution, is twelve inches in size, and runs through the main part of the city on the west side of the river. Five years hence the plan contemplates a duplicate twelve inch main on the east side. The present arrangement will adequately supply all demands up to that time, and the plan when fully completed will be better than if a larger *single* force main had been provided in the outset.

With the plan fully carried out the pumping station and the two reservoirs will occupy the three points of a triangle about equi-distant, with the entire street main distribution enclosed. Under this arrangement we will secure a very high degree of effectiveness in the service, the frictional loss of the water passing through the mains being very small. The street main distribution is so arranged as to give a double discharge fire hydrant at every street intersection. The mains cross the river five times, thus giving free and full service to all parts of the city on both sides.

The pumps are power pumps of an entirely new pattern, are triplicate in form, and promise to give an exceptionally high economic duty. A very great saving of expense will be made in the running of these works by water power.

There is water sufficient all of the year to operate the pumping plant, and for nine months in the year there is very much more than needed. The city will utilize the extra power to run the electric street lighting plant, which is now operated by steam power. The electric plant is now being placed in the pumping station, and will be run by the same power as the pumps when there is sufficient water. When not sufficient water then by a Corliss engine attached to the same line shaft, being so arranged as to permit of instant change from water to steam, or the reverse. It is estimated that this arrangement will save the city five thousand dollars a year in running the two plants, as compared with running both by steam.

The cost of the Ypsilanti Water Works has been a little less than one hundred and forty thousand dollars. Ten thousand dollars of this, however, should be charged to the electric light plant, and five thousand dollars to the private service development fund. This will leave the actual cost of the water works one hundred and twenty-five thousand dollars.

The elevated reservoir will cost seventeen thousand dollars, which is about six and one-half cents per gallon of its waters, or about one-third the cost per effective gallon as in the case of the naked stand pipe, or about one-sixth the cost per effective gallon in the enclosed and protected stand-pipe. And this comparison does not take into account the great saving in the operating expense that the elevated reservoir secures to us. This saving of expense alone will repay the entire cost of the reservoir, principal and interest, long before the thirty year four per cent bonds, issued for its construction, fall due. Added to all this, we have the greatly increased effectiveness of the service, which this reservoir insures to us.

The interest on the cost of these works, and the current running expenses, will not exceed eight thousand dollars per year. The revenue from private rates will exceed this at the end of the third year, and the City Council has only to credit the water works an exceeding low rate for fire protective service to provide a sinking fund that will take care of all the bonds issued for the *entire work*, long before their maturity, and this without levying one dollar in tax to redeem these bonds.

The transfer of the electric light plant to the pumping station will enable the city to sell several thousand dollars worth of buildings and machinery belonging to the present plant, that will not be needed at the new stand. The city can also sell her two fire steamers as there will be no further use for them, and the electric plant can be operated at the pumping station for less than one-half the cost in its present position.

It is very rarely indeed that we find a place where so many natural advantages can be utilized in the carrying out of a great public improvement, as in the case of Ypsilanti. Nor is it often that we find an improvement so thoroughly appreciated. It is not often that we find a Board of Commissioners, and the local banks so zealous in behalf of a public work, as to be willing to advance the money for it, months in advance of the sale of its bonds, but it has been the case at Ypsilanti, the money being advanced even before the bonds were issued, or signed.

This zealous spirit of appreciation pervades all classes. One public spirited lady, Mrs. Mary Ann Starkweather, making a free gift to the city, for the public good, of a bronze drinking fountain, costing seven hundred and fifty dollars.

To Professor Bellows of the State Normal School is due the chief credit for the development of the splendid water supply of the Ypsilanti works.

The engineer who was first employed by the city to make plans and estimates for water works, recommended a surface supply, to be taken from brooks about two miles outside the city. Prof. Bellows was not satisfied with the proposed water supply; believing that a better water could be obtained, he sent for another engineer, at his own expense; and the result is the present unrivaled water supply.

Nor is the improvement in quality all that has been gained to the city by the Professor's enterprise. Two miles distance in the conveyance of water has been saved, and more than twenty thousand dollars in expense for useless force mains, has been saved by the new location.

Before closing, it will perhaps not be amiss to say a few words relative to the question of public or private ownership of such public improvements.

For myself I believe the public good should be held as the paramount question always in the projection, execution and operation of such public improvements. In no case should a private corporation be intrusted with the ownership and management (for gain) of a public work, when the protection of the property, the health, and the lives of the people are at stake. Every city, every community, should exercise full authority and control over every public work involving these great public questions, and should never grant franchises by which these rights are taken away and given to private corporations.

The chief argument advanced by the advocates of private ownership and management of such public works, is the claim that such works can be constructed and operated more economically by private corporations than by municipalities.

This is not necessarily true, and even if true, it is a trivial surface argument, and totally ignores the deep meaning of the great underlying questions. But it is not true that private ownership and management is more economic.

Let us take the Ypsilanti works to illustrate. Under private ownership and management the private service alone at Ypsilanti would cost the consumers, at least, eight thousand dollars per year, and the fire service, at two-thirds the average of other cities in the state operating on the franchise plan, would cost eight thousand seven hundred and fifty dollars per year more, making sixteen thousand seven hundred and fifty dollars per year the citizens would have to pay under private ownership. Under city ownership and management, if the same amount is paid each year, it will pay all running expenses, the interest on the water works debt, and in twelve years entirely wipe out this debt, at the end of which time the works will bring to the city treasury an annual surplus revenue of at least twelve thousand dollars. Added to all this the city has a fire service far superior in effectiveness to that which any private corporation would have given.

In the construction of the Ypsilanti works, no contracts for work were let, everything being done by day labor. This made it much harder for the engineer, but has given the greatest satisfaction to the city, as not one dollar has left the city as contractor's profit; the home labor and tradesmen getting the full benefit of all the money paid out in the city.

W. R. Coats, C. & S. E.

SEWERAGE.

GENTLEMEN OF THE BOARD: I feel that I should not be doing my full duty should I close this report without calling your attention to the vital importance and necessity of a public sewerage system in your city. Public water supply and public sewerage naturally go together, and it is not easy to determine which is most necessary and important, but this much is very certain, no city can be healthy and prosperous without an abundant supply of pure water and pure air. And no city can obtain pure water from the ordinary private wells, nor pure air from the private cesspools and privy vaults.

A general system of public water supply is absolutely essential to secure the prosperity of any city at the present time, and an adequate public sewerage system is equally necessary.

Of course, all cannot see and understand the importance of these public improvements, and there are those who argue that they and their ancestors have got along through life without them—hence we can continue without them. This reasoning would speedily carry us back to the period in the world's history when the average duration of human life was only 23.8 years.

This was true of England as late as the seventeenth century, while it is claimed that under the present improved sanitary conditions, the average man may expect to live 49 years. The annual death rate in Chicago for a period of fourteen years before the present sewerage and water supply systems were inaugurated, was 37.91. The water supply and sewerage of Chicago is still far from excellent, but for the last fourteen years the annual death rate has been only 21.40, a reduction of nearly 45 per cent., as compared with the first fourteen years.

You now have in Ypsilanti a public water supply of the very highest degree of excellence and efficiency. The natural conditions are such that you can very easily, and cheaply, provide a public sewerage system of equally high excellence and efficiency.

Having been so closely identified with your water supply improvement, I feel much greater interest than I otherwise would, in the development of a proper public sewerage system, and should be very glad to see the good work go forward.

Through the public spirit and liberality of a member of your Board, I have prepared plans and estimates for a complete sewerage system for your entire city. If these plans are adopted and carried out, I can promise you a sewerage system as excellent and complete as is your water supply system.

The fears that so many entertain that the expense of such an improvement will prove burdensome on your tax payers, is entirely erroneous. In real truth you will be relieved directly, and indirectly, of more burdens and expense, than the improvement will cost you.

In providing for a general sewerage system, only that portion of the cost pertaining to the main, or trunk lines, should be raised by direct tax levy. All the laterals should be provided for by direct assessments upon the abutting property, and there will be a rebate of about 40 per cent. of the cost of the trunk lines from assessments upon abutting property that will connect direct with the main lines.

All your main, or trunk lines, for the entire city, can be put down complete for less than $25,000. About three-quarters of this cost would be called for on the west side of the river, and one-quarter on the east side. The lateral lines would cost about sixty cents per lineal foot, put down complete, or thirty cents per foot for each side of the respective streets. The revenue of your water works will be greatly increased by the development of a sewerage system. The overflow of the reservoir would serve as a most efficient flushing agent for the entire west side main, running from the reservoir through Cross, Huron, and Race Streets, to the outlet in the river below the pumping station, and on the other hand the sewer would afford a perfect and much needed avenue of escape for this overflow.

When the reservoir for the east side is constructed it will serve the same excellent purpose for the mains in that part of the city. It is very rarely that such an excellent and mutually advantageous service can be obtained in any city in the operation of a public water supply and sewerage system.

This single main line on the west side would instantly give relief to the one thousand people at the State Normal School, and to nearly as many more of your own children at the Union School; and also to all the residents along the line of the main; and besides would afford an outlet for all the rest as rapidly as they might choose to connect with it through lateral lines running to this main. In the inauguration of such an improvement I think it would be entirely safe to count upon five thousand dollars from the state. This amount was contributed at Kalamazoo to provide sewerage for the insane asylum. Certainly the 1,000 students and teachers at the Normal are worth more to the state than the 1,000 lunatics at Kalamazoo.

Your city will divide up naturally into three sewer districts. The east side of the river will all go naturally into one district, and all its sewage will be discharged from one outlet.

Very nearly all the west side will be embraced in one district, but ultimately it will be necessary to make an independent district of the small area north of Florence Street, lying between the river and Lowell Street. The sewage from this small district will have to go into the river at or above Forest Avenue. Not to exceed five per cent. of the population of the west side of the river will be embraced in this small district. All the rest will find an easy and natural outlet for sewage through a trunk line main starting at the tower, and running through Cross, Huron and Race Streets, and discharging into the river below the pumping station. It is rarely the case that so large a portion of a city can be so fully and perfectly taken care of by a single line of main sewer.

If only the interests of the Normal School and the Union School were involved, your city could not afford to delay this greatly needed improvement. When it is seen that the interests and wellfare of this entire portion of the city are so deeply involved and dependent upon this work, it would seem that the necessities of the situation demanded the earliest possible action.

The separate system of sewerage is best adapted to your situation. All the sewage of the city, except from the small area above excepted, should be carried to the river below the pumping station, so that there shall be no deposit above the dams in still water.

The general plan contemplates two trunk line mains, one on each side of the river, but both uniting near the supply well on Race Street, and discharging into the river through one outlet.

The west side main will be 9,500 feet in length, and will consist of 900 feet of 18 inch cast iron pipe, for the river outlet, 500 feet of 18 inch, 3,600 feet of 15 inch, 1,800 feet of 12 inch, and 2,700 feet of 10 inch vitrified clay pipe, with twenty man holes. The outlet section of iron pipe will be laid below the bed of the river, discharging beneath the water. All the vitrified clay pipe will be socket jointed, and laid with cement. This entire west side line complete, will cost, in round numbers, not to exceed $15,000. Of this, $1,000 will be chargeable to the east side, as a pro rata for the joint outlet expenses; $3,500 will be paid back by the property along the line that will connect directly with this sewer; if added to this, the State donates $5,000, it will reduce the cost of the work to the city to $5,500.

The east side main will require 200 feet of 12 inch iron pipe to go under the river, 3,860 feet of 12 inch and 1,310 feet of 10 inch vitrified clay pipe, with eight man holes.

The east side main will start at Forest Avenue, and following River Street, and run directly south and join the west side main at the intersection of Race Street. The cost of this line complete will be $9,000.

With these trunk lines constructed, all the most pressing needs of the city will be provided for. The Normal and Union schools will be at once relieved, as well as all the property abutting upon these lines, and an outlet will be afforded for the lateral lines for the entire city.

A sewerage system carried out on this plan will afford your city a perfect house drainage system, which with your admirable water supply system will place you in the very front rank, considered from a sanitary point of view.

Your people would receive more in direct benefits than this improvement would cost them, without counting the great value to the city, of the people who would be attracted by its high sanitary standing.

The class of people most desirable in building up a city, are people who know how to value such improvements, and they will not voluntarily locate in cities unprovided with them.

I can see nothing lacking but a system of sewerage to make Ypsilanti one of the most desirable residence places in this country.

The grand success of your water works, and the lightness of the burden imposed upon your tax payers by their construction, ought to dissipate all fears, and remove the last obstacle standing in the way of the sewer improvements.

W. R. COATS, Engineer.

TABLES ACCOMPANYING COMMISSIONERS' REPORT.

TABLE "A."

STREET MAIN DISTRIBUTION OF YPSILANTI WATER WORKS.

Street Name.	Size Pipe.	Point From.	Point To.	No. Feet.
Adams st.	6 inches.	Michigan st.	Forest ave.	3300
Ann st.	4 "	Huron st.	St. Johns st.	1175
Ballard st.	6 "	Congress st.	Forest ave.	2580
Brower st.	6 "	Cross st.	Forest ave.	660
Babbitt st.	2 "	River st.	Park st.	660
Congress st.	4 "	Fair Ground.	Summit st.	414
Congress st.	8 "	Summit st.	Prospect st.	6107
Congress st.	4 "	Prospect st.	Emerick st.	1320
Cross st.	12 "	Reservoir.	Grove st.	5630
Cross st.	10 "	Grove st.	Prospect st.	216
Catherine st.	12 "	Huron st.	Race st.	927
Chicago ave.	4 "	Congress st.	Summit st.	1856
Center st.	2 "	Towner st.	Congress st.	825
Emmet st.	2 "	Ballard st.	Brower st.	642
Ellis st.	2 "	Adams st.	Perrin st.	1196
Emerick st.	4 "	Congress st.	Miles st.	206
Forest ave.	6 "	Prospect st.	Huron st.	2506
Forest ave.	4 "	Huron st.	Lowell st.	990
Forest ave.	6 "	Lowell st.	Ballard st.	186
Forest ave.	4 "	Ballard st.	Summit st.	1465
Florence st.	2 "	Hamilton st.	Ballard st.	536
Grove st.	6 "	Cross st.	Congress st.	1732
Grove st.	4 "	Congress st.	Bell st.	3300
Huron st.	6 "	Harriet st.	Catherine st.	1475
Huron st.	12 "	Catherine st.	Cross st.	3050
Huron st.	10 "	Cross st.	Forest ave.	1320
Hamilton st.	6 "	Cross st.	Forest ave.	2715
Harriet st.	4 "	Huron st.	Washington st.	3080
St. Johns st.	4 "	Lowell st.	Ann st.	495
Lowell st.	6 "	Forest ave.	St. Johns St.	1155
Lowell st.	4 "	St. Johns st.	L. S. R. R.	495

Street Name.	Size Pipe.		Point From.	Point To.	No. Feet.
Lincoln st.	2 inches.		North st.	M. C. R. R.	495
Michigan st.	4	"	Washington st.	Adams st.	370
Miles st.	4	"	Cross st.	Emerick st.	2145
Norris st.	4	"	Forest ave.	Oak st.	660
Normal st.	6	"	Congress st.	Cross st.	1730
Oak st.	6	"	Prospect st.	River st.	1650
Oak st.	4	"	River st.	Norris st.	415
Park st.	2	"	Babbitt st.	M. C. R. R.	578
Park st.	4	"	South st.	Congress st.	655
Pearl st.	4	"	Ballard st.	Normal st.	35
Perrin st.	6	"	Congress st.	Forest ave.	2030
Prospect st.	6	"	Forest ave.	Locust st.	2225
Prospect st.	4	"	Congress st.	Davis st.	1495
River st.	6	"	Congress st.	Forest ave.	4145
River st.	2	"	Forest ave.	North st.	640
Race st.	12	"	Catherine st.	Pumping Station.	1824
Stewart st.	4	"	Pumping Sta'n.	Grove st.	1155
Summit st.	4	"	Forest ave.	Cross st.	415
Summit st.	6	"	Cross st.	Congress st.	1735
Summit st.	4	"	Congress st.	Chicago ave.	1160
Towner st.	4	"	Prospect st.	Center st.	4815
Washington st.	6	"	Huron st.	Harriet st.	5195
	16	"	Supply Well.	Pumping Station.	1050
	16	"	Reservoir.	Cross st.	3

TABLE "B."

Fire Hydrants.

Adams st., N E cor. Michigan st.
Adams st., N E cor. Congress st.
Adams st., S E cor. Pearl st.
Adams st., N E cor. Ellis st.
Adams st., N E cor. Emmet st.
Adams st., S E cor. Cross st.
Adams st., S E cor. Olive st.
Adams st., S E cor. Forest ave.
Ann st., N E cor. St. Johns st.
Ann st., 50 ft. south L. S. R. R.
Ballard st., N E cor. Congress st.
Ballard st., N E cor. Pearl st.
Ballard st., S E cor. Ellis st.
Ballard st., S E cor. Emmet st.
Ballard st., S E cor. Cross st.
Ballard st., N E cor. Florence st.
Ballard st., S E cor. Forest ave.
Brower st., N W cor. Cross st.
Brower st, midway between Cross st. and Forest ave.
Brower st., S W cor. Forest ave.
Buffalo st., S E cor. Washington st.
Buffalo st., S W cor. Huron st.
Congress st., entrance Fair Ground.
Congress st., N E cor. Summit st.
Congress st., N W cor. Normal st.

Congress st., midway bet. Normal and Ballard sts.
Congress st., N E cor. Ballard st.
Congress st., N E cor. Hamilton st.
Congress st., N E cor. Adams st.
Congress st., S E cor. Washington st.
Congress st., S W cor. Huron st.
Congress st., S E cor. Water st.
Congress st., midway bet. Water and River sts.
Congress st., N W cor. River st.
Congress st., N W cor. Park st.
Congress st., N W cor. Grove st.
Congress st. N W cor. Prospect st.
Congress st., opposite Center st.
Congress st., E line City Limits.
Cross st., N E cor. Summit st.
Cross st., at Normal st.
Cross st., N W cor. Brower st.
Cross st., S E cor. Perrin st.
Cross st., S E cor. Ballard st.
Cross st., S E cor. Hamilton st.
Cross st., S E cor. Adams st.
Cross st., S E cor. Washington st.
Cross st., S W cor. Huron st.
Cross st., opposite Rice st.
Cross st., alley opp. Follett House.
Cross st., opp. Thompson's res.
Cross st., S W cor. Park st.
Cross st., S W cor. Grove st.
Cross st., S W cor. Prospect st.
Catherine st., S W cor. Chidister st.
Catherine st., S E cor. Washington st.
Chicago ave., midway bet. Congress and Normal sts.
Chicago ave., at Normal st.
Center st., N W cor. Towner st.
Ellis st., N W cor. Huron st.
Ellis st., S E cor. Washington st.
Ellis st., N E cor. Adams st.
Ellis st., N E cor. Hamilton st.
Ellis st., S E cor. Ballard st.
Ellis st., S E cor. Perrin st.
Ellis st., S E cor. Normal st.
Emmet st., N W cor. Huron st.
Emmet st., S E cor. Washington st.
Emmet st., N E cor. Adams st.
Emmet st., N E cor. Hamilton st.
Emmet st., S E cor. Ballard st.
Emmet st., S E cor. Perrin st.
Factory st., N W cor. Grove st.
Forest ave., N W cor. Summit st.
Forest ave., midway bet. Summit and Brower sts.
Forest ave., S W cor. Brower st.
Forest ave., S E cor. Perrin st.
Forest ave., S E cor. Ballard st.
Forest ave., S E cor. Hamilton st.
Forest ave., S E cor. Adams st.
Forest ave., N E cor. Huron st.
Forest ave., at Howland's.
Forest ave., S W cor. Norris st.
Forest ave., N W cor. River st.
Forest ave., 400 ft. east of River st.
Forest ave., 900 ft. east of River st.
Forest ave., S W cor. Prospect st.
Florence st., N E cor. Ballard st.
Grove st., S W cor. Cross st.
Grove st., S W cor. High st.
Grove st., N W cor. Congress st.
Grove st., N W cor. South st.
Grove st., midway bet. South and Factory sts.
Grove st., S W cor. Factory st.
Grove st., S W cor. Stewart st.
Grove st., S W cor. Belle st.
Huron st., 50 ft. west on Harriet st.
Huron st., opp. Geo. McElcheran's.
Huron st., S W cor. Buffalo st.
Huron st., S W cor. Catherine st.
Huron st, N W cor. Woodard st.
Huron st., S W cor. Michigan st.
Huron st., S W cor. Congress st.
Huron st., S W cor. Pearl st.
Huron st., N W cor. Ellis st.
Huron st., N W cor. Emmet st.
Huron st., S W cor. Cross st.

Huron st., opp. Olive st.
Huron st., opp. Woolen Mill.
Huron st., N E cor. Forest ave.
Hamilton st., N E cor. Congress st.
Hamilton st., N E cor. Pearl st.
Hamilton st., N E cor. Ellis st.
Hamilton st., N E cor. Emmet st.
Hamilton st., S E cor. Cross st.
Hamilton st., S E cor. Olive st.
Hamilton st., S E cor. Forest ave.
Harriet st., N side near Huron st.
Lowell st., east side at creek.
Lowell st., opp. St. Johns st.
Michigan st., N E cor. Adams st.
Michigan st., S E cor. Washington st.
Michigan st., S W cor. Huron st.
Maple st., 400 ft. east of River st.
Maple st., 900 ft. east of River st.
Miles st., at Prospect and Cross sts.
Miles st., halfway between Cross and Congress sts.
Norris st., N E cor. Forest ave.
Norris st., N E cor. Oak st.
North st., N W cor. River st.
North st., N W cor. Park st.
Normal st., N W cor. Congress st.
Normal st., midway between Pearl and Ellis sts.
Normal st., S E cor. Ellis st.
Normal st., at Cross st.
Oak st., N E cor. River st.
Oak st., N E cor. Norris st.
Oak st., N side 400 ft. E River st.
Oak st., N side 900 ft. E River st.
Oak st., N W cor. Prospect st.
Olive st., S E cor. Adams st.
Olive st., S E cor. Hamilton st.
Park st., S W cor. Cross st.
Park st., N W cor. North st.
Park st., N W cor. Congress st.
Park st., N W cor. South st.
Pearl st., S E cor Huron st.
Pearl st., N E cor. Washington st.
Pearl st., S E cor. Adams st.

Pearl st., N E cor. Hamilton st.
Pearl st., N E cor. Ballard st.
Pearl st., N E cor. Perrin st.
Pearl st., midway bet. Perrin and Normal sts.
Perrin st., N E cor. Pearl st.
Perrin st., S E cor. Ellis st.
Perrin st., S E cor. Emmet st.
Perrin st., S E cor. Cross st.
Perrin st., midway bet. Cross st. and Forest ave.
Perrin st., S E cor. Forest ave.
Prospect st., S W cor. Forest ave.
Prospect st., S W cor. Oak st.
Prospect st., S W cor. Maple st.
Prospect st., S W cor. Cross st.
Prospect st., N W cor. Locust st.
Prospect st., N W cor. Congress st.
Prospect st., N E cor. Towner st.
Prospect st., midway bet. Davis and Towner sts.
River st., N W cor. Congress st.
River st., N W cor. North st.
River st., N E cor. Ferrier st.
River st., S W cor. Cross st.
River st., N W cor. Maple st.
River st., N E cor. Oak st.
River st., N E cor. Forest ave.
Race st., opp. Mr. Potts.
Race st., N E cor. Stewart st.
St. Johns st., junction of Lowell st.
Stewart st., N W cor. Race st.
Stewart st., S W cor. Grove st.
South st., N W cor. Park st.
South st., S W cor. Grove st.
Summit st., S E cor. Forest ave.
Summit st., N E cor. Cross st.
Summit st., midway bet. Pearl and Ellis sts.
Summit st., N E cor. Pearl st.
Summit st., N E cor. Congress st.
Summit st., 200 ft. N Chicago ave.
Towner st., N E cor. Prospect st.
Towner st., N W cor. Center st.

Washington st., midway bet. Harriet and Buffalo sts.
Washington st., S E cor. Buffalo st.
Washington st., S E cor. Catherine st.
Washington st., S E cor. Woodard st.
Washington st., S E cor. Michigan st.
Washington st., S E cor. Congress st.
Washington st., N end Hewitt Bl'k.
Washington st., N E cor. Pearl st.
Washington st., S E cor. Ellis st.
Washington st., S E cor. Emmet st.
Washington st., S E cor. Cross st.
Washington st., S W cor. Florence st.
Water st., S E cor. Congress st.

TABLE "C."

Valves.

ADAMS ST.

Size.	
6	N side Cross st.
6	S side Cross st.
6	N side Congress st.
6	S side Congress st.

BALLARD ST.

Size.	
6	N side Cross st.
6	S side Cross st.
4	W line at Ellis st.
4	W line at Pearl st.
6	N side Congress st.

BROWER ST.

Size.	
6	N side Cross st.

CROSS ST.

Size.	
4	N side at Summit st. 5 ft. N of hydrant.
12	W side Summit st.
6	W side Normal st.
6	N side at Brower st.
6	N side at Perrin st.
6	S side at Perrin st.
12	W side Ballard st.
6	N side at Ballard st.
6	S side at Ballard st.
6	N side at Hamilton st.
6	S side at Hamilton st.
6	N side at Adams st.
6	S side at Adams st.
6	S side at Washington st.
4	W side Washington st.
12	W side Huron st.
12	E side Huron st.
10	N side at Huron st.

CROSS ST.

Size.	
4	Galvin hydrant opp. Rice st.
12	E of hydrant Follett House alley.
6	S side at River st. 3½ ft. S of hydrant.
6	N side at River st.
6	At Park st., 3 ft. S of S line Cross st.
12	E side Park st.
6	S side at Grove st.
6	S side at Prospect ave.
6	N side at Prospect ave.
4	3 ft. S of S line Cross and Miles sts.

CHICAGO AVE.

Size.	
4	E side Summit st.
4	S side Congress st.

CONGRESS ST.

Size.	
4	S side at Summit st.
6	N side at Summit st.
8	E side Summit st.
6	N side at Normal st.
4	12 ft. W of W line Ballard st.
6	N side at Ballard st., 5 ft. N of Congress st.
6	N side at Hamilton st.
8	W side Hamilton st.
6	N side at Adams st.
4	S side at Adams st.
6	N side at Washington st.
6	S side at Washington st.
12	S side at Huron st.
8	W side Huron st.
8	E side Huron st.

CONGRESS ST.

Size.	
8	25 ft. E of hydrant at Water st.
6	N side at River st.
4	S side at Park st.
6	N side at Grove st.
6	S side at Grove st.
8	E side Grove st.
4	S side at Prospect ave.
4	E side Prospect ave.
4	S side at city limits.

CATHERINE ST.

12	N side at Huron st.
6	S side at Huron st.

ELLIS ST.

4	W side at Ballard st.
4	S side at Summit st.

FOREST AVE.

4	E side Lowell st.
6	N side at Lowell st.
6	W side Huron st.
6	E side Huron st.
4	Alley near Woolen Mill.
6	W side Norris st.
6	E side River st., 2½ ft. E of hydrant.
6	S side at Prospect ave.

GROVE ST.

6	S side Cross st.
6	N side Congress st.
6	S side Congress st.
8	W side at Congress st.
4	W side at Stewart st

HURON ST.

6	S side Catherine st.
12	N side Catherine st.
12	S side Congress st.
8	E side at Congress st.
8	W side at Congress st.
12	N side Ellis st.
10	N side Cross st.
12	E side Cross st.
12	W side at Cross st.
4	W side at Forest ave.
6	E side at Forest st.

HAMILTON ST.

Size.	
6	N side Congress st.
6	S side Cross st.
6	N side Cross st.
8	W side at Congress st.

HARRIET ST.

4	N side bet. Washington and Huron sts.

LOWELL ST.

4	W side at St. Johns st.
4	E side at Forest ave.
6	N side Forest ave.

MAPLE ST.

6	E side River st.

MILES ST.

4	3 ft. S of S line Cross st.
4	East city limits S line Congress st.

NORMAL ST.

6	S side Cross st.
6	N side Congress st.

NORRIS ST.

6	W side at Forest ave.

OAK ST.

6	E side River st.

PEARL ST.

4	E side Ballard st.

PROSPECT AVE.

6	S side Forest ave.
6	N side Cross st.
6	S side Cross st.
4	Miles st., 3 ft. S of S line Cross st.
4	S side Congress st.
4	E side Congress st.

PARK ST.

4	S side Congress st.

PERRIN ST.

6	S side Cross st.
6	N side Cross st.

RIVER ST.

Size.	
6	E side at Forest ave.
6	E side at Oak st.
6	E side at Maple st.
6	N side Cross st.
6	S side Cross st., 3½ ft. S of hydrant.
6	N side Congress st.

RACE ST.

12	At Pumping Station.
4	At Stewart and Grove sts.
12	At Huron and Catherine sts.
6	At Huron and Catherine sts.

SUMMIT ST.

4	N side Cross st., 5 ft. N of hydrant.

SUMMIT ST.

Size.	
12	W side at Cross st.
6	S side Ellis st.
6	N side Congress st.
4	S side Congress st.
8	E side at Congress st.
4	E side at Chicago ave.

STEWART ST.

4	W side Grove st.
12	At Pumping Station.

WASHINGTON ST.

4	N side Cross st.
6	S side Cross st.
4	Galvin hydrant at Hewitt's.
6	N side Congress st.
6	S side Congress st.
4	Harriet st.

TABLE "D."

SPECIALS.

AT PUMPING STATION—FLOWER PUMP.

1 16in. cross on suction.
1 16in. ell on suction.
1 16in. to 12 reducer, flange and spigot.
1 12in. ell flange.
1 12in. cross on force main.
1 12in. ell.
1 12in. x 10 reducer, flange and spigot.
1 10in. ell flange.

DUPLEX STEAM PUMP.

1 16 x 8 reducer, spigot and bell.
2 8in. ells S. E. suction.
2 7in. ells S. E. force main.
1 12 x 8 reducer, bell and spigot.
1 12 x 4 T, 10ft. north of north wall.
1 4in ell to Stewart St.

AT WELL.

1 16in. ell on suction.

ANN STREET

At St. Johns st., 1 4 x 4 T.

ADAMS STREET.

At Michigan st., 1 6 x 4 cross.
" Congress st., 1 8 x 8 cross.
" " " 2 8 x 6 reducers.
" Pearl st., 1 6 x 4 cross, 15 ft. from N. line.
" Ellis st., 1 6 x 4 cross.
" Emmett st., 1 6 x 4 T.
" Cross st., 1 12 x 6 cross.
" Forest ave., 1 6 x 4 cross.

BALLARD STREET.

At Congress st., 1 8 x 6 cross.
" " " 1 $\frac{1}{16}$ bend.
" Pearl st., 1 6 x 4 cross.
" Ellis st., 1 6 x 4 "
" Emmett st., 1 6 x 4 cross.
" Cross st., 1 12 x 6 cross.
" Florence st., 1 6 x 4 T, 17 ft. from S. line.
" Forest ave., 1 6 x 4 reducer, spigot end.
" " " 1 6 x 6 T.

BROWER STREET.

At Cross st., 1 12 x 6 cross.
" Forest Ave., 1 6 x 4 reducer spigot end.
" " " 1 4 x 4 T.

BABBITT STREET.

From River st. East, 1 T, 17 ft. E. of W. line of Park.
" " " 1 T, 14 ft. W. of Woodruff's E. line.
" " " 1 T, 32 ft. W. of Woodruff's W. line.
" " " 1 union on Cornwell's W. line.
" " " 1 T, 8 ft. W. of Lincoln st.
" " " 1 cross, 50 ft. E. of Max's E. line.
" " " 1 T, 48 ft. E. of River st.
" " " 1 union 12 ft. E. of River st.
" " " 1 union at River st.

CONGRESS STREET.

At River Crossing, 1 8in. ¼ bend.
" " " 3 8in. $\frac{1}{16}$ bends.

North of stores, E. from Washington, 2 x 1 T, E. from Washington 11 feet.

North of stores, 2 x 1 T, E. from Washington 37 feet.
" " " " " 59 feet.
" " " " " 82 feet.

CONGRESS STREET.

North of stores	2 x 1	T, E.	from	Washington	105 feet.
"	"	"	"	"	130 feet.
"	"	"	"	"	151 feet.
"	"	"	"	"	171 feet.
"	"	"	"	"	224 feet.
"	"	"	"	"	244 feet.
"	"	"	"	"	260 feet.
"	"	"	"	"	276 feet.
"	"	"	"	"	278 feet.
"	"	"	"	"	299 feet.
"	"	"	"	"	321 feet.

From	Washington st.	west,	2 x 1 T,	W. of	Washington	11 feet.
"	"	"	"	"	"	31 feet.
"	"	"	"	"	"	56 feet.
"	"	"	"	"	"	74 feet.
"	"	"	"	"	"	101 feet.
"	"	"	"	"	"	125 feet.

CATHERINE STREET.

From	Huron st.	west,	2 x 1 T,	W. of Huron	68 feet.
"	"	"	"	"	141 feet.
"	"	"	"	"	196 feet.

CROSS STREET.

At Tower, 1 12in. 1/4 bend.
" 1 8in. 1/4 bend.
" 1 16 x 12 reducer.
" 1 12 x 12 T.
At Bridge, 4 12in. 1/8 bends.
" 1 12 x 4 T.
" 1 4in. Flower valve, S. E.
40 ft. E of Grove st., 1 12 x 10 reducer.

CENTER STREET.

At Congress st., 1 4 x 4 cross.
" 1 4 x 2 bushing.

North of	Towner st.,	1 T, E. 35 ft. N. Stoup's S. Line.
"	"	1 T, E. 30 ft. S. " N. Line.
"	"	1 cross 20 ft. N. " N. Line.
"	"	1 cross 25 ft. N. Hlavine's N. Line.
"	"	1 union 42 ft. N. " N. Line.
"	"	1 T, E. 21 ft. N. of Heath's S. Line.
"	"	1 T, W. 19 ft. S. of Heath's N. Line.
"	"	1 T, W. 14 ft. N. of Heath's N. Line.

CENTER STREET.

North of Towner st., 1 T, E. 19 ft. S. of alley.
" " 1 cross 70 ft. N. of alley.
" " 1 T, W. 60 ft. S. of Congress st.
" " 1 union 32 ft. S. of Congress st.
At Towner st., 1 4 x 2 bushing.

ELLIS STREET.

West from Hamilton st., 1 4 x 2 reducer.
" " " 1 6 x 4 cross.
" " " 1 T, S. 27 ft. W. of Cutcheon's W. line.
" " " 1 T, N. 59 ft. W. of " "
" " " 1 cross 34 ft. E. of A. Martin's E. line.
" " " 1 union 17 ft. E. of " "
" " " 1 cross 22 ft. W. of " "
" " " 1 " 18 ft. " " W. line.
From Normal E., 234 ft. 2in. pipe.
" " 275 ft. 3in. "
" " 3in. T, W. line of Brower, plugged.

EMMETT STREET.

From Ballard West, 1 6 x 4 cross.
" " 1 cross 80 ft. W. of Ballard.
" 1 T, S. 22 ft. E. of Jay Worden's W line.
" " 1 T, S. 28 ft. W. of Seymour's E. line.
" " 1 T, N. 48 ft. " " "
" " 1 cross 69 ft. E. of Perrin st.
" " 1 union 50 ft. E. of "
" " 1 cross 19 ft. E. of "
From Perrin West, 1 6 x 4 cross.
" " 1 cross 64 ft. W. of Perrin st.
" " 1 cross 21 ft. W. of J. Fuller's E. line.
" " 1 cross 9 ft. W. of " center line.
" " 1 cross 30 ft. W. of Neat's E. line.
" " 1 T, S. 66 ft. W. of " "
" " 1 T, N. 90 ft. W. of " "
" " End of pipe 106 ft. W. of Neat's E. line.
From Brower West, T, S. 28 ft. E. of Brower 2in. pipe.
" " T, N. 12 ft. W. of " "
" " T, end of pipe 43 ft. W. of Brower 1in. pipe.

FOREST AVENUE.

At River Crossing, 2 ⅛ bends.
Opp. Woolen Mill, 1 6x4 T.

FLORENCE STREET.

East from Ballard, 2 x 1 T, 28 ft. E. of E. line of alley.
" " 2 x 1 T, 38 ft. W. of W. line of alley.
" " 2 x 1 T, 8 ft. W. of Scanlon's lot.
" " 1 2in. union, 25 ft. W. of Scanlon's lot.

FACTORY STREET.

From Grove W., 1 T, S. 23 ft. W. of Stirling's E. line.
" " 1 T, S. 50 ft. E. of Cornwell's E. line.

GROVE STREET.

At Stewart, 1 4 x 4 T, 27 ft. from S. line.
" Millard, 1 6 x 4 reducer.
" Factory, 1 6 x 4 cross 8 ft. from S. line.
" South, 1 6 x 4 T, 18 ft. from N. line.
" Congress st., 1 6 x 8 cross.
" Locust st., 1 6 x 4 T, 15 ft. from N. line.
" High st., 1 6 x 4 cross 22 ft. from N. line.
" Cross st., 1 12 x 6 T.

HAMILTON STREET.

At Congress st., 1 8 x 6 cross.
" Pearl st., 1 6 x 4 cross.
" Ellis st., 1 6 x 4 cross.
" Cross st., 1 12 x 6 cross.
" Florence st., 1 6 x 4 T.
" 1 4 x 2 bushing.
" Forest ave., 1 6 x 4 cross.
" " 1 6 x 4 reducer spigot end.

HURON STREET.

At Harriet st., 1 6 x 4 cross.
" Spring st., 1 6 x 4 T, 18 ft. from N. line.
" Buffalo st., 1 6 x 4 T, 19 ft. from N. line.
" Catherine st., 1 12 x 12 cross.
" " 1 12 x 6 reducer.
" Woodard st., 1 12 x 4 T.
" Michigan st., 1 12 x 4 T.
" Congress st., 1 12 x 8 cross.
" Pearl st., 1 12 x 4 T.
" Ellis st., 1 12 x 4 T.
" Cross st., 1 12 x 12 cross.
" " 1 12 x 10 reducer.
" " 2 $\frac{1}{16}$ bends.

HURON STREET.

Opp. Woolen Mill, 1 10 x 6 T.
" " " 1 6 x 4 reducer.
Junc. Washington st., 1 10 x 4 T.
" " 2 4in. ⅛ bends.
" Forest Ave., 1 6 x 6 cross.
" " 1 10 x 6 reducer.
" " 1 6 x 4 reducer.
" " 1 10 x 6 T.

LINCOLN STREET.

North of North st., 1 T, E. 27 ft. N. of Cook's N line.
" " 1 T, E. 39 ft. N. of Depuy's S. line.
" " 1 T, E. 25 ft. S. of Smith's N. line.
" " 1 T, E. 20 ft. S. of Dickinson's S. line.
" " 1 cross 18 ft. N. of Dickinson's S. line.
" " 1 union 23 ft. S. of Yost's S. line.
" " 1 T, E. 23 ft. N. of Yost's S. line.
" " end of pipe.

LOWELL STREET.

At Forest Ave., 1 6 x 6 T.
" " 1 6 x 4 reducer spigot end.

MICHIGAN STREET.

(Between Huron and Washington Sts.)

At Huron, 12 x 4 cross 19 ft. from N. line.
" " 1 1in. valve 5 ft. E. of Washington st.
" " 1 1in. check " " "
" " 1 1in. valve at Huron and 1 1in. check 1 ft. from Huron.
" " 1 T, N. 103 ft. from Washington.
" " 1 T, S. 139 ft. " "
" " 1 T, N. 158 ft. " "
" " 1 T, N. 213 ft. " "

MILES STREET.

At Congress st., 1 4 x 4 cross.

NORMAL STREET.

At Congress st., 1 8 x 6 cross.
" Pearl st., 1 6 x 4 cross 22 ft. from N. line.
" Ellis st., 1 6 x 4 cross 22 ft. from S. line.
" Cross st., 1 12 x 6 cross.
" " 1 6 x 4 reducer.

NORRIS STREET.

At Forest Ave., 1 6 x 4 cross.
" Oak st., 1 4 x 4 T.

PEARL STREET.

From Hamilton st. East, 1 T, S. 17 ft. E. of Hamilton.
" " " 1 T, N. 88 ft. E. of Hamilton.
" " " 1 T, S. 113 ft. E. of Hamilton.
From Ballard st. East, 1 T, S. 18 ft. W. of Thorn's E. line.
" " " 1 T, N. 22 ft. E. of Thorn's E. line.
" " " 1 T, S. 22 ft. W. of Cleveland's W. line.
" " " 1 T, N. 32 ft. E. of Cleveland's W. line.

PERRIN STREET.

At Pearl st., 1 6 x 4 reducer spigot end.
" " 1 4 x 4 T.
" Ellis st., 1 6 x 4 cross.
" Emmett st., 1 6 x 4 cross.
" Cross st., 1 12 x 6 cross.
" Forest Ave., 1 6 x 4 reducer spigot end.
" " 1 4 x 4 T.

PROSPECT AVENUE.

End of pipe 11 ft. S. of Slawson's S. line.
At Towner st., 1 4 x 4 T.
" Congress st., 1 8 x 6 cross.
" " 1 8 x 4 reducer.
" Locust st., 1 6 x 4 T, 15 ft. from N. line.
" High st., 1 6 x 4 T, 22 ft. from N. line.
" Cross st., 1 10 x 6 cross.
" " 1 10 x 4 T.
" " 1 4in. ⅝ bend.
" Maple st., 1 6 x 6 cross.
" Oak st., 1 6 x 6 cross.
" Forest ave., 1 6 x 6 cross.

PARK STREET.

At Congress st., 1 6 x 8 cross.
North from Babbitt st., 1 T, W. 29 ft. S. of S. line of North st.
" " " 1 T, E. 33 ft. N. of Haven's S. line.
" " " 1 union, 33 ft. N. of Haven's S. line.
" " " 1 cross, 55 ft. N. of Babbitt st.
North from North st., 1 4 x 4 T.
" " " 1 4 x 2 bushing.
" " " 1 T, N. 14 ft. from W. line of Park st.

PARK STREET.

North of North st., 1 T, E. 9 ft. N. of North st.
" " " 1 T, W. 5 ft. S. of Miller's S. line.
" " " 1 T, W. 34 ft. N. of Miller's N. line.
" " " 1 T, W. 11 ft. N. of Kinne's S. line.
" " " end of pipe.
South from Cross st., 1 T, E. 51 ft. S. of Cross st.
" " " 1 T, W. 109 ft. S. of Cross st.
" " " 1 T, W. 264 ft. S. of Cross st.
" " " 1 T, E. 267 ft. S. of Cross st.

PARSONS STREET.

West from Grove st., 1 T, 217 ft. W. of Grove st.
" " " 1 ell, 270 ft. W. of Grove st.
" " " 1 T to Hawkin's on Farmer st.
West from Park st., 1 T, S. 66 ft. W. of Park st.
" " " 1 T, N. 100 ft. W. of Park st.
" " " 1 T, S. 131 ft. W. of Park st.
" " " 1 T, S. 201 ft. W. of Park st.

RIVER STREET.

At Congress st., 2 8 x 8 crosses.
" " 1 8 x 6 reducer.
" Babbitt st., 1 2in. union.
" North st., 1 6 x 4 cross.
" Cross st., 1 12 x 6 "
" Maple st., 1 6 x 6 T.
" Oak st., 1 6 x 6 T.
" Forest ave., 1 6 x 6 cross.
" " 1 6 x 4 reducer.
" " 1 4 x 2 "
From Forest Ave. N., 1 T, W. 37 ft. N. of Barkers' S. line.
" " " 1 T, W. 47 ft. N. of Horrigan's S. line.
" " " 1 T, E. 18 ft. S. of Peck's S. line.
" " " 1 cross, 58 ft. S. of Peck's N. line.
" " " 1 T, E. 8 ft. S. of Peck's N. line.
" " " 1 T, W. 5 ft. S. of Worden's S. line.
" " " 1 cross, 24 ft. S. of alley.
" " " End of pipe, 16 ft. S. of alley.

RACE STREET.

1 12 x 4 T, 30 ft. S. of hydrant and 247 ft. N. W. of well.

SUMMIT STREET.

At Chicago Ave., 1 4 x 4 T.
" Congress st., 1 8 x 8 cross.

SUMMIT STREET.

At Congress st., 3 8 x 6 reducers.
" " 2 6 x 4 "
" Pearl st., 1 6 x 4 T, 12 ft. from hydrant.
" Ellis st., 1 6 x 4 cross.
" Cross st., 1 12 x 6 cross.
" " 1 6 x 4 reducer.
" Forest Ave., 1 4 x 4 T.

SOUTH STREET.

East from Park st., 1 T, S. 28 ft. E. of gravel pit.
" " " 1 T, S. 96 ft. E. of " "
" " " 1 T, S. 208 ft. E. of " "
" " " 1 T, S. 9 ft. W. of alley.

TOWNER STREET.

East from Center st., 1 T, 38 ft. E. of E. line.
" " " 1 T, 144 ft. E. of E. line.

WASHINGTON STREET.

At Harriet st., 1 6 x 4 cross.
" Buffalo st., 1 6 x 4 cross 19 ft. from N. line.
" Catherine st., 1 6 x 4 cross 20 ft. from S. line.
" Woodard st., 1 6 x 4 cross 18 ft. from N. line.
" Michigan st, 1 6 x 4 cross.
" Congress st., 1 8 x 8 cross.
" " 2 8 x 6 reducers.
" Pearl st., 1 6 x 4 cross 15 ft. from N. line.
" Ellis st., 1 6 x 4 cross.
" Cross st., 1 12 x 6 cross.
" " 1 6 x 4 reducer.

TABLE "E."

ACCOUNT SALES.

J. M. Chidister, brick..$	80
Cash, brick..	60
Mrs. H. C. Swift, brick..	12 00
Cash, brick..	70
C. L. Yost, brick..	3 30
R. W. Hemphill, brick..	1 20
Wm. Smith, two sash..	50
O. E. Thompson, pipe..	90
Cash, one pair boots..	50

James Wilson, brick	$ 10 00
R. W. Hemphill, cement and sash	2 90
Ypsilanti Gas Co., lead	170 00
W. R. Coats, well cover, engine and boiler	150 00
Bardeen Paper Co., lead and yarn	72 30
J. McCauley, cement	10 00
Deubel & Co., cement	13 33
Mr. Reese, brick	50
H. Briggs, two oil barrels	1 60
Mr. Ellis, cement	1 20
Hay & Todd M'f'g Co., laying pipe and cement	38 90
J. Remington, brick	2 10
L. Walker, brick	10 00
A. Williams, brick	$ 60
Ypsilanti Paper Co., labor and supplies	96 24
Cash, bats	2 00
Cash, brick	90
H. Briggs, barrels	3 10
T. McAndrew, brick	12 00
W. J. Clarke, brick	12 00
W. Smith, sash	50
	$630 67

INVENTORY.

LARGE PIPE AND SPECIALS.

	Value.
7 ft. 12 inch	$ 21 00
24 ft. 10 inch	65 10
80 ft. 8 inch	43 20
84 ft. 6 inch	45 36
208 ft. 4 inch	62 40
2 12 inch sleeves	
2 10 inch sleeves	
2 8 inch sleeves	74 00
2 6 inch sleeves	
2 4 inch sleeves	
7 Flower Bros. hydrants	175 00
6 6x4 inch crosses	30 00
6 4 inch crosses	24 00
1 12 inch clamp	4 00
4 4 inch clamps	3 00

2 10 inch wooden plugs	
2 8 inch wooden plugs	$ 1 50
4 6 inch wooden plugs	
6 4 inch wooden plugs	
98 pounds yarn	7 84
3170 pounds lead	126 80
1 crane for handling pipe	2 00
35 scaffolding horses	17 50
900 ft. scaffolding lumber	7 20

SMALL PIPE.

21 ft. 2½ inch black	5 25
86 ft. 2 inch black	9 46
450 ft. 1¼ inch black	31 50
160 ft. ½ inch black	4 80
360 ft. ¾ inch black	14 40
1044 ft. 1¼ inch galvanized	114 84
240 ft. 1 inch galvanized	19 20
980 ft. ¾ inch galvanized	58 80

COCKS.

4 ¾ inch hydrant	3 20
8 ½ inch hydrant	4 40
83 1 inch corporation	83 00
48 ¾ inch corporation	31 20
249 ½ inch corporation	87 15
10 1½ inch R. W	16 00
122 1 inch R. W	164 70
115 ½ inch R. W	63 25

FITTINGS.

21 1¼ inch ells	4 20
52 1 inch ells	9 38
150 ¾ inch ells	19 53
242 ½ inch ells	9 68
2 ¼ inch ells	08

TEES.

4 2 to 1	60
66 1¾ x ¾	9 90
53 1 inch	5 30
35 ¾ inch	2 80
36 ½ inch	2 52

BUSHINGS.

1 5 x 2	1 00
9 4 x 2	6 75

1	3 x 2	$ 60
17	2 x 1	1 87
2	1½ x 1¼	14
100	1¼ x 1	4 00
91	1 x ¾	2 73
134	¾ x ½	4 02
	COUPLINGS.	
42	2 inch	4 62
1	1½ inch	10
134	1¼ inch	12 06
714	1 inch	8 56
68	¾ inch	2 04
270	½ inch	8 13
1	1¼ to 1	07
128	1 to ¾	3 84
228	¾ to ½	6 84
	UNIONS.	
10	2 inch flange	3 90
14	1¼ inch	2 82
187	1 inch	22 44
184	½ inch	14 72
	PLUGS.	
18	2 inch	1 98
50	1¼ inch	2 00
92	1 inch	1 84
46	¾ inch	92
3	½ inch	06
	CAPS.	
2	2 inch	24
37	¾ inch	1 11
2	1 inch	08
4	½ inch	06
	TOOLS.	
1	Muehler tapper	85 00
2	stocks and dies	28 00
2	pipe cutters	10 00
2	Stilson wrenches	3 40
1	Alligator wrench	90
1	2 inch tap	2 65
1	1½ inch tap	1 65
1	1¼ inch tap	1 05
1	pipe and monkey wrench	1 50

1 spring wagon	$ 70 00
1 pipe vice	6 00
75 ft. hose	11 25
7 long handle shovels	4 00
68 short handle shovels	31 10
1 scoop	70
51 picks and handles	25 50
14 dirt barrows	14 00
2 stone barrows	5 00
8 long handle hoes	3 20
7 pair rubber boots	7 00
1 lead kettle	25 00
2 pouring kettles	1 00
4 pipe levers	80
5 tunneling bars	5 00
5 flat nose bars	5 00
1 square nose bar	1 00
2 iron wedges	1 50
4 diamond points	1 60
18 calking tools	7 20
2 handle chisels	2 00
1 wood chisel	50
2 calking hammers	1 00
3 sledge hammers	6 00
1 tape line	25
3 pairs chain tongs	9 00
1 pair screw tongs	3 68
1 funnel	20
1 dipper	10
4 pails	40
2 axes	1 50
2 five gallon oil cans	3 00
1 ten gallon oil can	3 00
3 one gallon oil cans	1 20
2 bushel baskets	30
5 cold chisels	1 50
23 lanterns, colored glass	11 50
18 ring chains	4 50
1 plow	25 00
2 rakes	1 50
4 tool boxes	16 00
1 pipe line wagon	10 00

SUPPLIES.

1 tank crude oil	90 00
3 bbls. Portland cement	9 00
120 sacks water lime	40 00
1 bbl. Kelley Island lime	70
43 6 inch tile	6 45
1 6 inch elbow	55
½ bbl. salt	25
150 fire brick	6 00
25 tons coal	60 00
21 stop boxes	23 10
34 stop boxes	45 90
	$2,348 76

OFFICE.

Desk	$ 45 00
Desk	30 00
Carpets and linoleum	40 00
Chairs	10 00
Table	7 00
Recording pressure gauge	75 00
Two large window screens	4 00
Two small window screens	1 00
Ink stand	1 00
Stamp	80
Draft board	3 00
Two baskets	50
Water meter	44 00
	$261 30

APPENDIX.

TESTIMONIALS SHOWING THE VALUE OF YPSILANTI WATER SUPPLY IN ORDINARY USE.

YPSILANTI, MICH., May 10, 1890.

To Whom it may Concern:

I, James H. Davis, of this city, do hereby testify that for nine years previous to November last, I was a great sufferer from catarrh and inflammation of the bladder, and from serious kidney and urinary troubles. I have been treated by several of the first physicians of the State, among them Drs. Maclean and Frothingham of the State University, all of whom pronounced my case incurable. There was no time during all these nine years that I did not suffer great pain, and at times excruciating agony, while urinating. Early in September last I commenced using the water from the mains of the city water works, and in two months I felt myself completely cured; and at no time since have any symptoms of my old disease returned. I have only used this water as a simple drinking water, have paid no attention to diet, eating whatever I chose. I ascribe my cure entirely to the use of this water, and I most gladly testify to this, hoping that other sufferers may be benefited thereby.

JAMES H. DAVIS.

Subscribed and sworn to before me, May 10, 1890.

FRANK JOSLYN, Notary Public.

For several years I have been seriously troubled with kidney and urinary difficulties, resulting in pain and soreness in my back, and in sedimentary deposits in my urine. Six months ago I commenced using the water furnished by the Ypsilanti water works, and I am very glad to be able to say that I am very greatly benefited. All evidence of sedimentary deposit in my urine have vanished. I have no more soreness or lameness in my back, except on one occasion after being deprived of the use of the water for a few days, symptoms of the old trouble in my back returned. I fully believe the simple use of this water for drinking, without any dietic *regime* whatever, has entirely cured me.

STEPHEN H. DODGE.

YPSILANTI, May 12, 1890.

YPSILANTI, May 10, 1890.

For several years I have been troubled with kidney difficulties and could find no remedy to relieve me, and finally gave up entirely taking medicine. Last November, on my return from Lake Superior, I commenced drinking the water from the city water works, and very soon I was free from all the old trouble, and no symptoms of it have since returned. I believe I am now entirely cured, and free from any kidney trouble whatever.

W. P. BEACH.

I have been troubled for the last three or four years with kidney complaint, and tried almost everything I could get in the shape of medicine, but did not get any permanent relief until I commenced using the water from the Ypsilanti Water Works, and almost immediately experienced relief, and have continued to use it since, and use it at the present time, and am almost cured, and can only attribute it to the water from the Ypsilanti city well.

G. FULLER.

YPSILANTI, May 9, 1890.

This is to certify that myself and family have been afflicted very seriously with kidney and urinary troubles for years. Last fall we commenced using the water from the supply well of the city Water Works. I had no thought when I commenced using this water that we should be cured, but only used it because I considered it better than the water of our private well. We had not used the water longer than two months before we were all entirely relieved of all kidney and urinary troubles. My house not being connected with the water mains, there was a brief period during the winter that we were deprived of the city water. Very soon our troubles returned. I at once took measures to obtain the city water again for permanent use, and soon all our troubles disappeared again, and I consider myself and family cured. There can be no question but that the drinking of this water has effected our cure.

E. B. MOREHOUSE.

YPSILANTI, May 12, 1890.

I can certify to the truth and genuineness of the above testimonials, from personal knowledge relative to the cases. Hundreds of similar cases could be cited, though the water has only been in use a few months.

I can also testify from my own personal experience to the marvelous sanitary excellence of this water. In all my long experience in the development of public water supplies, I have never known of anything in the remotest degree approaching it.

W. R. COATS, Engineer.

YPSILANTI, May 12, 1890.

W. R. COATS:

Dear Sir,—I wish to add my testimony concerning the remarkable excellence of our public water supply. It seems to me that in this connection some reminiscences of the early history of Ypsilanti will prove of interest. I came to Ypsilanti in 1834, while Michigan was still a territory. At that time there was a spring near where the great supply well of the Ypsilanti Water Works now stands. In those days thousands of Indians from the surrounding country, and from remote parts of the territory, used to visit this place, and camp about this spring, and drink of its waters. These Indians used to call the waters of this spring, "the sweet waters of the Huron," and claimed that the water possessed great medicinal virtues. I think that the water from the big well that supplies the city comes from the same source that formerly supplied the "sweet water" spring of Indian fame. Myself and family have derived great benefit from the use of this water. I believe it to be the best cure for kidney and urinary troubles known.

S. H. DIMICK, Druggist.

Concerning the above, I will say, that in my first investigations relative to the development of a public water supply for this city, I found this spring, or rather what was left of it, in the bottom of an old mill race that had been cut through it. I examined the spring closely, and made boring tests that convinced me that these spring waters came from the same stratum that now supplies the large well of the city Water Works.

W. R. COATS, Engineer.